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DISTRIBUTION AND STATUS OF WESTERN RED BATS (*LASIURUS BLOSSEVILLII*) IN CALIFORNIA

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EXECUTIVE SUMMARY

This study points to the Central Valley as being of primary importance to breeding populations of the red bat, *Lasiurus blossevillii* in California. Red bats appear to be strongly associated with riparian habitats, particularly mature stands of cottonwood/sycamore. We obtained significantly more records in stands that were dominated by mature trees and were greater than 50 m wide.

Direct observations of roosting behavior in *L. blossevillii* in California are limited primarily to collections or sightings that have occurred in fruit and nut orchards. Given the extensive loss of riparian forest in the Central Valley, it is highly likely that the orchards serve as alternative habitat, and to some extent compensate for the loss of gallery riparian forest. The effect of pesticide spraying on bats roosting in orchards is not known.

This study expanded our understanding of the distribution and habitat associations for *L. blossevillii* in that it added seven new higher elevation records (most likely males), extending the known elevational limit from 1,643 m to 2,484 m. This finding does not alter our expectation that breeding females are confined to low elevation riparian habitats.

Although there is evidence of a substantial north-south seasonal migration for eastern red bats, there is no comparable evidence for the western species. While both museum records and our data strongly suggest that red bats undergo seasonal shifts in distribution, there is no indication of mass migration. The majority of sites for which there are winter records in California are in areas that rarely experience freezing winter temperatures.

The separation of the eastern and western red bat into two species has important conservation implications for the western taxon. When viewed separately it is evident that both the habitat associations and the distributional patterns for *L. blossevillii* are very different from those for the more common *L. borealis*. When viewed in a regional context, the Central Valley of California, particularly the Sacramento and San Joaquin drainages and the lower reaches of the large rivers that drain the Sierra Nevada, take on disproportional importance for the future viability of this species. It seems evident that this species would benefit greatly from riparian restoration, particularly recruitment of cottonwood/sycamore and reinstatement of natural flood regimes.

In light of the findings in this study we recommend that *L. blossevillii* be added to the Department of Fish and Game list of Mammal Species of Special Concern, and be included in any state and/or federal planning efforts that involve the ecological health of watersheds, particularly watershed analyses or river restoration plans for the Central Valley.

1.0 INTRODUCTION

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

Red bats have long been considered to be relatively abundant in the midwestern and east-central states (Barbour and Davis, 1969; Harvey, 1992; LaVal and LaVal, 1979; Saugey et al., 1998, 1989; Shump and Shump, 1982). Likely for this reason, their status in the west was not really questioned until the western form was recognized as a separate species. Additionally, there had been no comprehensive review of existing records for the western red bat. In 1998, however, at a workshop sponsored by the Western Bat Working Group (1998a), the distribution of *L. blossevillii* in the United States was reviewed. While the overall distribution was confirmed to be quite broad, it was evident that it was extremely patchy, and the number of actual records were quite few for most of its range -- two records from British Columbia (Nagorsen and Brigham, 1993), none for Washington and Oregon, four for Utah (M. Perkins, personal communication), three for Nevada (Hall, 1946; J. Szewczak, personal communication), one for Texas (Schmidly, 1991), and fewer than a dozen localities each for Arizona (Hoffmeister, 1986; P. Brown, personal communication) and New Mexico (Constantine, 1961; Findley et al., 1975; Jones, 1961, 1966; Jones and Suttkus, 1972; Mumford et al, 1964; Valdez et al., 1999). The only state with relatively numerous records, particularly multiple breeding records, was California. In a ranking process conducted at this workshop, the western red bat emerged as a species of primary concern in all the regions in which it occurred (Western Bat Working Group, 1998b).

While a series of studies have documented that the eastern red bat roosts in the foliage of a number of deciduous tree species, primarily hardwoods and fruit trees (Constantine 1958, 1966; Hutchinson and Lacki, 2000; McClure, 1942; Menzel et al., 1998), observations on roosting behavior in the more xeric western United States are more limited, and with the exception of Constantine's study (1966), limited to chance observations (e.g., Grinnell, 1918; Hoffmeister, 1986; Orr, 1950). Although an association with riparian habitats has been inferred (Hoffmeister, 1986), there have been no focused investigations of habitat associations.

There are numerous observations of migration for the eastern red bat, dating back to 1890 (Miller, 1897). These include seasonal (fall or spring) records of red bats landing on ships at sea (Carter, 1950; Haagner, 1921; Mackiewicz and Backus, 1956; Peterson, 1970; Thomas, 1921), appearing on islands (Van Gelder and Wingate, 1961), and being picked up along with migratory birds as casualties at towers or high buildings (Avery and Clement, 1972; Crawford and Baker, 1981; Saunders, 1930; Terres, 1956; Timm, 1989). Migration has also been inferred from regional and seasonal changes in density (Barclay, 1984; Barkalow, 1948). In one account from 1898, the author describes seeing "great flights" of red bats throughout the day in late October and early November in the Hudson River Valley in New York (Mearns, 1898). There have been no comparable observations for red bats in the west. The assumption that western red bats are migratory is based primarily on observed shifts in seasonal occurrence or abundance

(Constantine, 1959; Cryan, 2003; Grinnell, 1913; Grinnell, 1918; Hoffmeister, 1986; Orr, 1950). No review of seasonal distribution has been conducted for red bats in California since Grinnell (1918).

Our goals in this study were: 1) to investigate the seasonal and geographic distribution of red bats in California by reviewing existing records; 2) to assess current distribution and status by conducting surveys for this species in areas that appeared to be historically the most significant for breeding females; 3) to investigate habitat associations, and 4) to evaluate current distribution in relation to habitat quality.

2.0 MATERIALS AND METHODS

2.1 Museum and Literature Records

To examine background information on the recent and historic distribution of *L. blossevillii* in California, records were compiled from publications (Benson, 1945; Constantine, 1959, 1998; Dalquest, 1945; Grinnell, 1918; Orr, 1950), museum collections, rehabilitation facilities, personal communications from colleagues, and our records collected prior to the initiation of this study. Most specimen records (58%) are from the Museum of Vertebrate Zoology (MVZ) at University of California, Berkeley. Another 21% come from the California Academy of Sciences (CAS), the San Diego Natural History Museum (SDNHM) and the Los Angeles County Museum (LACM). The remaining 21% come from all the other above named sources, including two rehabilitation facilities -- California Bat Conservation Fund (CBCF) and the Lindsay Wildlife Museum (LWM) -- and a number of other museum collections: Carnegie Museum of Natural History (CM), Cornell University (CU), Death Valley National Monument (DEVA), Field Museum of Natural History in Chicago (FMNH), University of Kansas (KU), Museum of Comparative Zoology at Harvard (MCZ), Santa Barbara Natural History Museum (SBNHM), San Diego State University (SDU), University of California at Los Angeles (UCLA), University of Illinois at Urbana (UIMNH), United States National Museum in Washington, DC (USNM), and University of California at Davis (MWFB). Some museum data are publicly available; other was obtained by query. Specimens were not examined.

2.3. Study Area

Based on analysis of prior records, the primary study area was the Central Valley. A complete list of sampling sites is provided in Appendix I. Sampling sites were selected in riparian settings along the Sacramento and San Joaquin rivers (and some tributaries) by driving along each drainage from where it entered the valley to where it emptied into the Delta. Preference was given to sites that had ready public access (e.g., fishing access points), were on protected land (e.g., state or county parks, wildlife refuges, Nature Conservancy Reserves), or were privately owned, but access had been specifically granted. Sites were then selected based on habitat quality. A limited number of sites on the lower reaches of the Merced and Stanislaus rivers were also included. These sites were being monitored as part of two parallel studies: a study of seasonal and altitudinal distribution in the Sierra Nevada (funded by the California Department of Transportation [CalTrans], the Yosemite Association, and the Yosemite Fund) and bat surveys associated with a highway repair and riparian restoration project along the Merced River (funded by CalTrans). The specific localities and monitoring schedule for these sites were dictated to a large extent by the mandates of these other projects, although in each case one investigator was focused primarily on surveying for red bats.

Habitat quality was assessed and each site was ranked semi-quantitatively, based on the size structure of woody vegetation and the width of the riparian forest (Table 1, Appendix I).The most intact habitat category (A) included sites dominated by mature Fremont cottonwood (*Populus fremontii*), California sycamore (*Plantanus racemosa*), and/or valley oak (*Quercus lobata*) and had a riparian forest that was at least 50 m wide on at least one side of the river. The next level (B) was dominated by mature trees, but comprised of a strip that was only two to three trees wide. The next level (C) was made up primarily of young trees and/or a riparian strip that was sparse, generally only one tree wide. The most degraded habitat (D) contained no trees, and was comprised of grassland or shrubs. An attempt was made to include approximately equal numbers of stations for each habitat category.

In addition to the systematically selected sites in the Central Valley, opportunistic sampling was conducted at a number of localities in the southern Coast Range, a few in the San Francisco Bay area, and a few in the Salinas Valley.

Geographical coordinates for sampling sites were collected in decimal degrees (Datum: NAD27 CONUS), using hand-held GPS units (Garmin 12XL). All field work for this project was conducted between June 1998 and September 1999 (Appendix I).

2.2 Acoustic Surveys

Acoustic sampling was conducted primarily by using broad band frequency dividing Anabat detectors (Titley Electronics, Ballina, NSW, Australia) coupled to laptop computers via zero crossing analyzers. At least two detector systems were actively monitored during each sampling period; one to three additional systems were placed at pre-selected sites for passive (unattended) monitoring. In either case, ultrasound events were stored as files on the hard drive of the computer for later analysis. On several occasions another broad band detector system, a Pettersson D980 (Pettersson Elektronik AB, Uppsala, Sweden) linked to a DAT recorder was also used.

Active monitoring has the advantage that the detector operator, with the aid of a spotlight, can simultaneously make visual observations of calling bats. This facilitates species identification for some acoustically problematic taxa, and also allows the observer to make some assessment of the relationship between levels of bat activity and bat abundance (since a bat detector records the number of acoustic events, not the number of individuals). Observers are also able to listen for audible bats (e.g., the mastiff bat, *Eumops perotis*), which may be detected more readily by the human ear than by the Anabat detector (which has filters to reduce interference from low [<15 kHz] frequency sounds).

For most sampling sessions conducted along the Sacramento and San Joaquin rivers, two or more sites of differing habitat quality rank were monitored simultaneously. This allowed for comparison between sites without having to consider night to night variation in bat activity, which is known to be large. Two recent critiques of acoustic studies (Hayes 1997, Ballantyne et al. 1999) argue that night to night variation in bat activity at any site is sufficiently high that statistically valid data can be obtained only by many nights of repeat sampling at the same sites or by establishing multiple survey points that are sampled concurrently. To the extent possible (based on availability of time and equipment), we chose the latter approach.

Although many bat calls remain difficult to assign reliably to species, about 50% of the calls produced by red bats are diagnostic for this species (Figure 1). The combination of the following characteristics taken together serve to separate red bats from other California species: a characteristic frequency of 35-50 kHz, a duration of 8 ms or longer, a low slope (down to below 20 octaves per second), and irregular fluctuations in characteristic frequency between adjacent calls in a sequence (Corben et al. 1999).

Other species that can generally be identified based on call sequences alone are: *Antrozous pallidus*, *Corynorhinus townsendii*, *Lasiurus cinereus*, *Myotis evotis*, *Myotis thysanodes*, *Pipistrellus hesperus*, and *Eumops perotis*. *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Tadarida brasiliensis* produce similar echolactation calls in a frequency range of between 20 kHz and 30 KHz. Although all three (especially *T. brasiliensis*) do produce calls that are diagnostic, a large percentage of calls in this frequency range cannot be assigned to a species unless the animal has also been visually observed.

Likewise, *Myotis californicus* and *Myotis yumanensis*, both of which give echolocation calls with a characteristic frequency of ca. 45-50 KHz, can be difficult to distinguish based on call structure alone, although some calls of each species appear to be diagnostic. If visual observation is possible, differences in flight style and foraging behavior often serve to distinguish these species -- e.g., *M. yumanensis* commonly forage by skimming the water surface and *M. californicus* often forage along an irregular flight path in close association with vegetation, often at canopy height.

