Bat Inventory of the Multiple Species Conservation Program Area in San Diego County, California, 2002-2004

California leaf-nosed bat (*Macrotus californicus*)

Pallid bat (*Antrozous pallidus*)

Prepared for:

County of San Diego
California Department of Fish and Game

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U.S. GEOLOGICAL SURVEY

Bat Inventory of the Multiple Species Conservation Program Area in San Diego County, California

By Drew C. Stokes, Cheryl S. Brehme, Stacie A. Hathaway, and Robert N. Fisher

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San Diego, CA 92123

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U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, SECRETARY

U.S. GEOLOGICAL SURVEY
Patrick Leahy, Acting Director

For additional information, contact:
Center Director
Western Ecological Research Center
U.S. Geological Survey
3020 State University Drive East, Modoc Hall, Room 3006
Sacramento, CA 95819

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Abstract

We conducted a bat species inventory of the Multiple Species Conservation Program (MSCP) area in San Diego County, California. The study began in the early summer of 2002 and terminated in the winter of 2003. We used a variety of bat survey techniques including ultrasonic bat detectors, mist-nets, hand-nets, unaided ears (audible), and spotlights to document both foraging and roosting bats within and immediately adjacent to the Multi-Habitat Preserve area. We conducted a total of 80 surveys at 27 foraging bat sites and 28 surveys of 18 potential bat roosting sites. We detected 16 bat species including five species of local concern at various sites within the study area during both foraging and roosting bat surveys. Other information provided by this study includes demographics, reproductive states, and injuries of captured bats, seasonal activity and richness patterns of bats in the study area, watershed associations of bats in the study area, and detection success of the various bat survey techniques used. We present specific recommendations for bat management and long-term monitoring strategies.

Introduction

Bats are a diverse group of mammals representing approximately one-third of the mammals found in San Diego County. Twenty-three species have been documented in the county (Krutzsch 1948, Bond 1977, Constantine 1998). Bats make use of a wide variety of habitats and typically have large home ranges. Twenty-one of the 23 bat species known to occur in the county are insectivorous. The other two bat species are nectivorous. As a group, they are good indicators of ecosystem health at a landscape level through their diverse life history needs (Ball 2002). Though they are diverse and widespread, bats have always been difficult to study because of their life history and ecology. Some historical information regarding bats exists for the study area from bat research done by Phillip Henry Krutzsch in the 1930's and 40's (Krutzsch 1948). This thesis provides information obtained by Krutzsch, as well as other naturalists working in the county before him. However, recent information about bats for the area is lacking. As a result, local land and resource managers have had very little information available from which to make management decisions regarding bats. Recent advances in technology such as ultrasonic bat detectors have allowed biologists to more efficiently and thoroughly survey for bats (Kunz et al. 1996b, Pierson 1998). Elucidation of basic information about bats is valuable to land and resource managers so they can consider bats in management activities and gain insight into the overall health of the ecosystem they manage (Ball 2002).

In the past several decades, there have been extensive changes to the coastal plain, inland valley, and foothill areas of San Diego County due to rapid population growth and associated urban expansion. In response, a network of lands for preservation of native species is currently being planned and executed throughout the county as part of a joint Habitat Conservation Plan (HCP)/Natural Community Conservation Planning program (NCCP). As part of this program, it is important to establish baseline information about the various plants and animals found within the conservation planning area. This is particularly important for taxonomic groups such as bats that are generally prevalent in the planning area, yet basic information about them is lacking.

We were contracted by the County of San Diego via a local assistance grant from the California Department of Fish and Game to conduct a bat species inventory study of the Multiple Species Conservation Program (MSCP) area preserve land in San Diego County. The data collection effort began in May 2002 and terminated in December 2003. The goals of the study were to: 1) gather baseline data on the presence, distribution, and activity levels of bat species in MSCP/NCCP preserve areas, 2) record all relevant information in a Geographic Information System (GIS) database, 3) identify significant roosts and foraging habitats that are in need of immediate protection, 4) recommend long-term monitoring sites based on data collected during this project, 5) provide preliminary evaluation of the functionality of the MSCP preserve system for bat species based on data gathered on species distribution and richness, and, 6) aid in the development of management plans for areas used by certain sensitive species deemed dependent on habitats in the preserve by providing data and making management recommendations. There are five state or federally sensitive bat species considered to be declining or of concern within the southcoast ecoregion which includes parts of San Diego County (Miner and Stokes 2005). The five bat species of local concern are 1) the California leaf-nosed bat (*Macrotus californicus*), 2) the western red bat (*Lasiurus blossevillii*), 3) the Townsend's big-eared bat (*Corynorhinus townsendii*), 4) the pallid bat (*Antrozous pallidus*), and 5) the western mastiff bat (*Eumops perotis*). We attempted to locate these species within the study area in addition to all other potentially occurring species. We also investigated important potential roost sites for bats, determined seasonal richness and activity patterns, and determined the effectiveness of survey techniques for detecting a variety of bat species.

Study Area

The San Diego County Multiple Species Conservation Program Subarea and City MSCP Subarea are located in the southwestern portion of San Diego County. The topographic regions encompassed by the study area are the coastal plains, inland valleys, and western foothills. Vegetation communities found within the study area include coastal sage scrub, chaparral, grassland, riparian, and oak woodland. There are several watersheds found within the study area including the San Dieguito River, Penasquitos Creek, San Diego River, Sweetwater River, Otay River, and Tijuana River. There is an extensive amount of exposed rock, various man-made structures, and a number of abandoned mines found in the study area. We targeted primarily reaches and tributaries of the five watersheds mentioned above to survey for foraging bats. Various man-made structures and other potential roost sites were surveyed for roosting bats. Our survey sites are represented in Table 1 and Figure 1.

Methods

Multiple bat survey techniques are needed to thoroughly document a diversity of bat species during an inventory study (Pierson 1993). For this study, we used acoustic, visual, hand-net, and mist-net capture techniques to observe and detect bats. These techniques were used in concert during two types of surveys: 1) foraging bat surveys and 2) roosting bat surveys. Survey locations are listed in Tables 1 and 2 and mapped in Figure 1.

Foraging Bat Surveys

When surveying for foraging bats, we utilized an Anabat II ultrasonic bat detector (Titley Electronics, New South Wales, Australia) to detect and record bat echolocation signals. The Anabat bat detector is a directional ultrasonic microphone that, when connected to a laptop computer, allows for real-time monitoring and recording of bat vocalizations. Bat vocalizations can be identified to the species level during real-time monitoring. Bat vocalizations can also be reviewed in the laboratory after field data collection and species identifications can be confirmed or made at that time. Although it is directional, the Anabat has a cone of reception that varies in size and sensitivity based on several factors including the specifications of each individual Anabat and the environmental conditions during use in the field (O'Farrell et al. 1999). The effective range of the Anabat also varies depending on the frequency and intensity of different bat species echolocation vocalizations, or ‘calls’. Species that produce low intensity calls are detectable at a shorter distance than species that produce high intensity calls using the standard Anabat microphone, division ratio (16) and sensitivity setting (7-8).

At foraging bat survey sites the Anabat was placed on a small table approximately 0.5 meters tall and was propped up at a 45-degree angle to maximize sound reception. We oriented the Anabat such that it was facing towards the area where bats were expected to be foraging so that the probability of detecting and recording bat vocalizations was maximized. We used the standard Anabat microphone. The division ratio used was ‘16’, and the sensitivity level was typically set at ‘8’ (maximum setting is ‘10’), except in habitat settings where background noise interfered with sound reception. In these instances the sensitivity setting was reduced to ‘7.5’ or ‘7’. We used the Anabat at foraging sites for a period of three hours beginning approximately at sunset. We then analyzed and identified bat vocalizations to the species level. For each survey site, a bat species list was created from analysis of the recorded bat vocalizations. Not every bat vocalization was identified to the species level; only the best representative vocalizations were used. Also, general bat activity was measured and quantified as the number of files recorded with the Anabat during the three-hour monitoring period. Anabat files typically contain only a single bat vocalization sequence, but occasionally there were multiple vocalization sequences within a single file. The total Anabat recording effort for this study was 240 hours (3 hours x 80 survey nights). Identification of bat calls using the Anabat bat detector was a subjective process that required experience and access to a reference library of ‘known’ bat calls for comparative purposes. This reference library was developed during various USGS bat research projects beginning in 2002.

We also listened (using the unaided ear) for audible bat echolocation and social vocalizations, which were identifiable to the species level in most cases. This technique was used primarily to detect echolocation calls of western mastiff bats and secondarily to detect echolocation calls of big free-tailed bats (*Nyctinomops macrotis*) and social calls of pallid bats. There was no quantification of these audible bat passes. If we heard an audible bat species, it was documented as present at the survey site. We often used visual techniques (i.e. a spotlight, unaided eyes) simultaneously with acoustic techniques to observe foraging bats, which typically aided in species identification.

We used mist-nets simultaneously with acoustic techniques during foraging bat surveys. Mist-nets are made of fine nylon mesh and are used to capture bats in flight. We usually placed mist-nets in areas where they are likely to intercept flying bats, such as over relatively small bodies of water and in vegetation flyways (Kunz et al. 1996a). We used from one to six mist-nets of various dimensions at foraging sites to capture bats. The dimensions of the mist-nets we used were 2.6 meters tall by 2.6 meters, 6 meters, 9 meters, 12 meters, and 18 meters long. We usually placed the mist-nets within 100 meters of the Anabat set-up location. We used mist-nets for a period of three hours beginning approximately at sunset. The total mist-netting effort for this study was 840 mist-net hours (three mist-net hours x 280 mist-nets used) and the average mist-net effort was 10.5 mist-net hours per survey night (840 mist-net hours/80 foraging bat survey nights). Captured bats were processed and then released immediately. The information recorded during processing included the species, age (adult or juvenile), tooth wear (rated

1-4 as rough estimate of age based on wear on the least worn upper canine: 1 = needle sharp, 2 = showing some wear, 3 = worn such that length of tooth approximates width, and 4 = tooth completely worn to base or missing completely), sex, reproductive status, parasite load, general measurements, and anything else noteworthy. In most cases, we used a digital camera to document captured bats. We also recorded the vocalizations of captured bats with the Anabat bat detector as we released them. The recorded vocalizations were then placed into a reference library of 'known' bat vocalization call sequences.

General Surveys

We conducted general foraging bat surveys with the intent to document as many species as possible in one survey night. We surveyed twenty-seven sites in this manner (Table 1). Most of these sites were surveyed on single visits, though a few were visited more than once. We selected general foraging bat survey sites based on the presence of a mosaic of habitat features that foraging bats are associated with in the southern Californian landscape (D. Stokes pers. obs.). These habitat features include open surface water (creeks, rivers, ponds, cattle troughs), woodland (willows, cottonwoods, sycamores, oaks), scrub vegetation (chaparral, coastal sage scrub, riparian scrub), and grassland. We often targeted riparian systems. Due to the amount of equipment used to conduct foraging bat surveys, access was limited to survey sites located within approximately one kilometer of roads accessible by a vehicle.

We targeted nine of the 27 general foraging bat sites with the intent to document a single species, the pallid bat, in addition to any other detectable bat species. The pallid bat was expected to occur at these sites based on historical records (Krutzsch 1948) or because of the presence of upland habitats (oak woodland/grassland) where pallid bats are expected to occur (Western Bat Working Group 2004). We have had success capturing pallid bats in these habitat settings during other USGS bat research studies (Fisher and Crooks 2002, Stokes and Fisher 2004). The sites we surveyed with the intent to document pallid bats based on their historical occurrence or the presence of appropriate habitats were: 1) Boden Canyon Ecological Reserve (North of Pond), 2) Boden Canyon Ecological Reserve (South of Pond), 3) Dos Picos County Park, 4) El Monte County Park, 5) Flinn Springs County Park, 6) Los Penasquitos Canyon Preserve (Oak Woodland Clearing), 7) San Pasqual Valley, 8) Sycamore Canyon/Gooden Ranch Open Space Preserves, and 9) Sycuan Peak Ecological Reserve (Lawson Creek) (Table 1).

Multi-Visit Survey Sites

We surveyed five of the 27 foraging bat sites multiple times at regular intervals across seasons during 2002 and 2003 (Table 1). The five sites were 1) Cottonwood Creek, Marron Valley (Spring), 2) Hollenbeck Canyon Wildlife Area, 3) Los Penasquitos Canyon Preserve (Lower Creek), 4) Mission Trails Regional Park, San Diego River, and 5) San Diego National Wildlife Refuge, Sweetwater River (URDS). We added three additional multiple survey sites in 2003: 1) Boden Canyon Ecological Reserve (South of Pond), 2) Fairbanks Ranch, and 3) Sweetwater County Park (Morrison Pond). The goals of the repeat surveys were to observe how bat richness and activity levels might change over seasons and to document rare species that might be missed during a single survey visit.

In total, we conducted foraging bat surveys on 80 nights at 27 foraging bat sites.

Roost Surveys

Some bat species are more easily detected at roost sites than foraging sites (i.e., American leaf-nosed bats belonging to family *Phyllostomatidae,* D. Stokes, pers. obs.), so this technique was used to supplement foraging bat surveys. Locating, characterizing, and monitoring roosts are all important to efforts to conserve and manage for bats in a given landscape (Pierson 1998, Ball 2002). Roost surveys must be conducted cautiously as many bat species are very sensitive to disturbance at roost sites (Kunz et al. 1996b). Habitats targeted for roost surveys included rocky cliffs and outcrops, natural caves, buildings, bridges, and artificial tunnels. There are a number of abandoned mines in the study area. They are located around Otay Mountain, McGinty Mountain, and along the San Diego River near El Monte Open Space Preserve. These mines were not surveyed due to: 1) United States Geological Survey (USGS) prohibitions on subterranean survey work (internal mine surveys) without proper training, certification, and equipment, and 2) the scope of work associated with external surveys of these mines (see management recommendations – further research). The types of roost surveys we conducted included: 1) diurnal internal inspections of day roosts, 2) nocturnal internal inspections of night roosts, and 3) external surveys of inaccessible roosts where we observed bats as they exited or entered day or night roosts. Techniques used to survey for roosting bats included: 1) visual observations of roosting bats during internal and external roost surveys, 2) visual observations of guano and/or culled insect parts deposited by bats at roosts during internal surveys (required familiarity and experience with species-specific bat guano), 3) unaided ears to listen for audible species during external surveys, 4) use of the Anabat to record bat vocalizations during external surveys, 5) use of mist-nets to capture bats during external surveys, and 6) use of hand-nets to capture bats at during internal surveys.

We conducted single roost survey visits at 18 potential roost sites. Of these, we visited four potential roost sites on multiple occasions. In total, we conducted 28 roost surveys using the various roost survey techniques at 18 suspected roosting sites within the study area (Table 2). Occasionally, we visited multiple roost sites during the day on the same date and some night roost visits were made following a foraging bat survey. In addition, we sometimes detected foraging bats in the survey area during roost surveys. These bats were reported as present on site but not reported as roosting on site.

We conducted one roost survey in Coronado (within the MSCP area but with its own sub-area plan) using USGS matching funds (site 28 – Coronado Cays). This survey was conducted in order to document one particular species, the Mexican long-tongued bat (*Choeronycteris mexicana*). This nectar-feeding species has been known to occur in western parts of the county dating back to the 1940's (Krutzsch 1948) but has not yet been detected on public lands (D. Stokes unpub. data).

Results and Discussion

Summary

We were able to detect 16 bat species within the study area (Table 3). All five of the targeted species of local concern were detected within the study area. The five species of local concern were: 1) the California leaf-nosed bat, 2) the western red bat, 3) the Townsend's big-eared bat, 4) the pallid bat, and 5) the western mastiff bat. Accounts of these species are found in the Conclusions and Management Recommendations section ('Accounts of Species of Local Concern'). A summary table of all bat species detections by site, date, and method can be found in Appendix I.

The bat species detected at the greatest number of sites during this study was the Yuma myotis (*Myotis yumanensis*), which was detected at 68% of our survey sites (Figure 2, Table 4). There were several other species detected at greater than half of the survey sites. The pocketed free-tailed bat (*Nyctinomops femorosaccus*) was detected at 61% of sites, the Mexican free-tailed bat (*Tadarida brasiliensis*) at 59% of sites, the big brown bat (*Eptesicus fuscus*) at 57% of sites, the western mastiff bat at 55% of sites, and the western pipistrelle (*Pipistrellus hesperus*) at 52% of sites. The rest of the bat species were detected at less than half of the survey sites. The western small-footed myotis (*Myotis ciliolabrum*) was detected at 39% of sites, the California myotis (*Myotis californicus*) and western red bat at 25% of sites, the hoary bat (*Lasiurus cinereus*) at 16% of sites, the long-eared myotis (*Myotis evotis*) and Townsend's big-eared bat at 9% of sites, the pallid bat and big free-tailed bat at 7% of sites, and the California leaf-nosed bat and Mexican long-tongued bat at 2% of sites. These results are pooled from a combination of the various survey techniques used during both foraging and roosting bat surveys. These results are influenced by various factors including: 1) the actual distributions of the bat species, 2) the detectability of the bat species using the various survey techniques during the two types of surveys, and 3) the seasonal occurrence of the bat species within the study area.

The results of bat surveys are presented in the following sections: 1) Foraging Bat Surveys, 2) Roosting Bat Surveys, 3) Demographics, Reproduction, and Injuries of captured bats, 4) Seasonal Bat Richness and Activity Patterns, 5) Watershed Associations, and 6) Detection Success of Survey Techniques.

Foraging Bat Surveys

Foraging bat surveys resulted in the detection of 14 of the 16 bat species during this study (Table 5). The two bat species not detected during foraging bat surveys were the California leaf-nosed bat and the Mexican long-tongued bat. An average of 5.4 bat species were detected per survey night using the combined foraging bat survey techniques. Foraging bat survey data are found in Appendix II.

Anabat

In 240 Anabat hours, 8,697 files were recorded that contained at least one bat vocalization sequence. The average number of Anabat files recorded per night was 108.7 (8697 files/80 survey nights) and the average number of Anabat files recorded per hour was 36.2. Fourteen of the 16 bat species were detected using the Anabat at foraging sites (Table 6). The two bat species not detected with the Anabat were the California leaf-nosed bat and Mexican long-tongued bat. The average number of bat species detected per survey night was 4.8. The three species most frequently detected with the Anabat were the big brown bat, Yuma myotis, and pocketed free-tailed bat. Representative sonograms of all bat species recorded in this study can be viewed in Appendix III. The sonograms shown are screenshots taken from the bat vocalization analysis program Analook 4.8p (Titley Electronics, New South Wales, Australia).

Maximum bat activity, was measured by the Anabat (number of files per 3-hour survey night) and was highest (>250 files per 3 hour night) during single night recording events at several sites: 1) Boden Canyon Ecological Reserve (north of pond), 2) Cottonwood Creek spring in Marron Valley, 3) San Diego River in Mission Trails Regional Park, 4) Padre Dam in Mission Trails Regional Park, and 5) Morrison Pond in the Sweetwater County Park (Appendix II). Caution is needed when drawing any conclusions about bat activity levels due to all of the different factors that influence the sensitivity of the Anabat and its ability to record bat calls, as well as the potential for naturally high night to night variation in bat activity (Corben and O'Farrell 1999). In addition, bat abundance is not necessarily correlated with bat activity levels. In general, bat abundance is very difficult to estimate and was not measured during this study (Kunz et al. 1996b).

We speculate that one factor influencing high bat activity levels at foraging bat sites may be the presence of open surface water. The highest bat activity levels were measured at the Morrison Pond (Sweetwater County Park) site. Six hundred thirty six and 518 files were recorded on visits to this site during the late summer and early fall of 2003. On both of these visits there appeared to be an unusually high abundance of midges (family *Chironomidae*), an aquatic emergent insect known to emerge in large numbers at slow moving open water sites such as lagoons, wastewater facilities, and lakes (Hogue 1993). Most of the recorded bat files on these dates were attributed to a single bat species, the Yuma myotis. Remington (2000) found that bat activity measured by the Anabat was unusually high at ponds in urban park settings in Orange County, California, with most of the recorded files being attributed to the Yuma myotis. This suggests that foraging Yuma myotis are prevalent at open water sites in relatively developed areas of southern California and may be particularly active foragers during aquatic insect emergent events. Because this species often occurs in the vicinity of open water and is fairly urban adapted, the Yuma myotis may play an important in controlling aquatic-emergent insect-born diseases such as West Nile Virus in and around human inhabited areas.

Audible

The use of the unaided ear as an audible survey technique was used at all foraging sites in conjunction with mist-netting and the Anabat. Three bat species, the western mastiff bat, big free-tailed bat, and pallid bat were detectable with the unaided ear (Table 7). We heard western mastiff bats at 17 foraging bat sites. We recorded western mastiff bats with the Anabat at 10 sites. This suggests that the Anabat, when used with standard microphone, division ratio of 16, and sensitivity of '8' is less effective than the unaided ear (assuming normal hearing) at detecting western mastiff bat echolocation calls. Remington (2003) made 84 western mastiff bat audible observations during research in Orange County, California, but only five Anabat recordings.

We heard big free-tailed bat echolocation calls at three foraging bat sites. This species was also recorded with the Anabat simultaneous with these audible detections. The big free-tailed bat appears to be less detectable with unaided ears than the western mastiff bat, probably because of producing an echolocation call that is higher pitched and of lower perceived intensity. Based on only three detection sites, the standard Anabat set-up and unaided ear appear to be equally effective at detecting big free-tailed bats.

Finally, we heard social calls of pallid bats during one visit each to two foraging bat sites. However, at these two sites the pallid bat was also either captured in mist-nets and/or recorded using the Anabat on four additional dates. This suggests that use of the unaided ear has some value but may be less effective at detecting pallid bats compared to mist-netting and use of the Anabat.

Visual

Visual techniques (use of unaided eyes and a spotlight) were used at all foraging sites in conjunction with mist-netting, the Anabat, and audible techniques to document foraging bats. We used visual techniques to observe bats as they were detected acoustically. Occasionally, we observed bats recognizable in flight (i.e., western red bats, hoary bats, big brown bats) simultaneous with recordings of their vocalizations using the Anabat. When this occurred, the recorded bat vocalizations were copied into a reference library of 'known' bat vocalization sequences.

Mist-netting

At foraging sites, we captured 143 bats representing 10 species (Table 8) in mist-nets. Representative digital images of the 10 bat species captured in mist-nets in this study can be viewed in Figures 3-14. The average capture rate per night was 0.2 bats/mist-net hour (143 bats/840 mist-net hours). While this rate appears low compared to local mist-netting efforts for birds, an average of 0.6 birds/mist-net hour (B. Kus pers. comm.), it is greater than the capture success rate of another recent southern Californian bat study in Orange County, California, which averaged only 0.02 bats/mist-net hour (Remington 2003). As no bats were marked, recapture rates were not known. We did not attempt to estimate bat abundance based on mist-net captures. An average of 0.76 bat species were detected per night based only on mist-net captures. The three species captured in mist-nets in the highest numbers were the Yuma myotis, big brown bat, and California myotis.

Species-Rich Foraging Sites

Detected bat species richness was greatest (13 species) at the foraging bat site on Cottonwood Creek in Marron Valley, Dulzura (Table 5), followed by Hollenbeck Canyon Wildlife Area (12 species), the URDS site on the Sweetwater River in the San Diego National Wildlife Refuge (11 species), the Boden Canyon Ecological Reserve (10 species), and the San Diego River in Mission Trails Regional Park (nine species).

The richest sites are characterized by the presence of a mosaic of habitat types including perennial surface water, one or more woodland types (oaks and/or riparian trees), and native scrub vegetation and grassland. All of these sites are found within fairly large, relatively undisturbed tracts of contiguous land. Mission Trails Regional Park has the greatest amount of developed land surrounding it. In southern California, the habitat types supportive of a diverse foraging bat community appear to be: 1) open surface fresh water and 2) woodland/scrub or grassland edge interface (D. Stokes, pers. obs). However, an important variable potentially influencing the number of bat species detected at any given foraging site is the juxtaposition of the site relative to appropriate roosting habitat(s). Although we did not measure this variable during this study, the sites listed above are within known commute distances of appropriate roosting habitats of most locally occurring bat species (Miner and Brown 1996, Pierson 1998, Fellers and Pierson 2002).

We surveyed these five foraging bat sites on multiple occasions across seasons over the duration of this study. The increased survey effort is likely a very important factor contributing to the high detected bat species richness at these sites. However, the Los Penasquitos Canyon Preserve (lower creek) site was also surveyed on multiple occasions and cumulatively only seven species were detected there. This preserve, like Mission Trails Regional Park, is surrounded by development. This preserve, however, unlike Mission Trails Regional Park, is lacking in extensive exposed rocky outcrops, cliffs, and caves suitable for roosting bats and is located quite some distance from these habitats. The lack of these important roosting habitats may limit the number of bat species occurring at this location. However, it is possible that a more diverse bat community may occur here with individuals arriving on site later into the night (beyond our 3 hour monitoring period), after commuting from inland roost sites.

Mist-netting vs. Acoustic Techniques at Foraging Sites

The use of mist-netting and acoustic techniques combined at foraging bat sites resulted in an average detection rate of 5.4 bat species per survey night (three hours of monitoring per night). Mist-netting alone resulted in the detection of 10 bat species at a rate of 0.8 species per night while use of the Anabat resulted in the detection of 14 bat species at a rate of 4.8 bat species per night. The use of unaided ears to document audible bat species resulted in the detection of three species at a rate of 0.7 species per survey night. Clearly, the Anabat was the most effective survey tool for detecting multiple bat species during this study. The superior effectiveness of the Anabat at detecting multiple bat species at foraging sites compared to mist-netting has been reported in other studies (O'Farrell and Gannon 1999, Remington 2000, 2003, Stokes and Fisher 2004).

Roosting Bat Surveys

We selected potential bat roosts and roosting areas to be surveyed based on the presence of appropriate bat roosting habitats that could support colonial bats, including rocky outcrops and cliffs, natural caves, and man-made structures such as artificial bat houses, bridges and abandoned or infrequently used buildings. Roosting areas differed from roosts in that a specific roost was not located, but rather a general roosting area was identified. This usually pertained to inaccessible cliff roosts. We did not survey potential tree roosts. Roost surveys conducted using the various roost survey techniques resulted in the detection of 13 bat species at 15 roost sites or areas (Table 9).

<u>Bat Roosts Surveyed During this Study</u>

We surveyed several bat roosts and roosting areas during this study (Table 2 and 9, Figure 1). Descriptions, techniques used to document bats, number of bat species, and significance of these roosts are described.

External Only Roost Surveys:

> 1) San Diego National Wildlife Refuge, Sweetwater River (Boulders), US Fish and Wildlife Service (site 43):
> We surveyed a granite boulder-covered hillside located on the south side of the Sweetwater River in the San Diego National Wildlife Refuge in October 2002. We used a single Anabat set facing towards the boulders and listened for audible bats. We recorded six bat species with the Anabat early in the evening indicating they were roosting somewhere among the boulders or near this boulder-covered hillside. The six species detected were the Yuma myotis, western pipistrelle, Mexican free-tailed bat, California myotis, pocketed free-tailed bat, and our most significant observation, a Townsend's big-eared bat.
>
> 2) Singing Hills Memorial Estates (Boulders), The Environmental Trust, (site 44):
> We surveyed a granite boulder-covered hillside located on the north side of the Sweetwater River near Singing Hills Memorial Estates in August 2002. We used a single Anabat set facing the boulders and listened for audible bats. We recorded five bat species early in the evening indicating they were roosting somewhere among the boulders or near this boulder-covered hillside. The five species detected were the western pipistrelle, small-footed myotis, Mexican free-tailed bat, pocketed free-tailed bat, and big brown bat. We also heard a sixth species, the western mastiff bat, in the area later in the evening and coming from the east.
>
> 3) Jamul Mountains, Bureau of Land Management/US Forest Service/Private, (site 36):
> We surveyed a granite boulder-covered hillside located in the Jamul Mountains near Lyons Peak in June 2002. We used an Anabat set facing the boulders and listened for audible bats. We recorded five bat species early in the evening,

indicating they were roosting somewhere among the boulders or near this boulder-covered hillside. The five species detected were the Yuma myotis, western pipistrelle, small-footed myotis, Mexican free-tailed bat, and pocketed free-tailed bat. We also heard a sixth species, the western mastiff bat, in the area later in the evening and coming from the east.

4) Jamul Creek Cliffs, California Department of Fish and Game, (site 35):
We surveyed a large granite outcrop/cliff face located along Jamul Creek in Hollenbeck Canyon Wildlife Area in July 2003. We used an Anabat set facing the outcrop/cliff and listened for audible bats. We determined only one species, the western pipistrelle, was roosting in this particular outcrop/cliff face during the survey.

Diurnal Roost Surveys:

1) Cottonwood Creek tunnel, City of San Diego, (site 29):
We internally surveyed an artificial tunnel located near Cottonwood Creek during the day using flashlights on four visits in 2002 and 2003. We observed four bat species roosting in various sections of this extensive tunnel system. We found a colony of approximately 500-1000 Yuma myotis on more than one occasion during this study and on previous visits to this site (D. Stokes unpub. data). We saw approximately 100 Townsend's big-eared bats roosting in two different sections of this tunnel with approximately half of the individuals found in one section and the other half in another section. We also found a few scattered individuals of this species in various other tunnel sections. We located a small group of five or six California leaf-nosed bats in one section on two separate visits. We captured one individual with a hand-net for species verification in September 2002 (Figure 2) Finally, we found a few scattered individual small-footed myotis in various sections of this tunnel system.

2) Otay Mountain Bunkers, Bureau of Land Management, (site 37):
We internally surveyed two historic military observation bunkers located on the west side of Otay Mountain during the day using flashlights in August 2003. We observed and hand-netted a single juvenile male Yuma myotis that was hanging on one of the walls in a room in the lower bunker. We also observed an extensive amount of bat guano in various parts of these structures, particularly in the lower bunker. All of the guano appeared to be deposited by a single species, the Yuma myotis. The amount of guano found in this particular bunker, combined with finding only one day roosting bat suggests this structure is used primarily as a night roost by the Yuma myotis. There is a known day roost site occupied by a Yuma myotis colony in Otay Lakes Dam located a few kilometers from this site. We suspect individuals of the Yuma myotis colony found day roosting in the Otay Lakes Dam use these bunkers as night roosts and occasionally as day roosts.

3) Otay Mountain, O'Neal Canyon, The Environmental Trust and Bureau of Land Management, (site 38):
We located a natural rock crevice located in O'Neal Canyon that appeared to be a suitable bat roost. We internally surveyed it during the day using flashlights in

July 2002. We observed and hand-netted a single juvenile male Yuma myotis that was roosting in this crevice.

4) Rancho Jamul Ecological Reserve (Maintenance Shed), California Department of Fish and Game, (site 42):
We internally surveyed a maintenance shed located near Jamul Creek on the Rancho Jamul Ecological Reserve during the day using flashlights in September 2003. We observed a small to medium sized group of big brown bats roosting between the aluminum walls and wooded beams up in one of the corners of this building. We followed this survey with an external survey on the same date at dusk using the Anabat and visual techniques and observed 23 big brown bats and a single Mexican free-tailed bat as they exited this structure. We captured reproductive female big brown bats in mist-nets at a cattle pond ('Kiln Pond') less than one km from this maintenance shed and had also made numerous visual and acoustic observations of this species during previous USGS multi-taxa research at RJER (Hathaway et al. 2002). This roost site may be used regularly as a day roost by a colony of breeding female big brown bats (maternity colony), which also use various foraging and drinking habitats on the reserve.

