CHAPTER 10
BATS

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ABSTRACT

This chapter presents the methods and results of a literature review and discussions with experts regarding the occurrences and ecology of bats within the eastern Merced County study area. No field surveys were conducted as part of this study. However, the authors also relied on their own knowledge based on their recently conducted bat surveys for other projects within the study area.

Seventeen bat species have potential to occur in eastern Merced County. Nine species have been documented by either museum records and/or recent field surveys. Another four species are likely to occur; and another four are possible. Roosting habitat for bats is relatively limited in the grassland habitat of eastern Merced County. Natural roost sites occur in rock outcrops, bluffs, caves, mature trees, orchards, and swallow nests. Anthropogenic roosts occur in buildings (in both rural and more developed areas) and bridges. Recent surveys documented foraging by bats along Bear Creek and the Merced River.

Species accounts are provided for ten species of bats known to occur or likely to occur in the study area, based on known records, plus a summary of their roosting and foraging requirements. In general, available information on bats in the study area is limited and more information is needed on seasonal distribution and habitat associations (e.g., the extent to which they use grasslands, agricultural areas, cottonwood riparian and vernal pools).

10.1 INTRODUCTION

The primary purpose of the study was to identify those bat species likely to occur in the study area and to describe their distribution, life history and habitat requirements as currently understood from the scientific literature and the author's recent work. Information from this study will be used to inform regional conservation planning for the long-term conservation of the bats in the study area. Since no field surveys were conducted for this study and information from past studies is limited, this summary should be regarded as a "first step" in understanding the occurrence and ecology of bats in the study area.

10.2 BACKGROUND INFORMATION

10.2.1 Target Species

There are 25 bat species known to occur in California (Barbour and Davis 1969; Constantine 1998). A number of these species have distributions primarily in Mexico, and their ranges within California are confined to areas south of the Transverse Ranges at the southern end of the Central Valley. There are records for 15 species in the Central Valley, most of which could occur in the study area.

Seventeen bat species potentially occur in the study area (Table 10.1). Of these, nine species are known to occur in the study area through identification in past studies and museum records.

10.2.2 Primary References

The work of Barbour and Davis (1969) is out of date, but provides the best summary of the distribution and natural history of North American bat species. Also, the species accounts in the publication, Mammalian Species by the American Society of Mammalogists, are available for many of the bats that occur in eastern Merced County. Reviews of bat roosting and foraging ecology can be found in Kunz (1982a), Hill and Smith (1984), Fenton (1983), and Kunz and Pierson (1994). The only recent field studies that specifically address the study area are Pierson (2000) and Pierson et al. (2000).

10.2.3 Bat Roosting Ecology

North American bats use a wide variety of roost sites, which fall into three general categories: crevices, cavities, and foliage (Barbour and Davis 1969; Kunz 1982b; Pierson 1998). In natural settings, cavity roosting species aggregate on open surfaces inside dark chambers, such as caves or large tree hollows; crevice roosting species occupy a variety of narrow "slots," such as rock crevices, exfoliating tree bark, and damaged wood in snags. While some species appear to be obligate dwellers of cavities or crevices, there is a continuum between crevices and cavities, and many species use a range of roosts. Foliage-roosting species, which are non-colonial, generally hang from petioles on the undersides of large, overhanging leaves, often at canopy level. With the exception of a few foliage-

Table 10.1. Bat species known to occur or with potential to occur in the eastern Merced County regional study area, CA.