The most challenging distinctions are for three *Myotis* species (*M. ciliolabrum*, *M. lucifugus*, and *M. volans)* that have characteristic frequencies of 35-45 KHz. Although visual observations of body size and flight behavior can sometimes serve to distinguish these species, all three are sufficiently poorly known in California that there are many situations in which positive identification is not possible. The features that were used to make tentative identification were: small size and fluttery, erratic flight for *M. ciliolabrum*; medium size, broad wings and water skimming behavior for *M. lucifugus*, and long, narrow wings producing rapid, straight flight for *M. volans*.

2.3. Capture Techniques

Although this study relied primarily on acoustic surveys, mist nets (Avinet) were used selectively to obtain demographic information. Following the procedures outlined by Kunz and Kurta (1988), 1.5 inch mesh black nylon or polyester nets of a size appropriate to the location (7' or 10' height; lengths of 18', 30', 42' and 60') were set on sectional poles in foraging areas or presumed roosting areas (across creeks or near possible roosting trees). Nets were generally opened 0.5 hrs after local sunset and remained open and closely tended for at least four hours.

On-site processing of netted bats involved species identification (see van Zyll de Jong 1985 for keys); weighing (to 0.1 or 0.01g) in temporary confinement on a portable electronic balance; measurement of one or both forearms with digital calipers (length read to 0.01 mm); assessment of age class (adult, juvenile) from ossification of the metacarpal phalangeal joints (Anthony 1988) combined with body size, pelage color and wing tissue texture; and reproductive characterization using a binocular microscope. For males, characterization involved examination of the testes and checking epididymal tissue for pigmentation or distention; in females mammae were evaluated for nipple development, presence of milk (by expression), and loss of hair.

3.0 RESULTS

3.1. Distribution

3.1.1. Distribution of *L. blossevillii* Based on Records Collected Prior to 1998

Figure 2 provides an overall distribution map for *L. blossevillii* in California based on records that predate the initiation of this study. Distribution is concentrated at lower elevations, in the Central Valley and along the central and southern coasts. There are no records from the Trinity Mountains, and only a few from the Sierra Nevada foothills. There are relatively few records from the desert areas of California east of the Los Angeles basin (Grinnell, 1918). Two records from Death Valley National Monument (Constantine, 1998; Death Valley National Monument, park records) and a single record from Bishop (J. Szewczak, personal communication) represent the only records east of the Sierra Nevada in California, although there is also a recent record from just across the Nevada line east of the White mountains (J. Szewczak, personal communication). Records obtained along the upper Sacramento River in Siskiyou County and at Squaw Creek in Shasta County are the most northern records for California (Rainey and Pierson, 1996).

There are California records for *L. blossevillii* for every month of the year (Figure 3). Most of these reflect one to several specimens per locality or per date with the exception of series collected by the Museum of Vertebrate Zoology in April, June and September of 1945 in Fresno County, where multiple red bats were located roosting in tamarisk plantings along agricultural field margins (Benson, 1945; Dalquest, 1945).

Review of museum records yielded 86 specimens from 54 localities that were likely breeding records -- either adult females collected during normal season for pregnancy and lactation (mid-May through August) or known juveniles. Most of these (83.3%) are from the Central Valley (including the Delta), typically in association with either the Sacramento or San Joaquin rivers (Figure 4, Table 2). Likewise, five of the eight southern California breeding records are from localities close to major drainages (e.g., San Diego, Santa Ana, and Los Angeles rivers), with the remaining records associated with smaller drainages (e.g., San Onofre Creek in San Diego County and Sycamore Canyon in Santa Barbara County). A recent (25 June 1997) record from Santa Barbara (a pregnant female weighing 15.6 g and carrying four embryos [one measuring 16x17 mm] -- P.W. Collins, Santa Barbara Natural History Museum, personal communication) provides the only breeding record along the coast north of the Los Angeles basin. During the reproductive period (May through August) the distribution of males is far less concentrated, with 52.5 % being found in the Central Valley and surrounding foothills, 27.5 % in southern California, and 20 % along the coast (Table 2).

Winter records (November through February) reveal a quite different distribution, with 54.0 % of the records occurring along the coast, 23.8 % in the Central Valley and Delta, and 20.6 % in southern California (Figure 5, Table 2). There is no obvious difference in distribution between males and females during this period.

3.1.2. Distribution Records for *L. blossevillii* - This Study

Given the clear indication from available records that breeding females were concentrated in the Central Valley in association with the Sacramento and San Joaquin rivers, we selected 30 sites along the axis of these rivers and a few tributaries, from near Redding at the north end of the Central Valley to the Mendota Wildlife Refuge in the south, with 7 additional sites along the Stanislaus and Merced rivers in the valley, 8 sites in the Coast Range and San Francisco Bay area, and three in the Salinas Valley (Table 3). We monitored each site acoustically during the summer and early fall of 1999 to obtain data on the current distribution of this species in areas of historical importance. Red bats were detected at a total of a total of 33 localities, including 28 of the 30 Central Valley localities (Table 3, Figure 2). Although the number of detections varied substantially among sites in relation to habitat quality (see Section 3.2. below), red bats were still detected wherever there was suitable habitat present. Although acoustic surveys do not permit identification of sex or age of individuals sampled, two red bats, a post-lactating female and a juvenile female, were captured at one site on the Sacramento River, and an injured juvenile female was found at another Sacramento River locality (R.M. Miller, personal communication). These records provide evidence that there are currently reproductive populations in the Central Valley (Table 4).

Our data suggest that *L. blossevillii* densities are at their peak in the Central Valley during July and August, and decline in the fall. Eleven sampling stations at five different localities were sampled during the summer and again in the September. Although there was considerable variation among sampling sites, overall level of bat activity was lower in September (Table 5).

Prior to this study there were only three records for red bats in California from elevations in excess of 1,000 m., one from the Sierra Nevada, one from the Coast Range, and one from the Laguna Mountains in southern California (Table 6). We obtained red bat records from seven additional higher elevation localities, all in Yosemite National Park. Three were at elevations >2,200 m, in predominantly conifer (red fir, *Abies magnifica*, and lodgepole pine, *Pinus contorta*) habitat. For three of these sites we also have seasonal data (Table 7). As part of two other studies seasonal bat abundance and diversity was being monitored along an altitudinal gradient at 12 localities from the floor of the Central Valley at ca. 60 m elevation to > 3,000 m near Tioga Pass in Yosemite National Park. Red bats were detected multiple times during every sampling period at the two lowest elevation sites located in the Central Valley, with peak numbers in July and August. The presence of red bats became less predictable with gain in elevation. None were detected at any of the three sites located above 2,500 m. Presence at sites between 200 m and 2,500 m tended to be sporadic and limited, with the notable exception of Carlon Meadow (see Section 3.2.1. below).

Evidence for winter residence in the Bay area was provided by Orr (1950), who observed red bats over a five year period roosting in African hemp, *Sparmannia africana*, in the Strybing Arboretum in San Francisco. The bats were present at this site from mid-September through early May. On 12 March 2000 a red bat was located roosting in a *Sparmannia africana*, also in the Strybing Arboretum. While no trees of appropriate size could be located in the African section of the Arboretum where Orr had made his observations, this bat was located within a few hundred meters of what must have been the original site. Consistent with Orr's observations, this bat was roosting on the south facing side of the tree, ca. 12 m above the ground, clinging to the veins on the underside of an overhanging leaf.

The additional evidence provided by museum records that red bats concentrate along the coast in the winter is supported by acoustic data collected in the San Francisco Bay area. All night acoustic monitoring has been conducted somewhat sporadically (averaging 10-15 nights per month) at the same station, out the window of a residence in Berkeley, California since early 1998. Red bats have never been detected in the summer, but have been detected repeatedly from late August (29 August 1998, 29 August 1999) through the late winter (2 February 2000). Although museum records document the presence of males along the coast in the summer, acoustic monitoring at two riparian sites in the Bay area in July 1999 (Strawberry Canyon and Briones Regional Park) yielded no red bats. Acoustic sampling by one of us (CJC) at Pt. Reyes National Seashore, along the coast north of San Francisco, obtained multiple acoustic detections of *L. blossevillii* on 21 November 1995, 6 February 1996 and 9 March 1996. Red bats were also observed on several occasions at Pt. Reyes in late September 1997.

Seasonal distribution of red bats in the coast ranges north of San Francisco are not well understood. One forested site in Lake County has been monitored three times (15 May 1999, 3 August 1999, and 26 March 2000). There were numerous (>10) detections of *L. blossevillii* during the spring (March and May) samples, and none in August. No red bats were detected at vegetated riparian sites sampled during the summer at several lower elevation sites in the Coast range (Russian River, Hunting Creek, Putah Creek, Pinnacle Rock). Red bats have, however, been detected farther north along the Eel River at Covelo (Table 3), in the coastal redwood forest (W.E. Rainey, unpublished data).

A few additional records were obtained from the Salinas Valley (Table 3), including two early spring records for Pacheco Creek and Pinnacle National Monument. While these records do not change the known distributional picture, they provide evidence that red bats are currently found in these areas.

3.2. Habitat Associations

3.2.1. Cottonwood/Sycamore Riparian

Levels of red bat activity were sampled during July and August at sites of differing habitat quality in the Central Valley (Table 1, Appendix I). There was significantly more red bat activity at the most intact sites (Rank A) , in association with wide riparian strips dominated by mature cottonwood and sycamore, and significantly less activity in the three other classes of habitat (Figure 6). While we observed little to no red bat activity over denuded river banks (grass slopes or rip-rapped levees), at two sites there was considerable activity over gravel bars. In both cases these gravel bars were at least 50 m wide and several hundred meters long, providing open space between the river and relatively intact (Rank A) habitat. The pattern of detections suggested that red bats were foraging over the gravel bars. At other sites we were able to observe the bats (acoustically and with spot lights) foraging along the river edge in association with relatively intact riparian forest.

On 26 August we observed a clearing inside a gallery cottonwood forest, ca. 500 m back from the river. In this gap, the cottonwood trees were heavily draped with wild grape vines. At dusk the clearing filled with foraging bats. For the first 15 minutes (19:53 until 20:08) there was intense activity by *Eptesicus fuscus* and a *Myotis* echolocating at 40 kHz. The small size, broad wings, and fluttery flight strongly suggested that this may have been *Myotis ciliolabrum*, although there are no records for this species from this area. There was also a small amount of activity from a *Myotis* echolocating at 50 KHz, which would have been either *Myotis californicus* or *Myotis yumanensis*. From 20:08 until it began to rain at 20:35 the dominant species flying and foraging in the clearing was *L. blossevillii*. Red bats appeared very suddenly, apparently from the canopy of the trees, and circled in this clearing (ca. 30 m in diameter) at heights of 5 to 20 m off the ground.

Although detections of *L. blossevillii* were rare at elevations in excess of 200 m, there was a notable exception at Carlon Meadow, a site at 1,329 m just inside Yosemite National Park (Table 8). Red bats were first detected at this station on 12 July 1999, showed a marked increase in activity at this site on 12 August, and were present again on 15 September. These detections all occurred on the edge of a meadow, ca. 50 m from the Tuolumne River, adjacent to a cluster of black cottonwood (*Populus trichocarpa*). The timing of this activity, and visual observations conducted at the site on 13 August, suggested all the calls were given by a single bat that was apparently roosting in the black cottonwood. Equally striking was the fact that, despite repeated sampling over several months, red bats were rarely detected at sites 100 m or 200 m distant from these trees, and never at a riparian site along the Tuolumne River 6 km downstream site (Table 8). On 13 August we set multiple mist nets in this cluster of black cottonwood, but no bats were captured.

3.2.2. Fruit Orchards and Other Non-Native Vegetation

Since all prior roosting records for *L. blossevillii* in California were associated with orchards or other non-native vegetation (Table 9), we also investigated the association between *L. blossevillii* and introduced vegetation. Following descriptions provided by Orr (1950) we were able to locate *L. blossevillii* roosting in African hemp, *Sparmannia africana*, an exotic plant frequently used in gardens in the Bay area (Section 3.1.2. above). An acoustic survey conducted on 31 August 1999 at Grizzly Island (a site with historic breeding records -- MVZ, UC Berkeley), yielded a large number (47) of red bat call sequences beginning at emergence time. The only likely roosting sites on this island are the abundant, mature *Eucalyptus* trees.

