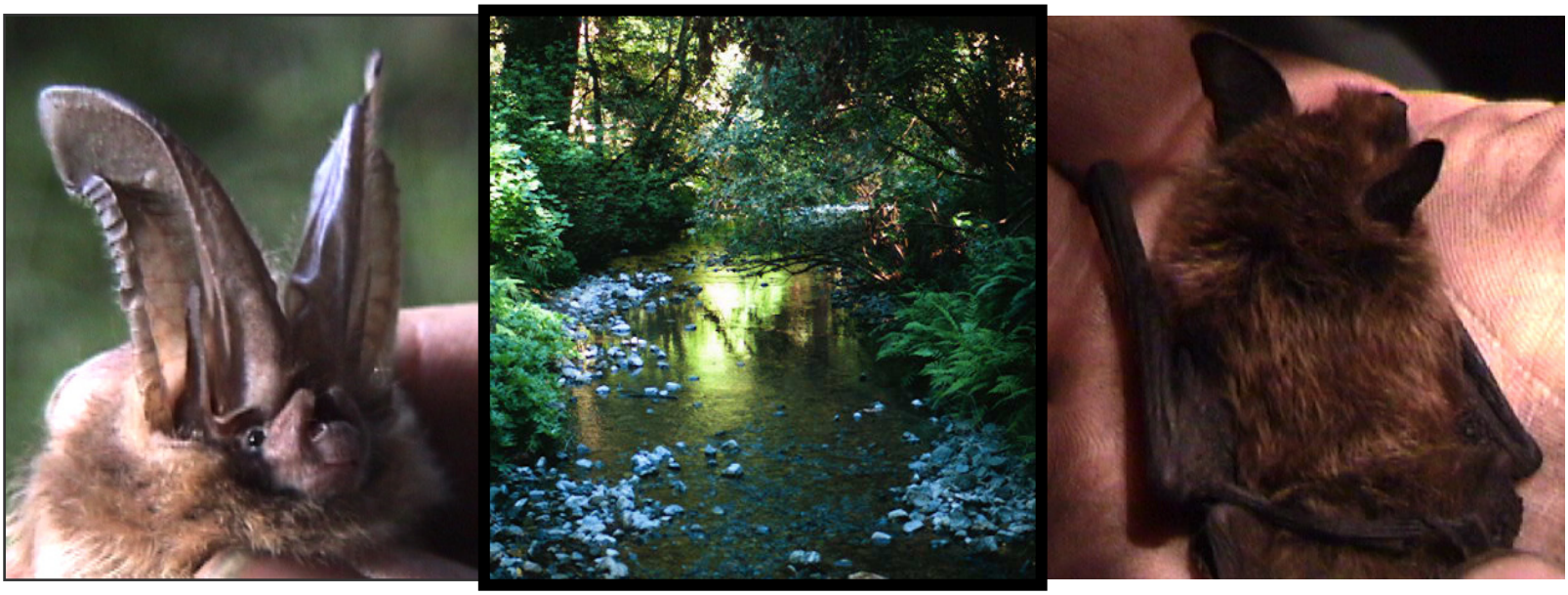
BAT INVENTORY OF
MUIR WOODS NATIONAL MONUMENT

FINAL REPORT



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1.0 INTRODUCTION

Despite their positive ecological roles, bats are often perceived negatively and are threatened by human activities. Bats are experiencing declines throughout their ranges due to human disturbance at roost sites, destruction of foraging and roosting habitat, and environmental contamination (Altringham 1996). Bats have extraordinarily low reproductive output for small mammals, typically rearing only one young per year, and therefore may be slow to recover from population decline (Findley 1993). In addition, bat species that roost in large, dense groups are particularly vulnerable to accidental or deliberate human disturbance.

Because bats are nocturnal, fly, and often roost in cryptic, inaccessible locations they are difficult to study in the wild. The difficulties associated with the study of bats have resulted in far less research being done in the wild on bats than on other mammals. For example, echolocation was only discovered a little over 50 years ago (Nagorsen and Brigham 1993). Much of the natural history information obtained has been the result of chance encounter between naturalist and bat. Recent technologies have allowed bat biologists to perceive bats in natural settings and document presence and behavior. As technologies, such as acoustic bat detectors, have become available and more readily used, survey protocols have developed to standardize survey methods. These new methods and materials allow bat biologists to collect new and useful data on species occurrence, relative abundance, and habitat associations.

Although most North American bats have broad geographical distributions, regional distributions are often patchy, making them vulnerable to extirpation or severe reduction as the result of human activity (Pierson 1998). Conservation of California bats should focus on protection of their roosting and foraging sites. However, because bats have received little research attention in many areas, details of their habitat needs are poorly known. Our study of the bats of Muir Woods National Monument sought to document how bats utilize coastal redwood habitat, specifically old-growth forest characteristics. Our work compliments the recent work of Pierson et al. at the Point Reyes National Seashore, which documented Townsend's big-eared bat use of redwood hollows.

Muir Woods National Monument (MWNM) is home to the last remaining contiguous stand of old growth coast redwoods in Marin County. Stands of Douglass fir occur upslope from the main redwood grove and continue into Mt. Tamalpais State Park. Redwood creek, a small coastal stream, drains through the main redwood grove. The natural features of MWNM make it suitable roosting and foraging habitat for numerous bat species. Twelve species are likely or possible to occur in the Muir Woods National Monument (Table 1). Two of these species (*Corynorhinos townsendii*, *Antrozous pallidus*) are California Department of Fish and Game Species of Special Concern and five are Federal Species of Special Concern (*Myotis yumanensis, Myotis evotis*, *Myotis thysanodes, Myotis volans*, *Corynorhinus townsendii*). MWNM is visited by over 1.5 million people annually with a peak attendance in the summer months averaging 8,000 to 10,000 people per day. The intense tourist use of the monument warrants concern over of how the

natural fauna may be impacted by human presence. The development of long-term monitoring and management strategies will hopefully allow for the co-existence of the natural fauna and human visitors.