5) Coronado Cays, Private, (site 28):
We internally surveyed the front porch alcove of a town home located in the Coronado Cays area during the day in October 2002 after receiving notification that a bat colony had taken up residence there. We found a group of approximately 18 Mexican long-tongued bats (*Choeronycteris mexicana*) roosting in an exposed area of the porch alcove above the front door of the town home. At dusk, we used a mist-net to capture a subset of individuals of the colony as they exited the roost. We captured eight individuals: six males and two females.

The occurrence of this species in San Diego County is interesting. This species has been observed in San Diego County roosting in very similar situations both historically and recently, usually during the fall and winter, but only for short time periods of a few months or less (Krutzsch 1948, S. Tremor pers. comm., D. Stokes pers. obs.). This migratory, obligate-cave roosting species feeds primarily on the nectar and pollen of various columnar cacti and agaves but has also been observed feeding at exotic landscape nectar producing plants and even hummingbird feeders (D.Stokes pers. obs.). In San Diego County, this species has only been found roosting individually or in small groups in man-made structures. It has been found primarily in urban and suburban areas, usually roosting in cave-like settings such as under porches and house decks, in open garages, and in maintenance buildings. The areas that they are found in are also typically characterized by the presence of an abundance of exotic landscape nectar producing plants; areas such as Mt Helix in La Mesa, Mt Soledad in La Jolla, and Imperial Beach as examples. They appear to migrate to the area in search of food source plants, temporarily roost in cave-like man-made structures, and then leave the area, presumably after the food source plants have ceased to bloom. It is possible this species has always migrated to San Diego County prior to human development in search of the native Shaw's agave (*Agave shawi*). The planting of exotic nectar producing plants in the county for landscaping purposes has probably created more feeding habitat for nectar feeding species such as the Mexican long-tongued bat. Climate change may also contribute to an increasing occurrence of this species locally.

6) Los Penasquitos Canyon Preserve (Batboxes 1-4), City of San Diego, (sites 33, 34):
We internally surveyed two pairs of artificial bat roosts (brown and white bat boxes paired together) located in Los Penasquitos Canyon Preserve using flashlights in May 2002. We observed one California myotis roosting in the brown bat box located just south of the main hiking trail (bat boxes 3 and 4) and a small group of approximately 10 California myotis in the brown bat box located near the main stream course (bat boxes 1 and 2). We did not observe any bats in the white boxes. We used a mist-net to capture bats as they exited from bat box 1 and caught two non-reproductive bats, a male and a female.

7) Tijuana River Valley County Park (Bunkers), San Diego County, (site 45):
We internally surveyed a set of historic military observation bunkers located adjacent to the U.S./Mexico international border fence during the day using flashlights in August 2003. We did not observe bats, bat guano, staining, or culled insect parts in any of the bunkers. We suspect these bunkers have had little or no use by bats. Identical structures occur on the Pt Loma peninsula. We previously surveyed these structures for roosting bats but found no evidence of roosting bats (Stokes et al. 2003). These structures may not be suitable as bat roosts, or are not used because they are in low bat density areas.

Nocturnal Roost Surveys:

1) Dulzura Creek bridge, Caltrans, (site 41):
We internally surveyed the Hwy 94 bridge over Dulzura Creek located between Hollenbeck canyon Wildlife Area and Rancho Jamul Ecological Reserve at night using flashlights on multiple occasions in both 2002 and 2003. Our intention was to find night roosting bats. We observed six species night roosting under this bridge over the course of the study, including two species of local concern, the pallid bat and Townsend's big-eared bat. We also observed a third species considered uncommon in the lower elevations of San Diego County, the long-eared myotis. Additionally, we observed a few individual California and western small-footed myotis, and a moderate number of Yuma myotis.

2) Otay Valley Regional Park, Upper Canyon (Caves), San Diego County, (site 39):
We internally surveyed an artificial cave located in the canyon below the Otay Valley Regional Park at night using flashlights in June 2003. We observed a group of approximately 50 Yuma myotis night roosting in this cave. We captured two individuals in a hand-net. They were both pregnant females. We suspect this cave is one of several night roosts in the Otay Valley/Mountain area used by the colony of Yuma myotis that uses the Otay Lakes Dam as a day roost.

3) Otay Valley Regional Park, Structures, San Diego County, (site 40):

We internally surveyed the restrooms found in the Otay Valley Regional Park main picnic area at night using flashlights in July 2003. We observed one Yuma myotis night roosting in one of the restrooms. We captured it in a hand-net and determined it was a juvenile male.

4) Cottonwood Cave 3, City of San Diego, (site 32):
We internally surveyed a natural rock cave located along Cottonwood Creek in Marron Valley at night using flashlights on one visit in September 2002 and once again in August 2003. We observed a pallid bat night roosting in this cave on both survey visits. On the first survey visit, we could hear the bat masticating a prey item. When we approached the cave, the pallid bat flew out and circled around outside of the cave. We could see the silhouette of the pallid bat with a large arthropod in its mouth each time the bat circled around.

5) Cottonwood Caves 1 and 2, City of San Diego, (sites 30, 31):
We internally surveyed two small natural caves located along Cottonwood Creek in Marron Valley during the day in October 2002. We did not observe bats roosting in the caves; however, we found bat guano in both caves indicating they were both being used as night roosts. The first cave had large, chunky guano and culled insect parts (White-lined sphinx moth *Hyles lineata* wings, various types of cricket legs, katydid wing cases, beetle wing cases, etc) that appeared to be deposited by pallid bats and/or California leaf-nosed bats. The second cave had guano that appeared to be deposited by a myotis species (small, dark pellets) and Townsend's big-eared bats (medium-sized thin, twisted pellets with a light brown/golden shimmer).

Previously Documented or Suspected Bat Roosts

A number of locations within the San Diego County MSCP area have either historically or could potentially support day roosting bat colonies. The following sites were not surveyed during our research but warrant further investigation and attention:

1) Otay Mountain Mines – there are a number of mines around Otay. One of these mines, known as the 'Golden Artery' mine, was supporting a hibernating group of approximately 12 Townsend's big-eared bats during the winter of 2000/2001 (D. Stokes unpub. data). A group of 40-50 bats with large ears temporarily occupied another mine, simply called the 'Artery' mine, in July 2001 (United States Border Patrol agent pers. comm.). A survey visit was made to this same mine approximately two weeks later. No bats were found inside but a large amount of guano and culled moth wings (small, pale brown in color, probably the California Oak Moth *Phryganidia californica*) were present (D.Stokes unpub. data). Based on these observations, we speculate a colony of Townsend's big-eared bats was using this mine at the time. Krutzsch (1948) found a dead California leaf-nosed bat in this same mine. Additionally, he found a long-eared myotis in another nearby mine, the 'Sequoia' mine. Dr. Patricia Brown also found a dead California leaf-nosed bat in the 'Artery' mine in the 1970's (P. Brown pers. comm.).

2) El Capitan Open Space Preserve (OSP) mines – there are a few mines located near or within the El Capitan OSP. Townsend's big-eared bats and other bat species may use these mines as roost sites.

3) Black Mountain mines – there are two historic arsenic mines located on the north side of Black Mountain near Los Penasquitos Canyon Preserve. These mines were previously surveyed on multiple occasions and no evidence of roosting bats was ever found (D. Stokes unpub. data). These mines could also support roosting bats.

4) Cottonwood Creek 'Gorge' – there is a steep rock-walled gorge located along Cottonwood Creek north of Tecate Mountain. There is an extensive amount of exposed fractured granite that could support a variety of roosting bat species including cliff-dwelling types such as the western mastiff bat. On several occasions, we heard multiple western mastiff bats coming from the direction of this gorge during bat surveys along Cottonwood Creek.

5) Loveland Reservoir – there are numerous rocky outcrops and cliffs near Loveland Reservoir. A pocketed free-tailed bat roost was previously documented at one of these cliff locations (K. Miner pers. comm.). We heard multiple western mastiff bats early in the evening down river from Loveland Reservoir on surveys conducted along the Sweetwater River. We suspect a colony of this species roosts in a rocky cliff somewhere near Loveland Reservoir.

6) El Cajon Mountain/El Capitan Reservoir – there are extensive amounts of rocky outcrops and cliffs located around El Cajon Mountain and El Capitan Reservoir that could support roosting bats including western mastiff bats. We heard multiple individuals of this species coming from this area early in the evening during a survey conducted at El Monte County Park.

7) San Vicente Reservoir - there are numerous rocky outcrops and cliffs near San Vicente Reservoir that could support roosting bats. Previous bat research around San Vicente Reservoir resulted in observations of large numbers of western mastiff bats early in the evening, consistent with there being a roost site near the reservoir (P. Brown pers. comm., D. Stokes unpub. data). We suspect this roost site is located in the south facing outcrops/cliffs located along the northeast portion of the reservoir.

8) San Pasqual Valley - there are numerous rocky outcrops and cliffs located along the San Dieguito River in and around San Pasqual Valley and near Lake Hodges that could support roosting bats, including western mastiff bats.

9) Mission Trails Regional Park - there are numerous rocky outcrops and cliffs located along the San Diego River that could support roosting bats. Pocketed free-tailed bat roosts have been documented in several of the historically mined rock quarries found along the river (K. Miner, pers. comm., D. Stokes unpub. data). There are several small natural caves within the park that were visited during previous research but no evidence of roosting bats was found (D. Stokes

unpub. data). A small mine also occurs in this park but has been eroded closed such that it is no longer accessible to humans and may not be accessible to bats (D. Stokes pers. obs.).

10) Lake Hodges Dam – there is a large colony of Yuma myotis roosting inside the dam at Lake Hodges. This roost was previously identified in the 1940s by Krutzsch (1948). At that time, it was occupied by up to 1000 Yuma myotis, including breeding females and juveniles. Recent visits to the dam revealed the presence of up to several thousand Yuma myotis (estimated), including breeding females and juveniles (S. Tremor pers. comm.., D. Stokes, pers. obs.). The dam appears to be occupied by large numbers of bats primarily during the months of April through November.

This is not an exhaustive list of potential roost sites/areas. In general, habitats that might support the roosting needs of colonial bat species include rocky outcrops and cliffs, natural and artificial caves, tree hollows/snags, and man-made structures such as bridges, dams, flumes, mines, and buildings.

Demographics and Reproduction of captured bats

We captured 151 bats representing 12 species in mist-nets and/or hand-nets at both foraging (143 bats) and roosting sites (eight bats) during this study (Table 10). Of the 151 individual bats captured, 76% were adults and 24% were juveniles. Sixty-four percent were females and 36% were males. We determined 40% of the female bats and 7% of the male bats were in breeding condition.

There were nine bat species that showed indications of breeding (either males or females): the pallid bat, Mexican long-tongued bat, Townsend's big-eared bat, big brown bat, western red bat, California myotis, western small-footed myotis, Yuma myotis, and western pipistrelle. We caught juveniles of five bat species: the big brown bat, western red bat, western small-footed myotis, Yuma myotis, and western pipistrelle.

Seasonal Patterns of Bat Richness and Activity

Seasonal Bat Richness Patterns

We surveyed five foraging bat survey sites multiple times across seasons over the duration of the study. We found that bat species richness varied among survey nights at the five multi-visit foraging bat survey sites (Figures 15-19). In general, bat species richness at these five sites was lowest on surveys conducted during the winter (November-February). However, at these five sites, we detected an increase in species from the initial spring-summer-fall to winter time periods and from data collection year one (2002) to data collection year two (2003). Combined species accumulation curves for all five multi-visit sites are shown in Figure 20.

Based on all surveys, we found bat species richness was greatest during the months of March and October due to the presence of both active resident and migratory bat species in the study area during these months (Table 11). Seasonal patterns of detected bat species richness are apparent when looking at our data. First, there is a suite of bat species (Yuma myotis, pocketed free-tailed bat, Mexican free-tailed bat, western pipistrelle, western mastiff bat, western red bat, California myotis, and small-footed myotis) that appeared to be active and detectable on a year-round basis in the study area. Second, there is a suite of bat species (big brown bat, long-eared myotis, Townsend's big-eared bat, and pallid bat) that appeared to be active and detectable primarily during the spring-summer-fall time period of March through October. Finally, two bat species (hoary bat and big free-tailed bat) appeared to be active and detectable within the study area primarily during the fall, winter, and spring months of September through May. However, hoary bats and big free-tailed bats have been occasionally detected in other study areas within San Diego County (Cleveland National Forest, Pt Loma) during the mid-summer months of June through August (Stokes et al. 2003, Stokes and Fisher 2004, USGS unpub. data). Hoary bats are migratory, and are considered rare or absent from the lower elevations of southern California during the mid-summer (Krutzsch 1948, Cryan 2003). It is possible the climatic conditions offered by the higher elevations of the Cleveland National Forest and, apparently, the extreme coastal Pt Loma peninsula are suitable for hoary bats during the mid-summer months. The occurrence of big free-tailed bats in San Diego County is not yet well understood. We have made most local observations of this species during the fall, winter, and spring (USGS unpub. data). However, we have made a few summer observations, and there appears to be an increase in the number of observations of this species locally in general. This could be a result of increased bat survey efforts in recent times. Climate change may also contribute to an increasing local occurrence of bat species that have sub-tropical origins (Constantine 1998). These species include representatives of the Molossids (free-tailed bats) and Phyllostomatids (American leaf-nosed bats), and the western yellow bat (*Lasiurus xanthinus*).

Any observed trends may be influenced by the survey techniques used and the seasons in which the surveys were conducted. For example, we detected two bat species, the Mexican long-tongued bat and California leaf-nosed bat, only during focused roost surveys, which we did not conduct year-round. The Mexican long-tongued bat is migratory and occurs in San Diego County primarily from September to January (Krutzsch 1948, D. Stokes unpub. data) though there have been recent summer observations (S. Tremor pers. comm.). The California leaf-nosed bat is active year-round in various parts of its range (Brown 1998). We suspect both these species may be active year-round in the study area, if they are present year round.

Seasonal Bat Activity Patterns

We determined that bat activity (number of Anabat files recorded per survey night) varied among nights and locations. It also varied among seasons at the five sites surveyed multiple times across seasons (Table 12). In this section and Table 12, seasons refer to blocks of months: 1) Mid-summer: June through August and 2) Mid-winter: December through February. At these multi-visit sites, bat activity tended to be greater during the mid-summer compared to visits made during the mid-winter. The average activity of the five multi-visit sites during the 2002 mid-summer surveys (mean = 235.8 [±102.9]) was much greater than the average measured activity during both the mid-winter surveys (means = 18.2 [±13.2] and 21.8 [±19.4] respectively). The average activity during the 2003 mid-summer surveys (mean = 122.8 [±43.5]) was also greater than the average measured activity during both the mid-winter surveys. Finally, the average measured activity during the 2002 mid-summer surveys was greater than the average measured activity during the 2003 mid-summer surveys. We suspect activity in summer 2002 was greater than summer 2003 due to the extreme drought of 2002. This may have resulted in, 1) a concentration of bat activity at sites such as the five multi-visit sites, where open water was present during the summer while much of the surrounding areas were dry, and/or 2) a decline in local bat populations from 2002 to 2003. However, real and measured bat activity levels could naturally vary substantially among nights, seasons, and years.

Watershed Associations

During this study, bat species richness measures among watersheds was variable (Table 13). We found the highest richness, 14 of the 16 bat species, at sites along or nearest to drainages associated with the Tijuana River watershed. We found 13 species at sites associated with the Otay River watershed, 12 species at sites associated with Sweetwater River watersheds, and 11 species at sites associated with the San Diego and San Dieguito River watersheds. Finally, we found only seven species at sites associated with Los Penasquitos Creek. Thus, it appears that the watersheds in the southern portion of the study area are supporting the greatest number of bat species, including rare types such as the Townsend's big-eared bat, pallid bat, and California leaf-nosed bat. The three watersheds located in the southern portion of the study area, the Tijuana, Otay, and Sweetwater Rivers, all occur within the largest continuous piece of undisturbed land within the MSCP area. This portion of the MSCP area is characterized by having a diversity of topographic features and vegetative communities, which may be necessary to support a rich bat community. There are a variety of roosting habitats in the form of mines, caves, numerous areas of exposed rock, bridges, abandoned structures, and large trees. This area also includes foraging habitats, such as riparian reaches, open water sites, oak woodland, coastal sage scrub, chaparral and grassland all located together in a fairly large, continuous area. In contrast, the central and northern portions of the MSCP area are more developed, have a greater degree of habitat fragmentation, and riparian systems often lack adjacent intact upland habitats.

The number of watersheds that each bat species was found in gave us an indication of how widely distributed each bat species was in the study area. We found several bat species at sites associated with all six watersheds, including the big brown bat, western mastiff bat, western red bat, hoary bat, California myotis, Yuma myotis, and Mexican free-tailed bat. We found the western small-footed myotis, pocketed free-tailed bat, and western pipistrelle associated with five watersheds (all but Penasquitos Creek). We found the Townsend's big-eared bat and big free-tailed bat in three watersheds, the pallid bat and long-eared myotis in two watersheds, and the California leaf-nosed bat in a single watershed.

Detection Success of Survey Techniques

The detection success of the survey methods varied among species during this study (Table 14). Detection refers to whether we found a particular species at a given site on a given date using one or more of the techniques. We may have detected a bat species at a particular site and date in multiple ways. In this section and in Table 15, mist-net, audible, and Anabat techniques refer to foraging bat surveys only. While we also used these during roost surveys, we categorized all detections at roost sites under 'roost' for detection method. The use of the Anabat at foraging sites was the most successful technique used to document the presence of most bat species. However, it was also the most widely used survey technique. We made over 75% of detections of several species using the Anabat at foraging sites. These species include the big brown bat, western red bat, hoary bat, pocketed free-tailed bat, western pipistrelle, and Mexican free-tailed bat. These are all bat species that are known to primarily use an aerial hawking foraging strategy. Bats, when using an aerial hawking foraging strategy, tend to produce high intensity echolocation vocalizations to hunt for prey in open uncluttered environments. The Anabat bat detector microphone is triggered at a minimum threshold of sound intensity and thus is most effective at recording high intensity vocalizations. In contrast, bats tend to produce low intensity echolocation vocalizations or simply listen for prey-generated noises when hunting and gleaning prey in structurally cluttered environments (Corben and O'Farrell 1999, Jones and Rydell 2003). Low intensity sounds, such as vocalizations of gleaning bats, may not be loud enough to trigger the threshold necessary to be recorded with an Anabat bat detector unless at very close range. Therefore, the Anabat is probably less effective at detecting bats utilizing a gleaning foraging strategy compared to bats using an aerial hawking strategy. Indeed, species that appear to primarily use a gleaning foraging strategy such as the California leaf-nosed bat and Townsend's big-eared bat were detected with the Anabat at frequencies of 0% and 22% respectively.

We had success detecting a variety of bat species using mist-nets. However, the species that we caught using mist-nets were usually detected more often using the Anabat. The use of mist-nets did provide valuable demographic and reproductive information that could not be obtained using the Anabat. Currently, the impacts of mist-netting on bats are not fully understood. Bats may avoid using resources such as open water where they have been caught previously in mist-nets.

We had the greatest success detecting a particular suite of species during focused roost surveys. These species include the Townsend's big-eared bat (66.67% of detections), California leaf-nosed bat (100% of detections) and the Mexican long-tongued bat (100% of detections). These species are all obligate cave-roosting species that typically hang from the ceiling of their cave or cave-like roosts and are usually highly visible. These species are not easily detected using bat detectors or mist-nets because they do not appear to always echolocate, they usually produce low intensity vocalizations when they do echolocate, and they typically have keen echolocation combined with slow, maneuverable flight such that they can detect and avoid mist-nets before becoming entangled in them (Western Bat Working Group 2004). These species may also be locally rare (Miner and Stokes in press). The low detection success of survey techniques other than roost surveys to document these species may contribute to their apparent rarity in areas where extensive roost surveys have not been conducted.

Conclusions and Management Recommendations

General

The San Diego County MSCP area is currently supporting at least part of the needs of a rich bat population. However, the entire area does not appear to be equally supportive of all bat species. Based on our research, the southern inland portion of the county MSCP area appears to be currently supporting the greatest number of bat species. We hypothesize the juxtaposition of structurally and vegetatively diverse upland habitats (rock outcrops, caves, cliffs, scrublands, grasslands, oak woodlands) and riparian and wetland habitats in intact pieces of land is important to a rich bat community in southern California. This characterizes the southern portion of the MSCP. However, suburban preserves such as Mission Trails Regional Park and Los Penasquitos Canyon Preserve are currently supporting at least part of the needs of a fairly rich bat population (nine and seven species respectively) indicating the importance of these preserves to the local bat community. As development occurs outside of the multi-habitat planning areas of the city and county's MSCP Subarea plans, the importance of the MSCP preserve system will increase for the occurring bat species.

Several bat species were detected frequently and distributed over most of the study area. These species included the Yuma myotis, pocketed free-tailed bat, Mexican free-tailed bat, big brown bat, western mastiff bat, and western pipistrelle. Another group of bat species were not detected as frequently, yet were distributed over most of the study area. These species included the western small-footed myotis, California myotis, western red bat, and hoary bat. Finally, a group of bat species were detected infrequently and only in specific parts of the study area. These species included the long-eared myotis, Townsend's big-eared bat, coastal pallid bat, big free-tailed bat, California leaf-nosed bat, and Mexican long-tongued bat. For most of these latter species, their apparent absence from most of the study area can be explained by 1) the core areas of their range within the county are not found within the MSCP area (California leaf-nosed bat, Townsend's big-eared bat, long-eared myotis), 2) they are locally rare (big free-tailed bat), or 3) they are primarily migrants to the MSCP area (Mexican long-tongued bat). The exception to this is the coastal pallid bat. Historically, the coastal pallid bat was abundant in the coastal plains, inland valleys, and western foothills of San Diego County (Krutzsch 1948). They were observed in relatively large numbers in a variety of areas within or adjacent to the current MSCP area including the lower Tijuana and Otay Rivers (Chula Vista, National City, Nestor), San Diego River (Santee), Sweetwater River (Jamacha and Harbison Canyon), and San Dieguito River (San Pasqual Valley). However, we observed the coastal pallid bat in very small numbers and only along the upper Tijuana River and Otay River watersheds at only four sites: Hollenbeck Canyon, Dulzura Creek bridge, and Cottonwood Creek (spring site) and Cottonwood Creek Cave #3. These sites are separated by less than 15 kilometers. Based on our recent research compared to available historical information, we conclude that the coastal pallid bat's distribution has become restricted and its population size may have declined greatly within the study area.

Accounts of Five Local Species of Concern

(listed in taxonomic order)

California leaf-nosed bat (*Macrotus californicus*)

General Biology:
The California leaf-nosed bat is an obligate cave-roosting species. It typically roosts in natural caves but will readily use cave-analogs such as abandoned mines. It forages in desert washes on large-bodied arthropods, which it typically gleans from vegetation and occasionally from the ground. It does not crawl on the ground like the pallid bat, however. This species has excellent night vision and may rely on it heavily while foraging when ambient light is available (starlight, for example). This species appears to be incapable of entering torpor and instead seeks out warm roosting areas during the winter, a period in which it remains active (Brown 1998).

Significant Findings:
This species was observed during roost surveys at only a single location, the Cottonwood Creek tunnel system. It was observed there during the month of September in 2002 and 2003. In 2002, five or six individuals were observed day roosting within a specific section of the tunnel system. In 2003, only two individuals were observed day roosting in the same section. Though usually found in the desert, there were a few historical observations of this species in the inland valley/western foothills of San Diego County, including what is currently the MSCP area. There were observations of this species in a mine on Otay Mountain (Krutzsch 1948), and in the 1970's, a group of approximately 20 individuals were observed in the Cottonwood Creek tunnel system (P. Brown pers. comm.). This may be the rarest bat species found in the MSCP area. We know that it is inhabiting the Cottonwood Creek tunnel system and could also utilize the complex of mines around Otay Mountain. The extent of this species' foraging range and habitats within the MSCP area is not known.

Management Recommendations:

1) Protect the Cottonwood Creek tunnel system from visitation by humans. This water transport system (also known as the 'Barrett Flume') is owned and managed by the City of San Diego water authority. It is not public land, though it is regularly visited by the public, including 'nature enthusiasts', who often go in search of herpetofauna. This flume is also used regularly as a stopover/hiding place by undocumented immigrants. In addition, United States Border Patrol (USBP) agents regularly visit the flume in search of undocumented immigrants (D. Stokes pers. obs.). Protection of this flume could be accomplished using a variety of strategies in concert. We suggest blocking key access points with fences at key foot trails and securely locked gates across access roads, installing 'bat-friendly' gates at the particular sections where this bats reside in large numbers, putting up signage reminding the public of no trespassing regulations,

diligently enforcing such violations, and educating the USBP about the potential impacts to bat colonies from human disturbance.

2) Locate and protect summer, winter, day, and night roost sites. The only known roost site for this species is the Cottonwood Creek tunnel system. We suspect the mines on Otay Mountain may also be used as roosts by the species. A radio telemetry study might reveal other day and night roosts used by this species.
3) Identify foraging habitats, delineate foraging area used, and determine distances this species forages from roosts using radio telemetry.
4) Supplement radio telemetry with dietary analysis study. This would help determine the foraging needs of this species within the MSCP area.
5) Conduct population genetics study. This inland valley/foothill population may be disjunct from populations found in the local deserts and/or in Baja California. If so, this population could be vulnerable to extirpation given that no more than six individuals have been observed in the entire study area.

Western red bat (*Lasiurus blossevillii*)

General Biology:
The western red bat is a solitary obligate foliage-roosting species that roosts by hanging from the limbs of native broadleaf deciduous trees. This species is also known to roost in non-native trees and large shrubs such as those associated with orchards and landscaped gardens. While this species appears to be migratory in other parts of its range, in southern California it is a year-round resident. It typically feeds along woodland edges (Bolster 1998). In San Diego County, this species is usually observed foraging in riparian areas and more rarely in suburban environments where large trees are found (D. Stokes, pers. obs.). We suspect this and other lasiurine species may not be able to maneuver well enough to drink from small artificial troughs as drinking sources since none have been caught over such sources during our bat research in southern California (USGS unpub. data). Therefore, it is likely dependent on larger, unobstructed sources of open water for drinking such as reaches of rivers and creeks, and large artificial ponds. There is evidence to suggest that foliage-roosting bats and other bat species bury themselves in leaf-litter during exceptionally cold winter periods (Saugey et al. 1998).

Significant Findings:
During this study, the western red bat was detected all 12 months of the year. It was also found associated with all six surveyed watersheds. Anabat detections of this species were made at Boden Canyon Ecological Reserve, Cottonwood Creek, Dos Picos County Park, Hollenbeck Canyon Wildlife Area, Los Penasquitos Canyon Preserve, Mission Trails Regional Park, Otay Valley Regional Park, the San Diego National Wildlife Refuge, San Pasqual Valley, and the Sycuan Peak Ecological Reserve. Captures were made at Boden Canyon Ecological Reserve, Hollenbeck Canyon Wildlife Area, and the San Diego National Wildlife Refuge. A breeding female and a juvenile male and female were all caught simultaneously at the San Diego National Wildlife Refuge in August 2002 indicating that this species does breed within the MSCP area.

Management Recommendations:

1) Preserve, maintain, and rehabilitate healthy, diverse riparian systems where large riparian trees such as cottonwoods and sycamores occur.
2) Maintain medium to large-bodied open, unobstructed water sources for drinking.
3) Minimize prescribed burning of leaf-litter.
4) Minimize use of pesticides in riparian and suburban park settings.
5) Identify foraging habitats, delineate foraging area used, and determine distances species forages from roosts using radio telemetry.
6) Supplement radio telemetry with dietary analysis study. This would help determine the foraging needs of this species within the MSCP area.
7) Conduct population genetics study to determine the extent of genetic interchange between local populations and populations presumed to be migratory.
8) Provide education to agency-contacted tree trimmers and landscapers informing them of the potential to encounter this species (and others) during tree trimming/shrub pruning practices. When bat encounters occur during such practices, the bats should never be handled with bare hands but the bats should be put back up into the trees or shrubs from which they were removed.

Townsend's big-eared bat (*Corynorhinus townsendii*)

General Biology:

The Townsend's big-eared bat is an obligate cave-roosting species whose distribution is strongly associated with the presence of natural caves and/or artificial cave-like structures such as mines (Sherwin 1998). It is colonial and usually occurs in San Diego County in relatively small groups of up to approximately 50 individuals (D. Stokes pers. obs.). It is the bat species most commonly found in abandoned mines in San Diego County and appears to be located wherever there are historic mining districts, including within the MSCP area. The use of specific mines by this species is dynamic and may vary among seasons and years (Sherwin et al. 2000). Any locally occurring mine could be used by this species as a roost site. However, we suspect mines located near open surface water and appropriate foraging habitats (oak and riparian woodland) would more likely support maternity colonies, which would be present during the late spring and summer. The winter roosting requirements for this species are different from their summer requirements. They prefer caves and mines with stable cool, humid environments to meet their winter roosting requirements (Pierson and Rainey 1996). The Townsend's big-eared bat appears to be vulnerable to and intolerant of human disturbance at roost sites (Pierson and Rainey 1996, Sherwin 1998). The Townsend's big-eared bat is considered a moth specialist. It feeds by foraging close to vegetation and may glean some insects directly from the branches of shrubs and trees. It forages in a variety of habitats, but in California prefers oak woodland, ironwood forests, and riparian woodland while avoiding grazed grasslands (Fellers and Pierson 2002). It has been documented making one-way commute distances of 5 to 13 km on foraging ventures (Brown et al. 1994, Fellers and Pierson 2002).

Significant Findings:

During this study, we observed over 100 individuals day roosting in various sections within the Cottonwood Creek tunnel on more than one occasion. We also caught one

Townsend's big-eared bat in a mist-net at the Cottonwood Creek Spring in Marron Valley. We recorded an individual with the Anabat during an external roost survey of the boulder-covered hillside located on the San Diego National Wildlife Refuge. We also observed one individual of this species night roosting under the Dulzura Creek bridge. At least 12 Townsend's big-eared bats were observed hibernating in the Golden Artery Mine (Otay Mountain) during previous research in the winter of 2000/2001(D. Stokes unpub. data).

Management Recommendations:

1) See Management Recommendation # 2 under California leaf-nosed bat.
2) Protect the 'Golden Artery Mine' as a hibernation and possible maternity site and the 'Artery Mine' as a possible maternity site. These and most of the Otay Mountain mines are on Bureau of Land Management (BLM) land. Many of the same impacts that occur at the Cottonwood Creek tunnel system also occur at this and the various other mines around Otay Mountain. Protection of this mine could be accomplished in a similar manner as the Cottonwood Creek tunnel system.
3) Conduct focused roost (including mine) surveys to locate and protect other summer, winter, day, and night roost sites within the MSCP area. It is particularly important to focus on those mines (and other roosts) that are the most vulnerable to human visitation and disturbance. These would include the mines on Otay Mountain and McGinty Mountain, since these areas are easily accessible and regularly visited by the public.
4) Conduct population genetics study to determine the relatedness of the Otay Mountain/Cottonwood Creek tunnel system population(s) to populations found further up the Tijuana River watershed (e.g., Noble Canyon population on United States Forest Service land – Miner and Brown 1996, Stokes and Fisher 2004) and outside the local area.
5) Enhance preserve lands with artificial bat roosting habitats that provide conditions suitable for obligate cave-roosting species. The standard design artificial bat houses or 'bat boxes' do not provide suitable conditions for cave-roosting species.