Orchards were sampled for red bats in three localities -- along Bear Creek, east of Merced, Merced County; along Cone Grove Road, east of Red Bluff, Tehama County; and adjacent to the Sacramento River in Bend, Tehama County.

We sampled the Bear Creek site on 15 July 1999 by driving slowly at night along public roads adjacent to mature orchards that had been selected in a daytime survey. In a 3 hour period beginning at 20:45, we detected red bats six times at five different sites between 20:59 and 22:59, twice in a fig orchard, twice in an apricot orchard, and twice in an almond orchard.

On 23 August 1999, at Antelope Creek we drove a 3 km transect along a public road adjacent to a mature walnut orchard. This transect was started at 20:20 and repeated 11 times, ceasing at midnight. Red bats were detected 16 times, with all the detections associated with 4 sites (4 detections per site) -- two sites were adjacent to mature walnut trees, one was at the interface between the orchard and the lighted yard of a house, and one was at a clearing in the orchard that was being watered with a sprinkler system.

The Bend site is a mature walnut orchard located on the Sacramento River, and separated from the river by a >50 m buffer of mature riparian forest. Three sampling stations were established: one in a clearing within the riparian zone, about 5 m from the river edge; one at the orchard edge, along a track that runs between the orchard and the riparian strip; and one at a clearing in the interior of the orchard, approximately 50 m from the orchard edge. These three sites were sampled twice, once on 24 August 1999 and again on 20 September 1999. Red bats were detected at emergence time and throughout a four hour sampling period both at the orchard edge and within the riparian strip. In the August sample activity at the orchard edge and in the riparian zone was approximately equal, whereas in September there was significantly greater activity at the orchard edge. In September we observed a red bat emerge from the orchard prior to dark and feed along the orchard edge. There was significantly less activity inside the orchard, where only one red bat was detected on either date (Figure 7). It was also at this site that a post-lactating female and juvenile female were netted on 24 August 1999 (Table 4).

3.3 Species Diversity

A total of 15 (and likely 16) species were detected in this study, 13 (possibly 15) in the Central Valley and two others in the Coast Range (Table 3). The limited number of sampling sites in the Coast Range do not permit a comparison of diversity between the mountains and the Valley. It is clear, however, even from this limited sample that both *L. blossevillii* and *L. cinereus* are less common outside the Central Valley, and that certain *Myotis* species occur more frequently in the Coast Range (e.g., *M. evotis*, *M. thysanodes)*, while others are more common in the Valley (particularly *M. yumanensis*). The uncertainty regarding numbers of species arises from the difficulty in distinguishing acoustically among the three *Myotis* species that echolocate at 40 KHz -- *M. ciliolabrum*, *M. lucifugus*, and *M. volans*.

Although *L. blossevillii* was generally not the most abundant species as measured by number of detections per site, it was nevertheless one of the most widely encountered, being found at 93% of the Central Valley sites (Table 3). Only the Mexican free-tailed bat, *Tadarida brasiliensis*, was more widely distributed. Of the thirteen species encountered in the Central Valley, five were encountered at >50% of the sites (Figure 8): the Mexican free-tailed bat, *T. brasiliensis*, the red bat, *L. blossevillii*, the hoary bat, *Lasiurus cinereus*, the big brown bat, *Eptesicus fuscus*, and the Yuma myotis, *Myotis yumanensis*. During the summer months most of the acoustic detections at most sites were attributable to *T. brasiliensis*, *M. yumanensis*, and *E. fuscus*. There were a few sites where *L. blossevillii* was the dominant species (particularly in the Delta), but generally this species, while widely distributed along these riparian corridors, was not common. Three other species (the California myotis, *Myotis californicus*, the pallid bat, *Antrozous pallidus*, and the western pipistrelle, *Pipistrellus hesperus*), although somewhat patchily distributed, were present at >30% of the sites. It is likely that the number of sites at which *M. californicus* was detected is underestimated due to the difficulties in distinguishing this species from *M. yumanensis* (and it would thus appear as *My50*).

A species assemblage here labelled *My40* was detected at 67% of the sites in Central Valley. Although there are very few museum or literature records from the Central Valley for any of the three possible *My40* species (two localities for *M. lucifugus* [MVZ], one locality for *M. ciliolabrum* in the Sutter Buttes [Johnson 2000], and none for *M. volans),* it seems likely that all three do, in fact, occur there at least part of the year. *M. lucifugus* is known from other settings (Rainey and Pierson, 1996; Herd and Fenton, 1983) to forage by skimming the water surface for aquatic emergent insects. Bats echolocating at 40 kHz were observed skimming the surface of the Sacramento River at two sites in September. We feel confident these were *M. lucifugus*, and they may represent animals migrating from higher elevations where this species is known to have summer populations. We remain more tentative regarding identification of *M. ciliolabrum* or *M. volans*, although think it likely that very small, broad winged bats foraging with fluttering flight near tree canopy height at Colusa-Sacramento State Recreation Area were *M. ciliolabrum*, and that bats observed flying with fast, direct flight along the shoreline of the river at Red Bluff Lake were *M. volans*. There are recent records for *M. ciliolabrum* from the Sutter Buttes (H. Johnson, personal communication), and an observation (4 June 1998) of *M. volans* at San Pedro Reservoir on the Merced River (E.D. Pierson and C.J. Corben, unpublished data).

The western mastiff bat, *Eumops perotis*, was detected on 10 occasions at seven sites in the Central Valley (Table 3). The Stanislaus River sites, where observations occurred in June, August, September and October, are 10-20 km from one roost that may be occupied year round, and 25-35 km from a roost known to be occupied year round. The closer site is within the known commuting distance between roosts and foraging areas for this species (Pierson, 1998). The Mendota site, where mastiff bats were detected in July, is 28 km, and thus within potential commuting distance, from a known roost. The data from the Merced and Sacramento Rivers suggest that western mastiff bat activity increases in the Central Valley in the fall. Mastiff bats were not detected at any station during July and August, and at three stations in September, one of which (SR59 on Merced River) had been sampled seasonally.

The silver-haired bat, *Lasionycteris noctivagans*, was never detected in the Central Valley in the summer, but appeared six times at five sites (once in April, and four times in September) in the spring and fall. This species, known to have breeding populations along the upper Sacramento River and in the Trinity Mountains (Pierson and Rainey, 1998; Rainey and Pierson, 1996) and a winter distribution in southern California (Constantine, 1998), likely migrates through the Central Valley in the spring and fall.

Myotis evotis, while detected at 63% of the sites in the Coast Range, was found at only three (10%) in the Central Valley. Two of these, Antelope Creek and Dye Creek, were on tributaries of the Sacramento River, close to the eastern edge of the valley, and all three were in close proximity to oak savannah habitat. *Corynorhinus townsendii* was detected at 50% of the Coast Range sites, but only two (10%) of the valley sites. Both these sites are in close proximity to cliff (and thus potential cave) habitat, and at one of the sites (Orange Blossom) an animal had been observed at an earlier date in a nearby irrigation tunnel. This species was never observed in the open areas of the Central Valley. *Myotis thysanodes* was detected at three sites (38%) in the

Coast Range (once in a cave and once in a mine tunnel), but was never detected on the floor of the Central Valley.

Although, as indicated above, the hoary bat, *Lasiurus cinereus,* was detected at 73% of the Central Valley sites, the majority of these detections were in the spring or fall. It was detected during each of the three spring samples, 16 of 22 fall samples (72%) and only 9 out of 20 (45%) summer samples (Table 3). During the summer there were generally no more than two to three detections per night, but the numbers of hoary bats increased dramatically in the fall at several sites. On 22 and 23 September at Bidwell-Sacramento River State Park, near Chico on the Sacramento River, we apparently observed a mass migration with > 1,500 sequences in one night (Pierson et al. in prep.).

4.0 DISCUSSION

Analysis of existing records and the data collected in the context of this study point to the Central Valley as being of primary importance to breeding populations of *L. blossevillii* in California. Whereas red bats were encountered infrequently or not at all in riparian areas outside the Central Valley (in the Coast Range, along the coast, or in the Sierra Nevada), they were predictably present during the summer at most sites sampled in the Central Valley. While it is possible that there are other areas that support populations, the historic records strongly suggest that the most significant distribution occurs in the Central Valley. The other area that would likely support substantial populations, based on its low elevation and the composition of its riparian habitat, would be the Salinas Valley. Historic records from this area, however, are surprisingly few. Although a systematic survey of the Salinas Valley was outside the scope of this study, we did obtain a few acoustic records from there, confirming that current distribution does include this area. An extensive survey at two military bases in this valley (Camp Roberts and Camp San Luis Obispo), detected no red bats (Gannon, 1996), whereas another study at Camp Roberts did (P.A. Heady, personal communication).

L. blossevillii appears to be strongly associated with riparian habitats, particularly mature stands of cottonwood/sycamore. Although this has not been previously noted for this species in California, it has been observed in both Arizona (Hargrave, 1944; Hoffmeister, 1986) and New Mexico (Findley et al., 1975; Jones, 1961; Levy, 1958; Mumford et al., 1964). The eastern red bat, *Lasiurus borealis*, has also been found in association with willow, cottonwood and sycamore in Mexico (Bogan and Williams, 1970). Recent studies have documented the importance of riparian areas, particularly for foraging, for many bat species in both North America and Europe (Grindal et al., 1999; Racey, 1998). What distinguishes *L. blossevillii* from most other California taxa is its foliage roosting habits (shared in northern California only with *L. cinereus),* and thus its apparent reliance on riparian forests for both roosting and foraging.

The fact that we obtained significantly more acoustic activity in stands that were dominated by mature trees and were greater than 50 m wide suggest that red bat populations require fairly extensive stands of riparian forest. Although we had no direct observations of red bats roosting in this habitat, we repeatedly observed them (acoustically and occasionally visually) active at dusk in the vicinity of large cottonwood, sycamore and/or valley oak. In light of two recent studies on roosting behavior of the closely related eastern red bat, *L. borealis* (Hutchinson and

Lacki, 2000; Menzel et al., 1998), it would be reasonable to hypothesize that *L. blossevillii* roosts preferentially in the canopy foliage of the largest trees. In a study in Kentucky, Hutchinson and Lacki (2000) located 44 day roosts by radiotracking. Although tree species appeared to be chosen at random from among the available hardwood species (with no conifers being used), all bats roosted in the upper canopy, at an average height of 16.5 m above the ground in trees that averaged 18.5 m tall and 40.8 cm DBH. Similarly, Menzel et al. (1998), in a study in Georgia, found that red bats roosted at heights that were on average 15.3 m above the ground, preferentially selecting hardwood trees that were taller (24.85 vs. 16.96 m) and had a larger DBH (37.75 vs. 22.53 cm) than a random selection of over-story trees. Our data suggesting that levels of red bat activity were significantly higher in the more extensive (>50 m wide) riparian stands were strikingly consistent with the finding by Hutchinson and Lacki (2000) that eastern red bats selected roosts that were on average 277 m, and never less than 50 m, from the forest edge.

Direct observations of roosting behavior in *L. blossevillii* in California are limited primarily to collections or sightings that have occurred in fruit orchards (Benson, 1945; Constantine, 1959; Dalquest, 1945; Grinnell, 1918), either in the fruit trees themselves or agriculture associated exotic vegetation (e.g, tamarisk or Chinaberry trees). In these settings the animals are roosting where they can be viewed from the ground. Constantine (1959) reported that the red bats he observed roosted between 1.5 and 7.6 m off the ground, at an average height of ca. 2.6 m. Benson (1945) reported that the red bats found in tamarisk were in the larger stands (12-15 m high), roosting at heights of 2 to 12 m. Similarly, the animals observed in the winter by Orr (1950) roosting in African hemp were also at heights of ca. 2.4 to 4.6 m above the ground.

