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Dear Daphne:

Here is a draft of the report. As you will notice the figures are missing. All are sonograms. Bill is the only one who knows how to generate these and he is out of town this week. Once I get your comments, I will send you a final version.

Thanks for your patience.

Best regards,

A handwritten signature in cursive script that reads "Dixie".

Elizabeth D. Pierson, Ph.D.

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Bat Surveys
Presidio
Golden Gate National Recreation Area
January-December 1994

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EXECUTIVE SUMMARY

The purpose of this survey was to examine species diversity, seasonal abundance, and habitat use for bats in forested or natural areas of the Presidio, and make recommendations for management of bat populations. Museum records document seventeen bat species in the coastal counties of central California. Five are known from San Francisco County: the red bat (*Lasiurus blossevillii*), the hoary bat (*Lasiurus cinereus*), the California myotis (*Myotis californicus*), the yuma myotis (*Myotis yumanensis*), and the Mexican free-tailed bat (*Tadarida brasiliensis*).

Because overall levels of bat activity encountered in the Presidio were too low to conduct effective netting surveys (the method of choice for species identification), this study relied primarily on ultrasound monitoring, which permitted some assessment of species diversity, and was effective for assessing seasonal patterns and habitat associations. Based on matching call characteristics to recordings of known bats, we infer that *L. blossevillii*, *L. cinereus*, *T. brasiliensis*, one or more *Myotis* sp. and the big brown bat, *Eptesicus fuscus*, forage in the Presidio.

Four habitat types were sampled regularly: forest/forest edge, open area/grassland, riparian areas along Lobos Creek, and open water (from the shores of Mountain Lake). By far the most abundant species, accounting for 70-90% of all identified acoustic events, in all seasons and in almost all habitat types was *T. brasiliensis*. The next most common species (fall, winter and spring only) was *L. cinereus*. All other species were rare. The site with much more activity than any other was Mountain Lake. This was the primary foraging area identified on the Presidio, particularly for *T. brasiliensis*. The next most important habitat type, and the one with the greatest species diversity, was forest edge, at the interface between multi-aged forest stands and open areas. There was little acoustic activity in open grassland areas and only two open air foraging species, *T. brasiliensis* and *L. cinereus*, were observed. Limited sampling on the coastal dunes also showed little activity.

In striking contrast to the mid-summer peak in bat activity typical at most temperate zone locations, levels of bat activity in Presidio were greater in the fall-winter-spring than in the summer. This is explained primarily by a large increase in the *T. brasiliensis* population in the area during these seasons. This non-hibernating, migratory species, which has large summer breeding colonies in hotter inland areas, apparently moves in numbers to the margins of San Francisco Bay, where the moderate temperatures allow it to forage all winter. Though the data are more limited, observations on the two *Lasiurus*, particularly *L. cinereus*, are consistent with the idea that the area is on a migratory flyway and serves as a winter refuge for these species.

The paucity of species at the Presidio, relative to other areas along the coast immediately to the north and south, suggests that urbanization is a significant filter for bat species. Insufficient and fragmented habitat (fewer suitable roosts and a more restricted insect assemblage), increased likelihood of direct disturbance by humans and indirect effects, including elevated densities of quasi-commensal predators (domestic cats and perhaps jays), may play a role in limiting species diversity. The species that currently persist can be best supported by maintaining year round water sources, like Mountain Lake, which have high insect productivity, and by managing forests to preserve large diameter trees, particularly those which are damaged (and thus at risk of removal for hazard abatement). *T. brasiliensis* most likely roosts in buildings in the Presidio or adjacent areas, especially under tile roofs, and special care should be taken to identify any roosts prior to building renovations or demolition. Construction projects associated with park re-development may also offer opportunities for habitat enhancement. The key to long term persistence of these native mammal species in the largely anthropogenic habitats of the Presidio lies in relatively minor adjustments of grounds and buildings maintenance practices from urban norms.

1.0 INTRODUCTION

Seventeen species of bats are known to occur along the central coastal region of California, and could potentially occur at the Presidio. Thirteen of these species have been recorded from the adjacent counties of Alameda, Contra Costa, Marin, and/or San Mateo; five are known from San Francisco County. Of the seventeen species, eight are Category 2 Candidates for protection under the Federal Endangered Species Act; four are considered Mammals of Special Concern by California Department of Fish and Game (see Table 1).

The purpose of this survey was to examine species diversity, seasonal abundance, and habitat use for bats in forested or natural areas of the Presidio, and make management recommendations for resident bat populations.

1.1. Background on Bat Biology and Ecology

Since the natural history of bats differs substantially from that of more familiar mammals (e.g., small rodents), salient features of their biology, relevant to the survey design and recommendations, are summarized below:

1. Western North American bats can be divided into solitary and colonial species (colony size ranging from a few animals to thousands). Colonial species roost during the day in tree hollows, caves, abandoned mines and building attics, or more restrictive sites such as rock crevices, under loose bark or manmade analogs (e.g., roof tiles and bridge expansion joints). Some solitary species are also crevice or cavity dwellers, but a few (two in Northern California) are distinctive in that they roost in foliage.
2. All the solitary and most of the colonial species are in the family Vespertilionidae. A few species (including the relatively common Mexican free-tail and rare western mastiff bat) in the family Molossidae have distinctive seasonal patterns of reproduction and activity.
3. Colonial species form maternity aggregations (containing adult females and, later, their young of the year) in the spring and summer. In most colonial species, a female has one young per year, which is born in late spring or early summer (molossid young may be born later in the summer). Maternal care lasts throughout the summer, and into the early fall, and may include training the young to forage. Concentration of a large fraction of a local population at one site makes maternity colonies particularly vulnerable to disturbance or destruction. Females of foliage roosting species rear their young solitarily and litter size ranges from one to four.
4. Typically bats are not reproductively mature until they are at least a year old, and individuals of several species are known to survive in the wild for more than 15 years. The primary source of natural mortality appears to be failure of the young to survive their first winter. Adult year to year survival is high for a small mammal and natural predation is apparently low. Bats rely for their survival on being able to escape detection by predators, both by the timing of foraging activity and by concealing themselves in cryptic roost sites. In wildland habitats, snakes, small carnivores, and raptors, particularly owls, take small numbers of bats. As for many songbirds, one of the primary identifiable causes of bat mortality and injury in urban and suburban landscapes is domestic cats.
5. Individual fidelity to roost sites, both within a single season and between years, seems to be high, even for foliage roosting species. Most maternity colonies appear to have alternatives to

their preferred site, and there may be within-season shifts among sites, particularly after disturbance. In a few cases that have been studied, exclusion from the preferred site has led to declines in reproductive success. For a number of species, including some listed by state or federal agencies as sensitive, the availability of suitable roost sites appears to limit populations. Roost disturbance or destruction by man is a significant cause of population decline. This seems to be particularly true for Townsend's big-eared bat which has relatively restrictive roost requirements.

6. Daytime roosting sites and primary foraging habitat frequently are not contiguous. The distance travelled between roosting sites and foraging areas may be many kilometers. Safe roosting sites, and adequate foraging areas are required to maintain viability of bat populations. Relatively little data are available on foraging habitat requirements for western North American bats, either in terms of species' specializations or in terms the habitat area required for maintenance of viable populations. Historical declines of some species in urbanizing landscapes suggest that foraging habitat alteration may play a role along with roost site loss.