2.0 STUDY OBJECTIVES

Inventory and monitoring objectives:

1. Determine bat species presence within MWNM and the upper reaches of Redwood Creek in Mount Tamalpais State Park.

2. Evaluate the spatial and seasonal distribution and relative abundance of the bat fauna in the old growth forest and surrounding habitat.

3. Evaluate the importance and role of late successional forests in sustaining bat populations in Marin County.

4. Provide recommendations for long-term monitoring needs and methods.

3.0 METHODS

Guano trapping, acoustic sampling, and mist netting were the three primary techniques used in the study. A combination of these methods provides the most thorough assessment of bat activity and presence. Guano traps were used to identify tree hollows used as bat roosts, acoustic surveys were used to monitor bat activity, and mist netting was used to capture bats to confirm identification and assess reproductive condition. A small radio-tracking project was also conducted in the first year of the project.

3.1 *Guano traps*

Guano traps were installed in redwood hollows to evaluate the use of hollows by roosting bats. Window screen material was suspended in tree hollows so that animals such as foxes and raccoons can enter below without disturbing the trap, but bat guano can be easily collected and retrieved. The main purposes of the guano traps were to determine which trees are being used by bats, calculate a relative index of tree use based on the amount of guano collected per day, and compare riparian and upland forest use by bats.

Traps were checked and guano pellets counted roughly once a month. Guano from *Corynorhinus townsendii* was identified by distinctive characteristics and recorded. Other guano was not identified to

species. Monthly collection of guano allowed for a detection of seasonal activity and shifts in roost sites. Trees that showed the most activity were subsequently mist-netted and acoustically monitored to identify species and type of use (e.g. maternity roost).

Twenty-six guano traps were installed in MWNM. Hollow trees were sampled in two different regions – the riparian corridor along Redwood Creek and the upland forest at mid-slope and on Deerpark Ridge. Fourteen trees were selected in the riparian corridor, all within 100 meters of Redwood Creek. Twelve upland trees were selected, including six trees at mid-slope and six trees on the Deerpark ridge. The creek elevation is 45 meters, the ridge is at 300 meters, making a 255 meter elevational gradient. To avoid vandalism and other tourist problems, guano traps were selected to not be visible to the public.

3.2 *Mist Netting*

Mist netting is a standard technique for capturing bats although it does not sample with equal effectiveness for different bat species. The advantage of mist netting is the ability to handle animals to confirm species identification and assess biological condition, e.g. age, sex, and reproductive status.

Generally, five standard mist-nets, including two 18-foot, two 30-foot and one 42-foot net, were opened at sunset and kept open for three hours. Twenty-one nights of mist netting were conducted along a .5 km stretch of Redwood creek. In addition, three nights of mist netting were conducted at Deerpark ridge.

Captured bats were identified to species, sexed, and aged (juvenile or adult) and forearm measurements recorded. Reproductive status for females was determined by abdominal palpation and mammary condition and classified as pregnant, lactating, post-lactating, or nulliparous. Males were noted as reproductively active if the testes were scrotal (Racey 1988). Juvenile status was determined by lack of epiphyseal closure (Anthony 1988). Bats were not banded because of extremely low recapture rates of free-flying bats. Animals were released on-site and hand-release echolocation calls were recorded at the time of release.

3.3 *Acoustic Sampling*

Acoustic sampling was done with an Anabat II bat detector system (Titley Electronics). Several acoustic sampling stations were established along Redwood creek. Detectors were set on the ground facing an opening in the canopy above the creek or in the parking lot adjacent to the creek at the park entrance. Thirty-three nights of acoustic sampling took place at roughly monthly intervals for 24 months, usually for two consecutive nights each visit.

The Anabat system uses a bat detector to detect bat ultrasonic echolocation calls in the field and uses a z-caim unit to convert the detected signals into time/frequency graphs on a laptop computer. The graphs are used to identify bat species and record number of bat passes. Species are identified by their vocal signature graphs by comparing calls recorded during previous mist-netting activities, calls recorded

from bats that are visually identified at the time of recording, and by comparing calls with existing bat vocal signature library databases.

3.4 *Radiotracking*

A pilot radio-tracking project was incorporated into the Muir Woods bat study to locate day roosts of two species, *Eptesicus fuscus* (Big brown bat) and *Lasionycteris noctivagans* (Silver haired bat). Three individuals were tracked for 12 days (the lifespan of a transmitter battery). Day roosts and nightly activity were recorded.

3.5 *Collections*

No collections were made during this study. All captured bats were released at point of capture, generally within 2-3 hours.

4.0 RESULTS

4.1 *Species Composition*

Ten bat species have been identified foraging and/or roosting in MWNM (Table 2). Nine of these species were captured in mist nets. The Mexican free-tailed bat (*T. brasiliensis*) was detected acoustically, but not captured. Visual observations made in redwood hollows identified at least four species (*M. thysanodes*, *M. volans*, *E. fuscus*, *C. townsendii*) using redwood hollows as day roosts, night feeding roosts, or maternity roosts. The Long-eared myotis (*Myotis evotis*) and the Pallid bat (*Antrozous pallidus*) are two species expected to occur in the region and are known to occur in redwood forest habitat, but were not identified during the study.