The extent to which fruit orchards are used by breeding females is unknown, although our capture data and that of Constantine (1959) suggest that females with dependent young do roost in orchards. Given the extensive loss of riparian forest in the Central Valley, where it is estimated that less than 6% of relatively intact forest remains (Katibah,1984; Smith, 1977), it is highly likely that the orchards, particularly the walnut orchards that flank the Sacramento River, serve as alternative habitat, and to some extent compensate for the loss of large cottonwoods, sycamores, and oaks. What is not known, however, is whether this habitat serves as a viable refugium. Orchards are subject to extensive spraying with pesticides, and deleterious effects have been demonstrated for some bird species (Wilson et al., 1991). Although a number of environmental contaminants have been shown to have negative effects on bat populations (Clark, 1981; Clawson ,1991; Clawson and Clark, 1989), the effects upon bats of the particular pesticides used in orchards is not known. If these chemicals negatively impact the bat populations, either directly (through mortality or reduced fecundity) or indirectly (through reduced prey base), then the orchards may be a population sink

Although the limited records of *L. blossevillii* outside California include localities in excess of 1, 000 m in Arizona and New Mexico (Hoffmeister, 1986; Jones and Suttkus, 1972), most records in California are from elevations below 200 m., with all the breeding records occurring at low elevation. The fact that the three museum specimens for elevations >1,000 m are males, and that the animals we captured in Yosemite National Park included two males and a non-reproductive female, suggest that the higher elevation records are predominantly males, or non-reproductive animals. The highest elevation record from pine-fir forest in Arizona (2,195 m) was also a male (Johnson and Johnson, 1964). This study expanded our understanding of the distribution and habitat associations for *L. blossevillii* in that it added seven new higher elevation records, extended the known elevational limit from 1,643 m to 2,484 m, and detected animals in habitats heavily dominated by conifers. While this is significant for our overall understanding of the distribution of this species, it does not alter our expectation that breeding females are confined to low elevation, cottonwood/sycamore and oak dominated riparian habitat.

Although there is both direct and indirect evidence of a substantial north-south seasonal migration for eastern red bats, there is no comparable evidence for the western species. While both museum records and our data strongly suggest that red bats undergo seasonal shifts in distribution, there is no indication of mass migration. Observations of migratory bats on the Farallon Islands off the coast of San Francisco by Tenaza (1966) included only *L. cinereus*. It has often been assumed that lack of thermal buffering would force foliage-roosting *Lasiurus* species to seek a moderate winter climate (Grinnell, 1918). Yet Davis and Lidicker (1956) found eastern red bats from November through February in areas of the central United States that experience frequent freezing temperatures. More recently there have been several reports of investigators locating red bats during the winter hibernating in leaf litter (Moorman et al., 1999; Saugey et al., 1998, 1989). Whether western red bats hibernate in leaf litter in the winter is unknown. The majority of sites for which there are winter records in California are in areas that rarely if ever experience freezing winter temperatures.

The bat assemblage in the heart of the Central Valley appears to be heavily dominated in the summer by four or five species, including *L. blossevillii*. Striking by their apparent scarcity or absence are *C. townsendii* and the two long-eared myotis species, *M. evotis* and *M. thysanodes*. Diversity in general was higher at sites that were either towards the eastern or northern margins of the valley. Although the data are limited and preliminary, there is a strong suggestion that the Sacramento River is used as a migration corridor for several bat species, particularly *L. cinereus*, *L. noctivagan*s, and *M. lucifugus*. The large number of acoustic detections for *Myotis* echolocating at 40 KHz indicates that one or more species for which there are currently either none or very few records for the Central Valley, not only occur there, but are relatively common. Identifying the composition of this *My40* assemblage, what proportion are *M. ciliolabrum*, *M. lucifugus*, or *M. volans*, would inevitably alter our understanding of the distribution of one or more of these species.

This study provides a demonstration of both the power and the limitation of acoustic surveys. For all species there are a certain percentage of detections that will not be identifiable, either because the retained call sequence is of poor quality (e.g., a fragment) or because the call is of a shape and frequency that is not distinguishable from that of some other species. For some species, like the 40 kHz and 50 kHz *Myotis*, this currently presents serious challenges. For other species, like *A. pallidus*, *L. blossevillii*, *M. evotis*, *M. thysanodes*, *P. hesperus*, and *E. perotis* acoustic methods, if used appropriately, can be a very powerful and efficient tool for obtaining distributional data. Because the frequency range for red bats is 35-50 KHz, there are a certain percentage of their calls that cannot separated from those of a 40 kHz or 50 kHz *Myotis*. Also, the calls given by *P. hesperus* are similar in shape to those of *L. blossevillii,* and differ only in being of longer duration and generally having less variation in frequency range within a given sequence. In sequences of insufficient duration (and thus containing too few calls) it is often not possible to distinguish with certainty between these two species. Nevertheless, the fact that an estimated 50% or more of red bat calls are diagnostic means that acoustic methods can be used effectively to locate them. In this study, not only would mist netting have been far more labor intensive, it would not have been feasible in many settings where we detected red bats -- e.g., along steep and heavily vegetated banks of the Sacramento and San Joaquin rivers, or along roads adjacent to private land. Additionally, in one setting (Carlon Meadow) where we had monitored intense red bat activity, and set multiple nets, we failed to catch any bats. Often when we were able to observe this species it was flying 5-15 m above the ground, well above the level of standard mist nets.

5.0 CONSERVATION IMPLICATIONS AND MANAGEMENT RECOMMENDATIONS

The separation of the eastern and western red bat into two species, *L. borealis* and *L. blossevillii*, has important conservation implications for the western taxon. When viewed separately it is evident that both the habitat associations and the distributional patterns for *L. blossevillii* are very different from those for the more common *L. borealis*. *L. blossevillii* appears to share with its eastern congener a dependence of deciduous trees for foliage roosting, yet it has to find suitable roost sites in a very different plant community. Throughout much of the xeric west *L. blossevillii* appears to be confined primarily to cottonwood riparian corridors. In desert regions, as are found in Arizona, New Mexico, and Nevada, the availability of suitable habitat is quite limited, and likely explains why the lush Central Valley of California may be the area in the west with the largest concentration of breeding females, and why this species has a generally patchy distribution.

When viewed in a regional context, the Central Valley of California, particularly the Sacramento and San Joaquin drainages and the lower reaches of the large rivers that drain the Sierra Nevada (e.g., Tuolumne, Merced, and likely the American and Cosumnes), take on disproportional importance for the future viability of this species. Given the rather convincing evidence that this species needs relatively intact riparian habitat, and so little of this remains, it seems highly likely that *L. blossevillii* is far less abundant than it once was in the Central Valley. It also seems evident that this species would benefit greatly from riparian restoration, particularly recruitment of cottonwood/sycamore and reinstatement of natural flood regimes.

In light of the findings in this study we recommend the following measures be taken to protect this species:

1. *L. blossevillii* should be added to the Department of Fish and Game list of Mammal Species of Special Concern;

2. It should be included in any state and/or federal planning efforts that involve the ecological health of watersheds -- particularly watershed analyses or river restoration plans for the Central Valley.

3. Additional surveys need to be conducted to obtain a more complete picture of the distribution of breeding females, particularly in the Salinas Valley, farther south in the Central Valley (e.g., the Kern River), and other areas (e.g., the lower Cosumnes) identified by the Riparian Habitat Joint Venture (1998) as being important to riparian dependent birds.

4. More survey work needs to be conducted in the fall and winter, particularly along the coast, to gain a better understanding of seasonal movements, and winter habitat needs.

5. Radiotracking studies would contribute greatly to our understanding of particular roosting requirements, and priority should be given to identifying roost characteristics in cottonwood/sycamore and oak riparian in the Central Valley.

6. Radiotracking studies and additional acoustic studies need to be conducted in orchards to help elucidate the extent to which red bats are currently relying on orchards as primary roosting areas.

7. Studies need to be conducted to determine if the pesticides used in orchards are having a deleterious effect on red bat populations.

8. Radiotracking studies need to be conducted in the fall to determine if western red bats are roosting in leaf litter as has been found with the eastern species. This possibility should be considered in areas where controlled burns are conducted.

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Figure 1. A composite sonogram depicting characteristic echolocation calls given by *L. blossevillii*.

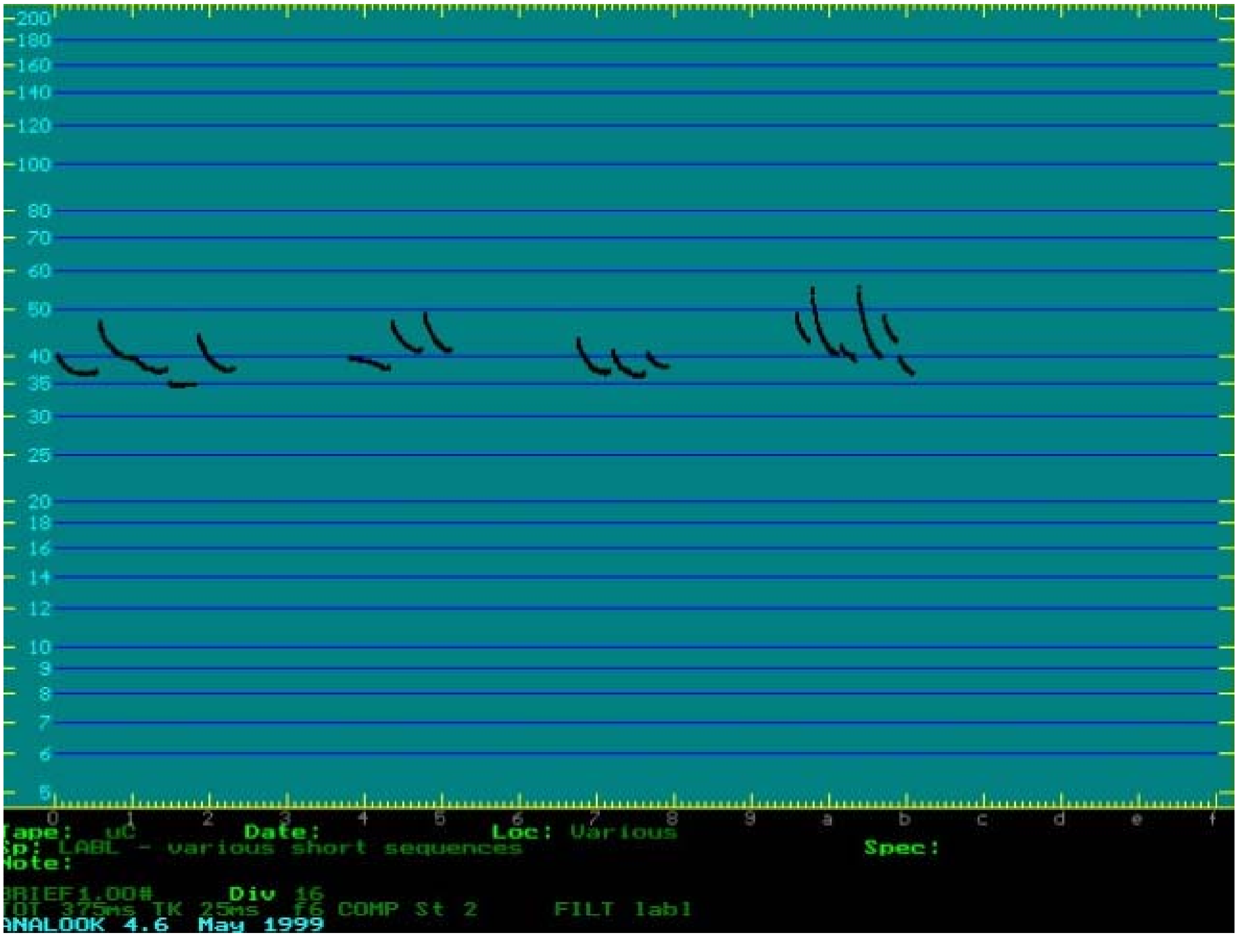

Figure 2. A distribution map for *L. blossevillii* in California, showing localities based on specimen records compiled from various sources and the acoustic records obtained in the course of this study.