7. All bats in northern California eat insects and other arthropods. Plant growth and insect availability peak in the warmer seasons. Bats that remain resident in areas with extended periods of sub-freezing temperatures may hibernate for several months, relying on stored fat. Bats are extremely vulnerable to disturbance at this time, since arousal from torpor depletes energy reserves which may be essential for their survival until insect availability increases in the spring. A number of species, including the free-tail bats (Molossidae) and the foliage roosting species do not hibernate for extended periods, and instead migrate to areas with non-freezing temperatures which allow them to forage at least intermittently all winter.

8. The timing and geographical pattern of migratory movements and winter refugia are much better known for birds than for bats, but limited evidence suggests the moderate maritime climate of the San Francisco Bay Region (non-freezing temperatures through the winter and relatively cool summers) plays a key role in the unusual seasonal patterns of bat activity in this area. In particular, the region appears to provide an overwintering area for foliage dwelling and non-hibernating bats.

9. Bats combine an unusually long life span for their body size with high diet throughput (processing perhaps twice their body mass in insects per night in midsummer). Thus the potential for trace environmental contaminant exposure (and bioaccumulation) is high. Acute and chronic toxicity of chlorinated hydrocarbon pesticides and structural timber treatment chemicals has been demonstrated experimentally and observed in the field. Surveys of bat tissue levels of other stable trace contaminants (e.g., PCBs and heavy metals) are uncommon, but those available show rising levels on rural to urban/industrial gradients. The population consequences of these contaminant trends are unknown.

2.0 SURVEY METHODS

2.1. Overview

The original scope of work proposed a combination of acoustic and netting surveys. The acoustic surveys were designed to assess seasonal levels of activity (and to some extent diversity) in different habitats. Netting surveys were intended to provide species identification, and information on population structure (i.e., sex and age distribution, reproductive condition). Field circumstances, however, required a modification in this original plan. It readily became

apparent that the labor intensive effort of mist netting was not going to yield the desired results. Bat activity levels were so low at most sites, that the likelihood of catching any bats was very remote. Additionally, at the one site where activity levels were high (Mt. Lake), animals consistently flew 10 m or more above the water surface, well above the level of standard mist nets. Thus, after two completely unsuccessful netting efforts (one at Mt. Lake, and one at Polin Spring), the decision was made to abandon the netting effort, and focus on acoustic surveys. While this reduced the certainty with which we could make species identifications, it allowed a more intensive investigation of seasonal patterns of habitat use.

2.2. Netting Surveys

Mist netting is generally the most effective technique for sampling bat diversity in an area. Although it has inherent biases (i.e., some species are more readily captured in nets than others), it nevertheless allows positive identification and the opportunity to obtain information on age and reproductive condition. This would have been the method of choice for establishing a bat species list for the Presidio. Net capture rates are generally highest for nets set in foraging areas, preferably over water. Prior to initiating acoustic surveys, it was our expectation that Lobos Creek would be the best netting site. This site was not used, however, since acoustic activity was so low in this area. Two other sites, which had water and higher levels of activity, were selected. Netting surveys were conducted at Mountain Lake on May 20 and at Polin Spring on June 8. On both nights nets were opened just prior to dark, and run for three hours. At Mountain Lake, 2 42' x 10', and one 60' x 10' nets were set from the shore leading out into the lake, and three 42' x 10' nets run along the bank. At Polin Spring four 60' x 10' and one 42' x 10' nets were set across the damp areas running out of the spring, and along the adjacent forest edge.

2.3 Acoustic Surveys

2.3.1. Acoustic Methods

Acoustic surveys take advantage of the fact that foraging bats use high frequency sound to locate prey. Bat calls are low duty cycle, pulsed signals which are sufficiently characteristic that they can be distinguished analytically from other repetitive environmental sounds (e.g., insect calls). It is thus possible, using acoustic survey techniques, to evaluate levels of bat activity in a particular habitat, and assess foraging intensity (i.e., "feeding buzzes" can readily be distinguished from "search phase" calls for all species). Echolocation calls can be monitored using "bat detectors," devices which convert the normally ultrasonic calls of bats into the audible range.

The Presidio surveys were conducted using exclusively broad band detectors. Two Pettersson D980 detectors (in a high resolution digital signal capture mode available only on this detector) were used preferentially. If more than two investigators were working simultaneously, two other broad band detectors were used, operating in a frequency divide mode: an Anabat and/or a Pettersson D940. All detectors were connected to analog cassette or DAT recorders, and bat calls were stored for later analysis using SoundEdit Pro for the MacIntosh.

2.3.2. Study Sites/ Sampling Regime

It was evident early in the study that the area which received by far the most bat activity was Mountain Lake. Thus, on each sampling night, one investigator was dedicated to this site,

monitoring activity continuously from shortly after sunset until bat activity declined or ceased (1.5 to 2.0 hours).

Simultaneously, additional investigators sampled other sites, generally for 20 minutes per site. These additional monitoring stations were selected using two criteria: 1) areas which appeared to have relatively high levels of bat activity, and 2) areas which were of botanical significance (i.e., contained or were adjacent to patches of native vegetation). The sites which were sampled on a consistent, and repeated basis, were: 1) Polin Spring, 2) the forest edge of Hicks Athletic Field, 3) the forest at the corner of Hunter Road and Central Magazine, 4) the natural grassland reserve to the east of Wedemeyer Street, 5) the heliopad (near hospital #1801) overlooking the Lobos Creek drainage, 6) Lobos Creek, 7) the golf course edge at the corner of Arguello Blvd. and West Pacific Avenue. Several other areas were sampled on an irregular basis (i.e., when weather permitted, or additional field assistants permitted more extensive sampling). These sites were: the dunes to the west of Bowman Rd., Inspiration Point, the forested northeastern shore of Mountain Lake, and the Cypress grove east of Julius Kahn Playground. These sites were generally monitored for 20 minutes per station.

Surveys were conducted on the following dates during 1994: January 14, 17; March 14; April 28, 30; May 1, 10, 29; June 8; July 1, 3; August 2; September 17, 18; October 2, 16, 31; November 30; December 18.

2.3.3. Species Identification

While acoustic surveys offer the most effective method for assessing levels of bat activity, they are of more limited usefulness in species identification, especially in California where a number of species have echolocation calls with overlapping frequencies. Given available information on call signatures (e.g., call structure, frequency range, call duration, interpulse interval) and the possible bat assemblage at the Presidio (Table 1), it was assumed that under most conditions the following species could be identified acoustically: the mastiff bat (*Eumops perotis*), the big free-tailed bat (*Nyctinomops macrotis*), the Mexican free-tail bat (*Tadarida brasiliensis*), the red bat (*Lasiurus blossevillei*), the hoary bat (*Lasiurus cinereus*) and the pipistrelle (*Pipistrellus hesperus*). All species identification was made by comparing field collected material with the published literature, and our own library of calls, recorded from known individuals in California.