4.11 *Mist netting Captures*

Sixty-nine individuals of nine different species were captured over 15 months of mist netting at Muir Woods (Table 3). Mist net captures declined steadily over the duration of the study. We believe this decrease in captures reflects bats' ability to learn to detect nets. Reproductively active females from four *Myotis* species were captured, indicating maternity use in Muir Woods by these species.

4.2 *Spatial Distribution*

We evaluated the spatial distribution of bat presence between the Redwood Creek riparian corridor and the Deerpark Ridge upland area through guano trap results, acoustic work, and mist netting. The upland area and riparian corridor were chosen for comparison because preliminary efforts showed that most bat activity was concentrated in the riparian corridor and the ridge areas and acoustic detection was limited

by the canopy in heavily forested areas. In addition, we compared the differences in species composition of mist-net captures between the lower stretches of Redwood creek, which occur outside the redwood grove, to captures inside the redwood grove to elucidate species' habitat associations.

4.21 *Riparian vs. Upland*

4.211 Guano trap results

Twenty-five of the 26 guano traps installed showed use by bats. Guano traps in both upland and riparian areas demonstrated regular use of basal redwood hollows by multiple species of bats. Guano deposition in redwood hollows was compared between hollows sampled in the riparian corridor to the traps in the upland areas. In the riparian corridor, guano levels increased significantly during the maternity season (May-August) in both 1999 and 2000. In upland hollows, guano deposition was stable throughout the year, demonstrating regular, light use (Figure 1). In 2000, one of the sampled hollows in the riparian area was identified as containing a maternity roost of *M. thysanodes* and *M. volans*. This tree showed a much more dramatic increase in guano deposition during the maternity season than the other hollows in both the riparian and the upland areas. These data suggest that hollows in both riparian and upland areas get regular use by bat species. There may be a tendency for maternity roosts to be selected to be near streams, but whether bats chose hollows to be near the creek or whether hollows were selected based on particular features of the hollow itself is difficult to interpret.

4.212 ***Mist netting and Acoustic results***

To compare the differences between bat species presence in the Deerpark ridge upland areas and the riparian corridor of Redwood creek, we have compared mist netting and acoustic data from three nights of sampling on Deerpark ridge with three adjacent nights of sampling in the riparian corridor (Tables 4 and 5). Yuma myotis (*M. yumanensis*) and the hoary bat (*L.cinereus*) were only detected in the riparian corridor and never detected nor captured on the ridge. All other species found using MWNM were detected in both the riparian corridor as well as in the upland area. Both the hoary bat and the yuma myotis are notably riparian species.

4.22 *Redwood Riparian vs. Hardwood Riparian*

We noticed two notable trends when we compared mist net captures between the mist netting stations placed within the redwood grove and mist netting that took place in the mixed hardwood riparian habitat adjacent and down stream of the parking lot. Silver-hair bats (*L. noctivagans*) were regularly captured in the redwood grove areas, but were never captured in the downstream areas. Conversely, yuma myotis (*M. yumanensis*) were conspicuously absent in the redwood grove habitat. Yuma myotis are one of the most commonly captured bats, because of their foraging habit of flying low over open water to trawl for

insects. Yuma myotis were detected acoustically within the redwood grove, but their low capture rate was surprising and may indicate unusually low numbers of the species in this setting.

4.3 *Seasonal Distribution*

Seasonal distribution was examined by comparing the presence of species in each month of sampling (Table 6). The silver-haired bat (*L.noctivagans*), California myotis (*M. californicus*), and yuma myotis (*M. yumanensis*) were the most commonly detected species and were detected in every month of sampling. The big brown bat (*E. fuscus*), red bat (*L. blossevillii*), and Mexican free-tailed bat (*T. brasiliensis*) were detected in all seasons and are probably year-round residents in the park. The red bat (*L. blossevillii*) and the silver-haired bat are known to be migratory in some parts of their range, which makes their year-round presence in Muir Woods especially interesting. The fringed myotis (*M. thysanodes*) and the long-legged myotis (*M. volans*) were mainly detected in the maternity season. Although these species might be present year-round, they were not active in the winter. The hoary bat (*L. cinereus*) was present in spring and fall, but absent in the summer months, which indicates that this migratory species moved through the monument during migration, but may not use the area for reproduction. The Townsend's big-eared bat (*C. townsendii*) is difficult to detect with acoustic equipment and rarely captured in mist nets, its low number of detections is likely not indicative of any seasonal activity pattern.

4.4 *Relative Abundance*

Relative abundance of species is difficult to quantify, therefore we assessed roosting and foraging potential in the old-growth redwood forest compared to surrounding habitat. Our radiotracking project revealed that bats most commonly use habitat features associated with old-growth redwood trees, such as bark crevices, anomalous features, and fire-scar hollows. The use of these features suggests that bats have more roosting potential within the protected old-growth forest than in surrounding second-growth and developed areas. Whereas a few species, such as the Mexican free-tailed bat and the big brown bat, are capable of adapting to suburban areas, species diversity in developed areas is generally lower than in intact habitats.