COMMON AND SCIENTIFIC NAME	STATUS[1]	REFERENCES[2]
Known to Occur:		
Family Molossidae (free-tailed bats)		
Western mastiff bat *Eumops perotis*	MSSC, SC	MVZ; Pierson 2000
Mexican free-tailed bat *Tadarida brasiliensis*	none	CSUH; MVZ; Pierson 2000
Family Vespertilionidae (mouse-eared bats)		
Pallid bat *Antrozous pallidus*	FSS, MSSC	MVZ; Pierson 2000
Big brown bat *Eptesicus fuscus*	none	MVZ; Pierson 2000
Red bat *Lasiurus blossevillii*	FSS, MSSC*	MVZ; Pierson 2000; Pierson et al. 2000
Hoary bat *Lasiurus cinereus*	none	CAS; MVZ; Pierson 2000
California myotis *Myotis californicus*	none	CSUH; Pierson 2000
Yuma myotis *Myotis yumanensis*	SC	MVZ; Pierson 2000
Western pipistrelle *Pipistrellus hesperus*	none	Pierson 2000
Likely to Occur:		
Family Vespertilionidae (mouse-eared bats)		
Townsend's big-eared bat *Corynorhinus townsendii*	FSS, MSSC, SC	AMNH; MVZ; Pierson et al. 2001
Silver-haired bat *Lasionycteris noctivagans*	none	Pierson et al. 2001
Small-footed myotis *Myotis ciliolabrum*	SC	MVZ; Dalquest 1946; Pierson et al. 2001
Long-legged myotis *Myotis volans*	MSSC*, SC	MVZ; Pierson et al. 2001
Might Occur:		
Family Molossidae (free-tailed bats)		
Big free-tailed bat *Nyctinomops macrotis*	MSSC, SC	Constantine 1998
Family Vespertilionidae (mouse-eared bats)		
Spotted bat *Euderma maculatum*	MSSC, SC	Pierson and Rainey 1998c
Western yellow bat *Lasiurus xanthinus*	MSSC*	D. F. Williams personal communication
Fringed myotis *Myotis thysanodes*	MSSC*, SC	Dalquest 1946

NOTES:
1. FSS = Forest Service Sensitive; MSSC = California Department of Fish and Game (CDFG) Mammal Species of Special Concern; MSSC* = Proposed as CDFG Mammal Species of Special Concern; SC = U.S. Fish and Wildlife Service Special Concern
2. AMNH = American Museum of Natural History; CAS = California Academy of Sciences; CSUH = California State University at Humboldt; MVZ = Museum of Vertebrate Zoology.

roosting species, all North American bat species will also roost in cave-like spaces and/or crevices in man-made structures, such as old mine workings, tunnels, buildings, and bridges.

During the summer months, bats of many species will occupy one site during the day (day roost) and one or more at night (night roosts). Day roosts are generally selected for low disturbance, protection from predators, and warmth (temperatures in maternity roosts often exceed 37°C). Night roosts are sites, usually near foraging areas, at which bats rest (often in aggregations) between foraging episodes. In night roosts, they can process large insect prey, feed dependent young, and engage in social interactions. While night roosts usually offer protection from wind and/or rain, and are somewhat buffered against temperature fluctuations, they are often in more exposed settings than day roosts.

During the late spring through the early fall, the most demographically significant roosts are those used by breeding females to raise young (nursery/maternity roosts). Colony size varies widely between and within species. Some, like the foliage roosting red bat, do not appear to form colonies, and single females are generally found only in association with their young. Some of the species most commonly found in association with human structures, particularly in the agricultural areas of the Central Valley, can form colonies of 100 to more than 1,000 (e.g., the Mexican free-tailed bat and Yuma myotis). Natural features and human-made structures can also serve as day roosts for males or non-reproductive females during the summer, as temporary aggregation sites for migrating animals in the spring and fall, and as refuges for both hibernating and non-hibernating species in the winter.

Overwintering behavior is poorly understood for most bat species in California. Some species or populations engage in extended hibernation (Barbour and Davis 1969; Marcot 1984; Pearson et al. 1952; Pierson and Rainey 1996a), and can move up in elevation to find suitably stable, low temperatures (Sherwin et al. 2000; Szewczak et al. 1998; W.E. Rainey and E.D. Pierson unpublished data). Others are capable of hibernation, but overwinter in more moderate climates (e.g., the Central Valley). There, they will use torpor during cold periods, and rouse from torpor to feed on warm nights. Still other species do not hibernate, and rely on overwintering in areas with primarily non-freezing temperatures. Recent acoustic monitoring at fixed stations, including Point Reyes National Seashore (Fellers and Corben 2001) and at 4,000 feet elevation in Yosemite National Park (W.E. Rainey unpublished data), has shown nearly year-round activity by a number of species.

