Distribution, Habitat Associations, Status, and Survey Methodologies for Three Molossid Bat Species *(Eumops perotis, Nyctinomops femorosaccus, Nyctinomops macrotis)* and the Vespertilionid *(Euderma maculatum)*

Final Report

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1.0. INTRODUCTION

The purpose of this study was to examine the California distribution, habitat associations, and current status of four poorly known bat species considered Mammal Species of Special Concern: three molossids (the western mastiff bat, *Eumops perotis,* the pocketed free-tail bat, *Nyctinomops femorosaccus,* and the big free-tailed bat, *Nyctinomops macrotis),* and one vespertilionid (the spotted bat, *Euderma maculatum).* All four are cliff-dwelling species that have e substantially overlapping distributions. The primary focus was on the molossids, particularly *E. perotis,* with information on *E. maculatum* being gathered at the same time in areas of distributional overlap. An additional goal of this study was to explore survey methods for these species, which share the unusual trait among bats that their echolocation falls largely within the range of human hearing. The report combines the results of two project phases conducted in 1991-1992 and in 1993-1995.

2.0. SURVEY METHODOLOGY

2.1. Distributional Surveys

Locality records were obtained from over 40 museums and other sources in California and elsewhere (see Appendix I). Colonial roosting sites for *E. perotis* and *N. femorosaccus,* identified from museum records and the literature, were visited to establish their current status. (No roost sites were known for *N. macrotis* or *E. maculatum).* If a roost had been destroyed or bats no longer occupied the site, the area was surveyed to determine if the species was still present in the vicinity of the former roost. This was done by searching for alternate roost sites and/or monitoring acoustically for foraging animals. Most available evidence indicates that, with the exception of mother-young pairs, *E. maculatum* roosts solitarily, so that roost searches were not expected to detect this species.

Although in areas with extensive vertical rock features, searching on the ground for roost sites can be labor intensive, roosts can sometimes be visually identified at a distance by yellow/white/tan urine deposits below the occupied crevice. Such stains are more obvious on some rock types, and should be examined where possible at close range, since colonies of other cliff-crevice dwelling vertebrates (including a more common molossid bat, *Tadarida brasiliensis,* and the white-throated swift, *Aeronautes saxatalis)* and seasonal water seepage can produce similar deposits. It should be emphasized that colonies of *Eumops* and *Nyctinomops* may be present in crevices with no evident external stains. An occupied or recently occupied roost may have an accumulation of guano below the crevice, but degradation by rain or seepage, insect activity, intervening inaccessible ledges which act as traps, or simply sufficient height for extensive wind dispersion all lessen detectibility. *E. perotis* guano is distinguishable from other cliff bat guano by the combination of large size and stubby fusiform shape. If the roost is occupied at the time of survey, audible vocalizations of this species, particularly as dusk approaches, makes their location obvious if observers are within 50-100 m of the site.

There were also a number of locality records for which the roost site was unknown. In such cases, the area was surveyed for the presence of animals using acoustic techniques (see Section 2.2. below).

Given the apparent dependence of all the target species on vertical fractured rock features for roosting sites, it was hypothesized that their distribution is geomorphically determined and that sites with high potential as roosting areas could be efficiently identified by aerial survey. Two aerial surveys searched for potential roost sites, focussing on the northern margins of the range of *E. perotis.* One covered portions of the Coast Range from Alameda County south along the hills rimming the Central Valley to Coalinga and returning north along the west side of the Salinas

Valley. A second survey followed the Coast Range north from the Sacramento San Joaquin delta, along the western rim of the Central Valley north to Red Bluff, and then south along the Sierra foothills before continuing west across the Sutter Buttes. Seventeen potential roosting areas were identified, and those that appeared most promising were examined on the ground.

Because they favor similar steep, unvegetated faces, there is a correlation between roosting sites for some raptors, particularly prairie and peregrine falcons, and these bat species, particularly *E. perotis* and *E. maculatum*. A number of the roosting sites for these two species also have falcon aeries. Similarly, it has been noted that *E.perotis* will roost in crevices close to (or the same as) those occupied by white-throated swifts (Johnson and Johnson 1964, Collins 1973). Thus we used information regarding the distribution of these birds species as a guide to potential roosting sites for bats.

2.2. Acoustic Surveys

2.2.1. Historical Context

General recognition that bats rely on echolocation for prey detection and ranging is remarkably recent (Griffin and Galambos 1941). Acoustic monitoring thus offered a new means to examine the poorly known world of bats (e.g., species identification, numbers of animals present in an area, diurnal and seasonal patterns of activity) (Fenton and Bell 1981, Fenton *et al.* 1987, Thomas and West 1989). These investigations were initially severely constrained by technology. Equipment for direct recording or down conversion of ultrasound was complex and heavy, difficult to use in the field, and required substantial technical sophistication to operate. As a consequence, field recordings were typically limited to a few pulses per individual bat detected. This (and perhaps the presumption that bat calls could be analogous to bird song in typically being species specific) lead to simplified categorical presentation of bat call traits in which each species is represented diagrammatically by a single pulse (Fenton 1982). With the acquisition of larger samples, cautionary papers emerged, focusing on the difficulties of species recognition. They discuss regional variation for single species (Fenton and Bell 198 l), plus variation among and within individuals (Thomas *et al.* 1987). One study showed that the call variation among individuals of one species exceeded between species variation (Brigham *et al.* 1989). It thus emerged that acoustic identification for at least some species presented considerable challenges (Zingg 1990, Betts and Haynes 1994).

In the last few years the relatively ready availability of commercial bat detectors has fueled and supported an expanding interest in inventory work on bats in North America. This has involved some resurgence of simplified views of acoustic species identification (e.g., the presumption that most call sequences are assignable to species with little or no uncertainty). At the same time, increased sampling effort combined with better recording equipment and faster analytic methods has underlined early observations indicating that the simple structure of foraging bat echolocation pulses is often combined with considerable ecological flexibility (i.e., calls change structure depending on activity and foraging habitat). Acoustic identification challenges are especially great in the frequency range where several versatile species overlap, but near the limits of the range exploited by bats, where fewer taxa occur, the probability of identification improves.

2.2.2. Acoustic Detection with the Unaided Ear

All the species considered in this study echolocate in the audible range, generally from 4-20 kHz. Because attenuation with distance is less at audible frequencies (Lawrence and Simmons 1982), bat calls can be detected at greater distances than ultrasonic calls of comparable intensity. An additional advantage is that persons with undamaged (typically, youthful) hearing can hear these species with unaided ears. This audibility offers tremendous advantages for initial screening of a habitat. One can simply go to an area, without equipment, and listen.

This method should not be relied on for species identification, without considerable preparation. One, there is quite large variation in human hearing in this frequency range. Field experience indicates a wide range of variation among observers in their ability to detect audible bats when they are present (pers. obs., K. Navo pers, comm.). A common practice in surveying for owls is to require hearing tests for observers -- a measure that would certainly be appropriate for monitoring of audible bats. Second, there is considerable overlap in call structure and frequency range between among several of these species, making identification uncertain even when the call is recorded and displayed as a sonogram or a time frequency plot.

Although reports of "audible bats" can be extremely useful, and provide the basis for further investigation, positive species identification should be made from recorded calls, which can be reviewed and analyzed. A study by Fenton *et al.* (1987) illustrates the potential problems of relying on unrecorded calls for species identification. They examined the distribution of *E. maculatum* in the Western U.S. using acoustic techniques, but because they did not record calls, and failed to address the issue of distributional overlap with *E. perotis* (a species not mentioned in their list of other "audible" bats), their findings cannot be verified.

2.2.3 Choice of Acoustic Hardware and Analytic Software

Choosing equipment for acoustic surveys of "audible" bats presents some technical challenges. Their frequency range (5-20 kHz) lies at an inconvenient intersection: largely below the design range of most bat detectors, and extending too high to be recorded well by common analog cassette recorders. Virtually all bat detectors, including those in widest use (e.g., the broadband Anabat, or any of the several "mini" heterodyne detectors) incorporate high pass filtration, so that audible sounds (e.g., below about 15 kHz) are suppressed to exclude leaf rustling, insect calls or conversation by observers. Detectors with filtration can detect audible species, but typically only very loud calls at close range. To detect these species more consistently with a bat detector, it is necessary to lower the frequency of the high pass filter (which has the practical consequence of also increasing response to other audible sound sources). In general we have used a Pettersson D980 (Pettersson Elektronik AB, Tallbacksvagen 51, S-756 45 Uppsala, Sweden) with the roll-off frequency reduced to about 9 kHz, but also have employed other less complex detectors with altered high pass filters.

Another approach is to record directly (i.e., without frequency down conversion) with a tape recorder and audio range microphone. The difficulty with this approach is that inexpensive tape recorders rely on normal bias tape, which typically do not retain frequencies above about 9 kHz. The performance of moderately inexpensive audio microphones is a less serious constraint, but their response between 16-20 KHz is quite variable. We have concluded that the best compromise (cost, portability, frequency response) for direct recording is a consumer digital audio tape recorder (e.g., a Sony D8, DlOO, or Ml DAT), which retains signals up to 22 kHz. This will not retain, for example, the higher frequency portions of some calls of *Nyctinomops femorosaccus*, but will retain in real time most of the fundamental harmonic of calls of these four species.

Frequently we have combined several approaches. Using the Pettersson D980 detector coupled with a stereo DAT recorder, we record frequency down-converted calls onto one track in either frequency division or a digital time expand mode (Ahlen et al 1983), and simultaneously record untransformed calls from the bat detector microphone on the other channel. The time expand mode provides maximum detail for call analysis, but is episodic (3 second samples are expanded on output to 30 seconds) so that only a fraction of all calls heard can be recorded. Unfortunately for the system described, the anti-aliasing filters of the Sony D7 and D8 do not roll off sufficiently sharply to prevent spurious signals resulting from aliasing of loud bat calls slightly above 24 kHz. This can be avoided either by adding a supplemental antialiasing filter for direct recording from broad band bat detector microphones or by using an audio microphone which rolls off above 20 kHz. Recorded calls were analyzed by variety of methods, including both zero crossing analysis using the ANABAT ZCAIM module and software and preparation of sonograms using several audio programs with Fast Fourier analysis.

2.2.4. Acoustic Identification of Bat Species Included in This Study

The four species included in this study all lend themselves to survey by acoustic methods. All have moderate to high intensity, low frequency echolocation calls, that are frequently audible to the unaided ear. One goal of this study was to determine whether it was possible to discriminate among these four bat species on the basis of acoustic characteristics alone. When the study began echolocation calls of one species, *E. maculatum*, had been characterized in the literature (Leonard and Fenton 1984, Woodsworth *et al.* 1981). Although three papers described calls of *N. macrotis* (Fenton and Bell 1981, Schum 1972, Simmons *et al.* 1978), they were not in agreement, and it was unclear which, if any, provided an adequate characterization. The calls of the other two species, *E. perotis* and *N. femorosaccus*, beyond anecdotal descriptions, had never been characterized.

With the work to date, we have been able to obtain multiple recordings of known individuals in a number of different settings for *E. perotis*, *N. femorosaccus*, and *E. muculatum*, and recordings of calls which are ahnost certainly *N. macrotis* in a few localities. Based on these data we offer guidelines which, in many situations, can serve to discriminate among the species. These are offered, however, with a number of caveats, since discrimination between some pairs of species remains uncertain in some circumstances.

We cannot stress strongly enough the complicating factors which must be taken into consideration when attempting to identify bat species acoustically. The primary difficulty is that most species of bats (and this is especially true of molossids) (Simmons *et al.* 1978) have a varied vocal repertoire, and will alter the structure of their echolocation calls depending on their immediate environment. For the four species in question, the calls most likely to allow species identification are the open-air "search phase" echolocation calls. This presents somewhat of a conundrum, since the only way to establish base line data is to record known individuals. This can be done either by monitoring a roost known to contain one of these species, or to record individual animals upon release following a capture. There are three potential problems with relying on information gamed by monitoring an exodus from a roost. First, in areas of geographic overlap, the molossid species, particularly *E. perotis* and *N. femorosaccus,* can co-occur in the same roosts. We identified such a roost in Anza Borrego Park, and monitored one rock face in San Diego County that had at least three molossid species present. Secondly, the roosts for all these species are generally in canyon settings, where the the echolocation calls are altered to deal with a relatively confined environment, and often have a different structure from the open-air search phase calls. Third, in the vicinity of a roost, molossids in particular exchange extensive social vocalizations. These calls are extremely complex. With more examples and additional analysis, it may be possible to make species distinctions based on these calls, but it is not obvious at this point how to do this.

Hand release of known individuals is one of the best available ways to obtain reliably assignable call sequences. Unfortunately, most bats do not emit typical open air search phase calls immediately upon release. By the time they adopt an open air search phase call they may be out of range of the recorder/detector system, or can no longer can be separated from the other bats (possibly of other species) that may be flying in the area. Thus it is necessary to use a spotlight or attach a chemiluminescent tag (Buchler 1976) to the animal, and attempt to follow it in isolation from other bats to obtain what appears to be 'normal' call sequence.

Distinguishing among the four species in question is aided somewhat by geography. *N. femorosaccus* appears to be limited in its distribution primarily to southern California (Los Angeles basin and south -- see Section 4.3). Although the distribution of *N. macrotis* is less predictable (it could occur almost anywhere in California), it appears to be extremely rare, and is also found primarily in southern San Diego County (see Section 5.3). Thus, throughout much of California, the only two audible species one is likely to encounter are *E. perotis* and *E. maculatum.* As is explained below, it is possible in most (probably > 95%) circumstances to distinguish between these two species.

Guidelines for distinguishing among the species are given in Table 1. The primary characteristics that separate the species are the asymptotic minimum frequency of the search phase call and call duration. In general, all molossids (in California, *E. perotis, N. femorosaccus, N. macrotis,* and *T. brasiliensis)* have nearly constant frequency open air search phase calls, of relatively long duration (15-30 ms). Typically, there is no more than a 4 kHz drop between the beginning of a call and its termination. By contrast, most vespertilionids (in this case, *E. maculatum)* have broad band, rapidly frequency-modulated calls of relatively short duration (5 ms).

2.2.4.1. <u>The echolocation call of *E. maculatum*</u>

The search phase call of *E. maculatum* is the most distinctive, and the most readily distinguishable from that of the other audible species (Table 1, Fig. 1). It has a steep frequency modulated (FM) sweep from approximately 15 to 6 kHz, a duration of ca. 5-8 ms, and an interpulse interval of ca. 320-365 ms (Woodsworth *et al.* 1981, Leonard and Fenton 1984). The search phase call takes two forms: one a single note, the other a double note; both with multiple harmonics. To the unaided ear, the rapid ticking has a slightly metallic quality, as though small metal balls were being jiggled on a string (D. Constantine pers. comm.). Also, the animals can often be spot-lighted (10-15 m above the ground), revealing their distinctive coloration pattern.

2.2.4.2. <u>The echolocation call of *E. perotis*</u>

The fact that the call of *E. perotis* is audible has been noted by various researchers

(Krutzsch 1955, Vaughan 1959, Cockrum 1960, Constantine 1961b), but never characterized quantitatively. Cockrum (1960) described it as a "high pitched 'cheep --- cheep --- cheep' of great intensity." To the unaided ear, it makes a sound similar to that made by the brown towhee at dusk (D. Constantine pers. comm.).

The open air search phase call of *E. perotis* falls in the same frequency range as that for *E. maculatum,* but is, by contrast, relatively constant frequency (CF), generally sweeping from ca. 11 to 8 KHz. Each call lasts about 25-30 ms, and the interpulse interval can be as long as 1.0-3.0 seconds (Table 1, Fig. 2a). This call, when recorded, is diagnostic for this species. Problems can arise, however, when animals are operating in a more cluttered setting, or approaching prey. Under these circumstances, they shift to a more frequency modulated call (e.g., Fig. 2b), and reduce the interpulse interval. In these settings, the call of *E. perotis* converges on that of *E. maculatum.* Although this call can be quite variable, it frequently sweeps from 16 to 8 kHz, with an interpulse interval of 200 ms or less. The pulse duration is longer than that of *E. maculatum,* yet this distinction is subtle to the unaided ear.

In 1994, we began encountering an insect (most likely a cicadid), which sounds to the unaided ear very much like *E. perotis.* This came to our attention when a stationary call, sounding like *E. perotis,* was being emitted from a low bush. Fortunately, since this insect appears to be widespread in California, especially in oak woodlands, this call can readily be distinguished from that of *E. perotis* when recorded.

2.2.4.3. The echolocation call of *N. femorosaccus*

Although Krutzsch (1944b) noted that *N. femorosaccus* produced shrill, high-pitched chattering calls when first taking flight, and Benson (1940) noted that this species sometimes "squawked and chattered shrilly" while in flight, we are not aware of any published sonograms or more detailed characterizations of the echolocation call for this species.

By sampling several known roosts, and recording calls of hand released animals, we are able to offer an initial description of this species' search phase call (Table 1, Fig. 3). Like the search phase call of other molossid species, it has a relatively constant frequency, sweeping from ca. 20 to 16 or 17 kHz, with a duration of ca, 15-20 ms. Although this species would not likely be confused with *E. perotis,* which emits at a considerably lower frequency, the differences between the calls of this species and those of *Tadarida brasiliensis* (which are higher, generally sweeping from 27 to 23 kHz), and *N. macrotis* (see Section 2.2.4.4) are small enough so that more frequency modulated calls overlap extensively. Given the tendency, mentioned above, for molossids to alter call structure with the environment, and a tendency to engage in extensive social vocalizations in flight, there are situations in which distinguishing among these species is not possible, even with good recordings.

2.2.4.4. The echolocation call of N. *macrotis*

The search phase echolocation call of *N. macrotis,* as described by Schum (1972), drops from 18 to 12 kHz, with the greatest intensity being at 12 kHz.The call has a duration of ca. 25 ms and an interpulse interval of ca. 500 ms. The call attributed to *N. macrotis* by Fenton and Bell (1981), based on hand released animals, had a sweep from 30 to 17 kHz, and a duration of 20 ms. These parameters are consistent with those we recorded for hand released *N. femorosaccus,* and not *N. macrotis***.** The echolocation call described by Simmons *et al.* (1978) does not fit the description of any known molossid call, and likely is in error.

The calls of *N.. macrotis* described by Constantine (1961a) as "barely audible whistling g sounds. . . vaguely suggestive of sounds made by flying mourning doves." Barbour and Davis (1969) describes foraging *N. macrotis* as emitting a "loud piercing chatter . . . . . .similar to the note of a flying squirrel, but louder and more piercing."

Although our characterization of *E. perotis* and *N. femorosaccus* calls are based on known animals, and/or recordings made at roosts where positive identification of the species present had been made, we were unable to capture any live *N. macrotis* for call characterization. Our identification of *N. mucrotis,* therefore, is inferential, based on recordings made at a locality in San Diego County where a mummified *N. macrotis* was found in 1991. Visual observations of large molossids (too small to be *E. perotis)* emerging from a rock crevice below which the specimen had been taken, combined with obtaining recorded calls which fit the description offered by Schum (1972), strongly suggest we were able to record *N. macrotis,* but this remains to be confirmed (Table 1, Fig. 4). These calls are also consistent with calls recorded at a known *N. macrotis* locality in northern Arizona (M. O'Farrell pers. comm.).