5.0 DISCUSSION

Our study establishes that Muir Woods National Monument provides both roosting and foraging habitat for at least ten different species of bats and is a valuable habitat resource for the local bat fauna. The old-growth redwood forest habitat at Muir Woods National Monument supports a high diversity of bat species because it provides both roosting habitat in the form of natural tree features as well as foraging habitat and access to water to drink at Redwood Creek. Roosting habitat (i.e. hollows, bark crevices, tree anomalies) for different species is more available in old-growth redwoods. Because most bat species using the redwood forest region are using either hollows or crevice features on large redwoods, protecting these

large trees is the key to protecting the bat fauna. Zielinski and Gellman (1999) found that bats use small remnant patches of old-growth redwood, indicating the value of preserving small patches of old-growth redwood forests.

Sixteen species are expected to occur in the central coast of California and thirteen of those species have been observed using redwood habitat. The ten species identified at MWNM represents at least 63% of the bats likely to occur in the general region, showing the significance of this habitat type and protected area to the bats of the region. Although developed areas can support large colonies of a few species, such as Mexican free-tailed bats and big brown bats, the high diversity associated with MWNM is unique to protected and ecologically intact areas. The role of the late successional forest within MWNM in protecting the bat fauna of Marin county is its ability to support a high diversity of species and a high percentage of the bats likely to occur in the general region.

5.1 *Spatial Distribution*

Bats were detected throughout the monument, although activity was concentrated along the riparian corridor and on the ridge. Radiotracking confirmed that individuals day-roosting in redwood trees on the ridge and in the riparian zone would fly to the creek to drink shortly after emerging. These individuals would forage over a 3-mile radius, encompassing mixed-evergreen, coastal shrub, and redwood forest habitats throughout a single night. Most of the species detected within the monument were detected in both the riparian corridor and along the ridge. The distribution of most species throughout the monument and in surrounding habitat reflects that bats are volant, highly mobile, and capable of utilizing well-dispersed resources. Unlike most songbirds, the home ranges of most bats are quite large and foraging extends over large areas. The bats that roost, forage, and drink inside the monument boundaries also utilize the surrounding habitat. The importance of the old-growth forest protected by MWNM is that it provides considerable roosting structures for multiple bat species as well as access to a healthy riparian corridor.

5.2 *Seasonal Distribution*

Year-round use by nearly all the species detected is remarkable and provides useful information about the regional patterns of activity and residency. Little is known about the migratory and hibernating patterns of many bat species in California. Detection of the western red bat and the silver-haired bat in all seasons indicates that these two species are likely resident in MWNM throughout the year. These two species are migratory in most parts of their range (Nagorsen and Brigham 1993).

Redwood hollows not only provide suitable habitat for maternity roosting, night roosting, and day-roosting for many different species, they also provide suitable thermal and protective conditions for winter hibernation. No large hibernacula were identified during the study, but individual animals were observed in redwood hollows during the winter months. The presence of suitable winter roosts and the mild climate associated with coastal California make MWNM an ideal place for over-wintering for bat species. Certain

species, such as the California myotis, are capable of foraging on warm winter days. We found evidence that activity on warm winter days was common, especially for California myotis.

5.3 *Management Concerns*

5.31 *Special Status Species*

Of the ten species that occur in the monument, four species are federal species of special concern (*M.thysanodes, M.volans, M.yumanensis, C.townsendii*) and Townsend's big eared bat (*C.townsendii*) is also a California species of special concern. In addition, the western red bat (*L.blossevillii*) and Townsend's big-eared bat are Forest Service sensitive species (CDFG 2001) (Table 5.3).

Sensitive-Status Bat Species

Federal Species of Concern	**California Species of Concern**	**Forest Service Sensitive Species**
Myotis yumanensis	*Corynorhinus townsendii*	*Corynorhinus townsendii*
Myotis thysanodes		*Lasiurus blossevillii*
Myotis volans		
Corynorhinus townsendii		

Townsend's big-eared bat prefers to roost in cave-like structures and has been experiencing population declines in California (Pierson et al. 1999). Historically, old-growth redwood forests offered excellent roosting habitat for this species and provided suitable habitat where natural cave structures were not common in coastal California. Because *C. townsendii* prefers spacious, open cave settings, only hollows located in large diameter trees tend to offer appropriate conditions for this species.

A maternity colony of approximately 40 bats was discovered in a large hollow in the riparian corridor of Muir Woods National Monument. The colony was comprised of both *Myotis thysanodes* and *Myotis volans*, two federal species of special concern. This discovery established that redwood hollows are suitable maternity roosting habitat for these species. *M. yumanensis* was also found using redwood hollows as maternity roosts in Monterey County (Pierson pers. comm.). Therefore, most of the special status bat species that occur in redwood riparian habitat are associated with using redwood hollows, the exception being the western red bat, which roosts in foliage.

5.32 *Long-term monitoring and management recommendations*

1. Survey selected burn areas for occupied hollows prior to prescribed burning.
2. Survey hollows along suggested trail routes prior to building of trails.
3. Establish a year-round, self-operating acoustic monitoring station at the visitor kiosk.

The main threats to the bats of MWNM are human disturbance to maternity roosts and, potentially, prescribed burning of the forest. Prescribed burns may be beneficial for bat species in the long-

term by creating new hollows, but the direct impact of burning on sensitive bat species using hollows is unknown. Danger to hollow-roosting bats could be exacerbated if hollows are used to ignite burns because of the large fuel load associated with them. We highly recommend as a long-term monitoring and management strategy that prescribed burns be monitored for impacts to bats. We suggest that areas selected for burning be surveyed prior to the burn to identify any potential maternity colony and measures be taken to reduce the potential for take of bat species during a burn.