10.2.4 Bat Foraging Ecology

All the bat species expected to occur in the study area are predominantly insectivorous (with a few also consuming other arthropods, such as scorpions and spiders). While bat species show some specialization for particular foraging styles and habitats, they also will opportunistically exploit locally abundant prey (Fenton 1982; Whitaker 1994). A diet study along the upper Sacramento River and a nearby control drainage showed that, while there were marked differences between species in average diet composition, when there was a large hatch of a particular insect (e.g., winged termites or caddisflies) many species took advantage of that resource (Rainey and Pierson 1996).

Nevertheless, species are distributed between foraging habitats in ways that can be partially predicted from wing size and shape (which constrain flight speed and maneuverability). Some species (e.g., Yuma myotis) feed largely on emergent aquatic insects by skimming near the surface of still or slowly moving water; others typically feed higher over the water. Some forage primarily along the water's edge in association with riparian vegetation, often taking insects from plant surfaces. Others are concentrated at canopy height. Still others are most frequently found away from the water (e.g., in meadows, over agricultural fields, or in association with forest trees). Recent studies in Canada (Grindal et al. 1999) and the Sierra Nevada (Pierson et al. 2001) are consistent with earlier work in finding that bat foraging activity is concentrated over water. Nevertheless, some of the species likely to be of greatest ecological significance in the study area frequently forage over grasslands, agricultural fields, or in oak savanna (e.g., pallid bat, western mastiff bat, and Mexican free-tailed bat). The extent to which bats might exploit insects associated with vernal pools has not been investigated.

10.2.5 Project Management and Review

Dr. Elizabeth Pierson and Dr. William Rainey conducted the literature reviews and writing for this chapter. They were also involved in most of the bat surveys that have been conducted in the study area in past years. Dr. Daniel Williams (pers. comm.) provided editorial review of the draft chapter.

10.3 METHODS

To examine background information on the recent and historic distribution of bat species in the project area and surrounding regions, records were reviewed in reports and published literature (Constantine 1998; Grinnell 1918; Grinnell and Storer 1924; Hall 1981; Pierson 2000; Pierson et al. 2001) and from 35 museum collections across the United States and Canada. Specimens from Merced County were found in collections at the American Museum of Natural History (AMNH); California Academy of Sciences (CAS), California State University at Humboldt (CSUH), and Museum of Vertebrate Zoology (MVZ).

No field surveys of bats were conducted for this study. The suitability of natural roosting habitat in rock features (Ione and Spring Valley formations) was assessed from photographs (provided by J. Vollmar) and one brief reconnaissance of Ione Formation exposures on the Nelson Ranch (viewing the sandstone outcrops with binoculars from ranch roads at a distance of several hundred meters).

10.4 RESULTS

10.4.1 Species Diversity in the Study Area

A list of bat species known or expected to occur in the study area is provided in Table 10.1. Records are available from museum collections for eight species. Those eight, plus one additional species were identified in two studies conducted in the area in 1999: (a) a survey funded by the California Department of Transportation (CalTrans) in association with the proposed replacement of the S.R. 59 bridge over the Merced River southwest of Snelling (Pierson 2000); and (b) a statewide status survey for the red bat, funded by the California Department of Fish and Game (CDFG), which included survey sites in eastern Merced County (Pierson et al. 2000). Four of the nine species have special status with the CDFG, U.S. Forest Service, and/or the U.S. Fish and Wildlife Service (USFWS).