2.2.4.5. Other Sometimes Audible Bat Species

The fourth and most common molossid species in California, the Mexican free-tailed bat, *Tadarida brasiliensis,* is smaller than the other three molossid species, and has a correspondingly higher frequency search phase call, which generally sweeps from about 27-28 kHz down to 20-23 kHz. Its social calls or approach phase calls could be mistaken for calls of *N. femorosaccus. T. brasiliensis* is one of the most commonly detected bats in many localities in California, and is generally present at the same localities as the other molossids. Even the search phase calls of this species are audible to some observers.

Although most North American vespertilionid bats have frequency modulated calls, the lasiurines sometimes emit nearly constant frequency calls (Barclay 1986). The largest species, the hoary bat, *Lasiurus cinereus,* produces calls that overlap in frequency with those of *T. brasiliensis* and *N. femorosaccus* and could potentially be confused with either. *L. cinereus* is a tree-dwelling bat, so would not likely to be encountered in a cliff roost setting, but is difficult to distinguish in open air foraging situations. Social calls of other bat species, particularly the pallid bat, *Antrozous pallidus,* and a number of insect calls also overlap in frequency with the calls of these audible bat species.

This discussion applies only to California, and thus does not consider the situation which may arise elsewhere in the southwest where other audible species co-occur with these four taxa (e.g., *Idionycteris phyllotis* in Arizona, New Mexico, Utah, Nevada, and possibly, although never documented, along the Colorado River in California; or *Eumops underwoodi* in Arizona) (Findley and Jones 1965, Hall 1981, Simmons and O'Farrelll977).

3.0. EUMOPS PEROTIS

3.1. Taxonomy

The California form of *Eumops perotis* (Family Molossidae) was first described by

Merriam in 1890 (Merriam 1890), and has been recognized as the subspecies *E. p. californicus* since 1932 (Sanborn1932). The type locality is Alhambra, Los Angeles County. Based on a recent revision of the genus (Eger 1977), there are nine species currently recognized in the genus *Eumops (auripendulus, bonariensis, dabbenei, glaucinus, hansae, maurus, perotis, trumbulli,* and *underwoodi),* and two subspecies of *E. perotis (californicus and perotis).* Most species have their centers of distribution in Mexico, Central and/or South America; three *(glaucinus, underwoodi,* and *perotis)* occur in the southern United States; only *E. perotis califomicus* occurs in California, with the other subspecies, *E. p. perotis,* being confined to South America.

3.2. Diagnosis

E. perotis is one of four molossid species currently known to occur in California. The molossids (Family Molossidae) are distinguished from all other bat species by the presence of a "free-tail," a tail which extends visibly beyond the edge of the interfemoral (= tail) membrane. *E. perotis* is distinguished from the other molossids on the basis of size. It is by far the largest bat species found in California. It has a wingspan of 53 to 56 cm, a forearm of 75-83 mm, and an adult weight of 60-72 g (Table 1).

3.3. Distribution

3.3.1 Geographic Range

E. p. californicus ranges from central Mexico across the southwestern United States (parts of California, southern Nevada, southwestern Arizona, southern New Mexico and western Texas) (Bradley and O'Farrell 1967, Eger 1977, Hall 1981).

3.3.2. Past Distribution in California

Prior to the initiation of this study in 1990 (Pierson 1992), with a continuation in 1993-1995, the primary distribution of *E. perotis* in California was thought to be the southern part of the state (Cockrum 1960, Eger 1977), with the majority of confirmed records concentrated in the Los Angeles basin, San Diego County, and the southern portion of the San Joaquin Valley (Fig. 5, Appendix I). The most northern records for which specimens were available was a single animal from the San Francisco Bay area (Hayward, Alameda County) (Sanborn 1932) and several records from Yosemite Valley in Yosemite National Park (Natural History Museum, Yosemite National Park). There were also reliable reports of a population at Hetch Hetchy Reservoir in Yosemite National Park (Vaughan 1959), and of a single animal (specimen not available), presumed to be a vagrant, found in 1973 in Butte County, near Oroville (A. Beck pers. comm., Eger 1977). Additionally, there are two unconfirmed records of large bats from Lake County (Storer 1926), tentatively identified as *E. perotis,* one from an area near Middletown, and the other from Arabella (near Cache Creek). The identification of these specimens is uncertain, and the identifying characteristic (a wingspan of 16") for one of these animals would be appropriate for *Nyctinomops macrotis,* not *E. perotis* (which has a wingspan of 21-22")(Barbour and Davis 1969). Zeiner *et al.*. (1990) describe *E. perotis* as "an uncommon resident in . . . [the] Coastal Ranges from Monterey County southward," presumably based on a few records from the Salinas area.

Although *E. perotis* is a colonial species, it is striking how few of the available California records represent colony sites. Most colony records are from southern California. Early in this century, Howell (1920a, 1920b) located several in buildings in the Los Angeles basin (e.g., in

Azusa, Colton, and Covina). In the 1940s Krutzsch (1943, 1945, 1948, 1955) identified two colonies in San Diego County, Additional significant locality records were contributed by Vaughan (1959) who monitored 22 sites, including eight colonies, located primarily in southern California. Leitner (1966) also focused his research on a colony located in a building at Citrus Junior college in Azusa in the Los Angeles basin. D. Constantine (pers. comm.) knew of a colony in a church in Highland in the 1960s. K. Stager (pers. comm.) reported a very large colony eliminated by an exterminator from a house in downtown Los Angeles in the early 1950s.

There are only three records of colonial roost sites north of the Los Angeles basin, all located in the 1940s and 1950s by researchers associated with the Museum of Vertebrate Zoology at the University of California, Berkeley -- a colony on the west side of the Central Valley in San Benito County (Dalquest 1946), one in Kern County near McKittrick (Krutzsch 1955), and one in the Kern River drainage east of Bakersfield (Koford 1948, Krutzsch 1955). Additionally Vaughan reported hearing this species on many evenings at Hetch Hetchy Dam in 1952 (Vaughan 1959).

3.3.3. Current Geographic Distribution in California

This study has changed the distributional picture for *E. perotis* in two significant ways. It is now apparent that the special is much more widely distributed than was previously realized (Fig. 5), and populations occur in areas for which only single or scattered records were previously available. All records obtained in this study are detailed in Table 2.

3.3.3.1. Northern California

All results of acoustic surveys for this area are given in Tables 3 and 4.

Prior to this study the only records for any locality north of the San Francisco Bay area were a supposed vagrant from Oroville in Butte County (A. Beck pers. comm., Eger 1977), and the two questionable, unconfirmed records from Lake County (Storer 1926). Surveys conducted in September 1994 revealed that the Oroville record was not a vagrant. Rather there is a significant population associated with the basaltic table mountains near Groville. On two nights of observation multiple animals were detected at several stations just after dark, within a mile of the west facing cliffs. There is also an additional population 25 km to the north, near Chico, which based on reports from a trained observer, appears to be resident year round (B. McMurtry pers. comm.), and another population about 40 km southwest at Sutter Buttes (W.E. Rainey pers. comm.).

Echolocation calls attributable to this species have also been recorded at several sites north of Chico: the Antelope Creek Nature Conservancy Reserve just east of Red Bluff (several individuals); Ney Springs, a narrow canyon near Mt. Shasta City; Gumboot Lake in the Trinity Alps west of Mt. Shasta City; and near Medicine Lake on the Modoc plateau, 45 km. south of the Oregon border.

No *E. perotis* were detected in single nights of observation near cliff sites at Black Butte Lake in Tehama County and at two promising rocks formations in Napa County (near Monticello Dam at Lake Berryessa and in Wooden Valley) located by aerial survey.

3.3.3.2. The Central and Southern Coast Ranges

All results for acoustic surveys in this area are given in Table 3.

Previous confirmed records for *E. perotis* in the central Coast Ranges were a roost found in the 1940s in a cliff face in the Silver Creek drainage near Panoche in San Benito County (Dalquest 1946), one or two animals picked up in a warehouse in the Salinas Valley near Soledad, Monterey County (von Bloeker 1943), one animal turned into California Department of Health Services from the East side of the Pinnacles in 1977 (D. Constantine pers. comm.), and a single specimen found dead in downtown San Luis Obispo in 1991 (NDDB). Additionally, there was a roost identified in the 1950s on the Twisselman Ranch in McKittrick, on the western margin of the Central Valley.

In these surveys, populations were located at two previously known sites, and at a number of additional sites. These results extend the known range for this species, and suggest it is more widely distributed in the Coast Ranges than was previously realized.

Surveys conducted in the Silver Creek drainage confirmed that this population still exists. The original roost. site, a crevice in a sandstone cliff, had broken away, and thus no longer exists. However, *E. perotis* was heard eighteen times passing over the original roost site within the first half hour after darkness, strongly indicating that a colony still roosts in this drainage, at a site farther upstream (which was not located in a search of the next 2.0 km).

Access to the Twisselman Ranch was denied (E. MacMillan pers. comm.), so it was not possible to survey this site. It was the impression of E. MacMillan (pers. comm.), however, that bats no longer occupy this roost.

Another population of *E. perotis* was identified in the Los Banos Creek drainage, ca. 50 km north of the Silver Creek site. On September 12, 1994, multiple animals were detected shortly after dusk, heading downstream. Others were recorded foraging in the area between 2200 and 0100. Two individuals (an adult male and a juvenile male) were captured in mist nets late in the evening. Another juvenile male was captured at this site in late November 1994 (L. Thompson pers. comm.). A probable roosting area, a prominent rock outcrop on private land, was examined by aerial survey, but not visited.

Another population was identified at Pinnacles National Monument, where multiple animals were heard at dusk at two simultaneously sampled sites, and throughout the evening at several foraging sites along Chalone Creek and in Bear Valley. The older isolated specimens from Pinnacles National Monument and Soledad were likely associated with this population.

Another population was identified along the North Fork of the San Antonio River, near a rock feature known as Wagon Caves (an area where bats had been heard [E. Remington pers. comm.] and which appeared promising based on aerial surveys). Although only a few animals were heard at the several stations sampled, the species clearly occurs here, only 12 km from the coast.

E. perotis was detected at several localities near Coalinga in May 1995, but not detected at two other sites sampled for one night only in the central Coast Ranges, Little Panoche Reservoir and Corral Hollow.

E. perotis had been reported as occurring in the southern Coast Range at Lake Piru, Ventura County (S. Sweet pers comm.). Its presence was confirmed at several stations in and near the Blue Point Campground in August 1992.

3.3.3.3. Sierra Nevada

Results for acoustic surveys in the Sierra Nevada are given in Table 4. Operating under the assumption that a cliff-dwelling species would most likely occur where there were significant rock features (as are common in California river drainages), twelve Sierra Nevada rivers were sampled for the presence of *E. perotis.* In most cases, multiple sites were sampled, representing an altitudinal gradient.

Prior to this study, the only indications that *E. perotis* occurred in the Sierra Nevada were several low to mid elevation records: the report by Vaughan (1959) of a population at Hetch Hetchy Reservoir, a few samples from Yosemite Valley (Natural History Museum, Yosemite National Park), a record from Trimmer on the Kings River, and the roost located by M. Koford in the 1940s along the Kern River (Koford 1948).

This study showed that populations of *E. perotis* occur in many of the Sierra Nevada river drainages, particularly in the central and southern Sierra, i.e, the Stanislaus, Tuolumne, Merced (North and South Forks), San Joaquin, Kaweah, Tule, and Kern rivers. The only river in the central Sierra on which the species was not detected was the Kings, but all sites sampled were above 1,450 m. Forest Service personnel have reported hearing audible bats at lower elevation, at Trimmer (K. Sorini pers. comm.), near where a specimen was taken in 1941, indicating the species does occur at lower elevations. We expect that this species does occur in the Kings River drainage, in areas like Tehipite Valley, not yet sampled.

Although the largest populations appear to occur at lower elevations, animals have been detected in the warm season as high as 2,660 m elevation on the Tuolumne River. In an altitudinal transect conducted in the Grand Canyon of the Tuolumne in 1994, *E. perotis* was detected twice just below Glen Aulin (2,380 m), not at all in the Muir Gorge (1,710 m) area, and numerous (> 10) times in Pate Valley (1,320 m) (Pierson and Rainey 1995).

The Kern River roost (Koford 1948), which contained about 100 animals on August 24, 1948 was relocated on September 4, 1992, and had 20-30 animals. Seventy-five animals were present in October 1994 (P. Brown pers. comm.). Multiple roost sites were identified in two basaltic table mountains, one near Fresno (MacKenzie Table) on the San Joaquin River (our data; W. Philpott and D. York pers. comm.) and the other near Jamestown on the Stanislaus River (our data; T. Rickman pers. comm.). At least four different roosting areas have been identified for the Jamestown population, with the largest roost containing approximately 50-60 animals on October 13, 1994and March 31, 1995(our data; T. Rickman pers. comm.). At least 3 roost sites have been identified on the MacKenzie Table, and appeared to contain at least 50 animals in December 1994 (W. Philpott and D. York pers. comm.). The identification of roosts in this area is of particular interest, since all previous records from the area were single male specimens.

The highest densities of *E. perotis* in the Sierra Nevada may occur in the central region from Yosemite to Sequoia Kings Canyon National Parks. Repeated acoustic monitoring since 1992 has documented substantial populations in three separate areas of Yosemite National Park: along the Tuolumne River at Hetch Hetchy Reservoir and in the Grand Canyon of the Tuolumne, along the Middle Fork of the Merced River in Yosemite Valley and near confluence with Cascade Creek, and at Wawona on the South Fork of the Merced River (Pierson and Rainey 1993, 1995, 1996). A radiotracking study conducted in Yosemite Valley in 1995 confirmed a reproductive population and identified two roosts (Pierson and Rainey 1996). Net capture of a juvenile animal at Wawona confirmed the presence of a reproductive population in this area (Pierson and Rainey 1995). In Sequoia National Park, *E. perotis* was detected repeatedly in Giant Forest Village and at nearby Moro Rock during bat surveys conducted for the Park in the summer of 1995 (Pierson and Heady 1996).

In the northern Sierra Nevada, limited sampling did not detect any *E. perotis* on the North Fork of the Yuba or the Mokelumne Rivers. A population was identified, however, associated with the basaltic tableland, on the Feather River, near Oroville (see Section 3.3.3.1 above).

3.3.3.4. Southern California (Los Angeles Basin. Imperial, Riverside. San Bernardino and San Diego Counties)

The urban landscape of coastal southern California, particularly the Los Angeles basin has undergone such alteration that it was frequently impossible to locate historic roost sites, particularly those that were in buildings. In most cases, the buildings no longer exist. Thus our approach was to conduct acoustic surveys in the vicinity of selected known roosts, and in other areas where relatively intact natural rock features offered potential roosting habitat.

We focused effort in the Los Angeles basin on two areas with concentrations of historic records: the north rim of the basin (where animals had been collected from buildings in communities like Pasadena, Altadena, Sierra Madre, Azusa, Highland, and Covina), and western Riverside County, where there are large granitic outcrops (e.g., at Lake Perris and Lake Mathews). In San Diego County we concentrated on the two previously identified roost areas: Lake Barrett (Krutzsch 1955) and the Suncrest/El Cajon area (Krutzsch 1945, Vaughan 1959). Additionally, we surveyed the rocky areas (canyons and/or boulder jumbles) in Joshua Tree National Monument, Painted Canyon near Mecca, and Anza Borrego State Park. Survey results are given in Table 5.

Our data suggest that populations are seriously reduced along the north rim of the Los Angeles basin. Early in this century, Howell (1920a) had identified several roosts, and pronounced *E. perotis* to be “common in the orange section or thermal belt of Los Angeles County.” Most of the buildings in which he located colonies are gone. Although there was a large colony (200-300 animals) in Azusa in the 1960s, there was no evidence acoustically that the species still occurs in Azusa, nor in the adjacent drainage leading into the San Bernardino Mountains. Likewise, no bats were detected in acoustic surveys in Altadena and Pasadena, an area with numerous records from earlier in the century. A roost in Highland, which had had 40-50 adults in 1969 (D. Constantine pers. comm.), had only three bats in September 1992. The Santa Ana Wash, east of Highland, where one *E. perotis* had been mist-netted in recent years (B. McKernon, San Bernardino County Museum, pers.comm.), and which appeared to offer a remnant patch of suitable foraging habitat, revealed no animals in a two-hour evening survey on September 1, 1992.Several *E. perotis* were tentatively identified (heard, but too distant to be recorded) at a series of three acoustic stations on Hwy 330, between Highland and Little Mill Creek.

Western Riverside County appears, however, to still have populations of *E. perotis.* A small colony (partially exterminated by public health personnel in January 1991) persists in Norco City Hall. Acoustic records obtained by ourselves and M.J. O’Farrell (pers. comm.) suggest a population also persists at Lake Perris, where it was first identified by Vaughan (1959). New records were obtained for Lake Mathews (P. Brown pers. comm.). Additionally, there are several independent reports of audible bats, most likely *E. perotis,* from the vicinity of Coal, Gypsum and

Fremont Canyons, Lake Elsinore, and the Santa Rosa Plateau in Riverside and Orange counties (G. Bell, P. Brown, J. Tutton pers. comm.).

In San Diego County, although the property owner denied access, we were able to determine acoustically that a colony of *E. perotis* still occupies the Barrett Junction roost first described by Krutzsch (1948 and 1955). At least ten animals were detected at a distance of at least 500 m downslope from the roost on May 20, 1991. At a site fitting the description of Vaughan's El Cajon roost, in an area that is now a housing subdivision, no *E. perotis* were detected. A previously unidentified small roost (10-12 adults) was located in Ramona (C. Mushet-Rogers pers. comm.), in a large boulder, within 100 m of a home.

A small colony of *E. perotis* (ca. 10 adults) was located in the Split Mountain area of Anza Borrego in July 1992. A lactating female was captured, confirming the site is a maternity roost. The colony shared a rock crevice with *N. femorosaccus* (although the two species were spatially separated within the crevice). Research being conducted by K. Miner (pers. comm.) in this canyon has further documented substantial populations of both these species in this area of the Park.

Following the lead of a *E. perotis* specimen collected in Painted Canyon north of Mecca (Collins 1973), populations of both *E. perotis* and *N. femorosaccus* were identified here. In Joshua Tree National Monument, 40 km to the north, echolocation calls of *E. perotis* were recorded at Barker Dam.

P. Brown (pers. comm.) has supplied a number of records from southern California, all identified as *E. perotis* based on auditory detection (Fig. 5).

3.3.3.5. Seasonal Distribution

Although molossid species generally do not hibernate, and certain populations, particularly of *Tadarida brasiliensis*, are migratory (moving to warmer climates in the winter), little information is available on seasonal distribution patterns of *E. perotis* in California outside southern California. Past research indicates that in southern California most roosts are not occupied year round, but the species is present in the same area during all seasons (Barbour and Davis 1969, Howell 1920a, Krutzsch 1948 and 1955, Leitner 1966).

Surveys conducted at various sites along the western base of the Sierra Nevada in the fall and winter suggested that the species likely moves down the river drainages as the weather cools, concentrating during the winter in areas that experience prolonged periods of above freezing temperatures (below 300 m). For example, there were many fewer *E. perotis* detected at sites in Yosemite National Park in mid-October than during the summer (Pierson and Rainey 1995). None were detected in areas where temperatures were below 4°C. Additionally, surveys of the Kern River drainage in February 1994 revealed that animals were not occupying the summer roost site at 580 m, but were detected flying above the river at several stations between 500 m and 245 m. The animals were most numerous immediately after dark near the mouth of the canyon, suggesting they were roosting in the canyon near the 245 m level.