Muir Woods National Monument is an exemplary example of how tourists and bats can co-exist. Muir Woods receives approximately 1.5 million visitors each year, but the park supports a diverse bat population. Hollows near the paved trails along the creek support maternity colonies of bats. This co-existence hinges on the diligence of Muir Woods staff to prevent visitors from straying from trails and entering and disturbing hollows. In addition, MW National Monument maintains their riparian habitat by keeping visitor disturbance at a minimum. Reserve and park managers should minimize human access to redwood hollows containing bats because of the potential disturbance to sensitive bat species. We recommend that surveys of hollows be done before any trail alterations are made to the main tourist trails to make sure that large maternity colonies are not exposed to human disturbance. As long as the hollow entrance is faced away from the trail, then the bats don't appear to be disturbed.

In terms of long-term monitoring, we suggest that MWNM install a permanent acoustic monitoring station at the visitor kiosk. The acoustic station would comprise of an Anabat bat detector, z-caim unit, and laptop computer for file storage. If connected to the kiosk power supply, the acoustic equipment could collect acoustic data on bat activity continuously with very little human maintenance. The acoustic files could then be used to analyze trends in species occurrence as well as for interpretive purposes. An acoustic system, complete with detector, z-caim, laptop, waterproof case, would cost approximately $1,000.

6.0 NATURAL HISTORY SPECIES ACCOUNTS FOR BATS OF MUIR WOODS NATIONAL MONUMENT

Yuma Myotis (*Myotis yumanensis*) is a Federal Special Concern and California Special Concern species. It is a year-round resident in most of California at lower elevations in a wide variety of habitats from coast to mid-elevation. It is very tolerant of human habitation and survives in urbanized environments. Day roosts are in buildings, trees, mines, caves, bridges, and rock crevices. Night roosts are in buildings, bridges, and other man-made structures. It is presumed to be non-migratory and hibernates in winter, but no large winter aggregations have been reported. A single young is born per year between June and July. Females form large maternity colonies of 200 to several thousand individuals. Males roost singly or in small groups. The Yuma myotis feeds on emergent aquatic insects, such as caddisflies and midges. Foraging occurs directly over the surface of still water ponds, reservoirs, or pools in streams and rivers

Fringed Myotis *(Myotis thysanodes)* is a Federal Special Concern species. This species is found in western North America from British Columbia to Veracruz and Chiapas. Over most of its range this species occurs at mid-elevations. It has been found at high elevations in New Mexico and was found in the Sequoia National Forest above 6000 feet. Along the west coast, this bat is found at low elevations (O' Farrell and Studier 1980) and is associated with redwood forests. Maternity colonies are large, up to 300 individuals (Nagorsen and Brigham 1993). These colonies are in caves, mines and buildings. Given this species association with redwood forests in coastal California it is likely to use redwood hollows. Males roost separate from the maternity colonies. Night roosts are in similar features. In portions of its range, *Myotis thysanodes* migrates to lower elevations and/or more southern locations, where the bats can be active during the winter months (O' Farrell and Studier 1980). In coastal California, such migrations may not occur. Only one young per year is common for the Fringed Myotis. Little is known of the reproductive cycle of this species. Ovulation and fertilization occur in late spring (May 1 to May 15) with parturition occuring June 25 to July 7 (O' Farrell and Studier 1980). Young are capable of limited flight at 16 days and are adult size by 21 days. *Myotis thysanodes* primarily eats beetles (73% of its diet) moths, flies, leafhoppers, lacewings, crickets, and harvestmen (O' Farrell and Studier 1980). The presence of flightless insects in its diet suggest that some of its prey is gleaned from foliage (Nagorsen and Brigham 1993).

Long-legged myotis *(Myotis volans)* is a Federal Special Concern species. *Myotis volans* inhabits western North America from South-east Alaska to Central Mexico. It is found in an elevational range from sea level to 3,770 m. *Myotis volans* is primarily a coniferous forest bat although it may also be found in riparian and desert habitats (Warner and Czaplewski 1984). Maternity colonies can be up to 300 individuals. Maternity roosts are found in buildings, rock crevices, and under exfoliating bark. Males roost singly or in small numbers in rock crevices, buildings and under tree bark. Night roosts are known to be found under bridges, in caves and mines, and in buildings (Nagorsen and Brigham 1993). In the northern portion of their range, *M. volans* commonly hibernate. It is unknown whether this bat migrates in the portion of its range where winters are less severe. Mating takes place in the fall and sperm is stored over winter. Ovulation and fertilization takes place from March to May and parturition occurs from May to August. There is extensive variation in the timing of reproductive activity in this species. *M. volans* is known to live 21 years in the wild (Warner and Czaplewski 1984). *M. volans* feeds primarily on moths, it is also know to feed on other soft bodied prey such as flies, termites, lacewings, wasps, bugs, leafhoppers, and small beetles. *M. volans* is a rapid, direct flier pursuing its prey over relatively long distances through, around, under and over forest canopy (Warner and Czaplewski 1984).

California Myotis *(Myotis californicus)* is common in most habitats throughout its range, which stretches from the Alaskan panhandle to Mexico (Samson 1993). Although this bat is common and can be regularly encountered flying along trails at dusk, it is rarely an abundant species in any one area. Maternity colonies are usually small, generally less than 10 individuals. Day roosts are in rock crevices, peeling bark, tree

hollows, and on buildings (Sampson 1993). These bats are very flexible in their choice of night roost and will use any natural or man-made shelter (Nagorsen and Brigham 1993). This bat is non-migratory and undergoes extended torpor during the winter months in most of its California range. It will arouse from torpor to forage during winter months and has been observed foraging in temperatures as low as -8C (Sampson 1993). *M. Californicus* usually produces 1 young per year and has a potential reproductive life span of 15 years. In California, mating takes place in early spring and young are born in late May and early June. The California myotis feeds primarily on lepidopteran (moths) and dipteran (flies) prey, with smaller amounts of coleopteran (beetles) and hemiptera (bugs). Hunting takes place along edges of vegetation and the canopy, over water, and above open ground (Sampson 1993). These bats emerge in the evening and alternate foraging and roosting through the night.