There are three bat species not covered by the species accounts below that likely occur in eastern Merced County, at least seasonally (Table 10.1). Acoustic surveys conducted as part of the S.R. 59 study (Pierson 2000) repeatedly recorded bats that were echolocating at 40 kilohertz. Review of these calls indicated that individuals belonged to one or more of three *Myotis* species: *M. ciliolabrum*, *M. lucifugus*, or *M. volans*. These taxa cannot currently be distinguished based on call characteristics alone. There are, however, records from the Central Valley and its margins for both *M. ciliolabrum* and *M. volans*, making it likely that both occur in the area. The silver-haired bat, *Lasionycteris noctivagans*, a tree-dwelling species that is thought to rear young farther north, probably migrates through the study area in the spring and/or the fall.

There are also four bat species that might occur either seasonally or in low numbers in eastern Merced County (Table 10.1). There is one record for the spotted bat, *Euderma maculatum*, a cliff dwelling species, from Table Mountain near Friant Dam (Fresno County), and multiple records from Yosemite National Park (Pierson and Rainey 1998c). This species is generally associated with substantial rock features, and is thought to roost high on cliff faces. None of the rock features in the project area (as seen in photographic records) is as extensive as the typical rock features for this species. However, the roosting ecology of this species is poorly understood, and records are widespread, though scattered, in western North America. Thus its presence in the study area cannot be ruled out.

There are records of the fringed myotis, *Myotis thysanodes*, from the 1940s through the 1970s from three localities along the western edge of the Central Valley in Fresno County (CAS, MVZ) and records from multiple localities in the Sierra foothills between 1,000 and 2,000 meters (3,280 and 6,562 feet) elevation. Surveys conducted along the Route 120 corridor suggested that this species is highly associated with forested habitat in the Sierra Nevada, and appears to be found predominantly at mid-elevations (Pierson et al. 2001). Thus it might not occur in eastern Merced County.

The western yellow bat, *Lasiurus xanthinus*, a foliage roosting species highly associated with palm oases (Barbour and Davis 1969; Constantine 1946), has a primarily Mexican distribution, and until recently was thought to reach the limits of its range in southern California (Hall 1981). More recent records document a northward extension of its range, likely associated with the planting of ornamental palms (Constantine 1998; Spencer at al. 1988). Acoustic records possibly attributable to this species have been obtained from northwest of Merced in Turlock (Williams pers. comm.). Thus this species potentially occurs in eastern Merced County.

The big free-tailed bat, *Nyctinomops macrotis*, appears to be rare in California, with the majority of records concentrated in southern California (primarily Los Angeles, Orange and San Diego counties) (Constantine 1998). There are, however, scattered records as far north as the San Francisco Bay area. While there are no records for the Central Valley, this species is known to fly long distances, and new records have often appeared in areas thought to be out of range (e.g., South Dakota and British Columbia).

10.4.2 Species Accounts

Pallid Bat
Antrozous pallidus

The pallid bat is a state and federal special-status species (Table 10.1, CDFG - MSSC; FSS). There are 20 museum records for pallid bats from the study area (MVZ), all taken on the same day (May 26, 1915) in Snelling. The date and gender composition of the series (19 females, one male) strongly suggests collection from a nursery roost. Also, pallid bats were identified in Merced County in the S.R. 59 study and found roosting in several bridges in the study area (Pierson 2000). They were also identified acoustically along the Merced River near the S.R. 59 bridge, and upstream at the Robinson Ranch.

This species is broadly distributed in California, and found in a number of habitats from sea level to over 2,000 meters (6,562 feet) elevation in the central Sierra Nevada. It will utilize a variety of roosting sites. Although better known from anthropogenic structures (buildings and bridges), it also roosts in caves, rock crevices, and tree hollows. At lower elevations it is strongly associated with oak savanna habitat. Colony size is typically 50-300 (Barbour and Davis 1969; Hermanson and O'Shea 1983; Lewis 1994; Orr 1954; Pierson et al. 1996; Vaughan and O'Shea 1976). It feeds primarily on large ground dwelling arthropods (e.g., scorpions and Jerusalem crickets), but also takes large flying insects (e.g., long-horned beetles and katydids). It has been observed in the Napa Valley feeding on tomato hornworm (*Manduca quinquemaculata*) caterpillars in gardens, suggesting it can take other large insect larvae (Winters pers. comm.).