One challenge is to make acoustic distinctions among the various *Myotis* species (which tend to have calls with a dominant frequency of 35 kHz or higher). It was possible from our material to identify at least two species at the Presidio with high frequency (40 kHz or greater) calls. These were most likely to be the two smallest *Myotis* species, *M. californicus* and *M. yumanensis* (Thomas *et al.* 1987), the two species also most likely on distributional grounds to occur at the Presidio. Because we are uncertain which species is which, and some calls could not be assigned to one or the other, the two *Myotis* species were treated as a unit, as *Myotis* spp.

It is also difficult to distinguish the calls of the remaining assemblage of larger bats, i.e., Townsend's big-eared bat (*Plecotus townsendii*), the pallid bat (*Antrozous pallidus*), the silver-haired bat (*Lasionycteris noctivagans*), and the big brown bat (*Eptesicus fuscus*). All have echolocation calls with a dominant frequency of 25 to 30 kHz, and are difficult to distinguish based on call characteristics alone. Although *P. townsendii* generally emits a very soft call (in contrast to very strong calls given by *E. fuscus* and *A. pallidus*), which has a larger

frequency sweep than that found in the other two species, these distinctions are subtle (e.g., a distant *A. pallidus* could sound on the detector like a "whispering" *P. townsendii*). In some settings the call of *E. fuscus* can be distinguished from that of other species by an abrupt, and brief, shift to constant frequency at the end, giving the call a reverse "J" shape when converted to a visual sonogram. Likewise, *A. pallidus* occasionally emits a highly distinctive "directive" call which is audible and allows positive species identification. Unfortunately, however, the degree of overlap and variation in the frequency range and shape (e.g. amount of sweep per unit time) of the calls frequently makes it difficult to identify any of these three species based solely on call characteristics. Behavioral observations can aid in species identification. For example, *E. fuscus* tends to emerge before dark, and forage in groups at canopy level. *A. pallidus* emerges only after dark, is more likely to be encountered foraging alone, within a few feet of the ground. Thus it was assumed that multiple feeding buzzes, recorded early in the evening high over Mt. Lake, in the appropriate frequency range (55 to 25 kHz) belonged to *E. fuscus*. Although *L. noctivagans* is more behaviorally similar to *E. fuscus*, and would be difficult to distinguish unless its lower aspect ration wing shape could be seen, it was assumed that in this habitat, a middle frequency vespertilionid was most likely to be *E. fuscus*. At other localities, calls were somewhat tentatively assigned to *E. fuscus* if they were considered too "heavy" to be *P. townsendii* and had the characteristic "J" shape. Although *E. fuscus* is more likely than *A. pallidus* to occur at the Presidio on ecological grounds, some of the calls recorded in the forest/forest edge settings, and assigned to *E. fuscus*, could have belonged to *A. pallidus*.

Although we offer some species identifications based on acoustic data, we also recognize that there are numerous problems associated this technique. Species identification issues are confounded by the fact that there is often considerable intraspecific variation in call frequencies (Brigham *et al.* 1989), that individual bats may alter call structure in response to habitat (i.e., *T. brasiliensis*, which uses a relatively constant frequency search phase call in open air switches to a frequency modulated call as it approaches vegetation), that animals may use more than one type of call in a call sequence (e.g., social agonistic calls can be emitted along with prey location calls)(Belwood and Fullard 1984). Additionally there may be regional differences in call structure, analogous to dialects in bird calls (Thomas *et al.* 1987), and many species, particularly the molossids, are known to have a varied vocal repertoire (Simmons *et al.* 1978). Thus it is important to obtain, when possible, multiple acoustic samples, plus supplemental behavioral and ecological data.

3.0 RESULTS

3.1. Species Diversity

Of the seventeen species which could potentially occur at the Presidio, six species were identified with some certainty (Table 1). There were pre-existing records for San Francisco County for five of these species: the red bat (*Lasiurus blossevillei*), the hoary bat (*Lasiurus cinereus*), the California myotis (*Myotis californicus*), the yuma myotis (*Myotis yumanensis*), and the Mexican free-tailed bat (*Tadarida brasiliensis*). The sixth species, the big brown bat (*Eptesicus fuscus*), is relatively common throughout the Bay area, and thus was expected. Pre-existing records were based primarily on the three largest museum collections for the state (California Academy of Sciences [CAS], Los Angeles County Museum [LACM], and the Museum of Vertebrate Zoology at the University of California, Berkeley [MVZ]) and a few published records (Grinnell 1918, Orr 1950).

T. brasiliensis was by far the most common species, accounting for 70-80 % of the total

detection events at most monitoring stations, and >90 % at Mt. Lake. The complex vocal repertoire of this species, discussed by Simmons *et al.* (1978) was observed in this study. The most distinctive call, an open air search phase call, has a relatively constant frequency, sweeping from ca. 27 to 23 kHz, with a call duration of 15-20 ms., and an interpulse interval of 200-400 ms (Fig. 1). This call was the one most commonly heard, and was used in all habitats, particularly the open areas (e.g., the golf course and grassland). Also distinctive were a number of vocal exchanges, unique to *Tadarida*, which appear to be "social" calls (i.e., they involve communication between individuals, and are not used for prey detection). More difficult to identify with certainty were calls with a higher minimum frequency, and a more frequency modulated structure, sweeping from 34-38 to 25-28 kHz (Fig. 2). These were the dominant calls observed over Mt. Lake in the spring and summer, and could potentially be identified as *E. fuscus*, based on the minimum frequency observed. We assigned them to *T. brasiliensis*, however, for three reasons: 1) the total frequency range was less than what would be expected for *E. fuscus* (ca. 10 kHz vs. ca. 25 kHz), 2) the call structure was consistent with that reported in the literature for *T. brasiliensis*, and consistent with our observations in other settings (e.g., that in more cluttered environments, like a forest edge, *T. brasiliensis* uses a more frequency modulated call), and 3) the numerical abundance of these calls seemed unlikely to belong to a species previously unknown from San Francisco County.

The two *Myotis* species combined (*M. californicus* and *M. yumanensis*) accounted for about 11 % of the acoustic events, and *Lasiurus cinereus* for about 9 %. All high frequency calls, with a strong FM sweep, and a minimum frequency of 45-55 kHz were identified at *Myotis* (Fig. 3). The search phase calls of *L. cinereus* calls are similar to those of *T. brasiliensis*, but were distinguished from them using two criteria. *L. cinereus* calls were more consistently FM (dropping no more than 3 to 4 kHz, and sometimes maintaining an absolutely constant frequency), and tended to have a lower minimum frequency (19 to 21 kHz) (Fig. 4). Since these distinctions were somewhat subtle, there are a number of calls which could not readily be assigned to one species or the other. Although tentative identifications were made, we tended to be conservative, and assign the questionable calls to the more abundant species, *T. brasiliensis*.

Only ca. 2 % of the calls belonged to medium frequency vespertilionids. These were all tentatively assigned to *E. fuscus*, based on the fact that all were recorded in habitats (forested edge or over water) more typical for *E. fuscus* than for either *A. pallidus* or *P. townsendii*, and the calls most generally had a constant frequency "tail" that is more typical of *E. fuscus* than either of the other species (Fig. 5).

L. blossevillii was only detected on one occasion. This identification is made with a degree of certainty, since *L. blossevillii* is the only species in the expected assemblage with a constant frequency call at ca. 40 kHz (Fig. 6) (Acharya and Fenton 1992).