Silver-haired bat *(L. noctivagans)* occurs throughout most of North America and is associated with forest habitats (Kunz 1982). In California, *L. noctivagans* is most common in the northwestern portions of the state and the Sierra Nevada. The silver-haired bat population in California is believed to be sexually segregated geographically for most of the year. A breeding female population exists in the interior of the state, while most bats observed along the coast are male. Small maternity colonies occur in tree cavities or under loose bark (Cambell et al 1996). The predominant tree species was ponderosa pine, but Douglas fir, black oak and big leaf maple were also used (Pierson 1994). Males have been documented roosting in bark fissures in redwoods (Heady 1999). This species is also known to hibernate in mines, caves, trees and buildings in the colder portions of their range. The species is primarily a tree roosting bat and forestry practices have the potential to greatly affect it (Nagorsen and Brigham 1993). Mating takes place in the fall and sperm is stored until ovulation in the late spring. Usually, silver-haired bats give birth to twins and gestation lasts 50-60 days and lactation lasts 36 days (Kunz 1982). Studies of relative seasonal abundance suggest that most populations of *L. noctivagans* migrate, although the British Columbia population (Nagorsen and Brigham 1993) and the Muir Woods population appear to not migrate. *L. noctivagans* is a generalist in terms of foraging. It feeds on a wide variety of prey, including, moths, midges, leafhoppers, caddisflies, flies, beetles, ants, and termites. *L. noctivagans* is particularly adept at exploiting large swarms of insects. Foraging typically occurs in or near coniferous and or mixed deciduous forest, adjacent to ponds, streams and other bodies of water (Kunz 1982).

Big brown bat *(Eptesicus fuscus)* occurs throughout most of North and Central America and reaches its southern limit in northwestern South America. Specimens are known from all the Canadian provinces bordering the US and from all the United States with the exception of Hawaii. This species decreases in numbers as one moves from a deciduous biome to a coniferous forest biome (Kurta and Baker 1990). Maternity colonies vary in size from small (ca. 5) to quite large (ca. 700) individuals and are found in buildings, bridges, rocks and trees. The name *Eptesicus fuscus* means dusky house flier and refers to the species' preference for man-made structures. Males roost singly or in small bachelor groups in similar

structures. In colder climates hibernacula are common in buildings and caves. In climates with less severe winters like California, migrations and/or periods of extended torpor take place (Nagorsen and Brigham 1993). In the west, *E. fuscus* usually produce one offspring per year. Copulation occurs between September and March and sperm is stored until spring. Gestation is 60 days and young are born from May to July. Young become volant 18 to 35 days after birth. Recorded longevity in the wild is 19 years for a banded individual (Kurta and Baker 1990). Foraging occurs through the night with most of the activity in the first two hours after sunset. In terms of foraging, *E. Fuscus* is a generalist, showing no preference for over-water versus over-land sites, edge versus non-edge habitats, canopy versus open, and urban versus rural environments. Diet consists primarily of beetles. Other prey include moths, termites, carpenter ants, lacewings and various flies (Nagorsen and Brigham 1993).

Hoary bat *(Lasiurus cinereus)* has the broadest range of any North American bat, ranging from Northern Canada to South America. This bat has even managed to colonize remote islands such as the Hawaiian islands (Nagorsen and Brigham 1993) and is the only endemic mammal to Hawaii. The hoary bat roosts in the branches of deciduous and coniferous trees. In Oregon, the hoary bat prefers old-growth Douglas fir forests (Nagorsen and Brigham 1993). Males are solitary and females roost with their young, but do not form maternity colonies. The hoary bat is a migratory species and the Pacific Northwest population appears to winter in California and Mexico. Over a portion of its range, males and females occupy separate summer areas. Mating occurs in fall or winter and sperm is stored over winter. Fertilization occurs in early spring and gestation is 80 to 90 days. One to four young are born in late May to late June (Nowak 1994). Young are capable of sustained flight at six weeks and family groups stay together for several weeks after young are flying. (Nagorsen and Brigham 1993). With its swift flight and low frequency echolocation calls, this bat is well adapted for capturing large prey. The primary prey of the hoary bat are moths, beetles, and dragonflies (Nagorsen and Brigham 1993). The hoary bat hunts above canopy level, in clearings, and over water. This species has been known to set up foraging territories at bright lights where insects congregate (Fenton 1997).