Radio-tracking in the upper Sacramento River drainage (Rainey and Pierson 1996) indicated that this species forages along river channels, but within a very broad riparian zone (primarily upslope from the river). A radio-tracking study in oak savanna in Santa Barbara County documented this species roosting predominantly in ranch buildings, plus solution cavities, crevices, and caves in sandstone outcrops. They foraged along dry streambeds and in oak savanna (E.D. Pierson unpublished data).

In the study area, suitable roosting habitat could be found in rock outcrops (particularly the solution cavities found in the Valley Springs formation), oaks, and ranch buildings. Foraging could occur along riparian corridors, over grasslands and possibly in agricultural areas. Pallid bats have also been captured while drinking at stock ponds (E.D. Pierson unpublished data).

Townsend's Big-eared Bat
Corynorhinus townsendii

Townsend's big-eared bat is a state and federal special-status species (Table 10.1, CDFG - MSSC; FSS; USFWS - SC). There are no museum records for this species from Merced County, although this species has been found at comparable elevations to the north (e.g., along the Stanislaus River near Oakdale [Pierson et al. 2001]), and to the south (e.g., near Porterville [AMNH]). Also, there are records from near Groveland and La Grange in Stanislaus County (MVZ), from mines near Cathay's Valley (MVZ) and in the Sierra National Forest (Pierson and Fellers 1998), and at several localities at lower elevations within Yosemite National Park (Pierson et al. 2001), all in Mariposa County.

Townsend's big-eared bat is widely distributed in California, with records from the margins of the Central Valley to all elevations in the Coast Ranges,

and moderately high elevations in the Sierra Nevada. Maternity roosts appear to be confined to elevations below about 1,800 m (5,905 feet) (Pierson and Fellers 1998).

Townsend's big-eared bat is an obligate cavity-dwelling species that is highly reliant on caves and abandoned mines for its maternity roosts. Roosts are also found in human-made structures with cave-like spaces (e.g., dark, unused attics or, rarely, bridges with large dark cavities). Individual males, while also roosting in caves and mines, can often be found roosting in rock shelters and small cavities in bridges (Barbour and Davis 1969; Graham 1966; Kunz and Martin 1982; Pierson and Fellers 1998; Pierson et al. 2001). Maternity colonies are typically 25-300 adult females. Radio-tracking studies in coastal California suggest that this species forages along vegetated creek drainages, and in forested areas (Fellers and Pierson in press). Several diet studies have indicated that this species typically feeds largely on moths.

In the study area, roosting habitat for this species appears to be limited. The most suitable natural roosting habitat occurs in the caves (as seen in photographs and described to the authors by J. Vollmar) in the Valley Springs and Ione formations located along a narrow, intermittent band situated near the eastern edge of the study area. If undisturbed, maternity colonies of this species will preferentially roost during part of the maternity cycle within the twilight zone, close to cave openings. Thus they can be found in relatively shallow caves as long as ceiling height is sufficient (generally greater than two meters [seven feet]) to provide protection from terrestrial predators (Pierson et al. 1991). Barn roosts are not uncommon in the coastal zone and could occur in the project area.

Big Brown Bat
Eptesicus fuscus

The big brown bat has no state or federal listing status (Table 10.1). There are five museum records for this species for eastern Merced County, all from one locality (0.8 kilometer [0.5 mile] west of Snelling), taken on August 1, 1968 (MVZ). During the S.R. 59 surveys, it was roosting in a number of bridges in Merced County, and was detected at several localities along the Merced River, particularly in association with cottonwood riparian habitat.