3.2. Habitat Associations

Bat activity was significantly higher at Mt. Lake than at any other site sampled in the Presidio (Table 2). The total number of acoustic events, plus the large proportion of "feeding buzzes," suggests that this is the most significant foraging site for the bat assemblage at the Presidio. The other habitat which had a significant amount of activity, and greater diversity (Table 3) was forest edge. At both Polin Spring and Hicks Athletic Field, the bats appeared to be foraging along the interface between the forest and open areas (e.g., grass and pavement). Both sites were selected for their proximity to multi-age forest stands. Given that bats appeared

at both these sites at dusk, it is presumed many were roosting in some of the larger trees in the adjacent forest.

Open areas, including a native grassland site, received significantly less activity, and had much lower species diversity. The only species detected at these sites was *T. brasiliensis* and *L. cinereus*, both open air foragers. The most unexpected result was the virtual absence of bat activity along Lobos Creek. Riparian areas with flowing streams are generally the most productive sites for bats. It was anticipated this creek, with its small intact patch of oak woodland, would be one of the most important sites on the Presidio for bats, particularly small vespertilionids. In fact, although overall activity was exceedingly low, two of the three detection events were assignable to *Myotis*.

3.3. Seasonal Patterns

As shown in Table 2, the habitat associations described above were consistent from season to season. Thus, Mt. Lake received more activity than other sites in all seasons. Likewise, the forest/forest edge habitat received more activity than the open/grassland areas. It also appeared that Lobos Creek received the least activity, although difficulty in obtaining access to this site (due to a construction project with locked gates) limited our ability to sample this site regularly, and there are significant gaps in the data.

A striking, and somewhat unexpected finding was significantly more bat activity in the fall, winter, and spring, than in the summer (Table 2). This is accounted for by the substantially greater number of *T. brasiliensis* occurring at the Presidio in the non-summer months. Also, the two *Lasiurus* species appear to be absent from the Presidio in the summer.

4.0 DISCUSSION

4.1. Species Diversity: Its Relation to Habitat and Season

The most striking finding of this study was the importance of the Presidio (presumably as representative of coastal central California) as fall-winter-spring habitat for *T. brasiliensis* and *L. cinereus*. The conventional wisdom regarding seasonal activity patterns in North American bats is based primarily on intensive study of a few vespertilionid species, particularly several *Myotis* species, which are widely distributed in areas that receive consistently freezing winter temperatures. In these settings, the expectation is peak activity during the brief summer months, and hibernation for most of the winter. This pattern does not hold in coastal central California, however, where freezing winter temperatures are extremely rare. In fact, since the coast tends to be cool and foggy in the summer, bat numbers are reduced along the coast, and diversity is higher in warmer inland areas, particularly the lower elevations of the Sierra Nevada Range. In the winter, the situation is reversed, and the moderate coastal zone becomes a winter refugium for those species, like *T. brasiliensis*, which do not hibernate at all, or the foliage roosting vespertilionids, *L. blossevillii* and *L. cinereus*, which tend to hibernate for limited periods of time. The coastal zone also serves as an important migratory flyway. This has been demonstrated a number of times for *L. cinereus*, which appears at the Farallon islands and in the Bay area every fall (Dalquest 1943, Tenaza 1966).

The extremely low levels of bat activity in the summer at the Presidio suggest that none of the species are maintaining breeding populations there. Because, *M. yumanensis*, *E. fuscus*, and *T. brasiliensis* are all highly colonial, one tends to detect multiple individuals in the vicinity

of a maternity roost in the summer. This did not happen at the Presidio. Our first expectation was that these observations could be explained by the cool, foggy weather. Such a conclusion is not supported, however, by numerous locality records (our own, plus museum and literature records) for summer populations for a number of species within the coastal fog zone (e.g., at Point Reyes National Seashore, the Carmel Valley, and the Monterey Peninsula). It is far more likely that the low absolute numbers, and the low diversity, are explained by factors relating to habitat loss and fragmentation in an urban environment.

4.2. Potential Factors Limiting Species Diversity.

4.4.1. Insufficient Habitat

In general, bat species are likely to be roost limited. Many species appear to have fairly restrictive roosting requirements, and are much more flexible in their foraging habits. Even those that are considered "specialists," are known to shift their diets with food availability. For many, it appears, that any bug of the right size will do. This generalization may break down, however, in urban settings, where insect diversity and abundance are likely to be much lower than in a natural setting. Particularly for colonial species, having sufficient habitat to support an entire colony (which may divide the habitat into feeding territories) is essential. Although sensitivity to disturbance at roost sites may provide a partial explanation for why species such as *A. pallidus* and *P. townsendii* appear to vanish in urban settings, it is likely for these highly colonial species that loss of foraging habitat is also a factor. Since both these species are known to forage extensively within oak woodland, it seems likely there is insufficient foraging habitat left at the Presidio to support resident populations of either species.

4.4.2. Predation

Predation is not generally considered to be a factor limiting bat populations. Bats have relatively few natural predators. Although they are occasionally taken by owls, snakes, carnivores and raptors, as long-lived animals with a low reproductive rate (i.e., a K-selected strategy), they tend to rely on their ability to avoid predation by selecting safe, cryptic roost sites. This situation can change when bats come in contact with humans and human development. Predation by house cats or feral cats can become a major factor in limiting populations. It is not unusual to hear of entire colonies being eliminated by house cats. Most bats that are turned into State public health facilities for rabies testing have been brought in by cats (Constantine 1993, 1994). Predation by cats, and other human adapted predators like skunks and raccoons could be a potential factor limiting populations of the two *Lasiurus* species. Recent work by Saugey *et al.* (1994) in Arkansas showed that radiotagged *L. blossevillii* hibernated in the leaf litter when temperatures became cold. There are also reports in the literature (Allan 1947, Hoffmeister 1964) and from animal rescue facilities (C. Scott pers. comm. and P. Winters pers. comm.) of predation on foliage roosting species (i.e., *Lasiurus* species) by jays. Since jays thrive in human disturbed environments, their role as bat predator may be differentially important in an urban setting. Human vandalism may also be a factor. Willful destruction of animals or roost sites is not uncommon, particularly in urban settings, where tolerance for coexistence with wildlife is often lower than in rural settings.

4.4.3. Pest Control Programs

We do not know the history of pest control efforts at the Presidio, but were struck, when conducting a limited building survey in 1993, that there was no sign of invertebrates in

any of the buildings. It is extremely unusual to enter the attic of an unused building and not find numerous spider webs. It thus seemed possible that application of insecticides both within buildings, and possibly in the habitat (e.g., mosquito control programs for the golf course or Mountain Lake) may have either poisoned animals directly, or reduced available food supply. Informal inquiries of maintenance personnel did not indicate the presence of bat colonies in any buildings at the Presidio, nor any efforts historically to exclude them.

4.3. Potential Factors Supporting Species Diversity

4.3.1. Climate

The mild winter climate of the San Francisco Peninsula makes this area suitable as a winter refugium for several species. It appears to be most important (based partly on historical data) for the lasiurine bats (*L. blossevillei* and *L. cinereus*) and for the non-hibernating *T. brasiliensis*.