Western red bat *(Lasiurus blossevillii)* is a Forest Service Sensitive species. Very little research has been done on the Western red bat and little is known about this species. Much of the natural history is inferred from what is known about the Eastern red bat although the degree of similarity of the biology of these two species is unknown at present. The Western red bat is a solitary foliage roosting bat. The genus *Lasiurus* are the hairy-tailed bats. These bats are adapted for this exposed roosting behavior with their hairy tail membrane and small ears. In California this species is known to roost in cottonwood trees and willows. Roost heights range from 3 to 15 meters (Pierson and Heady 1997). The range of the Western red bat is from British Columbia to Central and South America. Migration occurs throughout its range and bats of Canada move into the coastal low lands of California, and the California population is thought winter in Central America (Nagorsen and Brigham 1993). Mating takes place in late summer and fall, sperm is

stored over winter and fertilization occurs in early spring. Gestation period is 80 to 90 days and one to four young are born in late May to early July. The young are born small naked and underdeveloped (Nowak 1994). Females leave the young at the roosting site while foraging but will carry them when moving to a new roosting site. Young are capable of sustained flight at 6 weeks. Large moths are the primary prey of the Western red bat. This bat is a fast flyer, foraging in straight flights or large circles (Nagorsen and Brigham 1993). The echolocation calls are highly variable depending on the terrain. Though variable, these calls are very distinct.

Townsend's big-eared bat (*Corynorhinus townsendii*) is a Federal Special Concern and California Special Concern species as well as a Forest Service Sensitive species. It is a year-round resident in California, occurring from low desert to mid-elevation montane habitats. It is found primarily in rural settings, from inland deserts to coastal redwoods, oak woodland of the inner Coast Ranges and Sierra foothills, and low to mid-elevation mixed coniferous-deciduous forests. It typically roosts during the day in caves and mines, but can roost in buildings that offer suitable conditions (Kunz and Martin 1982). Night roosts are in more open settings and include bridges. It hibernates in mixed sex aggregations of a few to several hundred individuals. Hibernation occurs for prolonged periods in colder areas and intermittently in non-freezing areas. It arouses periodically and moves to alternative roosts, and actively forages and drinks throughout the winter. A single young is born per year between May and July. Females form maternity colonies of 35 to 200 individuals, while males roost individually (Kunz and Martin 1982). Townsend's' big-eared bat feed primarily on small moths that are gleaned from vegetation.

Mexican Free-Tailed Bat (*Tadarida brasiliensis)* is one of the most widely distributed mammalian species in the Western Hemisphere and is the famous bat of the Carlsbad caverns in the southwest. Maternity roosts occur in bridges, buildings, culverts, hollow trees and caves. The maternity colonies vary in size from 20 individuals to millions. In general, the maternity colonies in California do not reach the remarkable size of the southwestern cave roosts. The largest known colony in California consists of around 200,000 individuals in a cave. Although a year round resident of Northern California, evidence indicates localized migrations and in other parts of its range migrations can be longer than 1,800 km (Wilkins 1989). The Mexican free-tailed bat is found in many different habitats from sea level to over 3600 meters. Mating takes place in late February and March and ovulation occurs in March. Gestation is 77 to 82 days and young are typically born in late June or July (Nowak 1991) Single young are most typical and twins are rare. Ninety percent of the diet consists of moths. Foraging is usually at heights of six to 15 meters. *T. brasiliensis* will commute 50 km to forage and fly at altitudes of 3,000 meters or more (Wilkins 1989).

ACKNOWLEDGEMENTS

The Central Coast Bat Research Group would like to thank the Muir Woods National Monument, Golden Gate National Seashore, and the Point Reyes Bird Observatory for making this study possible. We would like to thank the MWNM staff, in particular, Mia Monroe, for help and support on site. Walter Heady was instrumental in project design and field work. Several field assistants participated in this study, including Kristen Kusic, and Nick Fisher.

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TABLE 1. BAT SPECIES LIKELY OR POSSIBLE TO OCCUR IN MUIR WOODS NAT'L MONUMENT

*Myotis yumanensis**	Yuma myotis
*Myotis evotis**	Long-eared myotis
*Myotis thysanodes**	Fringed myotis
Myotis californicus	California myotis
*Myotis volans**	Long-legged myotis
Lasionycteris noctivagans	Silver-haired bat
Eptesicus fuscus	Big brown bat
Lasiurus blossevillii	Western red bat
Lasiurus cinereus	Hoary bat
*Corynorhinus (=Plecotus) townsendii** ˜	Townsend's big-eared bat
Antrozous pallidus ˜	Pallid bat
Tadarida brasiliensis	Mexican free-tailed bat

* Federal Species of Concern
˜ California Species of Concern

TABLE 2. BAT SPECIES DETECTED IN MUIR WOODS NAT'L MONUMENT DURING THIS STUDY

*Myotis yumanensis**	Yuma myotis
*Myotis thysanodes**	Fringed myotis
Myotis californicus	California myotis
*Myotis volans**	Long-legged myotis
Lasionycteris noctivagans	Silver-haired bat
Eptesicus fuscus	Big brown bat
Lasiurus blossevillii	Western red bat
Lasiurus cinereus	Hoary bat
*Corynorhinus (=Plecotus) townsendii***	Townsend's big-eared bat
Tadarida brasiliensis	Mexican free-tailed bat

* Federal Species of Concern
** Both Federal Species of Concern and California Species of Concern

Table 3. MIST-NET CAPTURES FROM MUIR WOODS NAT'L MONUMENT (MAY 1999-AUG 2000)

Species	**Number of individuals**	**Evidence of reproductive activity**
Myotis yumanensis	**3**	**yes**
Myotis thysanodes	**5**	**yes**
Myotis volans	**2**	**yes**
Myotis californicus	**15**	**yes**
Lasionycteris noctivagans	**20**	**no**
Eptesicus fuscus	**11**	**no**
Lasiurus blossevillii	**4**	**no**
Lasiurus cinereus	**5**	**no**
Corynorhinus townsendii	**4**	**no**
Total	**69**	