The big brown bat is one of the most widely distributed and commonly detected bat species in a variety of habitats throughout California. It is primarily a crevice roosting species. Common roost sites are trees (particularly snags), old buildings, bridges, rock crevices, caves and mines (Barbour and Davis 1969; Brigham 1991; Kurta and Baker 1990). Big brown bats are colonial, with a typical colony containing 25-75 adults, although colonies up to 700 have been found (Kurta and Baker 1990). Big brown bats are generalists, feeding over both water and land, in forested and edge situations. They often emerge early (prior to dark) and can be seen foraging very high (up to 50 meters [164 feet] above the ground), descending later in the evening to 10-15 meters (33-49 feet) (Whitaker et al. 1977). In some habitats they feed predominantly on beetles (Coleoptera), including such important agricultural pests as scarab beetles (Scarabaeidae), the spotted cucumber beetle (*Diabrotica undecimpunctata*; Chrysomelidae), stinkbugs (Pentatomidae) and leafhoppers (Cicadellidae) (Whitaker 1995). In other localities they can feed primarily on aquatic insects, such as caddisflies (Trichoptera) (Brigham 1991; Verts et al. 1999), and have been known to consume a variety of other insect groups (e..g., Hemiptera, Hymenoptera, Diptera, Plecoptera and a few Lepidoptera). In northern California, radio-tracking and netting data suggest that individuals follow watercourses to forage, often flying above canopy level, and not travelling more than a few kilometers from their roosts. They feed over both open river corridors and in much more cluttered settings beneath the riparian canopy of small streams (E.D. Pierson and W.E. Rainey unpublished data).

In the study area, the most suitable roosting habitat for this species would be found in rock outcrops, bridges and ranch buildings. Foraging would occur primarily along riparian corridors, or in association with stock ponds, and possibly vernal pools.

Western Mastiff Bat
Eumops perotis

The western mastiff bat is a state and federal special-status species (Table 10.1, CDFG - MSSC; USFWS - SC). There is only one museum record for this species from Merced County: from the town of Merced on December 12 ,1991 (Constantine 1998).

This species was also detected along the Merced River, near S.R. 59, on September 27, 1999 (Pierson 2000).

Although most historic records for the western mastiff bat are from southern California and the Los Angeles basin, recent surveys indicate this species occurs widely in the low to mid-elevations on the western slope of the Sierra Nevada (Pierson and Rainey 1996b and 1998a). There are also historic and current records from several sites in the southern Coast Range. This species is associated with cliff habitat, where it roosts preferentially in large, overhanging crevices in colonies of ca. 30-300. There are records of roosting in buildings in the Los Angeles basin; and in crevices of large boulders in San Diego County (Barbour and Davis 1969; Best et al. 1996; Dalquest 1946; Krutzsch 1955; Pierson and Rainey 1996b and 1998a). This is California's largest bat. It is adapted for fast long-distance flight, and forages in the open air over meadows, grasslands, forests and open water. It's diet includes large moths and crickets.

Yosemite National Park, particularly Yosemite Valley, supports an unusually large summer population of western mastiff bats that use the Merced River corridor for foraging. It is highly likely that members of this population move down the Merced River in the fall, and seek overwintering sites at lower elevations along the river (Pierson and Rainey 1996b). Since this species does not hibernate, it needs winter habitat with predominantly non-freezing temperatures.

In the study area, potentially suitable roosting habitat for this species exists in rock outcrops (particularly bluffs), and ranch buildings. Foraging would occur primarily along riparian corridors and over grasslands.

Red Bat
Lasiurus blossevillii

The red bat is a state and federal special-status species (Table 10.1, CDFG -MSSC Proposed; FSS). There are five records for red bats from Merced County, all taken from one locality (Santa Rita Park near Dos Palos) in April 1946 (MVZ). More recent records are also available from several sites near the S.R. 59 bridge over the Merced River (Pierson 2000), from sites both downstream and upstream along the Merced River, e.g., Hatfield State Park near the confluence with the San Joaquin River (Pierson et al. 2000), and both Yosemite Valley and Wawona in Yosemite National Park (Pierson et al. 2001). There are also recent acoustic records for this species from public roads near Bear Creek in eastern Merced County, adjacent to almond, apricot and fig orchards (Pierson et al. 2000).