A survey in February 1994 to locate *E. perotis* in several major drainages of the western Sierra (Kern, San Joaquin, Merced and Tuolumne rivers), and at selected sites in the Central Valley and coast range (San Luis Reservoir, Carizzo Plain, and Buena Vista Lake) was hindered by inclement and unusually cold weather. The only site at which we detected bats was in the Kern River drainage (just prior to the onset of bad weather).

Information from reliable observers documented that populations are present throughout the winter at the cliff margins of three basaltic tablelands (near Oroville, Jamestown and Fresno) (B. McMurtry, W. Philpott, T. Rickman, and D. York pers. comm.). At the sites along the Stanislaus River, the colony abandoned the highest elevation roost (450 m) late in the fall, and numbers of animals increased and were present all winter at lower elevation sites (60 m and 215 m). Given the large number of reservoirs below 300 m elevation on rivers draining the Sierra Nevada, and the likelihood these water impoundments have inundated cliff roosting habitat, it is probable that the basaltic tablelands have become differentially important as winter refugia for this species.

3.4. Population Biology

Unlike vespertilionids, which mate in the fall, North American molossids, including *E. perotis,* appear to mate in the spring and give birth to a single young in the early to mid-summer. The small amount of data that are available suggest that, although most *E. perotis* young are born by early July (Krutzsch 1955), parturition dates vary extensively (Barbour and Davis 1969), and births are not synchronous, even within colonies (Cockrum 1960). We captured juveniles with open epiphyses in mid-August in Yosemite National Park, and in the Coast Range in mid-September. An individual, still identifiable as a juvenile, was also captured in the Coast Range in late November (L. Thompson pers. comm,). A lactating female was caught in Anza Borrego State Park in early July. A series of animals killed by the San Bernardino County Health Department on August 20, 1992, included 5 post-lactating females, and 3 juveniles with open epiphyses (R. McKernon pers. comm.).

3.5. Habitat Associations

The distribution of *E. perotis* is likely geomorphically determined, with the species being present only where there are significant rock features offering suitable roosting habitat. It is found roosting in a variety of habitats, from desert scrub to chaparral to oak woodland and into the ponderosa pine and mid-elevation conifer (e.g., giant sequoia) belts. It forages seasonally at higher elevations.

3.5.1. Roosting Ecology

3.5.1.1. Background Information

E. perotis is primarily a crevice dwelling animal. Natural roosts are generally on cliff faces of in large boulders, and can be in exfoliating granite, sandstone, or columnar basalt (Dalquest 1946, Krutzsch 1955, Vaughan 1959). A number of roosts have also been located in appropriately proportioned cracks in buildings (Barbour and Davis 1969, Howell 1920a). Roosts are generally high above the ground, usually allowing a clear vertical drop of at least 3 m below the entrance for flight (Barbour and Davis 1969, Vaughan 1959).

E. perotis is colonial, but colony size is generally small (fewer than 100 animals) (Barbour and Davis 1969). Howell (1920a) considered even twenty to be a large roost. Although maternity roosts for most bat species contain only adult females and their young, *E. perotis* colonies may contain adult males and females at all times of year (Krutzsch 1955).

3.5.1.2. This Study

The natural roost sites examined in this study were in exfoliating granite, sandstone, or columnar basalt. In all cases the bats were in a crevice at least 3.5 m above the ground. Most were identifiable at some distance (at least 500 m) by staining below the crevice. Close inspection sometimes permitted discrimination (based on patterns of staining and guano deposits) between bird nesting areas and bat roosts. As expected, *E. perotis* roosts were frequently located in the vicinity of raptor aeries (particularly prairie and peregrine falcon nests) and colonies of white throated swifts.

The importance of cliff margins in basaltic tablelands for this species was not appreciated prior to this study.

3.5.2. Foraging Ecology

3.5.2.1. Background Information

E. perotis emerges after dark, and can be heard flying every hour of the night. The animals characteristically fly, and perhaps forage, at high elevation, often up to 1,000 feet above the ground (Vaughan 1959). At one locality in Arizona, 58% of the diet of *E. perotis* consisted of small (about 8 mm) hymenopterous insects (Ross 1961). In another study, Ross (1967) reports on a sample of eight *E. perotis* from Arizona that had eaten only large Lepidoptera (up to 60 mm) and a few Homoptera. Easterla and Whitaker (1972) found that in 18 specimens from west Texas, almost 80% of the diet was Lepidoptera, and the rest predominantly Gryllidae and Tettigoniidae. *E. perotis* is a strong, fast flier, and its foraging range is likely extensive. It has been heard in open desert, at least 24 km from the nearest possible roosting site (Vaughan 1959).

3.5.2.2. This Study

E. perotis was detected numerous times in foraging areas in the course of this study. Although the habitat included dry desert washes, flood plains, chaparral, oak woodland, open ponderosa pine forest, giant sequoia/red fir forest, and grassland, animals were most frequently encountered in broad open areas. Given the frequency with which multiple animals are detected together or in rapid succession, it appears that this species sometimes travels or forages in groups. Generally they move through an area fairly rapidly; a burst of acoustic activity will frequently be followed by silence. Foraging will not predictably reoccur at the same site on sequential nights.

Whenever the opportunity presented itself we collected guano from either captured animals or known roost sites. That information is discussed in detail elsewhere (Whitaker *et al.* in prep.), but, in summary, this work showed that in California *E. perotis* feeds predominantly on moths (Lepidoptera), but also includes beetles (Coleoptera) and crickets (Gryllidae) in its diet.

3.6. Current Status

E. perotis is more widely distributed, particularly in the Sierra foothills, than was previously realized. The discovery of new localities is likely due to improved detection methods and the development of an improved roost search technique, rather than an expanding geographic range. Even though researchers have made reference to the audible calls of *E. perotis* (e.g., Vaughan 1959), we are not aware of this characteristic being used as a survey tool prior to this study.

Assessing the status of *E. perotis* populations presents certain challenges. Unlike many species which exhibit great roost fidelity, and whose status can be tracked by monitoring colony size at roost sites (e.g., *Corynorhinus townsendii* and several *Myotis* species [Pierson and Rainey 1995, Stihler and Hall 1993), *E. perotis* may occupy roost sites in an as yet unpredictable fashion. Krutzsch (1948) followed the Barrett Junction roost over a period of 11 years, and the population varied from 10 to 60 at comparable times of year. Certain roost sites, or series of roost sites, may be critical to particular populations, but we do not yet know enough about the roosting ecology of this species to determine roosting patterns. Data collected in the Jamestown area, and along the Kern River, would suggest that colonies, while shifting roost sites seasonally, appear to remain in the same area.

An absence of historical records makes it impossible to assess current trends for this species in most areas. The paucity of detection events along the north rim of the Los Angeles basis, in an area relatively rich in historic records, suggests population declines in this area. In two cases for which both historic and current roost counts could be compared, there appeared to be a decline: the church in Highland had 40-50 animals in June 1969 and only 3 on September 2, 1992; the Kern River roost had ca. 100 animals in August, 1948, and 23-75 in September and October 1992. With the exception of the north rim of the Los Angeles basin, *E. perotis* was detected in most sampled areas for which there were historic records.

More information would need to be gathered on the roosting ecology of each population before baseline population numbers could be estimated. Nevertheless, a number of important populations that warrant ongoing monitoring have been identified.

3.7. Conservation Concerns

There are various potential threats to the roosting and foraging habitat of *E. perotis* that need to be evaluated.

3.7.1. Urban/suburban Expansion

The loss of foraging habitat in the Los Angeles basin is likely primarily responsible for what appears to be a decline in *E. perotis* populations in this area. The numerous creek drainages flowing into the Los Angeles basin from the San Bernardino and San Gabriel mountains provided the kind of floodplain, desert wash vegetation that appears in other settings to be ideal foraging habitat for this species. Most of that habitat has now been lost to urban/suburban development.

In San Diego County, where houses are situated among boulder jumbles, people can be brought into close contact with these bats, which due to their size and loud vocalizations, are evident when present. Thus colonies in close proximity to human dwellings become vulnerable to disturbance and vandalism of their roosts.

3.7.2. Pest Control Operations

Extermination of colonies by pest control operators and Public Health Departments has also been responsible for the elimination of many *E. perotis* in the Los Angeles basin. In this area, where colonies occupy buildings, these large and noisy bats are very vulnerable to the hysteria which often surrounds bat colonies. K. Stager (pers. comm.) described a situation in a building near the Los Angeles County Museum in which "3 wash tubs full" of *E. perotis* were killed by exterminators in the 1950s. The only two recent colonies we know of in buildings in the Los Angeles basin both came to our attention because of attempts by public health officials to eliminate them (a school in Rancho Cucamonga and the Norco City Hall).

3.7.3. Water Impoundments

The same canyons that offer suitable cliff habitat for *E. perotis* also provide basins for storage reservoirs and other water projects. Almost every river that drains the west side of the Sierra Nevada has one or more such reservoirs. One or more storage reservoirs occur in the vicinity of four table mountain roosts (e.g., Lake Oroville, New Melones Reservoir, Tulloch Lake, Millerton Lake) and at Hetch Hetchy in Yosemite National Park Roosting and foraging habitat have inevitably been lost at many of these sites. For example, at Hetch Hetchy most of what was once a large, cliff-bordered valley resembling Yosemite Valley is now inundated. The population that once likely foraged in the valley directly below the cliffs, now must travel several miles downstream to find a suitable foraging area. It is thus of considerable concern that the habitat for the Los Banos Creek population (one of only two colonies known on the western rim of the Central Valley) is now threatened by a proposed reservoir.

It also should be noted that *E. perotis* has frequently been detected foraging in the vicinity of reservoirs (e.g., Tulloch Lake, Lake Kaweah, Lake Success), so it is also possible that reservoirs create foraging habitat. The situation needs further evaluation.

3.7.4. Highway Projects

Rivers and streams can create cliff-rimmed canyons that offer bat roosting habitat. River drainages, because they frequently offer the easiest routes through mountain ranges, are also favored corridors for highway construction. Such construction commonly entails blasting of cliff faces, either for initial highway construction or later improvements (i.e,. widening and straightening). Since bats are frequently overlooked in the environmental assessment process, cliff roosting species, such as *E. perotis,* are at risk of both direct impacts from blasting, and long-term loss of roosting habitat from cliff modifications. In some settings it is possible that soil removal and blasting may expose rock and create roost habitat, but this is not generally the case since heavily fractured, unstable rock is often removed, slope angles are reduced, and exposed faces are generally mantled with soil to encourage revegetation.

3.7.5. Recreational Climbing

There has been a rapid increase in recreational rock climbing in the West in recent years. A recent informal survey by personnel at Yosemite National Park has documented 3,000 new climbing routes within the park, where the unsanctioned use of various technical aids has made previously unclimbable areas accessible (Dept. of Resource Management, Yosemite National Park, pers. comm.). The popular sites, such as El Capitan in Yosemite Valley, literally experience climbing traffic jams, with 20-30 climbers on the face at once. Similarly, columnar basalt cliffs, which occur along the western base of the Sierra Nevada, until recently considered too hot and unpleasant for climbing, have experienced increasingly heavy use since about 1990. This is especially true in the Jamestown area Although no information is available regarding what proportion of the crevices used by climbers offer suitable roosting sites for *E. perotis,* it is reasonable to presume that hands or temporary climbing aids inserted into a roost crevice would be cause for disturbance and possible abandonment of a site. Also, climbers may alter cliff habitat, dislodging unstable rock, clearing ledges, and depositing human waste.

3.7.6. Mining and Quarry Operations

Mining and quarry operations that impact cliffs could potentially remove roosting habitat for *E. perotis.* Additionally, the noise generated by active mining and quarry operations could disturb roosting bats. Alternatively, quarries may create cliffs. One of the colony sites monitored by Vaughan (1959) was in an abandoned quarry west of Riverside. Also, toxic impoundments (primarily cyanide) associated with open pit, heap leach gold mining operations could pose threats to this species, which comes to water sources to drink. Mining operations can also result in a significant draw-down of the water table in desert areas.

3.7.7. Grazing/Meadow Management

Although a number of bat species appear to forage predominantly over water, or along vegetation edges (e.g., riparian zones, forest edges), *E. perotis* frequently forages in open areas, including meadows. To the extent that excessive grazing and trampling of meadows by livestock alters the insect productivity (particularly for lepidopterans), it may impact the foraging habitat of bats, including *E. perotis,* and could adversely affect local populations.

3.7.8. Pesticide Spraying and Environmental Contaminants

Pesticides have been shown to have detrimental effects on bat populations (Clark 1981). *E. perotis* is a moth specialist. Thus all non-target spraying poses a threat and could eliminate the prey base in an area. As mentioned above, cyanide ponds used in gold mining operations could pose a threat.

3.7.9. Sensitivity to Human Disturbance

No data are available on the behavioral sensitivity of *E. perotis* to human disturbance. Most bat species, however, are sensitive to human intrusion into roost sites, particularly during the maternity season.

4.0. *NYCTINOMOPS FEMOROSACCUS*

4.1. Taxonomy

Nyctinomops femorosaccus was first described by Merriam (1889) from a specimen found in Palm Springs, California. Although it was for many years known as *Tadarida femorosacca* (Barbour and Davis 1969), it was named *Nyctinomps femorosaccus* by Miller in 1902 (Kumirai and Jones 1990), and that name has recently been reinstated (Freeman 1981, Wilson and Reeder 1993). It is a monotypic species.

4.2. Diagnosis

N. femorosaccus, like all molossid species, has a free-tail which extends beyond the rear edge of the interfemoral membrane. It can generally be distinguished from the other three molossids which occur in California based on size or forearm length, This species, with a forearm length of 45-49 mm, and a weight of 12-18 g, is larger than *T. brasiliensis* (forearm 36-46 mm, weight 11-15 g), and smaller than *N. macrotis* (forearm 58-64 mm, weight 22-30 g) or *E. perotis* (forearm 75-83 mm, weight ca. 65 g) (Barbour and Davis 1969, Kumirai and Jones 1990, Schmidly 1991) (Table 1). It is closest in size to *T. brasiliensis,* and there is some overlap in forearm length between the two species. *N. femorosaccus* differs from *T. brasiliensis* in having its ears joined at the midline (a character which is common to all *Nyctinomops* species and *E. perotis).* The ears meet, but are not joined, in *T. brasiliensis* (Barbour and Davis 1969). A shallow fold of skin on the uropatagium, near the knee (thus the common name “pocketed free-tail bat”) is frequently hard to find, and should not be relied upon as a distinguishing characteristic.

4.3. Distribution

4.3.1 Geographic Range

This species ranges from southwestern Mexico through the southwestern Texas, southern New Mexico, southcentral Arizona, and southern California (Hall 1981, Kumirai and Jones 1990).

4.3.2. Past Distribution in California,

Prior to this study this species was known from very few localities in California (Fig. 6). The type specimen was from Palm Springs in Riverside County. Other localities were Borrego Palm Canyon, San Diego County (Neil 1940), and the vicinity of Suncrest, San Diego County (Krutzsch 1944a). Although colonies had been observed, there was no information on whether these colonies consisted of females and young. Thus it was not known if the California populations were reproductive.

4.3.3. Current Distribution in California

Our investigations in southern California suggest this species is relatively uncommon, but nevertheless more widespread in the region than was previously realized (Fig. 6, Tables 1 and 5). On 29 May 1995, *N. femorosaccus* was detected emerging at dusk from cliffs in Borrego Pahn Canyon, Anza Borrego State Park, at a locality fitting the description of that given by Krutzsch (1944b). Positive identification of *N. femorosaccus,* via net captures, was obtained at two localities in San Diego County. Animals captured in Anza Bon-ego Park on July 6, 199O were adult males, but pregnant females were captured by us 28 May 1995, and females in various stages of reproduction by K. Miner (pers. comm.) at other times. Young, with partially open epiphyses, were captured on November 24, 1994 at another site in San Diego County, providing evidence that the species raises young in southern California (K. Miner in prep).

An additional population, based on visual observations and acoustic records, was located in Painted Canyon, north of Mecca, Riverside County on August 29, 1992. P. Brown (pers. comm.) reports a *Nyctinomops* colony (most likely *femorusaccus)* in a large boulder near Lake Mathews, and K. Miner (pers. comm.) has located two colony sites in western San Diego County.

Records obtained by California Department of Health Services suggest *N. femorosaccus* could be expected anywhere in southern California south of the San Bernardino Mountains (D. Constantine pers. comm.).

4.4. Population Biology

Although very little is known specifically about the reproductive biology of *N. femorosaccus,* it appears to follow the molossid pattern of breeding in the spring, with females giving birth to a single young in June and July (Kumirai and Jones 1990). Our capture of young with only partially closed epiphyses in late November in San Diego County greatly extends the season for births, suggesting that some young may have been born as late as September.

4.5. Habitat Associations

This species appears to be confined primarily to arid lowland areas (Barbour and Davis 1969, Schmidly 1991). In Big Bend National Park in Texas it has been found only in desert shrub and river floodplain arroyo (Easterla 1973). It has been found as high as 2,160 m elevation in pine-oak forest in Mexico, however (Kumirai and Jones 1990). In California it has been found only in the Lower and Upper Sonoran life zones (Krutzsch 1948), associated with creosote bush and chaparral habitats.

4.51. Roosting Ecology

N. femorosaccus is a crevice dwelling species, usually associated with high cliffs and rugged rock outcroppings (Barbour and Davis 1969), although it has also been found in caves (Dalquest and Hall 1947), and in buildings -- e.g., a colony living under roof tiles in a building at the University of Arizona, Tucson (Gould 1961). Colony size may be relatively small. Krutzsch (1944b) reported 50-60 animals in a colony in Borrego Palm Canyon, Anza Borrego Park, San Diego County.

Two roost sites were described by Krutzsch for California. The roost in Borrego Palm Canyon (Krutzsch 1944b, 1948) was in several crevices on a southwest facing slope about 3.6 m above the base of a cliff. One crevice was ca. 5 cm wide, and formed an irregular horizontal opening several feet long. At the Suncrest site (Krutzsch 1945, 1948)the bats were in a vertical crevice in a large granite boulder. The crack varied in width from 2.5 to 7.5 cm. *N. femorosaccus* inhabited the higher, narrower portion of the crack, and *E. perotis* were in the lower, wider portion.

One roost for *N. femorosaccus* was identified in the Split Mountain area of Anza Borrego Park in July 1990. The animals were in several vertical cracks, on a rock wall in a narrow canyon, about 4-5 m above the ground. They shared one crack with a nursery roost of *E. perotis,* but appeared to be roosting separately. In Painted Canyon, the animals were also in a dry, narrow, rocky canyon, in a large horizontal crack, beneath an overhang, ca. 5 m above the ground. In a San Diego County site, animals presumed to be *N. femorosaccus* (as many as 100) emerged from a number of cracks on the cliff face. The eight animals that were captured in a net, were roosting in a small chamber beneath an unevenly shaped granite boulder, on a 70° slope. The Lake Mathews roost, located by P. Brown (pers. comm.), was under an exfoliating slab in a large granite boulder. The slope was such that the roost was at least 4 m above the ground.