4.3.2. Sources of Water

Mt. Lake is by far the most important foraging area for bats at the Presidio. This is likely due to high insect productivity associated with the lake and shoreline vegetation. Given that this was the only area where relatively large number of bats were observed foraging, and that this area receives very high recreational use, special attention should be given to preserving water quality and protecting surrounding vegetation.

4.3.3. Roosting habitat

The primary roosting habitat for most bat species on the Presidio, except *T. brasiliensis*, is likely to be trees -- sheltering foliage for the two *Lasiurus* species, and tree cavities or flaking bark for others. An increasing amount of research on forest dwelling bats is documenting the importance of trees, particularly snags and/or mature trees, as bat roosts (e.g., Kalcounis 1994, Morrell *et al.* 1994, Rainey and Pierson 1994). Maintenance of a diverse, multi-aged forest community, including protection of snags, is likely to be essential for supporting the bat community at the Presidio.

4.4. Species by Species Analysis

4.2.1. Species Occurring at the Presidio

4.2.1.1. Big brown bat, *Eptesicus fuscus*

Eptesicus fuscus is one of the most widely distributed bats in the United States, and is highly associated with human habitation (Barbour and Davis 1969). Although it shows a great deal of flexibility in its roosting habits (being found in buildings, caves, mines, bridges, rock crevices and trees), and is one of the species most frequently found in urbanized environments, recent radiotracking work has shown that *E. fuscus* is also an important forest dwelling bat, frequently using trees (in California, ponderosa pine snags and hollow redwoods) as roosts (Kurta & Baker 1990, Brigham 1991, Rainey *et al.* 1992, Rainey and Pierson 1994).

This species is known to be relatively common at Point Reyes National Seashore to the

north of Presidio (C. Corbin and G. Fellers pers. comm.), and one of the most common species in coastal Monterey pine forest to the south (Pierson and Rainey unpubl. data). Although it was identified at the Presidio in the spring, it was virtually absent from acoustic records at other times of year.

E. fuscus feed in a variety of habitats, over water and land, in edge and non-edge situations, areas with and without canopy enclosure. Although small Coleoptera appear to be its primary prey (Freeman 1981, Kurta and Baker 1990), this species feeds on a variety of insects. It frequently forages at considerable heights (10 to 50 m above the ground) (Kurta and Baker 1990). Although in Canada, foraging rates for the species were significantly higher in rural than urban areas (Geggie and Fenton 1985), it also was the only species which made significant use of lights as foraging sites in urban areas (Furlonger *et al.* 1987). At the Presidio, it was found predominantly associated with Mountain Lake, where it foraged at canopy height.

4.2.1.2. Red bat, *Lasiurus blossevillii*

There are multiple records for red bats occurring in the San Francisco Bay area in the spring, fall, and winter months, including records from Golden Gate Park in San Francisco (Grinnell 1918, Orr 1950, Constantine 1959). Although reproductive females and young do occur in central California in the summer (Constantine 1959, C. Scott & P. Winters, pers. comm.), they are more likely to be located inland, particularly in the Central Valley, where they can find the desired summer temperatures of 80-95°F (Constantine 1959).

L. blossevillii is a foliage roosting species, roosting in trees and shrubs, in edge habitats adjacent to streams and open fields (Shump and Shump 1982a). Constantine (1959) found the species roosting in fruit trees (apricot and orange) in the Central Valley of California. Although it has been observed foraging around lights in urban areas (Shump and Shump 1982a), Constantine (1959) found the species primarily in areas distant from human habitation, and Furlonger *et al.* (1987) found the species foraged around lights in towns and rural areas, more than in urban areas. The animals studied by Orr (1950) in Golden Gate Park in San Francisco were roosting in *Sparmannia africana*, a large-leaved, exotic, evergreen plant commonly planted in gardens in the Bay area. Winter behavior of this species is not well understood. Saugey *et al.* (1994) have recently documented through a radiotracking study in Arkansas, that when temperatures dropped, the bats moved from trees to hibernate in the leaf litter. 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 Bay area (Orr 1950). Red bats apparently forage on a number of insect taxa, flying at both canopy height and low over the ground (Shump and Shump 1982a).

4.2.1.3. Hoary bat, *Lasiurus cinereus*

L. cinereus is known from the Bay area primarily in the fall and winter (Grinnell 1918, Dalquest 1943, Vaughan and Krutzsch 1954, Tenaza 1966). Although seasonal movement patterns are not completely understood, it appears that the primary summer distribution is well north of the Bay area. The animals begin showing up in the Bay area in late August and early September (Dalquest 1943, Neil 1952, Constantine 1959, Tenaza 1966). Although there are numerous winter records from southern California, it also appears that many spend the winter in the Bay area. Although there are scattered summer records from the central coast (Grinnell 1918, Pierson unpubl records), all are males; females raise their young farther to the north, and are present only in the fall-winter-spring.

As would have been predicted, hoary bats were identified at the Presidio in fall, winter and spring.

L. cinereus is a solitary species, which roosts primarily in foliage, 3-12 m above the ground, 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. It forages over long distances, up to 40 km from its roost (Barclay 1984), feeding primarily on large moths dragonflies and beetles (Barclay 1985, Barclay 1985-1986).

4.2.1.4. California myotis, *Myotis californicus*

The California myotis was expected and potentially identified at the Presidio.

This non-colonial species, is widely distributed in many habitats, and is common throughout much of California. It roosts in a wide variety of crevice like places, e.g., in houses, barns, under bridges, under sign boards, in mine tunnels, rock crevices, hollow trees, and beneath loose bark (Barbour and Davis 1969, van Zyll de Jong 1985). It feeds on small dipterans and lepidopterans and Trichoptera (van Zyll de Jong 1985).

4.2.1.5. Yuma myotis, *Myotis yumanensis* (C2)

This species is one of the most widespread and relatively common bats in northern California; records are available for numerous sites in the central coast counties. Colonies are known in Marin Co., including at the Marin Headlands, and within San Francisco Co., south of the Presidio at the San Francisco Zoological Park. This species is somewhat tolerant of human disturbance, and is one of the few which persists in relatively urbanized areas. *M. yumanensis* has recently been placed on the Category 2 candidate list by the U.S. Fish and Wildlife Service.

Call sequences attributed to this species were detected sporadically at the Presidio, but not in sufficient numbers to suggest that a maternity colony close to any of the sampling sites. Both Mountain Lake and Lobos Creek appear to offer suitable foraging habitat, but relatively few acoustic samples attributable to *Myotis* were detected at either site.

M. yumanensis commonly forms substantial colonies (200 up to several thousand), in a wide variety of natural and man-made roost sites, e.g., caves, mines, buildings, bridges, and trees. In northern California, maternity colonies in trees include fire scarred coast redwoods, ponderosa snags and hollows in oaks (Rainey *et al.* 1992). It forages commonly over open water, where it consumes small emergent aquatic insects (e.g., Trichoptera and Ephemeroptera, Diptera) but the foraging habitat and dietary range is broad (also including Isoptera, Lepidoptera, and Coleoptera) (van Zyll de Jong 1985). It is often found in association with reservoirs in California (pers. obs.), but may roost at distances of several km from primary foraging areas.