This species is distributed primarily at lower elevations in California, with breeding females found in association with the cottonwood/sycamore riparian habitat along large river drainages in the Central Valley, and winter populations of both sexes concentrated along the central and southern coast (Pierson et al. 1999). This non-colonial species apparently roosts almost exclusively in foliage, under overhanging leaves. Animals have either been observed roosting or detected acoustically at emergence time in cottonwood/sycamore and willow riparian habitats, and in fruit orchards (Constantine 1959 and 1961; Pierson et al. 2000). A study sponsored by CDFG also showed that summering populations are substantially more abundant in remnant stands of cottonwood/sycamore riparian that extend more than 50 meters (164 feet) back from the river than they are in younger, less extensive stands (Pierson et al. 1999). This species is an open-air forager that feeds primarily on moths, hunting along river/stream corridors, over stock ponds and lakes, and possibly in open forested or grassland habitat.

This species is known to occur in the study area in association with both cottonwood riparian habitat and fruit orchards. The extent to which it feeds on orchard pests is not known.

Hoary Bat
Lasiurus cinereus

The hoary bat has no state or federal listing status (Table 10.1). There are four museum records for the hoary bat from Merced County, one from Planada (CAS), one from Snelling (MVZ), and two from vicinity of Dos Palos (MVZ). Acoustic records for this species were also obtained during the S.R. 59 surveys at all sampling localities along the Merced River between the S.R. 59 bridge and the Robinson Ranch (Pierson 2000).

Although this species is found throughout California in a wide variety of habitats, both museum records and more recent netting data suggest that all summer residents are males or non-reproductive females. This species raises its young north and east

of California (southern Canada and the U.S. Great Plains) and is known to undertake long-distance seasonal migrations (Cryan 2001; Findley and Jones 1964), with increased numbers of animals appearing along the California coast in the fall (Dalquest 1943; Tenaza 1966) and in southern California in the winter (Vaughan and Krutzsch 1954). Data obtained recently in the Central Valley and the Sierra foothills (Pierson et al. 2000; Pierson et al. 2001; E.D. Pierson and W.E. Rainey unpublished data) suggest that this species migrates through the Central Valley and adjacent foothills in the spring and the fall. Like the red bat, the hoary bat is a non-colonial foliage-roosting species that feeds primarily on moths. It forages along river and stream corridors, over open bodies of water, and in open forest habitats.

This species is known to occur in the study area in association with cottonwood riparian habitat.

California Myotis
Myotis californicus

The California myotis has no state or federal listing status (Table 10.1). There are two museum records for the species from Merced County (CSUH). This species was detected at multiple sites along the Merced River drainage in surveys conducted for the S.R. 59 bridge project (Pierson 2000).

This species is either non-colonial or forms small colonies (generally fewer than 30 animals). It is widely distributed throughout most of California. It roosts in crevices (rocks, trees, and a variety of human-made structures, including buildings, bridges and abandoned mines) (Barbour and Davis 1969; Brigham et al. 1997; Krutzsch 1954; Simpson 1993). While it is found in a wide variety of habitats at lower elevations on the western slope of the Sierra Nevada, it is often detected foraging around the canopy of oak trees or along riparian corridors in association with cottonwood, sycamore and willow. Diet data suggest that this species is a generalist, and consumes a variety of small insects.

This species is known to occur in the study area in association with cottonwood riparian habitat. Suitable roost sites would be found in rock outcrops, trees, bridges and buildings.

Yuma Myotis
Myotis yumanensis

The Yuma myotis is a federal special-status species (Table 10.1, USFWS - SC). There are only two museum records for the species from Merced County, both from Dos Palos (MVZ). Numerous records were obtained for this species along the Merced River near the S.R. 59 bridge, and roosting animals and colonies were found in multiple bridges throughout the county (Pierson 2000).