Krutzsch (1944b, 1948) noted that this species is very noisy in its roosts, and upon emergence. We also have observed a great deal of audible vocalization in the vicinity of the roosts. At both the Painted Canyon and Split Mountain sites, the animals swooped back and forth at emergence, calling to each other with an intense "chatter" for a number of minutes, before leaving the roost area. The literature indicates that this species leaves the roost well after dark (Gould 1961). Although bats observed in the summer left the roost after dark, those observed at a San Diego County site in November left well before dark (the first bat out of the roost at 1645 hr, 58 minutes prior to sunset).

Although there are not enough records for this species from California to document seasonal patterns, we expect it occurs year round. Krutzsch (1948) has records from March, May, July and August. Our records from San Diego County from late November suggest the species over-winters there. The species is present year round in southern Arizona (Gould 1961, Hoffmeister 1986).

4.5.2. Foraging Ecology

Limited data are available on the diet of this species. Easterla and Whitaker (1972) in an examination of 13 stomachs, found the species fed primarily on large moths (probably Sphingidae), but included a number of flying insects in their diet -- e.g., crickets (Gryllidae), grasshoppers (Tettigoniidae), flying ants (Formicidae), froghoppers (Cercopidae), and leafhoppers (Cicadellidae). The digestive tract of one *N. femorosaccus* from Arizona contained only Macrolepidoptera (probably hawk moths), and another from the same locality contained 85% Microlepidoptera and 15% Coleoptera (Ross 1967).

No new foraging or diet data were collected in the course of this study.

4.6. Current Status

The limited data collected during this study suggest this species is rare to uncommon, and should remain a Mammal Species of Special Concern.

4.7. Conservation Concerns

Not enough is known about this species in California to identify specific conservation concerns, although it is assumed that any impacts to cliffs (i.e., water impoundment projects, highway projects, and recreational climbing) within its range could potentially affect this species.

5.0. NYCTINOMOPS MACROTIS

5.1. Taxonomy

Nyctinomops macrotis was first described from a specimen found in a tree hollow in Cuba (Gray 1839). The California form was described by Allen (1893). Although in the past it has been called *Tadarida macrotis* or *Tadarida molossa,* the currently accepted nomenclature is *Nyctinomops macrotis* (Freeman 1981, Wilson and Reeder 1993). It is a monotypic species,

5.2. Diagnosis

N. macrotis, like all molossid species, has a free-tail which extends beyond the rear edge of the interfemoral membrane. It can be distinguished from the other three molossids which occur in California based on its size or forearm length. This species, with a forearm length of 58-64 mm, is larger than *N. femorosaccus* (forearm 45-49 mm) or *T. brasiliensis* (forearm 36-46 mm), and smaller than *E. perotis* (forearm 75-83 mm) (Barbour and Davis 1969, Milner *et al.* 1990) (Table 1). It has large, broad ears which are joined at the midline of the head, and extend beyond the tip of the nose when laid forward (Schmidly 1991). It weighs 22-30 g (Schmidly 1991).

5.3. Distribution

5.3.1 Geographic Range

N. macrotis is distributed from Uruguay and northern Argentina, northward through South America, mostly east of the Andes, through central America and Mexico into the southwestern United States, with records also from the Greater Antilles (Milner *et al.* 1990). In temperate North America, there are also scattered records from as far afield as eastern Kansas, Iowa, South Carolina and British Columbia (Di Salvo *et al.* 1992, Hall 1981, Nagorsen *et al.* 1993). Records are more common for Texas, Arizona, New Mexico, and Utah than for California.

5.3.2. Past Distribution in California

The type specimen for a form originally described at *Nyctinomops macrotis nevadensis* was most likely collected in California, although the exact locality is not known (Allen 1893, Allen 1894). There are several records from San Diego County (August and Dingman 1973, Huey 1932 and 1954), one from Alameda County (Museum of Vertebrate Zoology, UC Berkeley, 1916), and a number from scattered locations in California, with a concentration in southern California (D. Constantine pers. comm,) (Fig. 7).

5.3.3. Current Distribution in California

Possible records for *N. macrotis* are detailed in Tables 2 and 5, and depicted in Fig. 7. A moribund specimen was found below a cliff face in San Diego County in April 1991 (P. Brown pers. comm.). Although no live animals have been caught here, both acoustic and visual observations made in November 1994, and May 1995 suggest there is a small population of this species at this locality. Recorded echolocation calls were consistent with those described for *N. macrotis* (Schum 1972). Additionally,. small numbers (10-20 individuals) of molossids (identifiable by long tapered wings), too small to be *E. perotis,* and too large to be *N. femorosaccus* or *T. brasiliensis,* were seen emerging prior to dark from high on the cliff face. Recordings of echolocation calls possibly attributable to *N. macrotis* were also made at Barker Dam in Joshua Tree National Monument on 30 August 1992.

No additional records were obtained in California during the course of this study. Recent records collected by the California Department of Health Services, although all of isolated and dead individuals, suggest that, although this species is rare, it has a scattered distribution throughout much of the state, and could be expected almost anywhere (D. Constantine pers. comm.).

5.4. Population Biology

Information on the population biology of this species is limited. Available information suggests that adult females form nursery colonies, and give birth to a single young in June or July, with lactating females having been taken as late as mid-September (Barbour and Davis 1969, Constantine 1961b).

5.5. Habitat Associations

In the southwestern U.S. *N. macrotis* is primarily associated with arid, rocky country, i.e., Big Bend National Monument in Texas or the canyon lands of southern Utah (Barbour and Davis 1969, Easterla 1973, Milner *et al.* 1990, D. Rogers pers. comm.). Easterla (1973) found it in four plant communities -- arroyo, shrub desert, woodland, and moist Chisos woodland -- although the majority of animals were found in the floodplain-arroyo association. Although it has been found at about 2,440 m in elevation in New Mexico (Jones 1965), it is more typically found below 1,800 m (Milner *et al.* 1990).

5.5.1. Roosting Ecology

Relatively few roosts of *N. macrotis* have ever been found. A colony of about 130 was discovered by Bore11 (1939) in the Chisos Mountains of Texas. The animals were in a horizontal rock crevice (ca 15 cm wide and 6 m long), located about 12 m above a talus slope in a narrow, rocky canyon. Although animals have been found in buildings and caves (Mimer *et al.* 1990) -- two specimens from San Diego County were found in buildings (Huey 1932 and 1954) -- the few colonies of this species which have been located in the southwestern U.S. have been in rock crevices in canyon settings (Milner *et al.* 1990). In Cuba, the species appears to roost in small groups and has been found in tree hollows (Silva Taboada 1979).

5.5.2. Foraging Ecology

Very little is known about the foraging ecology of *N. macrotis.* Ross (1967) found only macrolepidopterans (probably hawk moths) in the stomach of one individual. Easterla and Whitaker (1972) examined 60 stomachs, and found that the most important food was large moths. Also, occasionally included in the diet were crickets (Gryllidae), grasshoppers (Tettigoniidae), and flying ants (Formicidae).

5.6. Current Status

Fairly extensive acoustic surveys were conducted at a number of localities throughout California, as detailed above under discussion of *E. perotis.* These recordings have revealed possible records of *N. macrotis* at one site in San Diego County and at Joshua Tree National Monument, Riverside County. Thus, although this species may occur almost anywhere in the state, we conclude it is very ram. Also, since no reproductive females or juveniles have been identified in any of the published records, it still is not known whether this species breeds in California. It should, however, remain as a Mammal Species of Special Concern.

5.7. Conservation Concerns

Not enough is known about this species in California to identify specific conservation concerns, although it is assumed that any impacts to cliffs (i.e., water impoundment projects, highway projects, and recreational climbing) could potentially affect this species.

6.0. EUDERMA MACULATUM

6.1. Taxonomy and Systematics

Euderma maculatum was first described by Allen (189 1) from a specimen collected in March 1890 in Ventura County in southern California. Although always recognized as a member of the Family Vespertilionidae, it was initially included in the genus *Histiotus* (now restricted to South America) (Wilson and Reeder 1993). It was subsequently recognized as a representative of a distinct genus, *Euderma* (Allen 1892). This genus has one species and no subspecies.

Handley (1959) viewed *Euderma* and *Plecotus* (= Corynorhinus) (including the taxon now recognized as *Idionycteris* [Williams *et al.* 1970]) as a phylogenetic unit, more closely related to one another than either is to any other genus within the Vespertilionidae. *Euderma* is placed in the tribe Plecotini (sensu Koopman and Jones 1970), which also includes *Idionycteris, Corynorhinus,* and *Barbastella.*

Relationships among plecotine genera have recently been re-examined by Frost and Timm (1992) and Tumlison and Douglas (1992). Using a similar set of morphological and karyological characters, these authors arrived at somewhat different conclusions. They concur in concluding that *Idionycteris* and *Euderma* are sister taxa, but Frost and Timm synonymize *Idionycteris* with *Euderma,* whereas as Tumlison and Douglas retain both genera. They offer differing views of the relationship between *Euderma* and the other genera. Tumlison and Douglas see *Idionycteris* and *Euderma* as the most derived taxa, and as a sister group to the Old World *Plecotus.* Frost and Timm, by contrast, treat *Euderma,* including *Idionycteris,* as the sister taxon to a clade comprised of *Barbastella, Corynorhinus* (= New World *Plecotus)* and *Plecotus* (= Old World species). A recent compilation of mammalian taxonomy (Wilson and Reeder 1993) retains both *Idionycteris* and *Euderma.*

6.2. Diagnosis

The spotted bat can be distinguished from all other North American species by its unique coloration (three dorsal white spots on a background of black fur), and very long, pinkish-red ears (39-50 mm). The spots, ca. 15 mm in diameter, are located over each shoulder, and in the center of the rump. Additionally, there is a white patch at the base of each ear. It is one of the largest North American vespertilionids (forearm 48-54 mm, tail 45-50 mm, total length 107-125 mm --Watkins 1977, Constantine 1987, Best 1988, Woodsworth *et al.* 1981). Mean weight is 15.3 g (n=6l)(Best 1988) (Table 1). Its wing and tail membranes, like the ears, are pinkish-red. Its ventral fur (like the dorsal spots) is white with a black base. Other North American species with very large ears (e.g., *Corynorhinus townsendii, Idionycteris phyllotis, Myotis evotis, Antrozous pallidus)* lack the black and white color pattern. The only other species with black fur, the silver-haired bat, *Lasionycteris noctivagans,* has short rounded ears, and its black fur, while often frosted in appearance, lacks distinct white spots.

6.3. Distribution

6.3.1 Geographic Range

This species is distributed throughout much of the western U.S. (Watkins 1977), with its range extending as far north as southern British Columbia (Woodsworth *et al.* 198l), and as far south as Durango, Mexico. The most generally accepted distribution map (Hall 1981), does not reflect more recent range extensions. The species has now been found at new localities in Colorado (K. Navo pers. comm.) and Oregon (McMahon *et al.* 1981, Barss and Forbes 1984).

Although this species covers a broad geographic range, its distribution appears to be patchy, and geomorphically determined, limited to areas with appropriate roosting habitat.

6.3.2 Past Distribution in California,

The past distribution for *E. maculatum* in California is depicted in Fig. 8, and detailed in Pierson and Rainey (In press). The type specimen for this species in California is from Castaic Creek, Ventura County (Allen 1891). The majority of records (mostly single, dead or moribund animals) come from low elevation, xeric settings (e.g., Red Rock Canyon State Park in Kern County, Mecca in Riverside County, and several from the Owens Valley -- Grinnell 1910, Hall 1939, Constantine *et al.* 1979, Bleich and Pauli 1988). Additionally there were two records from Yosemite Valley (Ashcraft 1932, Parker 1952). The most northern record was from a single specimen picked up alive in the garage of a residence in Palo Cedro, Shasta County (Bleich and Pauli 1988).

6.3.3. Current Distribution in California

Records obtained for *E. maculatum* in this study are detailed in Fig. 8. Investigation of the distribution of this species was limited to areas where it was presumed to overlap with *E. perotis,* the species of primary focus in this study. Thus the east side of the Sierra Nevada was not included in our surveys. We did, however, detect *E. maculatum* at two sites on the east side of the Sierra(Owens Gorge and Saline Valley) in the course of other studies (Pierson and Rainey in press). All records for *E. maculatum* obtained in this study are given in Table 2.

Although we encountered *E. maculatum* on relatively few occasions during the course of this study, the records we obtained shift the historic perspective in two significant ways. First, we identified a population in the vicinity of Castle Crags State Park, in Shasta and Siskiyou Counties. Multiple individuals were detected repeatedly and predictably at one site located in late July 1994 and monitored through August. Animals were again detected here in late April 1995 (R. Miller pers. comm.), and followed during the summer. Additionally, the species has been recorded at other sites close Castle Crags State Park, plus several additional localities in the region: a site in Dunsmuir to the north, at Castle Lake in the Trinity Alps west of Mt. Shasta City, at Squaw Creek northeast of Lake Shasta, and at Finley Lake in Lassen National Forest (T. Rickman pers. comm.). These observations suggest this species may be more widely distributed in the Trinity Alps, and that there is a need to investigate areas (particularly in Tehama and Trinity counties) not included in this survey.

The second significant finding is that this species is widely distributed in the central and southern Sierra Nevada. The largest populations encountered (the Yosemite Valley, Hetch Hetchy

Reservoir and Wawona areas of Yosemite National Park) were at mid-elevation (ca. 1,200-1,400 m), but one or more individuals were rather predictably encountered at several high elevation sites (up to 2,880 m) (e.g., Tuolumne Meadows in Yosemite National Park Giant Forest, Twin Lakes near Silliman Pass, Deadman Canyon, and a meadow below Bench Lake on the Middle Fork of the King's River -- all in Sequoia National Park). All high elevation detections were in the vicinity of large meadow below significant rock cliffs.

Although we found a number of new localities, we did not detect the species at most of the historic localities sampled (e.g., the vicinity of Mecca, the vicinity of Castaic Creek, Red Rock Canyon State Park, Friant Dam). The only place where previously reported specimens revealed significant populations was Yosemite Valley. K. Miner (pers. comm.) reported hearing *E. maculatum* at Red Rock Canyon in 1996.

At three sites in Yosemite National Park (Hetch Hetchy, Wawona, and Yosemite Valley), plus at several sites along the Grand Canyon of the Tuolumne (Pierson and Rainey 1995), populations of *E. perotis* and *E. maculatum* co-occur. This is not surprising, since a number of historic distribution records suggest an overlapping distribution (e.g., several collecting localities were virtually identical). *E. maculatum* appears, however, to be considerably rarer than *E. perotis* everywhere we sampled in Yosemite National Park. For example, at Wawona on August 13, 1994, during 80 minutes of observation, *E. perotis* was heard 16 times, and *E. maculatum* three times; and on August 14, 1994, during 155 minutes of observation, *E. perotis* was heard 26 times, and *E. maculatum* eight times.

6.4. Population Biology

Very little is known about the population biology of spotted bats, although available data suggest that the species gives birth to a single young (Findley and Jones 1965, Watkins 1977), and that births take place in June or early July. A female about to give birth was caught at Fort Pierce Wash in Utah on June 20 (Poche 1975). Woodsworth *et al.* (1981) collected a pregnant female on June 16, 1980 in British Columbia, with an embryo measuring 29 mm crown-rump. A pregnant female, captured on June 11, 1969, in a mist net in Big Bend National Park in western Texas gave birth to a single young, which weighed 4 g (25 % mother's weight)(Easterla 1971). Measurements (mm) for this young were: total length 59, tail 20, ears 12, and forearm 21. Lactating females have been caught as early as June 12 in Texas (Easterla 1973) and as late as mid-August at 2,313 m in Utah (Easterla 1965), and on the Kaibab Plateau in Arizona (Berna 1990).

A non-reproductive female, with closed epiphyses, presumed to be a juvenile was captured in a mist net on 19 July 19 1993 at Mirror Lake in Yosemite National Park (Forearm 50.53 mm, Weight 14.8 g).

No data are available on longevity.

6.5. Habitat Associations

E. maculatum is found in a variety of habitat types, from 57 m below sea level (Grinnell 1910) to 3,230 m above sea level (Reynolds 1981), in habitats ranging from desert scrub to montane coniferous forest (Findley and Jones 1965, Best 1988). It has been collected most often in rough desert terrain. Wherever the species is found, there are substantial cliff features (granite, basalt, limestone, sandstone, and other sedimentary rock) nearby (Parker 1952, Medeiros and

Heckmann 1971, Easterla 1973, O'Farrell 1981, Berna 1990, Navo *et al.* 1992, Pierson and Rainey 1993 and 1994), suggesting that the distribution of spotted bats may be limited by the availability of suitable roosting habitat. Also, at all sites where resident populations have been identified, there is water in the area (O'Farrell l981).

E. maculatum has been found in extremely arid areas, such as the Salton Sea (Grinnell 1910) and Red Rock Canyon (Hall 1939) in California. There are several records from the Owens Valley, east of the Sierra Nevada (Bleich and Pauli 1988), which is dominated by sagebrush *(Artemisia tridentata),* saltbrush *(Artiplex* spp.), greasewood *(Sarcobatus vermiculatus),* and rabbitbrush *(Chrysothamnus nauseosus).* In Big Bend National Park in western Texas, the species has been found only on the river floodplain (mesquite, willow, *Baccharis,* cottonwood) and the shrub desert (lechuguilla, creosote bush and cactus)(Easterla 1973), and in creosote *(Larrea tridentata)* dominated habitat in Fort Pierce Wash on the Arizona-Utah border (Ruffner *et al.* 1979). Constantine (1961) and Navo *et al.* (1992) found the species in the pinyon pine-juniper belt. The Colorado population studied by Navo *et al.* (1992) is found in a semi-arid area (20-38 cm annual precipitation), between 1,442 to 2,745 m elevation, with local vegetation dominated by pinyon-pine *(Pinus edulis* and *Juniperus* spp.), desert shrublands of sagebrush *(Artemesia tridentata),* rabbitbrush *(Chysothamnus)* and greasewood *(Sarcobatus vermiculatus),* with ponderosa pine and douglas fir at the higher elevations. The semi-arid (27 mm rain per year) Okanagan Valley in British Columbia, which supports the most intensively studied population, has vegetation dominated by sage brush *(Artemesia* spp.) and short grasses in lowlands, and open ponderosa pine montane forest in the foothills (500-l,500 m. above sea level)(Woodsworth *et al.* 1981).

A number of authors describe an association with ponderosa pine forest (Handley 1959, Findley and Jones 1965, Watkins 1977, Woodsworth *et al.* 1981, Berna 1990, Navo *et al.* 1992, Pierson and Rainey 1993), although there is no indication the species roosts in trees, nor forages within the forest. Most commonly, the bats are described as being detected in meadows, along the forest edge, or in open areas surrounded by ponderosa pine. They have also been observed in oak Savannah *(Quercus* spp.) (Bleich and Pauli 1988), or mixed oak/conifer woodland (this study).