Pallid bat (*Antrozous pallidus*), coastal form

General Biology:

The pallid bat is a multiple habitat-roosting species. It is found in a variety of crevice and/or cavity-type situations such as rock crevices, caves, tree hollows, mines, buildings, and bridges (Sherwin 1998). Colonies of this species are often found roosting in rural man-made structures such as barns and other infrequently used buildings (Krutzsch 1948). The pallid bat is unique among North American bat species in that it forages on terrestrial arthropods that it tackles by landing on the ground (Orr 1954). It occasionally consumes flying insects (Bell 1982) but, usually pins flying prey items against the ground or other surfaces during capture (Johnston and Fenton 2001). One of its preferred prey items in San Diego County is the Jerusalem cricket (*Stenopelmatus* spp.). The culled legs and other parts of Jerusalem crickets are often found beneath pallid bat night roosting areas in the county (D. Stokes pers. obs.). In western San Diego County, the pallid bat is usually found foraging in oak savannah-type habitats, grassy oak and sycamore-lined river terraces, native grasslands, and sparsely vegetated scrublands (Krutzsch 1948, D.

Stokes pers. obs.). Rambaldini and Brigham (2004) found that, in British Columbia (BC), pallid bats avoided foraging in areas grazed by cattle, in brightly lit areas, and in close proximity to human disturbances such as frequent loud noises. The pallid bat has often been observed drinking shortly after emergence from roosts (Orr 1954, Bell 1982, Ball 2002). Rambaldini and Brigham (2004) located 27 roosts during their radio tracking study in BC. Of the 27 roosts, the greatest distance from open water was 2.5 kilometers. Historically, the pallid bat was considered abundant on the coastal plains and in the inland valleys and western foothills. Twelve colonies previously existed in areas of the county that are now part of or adjacent to the MSCP area (Krutzsch 1948). In the 1970's, Dr. Patricia Brown attempted to relocate these colonies but only one colony, found in the old Ramona town hall, persisted at that time (P. Brown, pers. comm.). This structure has since experienced at least one major fire. It has not been recently surveyed for roosting pallid bats.

Significant Findings:
During our research, single individual pallid bats were captured in mist-nets at each of two foraging sites: Cottonwood Creek Spring and Hollenbeck Canyon Wildlife Area. One individual was observed night roosting in a shallow cave along Cottonwood Creek (Cottonwood Cave 3) and a maximum of six individuals under the Dulzura Creek bridge. These sites occur within 15 kilometers of one another. No day roosting colonies were located. Pallid bats were not detected in several areas where they were found historically. These areas include San Pasqual Valley, Santee, Jamacha, Harbison Canyon, and the lower Otay River Valley. It appears that the pallid bat has suffered a considerable range contraction in western San Diego County over the past 50-60 years.

Management Recommendations:

1) Locate day roosting colony sites using radio telemetry study on Dulzura/Jamul population(s) to characterize and protect roosts.
2) Identify foraging habitats, delineate foraging area used, determine average gradient (slope) of foraging habitats, and determine distances species forages from roosts using radio telemetry on Jamul/Dulzura population(s). This would also help to guide future conservation planning and reserve designs that seek to accommodate this apparently declining species.
3) Supplement radio telemetry with dietary analysis study. This would help determine the foraging needs of this species within the MSCP area.
4) Study the effects of exotic grasses, grazing, and prescribed fire on pallid bat foraging.
5) Study effects of land use changes (that result from human development and conversion of natural habitats) on pallid bat foraging. This may be particularly relevant in low gradient areas in the low to mid elevations – areas that we suspect are favored for pallid bat foraging. This may reveal possible reasons for the apparent local pallid bat range contraction/decline.

Western Mastiff Bat (*Eumops perotis*)

General Biology:
The western mastiff bat is the largest North American bat species (Barbour and Davis 1969). It is colonial and is usually found roosting in steep rocky cliffs but may also be found roosting in artificial rock quarries and sometimes in buildings. It has a large foraging range and typically forages over a variety of habitats including open scrublands and grasslands (Pierson and Rainey 1998). We suspect this species may be able to commute from inland roost sites out to forage over fragmented coastal preserves. It usually forages at heights such that it is very difficult to catch in standard mist-net sets. However, it produces a loud audible echolocation vocalization that can be heard by most people, therefore, it is readily detectable using the unaided ear.

Significant Findings:
During this study, western mastiff bats were detected at over half of the sites we surveyed and were found associated with all six major watersheds. No specific roost locations were verified for this species during this study. Though it was detected during two roost surveys, it is thought this species was not actually roosting at the surveyed sites but instead was coming from roosts located away from the surveyed roosts. Suspected or previously documented roost sites for this species within the MSCP area include San Pasqual Valley, near San Vicente Reservoir, El Cajon Mountain, near Loveland Reservoir, along Cottonwood Creek north of Tecate Mountain, and near Barrett Reservoir.

Management Recommendations:
1) Conduct focused field investigation to verify previously documented and suspected roost sites to establish baseline for purposes of long term monitoring and protection/management of identified roosts
2) Conduct radio telemetry study to determine foraging range and to what extent this species makes use of preserved habitats compared to use of urban habitats for foraging with the ultimate goal of attempting to determine if the locally adopted reserve designs will accommodate the foraging needs of such a far-ranging species.

The main threat to this species in the MSCP area would be destruction and disturbance of rocky cliff roost sites from activities such as water impoundment projects, highway/road construction projects, and recreational rock climbing. All of these activities should be prohibited or limited around roost sites. Roost sites still need to be verified. Focused surveys could be done on a case-by-case basis if potential projects arise in areas with suspected roost sites. Because this species appears to forage over large tracts of land that include a variety of habitat types, identification of important foraging habitat(s) is difficult. Preserving contiguous tracts of land and habitats, as is the goal of the MSCP system, will likely benefit western mastiff bats. However, this is one of the few species that may be able to take advantage of isolated coastal habitat fragments to forage because they are likely able to commute to these fragments from inland roost sites.

Effects of Urbanization on Bats

There are potentially numerous effects of urbanization on bats. Some of these effects may act independently of one another and some may act together synergistically or in a cumulative fashion. Some elements of urbanization may adversely affect bats while others may act in a beneficial manner. Determining the various effects of urbanization on bats appears to be a complex issue that warrants investigation beyond the scope of this inventory study. However, our experience with bats allows us to identify some locally relevant issues regarding urbanization and bats.

Aspects of urbanization that may affect bats include effects of pollution (noise, light, chemical, etc), availability and use of anthropogenic roosts, availability of artificial drinking sources (troughs, swimming pools, park ponds, reservoirs, etc) and associated altered water quality, availability of artificial food sources for nectar-feeding species (landscape exotic plants, hummingbird feeders), and effects of fragmentation and isolation of foraging habitats. The San Diego County MSCP area is an ideal setting to study the potential effects of urbanization on bats due to its pre-determined reserve boundaries. This allows for establishment of long-term monitoring stations to observe trends in bat populations in the combination of core reserve areas, recently fragmented areas, and areas that are currently undeveloped but will ultimately be surrounded completely or at least abutted by urban development as time progresses (see section 'Long-term Monitoring Strategies - Monitoring MSCP Reserve Functionality for Bats' below).

A few bat species appear to be locally adapted to urbanization or may persist in and around the urban environment due to their life histories. For instance, the Mexican long-tongued bat, an obligate cave-roosting, nectar feeding species, appears to be able to readily make use of urban environments where cave-like anthropogenic structures (porches, under decks of houses, unused accessible buildings, etc) are found in combination with exotic landscape nectar producing plants such as agaves and columnar cacti. Western red bats, hoary bats, and western yellow bats, all solitary obligate foliage roosting species, also appear to make use of urban environments where large trees are relatively abundant. Members of the free-tailed bat family (*Molossidae*) have long distance commuting ability, and possibly generalized foraging requirements that may allow them to commute from inland roosts out to urban coastal preserves and parks to forage. Finally, several bat species (Mexican free-tailed bat, Yuma myotis, and big brown bat) have both generalized roosting and foraging requirements that may allow them to persist in urbanized environments.

Functionality of MSCP Reserve

Though there are bats that may make use of or at least tolerate urbanization, we suspect a truly diverse bat community is dependent upon maintenance of a relatively undisturbed, connected landscape, which is the goal of the San Diego County MSCP reserve system. Evidence for the dependency of a diverse bat community on a connected, undisturbed landscape can be found in looking at the diverse bat community (which includes the rarer habitat specialists such as California leaf-nosed bats, Townsend's big-eared bats, and pallid bats) associated with the large core area of the MSCP reserve system (the land encompassing the Tijuana, Otay, and Sweetwater Rivers). In contrast, the bat community associated with relatively fragmented and/or isolated tracts of land, such as Los Penasquitos Canyon Preserve, the San Diego River in Mission Valley, Mission Trails Regional Park, and the 4S and Fairbanks Ranch preserves, is less diverse and lacks these rare habitat specialists.

In addition to preserving an undisturbed, connected landscape, we feel there are key management activities that are important to maintain a diverse bat community. A series of recommended management actions follows:

<u>Roosts within and adjacent to MSCP Lands</u>

Protection of roost sites of colonial bat species will be critically important to the maintenance of bat populations within the MSCP area. If the MSCP system is to serve as a functional preserve system for bats, roosts must be protected. The MSCP area consists of a mosaic of ownership of private land and preserves. While certain roosts and roost areas that occur on preserve land may be protected, there are potentially a significant number of unprotected roosts sites on private land. Bats using these roosts may spend much if not all of their foraging time foraging on MSCP preserved lands. Although these bats are part of the MSCP ecological community, they are vulnerable to extirpation at their roost sites. Protection of bat roosts on private property is a difficult task. Bats on private land are often unwanted guests, especially when they inhabit man-made structures. The myths and stigmas that are associated with bats often make them targets of vandalism, and those encountering bats on their property usually do not recognize their ecological benefits.

There are also roosts located on agency/preserve lands that may be vulnerable to disturbance, displacement, and/or destruction because they are found in man-made structures. Bats roosting in these structures are typically considered a nuisance and/or health threat to people who use or maintain occupied structures. There are several known structures occupied by bats within the MSCP area. For example, three large Yuma myotis colonies exist in man-made structures within the MSCP area: Lake Hodges Dam, Lower Otay Lakes Dam, and the Cottonwood Creek tunnel system. There is also a large colony of Townsend's big-eared bats and a small colony of the extremely rare (within MSCP area) California leaf-nosed bats occupying the Cottonwood Creek tunnel system. Undocumented immigrants, U.S. Border Patrol agents, hikers and 'nature enthusiasts' regularly visit this tunnel and pose a disturbance threat to roosting bats. A medium-sized big brown bat colony roosts in a maintenance shed on the CDFG Rancho Jamul Ecological Reserve. There are six species including the Townsend's big-eared bat, pallid bat, and long-eared myotis that use the Dulzura Creek bridge as a night roost. Finally, Townsend's big-eared bats roost in the mines around Otay Mountain. Undocumented immigrants and U.S. Border Patrol agents regularly visit these mines and pose a disturbance threat to the roosting bats.

These are some important examples of unprotected roosts on agency land that we are aware of. Roost surveys were not the focus of this research and further research efforts will likely reveal more examples of vulnerable roosts within and adjacent to the MSCP area. We recommend a management/mitigation strategy, similar to the one dealing with bats on private land, is adopted by the agencies that are partners in the MSCP program. However, one major difference would be that agencies allow bats to remain roosting in their structures unless it is necessary to exclude them. If it becomes necessary to exclude roosting bats from agency structures then appropriate alternate roosting habitat should be provided and exclusions should be done as recommended by bat biologists.

There are humane ways and appropriate time periods to exclude unwanted bats from man-made structures. It is illegal to kill bats in any way, including via pest-control practices, yet information regarding proper ways of dealing with 'nuisance bats' is not readily available, and enforcement of illegal pest-control practices appears to be even rarer (D. Stokes pers. obs.). Exclusions, when done properly and during the appropriate seasons (non-breeding and non-hibernating seasons i.e. September – mid-October, mid-February – mid-April), may spare the lives of the bats but result in the displacement of the colony. If an alternate roost, such as a bat box, is not provided the bats must find another roost site, which may be another man-made structure nearby. Here, they may ultimately end up facing the same fate of eviction. Placement of bat houses will not necessarily mitigate the loss of a particular roost as only a few bat species will readily use the standard design bat house and there is evidence to suggest that maternity colonies will not readily relocate into artificial bat houses (Racey and Antwistle 2003). While local agencies may not be able to control what happens to bats on private land adjacent to preserve land, they can coordinate efforts to ensure that the local public health department, the county veterinarian's office, vector control, law enforcement agencies, and any other public and/or private agency that might deal with 'nuisance bats' are educated as to how to properly and humanely deal with bats, particularly large colonies.

A suggested simplified plan of action to ensure protection of bats roosting on private land might be: 1) promote public educational programs that focus on bats, their ecosystem role, dispelling of myths and unfounded fears, and how to humanely deal with unwanted bats, 2) recommend all local privately owned pest-control companies to be educated on how to perform proper humane exclusions of bats and discourage practices resulting in direct mortality of bats (bat exclusion guidelines are available at Bat Conservation International's website www.batcon.org.), 3) recommend that companies place alternative bat roosts of proper design, color, and location depending on the bat species being excluded (batbox information is also provided at Bat Conservation's website), 4) enhance roosting habitat on agency/preserve lands so that displaced bats may find alternate roosts on protected land, and 5) ensure that local law enforcement agencies that deal with wildlife are aware of guidelines pertaining to protection of bats and are actively practicing enforcement, especially if bats are being killed as a direct result of pest-control practices.

We recommend the construction and placement of various types of artificial bat houses in a variety of areas on preserve land. We believe bat populations would benefit from the creation/construction of artificial roosts on preserve lands. Roosting habitat for bats is usually considered as a limited resource and bats often roost in man-made structures. As discussed, man-made structures are more often found on private land adjacent to preserve land rather than on preserve land itself. We believe this may result in bats being attracted to private land and away from preserve land for roosting needs. Therefore, we recommend increasing the amount of roosting habitats on preserve lands in the form of artificial structures. We feel it would be beneficial to construct a variety of roost structures that support the roosting needs of both crevice and cavity dependent species. Bat boxes typically serve the roosting needs of only a few crevice dwelling species. Concrete or rock cave-like structures could serve the roosting needs of cave-dwelling species. Any artificially constructed roost structures should be placed at locations away from areas of high human activity such that they are unlikely to be disturbed or vandalized.

Foraging Habitat

There are native habitats that appear to be regularly used by foraging bats in a southern California landscape. They include riparian systems, oak woodland, scrublands, and grasslands. A mosaic of these habitat types likely supports a greater number of species than one habitat type alone. There is evidence that bats may commute and forage along linear features such as woodland and shrubland edges and hedgerows and may be less inclined to venture out into or commute across open spaces (Fellers and Pierson 2002, Racey and Antwistle 2003). Therefore, we recommend maintaining habitat connectivity between potential roosting habitats and foraging habitats. This would be best accomplished by maintaining intact riparian stretches, woodlands, and shrublands along with other upland habitats containing roosting substrates such as rocky outcrops, cliffs, and caves. This type of landscape exists in the southern inland portion of the MSCP area as a result of key agency land acquisitions such as the San Diego National Wildlife Refuge, Rancho Jamul Ecological Reserve, Sycuan Peak Ecological Reserve, Hollenbeck Canyon Wildlife Area, McGinty Mountain, Otay Mountain Wilderness Area, and Marron Valley City Preserve.

A parcel of private land in this area that contains important habitats for bats in the form of extensive oak woodland, riparian systems, shrubland, grassland, and rocky outcrops and cliffs together in an intact setting is located in Sloan Canyon along the Sweetwater River. Acquisition and protection of this parcel of land would greatly benefit bats in the MSCP area and would contribute significantly to this core area of the MSCP preserve system.

Another property characterized by a variety of habitats in an intact setting that is adjacent to preserved MSCP land is Marine Corps Air Station Miramar. Bat populations already occur on this property and roost in several man-made structures on site (Miner and Stokes in press). Bats also make use of foraging habitats on site including open water, riparian systems, oak woodlands, scrubland, and grasslands. Though not documented, sensitive species such as the pallid bat and Townsend's big-eared bat may occur on this property since appropriate roosting and foraging habitats are present. Other local species of concern such as the western red bat and western mastiff bat were documented during the 1997-1998 bat study. We feel this property should continue to be managed consistent with practices that maintain the integrity of the landscape and habitat diversity.

Open Water

Natural and artificial open surface water as both a drinking source and foraging habitat (productive for insects) is critical for most bat species. Reproductive female bats appear to be particularly dependent on open water sources for drinking. During periods of drought, maintained artificial open water sources may become increasingly important to bats. Maintenance of open water sites on preserves may draw bats onto preserve land and away from private land, where artificial water sources are often present and maintained (golf courses, private ponds and lakes). Bats drink in flight from the surface of water and, therefore, require some amount of open space around water sources so they can maneuver to drink. Ponds and pooled areas that have become overgrown with vegetation may not be suitable for drinking bats. An example of this is the URDS dam pool on the Sweetwater River in the San Diego National Wildlife Refuge. This pool has been regularly utilized as a drinking source for bats, including the sensitive western red bat, but more recently has become overgrown with emergent vegetation (D. Stokes pers. obs.). We suspect this pool no longer serves as a drinking source for bats in an overgrown condition. Vegetation that blocks the access of flying bats to ponds and pooled areas may need be reduced or cleared to provide an open flyway so that bats can drink unobstructed.

Another factor influencing the ability of bats to drink at an open water source is the size of the body of water. Only the smallest and most maneuverable bat species appear to be able to drink from small water sources, such as artificial cattle troughs. Larger and less maneuverable bat species may require large, unobstructed water sources such as reservoirs, large ponds and lakes, and long, unobstructed river reaches for drinking.

Coordinated Multi-agency Management

Because of the large home ranges of many bat species combined with the mosaic-of-ownership/management nature of the MSCP reserve system, effective management of bat populations will require a coordinated multi-agency effort. For example, Townsend's big-eared bats probably belonging to the same population unit use various habitat features around the Tijuana, Otay, and Sweetwater River watersheds found within the MSCP area. These features include the Cottonwood Creek tunnel system owned/managed by the City of San Diego, the mines around Otay Mountain owned/managed by the BLM, the Dulzura Creek bridge owned/managed by Caltrans, the boulder field in the San Diego National Wildlife Refuge owned/managed by the U.S. Fish and Wildlife Service, and Cottonwood Creek in Marron Valley owned/managed by the City of San Diego. If this bat population is to be managed effectively, all or most of these agencies will have to manage their parts of the population's 'ecological neighborhood' (Ball 2002) in a coordinated fashion or the population may decline or cease to persist even though large-scale habitat connectivity is being maintained in the area. Ball (2002) defines an ecological neighborhood as "the space used by a single organism or a group of organisms during a time period of interest."

Additionally, changes that affect this population and others within the MSCP area may have an effect at a larger landscape level outside the MSCP area. For migratory species that potentially commute long distances, such as the hoary bat and Mexican long-tongued bat, these effects may even be realized at a much larger regional scale that crosses state and even international borders. Local interconnected tracts of preserved natural habitats, which include the current MSCP area, USFS and BLM land, and proposed North and East County Habitat Conservation Plans, will undoubtedly help maintain diverse bat populations within the region. However, coordinated management of specific habitat features within these tracts may also be required.

Efficacy and Limitations of Survey Techniques

Foraging vs. Roosting Bat Surveys

Bats that roost in different habitats or in different locations can often be found foraging at the same locations. This results in a higher likelihood of detecting multiple bats at foraging sites rather than roosting sites during any single survey visit. However, a few bat species are more readily detected at roosting sites because they are able to avoid mist-nets and/or are more difficult to detect acoustically.

Roost sites are extremely important to bats, locating roosts is very important for bat management. However, roost surveys can be extremely time consuming and labor intensive. The result is that roost surveys are much less efficient at inventorying bat species and often are cost-prohibitive. For a bat inventory study such as this, it was more efficient to focus our survey efforts primarily on foraging bats and supplement foraging bat surveys with roosting bat surveys.

Use of Multiple Techniques

No single survey method is effective at detecting all bat species (Pierson 1993). The use of the following multiple survey techniques in concert has proven to be most effective at detecting a variety of bat species.

Anabat - During foraging bat surveys there were several techniques used. Use of an Anabat bat detector in combination with a laptop computer allowed us to actively monitor and record bat vocalizations that we could also review at a later time in the laboratory. It is a very powerful survey tool for detecting bats but has some major limitations. First, several species produce vocalizations that can appear identical or very similar such that they are indistinguishable to the researcher (see Appendix III). Several of the myotis species fit into this category. Hoary bats often produce vocalizations that appear similar to other bat species including pocketed free-tailed bats and Mexican free-tailed bats. Pallid bats sometimes produce vocalizations that appear similar to those of big brown bats and long-eared myotis. Big brown bats and Mexican free-tailed bats often produce similar vocalizations. These examples are not exhaustive. There is enough overlap between vocalizations of various bat species that even an experienced bat/Anabat biologist can sometimes have difficulty making distinctions. Second, some bats produce low intensity calls that do not always trigger the threshold of the Anabat microphone and, therefore, do not get recorded. These species may often be missed at survey sites where the Anabat is used and thus may be underrepresented. Some species that fit into this category include the California leaf-nosed bat, Townsend's big-eared bat, fringed myotis, and long-eared myotis. Third, while it is possible to make species identifications from recorded bat vocalizations, it is not possible at this time to determine any other information about the recorded bat such as its age, sex and reproductive status. Finally, estimates of bat abundance cannot be made using the Anabat. It can be used to quantify bat activity, however, it cannot be determined how many bats produced the recorded bat vocalizations using the detector alone. Coupling use of the detector with visual enhancement devices, such as night vision or thermal imaging devices, may help to provide estimates of bat abundance during Anabat surveys.

Mist-netting - Due to the limitations of the Anabat, it has been recommended that Anabat surveys should be conducted simultaneous with mist-netting (Pierson 1993, O'Farrell and Gannon 1999). Capturing bats in mist-nets provides definitive proof of species occurrences, as well as information about the bat's age, sex, reproductive status, and overall health condition. Captured bats can be photo-documented for reports and publications. Bat vocalizations can be recorded with the Anabat as they are released from the hand. This results in obtaining a vocalization from a known bat species that can be used as a reference for making identifications in the future. Mist-netting for bats also has limitations. First, mist-nets sample such a small percentage of the air space available to flying bats that the likelihood of catching bats can be low. Second, bats have the ability to detect mist-nets using echolocation so they are often able to avoid being caught. Third, it is suspected that bats learn to avoid mist-nets once they have been caught, which may result in low recapture rates. This makes it virtually impossible to make estimates of bat abundance using mist-nets at foraging sites. Fourth, frequent mist-netting of bats at particular sites, drinking sources for instance, may result in bat avoidance of those resources. There could be negative consequences for bats if they are avoiding important resources as a result of distress experienced during mist-net capture.

Audible Surveys - A third technique used to survey for foraging bats is the use of the unaided ear to listen for audible bat vocalizations. The western mastiff bat produces an easily recognizable audible echolocation vocalization that is of such a high intensity that it is loud enough for all to hear but those with hearing difficulties. However, the Anabat often does not record this species unless one is flying in close proximity to the detector. Thus, the use of the unaided ear appears to be the most effective method for detecting this species. The big free-tailed bat, which appears to be much rarer than the western mastiff bat in California, produces a vocalization that is similar but higher pitched and fainter sounding. The pocketed free-tailed bat also produces an echolocation vocalization audible to people with very good high frequency hearing. There is another bat species, the pallid bat, which sometimes produces an audible social vocalization while foraging. This vocalization is also fairly distinct but only to the trained observer.

Long-term Monitoring Strategies

Monitoring MSCP Reserve Functionality for Bats

The MSCP reserve area has pre-determined boundaries for preserve areas. This allows for a long-term strategy with the goal of monitoring changes in bat populations within the MSCP reserve by selecting monitoring sites within 1) core reserve areas, 2) currently fragmented areas, and 3) areas that will become fragmented or abutted by development over time. We recommend selecting long-term bat monitoring sites (Anabat stations, mist-netting sites, and roosts) within these three categories of areas. This strategy may provide insight into the effects of human land-use change (including urbanization) on bats. This strategy may also help determine if the MSCP reserve system will support a rich bat population over time.

Development of a long-term bat monitoring strategy for the MSCP area is beyond the scope of this technical report. However, based on knowledge of available survey techniques and data collected during this study we can make general recommendations for a simplified long-term bat monitoring strategy for the San Diego County MSCP area.

1. Require Experienced Oversight

Due to the amount of experience required to utilize bat survey techniques effectively, our first recommendation is bat monitoring efforts should be closely advised/supervised by a biologist experienced with bat survey techniques.

2. Use Acoustic Survey Techniques

The use of an ultrasonic bat detector to record bat vocalizations at foraging sites was the single most effective survey tool during our research. The use of an ultrasonic bat detector does not require any permits and is a passive monitoring tool such that there are minimal disturbances or impacts to the bats being surveyed. Although it is the simplest and most effective survey tool for bats, it is limited to only determining species richness and bat activity levels. At this time, use of most ultrasonic bat detectors is also dependent on having bat call identification experience or at least access to a comprehensive bat call reference library to make identifications of recorded bat vocalizations. Also, bat call identification is a time consuming process. Ultimately, a standardized, automated method of call identification is needed. This will greatly reduce call identification time and will be more powerful for larger-scale analyses since ultrasonic bat detector data could be collected over a large region and calls could be identified using standardized parameters.

> 2a. Select sites with high probability of bat activity –
> During foraging bat surveys, our goal was usually to detect as many bat species as possible per survey effort. We had success detecting a rich bat population with the ultrasonic bat detector set primarily along riparian reaches and

woodland/scrub (or grass) edges, usually with open surface water nearby and, ideally, a scrub-covered slope on the opposite side of the forest edge, creating a natural funnel for foraging bats. If multiple ultrasonic bat detectors are available (recommended), they could be placed in a variety of situations. If the research goal is something other than maximizing detection of multiple species, such as monitoring of a particular habitat type, then ultrasonic bat detector sites should be selected accordingly.

2b. Survey during period(s) of highest activity –
We recommend surveying during at least three sample periods per year; once in the spring, summer, and fall. Following of this timing will allow for detections of both resident and migratory bat species. Bat activity was generally the highest during the summer (June – August). If the research goal is dependent on having the highest amount of bat activity possible regardless of number of species detectable (bat richness is also high during the summer but migrants may be absent), survey efforts should focus on this period.

3. Use Mist-netting

We recommend the use of mist-nets in conjunction with the Anabat at foraging sites so that valuable information regarding bat demographics and reproduction can continue to be collected. This information is important to understanding the overall health of the bat population and cannot be obtained in any other way. However, 1. use of mist-nets requires training and having a special permit, 2. mist-nets, when used improperly, can be hazardous to wildlife, and 3. pre-immunization shots for rabies virus are strongly recommended for handling bats. These shots are usually expensive.

3a. Select a variety of mist-net sites –
In order to be able to catch a variety of species we feel it is essential to mist-net over different sized bodies of water and to mist-net in upland vegetation flyways.

3b. Mist-net efficiently on a limited basis –
As result of possible negative impacts to bats from mist-netting, we recommend mist-netting at long-term monitoring sites on a limited basis (i.e. used as a supplement to acoustic surveys but utilized less regularly than acoustic techniques). Focusing mist-netting efforts during July and August will provide the best opportunities to observe breeding in the local bat populations, as this is the time when females are in breeding condition and juveniles become volant. Bat activity is also generally high during these months maximizing the potential to catch bats.

4. Conduct Roost Surveys

Roost surveys should be used to document and confirm roosts in appropriate structures and general roosting areas. For purposes of long-term bat monitoring, the documentation and characterizations of roosts including making standardized counts of bats at roosts should be used to supplement foraging bat surveys. The establishment of baseline data of bat species richness and activity levels at foraging sites combined with documentation of roosts and estimates of population sizes at roosts allows for thorough monitoring of trends in local bat populations. However, disturbance associated with roost surveys may result in negative impacts to bats such as roost abandonment. Roost surveys should be conducted selectively, with minimal disturbance to the roosting bats, and in compliance with local, state, and federal permits. Certain types of roost surveys, such as internal surveys of abandoned mines, require special underground/confined space training, permits, and often use of expensive equipment used to monitor toxic gases in underground situations.

4a. Select appropriate sites –
Previously documented (or a sub-set of) roosts could be used for long-term monitoring (Table 15). There could also be focused efforts to locate more roosts for long –term monitoring purposes, as this was not the focus of our research. We suggest monitoring roosts in both core areas of the reserve, as well as in fragmented areas and areas that will ultimately become fragmented or abutted by development. This will allow for monitoring of trends in bat populations over time as the areas surrounding the MSCP reserve develop, and may provide insight into the effects of urbanization on bats (see section 'Monitoring MSCP Reserve Functionality for Bats).

4b. Conduct surveys during period(s) that roosts are most likely to be occupied –
Generally, bats will be most active at roosts during the summer (June – August). However, there may be instances when roosts are more likely to be occupied outside this time frame, for instance, when occupied by migratory species, during fall swarming events, and during hibernation. We recommend focusing roost surveys during the summer to maximize likelihood of finding bats but hibernation sites are very valuable to bats, thus some effort to locate hibernacula is recommended.

2003 Cedar and Otay Fires

The full effects of the recent fires on bats found within the MSCP area are not known. Very little is known about the effects of fire on bats in southern California. The Cedar fire burned two of our study sites: the two foraging bat sites within Mission Trails Regional Park. The Otay fire also burned two of our study sites: the foraging sites in Cedar Canyon and along Jamul Creek in the Rancho Jamul Ecological Reserve. Much of the vegetation on Otay Mountain was burned in the Otay fire. There are undoubtedly consequences for foraging bats resulting from this extensive loss of vegetation. However, post-fire succession of plant communities may result in increased insect abundance and, therefore, may benefit bats. Also, the Otay fire burned in most of the canyons where the abandoned mines on and around Otay Mountain are found. The fire occurred at a time (late October) when bats could be present in large numbers. It is not known if or how the fire affected any bats that may have been roosting in these mines.

Summary of Conservation Issues and Suggested Management Recommendations

1. Protection of Roosts – arguably the highest immediate priority for local bat conservation and management.
    a. Anthropogenic Roosts – several structures were identified during this study and past bat research in the area that warrant protection. The structures and suggested protection measures are listed in Table 16. The most significant anthropogenic roost in need of protection in the MSCP area is the Cottonwood Creek tunnel system. Many bat species use mines as roosts including sensitive species such as the Townsend's big-eared bat and California leaf-nosed bat. As human populations increase, the chance of disturbances at roosts such as mines increases. There is an opportunity to be proactive about locating and protecting important mine roosts. Mine roost protection can be accomplished by gating identified mine roosts with 'bat-friendly' gates that allow bats to pass through but not people. As an option, educational signs could be posted at gated mines to let people know why the mine has been gated.Some general types of anthropogenic roost structures include:
        i. Mines
        ii. Buildings
        iii. Bridges
        iv. Flumes
        v. Dams

    b. Natural Roosts – though no significant natural roosts were located, several potential roosting areas were identified. When projects arise that may affect roosting bats, we recommend conducting focused roosts surveys in potentially affected areas on a case-by-case basis.