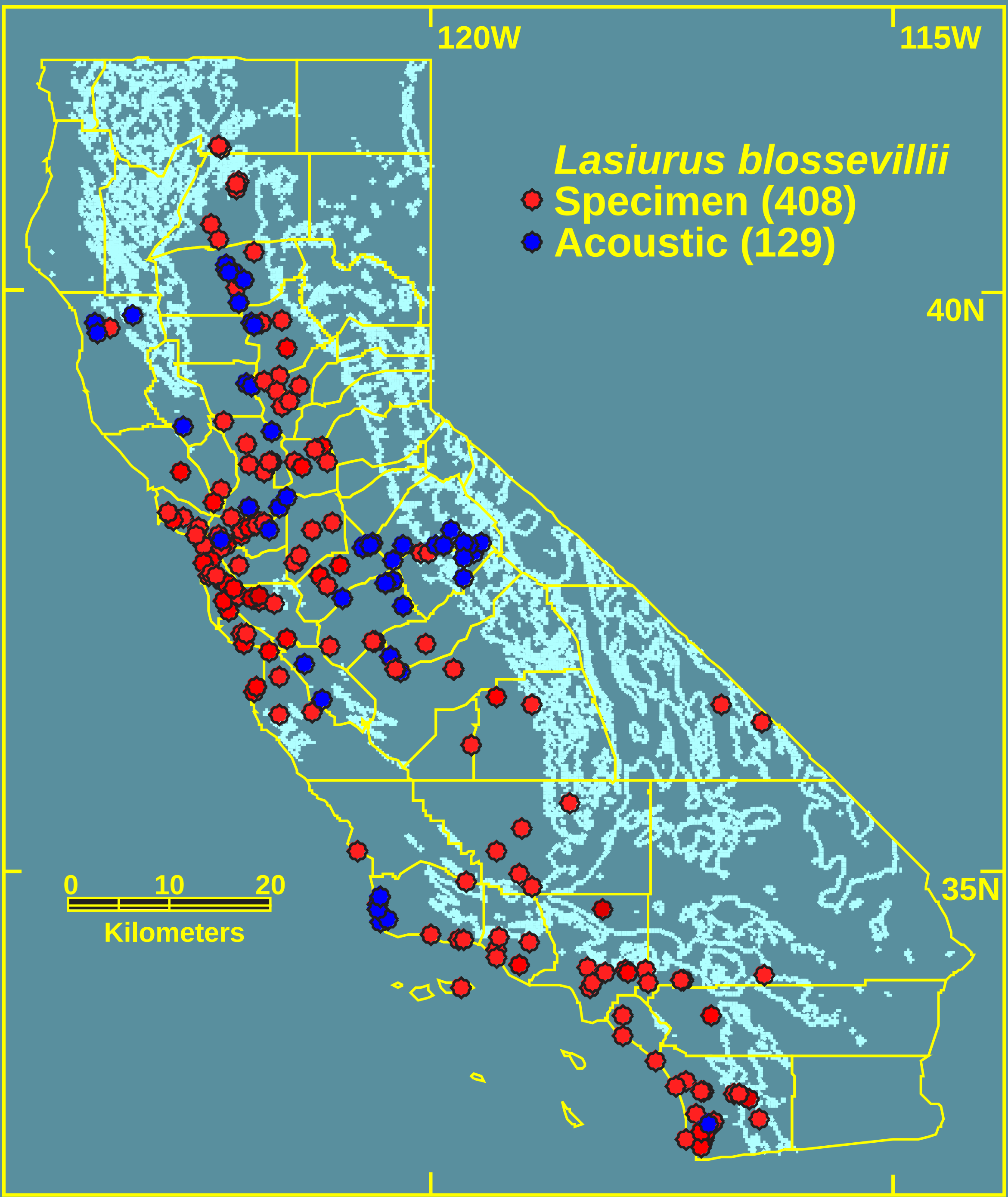

Figure 3. A bar graph showing the distribution by month of museum records for *L. blossevillii* in California.

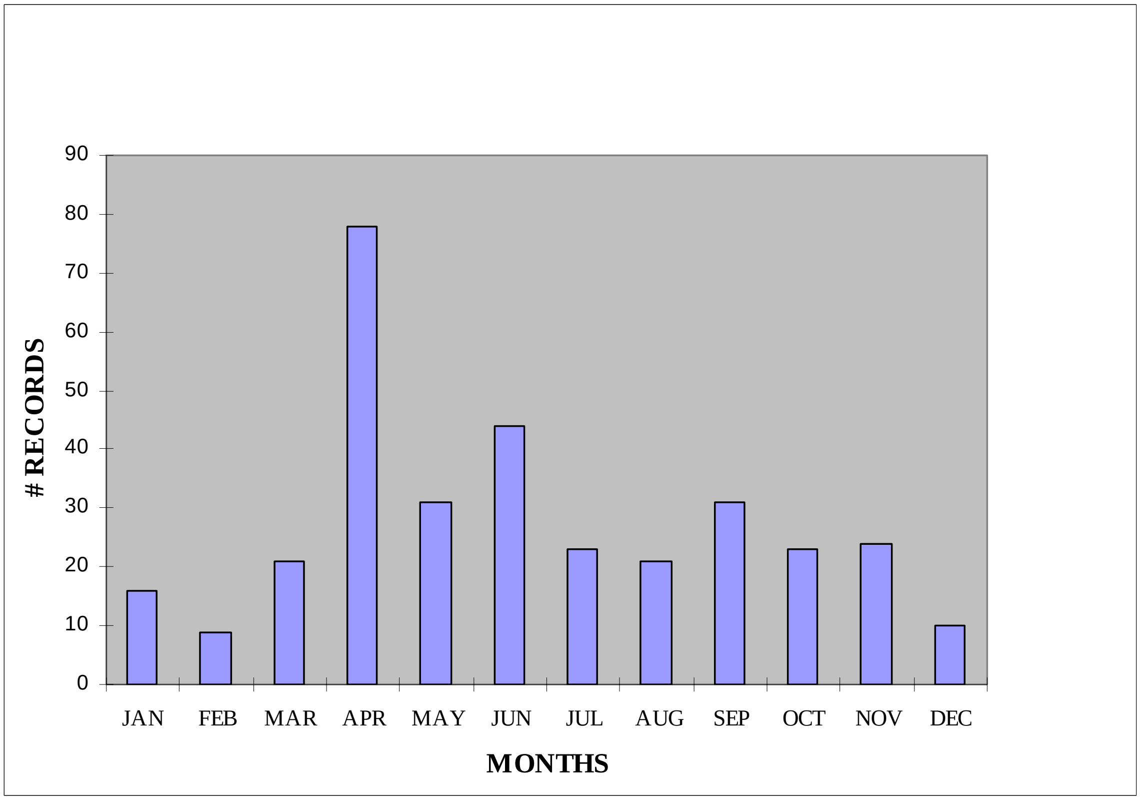

Figure 4. A map based on museum and literature records showing the distribution of adult females and/or juveniles during May, June, July and August.

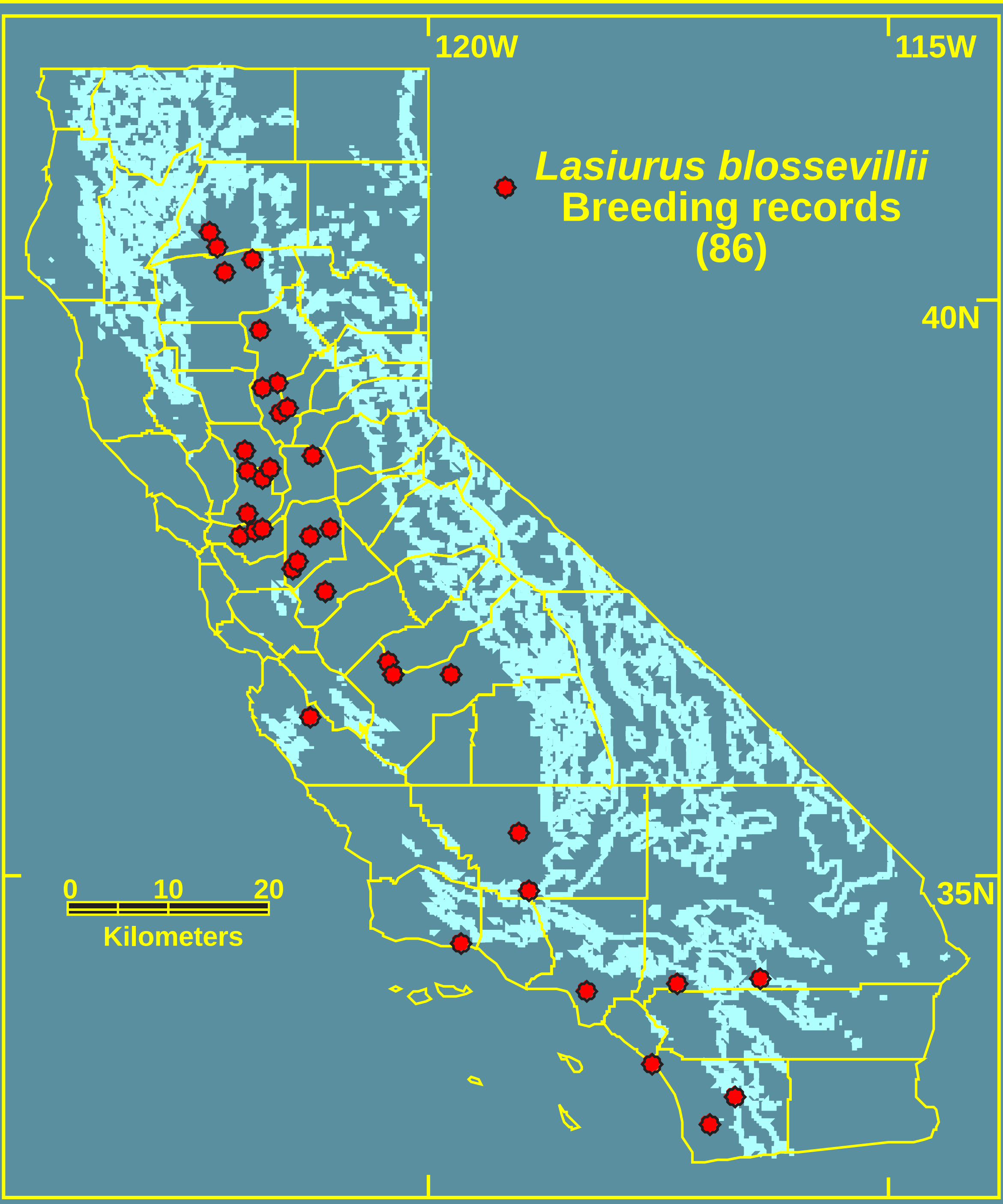

Figure 5. A map based on museum and literature records showing the distribution of *L. blossevillii* during November, December, January, and February.