6.5.1. Roosting Habitat

6.5.1.1. Background Information

Very limited information is available on the specific roosting requirements of *E. maculatum.* Available data suggest, however, that the species roosts predominantly in small crevices in substantial cliff faces (Easterla 1970, Easterla 1973, Poche 1975, Poche and Ruffner 1975). Barss and Forbes (1984) report finding a mummified adult male on the floor of a small crevice in the base of a west facing andesitic cliff overlooking John Day River in Oregon. The cliff, fractured and in many places overhanging, was 20-30 m high. Animals captured at foraging areas, and followed upon release, have always flown to rock crevices, generally on cliff faces (Easterla 1973, PochC and Baillie 1974, Poche 1975, PochC and Ruffner 1975, Berna 1990). In the few cases in which it was possible to locate the released animals, they were in narrow cracks, one 3 cm wide (PochC and Ruffner 1975), another with an interior opening 10 cm wide, and the bat hanging by its feet 1.5 m from the base of the hole (Poche 1975). While these observations may offer a general indication of roosting preferences, sites chosen by captured, stressed animals released at dawn or in daylight should be viewed with caution.

Radiotracking studies, conducted in the Okanagan Valley in British Columbia (Leonard and Fenton 1983, Taylor and Wai-Ping 1987), suggest that individual spotted bats roost singly in high cliffs, and are loyal to roosts. Leonard and Fenton (1983) monitored activity at two roost sites from May through August. Although they could identify 4-36 individuals at one cliff, and 5- 11 at the other, individuals emerged after sunset from many places on the face of the cliffs. In this and another study (Wai-Ping and Fenton 1989), radiotagged bats consistently used the same day roosts, and departed in the evening at predictable times.

Although *E. maculatum* is not generally viewed as a cave dwelling bat, there are several records of this species roosting in caves and mines. Hardy (1941) reports the finding of four spotted bats hibernating in February on the walls of a cave in Utah, hanging by their thumbs over a large pool of water. There are additional records of a spotted bat found in a natural cave in Nevada in April (Soulages 1966), and in Wyoming (Wyoming Department of Fish and Game 1994). A spotted bat was also found in a mine in Sonora, Mexico (Vorhies 1935), and in a wet “cave dug into the side of a hill” in March, 1948 in San Bernardino County, California (Parker 1952).

Although *E. maculatum* has been reported from in or around buildings, these have generally been considered aberrant records, and not indicative of normal behavior (O’Farrell 1981). For example, a spotted bat found at a fish hatchery in Fresno County, California proved to be rabid (Medeiros and Heckmann 1971). Others were found in odd circumstances (e.g., hanging from a second story window sill [August and Dingman 1973], clinging to a screen door [Rodeck 1961], or hanging on the sides of buildings [Ashcraft 1932, Vorhies 1935, Benson 1954, Easterla 19651). A large proportion of the animals found in association with human habitation were discovered dead or moribund (e.g., Grinnell 1910, Deacon and Bradley 1962, Nicholson 1950, Parker 1952, Tucker 1957, Bleich and Pauli 1988).

Little is known of seasonal roosting patterns for this species. It is not known whether the species migrates, although, since other plecotine bats (i.e., *Corynorhinus*) are known to be relatively sedentary, long distance migration seems unlikely. *Euderma* has been found hibernating in the colder portions of its range (e.g., Hardy 1941), yet is present and periodically active throughout the winter in southwestern Utah (Ruffner *et al.* 1979, Poche 1981).

6.5.1.2. <u>This Study</u>

No roosts of *E. maculatum* were located during the course of this study. The appearance, however, of up to six individuals right after dark in the vicinity of Mirror Lake in Yosemite National Park suggests animals are roosting nearby. Likewise, a few *E. maculatum* are predictably heard at dark near the Cascades, just west of Yosemite Valley. All but one observation of *E. maculatum* in this study were within view of substantial cliff faces that offered potential roosting habitat. Likewise, at Hetch Hetchy they were detected right after dark, coming from the direction of Kolana Rock and Hetch Hetchy Dome. The one exception was acoustic detection of *E. maculatum* at the Merced Grove parking area in Yosemite National Park, several miles from the nearest cliffs. In a separate radiotracking study conducted in Yosemite Valley in 1995, we located four roosting areas within 1 km of Mirror Lake. All were in areas of fractured rock, and three were high on the cliff faces (Pierson and Rainey 1996).

The presence of foraging animals in Yosemite Valley in early November 1993 and at Castle Crags in January 1996 suggests that those populations do not migrate.

6.5.2. Foraging Habitat

6.5.2.1. Background Information

E. maculatum appears to be a lepidopteran specialist (Ross 1961, Easterla 1965, Easterla and Whitaker 1972), feeding primarily on moths (most likely noctuids) 5-12 mm in length. In two studies it was found to feed entirely on moths; in one study, the stomach contents of two individuals was l0-30 % by volume June beetles (Scarabaeidae)(Easterla and Whitaker 1972).

E. maculatum has been observed foraging in a wide range of habitat types from arid canyonlands to marshes and wet, montane meadows, often in association with sagebrush, pinyon-pine juniper, or ponderosa pine habitat (Wang and Fenton 1982, Leonard and Fenton 1983, Wai-Ping and Fenton 1989, Navo *et al.* 1992). They are most frequently found foraging aerially in open areas, and thus do not appear to be gleaners (Leonard and Fenton 1983). Leonard and Fenton (1983) assessed patterns of habitat use in six habitats: an old field dominated by knapweed (*Centaurea* spp.), with patches of bunch grass (*Agropyron* spp.) and surrounded by ponderosa pine; an irrigated valley planted with alfalfa (*Medicago sativa*) and bordered by ponderosa pine (*Pinus ponderosa*); mature ponderosa pine-Douglas fir (*Pseudotsuga menziesii*) forest; a ponderosa pine burn area; a cherry orchard; and a river, bordered by steep cliffs on one side and a hayfield on the other. The only areas which received significant use, and in which feeding buzzes were detected, were the two open areas (field and irrigated valley) surrounded by ponderosa pine forest. In a study by Wai-Ping and Fenton (1989), spotted bats were most active over marshes and in open ponderosa pine woodland. Navo *et al.* (1992) found no restricted association with any habitat type. They observed spotted bats over a river, sand/gravel bars, riparian vegetation, and pinyon-jumper habitat.

Most observations suggest *E. maculatum* forages alone (Wong and Fenton 1982, Wai-Ping and Fenton 1989), sometimes maintaining exclusive feeding areas (Leonard and Fenton 1983), and other times using a “trapline” strategy (Woodsworth *et al.* 1981). Leonard and Fenton (1983) note that individuals give a different call, and “interaction buzz” when encountering each other on the wing. Individuals generally forage 5- 15 m off the ground in large elliptical paths, with axes of 200-300 m (Wai-Ping and Fenton 1989, Navo *et al.* 1992). Unlike many species, spotted bats are not known to night-roost. They are active all night, travelling one way distances from the roost site of 6- 10 km each night (Wai-Ping and Fenton 1989).

6.5.2.2. This Study

We observed *E. maculatum* foraging predominantly over open areas -- wet, sedge dominated meadows, surrounded by mixed oak/conifer (predominantly ponderosa pine) woodland in Yosemite Valley, and over drier meadows, in mixed oak/conifer (predominantly black oak, incense cedar, ponderosa pine) habitat, in the Trinity Alps. Although spotted bats have been heard foraging within 100 m of two major rivers (the Merced and Sacramento), they have not been detected foraging over these rivers, nor within the forest,

We observed two kinds of behavior for *E. maculatum* in Yosemite National Park. At Mirror Lake, Bridal Veil Meadow and El Capitan Meadow animals appeared to maintain small exclusive feeding territories for extended periods of time. At Mirror Lake, we were able to observe that the same sites were occupied year to year (1992, 1993, and 1994), summer and fall, and on three consecutive nights, for up to four hours. In this setting, up to five animals used adjacent territories in once section of the meadow, and would make a buzzing sound when they encountered each other. At the same time, however, we observed other animals passing through the area. Although the data are limited, these events suggest that some proportion of the population was using a "trap-line" approach, as has also been observed elsewhere (Wai-Ping and Fenton 1989, Woodsworth *et al.* 1981).

Although all our foraging observations were in meadow settings, the distribution of this species in California extends into very dry habitats in the Owens Valley (Inyo County), Red Rock Canyon State Park (Kern County), near Mecca (Riverside County), China Lake (San Bernardino County) and Anza Borrego State Park (San Diego County), suggesting it does not feed over meadows elsewhere in its range.

6.6. Current Status

Given how few times this species was detected, it is presumed to be very rare. The only areas where it could somewhat predictably be detected were mid to high elevation meadows in the Sierra Nevada.

6.7. Conservation Concerns

Many of the potential threats identified for *E. perotis* (see Section 3.7) likely apply to *E. maculatum.* As with *E. perotis,* of particular concern are water projects, highway projects, and recreational climbing. Urban/suburban expansion and extermination by pest control operators or public health officials are not likely to pose threats to *E. maculatum* since the species appears to be non-colonial and is only rarely found in human-made structures.

Other potential threats, not shared with *E. perotis,* are detailed below.

6.7.1. Patchy Distribution and Small Population Size

Although *E. maculatum* occurs in a number of different habitats, and has a broad distribution throughout the western U.S., its occurrence appears to be very patchy, with sometimes hundreds of miles separating populations. Also, even in areas that appear to have consistently detectable populations (e.g., the Okanagan Valley in British Columbia, Dinosaur National Monument in Colorado, Fort Pierce Wash in southern Utah, Yosemite National Park and Castle Crags State Park in California), the species is relatively uncommon. This combination of small population size and patchy distribution place individual populations at risk of local extirpation from anthropogenic and stochastic causes.

6.7.2. Sensitivitv to Human Disturbance

No data are available on the sensitivity of *E. maculatum* to human disturbance. As a plecotine bat and a close relative of *Corynorhinus,* one of the taxa most sensitive to disturbance at roost sites, it would be expected, however, that intrusion into roosting sites would pose a threat to this species.

6.7.3. Recreational Caving

Although *E. maculatum* is not generally considered a cave roosting species, it has been found in caves on several occasions (Section 6.51). Although dates are not always available for these records, there is the suggestion that this species is more likely to use caves for hibernation. Disturbance of cave dwelling bats at roosting sites has been a major cause for population declines for a number of species in the eastern United States, and could potentially have similar impacts on *E. maculatum.*

6.7.4. Closure of Abandoned Mines

Aggressive mine closure programs for hazard abatement have been underway for ten or more years in a number of western states. Until very recently, most closures were undertaken without any prior biological assessment. Given that up to 80 % of mines are inhabited by bats, and ca. 10 % serve as major roosts, it is virtually certain that a number of bat colonies have been eradicated by mine closure practices. To the extent that *E. maculatum* uses abandoned mines, they too would be at risk from these practices.

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Table 1. Characteristics of search phase echolocation calls of *E. perotis* , *N. macrotis* , *N. femorosaccus* and *E. maculatum* as they relate to body size

Species	**Forearm (mm)**	**Weight (g)**	**Fundamental Frequency (kHz)**	**Call Duration (ms)**	**Interpulse Interval (ms)**
E. perotis	75 to 83	60 to 72	7 to 9	20 to 30	200 to 2, 000
N. macrotis	58 to 64	22 to 30	10 to 12	15 to 20	200 to 800
N. femorosaccus	45 to 49	10 to 14	15 to 18	10 to 15	250 to 800
E. maculatum	48 to 54	ca. 15	5 to 8	5 to 6	300-400

Table 2. Records for aubible bats in California, 1991-1995. Those records marked with an asterisk {*) were supplied by other observers (P. Brown, R, Miller, W. Philpott, or L. Thompson).

County	Locality	Latitude	Longitude	Elevation m	Roost Located	Roost in Area	Multiple	1-3 Animals	Date
Eumops perotis									
Butte	E side Table Mt., Oroville	393351N	1213402W	300				X	8/24/94
Butte	W side Table Mt., Oroville	393605N	1213532W	200		X			8/24/94
Calaveras	Table Mt., Tulloch Lake	375257N	1203342W	305	X				11/20/94
Calaveras	N.Shore, Tulloch Reservoir	375236N	1203614W	155			X		10/13/94
Fresno	Auberry	370451N	1192904W	506		X			10/7/94
Fresno	Coalinga, Jct. 33 & 198	360725N	1202116W					X	5/26/95
Fresno	Los Gatos Creek, W. of Coalinga	361300N	1200800W					X	5/26/95
Fresno	MacKenzie Table Mt.	370108N	1193623W	450		X			10/7/94
Fresno	MacKenzie Table Mt.	370108N	1193623W	450		X			10/9/94
Fresno	MacKenzie Table Mt.	370108N	1193623W	450	X*				1/95
Fresno	San Joaquin River, Below Falls	370337N	1193514W	640		X			10/8/94
Fresno	San Joaquin River, Guaging Sta.	370842N	1192636W	671		X			10/8/94
Fresno	San Joaquin River, Powerhouse 8	371247N	1191925W	732		X			10/8/94
Fresno	San Joaquin River, Squaw Leap	370406N	1193235W	305				X	10/8/94
Kern	Democrat Hot Springs	353141N	1184001W	774	X				9/5/92
Los Angeles	Elsmere Canyon	342151N	1183018W					X*	Spring 1992
Los Angeles	Paramount Ranch (2 mi E Cornell)	340652N	1184627W					X	5/31/95
Madera	Little Table Mt.	370032N	1194557W	162				X	10/7/94
Mariposa	Cascades, Yosemite NP	374338N	1194243W	1036		X			8/11/94
Mariposa	Cascades, Yosemite NP	374338N	1194243W	1036		X			10/12/94
Mariposa	Crane Flat, Yosemite National Park	374534N	1194759W				X		8/5/94
Mariposa	El Capitan Meadow, Yosemite NP	374329N	1193815W	1190			X		10/12/94
Mariposa	El Capitan Meadow, Yosemite NP	374329N	1193815W	1190			X		7/22/93
Mariposa	El Portal	374029N	1194659W					X	9/5/95
Mariposa	Glen Aulin, Yosemite NP	375442N	1192525W					X	8/8/94
Mariposa	Hart Lake, Yosemite NP	373712N	1193139W					X	8/26/95
Mariposa	Mirror Lake, Yosemite NP	374455N	1193253W	1250		X			7/19/93
Mariposa	Mirror Lake, Yosemite NP	374455N	1193253W	1250		X			8/11/94

Table 2. cont'd.

County	Locality	Latitude	Longitude	Elevation m	Roost Located	Roost in Area	Multiple	1-3 Animals	Date
Eumops perotis									
Mariposa	Mirror Lake, Yosemite NP	374455N	1193253W	1250		X			10/12/94
Mariposa	Olmstead Point, Yosemite NP	374834N	1192858W				X		9/2/95
Mariposa	Pate Valley, Tuolumne River, Yosemite	375600N	1193545W					X	8/10/94
Mariposa	Tenaya Lake, Yosemite NP	374951N	1192730W				X		9/2/95
Mariposa	Tuolumne Meadow	375239N	1191955W				X		7/26/95
Mariposa	Wawona, Yosemite NP	373252N	1194038W	1220		X			8/12/94
Mariposa	Wawona, Yosemite NP	373213N	1193919W	1189		X			8/13/94
Mariposa	Wawona, Yosemite NP	383108N	1221535W	1210		X			8/14/94
Mariposa	Yosemite Institute, Yosemite NP	374530N	1194850W				X		9/2/95
Mariposa	Yosemite Valley	374259N	1193951W	1190		X			7/24/94
Merced	Los Banos Creek	365733N	1210029W	122		X			8/12/94
Merced	Los Banos Creek	365733N	1210029W	122		X*			11/30/94
Monterey	Wagon Caves	360708N	1212751W	460			X		5/18/92
Orange	Blind Canyon	334743N	1174346W			X*			Spring 1992
Orange	Coal Canyon	335218N	1174116W			X*			Spring 1992
Orange	Fremont Canyon, nr. Santiago Res.	334726N	1174327W			X*			Spring 1993
Orange	Laguna Hills	333645N	1174243W					X*	9/91
Riverside	Barker Dam, Joshua Tree NM	340151N	1160843W					X	8/30/92
Riverside	Painted Canyon, NE of Mecca	333620N	1160122W			X			8/29/92
Riverside	Lake Mathews	335033N	1172740W	424			X*		5/92
Riverside	Lake Perris	335057N	1171119W				X		5/92
Riverside	Norco City Hall	335552N	1173252W	195	X				9/2/92
San Benito	Pinnacles NM, Bear Creek Parking	362844N	1211056W	390		X			5/17/92
San Benito	Pinnacles NM, Bear Gulch Reservoir	362822N	1211109W	520			X		5/17/92
San Benito	Pinnacles NM, Camping Area	362931N	1211009W	335			X		5/17/92
San Benito	Silver Creek, nr. Panoche	363036N	1204155W			X			8/27/92
San Bernardino	Highland	340742N	1171228W		X				9/2/92
San Bernardino	HWY 330, Little Mill Creek	340905N	1170759W					X	9/2/92
San Bernardino	Rancho Cucamonga School	340658N	1173559W		X				8/31/92
San Diego	Anza Borrego Park, Borrego Palm Cyn	331615N	1162445W					X	5/29/95

Table 2. cont'd.

County	Locality	Latitude	Longitude	Elevation m	Roost Located	Roost in Area	Multiple	1-3 Animals	Date
Eumops perotis									
San Diego	Anza Borrego Park, Split Mt.	330017N	1160708W	102	X				7/6/90
San Diego	Lake Barrett	324046N	1164011W		X				5/22/91
San Diego	Mission Gorge	324639N	1170729W				X		5/30/95
San Diego	Ramona	330027N	1165738W		X				9/15/90
Siskiyou	Dunsmuir	411230N	1221615W					X*	7/31/93
Siskiyou	Gumboot Lake	411242N	1223033W					X*	9/1/93
Siskiyou	Medicine Lake	413454N	1213552W					X*	9/9/93
Siskiyou	Medicine Lake	413454N	1213552W					X	9/10/94
Siskiyou	Ney Springs, nr. Mt. Shasta City	411540N	1221940W					X	9/93
Stanislaus	Knight's Ferry	374911N	1204016W				X		10/13/94
Tehama	Antelope Creek	400905N	1220730W				X*		9/94
Tehema	Meridian Rd., N. of Chico	395300N	1215330W				X		8/26/94
Tehema	Meridian Rd., N. of Chico	395300N	1215330W				X*		11/30/94
Tulare	Ash Mt., Sequoia NP	362931N	1184950W					X	10/11/94
Tulare	Giant Forest, Sequoia NP	362811N	1185503W				X		6/27/95
Tulare	Lake Kaweah	362410N	1190010W				X		10/11/94
Tulare	Lake Success	404111N	1212457W				X		10/11/94
Tulare	Sequoia Village Inn	363351N	1184622W					X	10/11/94
Tulare	Sycamore Ck, Seq.NP	361109N	1184750W				X		7/13/95
Tulare	Three Rivers, in town	362620N	1185413W					X	7/14/95
Tulare	Yokohl Valley	361932N	1190453W					X	10/11/94
Tuolumne	Glen Aulin, Yosemite NP	375442N	1192525W	2380				X	8/8/94
Tuolumne	Goodwin Dam, Stanislaus Riv.	375146N	1203745W				X		10/13/94
Tuolumne	Hetch Hetchy Reservoir	375651N	1194713W	1157		X			8/26/92
Tuolumne	Hetch Hetchy Reservoir	375651N	1194713W	1157			X		7/12/93
Tuolumne	Merced Grove, Yosemite NP	374458N	1195010W	1768				X	8/5/94
Tuolumne	O'Byrne's Ferry Rd. & Stanislaus River	375236N	1203614W					X	10/13/94
Tuolumne	Pate Valley, Yosemite NP	375600N	1193545W	1320		X			8/10/94
Tuolumne	Table Mt., Jamestown	375130N	1203741W		X				11/20/94

Table 2. cont'd.