Actions within the Presidio which are likely to affect this species are removal of cavity trees (potential or actual roost sites) or other forest management practices which reduce the standing stock and regeneration of wildlife trees, exclusion of identified colonies from buildings or maintenance pest control chemical treatments of attic spaces (e.g., timber treatment) which inadvertently poison undetected colonies, and grounds maintenance practices which acutely

reduce insect production, especially from surface waters (e.g., non-specific treatment for mosquito abatement).

4.2.1.6. Mexican-free tailed bat, *Tadarida brasiliensis*

As was expected, *Tadarida brasiliensis* was the species most commonly detected in all habitats at the Presidio. This is one of the most common and widespread California bat species, occurring from sea level to over 10,000 ft. in the Sierra Nevada Range. It is also the species most tolerant of urbanization. While its natural roost sites are most commonly rock crevices, it will readily occupy man-made crevices (e.g., bridge expansion joints, the spaces under Spanish tile roofs or loose siding).

This species occurred in largest numbers at Mountain Lake. Although no roost sites were located, the appearance of bats at dusk, suggests roosts were nearby. Buildings on the Presidio with Spanish tile roofs would offer potential roost sites.

Seasonal patterns of abundance (with *T. brasiliensis* being far more common in the fall, winter, and spring than in the summer) suggest that the temperate coastal zone provides an important winter refugium for this non-hibernating species. The relatively low number of animals in the summer suggests that females do not form maternity colonies at the Presidio. It is likely, given the preference of this species for very warm maternity sites and their known abundance in the Central Valley and Sierra foothills in the summer, that the species moves inland to raise their young.

T. brasiliensis can form extremely large maternity colonies (up to 20 million in caves in Texas), but in California tends to form smaller colonies (several hundred). This species is an open air forager, often flying quite high, feeding almost exclusively on small moths (5-9 mm in length).

4.2.2. Other Species -- Possibly Occurring at the Presidio

From a distributional perspective most of the species discussed below would be expected to occur at the Presidio, yet none were detected in the survey work. It is possible that some do occur there, and were either so rare we failed to detect them, or their calls were mistaken for that of one of the more common species. Ecological information suggests, however, that most of these species, although they occur along the coast in more natural settings, cannot tolerate the degree of habitat alteration/urbanization that has taken place at the Presidio.

4.2.2.1.. Pallid bat, *Antrozous pallidus* (MSSC)

This species is currently found at Point Reyes National Seashore to the north, and at a number of sites along the coast to the south, and thus might be expected at the Presidio, especially in the oak woodland along Lobos Creek. Throughout northern and central California, pallid bats show a high association with oak woodland, where they roost in tree hollows and forages on large ground dwelling arthropods, like Jerusalem crickets (Gryllacrididae) and long-horned beetles (Cerambycidae) (Hermanson & O'Shea 1983, Pierson & Rainey unpubl. data). It is likely, however, that this highly social, colonial species requires more habitat than is

available at the Presidio. A typical colony contains 30-70 animals, although colonies of several hundred are known.

Although this species occurs in a variety of habitats from true desert to the moister oak woodlands and redwood forests, and appears fairly flexible in its roosting habits, using a number of crevice like settings from rocks to hollow trees, buildings, bridges, caves, and mines (Orr 1954, Barbour and Davis 1969), it is exceedingly sensitive to human disturbance and appears intolerant of urbanization. Records from Berkeley (MVZ) are fairly common early in the century, and cease in the 1940's. A colony that was resident at Stanford University in the 1950's no longer exists. A number of colonies appear to have vanished from the Napa Valley in the last 15 years, possibly due to the conversion of oak woodland to vineyards. Substantial colonies still occur in Marin County where there are extensive patches of oak woodland (e.g., Olompali State Park or Point Reyes National Seashore), but records are limited or absent from the suburban communities. Pallid bats are also sensitive to disturbance at the roost. When perturbed, they generally retreat into crevices, and with repeated disturbance, may abandon the roost. They frequently occur in walls and attics of utilized barns, but less commonly in occupied dwellings.

4.2.2.2. Silver-haired bat, *Lasionycteris noctivagans*

The only two records for *L. noctivagans* in the Bay area are spring and fall records from western Marin County (CAS and MVZ), suggesting that the species is a rare seasonal migrant. The summer range of this species in California occurs primarily either farther to the north, or at higher elevations (Rainey *et al.* in press). A single adult male was caught recently during the summer, near the coast, in Monterey County (Pierson, unpubl. data). The winter distribution for this species could include the Bay area.

Although it could occur at the Presidio, *L. noctivagans* is a forest dwelling species, and is generally found in areas with extensive, relatively mature forest. Its maternity roosts appear to be exclusively in trees (under bark and in woodpecker hollows) (Rainey *et al.* in press, Rainey and Pierson 1994). Its densities appear highest in areas of high snag density (Cross 1976). It feeds opportunistically on a variety of insects (Barclay 1985, Barclay 1985-1986), feeding in or near coniferous and/or mixed deciduous forest, adjacent to ponds, streams, and other bodies of water (Kunz 1982), and along water courses in northern California (Pierson unpubl. data).

4.2.2.3. Long-eared myotis, *Myotis evotis* (C2)

Although this species is known from most of the surrounding and coastal counties, it is nowhere common, and is considered a forest associated species throughout much of its range (Barbour and Davis 1969, Cross 1976, Barclay 1986). It appears to occur primarily in rural and wilderness areas. We know of no records from urban, or heavily suburbanized areas. There is no indication it occurs at the Presidio.

It forms small maternity colonies (10-30 individuals), which can be found in man-made structures, but are extremely sensitive to human disturbance, and will abandon a roost at the slightest intrusion. Natural roosts have been found under loose bark, in hollow trees, rock crevices, rimrock cliffs, and fissures in clay banks (van Zyll de Jong 1985, Cross 1976). It forages primarily on beetles and moths (van Zyll de Jong 1985), and has been netted over ponds in coniferous forests, at forest edges, over open meadows near tall timber, and along

creeks fringed with willow (Barbour and Davis 1969, Manning and Jones 1989). It appears to be flexible in foraging strategy, catching insects both by substrate gleaning and aerial pursuit (Faure 1990). Although Lobos Creek offers a willow lined riparian zone, it does not have the apparently requisite associated forest.

4.2.2.4. Fringed myotis, *Myotis thysanodes* (C2)

M. thysanodes is known from most of the coastal counties of central California. A colony lived in the Red Barn at Pt. Reyes National Seashore until the late 1970's. Although this species is relatively widely distributed from semi-arid desert to a number of forest types, it is generally rare. In northern and central California, it is typically found within or in close proximity to mature forest. Although it will roost in occupied human structures, it is relatively sensitive to disturbance, and is not known to occur in urbanized areas. Thus, although it could occur at the Presidio, this does not seem very likely.

Colonies, which are typically 20 to 40 animals, occur in caves, mines, rock crevices, buildings, and trees (Barbour and Davis 1969, O'Farrell and Studier 1980, W. Rainey & E. Pierson unpubl. data). They feed primarily on beetles, moths, harvestmen and crickets (van Zyll de Jong 1985).