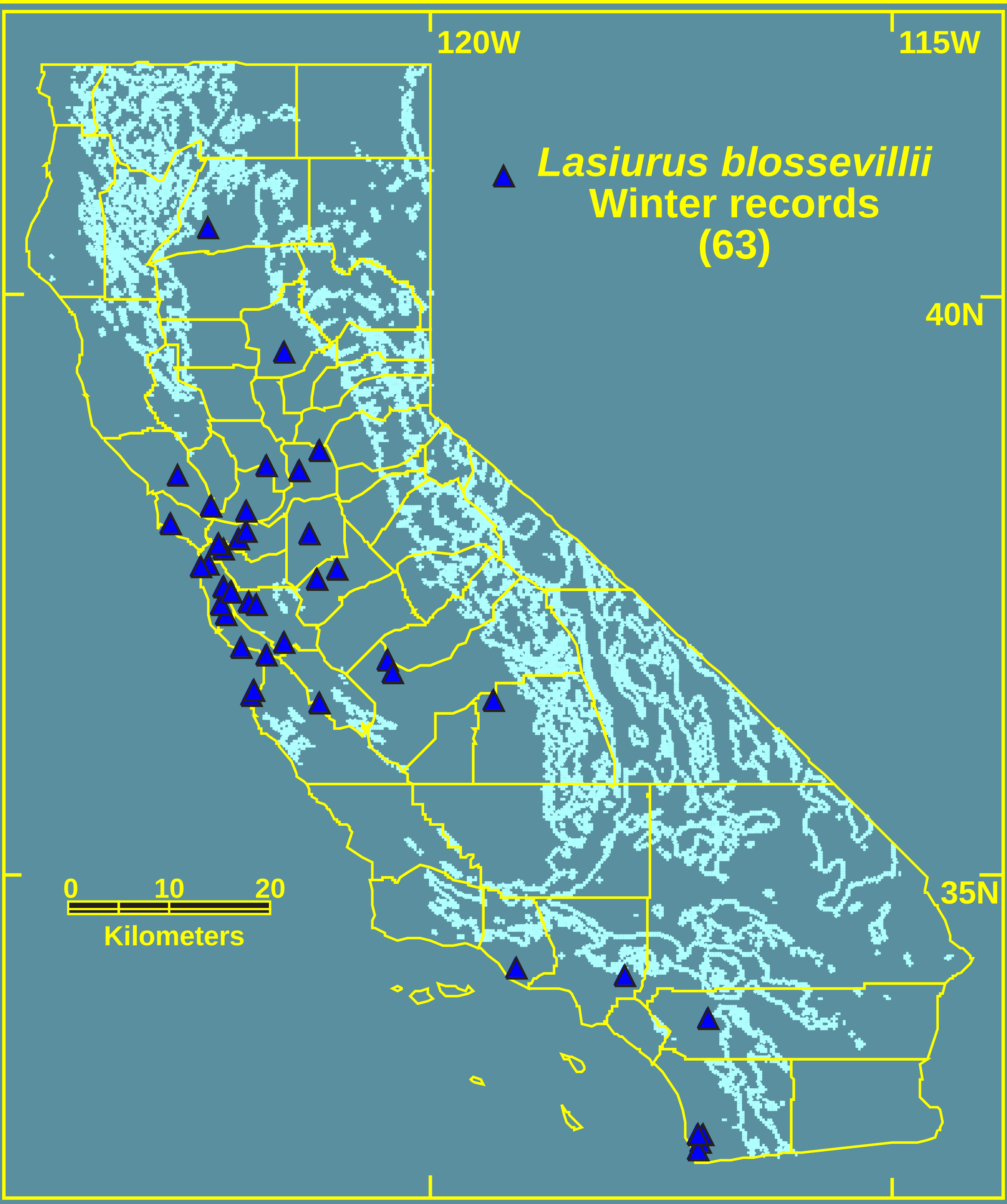

Figure 6. The maximum number of red bat call sequences obtained in any twenty minute period at sites ranked for habitat quality. See Table 1 for explanation of ranking. Clsa = Colusa; Frbh = Firebaugh; Htfd = Hatfield State Park; Rdbf = Red Bluff Lake; AnCk = Antelope Creek; DyRh = Dry Creek Ranch; Istn = Isleton Cottonwoods; KnFy = Knight's Ferry; Knlg = Knight's Landing; MdDn = Merced SR 59, downstream; DyCn = Dry Creek Canyon; DyCf = Dry Creek Canyon; Ispk = Iselton, carpark; MnWR = Mendota Wildlife Refuge; MdUp = Merced SR 59, upstream. For more information on localities see Appendix I.

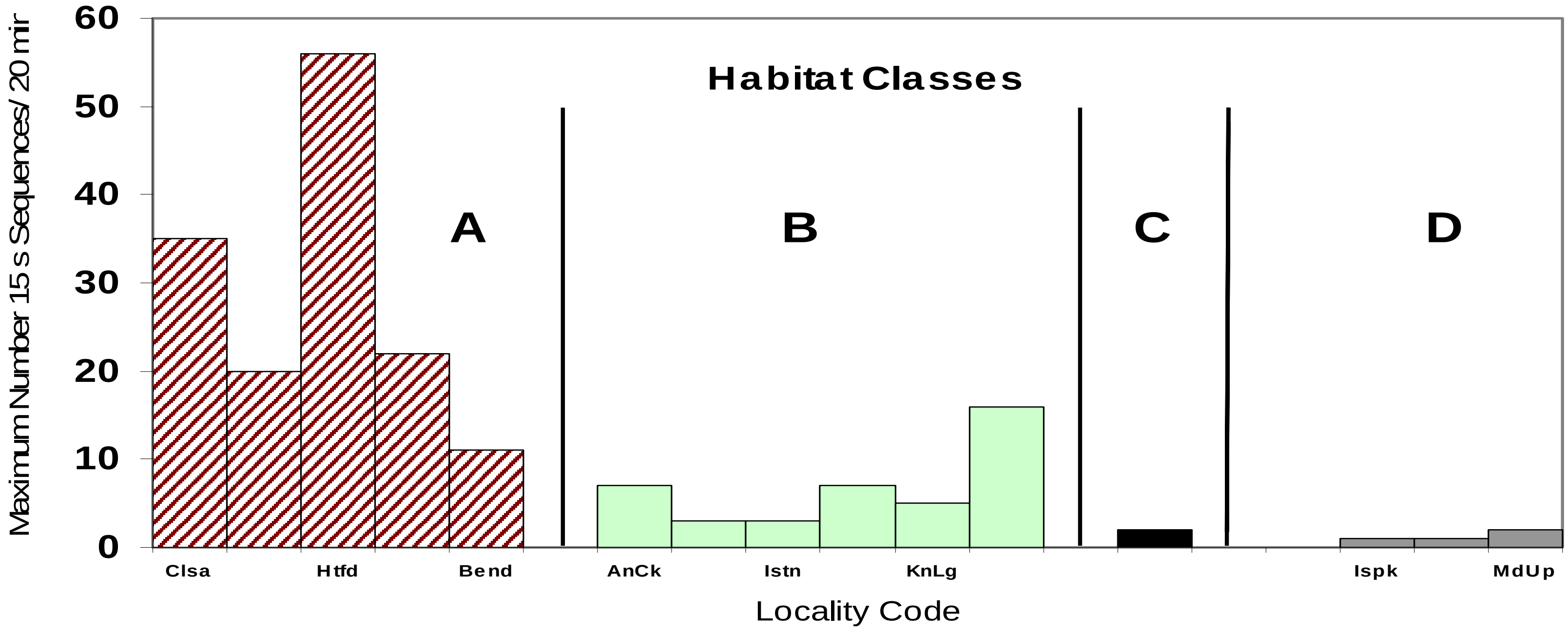

Figure 7. A comparison of number of red bat sequences obtained during the first four hours after sunset in August and September at three sites associated with an orchard on the Sacramento River at Bend, Tehama County.

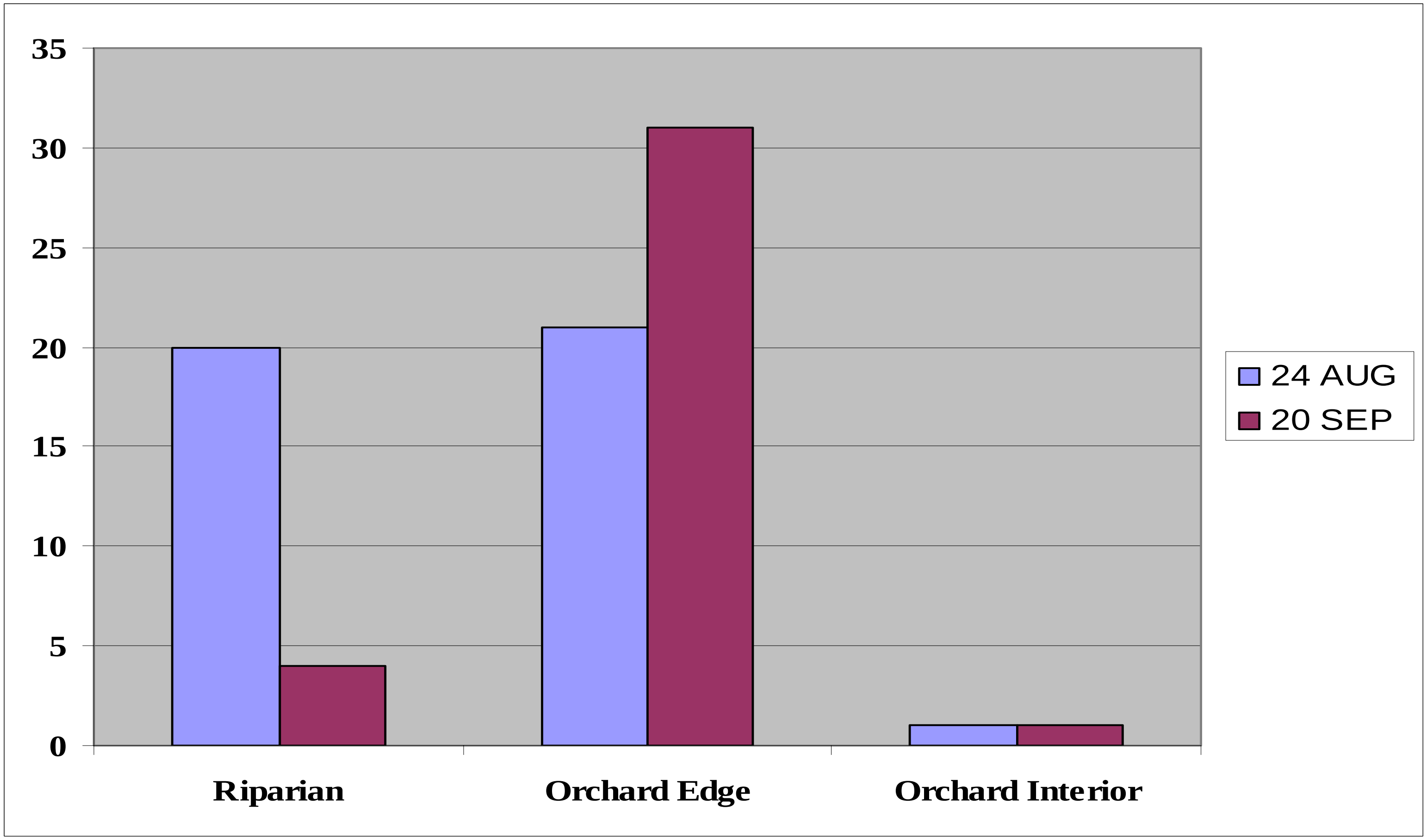

Figure 8. The percentage of sites at which all potential bat species were detected in the Central Valley in this study. Tabr = *Tadarida brasiliensis*; Labl = *Lasiurus blossevillii*; Laci = *Lasiurus cinereus*; My40 = 40 kHz *Myotis* (*M. ciliolabrum*, *M. lucifugus*, or *M. volans*); Epfu = *Eptesicus fuscus*; Myyu = *Myotis yumanensis*; Myca = *Myotis californicus*; Pihe = *Pipistrellus hesperus*; My50 = 50 kHz *Myotis* (*M. californicus* or *M. yumnanensis*); Anpa = *Antrozous pallidus*; Eupe = *Eumops perotis*; Lano = *Lasionycteris noctivagans*; Coto = *Corynorhinus townsendii*; Myev = *Myotis evotis*; Mylu = *Myotis lucifugus*; Myvo = *Myotis volans*; Myth = *Myotis thysanodes*. Identification of Myca, Myyu, Mylu and Myvo are based on visual observations in conjunction with acoustic records.