County	Locality	Latitude	Longitude	Elevation m	Roost Located	Roost in Area	Multiple	1-3 Animals	Date
Eumops perotis									
Tuolumne	Table Mt., Tulloch Lake	375236N	1203614W	305	X				11/20/94
Tuolumne	Table Mt., Jamestown	375130N	1203741W	457	X				10/13/94
Tuolumne	Tuolumne	375739N	1201411W				X*		7/11/95
Tuolumne	Tuolumne River, Early Intake	375241N	1195758W					X	7/11/93
Ventura	Blue Pt. Campground, Lake Piru	343147N	1184525W				X		8/28/92
Ventura	2 km. S, Blue Pt. Camp., Lake Piru	342742N	1184501W				X		8/28/92
Nyctinomops femorosaccus									
Riverside	Lake Mathews	335033N	1172740W	424	X*				5/92
Riverside	Painted Canyon, NE of Mecca	333620N	1160122W			X			8/29/92
San Diego	Anza Borrego Park, Borrego Palm Cyn	331615N	1162445W			X			5/29/95
San Diego	Anza Borrego Park, Split Mt.	330017N	1160713W			X			7/6/90
San Diego	Anza Borrego Park, Split Mt.	330017N	1160713W			X			5/28/95
San Diego	Anza Borrego Park, Split Mt.	330017N	1160713W			X			5/29/95
San Diego	Mission Gorge	324844N	1170412W			X			11/27/94
San Diego	Sweetwater Reservoir	324129N	1170026W			X			5/26/95
Nyctinomops macrotis									
Riverside	Barker Dam, Joshua Tree NM	340151N	1160843W						11/27/94
San Diego	Mission Gorge	324844N	1170412W						11/27/94
Euderma maculatum									
Fresno	Muro Blanco, Kings River, Sequoia NP	365434N	1183116W	2,840				X	8/29/94
Inyo	Hunter Canyon, Saline Valley	364208N	1175055W	475				X	4/10/97
Mariposa	Briceburg	373618N	1195757W	439				X	9/3/96
Mariposa	Cascade Creek, Yosemite NP	374338N	1194243W	1,048			X		8/11/94
Mariposa	Crane Flat, Yosemite NP	374534N	1194759W	1,790			X		8/5/94
Mariposa	Glen Aulin, Yosemite NP	375442N	1192525W	2,370				X	8/8/94
Mariposa	Merced Lake, Yosemite NP	374417N	1192453W	2199				X	10/9/96

Table 2. cont'd.

County	Locality	Latitude	Longitude	Elevation m	Roost Located	Roost in Area	Multiple	1-3 Animals	Date
Euderma maculatum									
Mariposa	Ostrander Lake, Yosemite NP	373726N	1193300W	2,592				X	8/25/95
Mariposa	Pate Valley, Yosemite NP	375600N	1193545W	1,320			X		8/10/94
Mariposa	Wawona, Yosemite NP	373213N	1193919W	1,200			X		8/12/94
Mariposa	Yosemite Valley, Yosemite NP	374455N	1193253W	1,248			X		7/1/92
Mono	Owens River Gorge	373143N	1183431W	1,828		X			4/12/97
Shasta	Castle Crags State Park	411200N	1222246W	646		X			7/1/94
Shasta	Squaw Creek/Ash Creek	405120N	1220728W	411				X	8/23/95
Siskiyou	2 km. S of Mt. Shasta City	411642N	1221804W	1,000				X*	7/31/93
Siskiyou	Castle Lake	411339N	1222257W	1,657				X	8/8/93
Tehama	Finley Lake, Lassen NF	401613N	1215104W	856				X*	9/11/96
Tulare	Deadman Canyon, Sequoia NP	360913N	1182405W	2,926					9/10/93
Tulare	Giant Forest Village, Sequoia NP	363404N	1184606W	1,960			X		9/11/95
Tulare	Twin Lakes, Silliman Pass, Sequoia NP	361759N	1183709W	2,879				X	9/3/93
Tuolumne	Hetch Hetchy Reservoir, Yosemite NP	375651N	1194713W	1,163			X		8/26/92
Tuolumne	Mi Wok Ranger District, Stanislaus NF	380609N	1201412W	1,050			X*		7/19/95
Tuolumne	Tuolumne Meadow, Yosemite NP	375238N	1192145W	2,652				X	9/2/95
Tuolumne	Tuolumne	375739N	1201411W	823				X	7/11/95

Table 3. Sampling for audible bats in the coast ranges and Northern California, north to south

COUNTY	LOCALITY	DATE	*E. PEROTIS*	*E. MACULATUM*
Siskiyou				
	Gumboot Lake	9/1/93	**YES**	No
	Castle Lake	8/8/93	No	**YES**
	Ney Springs	9/1/93	**YES**	No
	Dunsmuir	7/31/93	No	**YES**
	Medicine Lake	9/9/93	**YES**	No
Shasta				
	Castle Crags	8/1/94	No	**YES**
Tehema				
	Antelope Creek	9/1/94	**YES**	No
	Black Butte	9/27/94	No	No
	Finley Lake	9/11/96	**YES**	**YES**
Napa				
	Monticello Dam	5/15/95	No	No
	Wooden Valley	5/15/95	No	No
Alameda				
	Corral Hollow	8/28/94	No	No
Fresno				
	Coalinga	5/26/95	**YES**	No
	Little Panoche Res.	11/28/94	No	No
San Benito				
	Silver Creek	8/27/92	**YES**	No
	Pinnacles NM	5/17/95	**YES**	No
Monterey				
	Wagon Caves	5/18/95	**YES**	No
Ventura				
	Lake Piru	8/28/92	**YES**	No

Table 4. Sampling for *E. perotis* and *E. maculatum* in Sierra Nevadan river drainages, north to south.

RIVER DRAINAGE	DATE	ELEVATION (m)	*E. PEROTIS*	*E. MACULATUM*
Feather				
Bell Canyon	9/25/94	1,067	No	No
Twain Sawmill	9/25/94		No	No
Rich Bar	9/25/94		No	No
Chambers Creek	9/25/94		No	No
Arch Rock	9/25/94	460	No	No
Power Station	9/25/94	610	No	No
Lake	9/25/94		No	No
Table Mt.	9/24/94		YES	No
N. Fork Yuba				
Yuba Pass	6/20/94	1,956	No	No
Hwy 49, MP 21	6/23/94	1,036	No	No
2 km S. Indian Valley	6/22/94	685	No	No
Mokelumne				
Salt Spring Res. Dam	5/10/95	1,200	No	No
2 km. S, Salt Spg. Res.	5/10/95	ca. 1,000	No	No
Hwy 26 at Mokelumne R.	5/10/95	610	No	No
Pardee Res. Dam	5/10/95	175	No	No
Comanche Greens	5/10/95	90	No	No
Comanche Reservoir	5/10/95	70	No	No
Stanislaus				
Jamestown Table Mt.	10/3/94	460	YES	No
Table Mt., Tulloch Lake	11/20/94	215	YES	No
Tulloch Lake	10/3/94	150	YES	No
Tulloch Rd.	10/3/94	105	YES	No
Knight's Ferry	10/3/94	60	YES	No
Tuolumne				
Tuolumne Meadow	8/5/94	2,620	No	YES
Tuolumne Meadow	8/6/94	2,620	No	No
1 km below Glen Aulin	8/8/94	2,380	YES	YES
2 km above Muir Gorge	8/9/94	1,710	No	YES
Pate Valley	8/10/94	1,320	YES	YES
Hetch Hetchy	8/26/92	1,162	YES	YES
Hetch Hetchy	7/12/93	1,162	YES	YES
Hetch Hetchy	7/13/93	1,162	YES	YES
Hetch Hetchy	7/14/93	1,162	YES	YES
Hetch Hetchy	7/16/93	1,162	YES	YES
Early Intake	7/11/93	719	YES	No

Table 4. Cont'd.

RIVER DRAINAGE	DATE	ELEVATION (m)	*E. PEROTIS*	*E. MACULATUM*
N. Fork Merced				
Yosemite Valley	7/19/93	1,220	YES	YES
Yosemite Valley	7/24/93	1,220	YES	YES
Yosemite Valley	8/11/94	1,220	YES	YES
S. Fork Merced				
Wawona	8/12/94	1,200	YES	YES
Wawona	8/13/94	1,200	YES	YES
Wawona	8/14/94	1,200	YES	YES
San Joaquin				
Powerhouse 8	10/8/94	730	YES	No
Gauging Station	10/8/94	670	YES	No
The Falls	10/8/94	640	YES	No
McKenzie Table Mt.	10/7/94	530	YES	No
McKenzie Table Mt.	10/9/94	530	YES	No
S. Fork Kings				
Deadman Canyon	9/5/93	2,930	No	YES
Twin Lakes	8/27/95	3,230	No	No
Bench Lake	8/28/95	3,290	No	No
S. Fork Kings Mdw.	8/29/95	2,840	No	YES
Woods Ck. Jct.	8/26/95	2,590	No	No
Muro Blanco	8/30/95	2,500	No	No
Paradise Valley	8/25/95	2,010	No	No
Cedar Grove	10/10/94	1,460	No	No
Kaweah				
Twin Lakes, Silliman Pass	9/2/93	2,880	No	YES
Giant Forest Village	Summer 1995	1,900	YES	YES
Pish Wisha	10/11/94	670	No	No
Ash Mt.	10/11/94	425	YES	No
Lake Kaweah	10/11/94	240	YES	No
Yokohl Valley	10/11/94	140	YES	No
Tule				
Lake Success	10/11/94	210	YES	No
Kern				
Democrat Hot Springs	9/4/92	580	YES	No
Democrat Hot Springs	2/16/94	580	No	No
3.2 km below Democrat	2/16/94	530	No	No
6.4 km below Democrat	2/16/94	500	YES	No
Upper Rich Bar	2/16/94	470	YES	No
Mouth of Canyon	2/16/94	245	YES	No

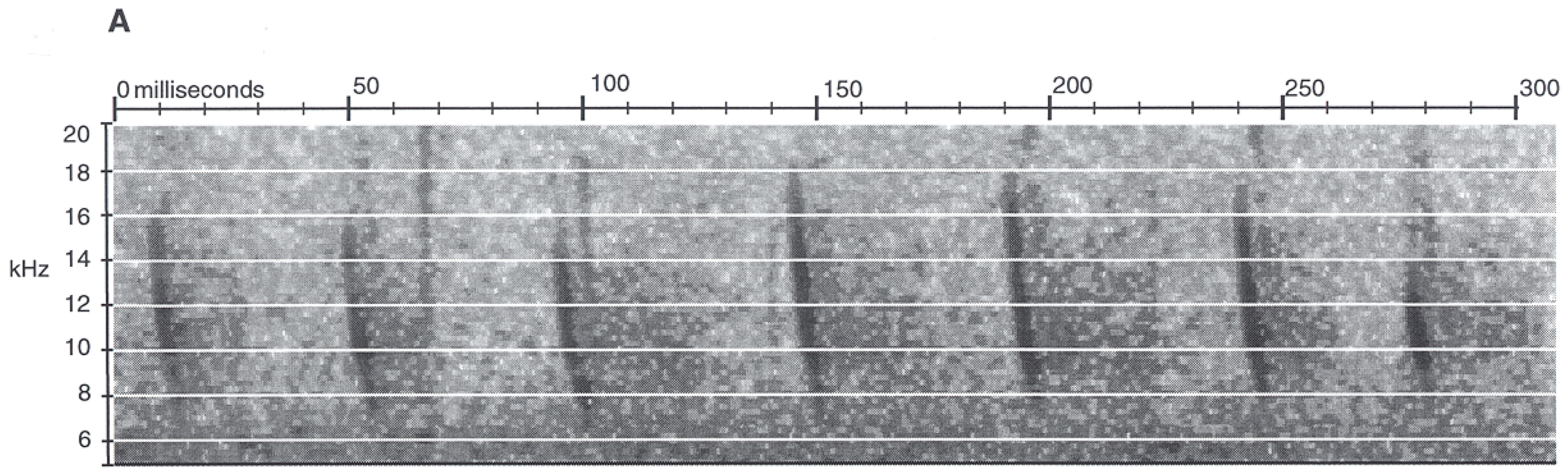
Table 5. Sampling for Audible Bats in Southern California

LOCALITY	DATE	*E. PEROTIS*	*N. FEMOROSACCUS*	*N. MACROTIS*	*E. MACULATUM*
Los Angeles					
Azusa	9/3/92	No	No	No	No
Mouth San Gabriel Cyn	9/3/92	No	No	No	No
San Gabriel Canyon	9/3/92	No	No	No	No
Morris Reservoir	9/3/92	No	No	No	No
Altadena	9/3/92	No	No	No	No
Pasadena	8/28/92	No	No	No	No
Pasadena	11/24/94	No	No	No	No
Riverside					
Painted Canyon	8/29/92	**YES**	**YES**	No	No
Joshua Tree NM	8/30/92	**YES**	No	**YES****	No
Lake Mathews	7/1/92	**YES***	**YES***	No	No
Norco City Hall	9/3/92	**YES**	No	No	No
Lake Perris	5/22/91	**YES**	No	No	No
San Bernardino					
Rancho Cucamonga	8/31/92	**YES***	No	No	No
Etiwanda Rd.	8/31/92	No	No	No	No
Santa Ana Wash	9/1/92	No	No	No	No
Highland	9/2/92	**YES**	No	No	No
Hwy 330	9/2/92	**YES***	No	No	No
Hwy 330, Mud Flat	9/2/92	**YES***	No	No	No
Hwy 330, Little Mill Ck.	9/2/92	**YES**	No	No	No
San Diego					
Split Mt., Anza Borrego	7/6/92	**YES**	**YES**	No	No
Palm Cyn., Anza Borrego	5/29/95	**YES**	**YES**	No	No
Ramona	9/15/90	**YES**	No	No	No
Ramona	5/21/91	**YES**	No	No	No
Suncrest/El Cajon	5/21/91	No	No	No	No
Barrett Jct.	5/20/91	**YES**	No	No	No

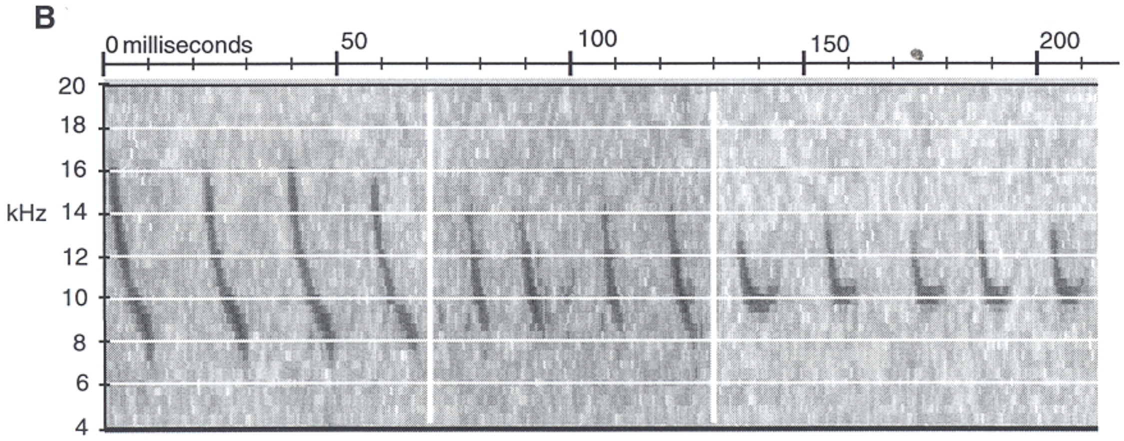
* = Not recorded
** = Recorded, but identification uncertain

Euderma maculatum

Fig. 1a & b. Search phase echolocation calls of *Euderma maculatum*



Extracted search phase pulses
(Interpulse interval reduced)
Siskiyou Co.



Extracted search phase pulses
(Interpulse interval reduced)
Mono Co.