2. Maintenance of foraging habitat – there are habitats that are regularly used by foraging bats: Maintaining habitat and structural diversity is ideal
    a. Riparian forest and scrub
    b. Oak woodland
    c. Scrublands
    d. Grasslands

3. Maintenance of open water drinking sites– critically important to most bat species.
    a. Small and large bodies of water recommended
    b. Unobstructed flight paths for bats
    c. Water quality

4. Roost enhancement on preserves – helps to offset loss of natural roosting habitat and provides alternative roosting sites for bats being evicted from anthropogenic roosts in and adjacent to reserve land.
    a. Standard bat houses
    b. Creativity in design of artificial structures that will accommodate a variety of bat roosting requirements (crevices and caves).

5. Research and Monitoring – bats are generally poorly understood and are usually left out of habitat conservation and management plans due to a lack of information. More local bat research is needed.
    a. Conduct focused studies for the documentation and characterization of bat roosts, particularly mine roosts.

    b. Conduct radio telemetry study on sensitive colonial species (Pallid bat, Townsend's big-eared bat, California leaf-nosed bat, western mastiff bat) and other 'indicator' species to determine roosts, important foraging habitats, and home range estimates. Recommend using Ball's (2002) strategy to describe radio-tracked bats' 'ecological neighborhood' based on empirical data obtained via telemetry.

    c. Begin long-term monitoring for bats within MSCP area to investigate the effects of human land-use change on (and functionality of the MSCP reserve design for) bats. Establish long-term monitoring sites in core reserve areas, currently fragmented areas, and in areas that will become fragmented or abutted by development over time.

    d. Conduct smaller, focused studies to investigate specific effects on bats associated with urbanization: topics include artificial structures, artificial water sources, exotic nectar producing plants, artificial lights, domestic and other suburban predators, pollution, urban insect community, and vector-control practices.

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Western Bat Working Group website: www.wbwg.org

Table 1. Foraging Bat Survey Sites. Includes site numbers for map reference, site names, associated watershed, survey dates, survey techniques used, and site coordinates.

Site Number	Site Name	Land Owner/Manager	Survey Dates	Foraging Bat Survey Methods	Lat (WGS84)	Long (WGS84)
1	4S Ranch (Pond)	County of San Diego	7/23/2002	Anabat only	33.00042	117.10353
2	Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	California Department of Fish and Game	5/7/2002 11/20/2002 5/15/2003 7/29/2003 9/16/2003	Anabat, Mist-nets	33.09017	116.89565
3	Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)	California Department of Fish and Game	6/3/2002 9/2/2003	Anabat, Mist-nets	33.13998	116.89432
4	Cottonwood Creek, Marron Valley (Crossing)	City of San Diego	5/13/2003	Anabat, Mist-nets	32.57605	116.75023
5	Cottonwood Creek, Marron Valley (Spring)	City of San Diego	7/2/2002 8/12/2002 9/12/2002 10/29/2002 1/14/2003 3/11/2003 6/10/2003 8/7/2003 9/18/2003 12/4/2003	Anabat, Mist-nets	32.56932	116.76347
6	Crestridge Ecological Reserve	California Department of Fish and Game	6/10/2002	Anabat, Mist-nets	32.82860	116.85748
7	Dos Picos County Park	County of San Diego	9/11/2003	Anabat, Mist-nets	32.99705	116.93770
8	El Monte County Park	County of San Diego	5/21/2003	Anabat, Mist-nets	32.89187	116.84748
9	Fairbanks Ranch	County of San Diego	6/11/2003 8/6/2003 9/25/2003	Anabat, Mist-nets	32.99932	117.20545
10	Flinn Springs County Park	County of San Diego	9/3/2003	Anabat, Mist-nets	32.84777	116.86133
11	Hollenbeck Canyon Wildilfe Area	California Department of Fish and Game	5/9/2002 6/25/2002 8/5/2002 10/23/2002 1/7/2003 3/13/2003 5/20/2003 7/30/2003 10/1/2003 12/16/2003	Anabat, Mist-nets	32.67870	116.82263
12	Los Penasquitos Canyon Preserve (Lower Creek)	City/County of San Diego	5/13/2002 8/6/2002 10/2/2002 11/7/2002 2/5/2003 4/2/2003 5/5/2003 7/28/2003 9/17/2003	Anabat, Mist-nets	32.92737	117.17638
13	Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	City/County of San Diego	7/16/2003	Anabat, Mist-nets	32.93735	117.14850
14	Mission Trails Regional Park, Shephards Pond	City of San Diego	7/14/2003	Anabat, Mist-nets	32.84895	117.07337
15	Mission Trails Regional Park, San Diego River (Padre Dam)	City of San Diego	6/24/2002	Anabat, Mist-nets	32.83970	117.04340

Table 1. (continued) Foraging Bat Survey Sites.

Site Number	Site Name	Land Owner/Manager	Survey Dates	Foraging Bat Survey Methods	Lat (WGS84)	Long (WGS84)
16	Mission Trails Regional Park, San Diego River	City of San Diego	5/8/2002 7/30/2002 8/26/2002 10/24/2002 1/9/2003 6/16/2003 8/5/2003 10/22/2003 12/3/2003	Anabat, Mist-nets	32.82125	117.06225
17	Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))	Private, managed by City of San Diego	5/16/2002	Anabat only	32.77310	117.14063
18	Otay Mountain, Cedar Canyon	Bureau of Land Management	7/13/2002	Anabat, Mist-nets	32.64452	116.84843
19	Otay Valley Regional Park, Upper Canyon	Joint Executive Powers Agreement	7/15/2003	Anabat only	32.60138	116.92987
20	Rancho Jamul Ecological Reserve (Jamul Creek)	California Department of Fish and Game	5/6/2002	Anabat, Mist-nets	32.66503	116.86777
21	San Diego National Wildlife Refuge, Sweetwater River (Upper)	United States Fish and Wildlife Service	12/11/2002	Anabat, Mist-nets	32.76758	116.87993
22	San Diego National Wildlife Refuge, Sweetwater River (URDS)	United States Fish and Wildlife Service	6/4/2002 8/8/2002 10/10/2002 11/14/2002 12/11/2002 1/29/2003 3/26/2003 5/29/2003 8/4/2003 10/14/2003 12/18/2003	Anabat, Mist-nets	32.71988	116.95050
23	San Pasqual Valley	County of San Diego	7/23/2003	Anabat, Mist-nets	33.09285	116.95682
24	Sweetwater County Park, Morrison Pond	County of San Diego	6/26/2003 8/18/2003 10/16/2003	Anabat, Mist-nets	32.67200	117.02375
25	Sycamore Canyon / Gooden Ranch Open Space Preserves	County of San Diego	5/14/2002	Anabat, Mist-nets	32.92273	116.98728
26	Sycuan Peak Ecological Reserve, Lawson Creek	California Department of Fish and Game	6/11/2002	Anabat, Mist-nets	32.77077	116.79840
27	Sycuan Peak Ecological Reserve, Sweetwater River	California Department of Fish and Game	5/23/2002	Anabat, Mist-nets	32.76993	116.81667

Table 2. Roost Survey Sites. Includes site numbers for map reference, site names, nearest watershed, type of roost survey, and coordinates of roost survey location (note: bat roost locations sensitive, full coordinates not provided here).

Site Number	Site Name	Land Owner/Manager	Survey Dates	Roost Survey Type	Lat (WGS84)	Long (WGS84)
28	Coronado Cays	Private	10/8/2002	Diurnal, External	32.6xxx	117.1xxx
29	Cottonwood Creek Tunnel	City of San Diego	7/25/2002	Diurnal	32.6xxx	116.7xxx
			9/19/2002	Diurnal		
			8/26/2003	Diurnal		
			9/4/2003	Diurnal		
30	Cottonwood Cave 1	City of San Diego	10/17/2002	Diurnal	32.5xxx	116.7xxx
31	Cottonwood Cave 2	City of San Diego	10/17/2002	Diurnal	32.5xxx	116.7xxx
32	Cottonwood Cave 3	City of San Diego	9/12/2002	Nocturnal	32.5xxx	116.7xxx
			8/7/2003	Nocturnal		
33	Los Penasquitos Canyon Preserve (Batboxes 1 & 2)	City/County of San Diego	5/13/2002	Diurnal, External	32.9xxx	117.1xxx
34	Los Penasquitos Canyon Preserve (Batboxes 3 & 4)	City/County of San Diego	5/13/2002	Diurnal, External	32.9xxx	117.1xxx
35	Jamul Creek Cliffs	California Department of Fish and Game	7/2/2003	External	32.6xxx	116.8xxx
36	Jamul Mountains	Bureau of Land Management	6/18/2002	External	32.6xxx	116.7xxx
37	Otay Mountain Bunkers	Bureau of Land Management	8/25/2003	Diurnal	32.5xxx	116.8xxx
38	Otay Mountain, O'Neal Canyon	The Environmental Trust/Bureau of Land Management	7/16/2002	Diurnal	32.5xxx	116.9xxx
39	Otay Valley Regional Park, Upper Canyon (Caves)	Joint Executive Powers Agreement	6/12/2003	Nocturnal	32.6xxx	116.9xxx
40	Otay Valley Regional Park, Structures	Joint Executive Powers Agreement	7/15/2003	Nocturnal	32.6xxx	116.9xxx
41	Dulzura Creek Bridge	Caltrans	5/10/2002	Nocturnal	32.6xxx	116.8xxx
			7/31/2002	Nocturnal		
			10/29/2002	Nocturnal		
			12/11/2002	Nocturnal		
			1/7/2003	Nocturnal		
			3/13/2003	Nocturnal		
			7/2/2003	Nocturnal		
42	Rancho Jamul Ecological Preserve (Maintenance Shed)	California Department of Fish and Game	9/10/2003	Diurnal, External	32.6xxx	116.8xxx
43	San Diego National Wildlife Refuge, Sweetwater River (Boulders)	United States Fish and Wildlife Service	10/3/2002	External	32.7xxx	116.9xxx
44	Singing Hills Memorial Estates (Boulders)	The Environmental Trust	8/21/2002	External	32.7xxx	116.8xxx
45	Tijuana River Valley County Park (Bunkers)	County of San Diego	8/25/2003	Diurnal	32.5xxx	117.1xxx

Table 3. Bat Species of San Diego County. Listed in taxonomic order, includes family name, scientific name, common name, 4-letter species code, legal status, and bat species detected during this study. Species not detected indicated by an 'x'.

Bat Species (23 known from San Diego County)				Legal Status*	Detected during 2002-2003 USGS Study
Family	**Scientific name**	**Common name**	**4-letter Species Code**	**CSC, FSS, BLM**	
Phyllostomatidae	*Macrotus californicus*	California leaf-nosed bat	MACA	CSC, FSS	MACA
	Choeronycteris mexicana	Mexican long-tongued bat	CHME	CSC	CHME
	Leptonycteris curasoae	Lesser long-nosed bat	LECU	FE	x
Vespertilionidae	*Myotis yumanensis*	Yuma myotis	MYYU	BLM	MYYU
	Myotis lucifugus	Little brown bat	MYLU	none	x
	Myotis evotis	Long-eared myotis	MYEV	BLM	MYEV
	Myotis thysanodes	Fringed myotis	MYTH	BLM	x
	Myotis volans	Long-legged myotis	MYVO	none	x
	Myotis californicus	California myotis	MYCA	none	MYCA
	Myotis ciliolabrum	Small-footed myotis	MYCI	BLM	MYCI
	Lasionycteris noctivagans	Silver-haired bat	LANO	none	x
	Pipistrellus hesperus	Western pipistrelle	PIHE	none	PIHE
	Eptesicus fuscus	Big brown bat	EPFU	none	EPFU
	Lasiurus blossevillii	Red bat	LABL	FSS	LABL
	Lasiurus xanthinus	Yellow bat	LAXA	none	x
	Lasiurus cinereus	Hoary bat	LACI	none	LACI
	Euderma maculatum	Spotted bat	EUMA	CSC, BLM	x
	Corynorhinus townsendii	Townsend's big-eared bat	COTO	CSC, FSS, BLM	COTO
	Antrozous pallidus	Pallid bat	ANPA	CSC, FSS, BLM	ANPA
Molossidae	*Tadarida brasiliensis*	Mexican free-tailed bat	TABR	none	TABR
	Nyctinomops femorosaccus	Pocketed free-tailed bat	NYFE	CSC	NYFE
	Nyctinomops macrotis	Big free-tailed bat	NYMA	CSC	NYMA
	Eumops perotis	Western mastiff bat	EUPE	CSC, BLM	EUPE

* Legal status categories include California Species of Special Concern (CSC), Federally Endangered (FE), Forest Service Sensitive (FSS), and Bureau of Land Management Sensitive (BLM). Source: Calif. Dept. of Fish and Game, Special Animals List, August 2004.

Table 4. All Bat Detections. Includes site names, associated watershed, survey type, and species detected at each site including foraging bats at roost sites. Survey effort varied among sites (see Tables 1 and 2). Species abbreviations are explained in Table 3.

			Species																
Site Name	**Watershed**	**Survey Type**	MYYU	NYFE	TABR	EPFU	EUPE	PIHE	MYCI	MYCA	LABL	LACI	MYEV	COTO	ANPA	NYMA	MACA	CHME	**Total No. of Species**
Cottonwood Creek, Marron Valley (Spring)	Tijuana River	Foraging Bats	X	X	X	X	X	X	X	X	X	X		X	X	X			13
Hollenbeck Canyon Wildlife Area	Otay River	Foraging Bats	X	X	X	X	X	X	X	X	X	X	X		X				12
San Diego National Wildlife Refuge, Sweetwater River (URDS)	Sweetwater River	Foraging Bats	X	X	X	X	X	X	X	X	X	X				X			11
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	San Dieguito River	Foraging Bats	X	X	X	X	X	X	X	X	X	X							10
Mission Trails Regional Park, San Diego River	San Diego River	Foraging Bats	X	X	X	X	X	X			X	X				X			9
Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)	San Dieguito River	Foraging Bats	X	X	X	X		X	X	X			X						8
Dos Picos County Park	San Diego River	Foraging Bats	X	X	X	X	X	X	X		X								8
San Pasqual Valley	San Dieguito River	Foraging Bats	X	X	X	X	X	X			X		X						8
Cottonwood Creek, Marron Valley (Crossing)	Tijuana River	Foraging Bats	X	X		X	X	X	X			X							7
Los Penasquitos Canyon Preserve (Lower Creek)	Penasquitos Creek	Foraging Bats	X		X	X	X			X	X	X							7
Sycuan Peak Ecological Reserve, Lawson Creek	Sweetwater River	Foraging Bats		X	X	X	X	X	X		X								7
Sycuan Peak Ecological Reserve, Sweetwater River	Sweetwater River	Foraging Bats	X	X	X	X	X	X	X										7
Dulzura Creek Bridge	Otay River	Roosting Bats	X						X	X			X	X	X				6
Flinn Springs County Park	San Diego River	Foraging Bats	X	X		X	X	X		X									6
Jamul Mountains	Otay River	Roosting Bats	X	X	X		X	X	X										6
Otay Mountain, Cedar Canyon	Otay River	Foraging Bats	X		X	X	X	X	X										6
Otay Valley Regional Park, Upper Canyon	Otay River	Foraging Bats	X		X		X	X	X		X								6
Singing Hills Memorial Estates (Boulders)	Sweetwater River	Roosting Bats		X	X	X	X	X	X										6
San Diego National Wildlife Refuge, Sweetwater River (Boulders)	Sweetwater River	Roosting Bats	X	X	X			X		X				X					6
El Monte County Park	San Diego River	Foraging Bats		X	X	X	X	X											5
Fairbanks Ranch	San Dieguito River	Foraging Bats	X	X	X	X	X												5
Mission Trails Regional Park, San Diego River (Padre Dam)	San Diego River	Foraging Bats	X	X	X	X		X											5
Rancho Jamul Ecological Reserve (Jamul Creek)	Otay River	Foraging Bats	X		X	X		X	X										5
Rancho Jamul Ecological Reserve (Maintenance Shed)	Otay River	Roosting Bats		X	X	X	X	X											5
Sweetwater County Park, Morrison Pond	Sweetwater River	Foraging Bats	X	X	X	X	X												5
Cottonwood Creek Tunnel	Tijuana River	Roosting Bats	X						X					X			X		4
Crestridge Ecological Reserve	San Diego River	Foraging Bats			X	X			X	X									4
Sycamore Canyon / Gooden Ranch Open Space Preserves	San Diego River	Foraging Bats	X	X	X	X													4
4S Ranch	San Dieguito River	Foraging Bats	X		X		X												3
Hollenbeck Canyon Wildlife Area (Jamul Creek Cliffs)	Otay River	Roosting Bats		X			X	X											3
Mission Trails Regional Park, Shephards Pond	San Diego River	Foraging Bats	X			X		X											3
Otay Valley Regional Park, Upper Canyon (Caves)	Otay River	Roosting Bats	X	X			X												3
Los Penasquitos Canyon Preserve (Bat Boxes)	Penasquitos Creek	Roosting Bats				X				X									2
Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))	San Diego River	Foraging Bats	X		X														2
Otay Mountain Bunkers	Otay River	Roosting Bats	X	X															2
Otay Valley Regional Park, Structures	Otay River	Roosting Bats	X	X															2
Coronado Cays	n/a	Roosting Bats																X	1
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	Penasquitos Creek	Foraging Bats		X															1
Otay Mountain, O'Neal Canyon	Otay River	Roosting Bats	X																1
San Diego National Wildlife Refuge, Sweetwater River (Upper)	Sweetwater River	Foraging Bats		X															1
Total No. of Sites			30	27	26	25	24	23	17	11	11	7	4	4	3	3	1	1	

Table 5. Foraging Bat Survey Results (combines Anabat, mist-net, and acoustic results). Includes site names and species detected at each foraging bat site. Survey effort varied among sites (see Tables 1 and 2). Species abbreviations are explained in Table 3.

SiteName	Species														Total No. of Species
	EPFU	TABR	MYYU	NYFE	EUPE	PIHE	MYCI	LABL	MYCA	LACI	MYEV	NYMA	ANPA	COTO	
Cottonwood Creek, Marron Valley (Spring)	■	■	■	■	■	■	■	■	■	■		■	■	■	13
Hollenbeck Canyon Wildlife Area	■	■	■	■	■	■	■	■	■	■	■		■		12
San Diego National Wildlife Refuge, Sweetwater River (URDS)	■	■	■	■	■	■	■	■	■	■		■			11
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	■	■	■	■	■	■	■	■	■	■					10
Mission Trails Regional Park, San Diego River	■	■	■	■	■	■		■		■		■			9
Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)	■	■	■	■		■	■		■		■				8
Dos Picos County Park	■	■	■	■	■	■	■	■							8
San Pasqual Valley	■	■	■	■	■	■		■			■				8
Cottonwood Creek, Marron Valley (Crossing)	■		■	■	■	■	■			■					7
Los Penasquitos Canyon Preserve (Lower Creek)	■	■	■		■			■	■	■					7
Otay Mountain, Cedar Canyon	■	■	■	■	■	■	■								7
Otay Valley Regional Park, Upper Canyon		■	■	■	■	■	■	■							7
Sycuan Peak Ecological Reserve, Lawson Creek	■	■		■	■	■	■	■							7
Sycuan Peak Ecological Reserve, Sweetwater River	■	■	■	■	■	■	■								7
Flinn Springs County Park	■		■	■	■	■			■						6
Rancho Jamul Ecological Reserve (Jamul Creek)	■	■	■	■		■	■								6
El Monte County Park	■	■		■	■	■									5
Fairbanks Ranch	■	■	■	■	■										5
Mission Trails Regional Park, San Diego River (Padre Dam)	■	■	■	■		■									5
Sweetwater County Park, Morrison Pond	■	■	■	■	■										5
Crestridge Ecological Reserve	■	■					■		■						4
Mission Trails Regional Park, Shephards Pond	■		■	■		■									4
Sycamore Canyon / Gooden Ranch Open Space Preserves	■	■	■	■											4
4S Ranch		■	■		■										3
Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))		■	■												2
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	■														1
San Diego National Wildlife Refuge, Sweetwater River (Upper)				■											1
Total No. of Sites	23	22	22	22	18	18	13	10	8	7	3	3	2	1	

Table 6. Anabat at Foraging Sites Results. Includes site names and species detected. Survey effort varied among sites (see Tables 1 and 2). Species abbreviations are explained in Table 3.

SiteName	EPFU	MYYU	NYFE	TABR	PIHE	MYCI	EUPE	LABL	LACI	MYCA	MYEV	NYMA	ANPA	COTO	No. of Species
	Species														
Cottonwood Creek - Marron Valley (Spring)	■	■	■	■	■	■	■	■	■	■		■	■	■	13
Hollenbeck Canyon Wildlife Area	■	■	■	■	■	■	■	■	■	■	■		■		12
San Diego National Wildlife Refuge, Sweetwater River (URDS)	■	■	■	■	■	■	■	■	■	■		■			11
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	■	■	■	■	■	■	■	■	■	■					10
Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)	■	■	■	■	■	■				■	■				8
Dos Picos County Park	■	■	■	■	■	■	■	■							8
Mission Trails Regional Park, San Diego River	■	■	■	■	■			■	■			■			8
Otay Mountain - Cedar Canyon	■	■	■	■	■	■	■								7
Otay Valley Regional Park, Upper Canyon		■	■	■	■	■	■	■							7
San Pasqual Valley	■	■	■	■	■			■			■				7
Sycuan Peak Ecological Reserve, Lawson Creek	■		■	■	■	■	■	■							7
Cottonwood Creek - Marron Valley (Crossing)	■	■	■		■	■			■						6
Los Penasquitos Canyon Preserve (Lower Creek)	■	■		■				■	■	■					6
Rancho Jamul Ecological Reserve (Jamul Creek)	■	■	■	■	■	■									6
Sycuan Peak Ecological Reserve, Sweetwater River	■	■	■	■	■	■									6
El Monte County Park	■		■	■	■		■								5
Mission Trails Regional Park, San Diego River (Padre Dam)	■	■	■	■	■										5
Crestridge Ecological Reserve	■			■		■				■					4
Fairbanks Ranch	■	■	■	■											4
Flinn Springs County Park	■	■	■		■										4
Mission Trails Regional Park, Shephards Pond	■	■	■		■										4
Sweetwater County Park, Morrison Pond	■	■	■	■											4
Sycamore Canyon / Gooden Ranch Open Space Preserves	■	■	■	■											4
4S Ranch		■		■			■								3
Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))		■		■											2
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	■														1
San Diego National Wildlife Refuge, Sweetwater River (Upper)			■												1
No. of Anabat Detection Sites	23	22	22	22	18	13	10	10	7	7	3	3	2	1	

Table 7. Foraging Sites Results Using Audible Techniques (Unaided Ears). Includes site names, species heard at foraging bat sites using unaided ears, and number of sites each species was heard. Species abbreviations are explained in Table 3.

SiteName	Species		
	ANPA	NYMA	EUPE
4S Ranch			■
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)			■
Cottonwood Creek, Marron Valley (Crossing)			■
Cottonwood Creek, Marron Valley (Spring)	■	■	■
Dos Picos County Park			■
El Monte County Park			■
Fairbanks Ranch			■
Flinn Springs County Park			■
Hollenbeck Canyon Wildlife Area	■		■
Los Penasquitos Canyon Preserve (Lower Creek)			■
Mission Trails Regional Park, San Diego River		■	■
Otay Mountain, Cedar Canyon			■
San Diego National Wildlife Refuge, Sweetwater River (URDS)		■	■
San Pasqual Valley			■
Sweetwater County Park, Morrison Pond			■
Sycuan Peak Ecological Reserve, Lawson Creek			■
Sycuan Peak Ecological Reserve, Sweetwater River			■
No. of Foraging Sites Heard at	2	3	17

Table 8. Mist-net Results. Includes site names, species captured in mist-nets, number of individuals of each species captured, number of species captured at each site, number of individuals captured at each site, and number of sites each species was captured. Survey effort varied among sites (see Tables 1 and 2). Species abbreviations are explained in Table 3.

	Species											
SiteName	MYYU	EPFU	PIHE	LACI	MYCI	LABL	MYCA	ANPA	MYEV	COTO	**No. of Individuals**	**No. of Species**
Hollenbeck Canyon Wildlife Area	9	18	3	3	8	2		1	3		47	8
Cottonwood Creek, Marron Valley (Spring)	40	4	1		1			1		1	48	6
San Diego National Wildlife Refuge, Sweetwater River (URDS)	2	1	1	1		4					9	5
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	1			2		2					5	3
Los Penasquitos Canyon Preserve (Lower Creek)		1		1			4				6	3
Mission Trails Regional Park, San Diego River	2		5								7	2
Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)							9				9	1
Dos Picos County Park	1										1	1
El Monte County Park		1									1	1
Fairbanks Ranch	3										3	1
Flinn Springs County Park							1				1	1
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)		3									3	1
Sweetwater County Park, Morrison Pond	1										1	1
Sycamore Canyon / Gooden Ranch Open Space Preserves		1									1	1
Sycuan Peak Ecological Reserve, Sweetwater River					1						1	1
No. of Individuals	59	29	10	7	10	8	14	2	3	1	143	
No. of Mist-net Capture Sites	8	7	4	4	3	3	3	2	1	1		

Table 9. Roost Survey Results. Includes site names, type of roost survey conducted, species detected and identified as roosting on site versus foraging in the area, number of species detected, and number of sites each species was detected. Survey effort varied among sites (see Table 2). Species abbreviations are explained in Table 3.

SiteName	Roost Survey Type	Species													No. of Species
		MYYU	PIHE	MYCI	TABR	MYCA	NYFE	COTO	EUPE	EPFU	ANPA	MACA	MYEV	CHME	
San Diego National Wildlife Refuge, Sweetwater River (Boulders)	External	■	■		■	■	■	■							6
Dulzura Creek Bridge	Nocturnal	■		■		■		■			■		■		6
Jamul Mountains	External	■	■	■	■		■		■						6
Singing Hills Memorial Estates (Boulders)	External		■	■	■		■		■	■					6
Cottonwood Creek Tunnel	Diurnal	■		■				■				■			4
Rancho Jamul Ecological Reserve (Maintenance Shed)	Diurnal, External				■					■					2
Cottonwood Cave 3	Nocturnal										■				1
Hollenbeck Canyon Wildlife Area (Jamul Creek Cliffs)	External		■												1
Otay Valley Regional Park, Upper Canyon (Caves)	Nocturnal	■													1
Coronado Cays	Diurnal, External													■	1
Los Penasquitos Canyon Preserve (Bat Boxes 1 & 2)	Diurnal, External					■									1
Los Penasquitos Canyon Preserve (Bat Boxes 3 & 4)	Diurnal, External					■									1
Otay Mountain Bunkers	Diurnal	■													1
Otay Mountain, O'Neal Canyon	Diurnal	■													1
Otay Valley Regional Park, Structures	Nocturnal	■													1
	No. of Roost Sites	8	4	4	4	4	3	3	2	2	2	1	1	1	

Table 10. Bat Demographics Summary. Includes number of males and females captured in mist-nets and hand-nets, number of adults and juveniles captured, and number of males and females in reproductive states (in parentheses).

	No. of Males	No. of Females	Total
Adults	34 (4)	81 (39)	115 (43)
Juveniles	20	16	36
Total	54	97	151

Table 11. Seasonal Bat Richness for 2002-2003. Includes survey months, number of surveys conducted during each month, species detected, number of species with means and standard deviations. The bat species represented with 'X's were only detected during focused roost surveys, which were not conducted year-round. Species abbreviations are explained in Table 3.

Month	No. of Surveys	Seasonal Detectability: year-round / spring-fall / fall-spring — Species: MYYU	NYFE	TABR	PIHE	EUPE	LABL	MYCA	MYCI	EPFU	MYEV	COTO	ANPA	LACI	NYMA	CHME	MACA	No. of Species	Mean	Standard Deviation
January	4																	8	4.75	0.96
February	1																	2	2.00	--
March	4																	13	6.50	2.65
April	1																	5	5.00	--
May	15																	12	5.27	1.91
June	12																	10	5.17	1.64
July	14																	11	5.00	2.69
August	13																	12	5.62	2.33
September	11																X	13	5.73	1.95
October	11															X		12	5.18	2.32
November	3																	8	4.00	2
December	5																	7	2.60	1.34

Table 12. Seasonal Bat Activity (Anabat) at Multi-visit Sites. Includes site names and number and means of Anabat files recorded at each site. All mid-summer surveys fell between June and August, while all mid-winter surveys fell between December and February.

	Bat Activity (No. of Anabat Files)			
Season/Year	**Mid-Summer 2002**	**Mid-Winter 2002-2003**	**Mid-Summer 2003**	**Mid-Winter 2003**
Cottonwood Creek, Marron Valley (Spring)	257	27	165	15
Hollenbeck Canyon Wildlife Area	188	7	78	2
Los Penasquitos Canyon Preserve (Lower Creek)	117	9	74	not surveyed
Mission Trails Regional Park, San Diego River	395	37	142	22
San Diego National Wildlife Refuge, Sweetwater River (URDS)	222	11	155	48
Means	235.8	18.2	122.8	21.8

Table 13. Watershed Associations. Includes watershed, number of sites in each watershed, species detected, number of species detected at each watershed, and number of watersheds that each species was detected. Species abbreviations are explained in Table 3.

Watershed	No. of Survey Sites in Watershed	Species															No. of Species
		EPFU	EUPE	LABL	LACI	MYCA	MYYU	TABR	MYCI	NYFE	PIHE	COTO	NYMA	MYEV	ANPA	MACA	
Tijuana River	7																14
Otay River	12																13
Sweetwater River	7																12
San Diego River	9																11
San Dieguito River	5																11
Penasquitos Creek	4																7
No. of Watersheds		6	6	6	6	6	6	6	5	5	5	3	3	2	2	1	

Table 14. Detection Frequency of Bat Species Among Survey Methods. Includes species and percentage of detections by method for each species. In this table, species detections are limited to one per site and date for each method. Species abbreviations are explained in Table 3.

Bat Species	Percent Detections			
	Anabat	Audible	Mist-net	Roost
ANPA	45.5	27.3	18.2	9
CHME	0	0	0	100
COTO	22.2	0	11.1	66.7
EPFU	79.7	0	18.6	1.7
EUPE	30.8	69.2	0	0
LABL	82.8	0	17.2	0
LACI	76.2	0	23.8	0
MACA	0	0	0	100
MYCA	60.6	0	12.1	27.3
MYCI	71.9	0	18.8	9.4
MYEV	66.7	0	16.7	16.7
MYYU	65.9	0	20	14.1
NYFE	100	0	0	0
NYMA	38.5	61.6	0	0
PIHE	86.4	0	12.1	1.5
TABR	98.4	0	0	1.6

Table 15. Identified Bat roosts in Man-made Structures. Includes species documented occupying each structure (* refers to species of local concern), structure ownership, and suggested protection measures.