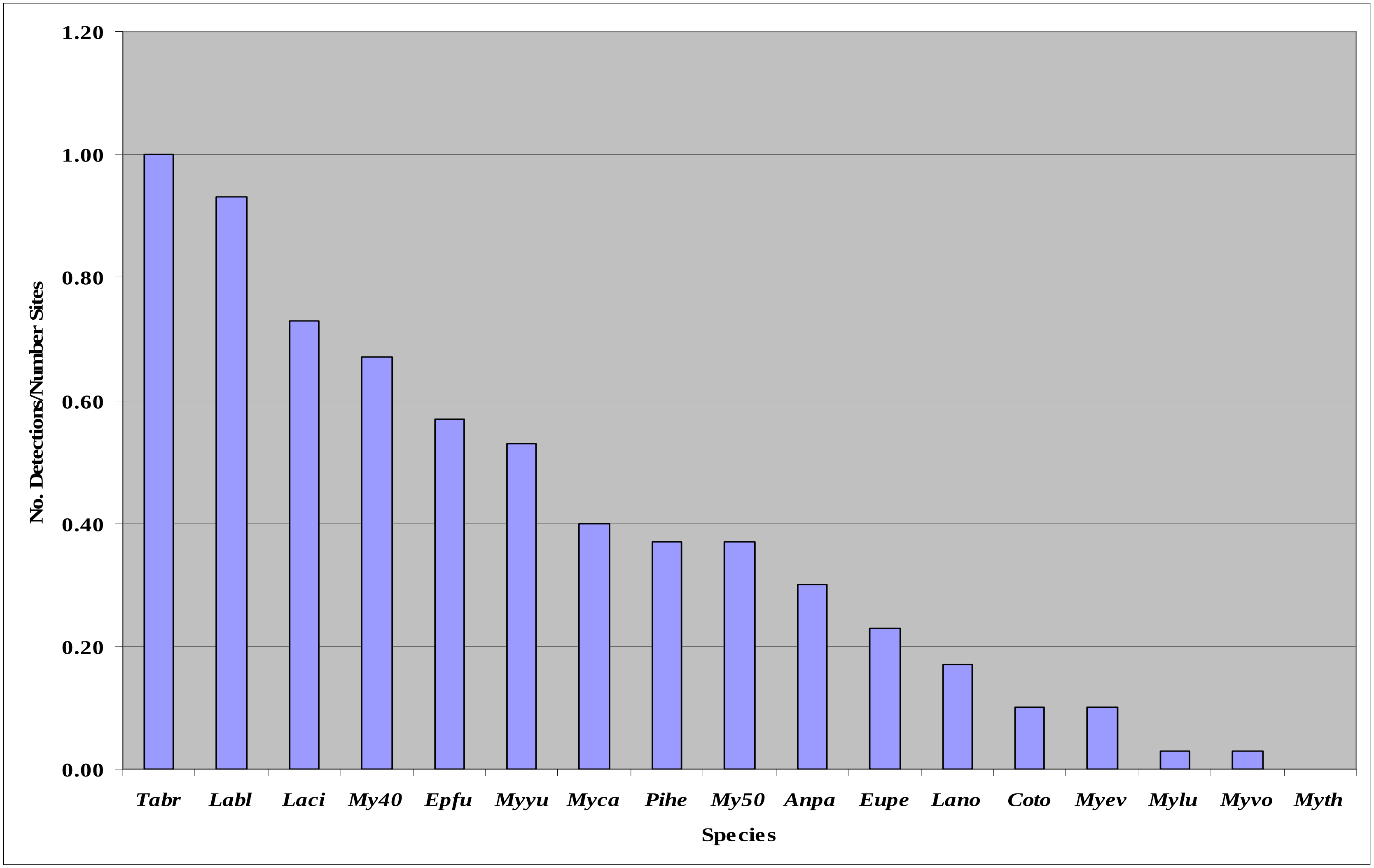

Table 1. Criteria for ranking riparian habitat categories based on width of riparian and age structure of vegetation.

RANK	HABITAT QUALITY: RIPARIAN WIDTH	HABITAT QUALITY: AGE STRUCTURE
A	> 50 m	Old growth
B	2-3 trees	Mix old growth/ 2nd growth
C	1 tree	2nd growth/young
D	Grass/Shrubs >100 m to nearest trees	Young

Table 2. Distribution of summer breeding records, males in all seasons, and winter populations of *L. blossevillii* , showing percentage of localities in four geographic areas. A Locality is defined by any record or records occurring at a particular site on a particular date. An animal was designated as belonging to a summer breeding population if it was an adult female collected during May, June, July or August or if it was a juvenile of either sex collected during the same time period.

GEOGRAPHIC AREA	SUMMER BREEDING (M,J,J,A) N=54	MALES (M,J,J,A) N = 40	WINTER (N,D,J,F) N=63
Central Valley	83.3 (45)	52.5 (21)	23.8 (15)
Salinas Valley	1.9 (1)	0.0 (O)	1.6 (1)
Southern California	14.8 (8)	27.5 (11)	20.6 (13)
Pacific Coast	0.0 (O)	20.6 (8)	54.0 (34)

Table 3. List of bat species detected acoustically or captured in mist nets at various sites in the Central Valley, Salinas Valley, and the Coast Range. Most records were collected between March and October 1999; others between June and September 1998, or in March 2000. An "X" indicates the species was detected at this site, and "X" in parentheses indicates the species was not detected on the given date, but is known to occur at the site. An asterisk (*) indicates the identification was based on a combination of visual and acoustic observation, but is nevertheless somewhat uncertain. Abbreviations are as follows: *Antrozous pallidus* (Anpa), *Corynorhinus townsendii* (Coto), *Eptesicus fuscus* (Epfu), *Lasionyscteris noctivagans* (Lano), *Lasiurus blossevillii* (Labl), *Lasiurus cinereus* (Laci), *Myotis californicus* (Myca), *Myotis ciliolabrum* (Myci), *Myotis evotis* (Myev), *Myotis lucifugus* (Mylu), *Myotis thysanodes* (Myth), *Myotis volans* (Myvo), *Myotis* of the calls could be identified as belonging to one of the species known to echolocate at 40 kHz (*Myotis ciliolabrum, Myotis lucifugus, Myotis volans*) or 50 kHz (*Myotis californicus* or *Myotis yumanensis*).

Drainage and Date	**Locality**	**Species**																	
		Anpa	*Coto*	*Epfu*	*Lano*	*Labl*	*Laci*	*Myca*	*Myci*	*Myev*	*Mylu*	*Myth*	*Myvo*	*Muyu*	*My40*	*MY50*	*Pihe*	*Eupe*	*Tabr*
Sacramento River																			
23-Sep-99	Ball's Ferry				X		X				X*			X	X	X			X
24-Aug-99	Bend	X		X		X	X	X		X				X	X				X
20-Sep-99	Bend	X		X		X									X	X			X
23-Sep-99	Red Bluff Adobe					X								X	X				X
22-Aug-99	Red Bluff Lake	X		X		X	X	X					X*	X	X		X		X
19-Sep-99	Red Bluff Lake	X		X	X	X		X						X	X				X
23-Aug-99	Antelope Creek	X		X		X	X	X		X				X	X		X		X
25-Aug-99	Dye Creek	X	X	X		X	X	X		X				X	X		X		X
20-Sep-99	Woodson			X	X	X									X	X	X		X
23-Sep-99	Woodson				X	X	X								X	X		X	X
23-Sep-99	Irvine Fish Access					X									X	X			X
21-Sep-99	Bidwell			X	X	X	X	X						X	X		X	X	X
23-Sep-99	Bidwell					X	X	X			X			X	X			X	X
23-Sep-99	Ord Ferry Rd.						X								X	X			X
23-Sep-99	Butte City Bridge					X	X									X			X
26-Aug-99	SRA			X		X		X	X*						X	X			
22-Sep-99	SRA			X		X	X								X	X			X
23-Sep-99	Colusa River Rd. Br.					X	X								X				X
22-Sep-99	2 km S. Colusa			X		X	X								X	X			X
22-Sep-99	County Line			X		X	X								X	X			X
22-Sep-99	Moon's Bend					X	X							X			X		X
27-Aug-99	Knight's Landing			X		X									X	X			X
23-Sep-99	Knight's Landing						X								X	X			X
24-Sep-99	Brannan					X	X												X
24-Jun-98	Antioch					X		X											X
26-Jul-99	Grand Island, Isleton					X													X
31-Aug-99	Grizzly Island					X													X

										Species									
Date	**Locality**	*Anpa*	*Coto*	*Epfu*	*Lano*	*Labl*	*Laci*	*Myca*	*Myci*	*Myev*	*Mylu*	*Myth*	*Myvo*	*Muyu*	*My40*	*MY50*	*Pihe*	*Eupe*	*Tabr*
San Joaquin River																			
7-Jul-99	Firebaugh					X								X					X
7-Jul-99	Refuge					X								X				X	X
Stanislaus River																			
16-Sep-99	Two Mile Bar			X		X								X	X	X	X	X	X
29-Apr-99	Knight's Ferry			X	X	X	X							X			X		X
17-Jun-99	Knight's Ferry	X		X		X	X							X	X		X	X	X
3-Jul-98	Knight's Ferry	X		X		X	X										X		X
15-Aug-99	Knight's Ferry	X	X	X		X		X						X	X		X	X	X
16-Sep-99	Knight's Ferry			X		X	X	X							X		X		X
22-Oct-99	Knight's Ferry					X	X	X						X			X	X	X
15-Aug-99	Horsehoe Bend	X		X		X	X							X	X	X	X	X	X
29-Apr-99	Orange Blossom		(X)			X	X	X						X	X				X
15-Aug-99	Orange Blossom			X										X					X
Merced River																			
7-Jul-99	Fish Hatchery			X		X		X									X		X
5-Aug-99	Fish Hatchery	X		X		X	X	X							X		X		X
19-May-99	SR59 Crossing	X		X		X	X	X						X					X
6-Jul-99	SR59 Crossing	X		X		X		X						X			X		X
27-Sep-99	SR59 Crossing					X	X	X						X	X			X	X
8-Jul-99	Hatfield State Park	X		X		X	X	X						X					X
Coast Range																			
3-Sep-98	Covelo	X	X	X		X	X	X		X									X
17-Jul-99	Russian River			X				X						X			X		X
25-Jun-99	Pinnacle Rock		X							X		X							
16-May-99	Ettawa Springs	X	X	X		X	X	X		X		X			X				X
3-Aug-99	Ettawa Springs	X		X				X		X		X			X				
26-Mar-00	Ettawa Springs		X			X		X		X					X		X		
2-Aug-99	Hunting Creek	X	(X)	X				X		X		(X)			X		X		(X)
3-Aug-99	Putah Creek			X						X				X	X	X	X		X
24-Jul-99	Strawberry Canyon							X											X
25-Jul-99	Park							X											X
Salinas Valley																			
25-Jun-98	Hollister			X		X		X										X	X
4-Mar-99	Pacheco Creek		X	X		X		X						X					
30-Jul-99	Pacheco Creek	X		X				X						X					X
3-Mar-99	Pinnacles NM		X			X												X	

Table 4. Capture records that provide new localities and evidence of reproduction for *L. blossevillii* in the Central Valley.

DATE	COUNTY	DRAINAGE	LOCALITY	LAT	LONG	SEX	AGE	REPRO	FOREARM (mm)	WEIGHT (g)	RECORD TYPE
4-Aug-99	Shasta	Sacramento R.	Anderson	402654N	1221748W	F	Juv	Nulliparous	39.55	11.90	Hand Capt
24-Aug-99	Tehama	Sacramento R.	Bend	401432N	1221248W	F	Ad	Post-lact.	40.95	NA	Net Capt
24-Aug-99	Tehama	Sacramento R.	Bend	401432N	1221248W	F	Juv	Nulliparous	38.17	NA	Net Capt

Table 5. Maximum number of red bat sequences obtained in any 20 min period at five localites (11 sampling stations) in the summer and the fall.

LOCALITY	SUMMER	FALL
Bend, Tehama County		
River Edge	11	17
Orchard Edge	8	2
Colusa Sacramento RA, Colusa County		
River Edge	5	15
50 m from River	12	0
500 m from River	35	2
Knight's Ferry, Stanislaus County		
River Edge	7	1
Cottonwood Edge	0	1
Red Bluff Lake, Tehama County		
River Edge	18	1
Sycamore Edge	8	2
SR59 at Merced River, Merced County		
River Edge - Grass	2	1
Rever Edge -Cottonwood	16	1
TOTALS	**122**	**43**

Table 6. Records for *L. blossevillii* in California at elevations greater than 1,000 m. An asterisk (*) indicates the locality is within Yosemite National Park.

LOCALITY	COUNTY	LAT	LONG	ELEVATION (M)	RECORD TYPE	DATE	SOURCE
PRIOR TO 1998							
Dudley	Mariposa			1,052	1 Male	25 JUL 33	MVZ71612
Miller Canyon	Monterey			1,220	1 Male	15 JUL 36	MVZ108029
Laguna Meadow	San Diego			1,643	1 Male	31 JUL 96	K.Miner, pers. comm.
POST 1998							
Hetch Hetchy*	Tuolumne	N37.9597	W119.7768	1,163	Acoustic	17 SEP 98	This Study
Wawona*	Mariposa	N37.5388	W119.6597	1,223	2 Males, 1 Female	16 SEP 98	This Study
Mirror Lake*	Mariposa	N37.7487	W119.5497	1,248	Acoustic	18 SEP 98	This Study
Carlon Meadow*	Tuolumne	N37.4843	W119.5137	1,329	Acoustic	12 JUL 99	This Study
Yosemite Creek at Tioga Road	Mariposa	N37.5124	W119.3435	2,281	Acoustic	17 SEP 99	This Study
Siesta Lake*	Tuolumne	N37.8505	W119.6599	2,434	Acoustic	03 AUG 98	This Study
Tenaya Lake*	Mariposa	N37.4951	W119.2730	2,484	Acoustic	16 JUN 99	This Study

Table 7. Maximum number of acoustic records obtained by a single detector for *L. blossevillii* along an altitudinal gradient in the Sierra Nevada between April and October, 1999. Each site was monitored with one to three detectors for a minimum of 4 hr. Sites marked with an asterisk (*) are located within Yosemite National Park.