Eumops perotis

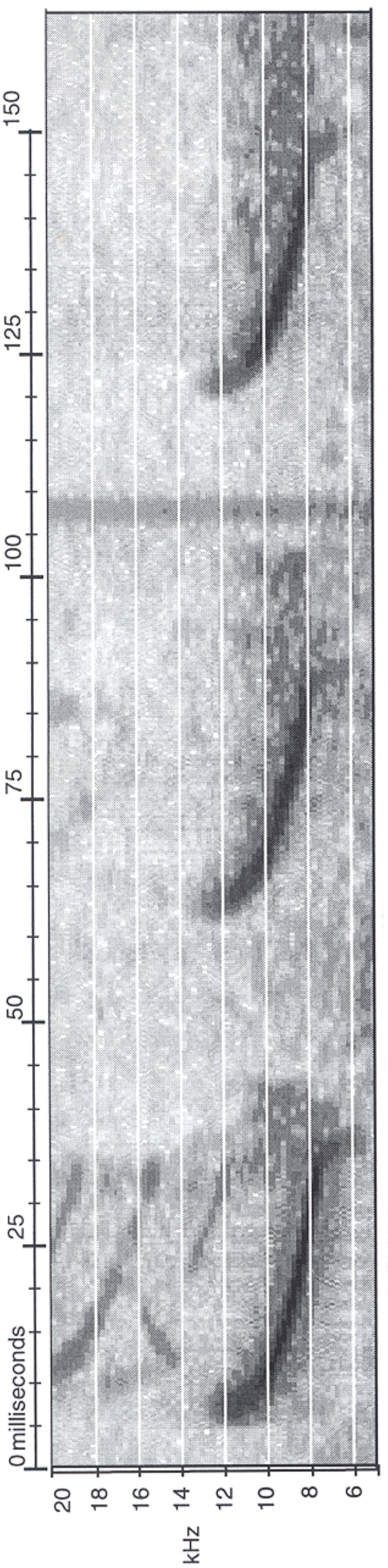


Fig. 2a. Search phase echolocation calls of *Eumops perotis*

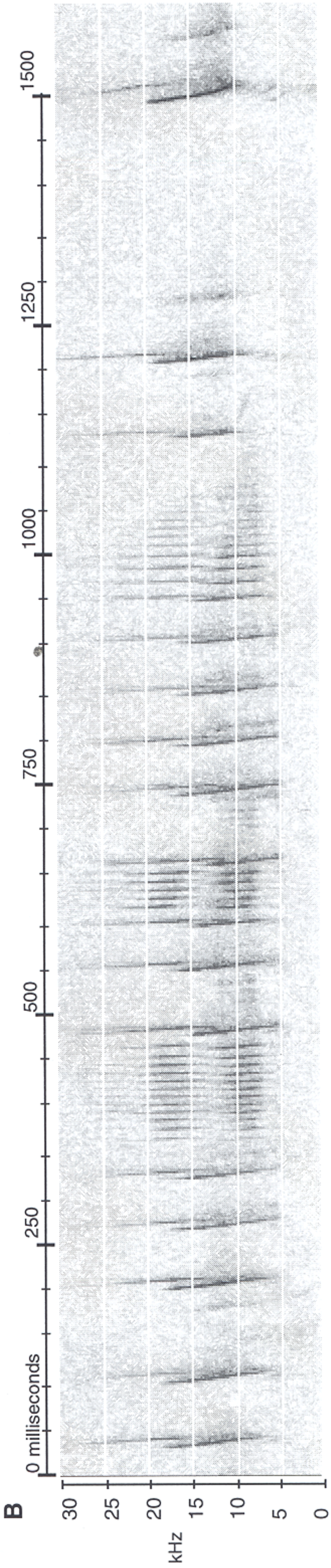


Fig. 2b. Feeding buzzes of *Eumops perotis*

Nyctinomops femorosaccus

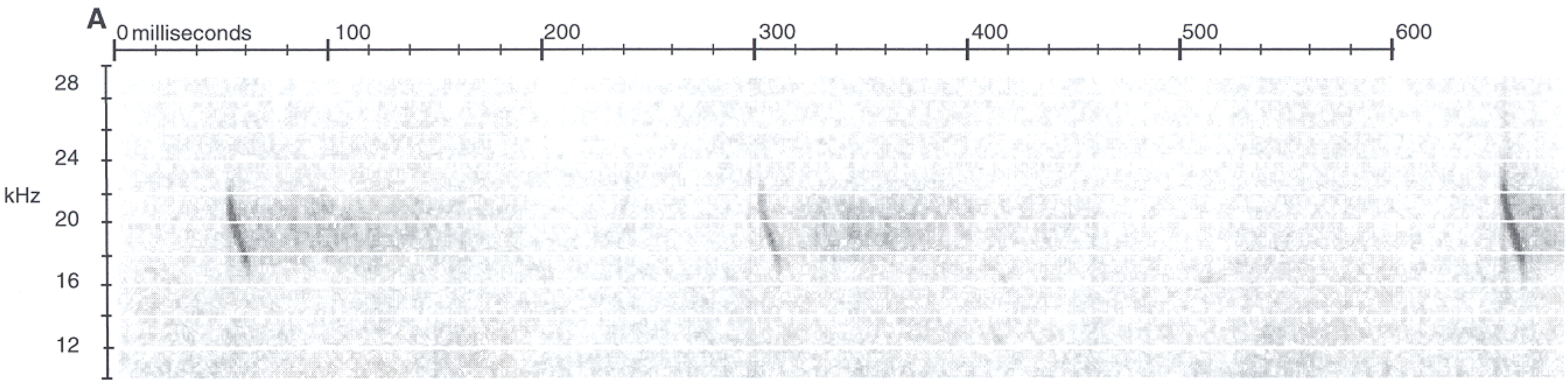
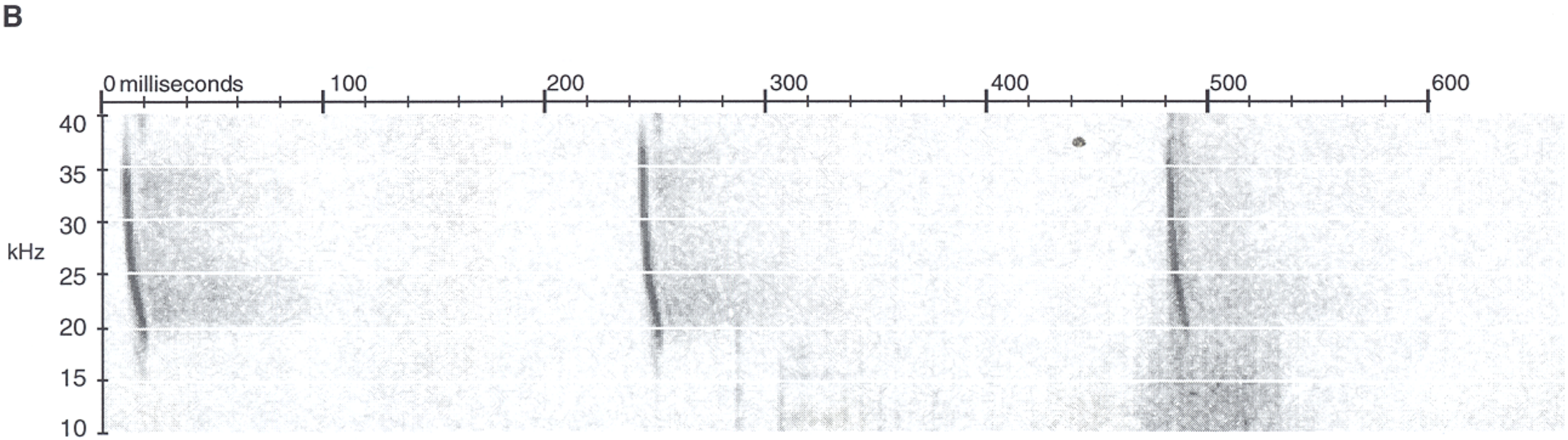


Fig. 3. Search phase echolocation calls of *Nyctinomops femorosaccus*

Search phase pulses
(San Diego Co.)



Release of known individual
(San Diego Co.)

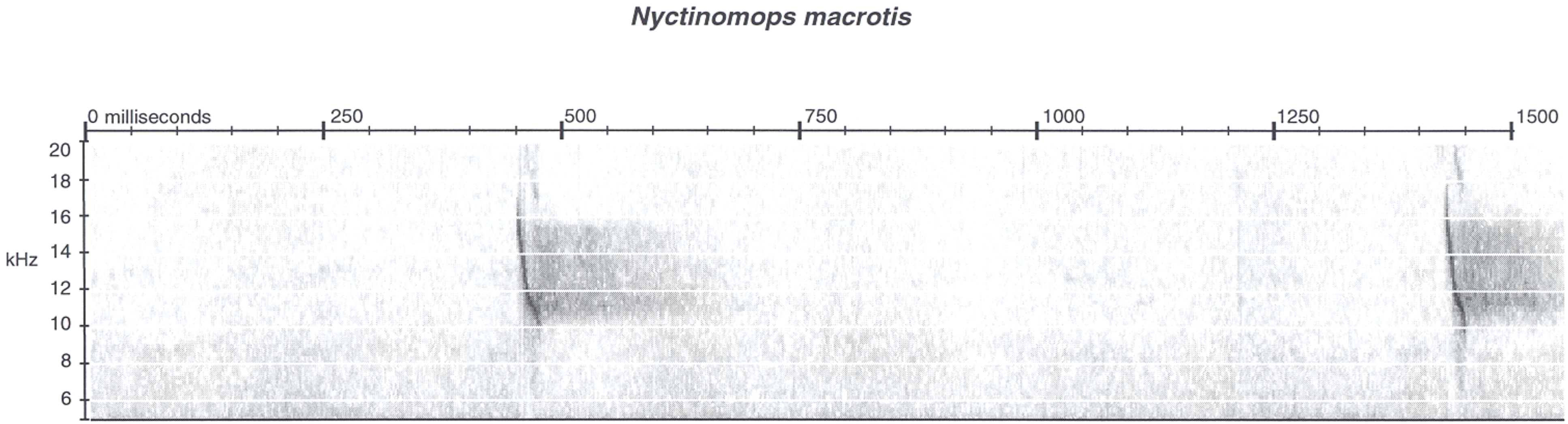


Fig. 4. Search phase echolocation calls of *Nyctinomops macrotis* . (This species identification is based on inference, and not confirmed).

Search phase pulses
(San Diego Co.)

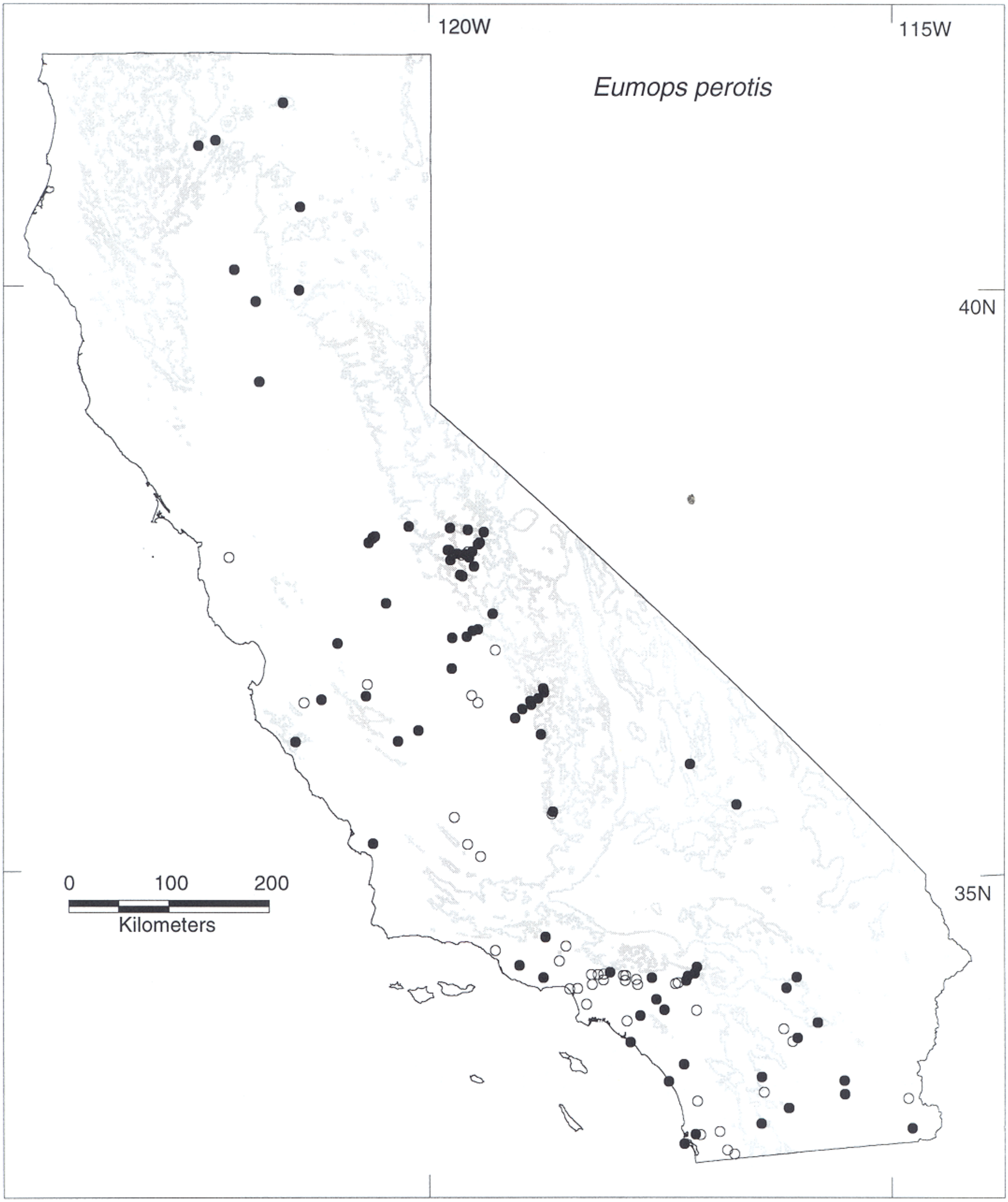


Fig. 5. Map showing the past and present distribution of *Eumops perotis* in California. Open circles represent records existing prior to this study; closed circles represent records obtained during this study.

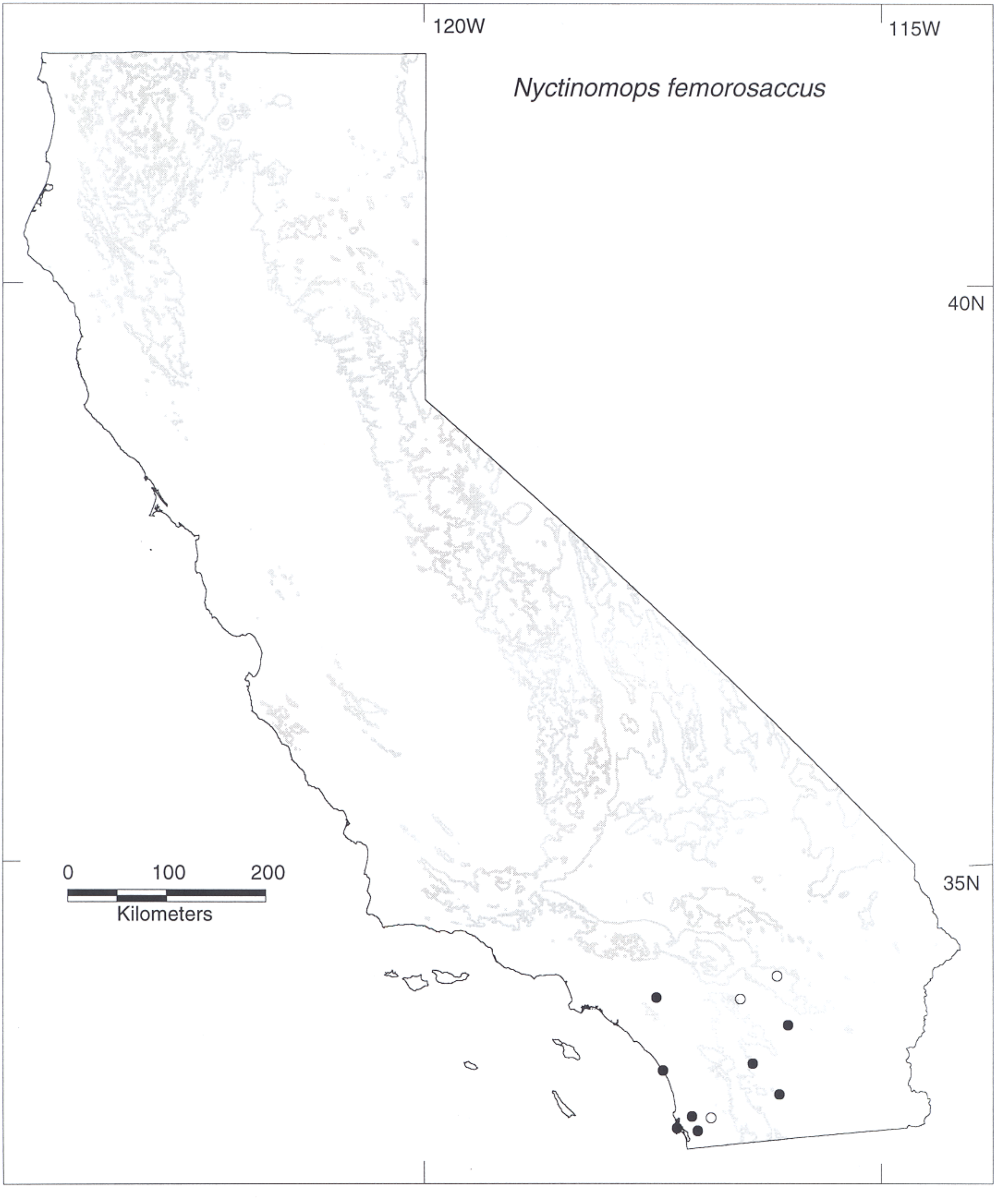


Fig. 6. Map showing past and current distribution of *Nyctinomops femorosaccus* in California. Open circles represent records existing prior to this study; closed circles represent records obtained during this study.

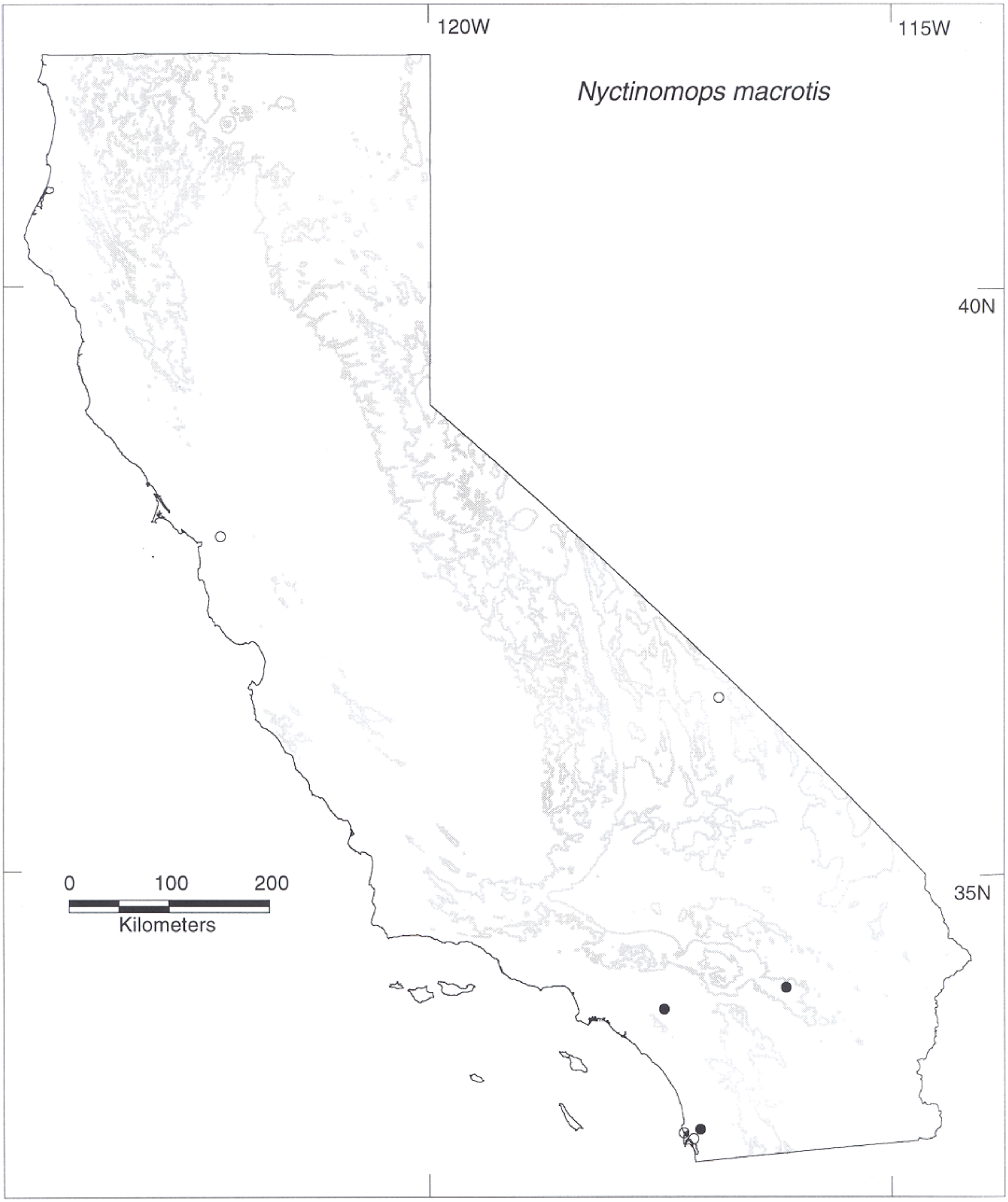


Fig.7. Map showing past and current distribution of *Nyctinomops macrotis* in California. Open circles represent records existing prior to this study; closed circles represent records obtained during this study.