4.2.2.5. Long-legged myotis, *Myotis volans* (C2)

Records of *Myotis volans* are very rare in the San Francisco Bay area, and relatively uncommon in coastal counties. For example, the only records for San Mateo County in the primary California museum collections are from a couple of sites in the early 1900's. The only record for Marin County is an autumn net capture of an adult male at Point Reyes National Seashore (G. Fellers, pers. comm.). Reproductive populations have been identified in Sonoma and Monterey Counties (LACM, MVZ, E.D. Pierson unpubl. records). Like *M. evotis* and *M. thysanodes*, this species appears to be highly associated with forest habitat, and is not known to occur in urbanized settings. It is most common in montane, coniferous forests (Warner and Czaplewski 1984).

Although it has been found in buildings and rock crevices, and is known to hibernate in caves, its maternity colonies are likely most often in trees (Barbour and Davis 1969, van Zyll de Jong 1985). This species feeds primarily on moths, often at canopy level (Warner and Czaplewski 1984).

4.2.2.6. Townsend's big-eared bat, *Plecotus townsendii* (C2, MSSC)

Plecotus townsendii is one of the species not detected in this survey, which may well occur at the Presidio. It was located in buildings and bunkers at the Marin Headlands as recently as 1993 (Pierson 1993). Two of the largest known populations in California occur at Point Reyes National Seashore; another colony occurs along the coast in San Mateo County (Pierson and Rainey 1994). Because it has a "whispering" echolocation call, it is difficult to detect acoustically. Roost surveys, which are the most appropriate way to search for this species, were not included in the scope of work.

If *P. townsendii* occurs at the Presidio, it likely roosts in a protected attic or unused building. It is primarily a cave dwelling species, but will use a number of cave analogues (i.e., mine tunnels and abandoned buildings with cave-like attics) as day roosts. It typically forms maternity colonies of 100-300 females. It is more sensitive than most species to

disturbance at its roosting sites. It has fairly restrictive roosting requirements (Pierson *et al.* 1991), and in most settings is likely to be roost limited. It is questionable, however, whether there would be adequate foraging habitat to support a colony of this species at the Presidio. It feeds primarily on small moths (Dalton *et al.* 1986, Sample and Whitmore 1993).

Radiotracking studies (V. Dalton, pers. comm. G. Fellers, pers. comm., pers. obs.) have documented it feeding in closed forest settings, particularly along stream corridors, and over corn and alfalfa fields. It has been netted over damp, marshy patches of meadow and in willow, riparian vegetation (pers. obs.).

4.2.2.7. Mastiff bat, *Eumops perotis* (C2, MSSC)

Although there is only one record of *Eumops perotis* for the Bay area from Hayward (Sanborn 1932), it is possible that this species follows the same pattern as the more common molossid, *T. brasiliensis*, and moves to the coastal region in the winter. Work currently being conducted for California Department of Fish and Game (Pierson and Rainey in progress) has expanded the range of this species, and documented more localities in the Coast Range.

E. perotis is a colonial, crevice dwelling species. Natural roosts are often found under large exfoliating slabs of granite or sandstone, on cliff faces or in large boulders (Vaughan 1959), but there are also a number of records from buildings (Barbour and Davis 1969). Roosts are generally high above the ground, usually allowing a clear vertical drop of at least ten feet below the entrance for flight (Barbour and Davis 1969). If it occurs at the Presidio, it would be expected to be found in buildings. The animals characteristically fly, and perhaps forage, at high elevation, often up to 1,000 feet above the ground (Vaughan 1959). They appear to feed predominantly on moths (Lepidoptera), but are known to take Hymenoptera, Homoptera, and Orthoptera (Ross 1967, Easterla and Whitaker 1972). The mastiff bat is a strong, fast flier, and its foraging range is likely extensive. It has been heard in open desert, at least 15 miles from the nearest possible roosting site (Vaughan 1959). It has been detected feeding over large open meadows in the Sierra, in blue oak/grey pine habitat at lower elevations in the Sierra, and over desert washes, streams, and drying creek beds in San Diego and San Benito Counties (unpubl. data). Based on the limited available information, the Presidio does not appear to offer suitable foraging habitat for this species.

4.2.3. Other Species Known from Coastal Counties, but Unlikely to Occur at the Presidio.

4.2.3.1. Small-footed myotis, *Myotis ciliolabrum* (C2)

There are records for *M. ciliolabrum* from Monterey County to the south (CAS, MVZ), but these are winter hibernating records from inland sites in the San Joaquin Valley (Parkfield & Patriquin). There is no indication this species occurs along the coast in the Bay area, and thus was not expected at Presidio.

4.2.3.2. Little brown myotis, *Myotis lucifugus*

M. lucifugus would be unlikely to occur at the Presidio. Although this species has an extensive range, which covers most of North America, in California it is relatively uncommon along the coast, being found primarily at higher latitudes and altitudes. Except for an isolated record (multiple specimens) from Lake Espinosa in Monterey County (MVZ), this species is not known from the coastal region south of Sonoma County.

Human development does not appear to be a primary barrier to its distribution, since it is one of the species most likely to roost in buildings.

4.2.3.3. Big free-tailed bat, *Nyctinomops macrotis* (C2, MSSC)

The distribution of this rare species is not well understood. Although it appears to be primarily of species of the southwestern desert, there are isolated records from as far north as British Columbia. There is a single winter record (MVZ) from Alameda County, raising the possibility that *N. macrotis* could occur at the Presidio. Since there are fewer than a dozen records for all of California, and most are from San Diego County, its presence at the Presidio seems unlikely.

4.2.3.4. Pipistrelle, *Pipistrellus hesperus*

P. hesperus would be highly unlikely to occur at the Presidio. Although there is a record from the coastal region of Monterey County (MVZ), this species is generally associated with xeric habitats (e.g., it is very common in the desert), and is found more commonly inland. In the San Francisco Bay area, it is known from eastern Contra Costa County, and not along the coast.

5.0 MANAGEMENT RECOMMENDATIONS

A limited assemblage of bats was found at the Presidio. Although it is not clear what steps could be taken to encourage some of the rarer and more sensitive species to colonize an essentially urbanized environment, it is possible to identify those features of the habitat which appear to support the bat species which are there, and make recommendations regarding maintenance of these habitat features.

5.1. Habitat management

5.1.1. Surface water

Surface water is a key resource shaping patterns of bat activity in almost all regions. The Presidio is no exception. Shallow open water and adjacent mesic vegetation are typically sites of high insect productivity, offering bats the opportunity to both forage and drink. Mountain Lake is the most important foraging site identified for bat populations at the Presidio, and processes or events which substantially degrade water quality or severely reduce insect populations will likely affect bat populations. It is recommended that steps be taken at this site to maintain water quality, and protect shoreline vegetation, as a reservoir of insect production.

5.1.2. Forest management

It is likely that the majority of bats at the Presidio, except for the *T. brasiliensis*, are roosting in trees on the property, either in the foliage (e.g., *L. blossevillii* and *L. cinereus*), or under bark and in tree hollows (e.g., *E. fuscus* and any *Myotis* species). These populations can best be supported by maintaining a multi-age forest community, with special attention being given to the preservation of snags and/or dead tree limbs. The tendency in a setting which receives extensive recreational use is to remove dead and dying trees for hazard abatement or

cosmetic enhancement. It is the "unaesthetic," and "dangerous" trees that are most likely to provide good roosting habitat for bats. Thus, it is recommended, that any dead and dying trees which do not pose a direct threat to humans (e.g., are not located on the edge of a trail, or next to a playground) be left in place as wildlife habitat.