Roost Structure	Occupying Species	Ownership	Protection Action(s)
Cottonwood Creek tunnel	COTO*, MACA*, MYYU, MYCI	City water authority	Install gates that will allow bats (but not people) to pass through; gates would need to be movable to allow for water releases. Install gated fences at main access points. Post signs to keep people out of tunnel. Increase law enforcement to prevent people from accessing tunnel.
Otay Lakes Dam	MYYU	City water authority	Schedule dam maintenance activities around breeding season for bats (bats breed April-September). If bats are forced to be evicted as a last resort, ensure that alternative roosting habitat provided on site in form of multiple nursery-style bat boxes of different color tones (dark and light) and ensure proper bat exclusion is conducted.
Lake Hodges Dam	MYYU	City water authority	Schedule dam maintenance activities around breeding season for bats (bats breed April-September). If bats are forced to be evicted as a last resort, ensure that alternative roosting habitat provided on site in form of multiple nursery-style bat boxes of different color tones (dark and light) and ensure proper bat exclusion is conducted.
Rancho Jamul Ecological Reserve maintenance shed	EPFU, TABR	California Department of Fish and Game	Inform maintenance workers of presence of bat roost - should be left alone. If bats are forced to be evicted, ensure that alternative roosting habitat provided on site in form of multiple nursery-style or single-slot bat boxes of different color tones (dark and light) and ensure bat proper bat exclusion is conducted.
Dulzura Creek Bridge	ANPA*, COTO*, MYEV, MYYU, MYCI, MYCA	Caltrans	Perform maintenance activities during winter (Nov-Feb), ensure bridge design is not compromised, if design is to be compromised then build in bat-friendly features (crevices, cavities).

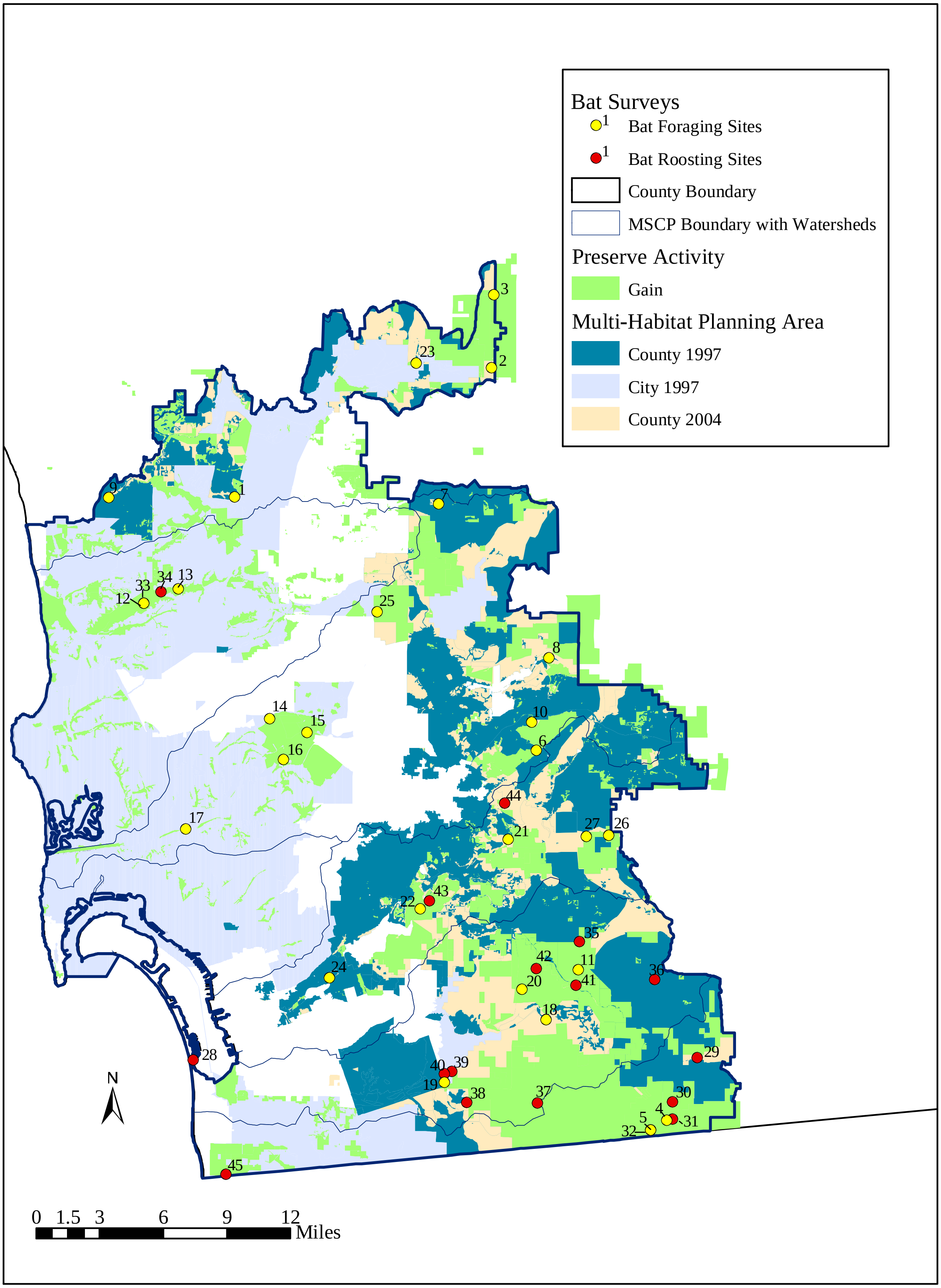


Figure 1. Map of bat survey sites.

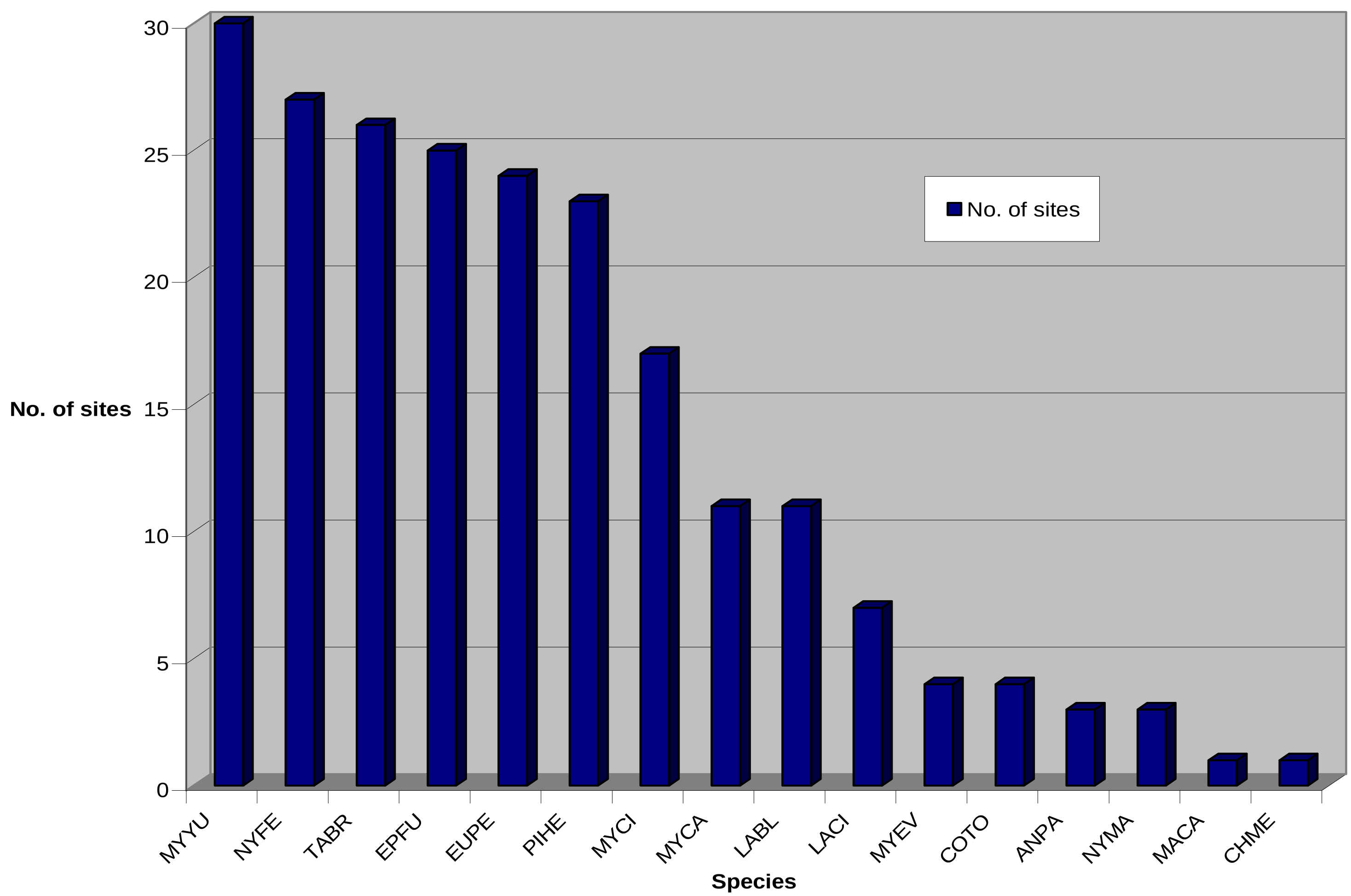


Figure 2. Frequency of Detections of Different Bat Species. Graph shows bat species by number of sites that each species was detected. There were a total of 45 sites surveyed.

Figures 3 and 4. Top: California leaf-nosed bat (*Macrotus californicus*) from Cottonwood Creek tunnel. Bottom: Mexican long-tongued bat (*Choeronycteris mexicana*) from Coronado Cays. Photos by Cheryl Brehme.

Figures 5 and 6. Top: Juvenile Yuma myotis (*Myotis yumanensis*) from Cottonwood Creek Spring. Photo by Cheryl Brehme. Bottom: Long-eared myotis (*Myotis evotis*) from Hollenbeck Canyon Wildlife Area. Photo by Drew Stokes.

Figures 7 and 8. Top: California myotis (*Myotis californicus*) from Los Penasquitos Canyon Preserve. Photo by Denise Clark. Bottom: Small-footed myotis (*Myotis ciliolabrum*) from Sycuan Peak Ecological Reserve. Photo by Drew Stokes.

Figures 9 and 10. Top: Western pipistrelle (*Pipistrellus hesperus*) from Mission Trails Regional Park. Photo by Drew Stokes. Bottom: Big brown bat (*Eptesicus fuscus*) from Sycamore Canyon Open Space Preserve. Photo by Cheryl Brehme.

Figures 11 and 12. Top: Western red bat (*Lasiurus blossevillii*) from the San Diego National Wildlife Refuge. Photo by Cheryl Brehme. Bottom: Hoary bat (*Lasiurus cinereus*) from Los Penasquitos Canyon Preserve. Photo by Allan Hebert.

Figure 13. Townsend's big-eared bat (*Corynorhinus townsendii*) from Cottonwood Creek tunnel. Photo by Manna Warburton.

Figure 14. Pallid bat (*Antrozous pallidus*) from Hollenbeck Canyon Wildlife Area. Photo by Cheryl Brehme.

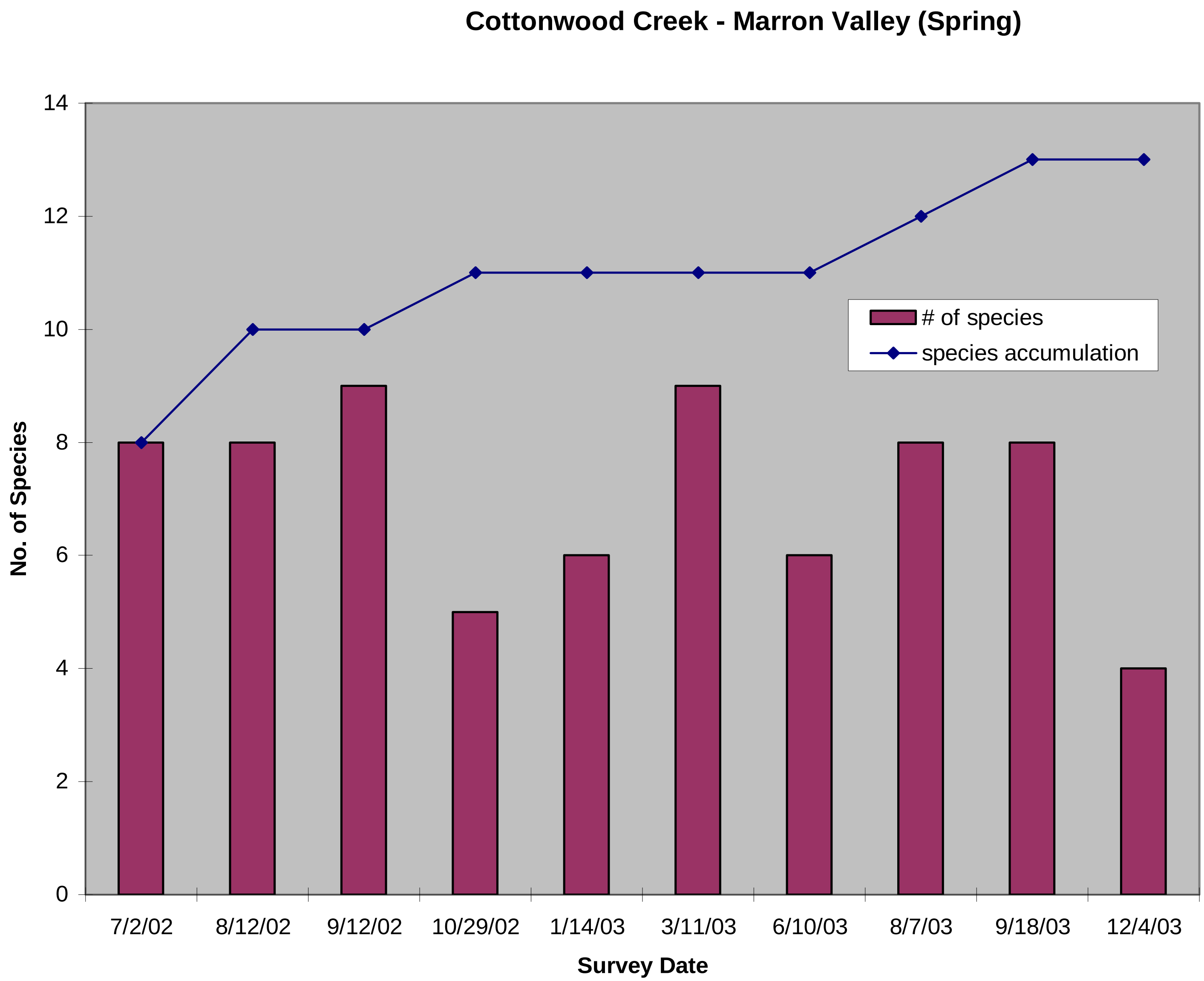


Figure 15. Species Accumulation Curve for Multi-visit Foraging Site: Cottonwood Creek.

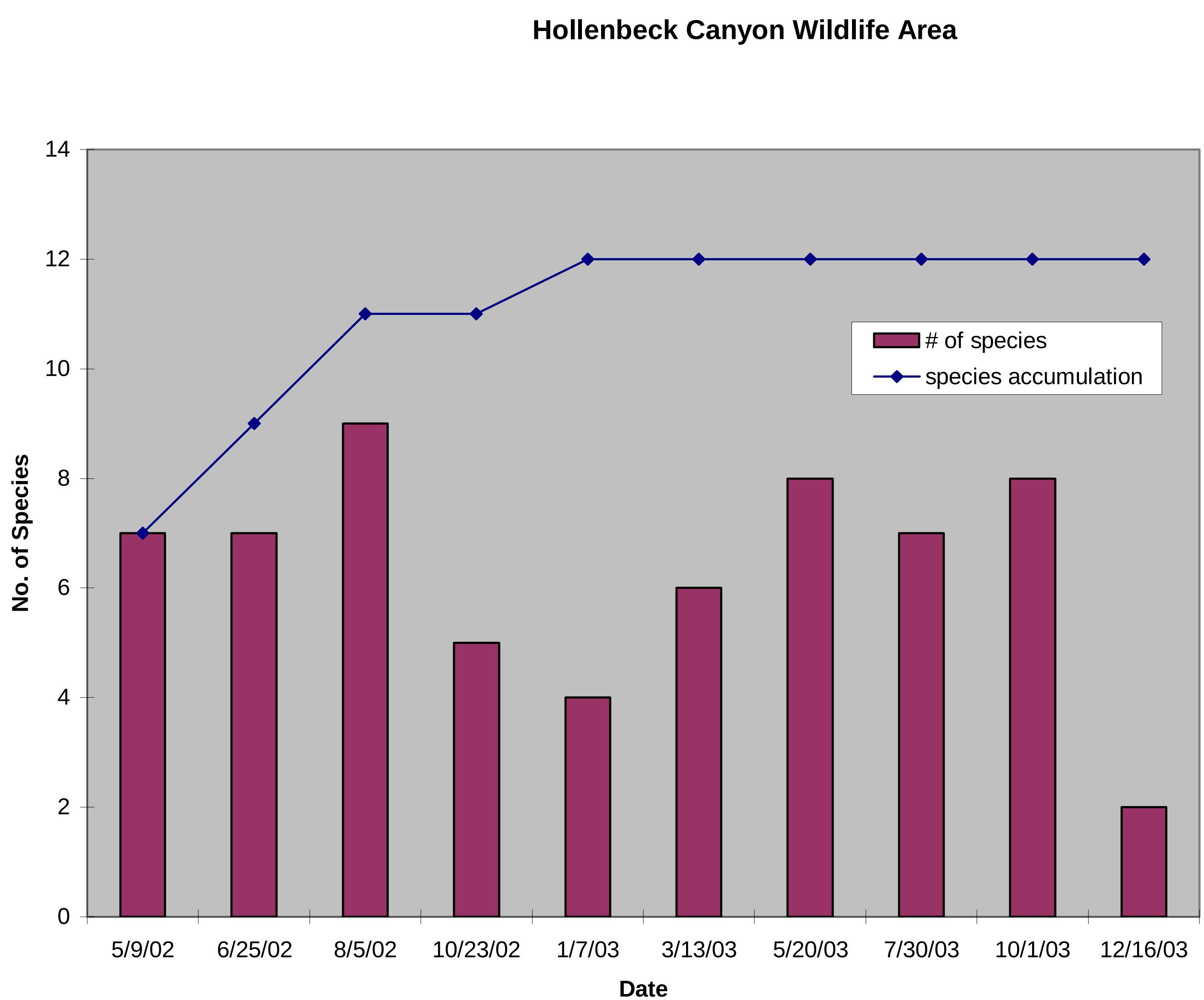


Figure 16. Species Accumulation Curve for Multi-visit Foraging Site: Hollenbeck Canyon Wildlife Area.

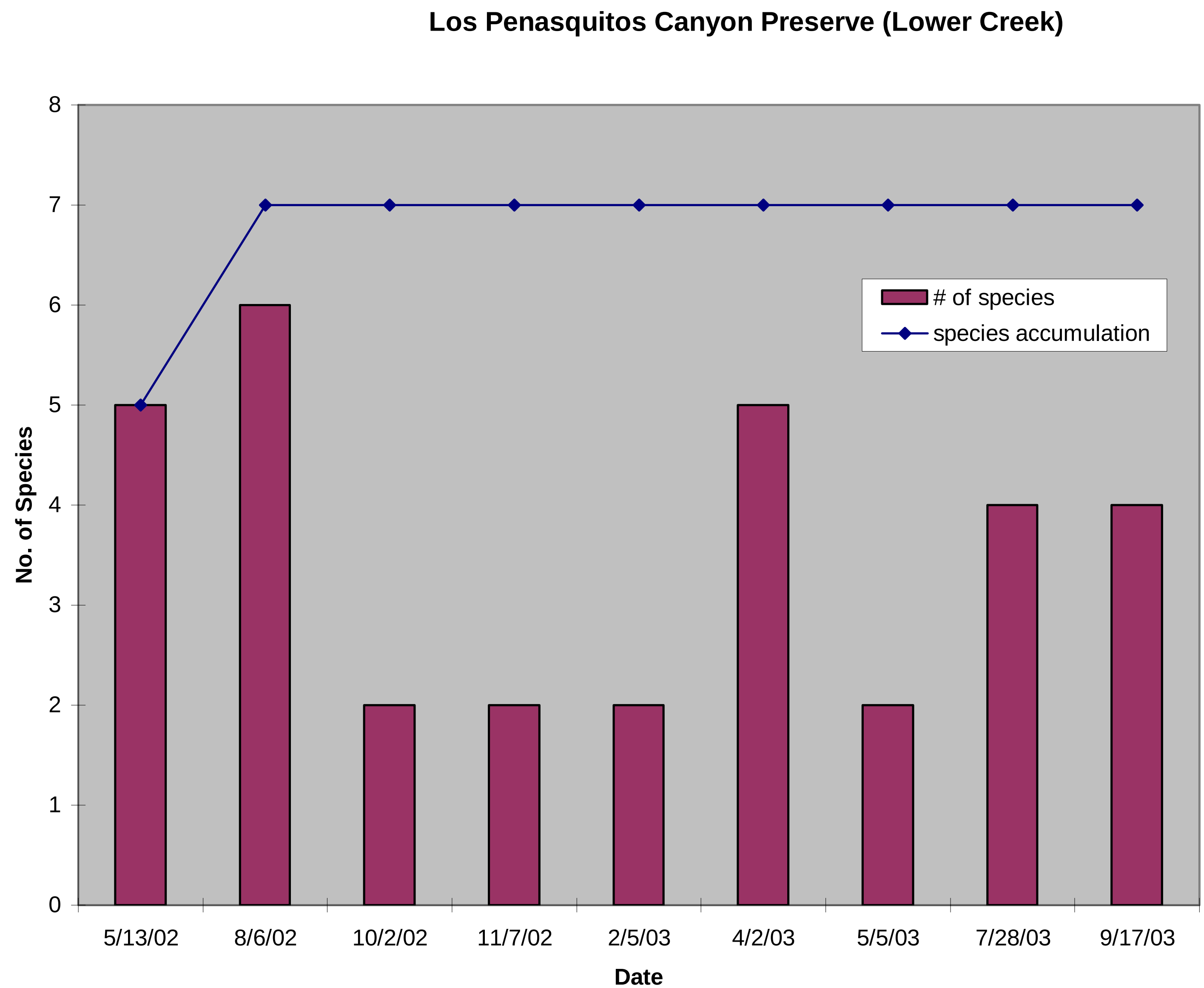


Figure 17. Species Accumulation Curve for Multi-visit Foraging Site: Los Penasquitos Canyon Preserve.

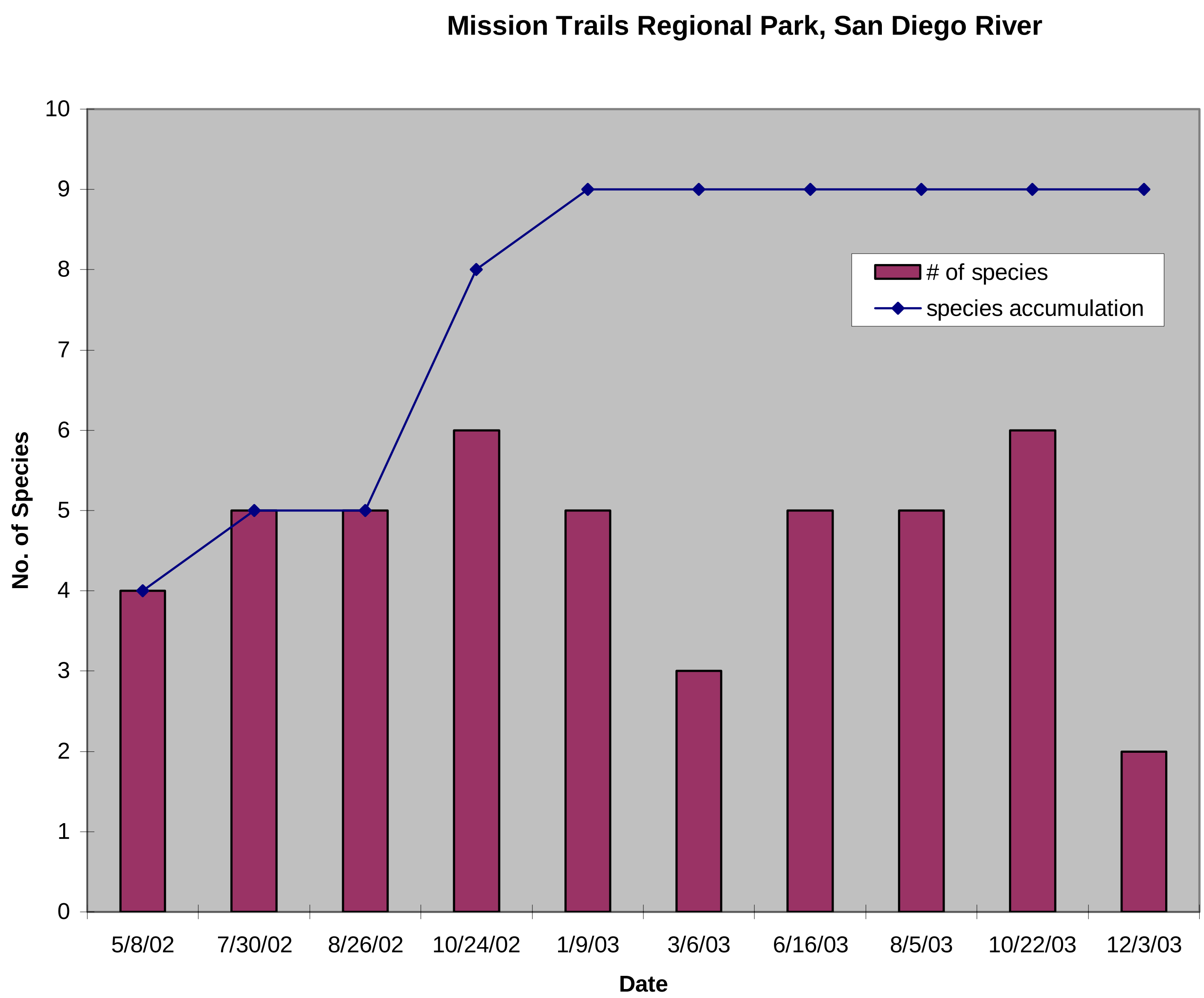


Figure 18. Species Accumulation Curve for Multi-visit Foraging Site: Mission Trails Regional Park.

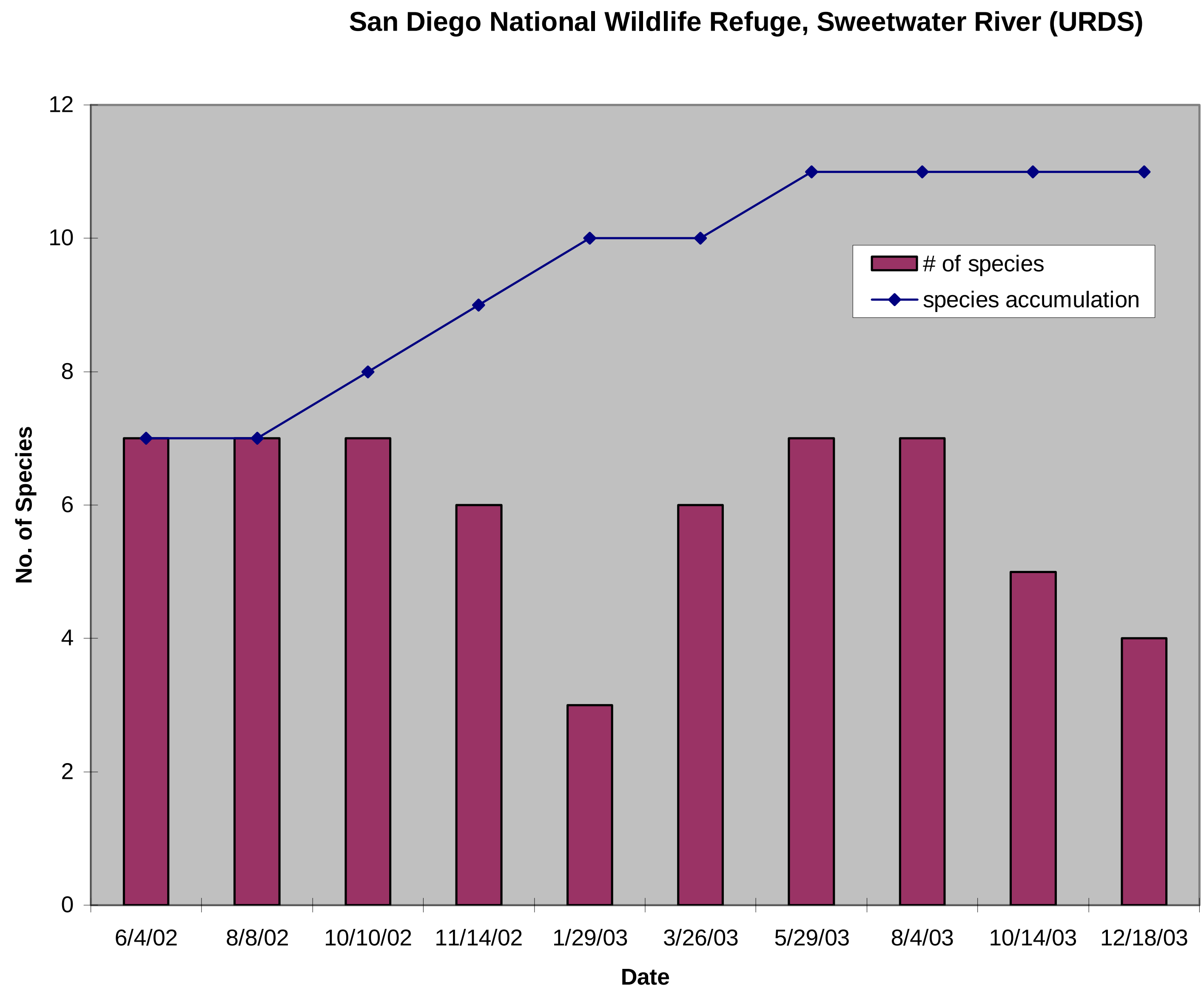


Figure 19. Species Accumulation Curve for Multi-visit Foraging Site: San Diego National Wildlife Refuge (URDS).