TABLE 4. PAIRED COMPARISON OF DEERPARK RIDGE AND REDWOOD CREEK MIST-NET CAPTURES

	July 1999		September 1999		August 2000	
SPECIES	DR	RC	DR	RC	DR	RC
Myotis yumanensis				1		
Myotis thysanodes	1			1	1	
Myotis volans						
Myotis californicus	1					
Lasionycteris noctivagans						
Eptesicus fuscus	1	5			2	
Lasiurus blossevillii						
Lasiurus cinereus				1		1
Corynorhinus townsendii					1	

TABLE 5. PAIRED COMPARISON OF DEERPARK RIDGE AND REDWOOD CREEK ACOUSTIC DETECTION

	July 1999		September 1999		August 2000	
SPECIES	DR	RC	DR	RC	DR	RC
Myotis yumanensis						X
Myotis thysanodes		X	X			
Myotis volans	X	X		X	X	X
Myotis californicus	X	X	X	X	X	X
Lasionycteris noctivagans		X	X		X	X
Eptesicus fuscus	X	X	X		X	X
Lasiurus blossevillii		X	X	X		X
Lasiurus cinereus						X
Corynorhinus townsendii						X

X = Presence detected

TABLE 6. SPECIES PRESENCE DETECTED BY MONTH

Species	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Nov**
M.yumanensis	X	X	X	X	X	X	X	X	X
M.thysanodes				X	X	X	X	X	
M.volans		X	X	X	X	X	X	X	
M.californicus	X	X	X	X	X	X	X	X	X
L.noctivagans	X	X	X	X	X	X	X	X	X
E.fuscus			X	X	X	X	X	X	X
L.blossevilli	X		X	X	X	X	X	X	X
L.cinereus	X		X	X			X	X	X
C.townsendii				X	X			X	
T.brasiliensis	X	X		X	X			X	

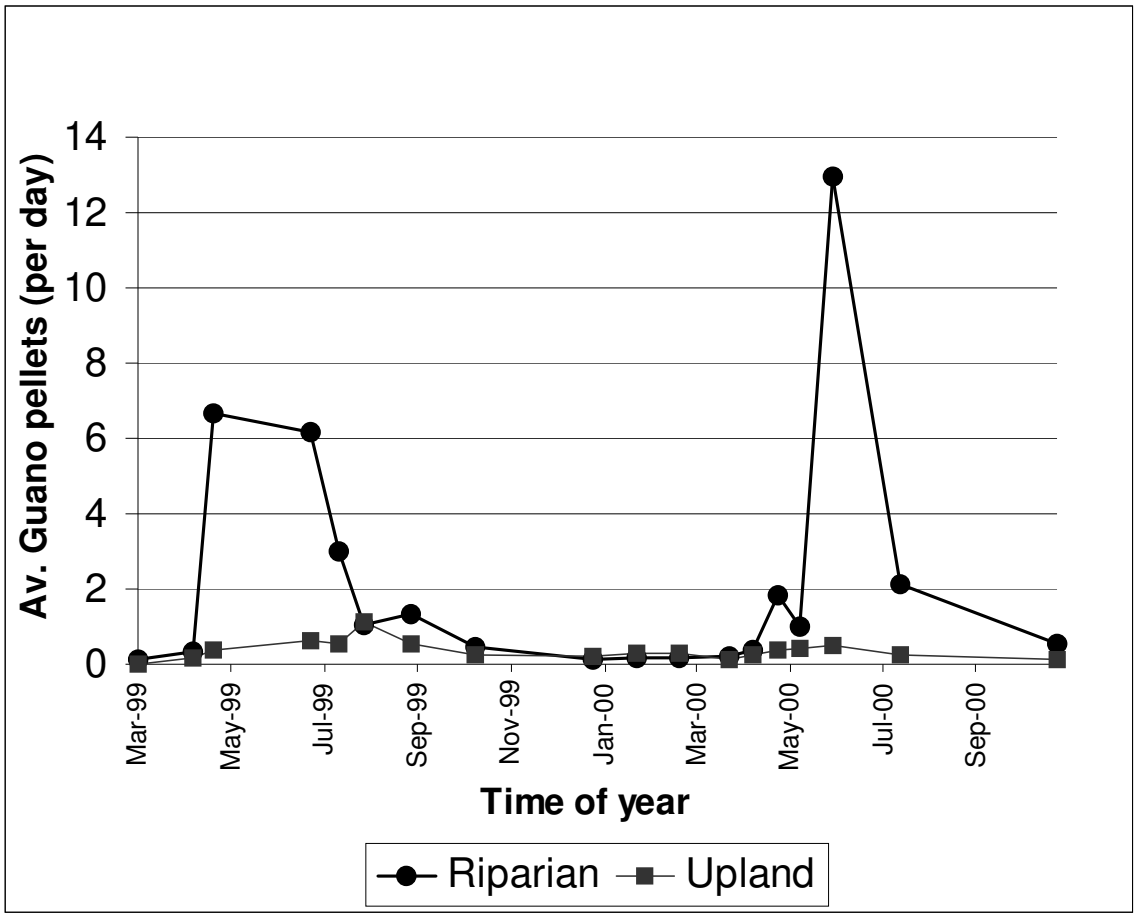

Figure 1. Seasonal Guano Deposition in Riparian and Upland Habitats. Guano was averaged for all trees in riparian and upland settings by dividing the number of pellets collected at each tree by the number of days between sampling. The graph shows that the riparian areas had more use during the maternity season. One particular tree with a large maternity roost in the riparian zone had substantially more use than other trees in both the riparian and the upland areas and accounts for most of the difference represented in this graph.