Sites	Drainage	Elev. (m)	Lat	Long	APR	MAY	JUN	JUL	AUG	SEP	OCT
Knight's Ferry[a]	Stanislaus	60	374911N	1204016W	2	na	2	11	12	5	1
SR59 Crossing	Merced	62	372937N	1203007W	na	6	na	30	na	4	na
Moccasin Creek	Tuolumne	259	374836N	1201756W	na	na	1	0	0	5	0
Lumsden Bridge	Tuolumne	451	375083N	1200176W	0	na	0	0	0	0	0
Big Creek	Tuolumne	859	374915N	1200895W	0	na	0	0	0	1	0
SR120 Crossing	Tuolumne	1,134	374935N	1195515W	0	na	0	0	0	0	0
Carlon Meadow*	Tuolumne	1,329	374843N	1195137W	0	na	0	4	62	26	0
Yosemite Creek*	Merced	2,281	375124N	1193435W	na	na	0	0	0	1	0
Tenaya Lake*	Merced	2,482	374951N	1192730W	na	na	2	0	0	0	0
Tuolumne Meadow*	Tuolumne	2,614	375254N	1192103W	na	na	0	0	0	0	0
Dana Meadows*	Tuolumne	2,932	375349N	1191556W	na	na	0	0	0	0	0
Tioga Pass Lake*	Tuolumne	3,017	375528N	1191523W	na	na	0	0	0	0	0

[a] July sample collected in 1998

Table 8. Number of Anabat sequences obtained during 4 hour sampling periods at varying distances from a stand of black cottonwood, *Populus trichocarpa* , at Carlon Meadow, Yosemite National Park, located at 1,316 m, adjacent to the South Fork of the Tuolumne River.

DATE	1 M	100 M	200 M	6 KM
13 SEP 1998	ND	ND	1	0
12 JUL 1999	4	1	ND	0
12 AUG 1999	62	0	ND	0
15 SEP1999	24	2	ND	0
20 OCT 1999	0	0	ND	0

Table 9. Documented roost sites or habitat associations for *L. blossevillii* in non-native vegetation.

PLANT SPECIES		SOURCE
EXOTICS AND ORNAMENTALS		
African hemp	*Sparmannia africana*	Orr, 1950; This Study
Chinaberry	*Melia azedarach*	Constantine, 1959
Eucalyptus	*Eucalyptus spp.*	This Study
Mulberry	*Morus rubra*	Grinnell, 1918
Tamarisk	*Tamarix spp.*	Dalquest, 1945
ORCHARDS		
Almond	*Prunus amygdalus*	This Study
Apricot	*Prunus armeniaca*	Constantine, 1959; This Study
Fig	*Ficus carica*	Constantine, 1959; Hargrave, 1944;This Study
Orange	*Citrus sinensis*	Constantine, 1959; Grinnell, 1918
Peach	*Prunus persica*	Benson, 1945; Cahalane, 1939; Grinnell, 1918
Pear	*Pyrus communis*	Constantine, 1961
Walnut	*Juglans regia*	Hoffmeister, 1986; This Study

Appendix I. List of all sampling localites and dates, alphabetical by county and locality. Habitat type is provided for each locality as CTSY (= cottonwood/sycamore), EXOT (= exotic), GRSS (= grassland), GRVL (= gravel bar), MIXD (= mixed deciduous/conifer), VYOK (= valley oak). Habitat quality is ranked as A,B,C, or D (see text p. 4 for explanation).

COUNTY	GENERAL LOCALITY	SPECIFIC LOCALITY	LATITUDE	LONGITUDE	HABITAT TYPE	HABITAT QUALITY	DATES SAMPLED
Butte	Bidwell-Sacramento River State Park	Carpark	39.72806	121.94500	CTSY	A	21-Sep-99
		Cottonwood Clearing	39.70716	121.94269	CTSY	A	21-Sep-99
		Cottonwoods along Road	39.70672	121.94130	CTSY	A	21-Sep-99
		Grass slope at river edge	39.71210	121.94335	GRSS	D	21-Sep-99
		Gravel Bar, middle	39.70384	121.94180	GRVL	D	21-Sep-99
		Gravel Bar, northern end	39.70594	121.94307	CTSY	A	21-Sep-99
		Gravel Bar, southern end	39.70184	121.94041	GRVL	D	21-Sep-99
		Gravel Bar, southern end	39.70184	121.94041	GRVL	D	23-Sep-99
		Indian Fish Picnic Area	39.72955	121.94459	VYOK	A	21-Sep-99
		River Edge, in Cottonwoods	39.70824	121.94402	CTSY	A	21-Sep-99
		Slough Edge	39.72921	121.94516	VYOK	A	21-Sep-99
Colusa	Colusa, a few km south	Levee along Sacramento River	39.21058	121.98712	CTSY	C	22-Sep-99
	Colusa-Sacramento River State Recreation Area	SRA - 20m Back	39.22421	121.00672	CTSY	A	26-Aug-99
			39.22421	121.00672	CTSY	A	22-Sep-99
		SRA - 50m Back	39.22377	121.00711	CTSY	A	26-Aug-99
		SRA - 200m Back	39.22314	122.00848	CTSY	A	22-Sep-99
		SRA - 500m Back	39.22111	122.01306	CTSY	A	26-Aug-99
		SRA - River Edge	39.22314	122.00591	CTSY	A	22-Sep-99
		SRA River Edge Bluff	39.22221	122.00559	CTSY	A	26-Aug-99
	Sutter County Line	Levee along River	39.19194	121.93833	CTSY	B	22-Sep-99
Fresno	Firebaugh	San Joaquin River, W bank	36.85889	120.45500	CTSY	A	07-Jul-99
Merced	C.J. Hatfield State Recreation Area	Picnic area with old sycamores	37.35778	120.95944	CTSY	A	08-Jul-99
		River edge	37.35736	120.95759	CTSY	A	08-Jul-99
	Mendota Wildlife Refuge	San Joaquin River edge	36.73278	120.34139	GRSS	D	07-Jul-99
	SR 59 Bridge over Merced River	1 km downstream	37.49361	120.50194	CTSY	B	19-May-99
			37.49361	120.50194	CTSY	B	06-Jul-99
			37.49361	120.50194	CTSY	B	27-Sep-99
		1 km upstream	37.47587	120.49460	GRSS	D	19-May-99
			37.47587	120.49460	GRSS	D	06-Jul-99
			37.47587	120.49460	GRSS	D	27-Sep-99
		Bluff above road, downstream	37.46938	120.50461	CTSY	B	27-Sep-99
Sacramento	Brannan State Recreation Area	Camping area	38.11114	121.69313	EXOT	C	24-Sep-99
		River edge	38.14667	121.64694	GRSS	D	24-Sep-99
		Shrubs	38.11256	121.69307	EXOT	C	24-Sep-99
		Sycamores, young stand	38.11534	121.69399	CTSY	C	24-Sep-99
	Iselton, Grand Island	Parking	38.23556	121.57806	GRSS	D	26-Jul-99
		Rock Levee	38.23437	121.55855	GRSS	D	26-Jul-99
		Willow/cottonwood	38.23103	121.56138	CTSY	B	26-Jul-99
Solano	Grizzly Island	near CDFG Headquarters	38.15139	121.97167	EXOT	C	31-Aug-99
Sutter	Colusa County Line, just South	River Road, grass slope	39.21111	121.99472	GRSS	D	22-Sep-99

COUNTY	GENERAL LOCALITY	SPECIFIC LOCALITY	LATITUDE	LONGITUDE	HABITAT TYPE	HABITAT QUALITY	DATES SAMPLED
Stanislaus	Knight's Ferry	Cottonwood Grove	37.81972	120.67111	CTSY	B	03-Jul-98
	Stanislaus River		37.81972	120.67111	CTSY	B	17-Jun-99
	Park		37.81972	120.67111	CTSY	B	15-Aug-99
			37.81972	120.67111	CTSY	B	16-Sep-99
		Floodplain	37.82013	120.66189	CTSY	B	29-Apr-99
		HC Platform, River edge	37.81998	120.66121	CTSY	B	15-Aug-99
			37.81998	120.66121	CTSY	B	16-Sep-99
		Picnic Area	37.81974	120.66232	CTSY	B	03-Jul-98
			37.81974	120.66232	CTSY	B	15-Sep-98
			37.81974	120.66232	CTSY	B	29-Apr-99
			37.81974	120.66232	CTSY	B	17-Jun-99
			37.81974	120.66232	CTSY	B	18-Jun-99
Tehama	Antelope Creek	At Creek	40.16194	122.13306	CTSY	A	22-Sep-99
	at Cone Cove	Parking area	40.16895	121.13299	VYOK	B	22-Sep-99
	Road						
	Bend	Orchard-riparian interface	40.25136	122.22237	CTSY	A	24-Aug-99
			40.25136	122.22237	CTSY	A	20-Sep-99
		Riparian	40.25134	122.2237	CTSY	A	24-Aug-99
			40.25134	122.2237	CTSY	A	20-Sep-99
	Dye Creek	Base of cliffs, up canyon	40.02017	122.01649	GRSS	D	25-Aug-99
	Reserve, Nature	On creek, below ranch	40.10861	122.01861	CTSY	B	25-Aug-99
	Conservancy	Canyon mouth	40.02301	122.01554	CTSY	C	25-Aug-99
		Mid-canyon	40.05460	122.01376	CTSY	C	25-Aug-99
	Red Bluff Lake	Picnic area	40.15639	121.20454	CTSY	B	22-Aug-99
		River edge, grass	40.15903	121.20849	GRSS	D	19-Sep-99
		River edge, forested	40.15917	122.20583	CTSY	B	22-Aug-99
					CTSY	B	19-Sep-99
		Snag at river edge	40.15409	121.10894	CTSY	B	22-Aug-99
					CTSY	B	19-Sep-99
		Streetlight in parking area	40.15624	121.30359	CTSY	B	22-Aug-99
					CTSY	B	19-Sep-99
		Sycamore clearing	40.15414	121.19760	CTSY	B	22-Aug-99
					CTSY	B	19-Sep-99
		Sycamores in parking area	40.15478	121.19913	CTSY	B	19-Sep-99
		Sycamores, young stand	40.15839	121.20658	CTSY	C	19-Sep-99
		Valley oak	40.15874	121.20709	VYOK	C	19-Sep-99
	Woodson Bridge	Gravel Bar North of Bridge	39.91064	122.09134	GRVL	D	23-Sep-99
		Picnic Area	39.91049	122.08988	VYOK	A	20-Sep-99
		Line of Oaks	39.91147	122.09032	VYOK	A	20-Sep-99
		Sacramento River, edge	39.91269	122.09172	VYOK	A	20-Sep-99
Tuolumne	Yosemite	Meadow	37.81194	119.86028	CTSY	A	14-Jun-99
	National Park,		37.81194	119.86028	CTSY	A	15-Jun-99
	Carlon Day Use		37.81194	119.86028	CTSY	A	12-Jul-99
			37.81194	119.86028	CTSY	A	12-Aug-99
			37.81194	119.86028	CTSY	A	13-Aug-99
			37.81194	119.86028	CTSY	A	13-Aug-99
			37.81194	119.86028	CTSY	A	13-Aug-99
			37.81194	119.86028	CTSY	A	15-Sep-99
		River Edge, East	37.81333	119.85961	MIXD	A	15-Jun-99
			37.81333	119.85961	MIXD	A	12-Jul-99
			37.81333	119.85961	MIXD	A	13-Aug-99
			37.81333	119.85961	MIXD	A	15-Sep-99

COUNTY	GENERAL LOCALITY	SPECIFIC LOCALITY	LATITUDE	LONGITUDE	HABITAT TYPE	HABITAT QUALITY	DATES SAMPLED
Yolo	Knight's Landin[g]	10m North SR 45	38.80571	121.72297	CTSY	B	27-Aug-99
		60m North SR 45	38.80585	121.72297	CTSY	B	27-Aug-99
		200m North SR 45	38.80709	212.72297	CTSY	B	27-Aug-99