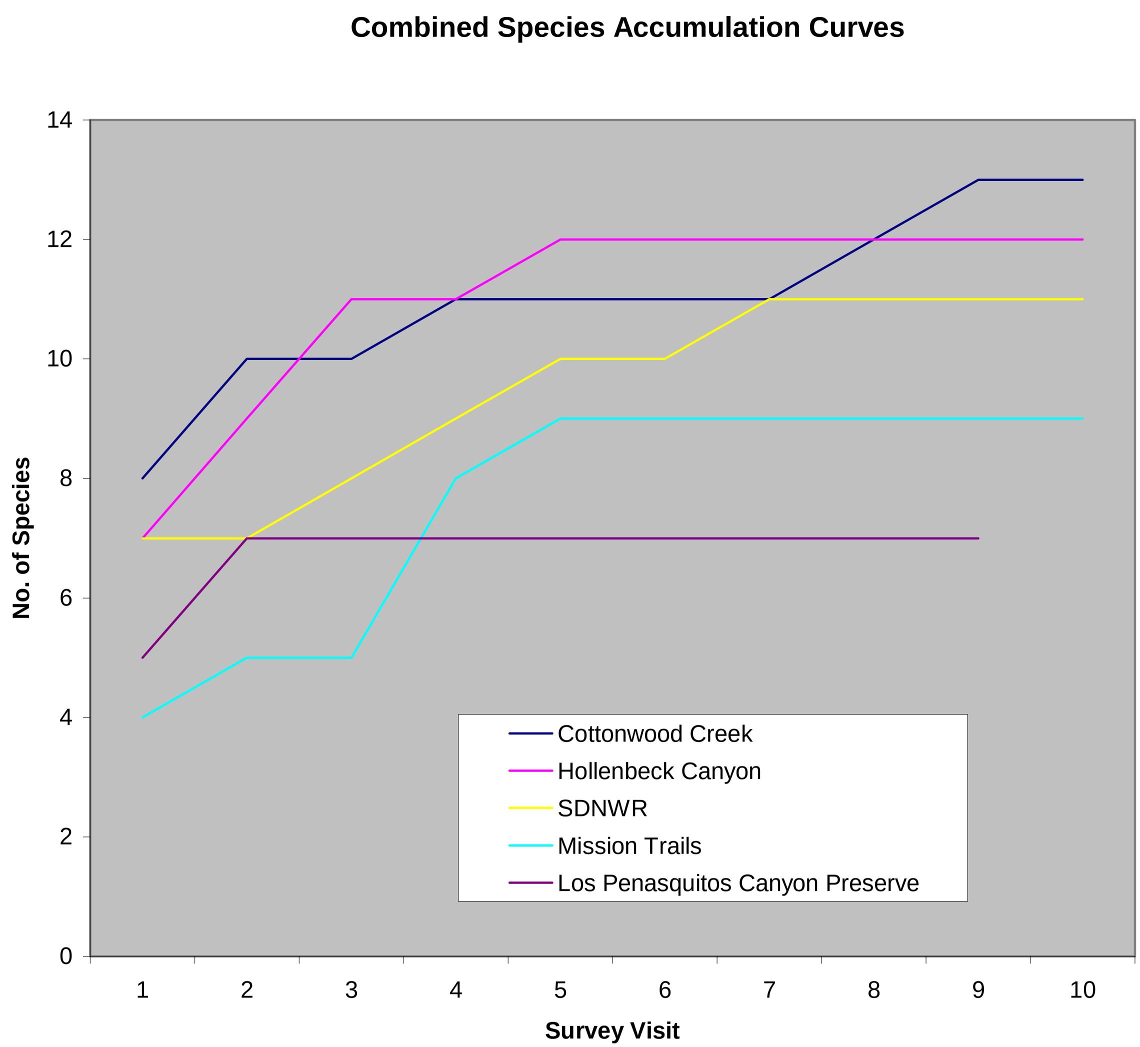


Figure 20. Combined Species Accumulation Curves for Multi-visit Foraging Sites.

Survey Site	Date	ANPA				CHME	COTO			EPFU			EUPE		LABL		LACI		MACA	MYCA			MYCI			MYEV			MYYU			NYFE		NYMA		PIHE			TABR	
		Anabat	Audible	Mist Net	Roost	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Mist Net	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Audible	Anabat	Mist Net	Roost	Anabat	Roost
4S Ranch	7/23/02												■	■															■										■	
Boden Canyon Ecological Reserve, Unnamed Tributary	6/3/02									■										■	■		■			■						■							■	
	9/2/03									■										■									■			■				■			■	
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	5/7/02												■	■	■		■	■		■												■							■	
	11/20/02																■															■				■			■	
	5/15/03														■	■				■										■		■				■			■	
	7/29/03									■				■	■					■									■			■				■				
	9/16/03													■	■		■			■			■									■								
Coronado Cays	10/8/02					■																																		
Cottonwood Creek, Marron Valley (Crossing)	5/13/03									■				■			■						■						■			■				■				
Cottonwood Creek, Marron Valley (Spring)	7/2/02							■		■	■		■							■			■						■	■		■				■				
	8/12/02	■	■							■	■		■	■									■						■	■		■				■			■	
	9/12/02	■								■			■	■						■			■						■	■		■				■			■	
	10/29/02												■	■															■			■		■	■	■				
	1/14/03																			■									■			■			■	■			■	
	3/11/03						■			■			■	■									■						■	■		■			■	■	■		■	
	6/10/03									■				■									■	■					■	■		■				■				
	8/7/03	■		■						■				■	■								■						■	■		■				■				
	9/18/03	■	■										■				■						■						■	■		■				■			■	
	12/4/03													■	■																	■				■				
Cottonwood Creek Tunnel	7/25/02								■																						■									
	9/19/02								■										■						■						■									
	8/26/03								■																						■									
	9/4/03								■										■												■									
Crestridge Ecological Reserve	6/10/02									■										■			■																■	
Dos Picos County Park	9/11/03									■			■	■	■								■						■	■		■				■			■	
Dulzura Creek Bridge	5/10/02				■																	■									■									
	7/31/02								■																			■			■									
	10/29/02																											■			■									
	3/13/03								■													■			■															

Appendix I. All Bat Detections. Includes site, date, and survey method (Foraging bats: anabat, audible, mist-net; Roosting bats: roost).

Survey Site	Date	Species and Detection Method																																				
		ANPA				CHME	COTO			EPFU			EUPE		LABL		LACI		MACA	MYCA			MYCI			MYEV			MYYU			NYFE		NYMA		PIHE			TABR	
		Anabat	Audible	Mist Net	Roost	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Mist Net	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Audible	Anabat	Mist Net	Roost	Anabat	Roost
El Monte County Park	5/21/02									■	■		■	■																		■				■			■	
Fairbanks Ranch	6/11/03									■				■															■										■	
	8/6/03									■				■															■	■									■	
	9/25/03									■																			■			■							■	
Flinn Springs County Park	9/3/03									■				■							■								■			■				■				
Hollenbeck Canyon Wildlife Area	5/9/02									■	■			■			■						■	■		■	■									■			■	
	6/25/02									■	■		■										■	■					■	■		■				■	■		■	
	8/5/02			■						■	■		■	■						■			■	■		■						■				■	■		■	
	10/23/02													■												■				■		■				■				
	1/7/03														■			■														■								
	3/13/03													■										■		■			■			■							■	
	5/20/03	■	■							■	■			■		■		■														■				■	■		■	
	7/30/03									■				■	■								■			■			■							■				
	10/1/03												■			■	■										■		■			■				■			■	
	12/16/03																												■			■								
Hollenbeck Canyon Wildlife Area (Jamul Creek Cliffs)	7/2/03													■															■			■				■				
Jamul Mountains	6/18/02												■	■									■						■			■				■			■	
Los Penasquitos Canyon Preserve (Lower Creek)	5/13/02									■								■				■							■										■	
	8/6/02									■				■	■					■	■	■							■										■	
	10/2/02																			■		■																	■	
	11/7/02																			■																			■	
	2/5/03														■		■																							
	4/2/03									■					■		■			■		■																	■	
	5/5/03																			■		■																	■	
	7/28/03									■	■			■						■	■	■																	■	
	9/17/03									■				■						■		■																	■	
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	7/16/03									■	■																													

Appendix I (cont.). All Bat Detections. Includes site, date, and survey method (Foraging bats: anabat, audible, mist-net; Roosting bats: roost).

Survey Site	Date	Species and Detection Method																																						
		ANPA				CHME	COTO			EPFU			EUPE		LABL		LACI		MACA	MYCA			MYCI			MYEV			MYYU			NYFE		NYMA		PIHE			TABR	
		Anabat	Audible	Mist Net	Roost	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Mist Net	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Audible	Anabat	Mist Net	Roost	Anabat	Roost
Mission Trails Regional Park, San Diego River	5/8/02																												■	■		■				■			■	
	7/30/02									■																			■			■				■	■		■	
	8/26/02									■																			■			■				■	■		■	
	10/24/02													■			■												■			■			■	■				
	1/9/03														■																	■		■	■	■			■	
	3/6/03																												■			■				■				
	6/16/03														■														■			■				■			■	
	8/5/03									■																			■			■				■	■		■	
	10/22/03													■			■												■	■		■		■	■	■				
	12/3/03																															■				■				
Mission Trails Regional Park, San Diego River (Padre Dam)	6/24/02									■																			■			■				■			■	
Mission Trails Regional Park, Shephards Pond	7/14/03									■																			■			■				■				
Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))	5/16/02																												■										■	
Otay Mountain Bunkers	8/25/03																														■									
Otay Mountain, Cedar Canyon	7/31/02									■			■	■									■						■			■				■			■	
Otay Moutnain, Oneil Canyon	7/16/02																														■									
Otay Valley Regional Park, Structures	7/15/03																														■									
Otay Valley Regional Park, Upper Canyon	7/15/03												■		■								■						■			■				■			■	
Otay Valley Regional Park, Upper Canyon (Caves)	6/12/03													■																	■									

Appendix I (cont.). All Bat Detections. Includes site, date, and survey method (Foraging bats: anabat, audible, mist-net; Roosting bats: roost).

Survey Site	Date	Species and Detection Method																																						
		ANPA				CHME	COTO			EPFU			EUPE		LABL		LACI		MACA	MYCA			MYCI			MYEV			MYYU			NYFE		NYMA		PIHE			TABR	
		Anabat	Audible	Mist Net	Roost	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Mist Net	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Mist Net	Roost	Anabat	Audible	Anabat	Audible	Anabat	Mist Net	Roost	Anabat	Roost
Rancho Jamul Ecological Reserve (Jamul Creek)	5/6/02									■													■						■			■				■			■	
Rancho Jamul Ecological Reserve (Maintenance Shed)	9/10/03									■		■		■															■							■				■
San Diego National Wildlife Refuge, Sweetwater River (Boulders)	10/3/02						■							■	■					■									■			■				■			■	
San Diego National Wildlife Refuge, Sweetwater River (Campbell Lane)	12/11/02																															■								
San Diego National Wildlife Refuge, Sweetwater River (URDS)	6/4/02									■			■	■		■													■	■		■				■	■	■	■	
	8/8/02									■	■		■	■	■	■													■			■				■			■	
	10/10/02													■	■		■												■			■				■			■	
	11/14/02														■								■						■			■				■			■	
	1/29/03																■	■														■		■	■					
	3/26/03													■	■		■												■							■			■	
	5/29/03									■					■					■									■			■				■			■	
	8/4/03									■			■	■	■														■			■				■			■	
	10/14/03																■												■	■		■		■	■	■				
	12/18/03																■															■				■			■	
San Pasqual Valley	7/23/03									■				■	■											■			■			■				■			■	
Singing Hills Memorial Estates	8/21/02									■				■									■									■				■			■	
Sweetwater County Park, Morrison Pond	6/26/03									■																			■	■									■	
	8/18/03									■				■															■			■							■	
	10/16/03													■															■										■	
Sycamore Canyon / Gooden Ranch Open Space Preserves	5/14/02									■	■																		■			■							■	
Sycuan Peak Ecological Reserve, Lawson Creek	6/11/02									■			■	■	■								■									■				■			■	
Sycuan Peak Ecological Reserve, Sweetwater River	5/23/02									■				■									■	■					■			■				■			■	

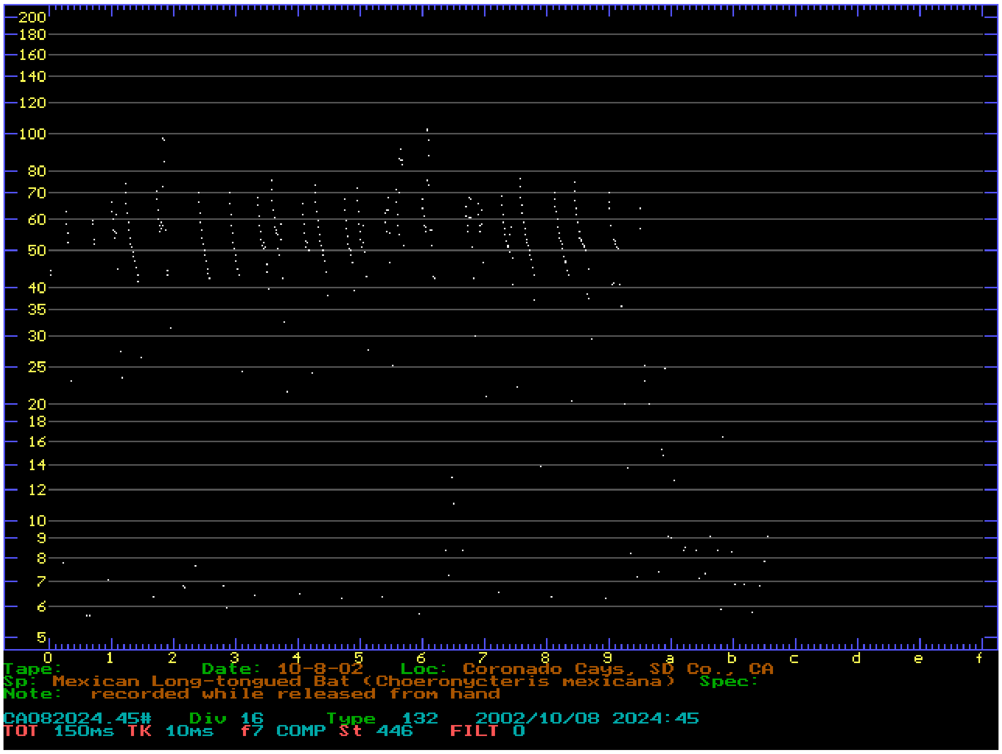
Appendix I (cont.). All Bat Detections. Includes site, date, and survey method (Foraging bats: anabat, audible, mist-net; Roosting bats: roost).

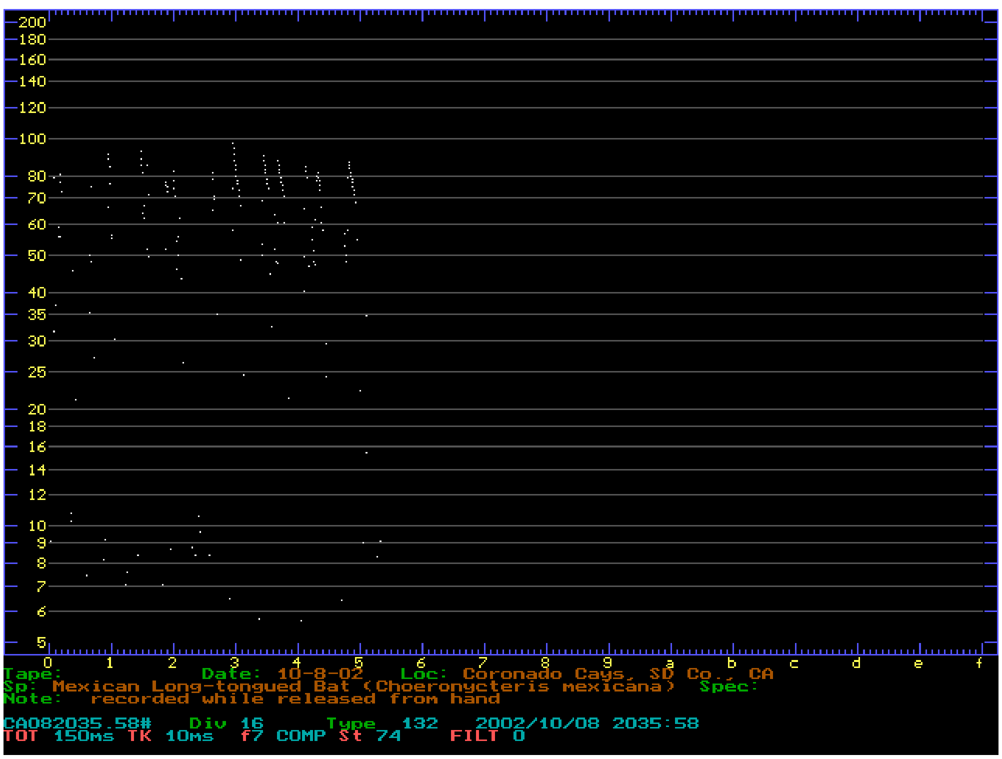
Foraging Bat Survey Site	Survey Date	Mist-net Hours (# of nets X 3)	No. of Mist-net Captures	No. of Species	Acoustic (Anabat, unaided ears) Hours	Total No. of Anabat Files	No. of Species	No. of Audible Species	Total No. of Species
4S Ranch	7/23/02	0	0	0	3	138	3	1	3
Boden Canyon Ecological Reserve, Unnamed Tributary (North of Pond)	6/3/02	15	9	1	3	429	6	0	6
	9/2/03	15	0	0	3	54	6	0	6
Boden Canyon Ecological Reserve, Unnamed Tributary (South of Pond)	5/7/02	15	2	1	3	70	6	1	6
	11/20/02	15	0	0	3	87	4	0	4
	5/15/03	15	3	2	3	27	5	0	6
	7/29/03	15	0	0	3	29	6	1	7
	9/16/03	15	0	0	3	25	5	1	6
Cottonwood Creek, Marron Valley (Crossing)	5/13/03	12	0	0	3	121	6	1	7
Cottonwood Creek, Marron Valley (Spring)	7/2/02	12	23	3	3	231	7	0	8
	8/12/02	12	7	2	3	257	8	2	8
	9/12/02	12	1	1	3	220	9	1	9
	10/29/02	12	0	0	3	56	5	2	5
	1/14/03	12	0	0	3	27	5	1	6
	3/11/03	12	4	2	3	150	8	2	9
	6/10/03	15	8	2	3	154	5	1	6
	8/7/03	12	4	2	3	165	7	1	8
	9/18/03	15	1	1	3	117	8	1	8
	12/4/03	9	0	0	3	15	3	1	4
Crestridge Ecological Reserve	6/10/02	15	0	0	3	25	4	0	4
Dos Picos County Park	9/11/03	15	1	1	3	63	8	1	8
El Monte County Park	5/21/02	15	1	1	3	59	5	1	5
Fairbanks Ranch	6/11/03	9	0	0	3	100	3	1	4
	8/6/03	12	3	1	3	134	3	1	4
	9/25/03	12	0	0	3	41	4	0	4
Flinn Springs County Park	9/3/03	15	1	1	3	19	4	1	6
Hollenbeck Canyon Wildlife Area	5/9/02	18	12	3	3	107	6	1	7
	6/25/02	15	19	4	3	188	7	0	7
	8/5/02	15	4	4	3	199	8	1	9
	10/23/02	15	1	1	3	15	3	1	5
	1/7/03	15	2	1	3	7	3	0	4
	3/13/03	15	1	1	3	42	4	1	6
	5/20/03	15	6	4	3	71	5	2	8
	7/30/03	15	0	0	3	78	6	1	7
	10/1/03	15	2	2	3	26	6	0	8
	12/16/03	15	0	0	3	2	2	0	2
Los Penasquitos Canyon Preserve (Lower Creek)	5/13/02	12	1	1	3	49	3	1	5
	8/6/02	12	2	1	3	117	5	1	6
	10/2/02	9	0	0	3	57	2	0	2
	11/7/02	9	0	0	3	54	2	0	2
	2/5/03	9	0	0	3	9	2	0	2
	4/2/03	9	0	0	3	54	5	0	5
	5/5/03	3	0	0	3	18	2	0	2
	7/28/03	12	3	2	3	74	3	1	4
	9/17/03	6	0	0	3	23	3	1	4
Los Penasquitos Canyon Preserve (Oak Woodland Clearing)	7/16/03	15	3	1	3	104	1	0	1

Appendix II. Foraging Bat data using combined techniques. Sites are listed alphabetically.

Foraging Bat Survey Site	Survey Date	Mist-net Hours (# of nets X 3)	No. of Mist-net Captures	No. of Species	Acoustic (Anabat, unaided ears) Hours	Total No. of Anabat Files	No. of Species	No. of Audible Species	Total No. of Species
Mission Trails Regional Park, San Diego River	5/8/02	9	1	1	3	94	4	0	4
	7/30/02	9	1	1	3	395	5	0	5
	8/26/02	9	3	1	3	136	5	0	5
	10/24/02	9	0	0	3	282	4	2	6
	1/9/03	9	0	0	3	37	5	1	5
	3/6/03	6	0	0	3	63	3	0	3
	6/16/03	6	0	0	3	54	5	0	5
	8/5/03	9	1	1	3	142	5	0	5
	10/22/03	9	1	1	3	181	5	2	6
	12/3/03	6	0	0	3	22	2	0	2
Mission Trails Regional Park, San Diego River (Padre Dam)	6/24/02	6	0	0	3	260	5	0	5
Mission Trails Regional Park, Shephards Pond	7/14/03	9	0	0	3	17	4	0	4
Mission Valley, San Diego River (First San Diego River Improvement Project (FSDRIP))	5/16/02	0	0	0	3	44	2	0	2
Otay Mountain, Cedar Canyon	7/31/02	12	0	0	3	163	7	1	7
Otay Valley Regional Park, Upper Canyon	7/15/03	0	0	0	3	65	7	0	7
Rancho Jamul Ecological Reserve (Jamul Creek)	5/6/02	9	0	0	3	77	6	0	6
San Diego National Wildlife Refuge, Sweetwater River (Campbell Lane)	12/11/02	15	0	0	3	2	1	1	1
San Diego National Wildlife Refuge, Sweetwater River (URDS)	6/4/02	6	3	3	3	119	6	1	7
	8/8/02	9	4	2	3	222	7	1	7
	10/10/02	9	0	0	3	84	6	1	7
	11/14/02	3	0	0	3	83	6	0	6
	1/29/03	6	1	1	3	11	4	1	4
	3/26/03	6	0	0	3	43	5	1	6
	5/29/03	6	0	0	3	73	7	0	7
	8/4/03	3	0	0	3	155	7	1	7
	10/14/03	6	1	1	3	33	5	1	5
	12/18/03	0	0	0	3	48	4	0	4
San Pasqual Valley	7/23/03	12	0	0	3	107	7	1	8
Sweetwater County Park, Morrison Pond	6/26/03	9	1	1	3	193	3	0	3
	8/18/03	6	0	0	3	636	4	2	5
	10/16/03	6	0	0	3	518	2	1	3
Sycamore Canyon / Gooden Ranch Open Space Preserves	5/14/02	12	1	1	3	83	4	0	4
Sycuan Peak Ecological Reserve, Lawson Creek	6/11/02	15	0	0	3	44	7	1	7
Sycuan Peak Ecological Reserve, Sweetwater River	5/23/02	12	1	1	3	104	6	1	7
	Totals	840	143	61	240	8697	386	53	428
	Means	10.50	1.79	0.76	3.00	108.71	4.83	0.66	5.35

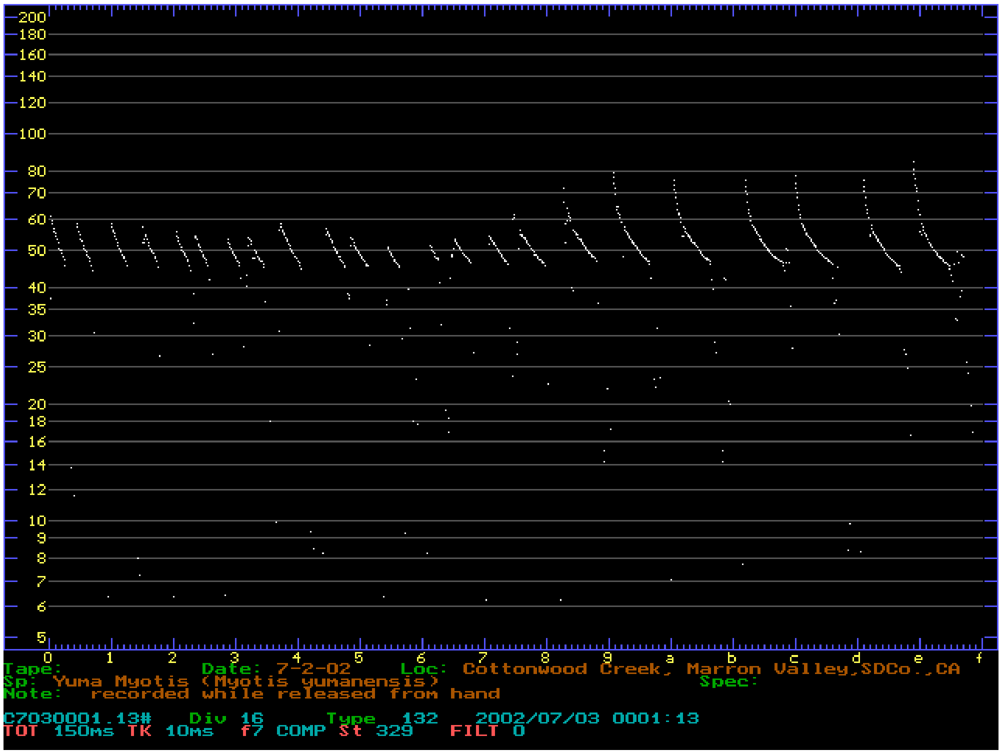
Appendix II (cont.). Foraging Bat data using combined techniques. Sites are listed alphabetically.

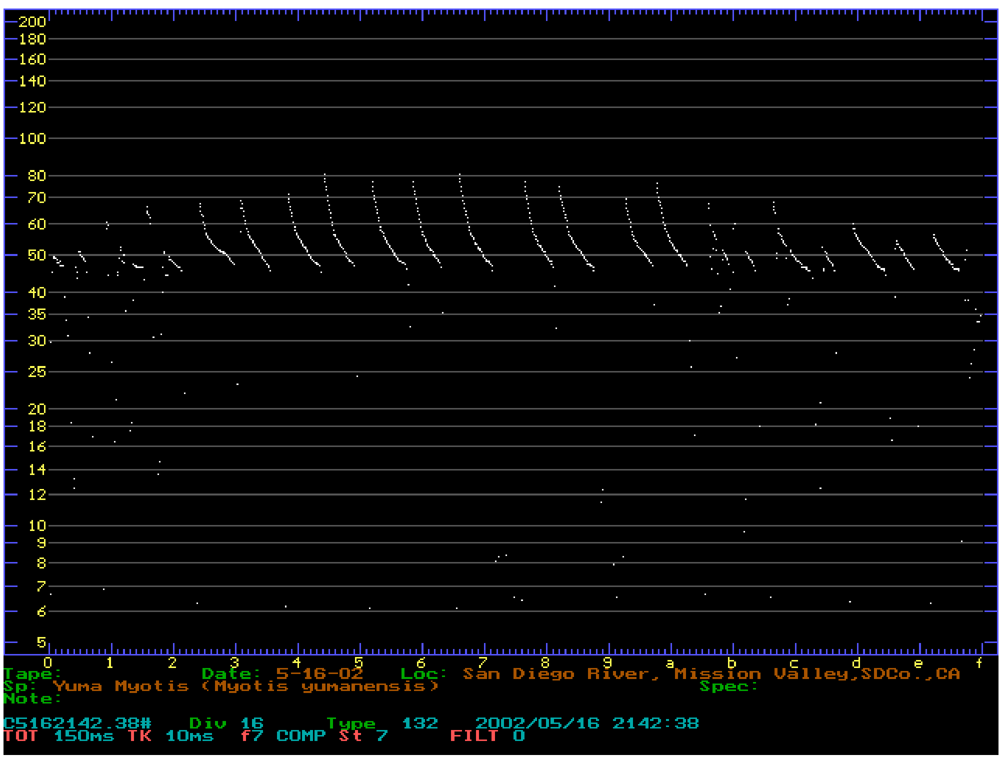




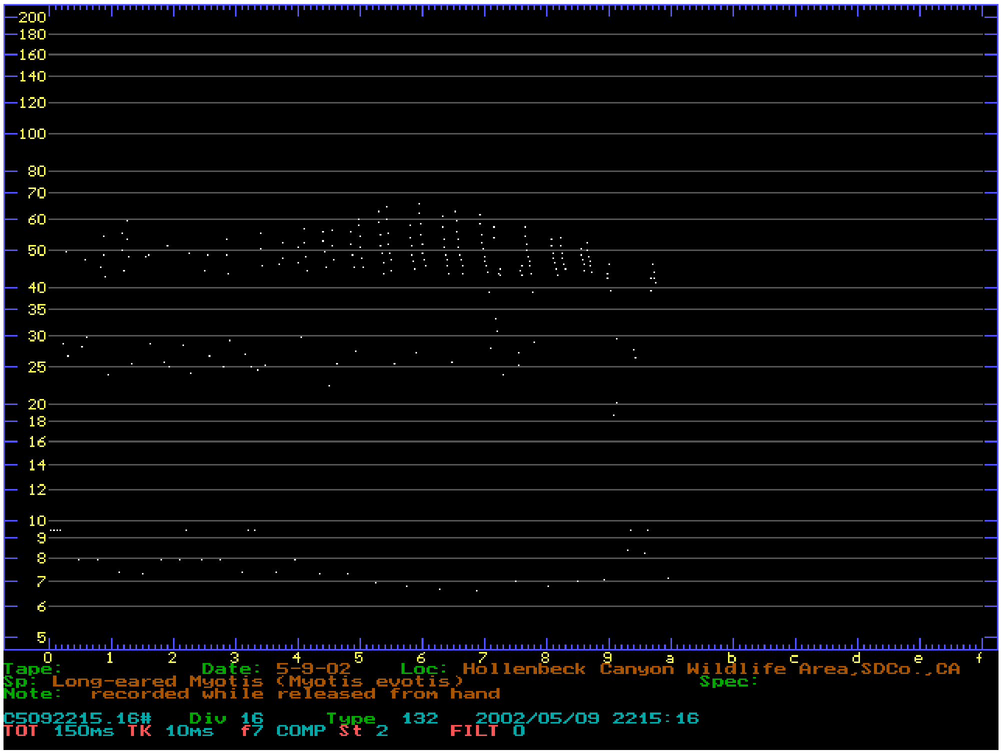
Appendix III. Representative Bat Vocalizations.

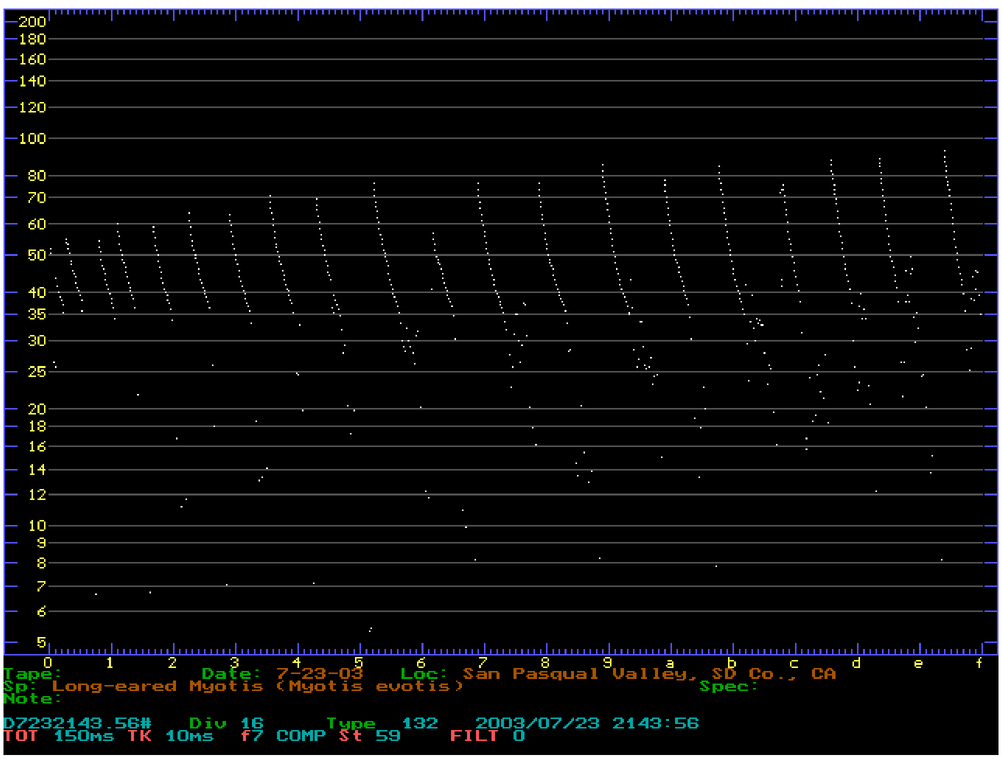
A (top) and B (bottom): Mexican long-tongued bat (*Choeronycteris mexicana*) vocalizations recorded as bats released from the hand.