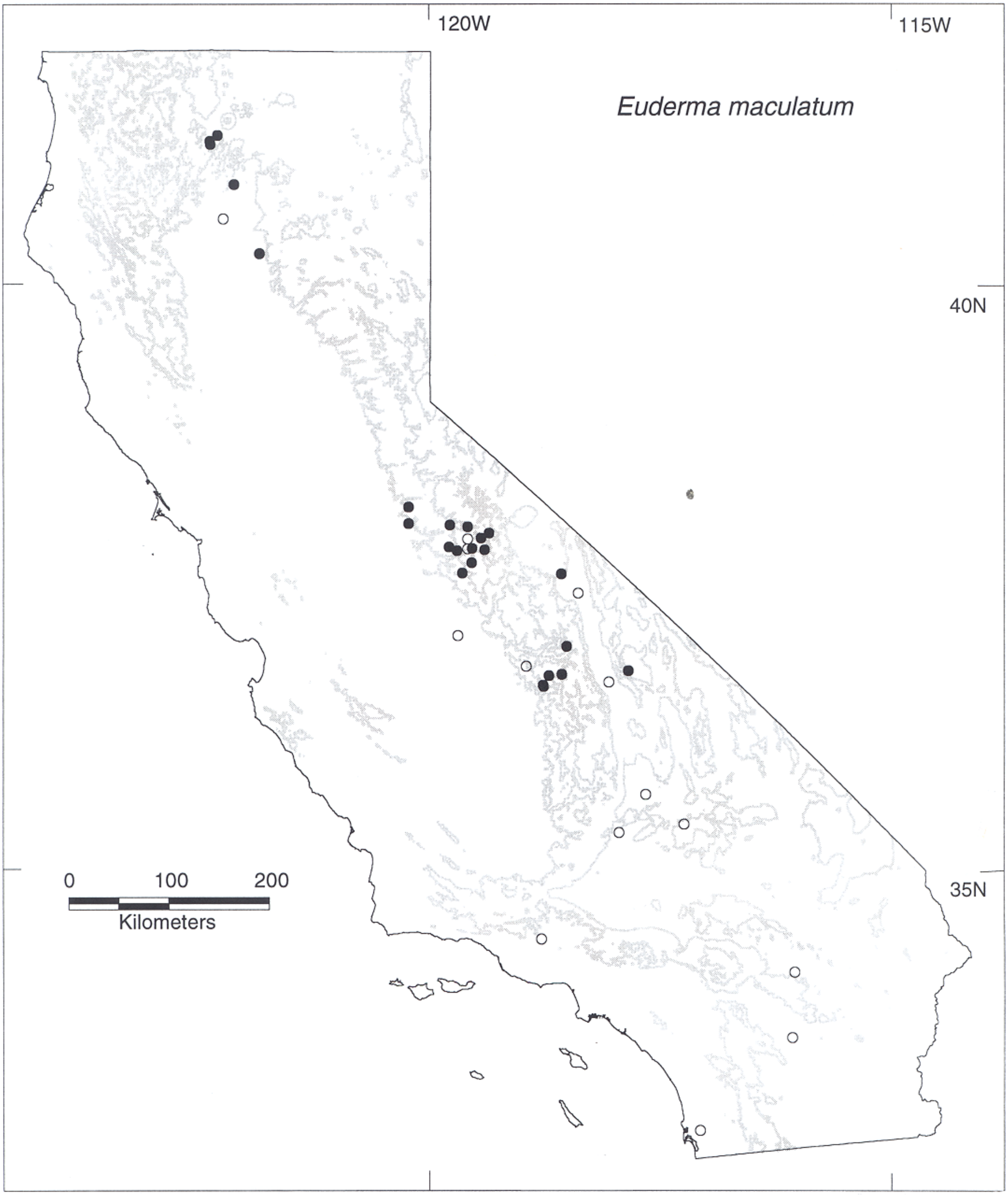


Fig. 8. Map showing the past and current distribution of *Euderma maculatum* in California. Open circles represent records existing prior to this study; closed circles represent records obtained during this study.

APPENDIX I. Pre-exisitng locality records for three molossid species and *Euderma maculatum* .

Species	County	Locality	LatLong	Date	Source
Nyctinomops femorosaccus					
	Riverside	Palm Springs	334949N1163240W	1903FEB02	FMNH
	Riverside	Barker Dam, Joshua Tree NM	340151N1160843W	1977MAY21	JTNM
	San Diego	Borrego Valley, Palm Canyon	331615N1162445W	1939MAY07	MVZ
	San Diego	Borrego Valley, Palm Canyon	331615N1162445W	1940MAR19	FMNH
	San Diego	Suncrest Store, 2 mi SE OF	324815N1165149W	1943MAR23	CM
	San Diego	Suncrest Store, 2 mi SE OF	324815N1165149W	1943MAY09	Krutzsch 1943
	San Diego	Suncrest Store, 2 mi SE OF	324815N1165149W	1947JUL07	KU
	San Diego	Palm Canyon; Borrego Valley	331615N1162445W	1939MAY07	MVZ
	San Diego	Palm Canyon; Borrego Valley	331615N1162445W	1940UNK00	MVZ
Nyctinomops macrotis					
	Alameda	Berkeley	375218N1221618W	1916DEC18	MVZ
	Inyo	Death Valley NM	362959N1165207W	1959NOV18	DEVA
	San Diego	Mission Gorge	324844N1170412W	1991MAY27	LACM
	San Diego	Balboa Park, San Diego	324354N1170846W	1930DEC30	SDNHM
	San Diego	Mission Beach	324657N1171505W	1970OCT07	UCSD
Eumops perotis					
	Alameda	Hayward	374008N1220447W	1899JAN	USNM
	Butte	Oroville	393050N1213319W	1973	Eger 1977
	Fresno	Easton	363901N1194723W	1958	CSUF
	Fresno	Fresno	364452N1194617W	1895APR	CAS
	Fresno	Fresno	364452N1194617W	1958NOV20	CAS
	Fresno	Fresno	363346N1193656W	1916OCT06	MVZ
	Fresno	Fresno	364452N1194617W	1991APR17	MVZ
	Fresno	Mendota	364513N1202250W	1911DEC	Grinnell 1918
	Fresno	Table Mountain	370108N1193623W	1933NOV19	CSUF
	Fresno	Trimmer	365418N1191743W	1941MAY04	MVZ
	Imperial	Palo Verde, 24 mi S	330521N1144920W	1929DEC16	MVZ
	Imperial	Salton Sea, W. side	332826N1155302W	1967MAR	SDSU
	Kern	Bakersfield	352224N1190104W	NO DATE	Grinnell 1918
	Kern	Buena Vista Dry Lake	351142N1191747W	1959NOV28	CSULB
	Kern	Buttonwillow	352402N1192807W	NO DATE	CAS
	Kern	Democrat Springs	353024N1184043W	1948AUG24	MVZ
	Kern	Democrat Springs	353024N1184043W	1963JUL29	CAS, UCSB
	Kern	McKittrick, 10 mi N	352832N1194429W	1953JUN07	CAS
	Kern	Taft, 10 mi NW	351450N1193540W	1958DEC22	CSULB
	Kern	NW Taft, 16 km NW	350833N1192720W	1959NOV28	ROM
	Los Angeles	Alhambra	340543N1180734W	1890OCT18	AMNH
	Los Angeles	Alhambra	340543N1180734W	1918JUL23	LACM
	Los Angeles	Alhambra	340543N1180734W	1918MAY 06	UCLA
	Los Angeles	Alhambra	340543N1180734W	1907SEP30	UIMNH
	Los Angeles	Alhambra	340543N1180734W	1889DEC14	USNM

APPENDIX I. Cont'd.

Species	County	Locality	LatLong	Date	Source
Eumops perotis (cont'd.)					
	Los Angeles	Altadena	341123N1180749W	1958DEC10	CSULA
	Los Angeles	Azusa	340801N1175424W	1919MAR03	CAS
	Los Angeles	Azusa	340801N1175424W	1919MAR18	UCLA
	Los Angeles	Azusa	340801N1175424W	1919MAY31	MVZ
	Los Angeles	Azusa	340801N1175424W	1925SEP28	SBMNH
	Los Angeles	Azusa	340801N1175424W	1935NOV23	LACM
	Los Angeles	Azusa	340801N1175424W	1936MAR14	LACM
	Los Angeles	Azusa	340801N1175424W	1942AUG01	LACM
	Los Angeles	Azusa	340801N1175424W	1943MAR10	LACM
	Los Angeles	Azusa	340801N1175424W	1943MAR13	SBMNH
	Los Angeles	Azusa	340801N1175424W	1943AUG16	LACM
	Los Angeles	Azusa	340801N1175424W	1964AUG 9	MVZ
	Los Angeles	Azusa	340801N1175424W	1953SEP28	CSUN
	Los Angeles	Azusa	340801N1175424W	1959OCT03	LACM
	Los Angeles	Azusa	340801N1175424W	1965JUL13	SDSU
	Los Angeles	Chatsworth, NW of	341526N1183601W	1954JUL27	KU
	Los Angeles	Covina	340524N1175322W	1918OCT23	UCLA
	Los Angeles	Covina	340524N1175322W	1919MAR20	MVZ, UCLA
	Los Angeles	Covina	340524N1175322W	1919APR15	AMNH
	Los Angeles	Covina	340524N1175322W	1919MAY15	UCLA
	Los Angeles	Covina	340524N1175322W	1919DEC06	MVZ
	Los Angeles	Covina	340524N1175322W	1919DEC20	USNM
	Los Angeles	Covina	340524N1175322W	1920NOV14	MVZ, UCLA
	Los Angeles	Covina	340524N1175322W	1920NOV24	LACM
	Los Angeles	Covina	340524N1175322W	1923JUN16	UCLA
	Los Angeles	Covina	340524N1175322W	1954SEP18	LACM
	Los Angeles	Covina	340524N1175322W	1957MAY10	LACM
	Los Angeles	Covina	340524N1175322W	1957MAY14	LACM
	Los Angeles	Covina	340524N1175322W	1958AUG21	LACM
	Los Angeles	Eagle Rock	340835N1181055W	1972FEB13	LACM
	Los Angeles	Gardena	335318N1181829W	1929JUL22	SBMNH
	Los Angeles	Glendora	340810N1175152W	1958JUN18	CSULB
	Los Angeles	Glendora	340810N1175152W	1958AUG21	CSULB
	Los Angeles	La Verne	340603N1174601W	1952SEP29	LACM
	Los Angeles	Llano	342935N1174638W	1929OCT24	LACM
	Los Angeles	Los Angeles	340325N1181443W	1890	AMNH
	Los Angeles	Los Angeles	340325N1181443W	1929	LACM
	Los Angeles	Los Angeles	340325N1181443W	1935	LACM
	Los Angeles	Los Angeles	340325N1181443W	1936APR04	LACM
	Los Angeles	Los Angeles	340325N1181443W	1937JUL10	LACM
	Los Angeles	Los Angeles	340325N1181443W	1938NOV23	LACM
	Los Angeles	Los Angeles	340325N1181443W	1939JUN15	LACM
	Los Angeles	Los Angeles	340325N1181443W	1939JUN28	LACM
	Los Angeles	Los Angeles	340325N1181443W	1940MAY18	MVZ

APPENDIX I. Cont'd.

Species	County	Locality	LatLong	Date	Source
Eumops perotis **(cont'd.)**					
	Los Angeles	Los Angeles	340325N1181443W	1942MAR09	LACM
	Los Angeles	Los Angeles	340325N1181443W	1942MAY14	LACM
	Los Angeles	Los Angeles	340325N1181443W	1943MAY17	LACM
	Los Angeles	Los Angeles	340325N1181443W	1944FEB12	LACM
	Los Angeles	Los Angeles	340325N1181443W	1944FEB14	LACM
	Los Angeles	Los Angeles	340325N1181443W	1948	SBMNH
	Los Angeles	Newhall, SW of	342305N1183148W	1954AUG05	KU
	Los Angeles	Palms	340122N1182417W	1925DEC22	LACM
	Los Angeles	Palms	340122N1182417W	1925OCT02	SDNHM
	Los Angeles	Pasadena	340841N1180702W	1903SEP07	MVZ
	Los Angeles	Pasadena	340841N1180702W	1909MAR08	MVZ
	Los Angeles	Pasadena	340841N1180702W	1941	MSU
	Los Angeles	Pomona	340319N1174505W	1921APR21	SDNHM
	Los Angeles	Pomona	340319N1174505W	1925SEP28	KU
	Los Angeles	Santa Monica	340110N1182925W	1921JAN01	SDNHM
	Los Angeles	Santa Monica	340110N1182925W	1921APR07	SDNHM
	Los Angeles	Santa Monica	340110N1182925W	1921APR21	SDNHM
	Los Angeles	Sierra Madre	340942N1180307W	1904MAY26	MVZ
	Los Angeles	Sierra Madre	340942N1180307W	1912DEC27	MVZ
	Los Angeles	Sierra Madre	340942N1180307W	1913JUN 5	MVZ
	Los Angeles	Sierra Madre	340942N1180307W	1913OCT12	MVZ
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1924SEP	YNP
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1932SEP03	YNP
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1933APR13	YNP
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1934SEP13	YNP
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1940AUG28	YNP
	Merced	Merced	371808N1202855W	1991DEC12	MVZ
	Monterey	Camphora, N. of Soledad	362711N1212212W	1938SEP22	MVZ
	Orange	Santa Ana	334444N1175201W	1949JUL28	SBMNH
	Orange	Santa Ana	334444N1175201W	1949AUG08	SBMNH
	Riverside	Coachella	334049N1161023W	1939MAR15	LACM
	Riverside	Lakeview, 4 mi NW of	335019N1170702W	1954JUL13	KU
	Riverside	Lakeview, 4 mi NW of	335019N1170702W	1954AUG01	KU
	Riverside	Lakeview, 4 mi NW of	335019N1170702W	1957AUG28	KU
	Riverside	Mecca	333620N1160122W	1973FEB25	MVZ
	Riverside	Painted Canyon, NE Mecca	333418N1160435W	1907OCT11	CSULB
	Riverside	Perris, 3 mi. NE	335057N1171119W	1954JUL13	Vaughan 1959
	Riverside	Riverside, 6 mi W	335831N1172830W	1954JUL09	Vaughan 1959
	San Benito	Silver Creek	363631N1204108W	1945MAY	MVZ
	San Benito	Silver Creek	363631N1204108W	1955MAR	MVZ
	San Bernardino	Colton	340426N1171846W	1912APR 8	MVZ
	San Bernardino	Colton	340426N1171846W	1918NOV05	UCLA
	San Bernardino	Colton	340426N1171846W	1918NOV24	MVZ, UCLA
	San Bernardino	Colton	340426N1171846W	1918DEC13	UCLA

APPENDIX I. Cont'd.

Species	County	Locality	LatLong	Date	Source
Eumops perotis **(cont'd.)**					
	San Bernardino	Slover Mt., Colton	340355N1172026W	1924OCT	MVZ
	San Bernardino	Colton	340426N1171846W	1931MAY 9	MVZ
	San Bernardino	Colton	340426N1171846W	1932MAY13	MVZ
	San Bernardino	Colton	340426N1171846W	1933APR26	MVZ
	San Bernardino	Highland	340742N1171228W	1969JUN20	D. Constantine
	San Bernardino	Highland, 3 mi NE	340953N1170932W	1969JUN21	D. Constantine
	San Bernardino	Lucerne, 1 mi N	343015N1165712W	1954	Vaughan 1959
	San Bernardino	Santa Ana Wash	340529N1171335W	1991JUL	B. McKernon
	San Diego	Barrett Junction	323641N1164223W	1939APR 6	MVZ
	San Diego	Barrett Junction	323641N1164223W	1943AUG28	SDSU
	San Diego	Barrett Junction	323641N1164223W	1946JUL 3	MVZ
	San Diego	Barrett Junction	323641N1164223W	1946JUL16	MVZ
	San Diego	Barrett Junction	323641N1164223W	1949OCT29	CM
	San Diego	Barrett Junction	323641N1164223W	1953AUG26	KU
	San Diego	Barrett Junction	323641N1164223W	1957AUG25	KU
	San Diego	Bow Willow Ranger Station	325031N1161331W	1962AUG31	SDNHM
	San Diego	Dulzura	323839N1164650W	1935NOV23	SDNHM
	San Diego	Dulzura	323839N1164650W	1936JUL19	SDNHM
	San Diego	Dulzura	323839N1164650W	1936AUG19	SDNHM
	San Diego	Dulzura	323839N1164650W	1936SEP07	SDNHM
	San Diego	Dulzura	323839N1164650W	1937JUL18	SDNHM
	San Diego	Dulzura	323839N1164650W	1938JUL29	SDNHM
	San Diego	El Cajon, 3 mi E	324700N1171014W	ca. 1954	Vaughan 1959
	San Diego	Lake Hodges	330342N1170625W	1933MAR05	MVZ
	San Diego	Otay	323541N1170349W	-0-	CAS
	San Diego	San Diego	324636N1170412W	1933	SDNHM
	San Diego	San Diego	324636N1170412W	1946	SDNHM
	San Diego	2 mi W Suncrest	324815N1165149W	1943MAY09	CM
	San Diego	Yaqui Well	330822N1162313W	1952JUL19	SDNHM
	San Luis Obispo	San Luis Obispo	351658N1203931W	1991APR29	NDDB
	Tulare	Traver	362719N1192902W	1899MAR01	CAS
	Tuolumne	Hetch Hetchy, Yosemite NP	375633N1194708W	1952	Vaughan 1959
	Ventura	Weldon	342042N1191746W	1907	LACM
Euderma maculatum					
	Fresno	Friant Dam	365957N1194212W	1970JUN06	Medeiros & Heckman 1971
	Inyo	Lone Pine	363622N1180343W	1985AUG09	CSULB
	Inyo	Bishop	372149N1182339W	1977MAY11	MVZ
	Kern	Red Rock Canyon	351930N1175659W	1933DEC01	MVZ
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1931AUG01	MVZ
	Mariposa	Yosemite Valley, YNP	374259N1193951W	1951AUG13	MVZ
	Riverside	Mecca	333418N1160435W	1907OCT 1	MVZ
	San Bernardino	Pilot Knob	352350N1171448W	1948MAR22	Parker 1952

APPENDIX I. Cont'd.

Species	County	Locality	LatLong	Date	Source
Euderma maculatum **(Cont'd)**					
	San Bernardino	China Lake	354325N1173649W	1956JAN24	LACM
	San Bernardino	Twenty Nine Palms	340808N1160312W	1939MAY01	MVZ
	San Diego	UC San Diego Campus	324636N1170412W	1955SEP09	August & Dingman 1973
	Shasta	Palo Cedro	403350N1221416W	1983MAR14	Bleich & Pauli 1988
	Tulare	Wilsonia, Kings Canyon NP	364406N1185720W	1975JUN20	CAS
	Ventura	Castaic Creek, Piru	342455N1184735W	1890APR	AMNH

Key to Acronyms:

AMNH = American Museum of Natural History
CAS = California Academy of Sciences
CM = Carnegie Museum
CSUF = California State University, Fresno
CSULA = California State University, Los Angeles
CSULB = California State University, Long Beach
CSUN = California State Universtiy, Northridge
DEVA = Death Valley National Monument
FMNH = Field Museum of Natural History
JTNM = Joshua Tree National Monument
KU = University of Kansas
LACM = Los Angeles County Museum
MSU = Michigan State University
MVZ = Museum of Vertebrate Zoology, University of California, Berkeley
NDDB = Natural Diversity Data Base
ROM = Royal Ontario Museum
SBMNH = Santa Barbara Museum of Natural History
SDSU = San Diego State University
UCLA = University of California, Los Angeles
UCSB = University of California, Santa Barbara
UCSD = University of California, San Diego
USNM = U.S. National Museum
YNP = Yosemite National Park