5.1.3. Roost management and enhancement

It also would be possible to offer potential roosting habitat in man-made structures, without posing any risk to humans. For example, Spanish tile roofs provide excellent roosting habitat for a number of species, especially *T. brasiliensis* and *E. fuscus*. Because the bats are on the exterior of the building, people are often not even aware of their presence. They cause no structural damage, and can easily coexist with humans in such a setting. If any bridges are to be constructed during park development, it would be possible to incorporate bat roosts into the design. Such roosts, because they are rarely explored by people, often provide ideal, safe roosting habitat for the animals. It would also be possible to incorporate potential bat roosting habitat into structures which receive relatively little human use (e.g., storage buildings), in such a way it would cause no problems for people or the structure.

5.2. Public Education and Interpretation.

Increased media coverage, high interest in availability of school programs, and consistently heavy attendance at lectures on bat natural history attest to a marked increase in public interest in bats. We recommend bat education and interpretation not only for the visiting public, but also for residents and site staff at the Presidio. This is particularly important for maintenance personnel or contractors, because occasional contact between people and bats is likely given the human density, the limited amount of woodland, and the probability that the most common species roosts in structures. As noted earlier, some bat species are highly aggregated and elimination of colonies by an uninformed pest control contractor, possibly employed directly by a tenant, could materially influence bat populations in the Presidio.

A common complaint of people attempting to deal with bats in buildings is that they have difficulty finding a knowledgeable person to assist them. A valuable simple step would be to include a wildlife problem/sighting telephone number in whatever directory of NPS resource personnel/contractors is provided to tenants. The office receiving these calls should have a protocol of recommended actions for single downed bats, temporary intrusions in buildings, and discovery of resident colonies, and be prepared to offer calming advice to sometimes agitated callers.

A difficulty in introducing bats to the public, other than through pictures and descriptions, is that free-living bats are relatively hard to observe away from high density roost sites (e.g., Carlsbad Caverns). As has been experienced at Lava Bed NM, public access to roosting bat populations without access control leads to fairly frequent incidents of mass bat mortality through vandalism. For public interpretive programs on bat natural history in the Presidio, Mountain Lake provides an unusually good site because of the concentrated foraging activity there at dusk at almost all times of year. Bats, sometimes in considerable numbers, usually can be seen over the lake before it is fully dark. A relatively inexpensive bat detector would let interpretive staff convert bat calls into the audible, including the distinctive feeding buzzes made as insects are captured. Rates of insect capture over the lake are frequently high and offer a direct demonstration of an aspect of bat ecology of great public interest.

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Table 1. Bats of San Francisco Bay region. Listed species are present in museum collections from Central Coast or Bay margin counties. Species in light grey have been identified acoustically in the Presidio in this survey. Dark grey indicates special status species.

		DFG Special Concern ¹	ESA Candidate 2 ²
Family Molossidae			
<i>Tadarida brasiliensis</i>	Mexican free-tailed bat		
<i>Nyctinomops macrotis</i>	Big free-tailed bat		
<i>Eumops perotis</i>	Western mastiff bat		
Family Vespertilionidae			
<i>Antrozous pallidus</i>	Pallid bat		
<i>Eptesicus fuscus</i>	Big brown bat		
<i>Lasionycteris noctivagans</i>	Silver-haired bat		
<i>Lasiurus blossevillei</i> (= <i>borealis</i>) ³	Western red bat		
<i>Lasiurus cinereus</i>	Hairy bat		
<i>Myotis californicus</i>	California myotis		
<i>Myotis ciliolabrum</i> (= <i>leibii</i>) ³	Western small-footed myotis		
<i>Myotis evotis</i>	Long-eared myotis		
<i>Myotis lucifugus</i>	Little brown myotis		
<i>Myotis thysanodes</i>	Fringed myotis		
<i>Myotis volans</i>	Long-legged myotis		
<i>Myotis yumanensis</i>	Yuma myotis		
<i>Pipistrellus hesperus</i>	Western pipistrelle		
<i>Plecotus townsendii</i>	Townsend's big-eared bat		

¹ California Department of Fish and Game, Mammalian Species of Special Concern (Williams 1986)

² Candidate (Category 2) for listing under U.S. Endangered Species Act (1994 FR 59(219):58984-9).

³ Names as listed by Koopman in Wilson and Reeder 1993

Table 2. Acoustic Activity at Monitoring Stations by Season

Monitoring Station	Winter			Spring			Summer			Fall			Total	
	Time (Min.)	# Events	Events/Min.	Time (Min.)	# Events	Events/Min.	Time (Min.)	# Events	Events/Min.	Time (Min.)	# Events	Events/Min.	Time (Min.)	# Events
FOREST/FOREST EDGE														
Polin Spring	20	21	1.050	130	17	0.131	295	7	0.024	270	30	0.111	715	75
Hicks Athletic Field	20	3	0.150	181	10	0.055	35	5	0.143	310	75	0.242	546	93
Central Magazine	50	4	0.080	50	0	0	15	0	0	80	2	0.025	195	6
Total	90	28	0.311	361	27	0.075	345	12	0.035	660	107	0.162	1456	174
OPEN AREA/GRASSLAND														
Native Grassland	20	1	0.050	40	2	0.050	60	2	0.033	135	6	0.044	255	11
Heliopad	25	3	0.120	40	0	0	35	0	0	130	8	0.062	230	11
Golf Course	96	5	0.052	80	3	0.038	29	0	0	152	13	0.086	357	21
Total	141	9	0.064	160	5	0.031	124	2	0.016	417	27	0.065	842	43
RIPARIAN														
Lobos Creek	-	-	-	155	2	0.013	249	1	0.004	-	-	-	404	3
WATER														
Mountain Lake	-	-	-	20	30	1.500	206	33	0.160	125	62	0.496	-	-
TOTAL	231	37	0.160	696	64	0.092	924	48	0.052	1202	196	0.163	2702	220

Table 3. Species Distribution at Monitoring Stations

(Pooled across all dates from subsamples of recorded events)

Monitoring Station	<i>E. fuscus</i>	<i>L. blossevillii</i>	<i>L. cinereus</i>	<i>Myotis spp.</i>	<i>T. brasiliensis</i>	No ID	Total
FOREST/FOREST EDGE							
Polin Spring		1	5	15	28	26	75
Hicks Athletic Field	1		8	4	38	42	93
Central Magazine	1		1		4		6
OPEN AREA/GRASSLAND							
Native Grassland					4	7	11
Holopad			2		9		11
Golf Course			1		20		21
RIPARIAN							
Lobos Creek				2	1		3
OPEN WATER							
Mountain Lake	3		2	2	65	53	125
Total # of bat pass samples	5	1	19	23	169	128	345
% of Total Identified events	2.3	0.4	8.7	10.6	77.9		

Table 4. Seasonal Acoustic Detection of Bat Species at the Presidio

(based on a subsample of acoustic events)

	Winter	Spring	Summer	Fall
<i>Eptesicus fuscus</i>	X		X	X
<i>Lasiurus blossevillii</i>		X		
<i>Lasiurus cinereus</i>	X	X		X
<i>Myotis spp.</i>		X	X	X
<i>Tadarida brasiliensis</i>	X	X	X	X