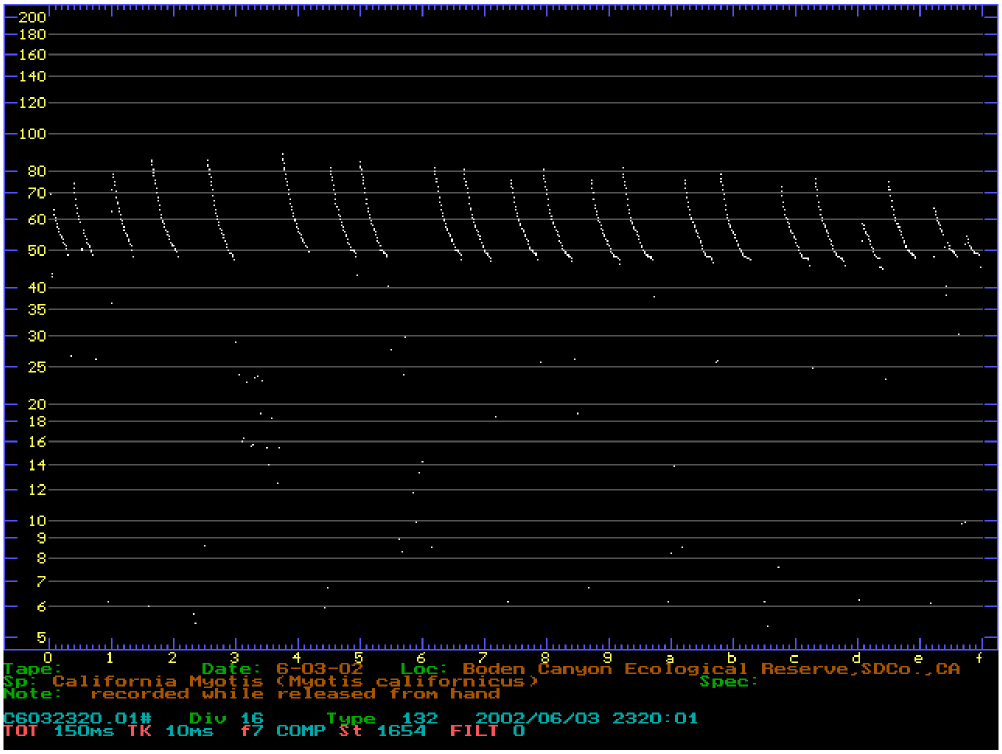


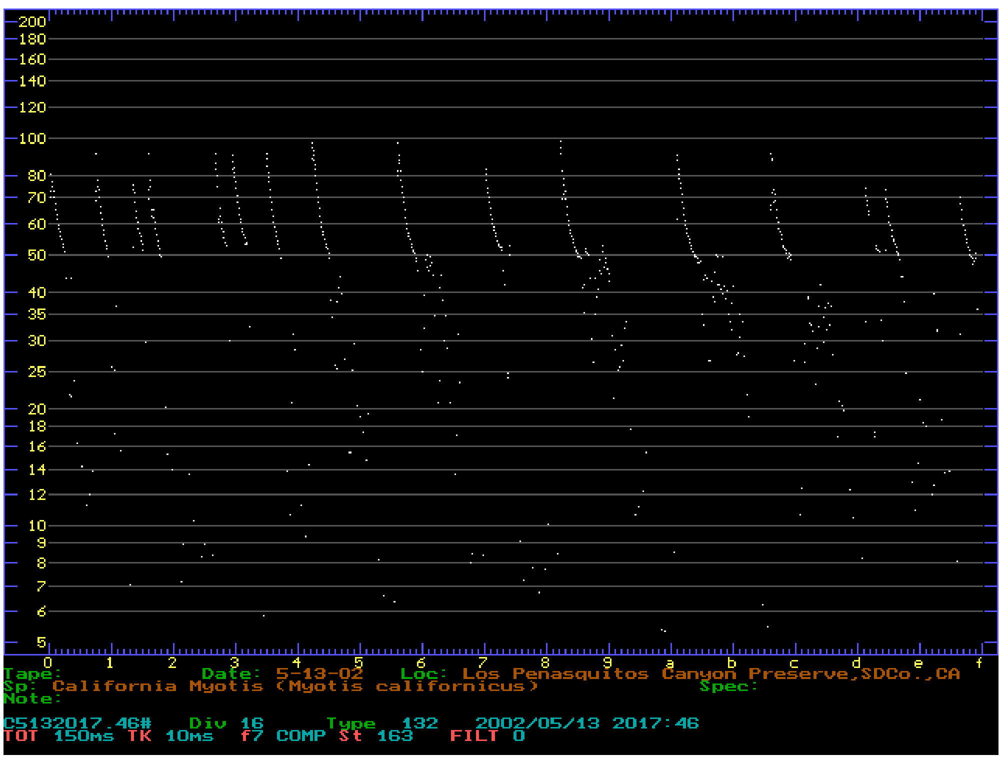
C (top): Yuma myotis (*Myotis yumanensis*) vocalization recorded as bat released from hand. D (bottom): Yuma myotis (*Myotis yumanensis*) vocalization recorded at foraging bat site along San Diego River in Mission Valley.



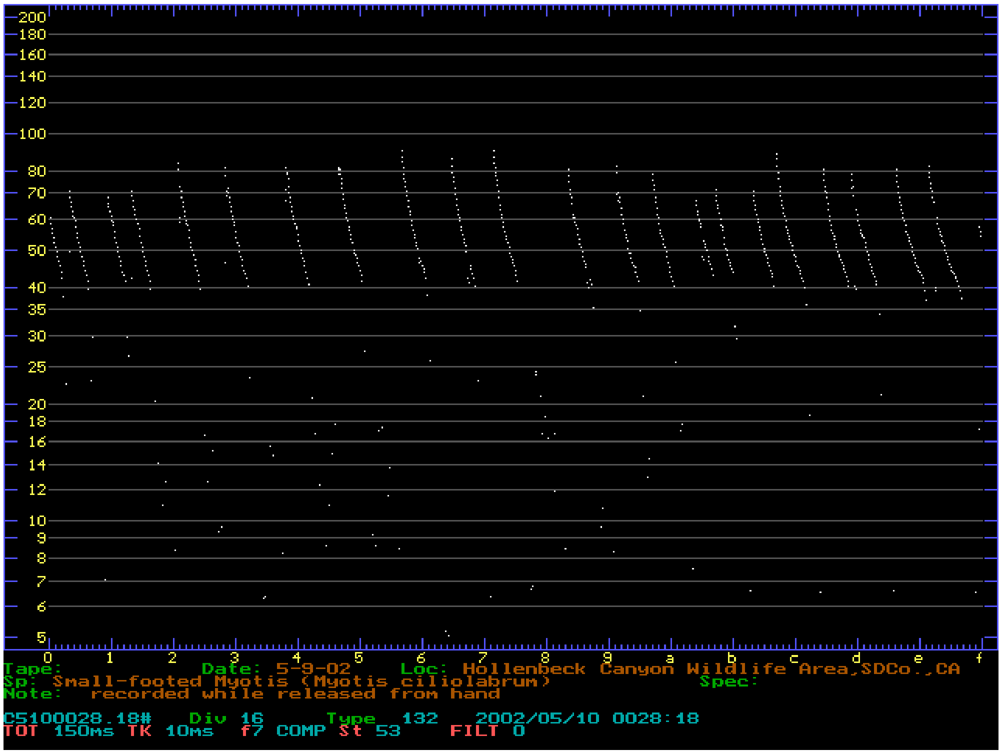


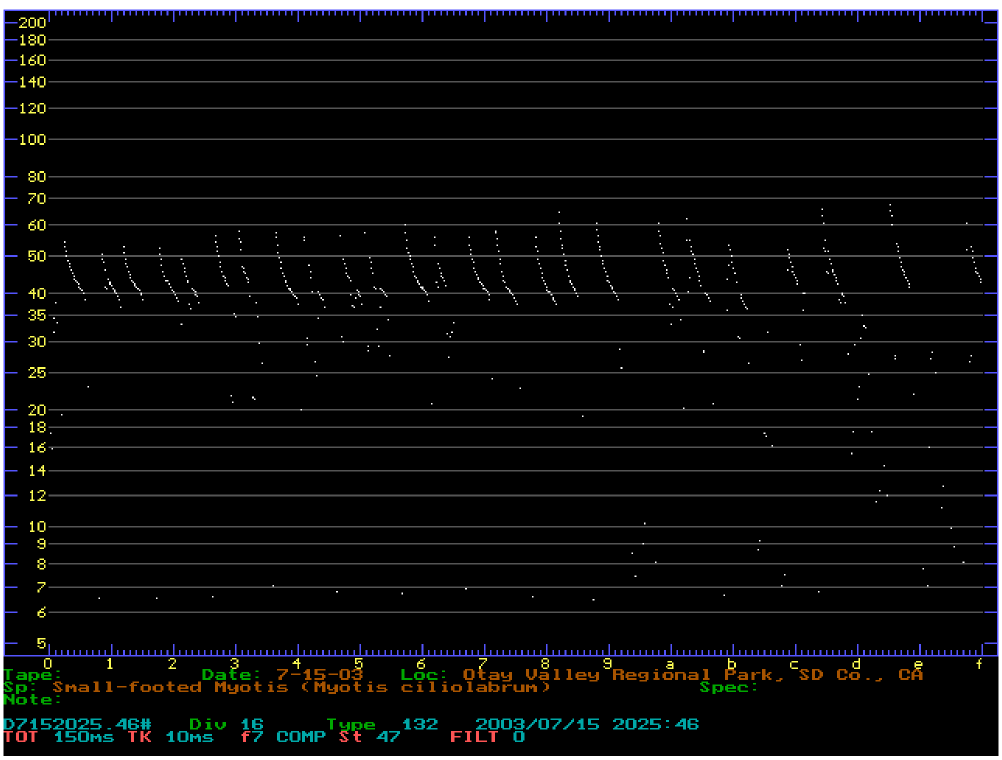
E (top): Long-eared myotis (*Myotis evotis*) vocalization recorded as bat released from hand. F (bottom): Long-eared myotis (*Myotis evotis*) vocalization recorded at foraging bat site in San Pasqual Valley. In this example, the vocalization recorded during hand release was a low quality recording, and does not adequately represent this species' typical foraging vocalization.



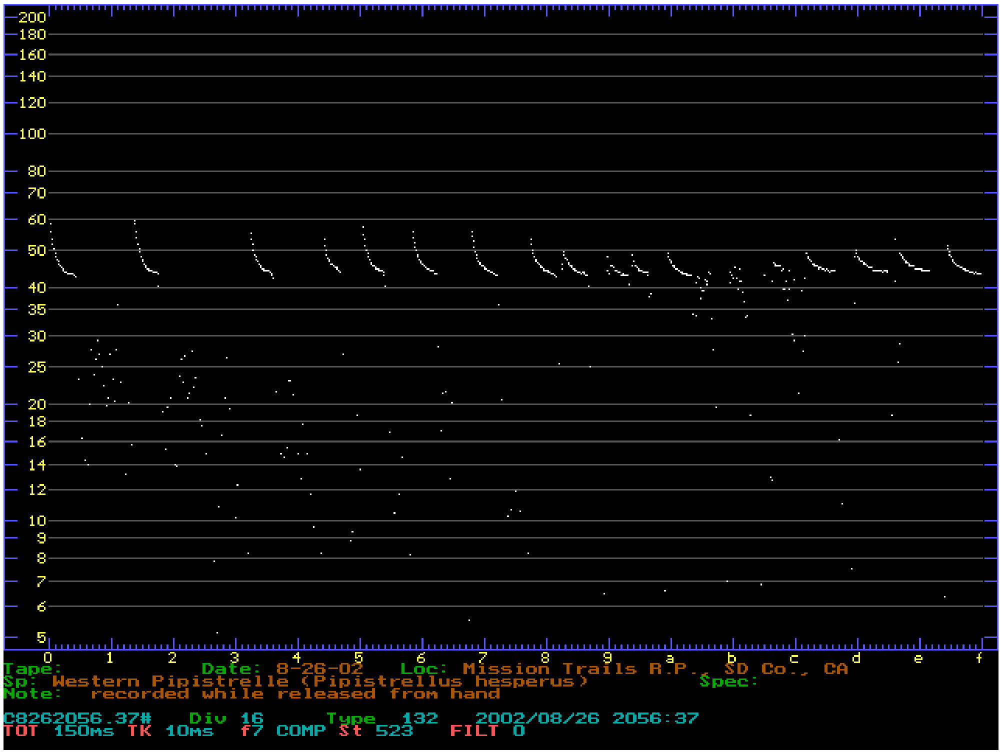


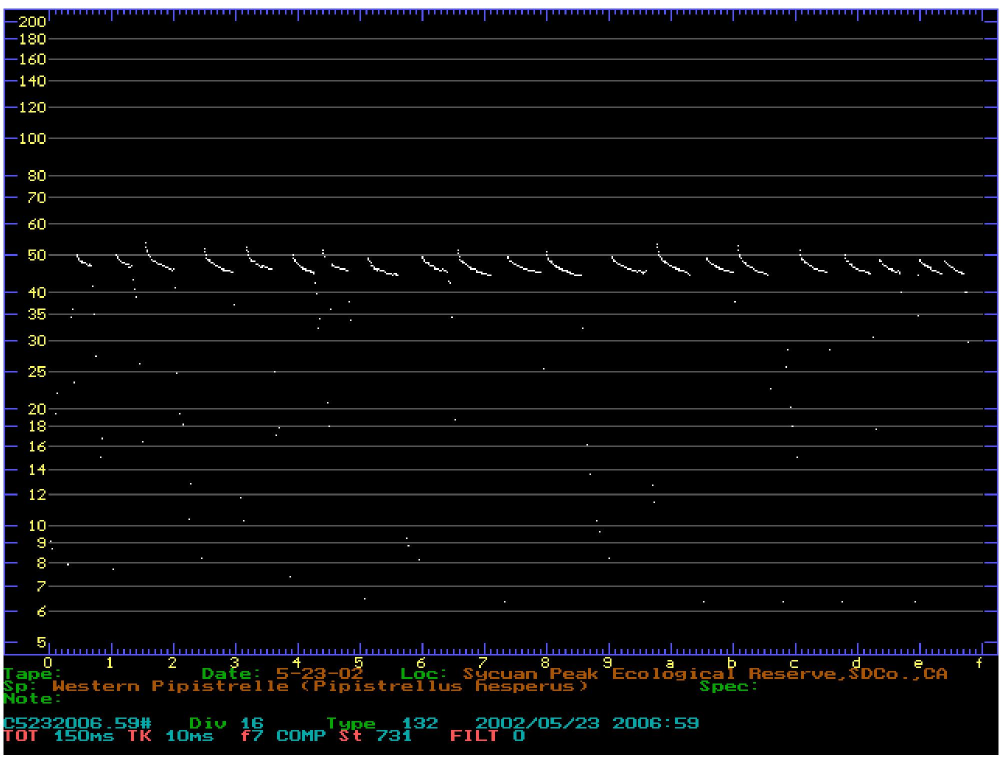
G (top): California myotis (*Myotis californicus*) vocalization recorded as bat released from hand. H (bottom): California myotis (*Myotis californicus*) vocalization recorded at foraging bat site in Los Penasquitos Canyon Preserve.



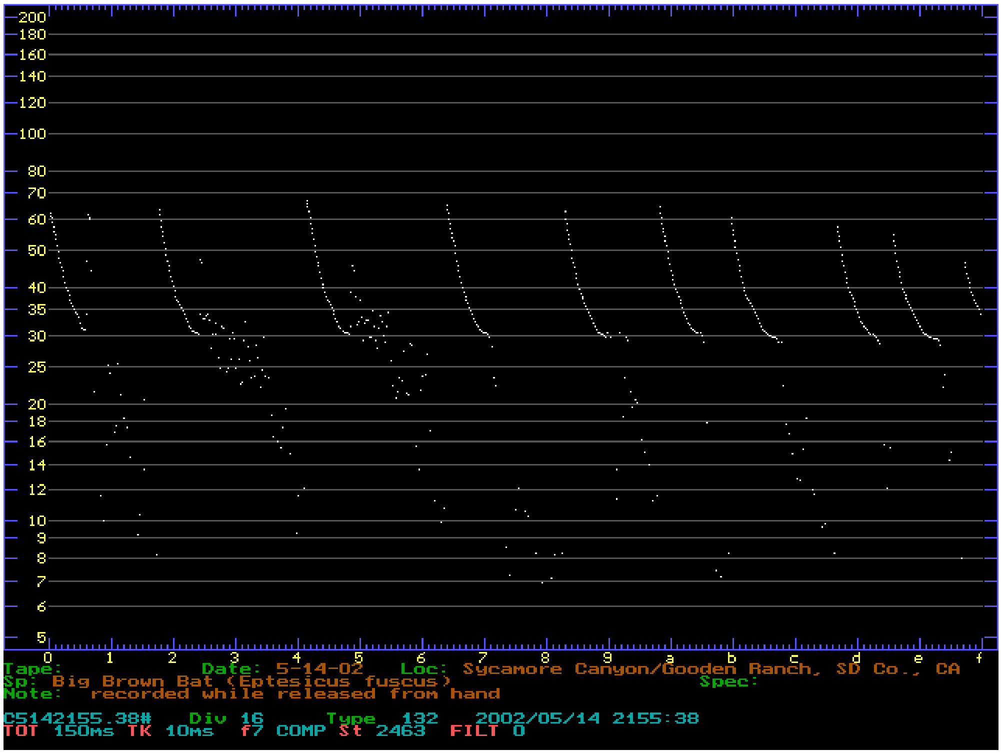


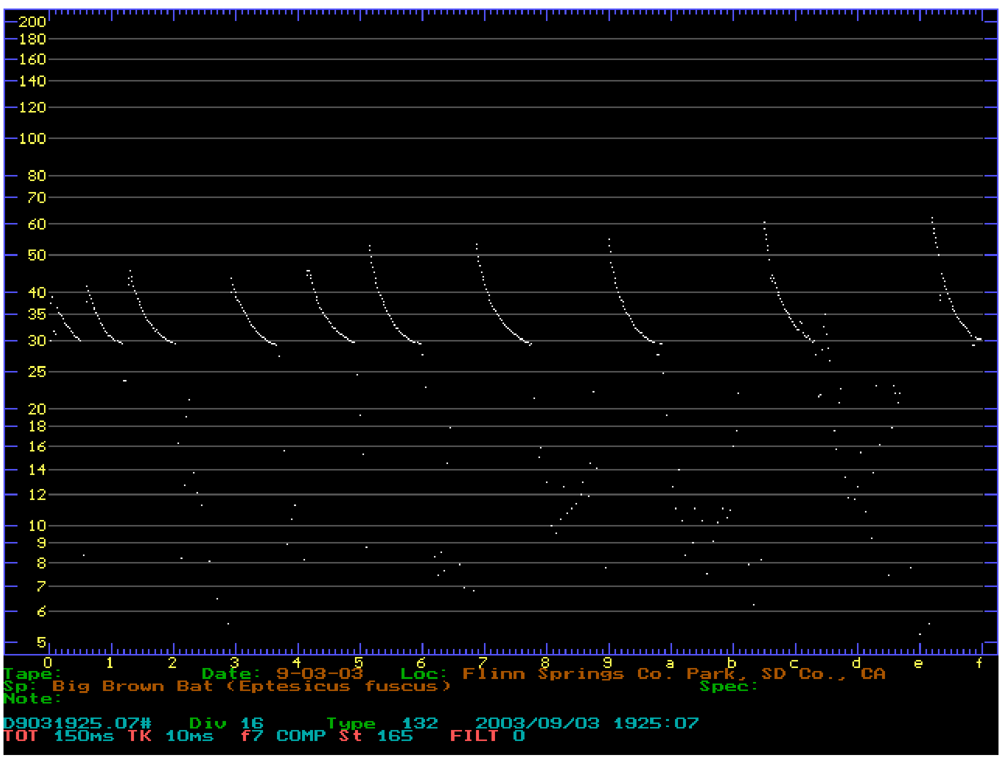
I (top): Western small-footed myotis (*Myotis ciliolabrum*) vocalization recorded as bat released from hand. J (bottom): Western small-footed myotis (*Myotis ciliolabrum*) vocalization recorded at foraging bat site in Otay Valley Regional Park.



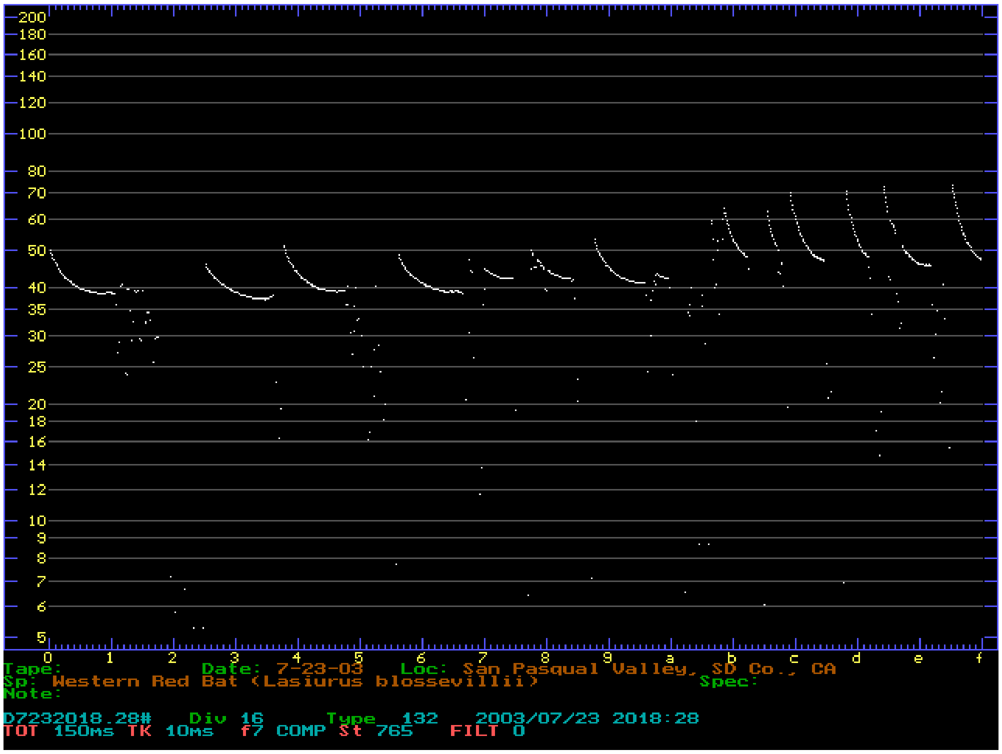


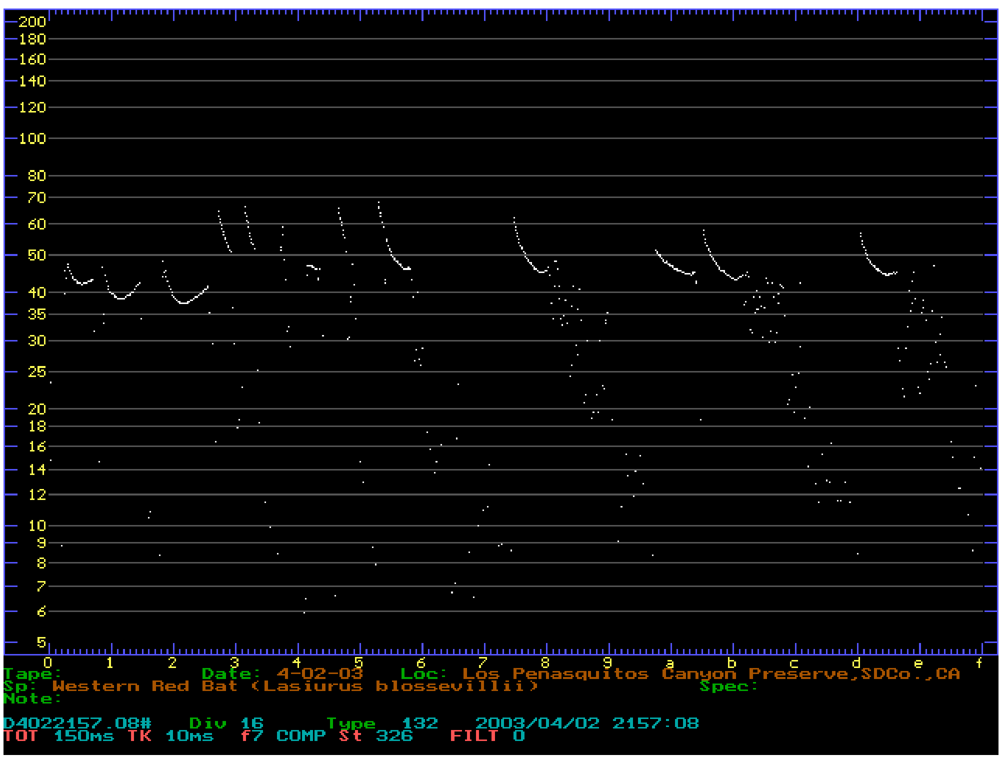
K (top): Western pipistrelle (*Pipistrellus hesperus*) vocalization recorded as bat released from hand. L (bottom): Western pipistrelle (*Pipistrellus hesperus*) vocalization recorded at foraging bat site in Sycuan Peak Ecological Reserve.



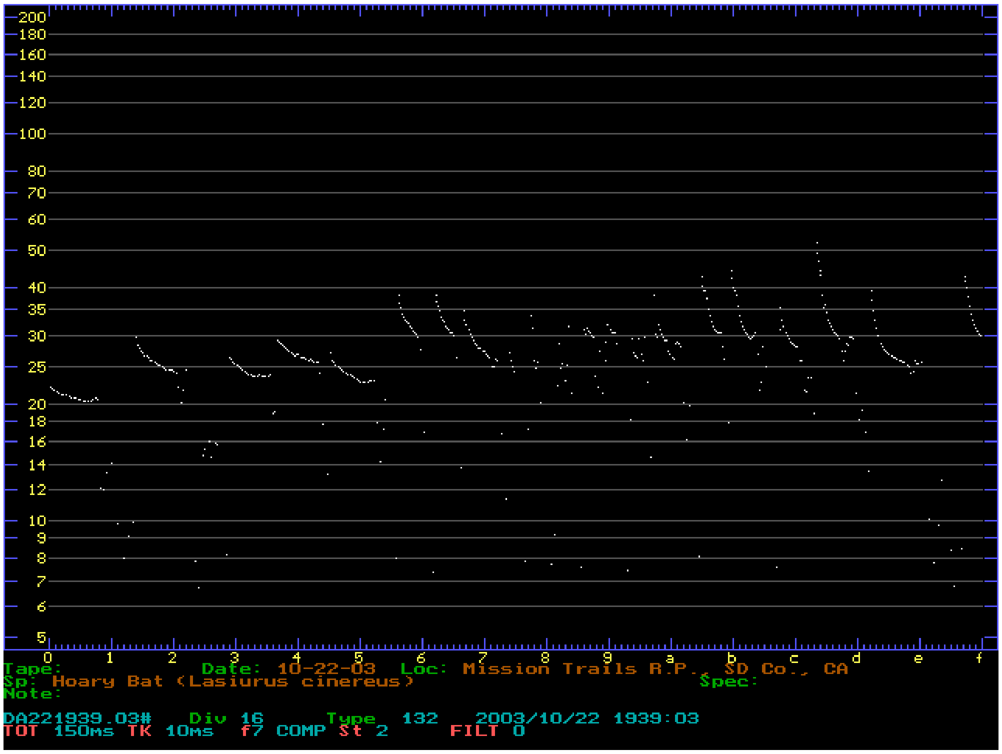


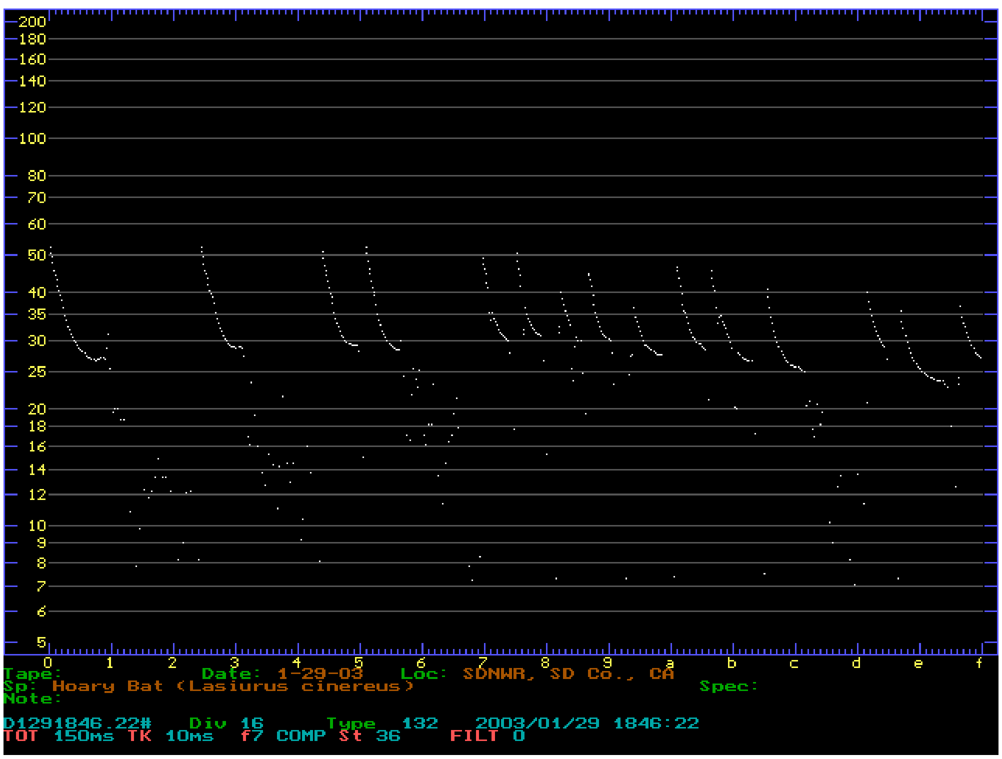
M (top): Big brown bat (*Eptesicus fuscus*) vocalization recorded as bat released from hand. N (bottom): Big brown bat (*Eptesicus fuscus*) vocalization recorded at foraging bat site in Flinn Springs County Park.



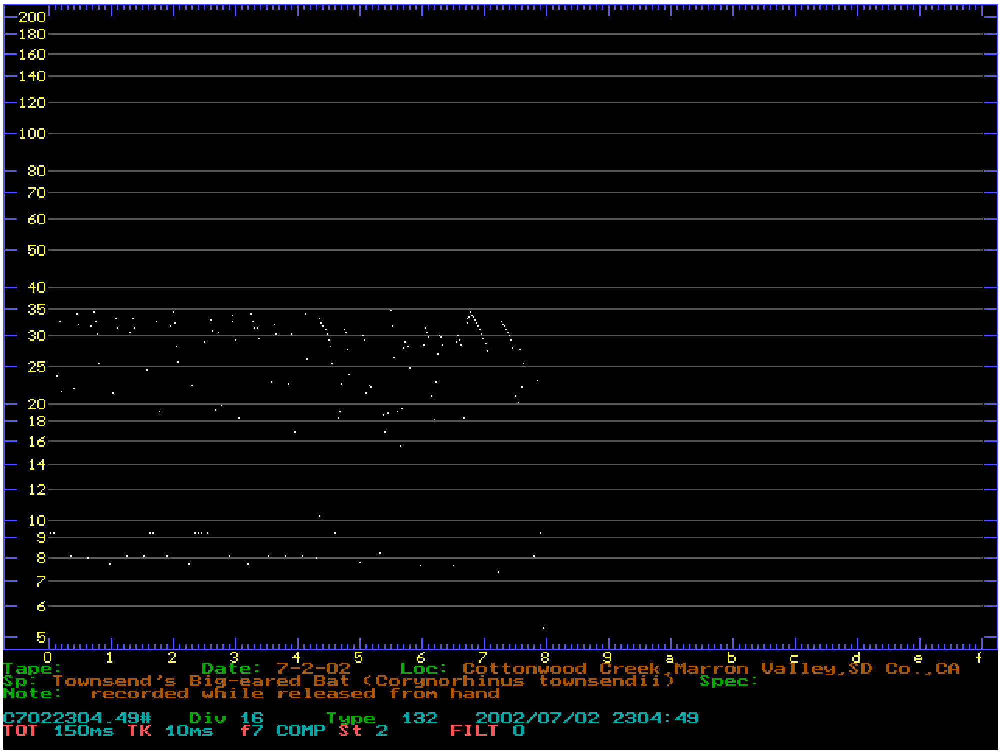


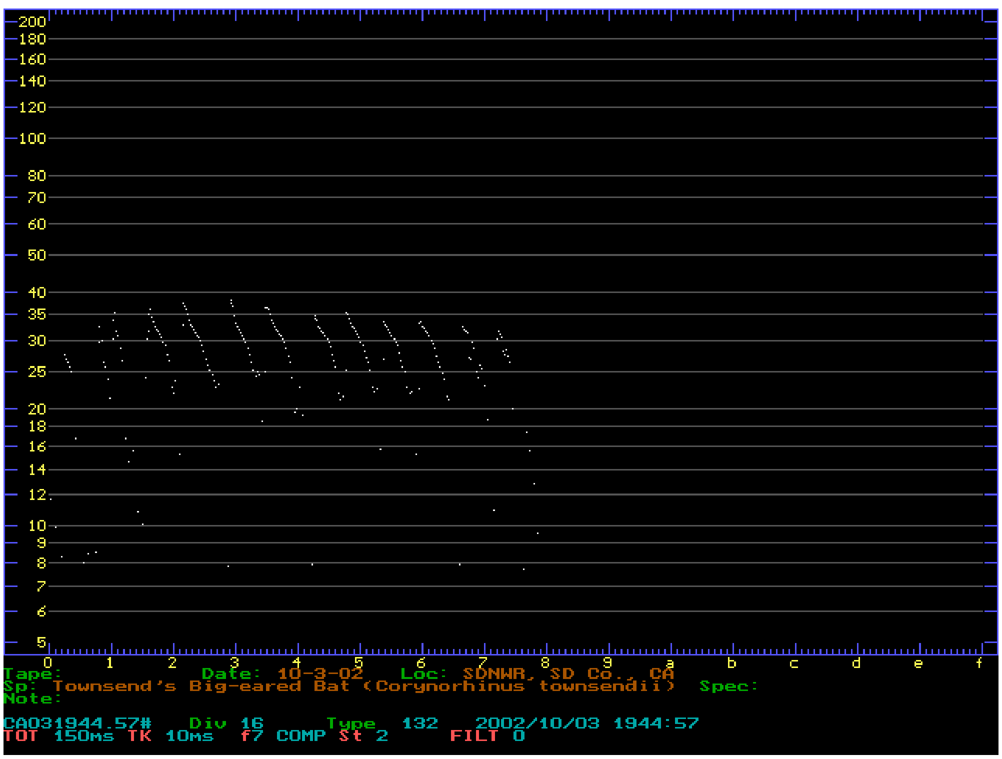
O (top) and P (bottom): Western red bat (*Lasiurus blossevillii*) vocalizations recorded at foraging bat sites in San Pasqual Valley and Los Penasquitos Canyon Preserve. Usable hand release vocalizations for this species were not recorded.



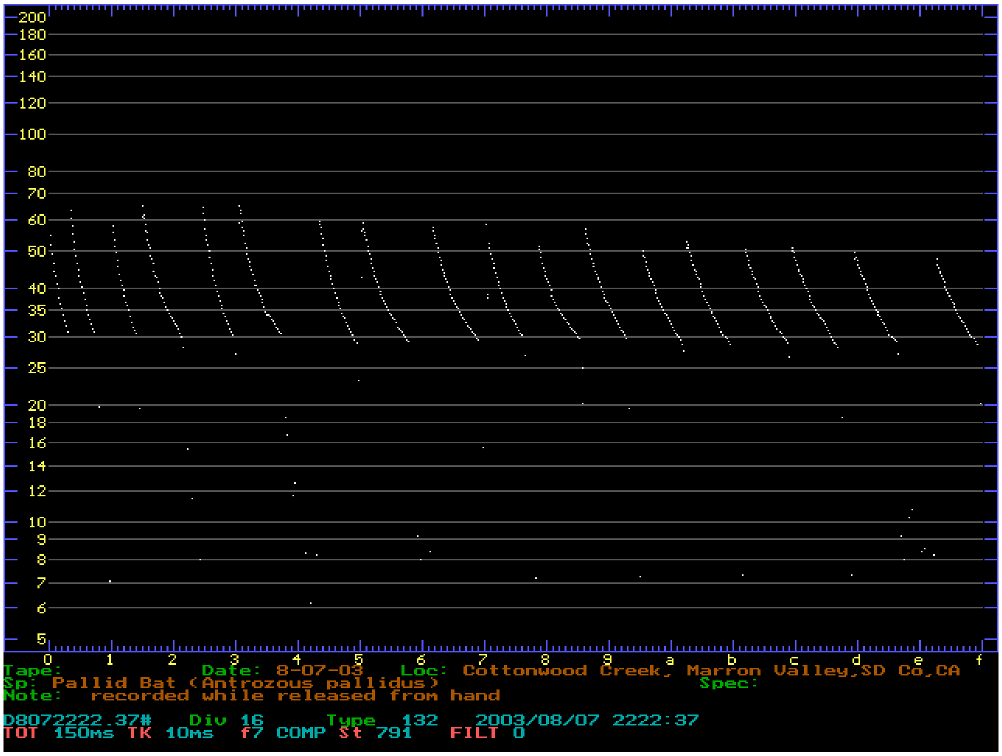


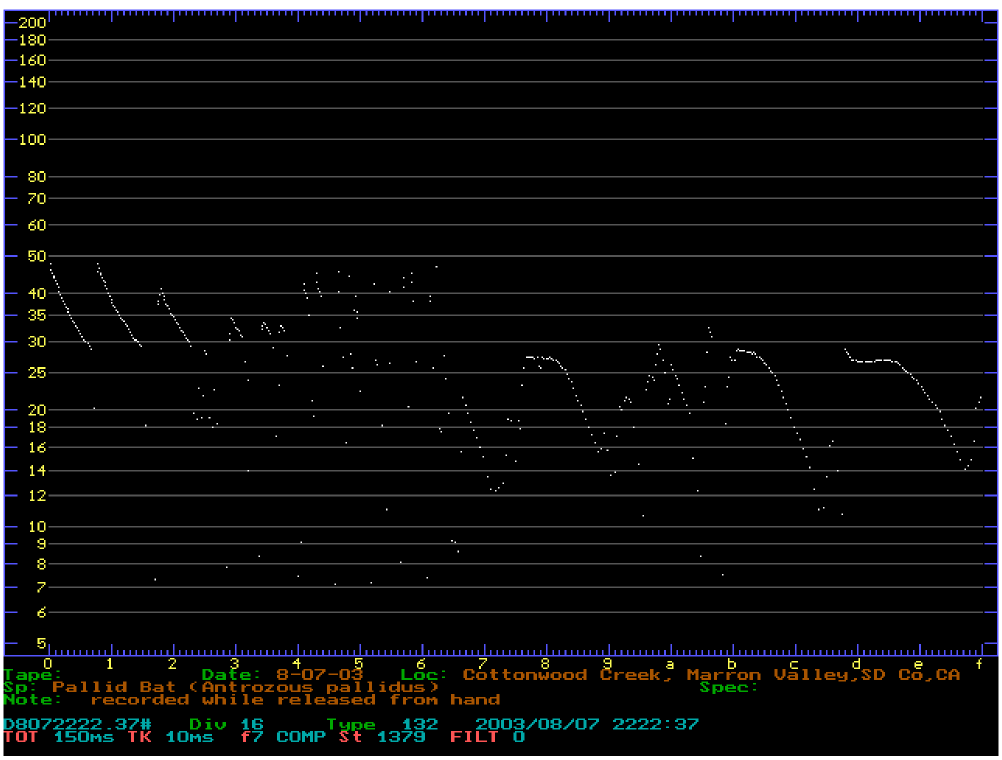
Q (top) and R (bottom): Hoary bat (*Lasiurus cinereus*) vocalizations recorded at foraging bat sites in Mission Trails Regional Park and the San Diego National Wildlife Refuge. Usable hand release vocalizations for this species were not recorded.



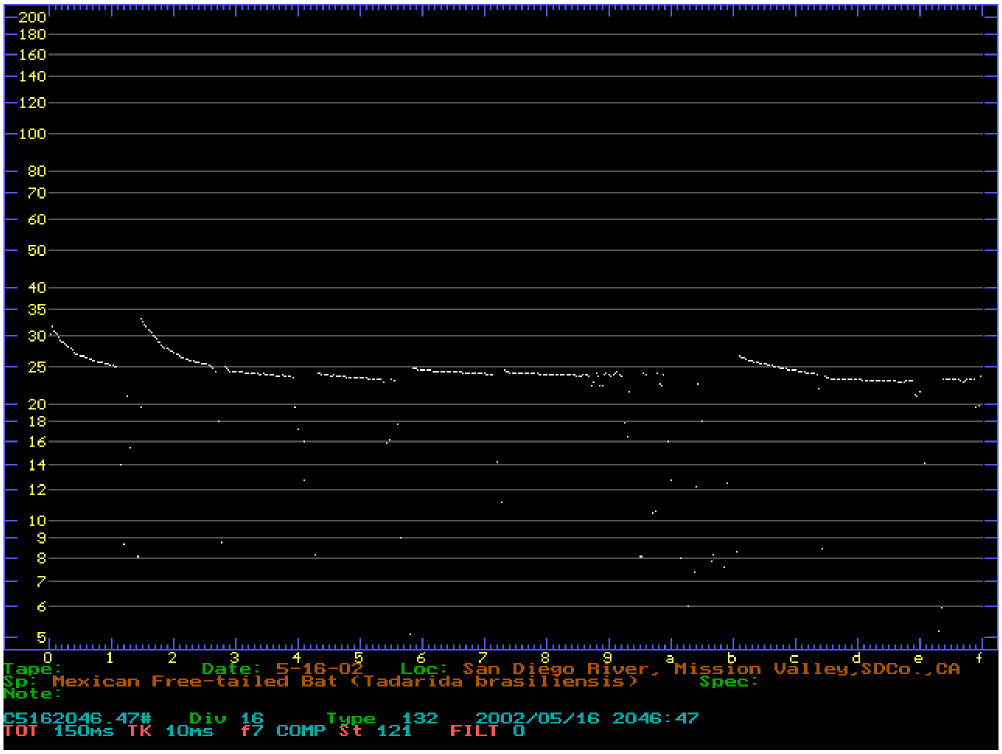


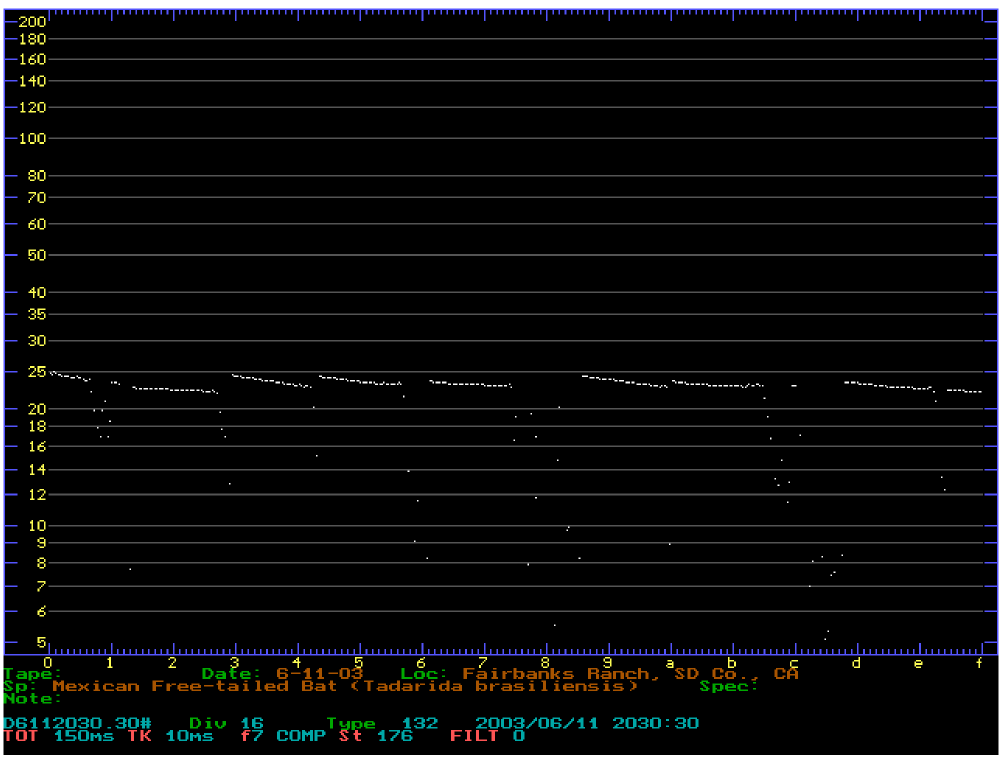
S (top): Townsend's big-eared bat (*Corynorhinus townsendii*) vocalization recorded as bat released from hand. T (bottom): Townsend's big-eared bat (*Corynorhinus townsendii*) vocalization recorded at roosting bat site in the San Diego National Wildlife Refuge.



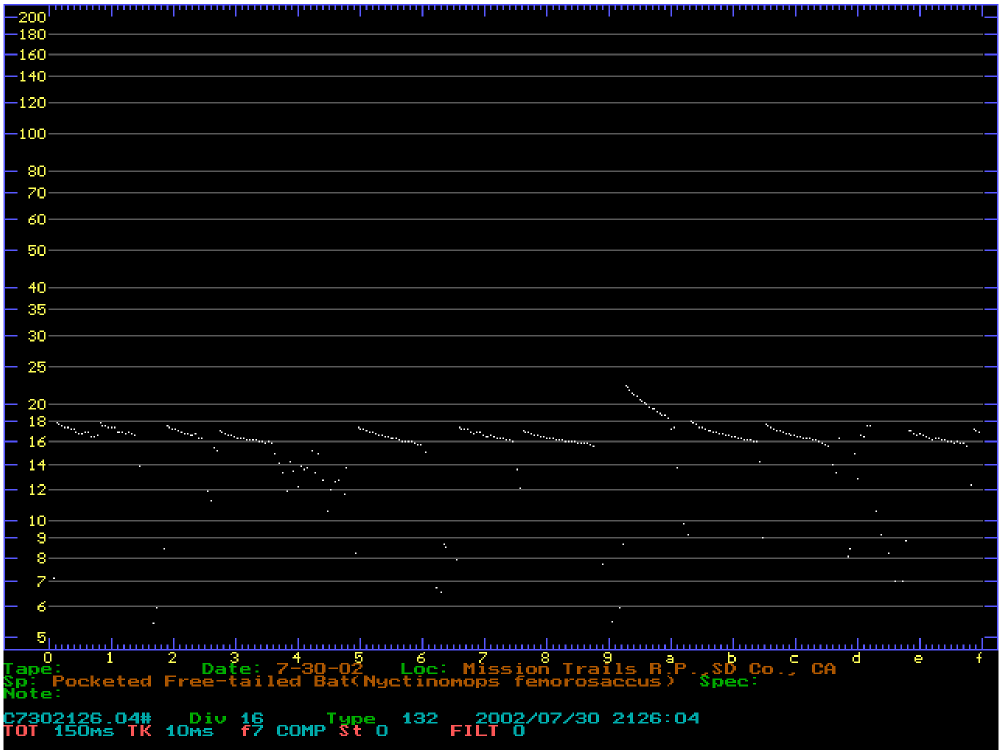


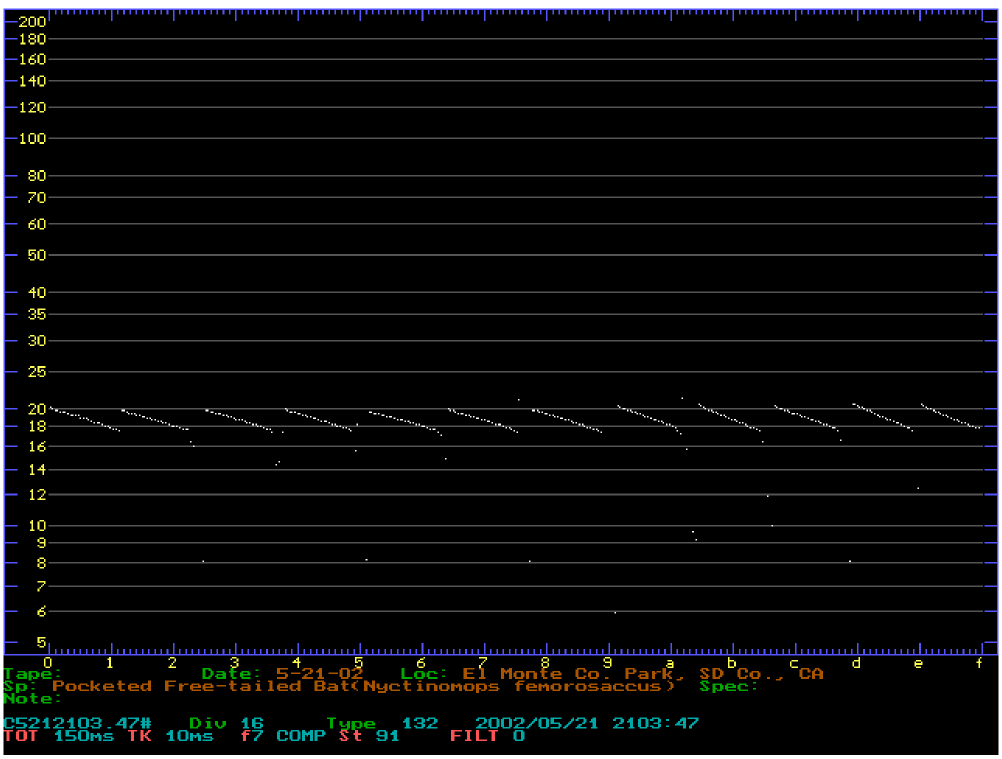
U (top) and V (bottom): Pallid bat (*Antrozous pallidus*) vocalizations as bat released from hand. The bottom screenshot is a continuation of vocalization in the top screenshot. Notice the low frequency sweeps at the end of the call sequence in bottom figure. These are social calls that are audible to most humans; they sweep below the level of ultrasound (approximately 20 kilohertz).



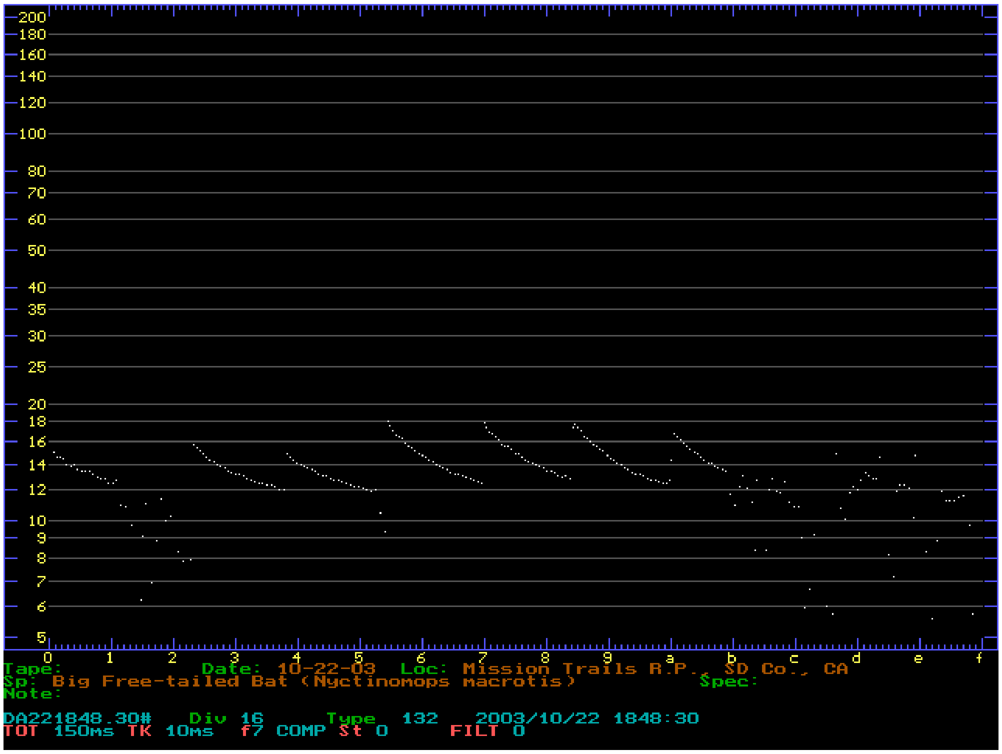


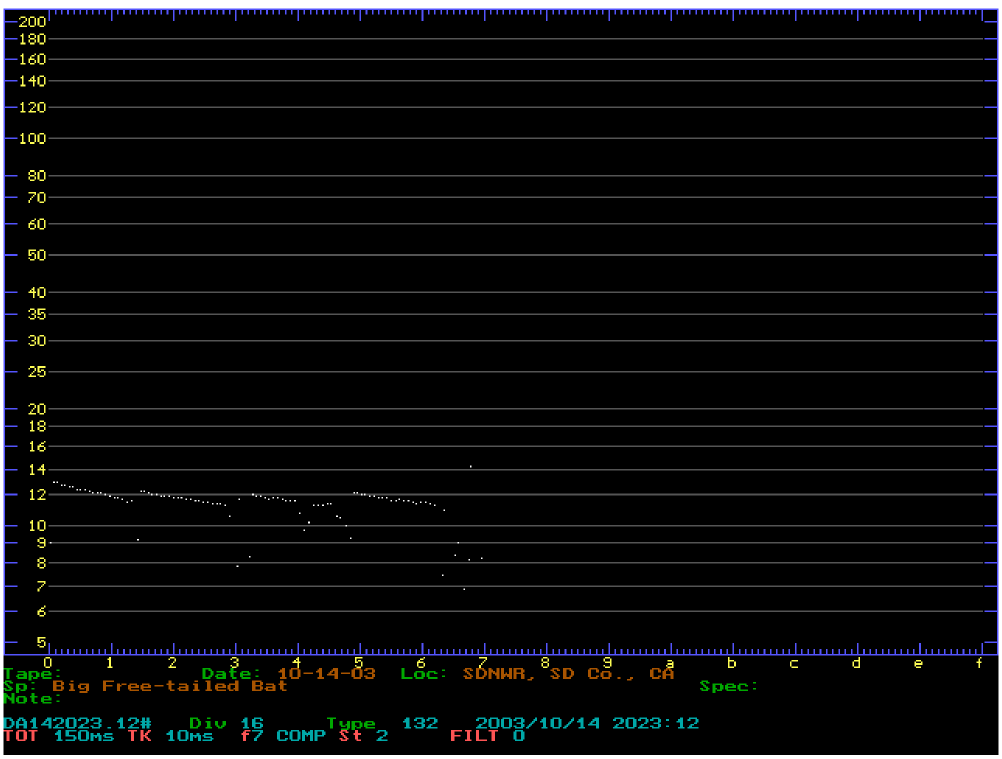
W (top) and X (bottom): Mexican free-tailed bat (*Tadarida brasiliensis*) vocalizations recorded at foraging bat sites along the San Diego River in Mission Valley and at Fairbanks Ranch. This species was not captured during this study; therefore, we do not have representative hand release vocalizations to present here.



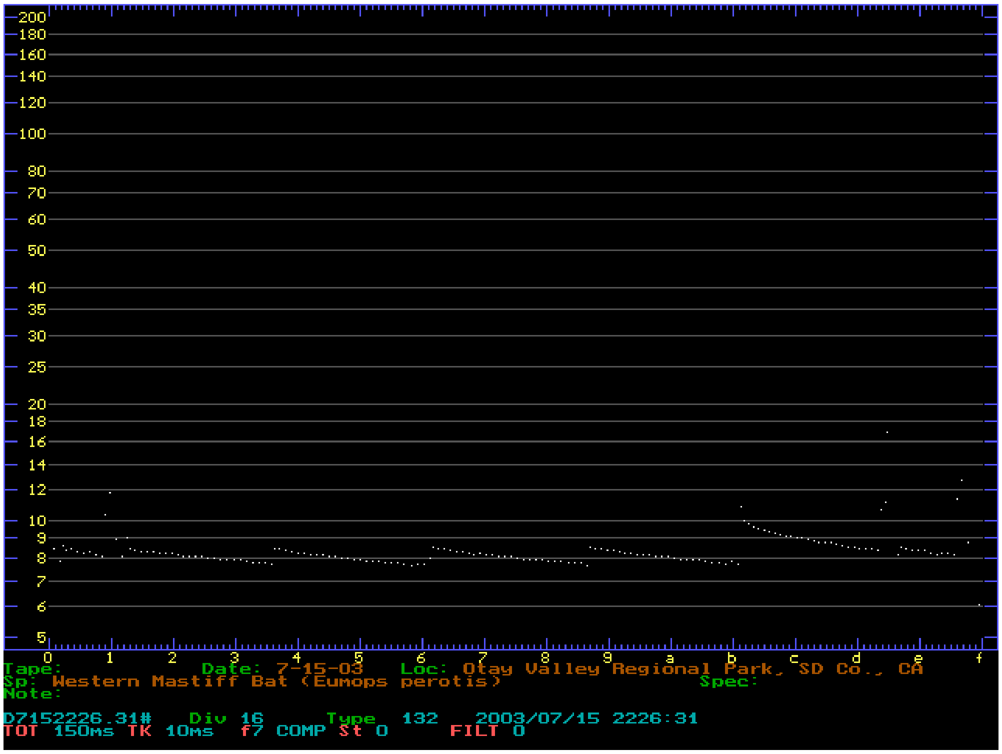


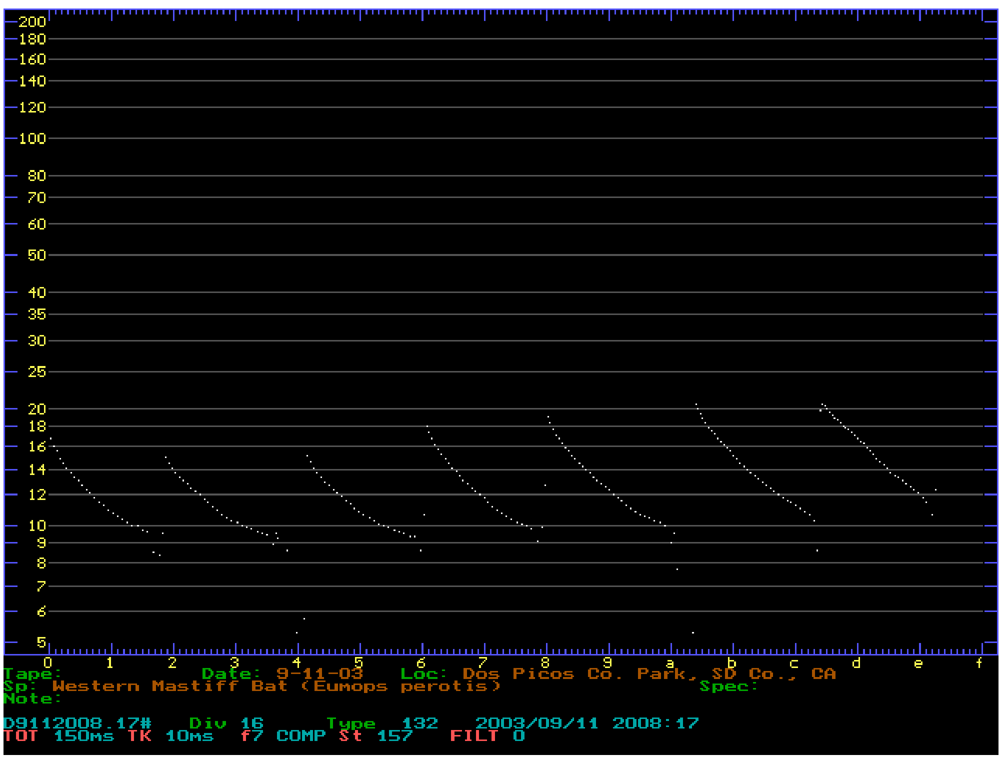
Y (top) and Z (bottom): Pocketed free-tailed bat (*Nyctinomops femorosaccus*) vocalizations recorded at foraging bat sites in Mission Trails Regional Park and El Monte County Park. This species was not captured during this study; therefore, we do not have representative hand release vocalizations to present here.





AA (top) and AB (bottom): Big free-tailed bat (*Nyctinomops macrotis*) vocalizations recorded at foraging bat sites in Mission Trails Regional Park and in the San Diego National Wildlife Refuge. This species was not captured during this study; therefore, we do not have representative hand release vocalizations to present here.





AC (top) and AD (bottom): Western mastiff bat (*Eumops perotis*) vocalizations recorded at foraging bat sites in Otay Valley Regional Park and in Dos Picos County Park. This species was not captured during this study; therefore, we do not have representative hand release vocalizations to present here. The top vocalization represents a bat foraging in open, uncluttered habitat while the bottom vocalization represents the same species altering its call while foraging closer to structure.