The Yuma myotis is widely distributed throughout much of California, being most abundant below 1,500 meters (4,921feet) elevation (Barbour and Davis 1969). Although it is listed as a USFWS Species of Concern (largely due to issues occurring elsewhere in its range), it is one of the most abundant species at lower elevations in California (e.g., Barbour and Davis 1969; Pierson et al. 2000 and 2001). It is one of the species most commonly associated with anthropogenic structures, including barns and bridges, although it will also roost in caves, mines, abandoned swallow nests, and under flaking bark of large snags (Barbour and Davis 1969; Dalquest 1947; Rainey and Pierson 1996). It forms maternity colonies of several hundred to several thousand animals. In California, this species forages primarily on emergent aquatic insects over relatively calm water (reservoirs, ponds, or slowly flowing reaches and pools of rivers and streams). However, it is also known to forage over fields, and some diet samples from orchard roosts are composed largely of moth remains (Brigham et al. 1992; Rainey and Pierson 1996).

Within the study area, this species is known to have nursery colonies and it is also one of the species most likely to be found roosting in ranch buildings. This species could roost in rock outcrops in the study area.

Western Pipistrelle
Pipistrellus hesperus

The western pipistrelle has no state or federal listing status (Table 10.1). There are no museum records for this species from Merced County. This species was, however, detected acoustically in 1999 along the Merced River, 2.3 kilometers (1.4 miles) upstream from the S.R. 59 bridge and at the Robinson Ranch (Pierson 2000).

This species, which roosts almost exclusively in cliffs or rock outcrops, is generally regarded as a bat of desert canyons (Barbour and Davis 1969). Yet it is locally common in river canyons along the western slope of the Sierra Nevada, and occurs as far north as Shasta and Siskiyou counties (Constantine 1982; Pierson and Rainey 1998b; Rainey and Pierson 1996). It is thought to be non-colonial, with each female giving birth to twins. It forages in the open air on a variety of small insects.

Suitable roosting habitat for this species in the study area would be found in rock outcrops, particularly in the Valley Springs bluffs located along the Merced River corridor (e.g., bluffs on the Chance Ranch).

Mexican Free-tailed Bat
Tadarida brasiliensis

The Mexican free-tailed bat has no state or federal listing status (Table 10.1). There are 40 museum records for this species from Merced County, 17 from a locality west of Snelling (MVZ), 18 from Los Banos (MVZ), and the remainder from several localities from Newman to La Grange (CSUH, MVZ). This species was detected at multiple localities in eastern Merced County during surveys for the S.R. 59 bridge project — in multiple bridges, along the Merced River, over grasslands and agricultural lands, and around streetlights in the city of Merced (Pierson 2000; E.D. Pierson unpublished data).

Mexican free-tailed bats are crevice or cavity dwellers, and can fit in cracks smaller than 2.5 centimeters (one inch) wide. While this species roosts in a number of natural features (rock crevices, caves, and abandoned swallow nests), it is also the species most often found in human-made structures (e.g., ranch buildings and bridges) in California (Barbour and Davis 1969; Wilkins 1989). Colonies also appear to be more mobile than many bat species, apparently displaying less loyalty to particular roost sites, with the exception of major maternity sites that are occupied year to year. Mexican free-tailed bats form colonies of up to 20 million in some caves in Texas; but in California, with the exception of one population of about 250,000 (in a lava cave in northern California), most colonies in California range in size from a few hundred to a few thousand. Free-tailed bats can tolerate torpor during cold weather, but do not hibernate. They occupy roosts year round in the Central Valley at least as far north as Redding (Johnston 1998; E.D. Pierson and W.E. Rainey unpublished data).

Although some populations of Mexican free-tailed bats migrate large distances (e.g., Texas populations overwinter in Mexico), seasonal movement patterns and population structure within California are poorly understood. While numbers decrease in the Central Valley and increase in the San Francisco Bay Area and elsewhere along the coast in the winter, it is not known whether the animals that overwinter in the Valley are a subset of the summer population or belong to populations that summer elsewhere. It is also possible that the Central Valley serves as a migratory corridor for populations that raise their young farther north (e.g., in the volcanic landscapes of Lassen, Modoc and Shasta counties).

Mexican free-tailed bats are aerial foragers, and feed on a wide variety of flying insects (Whitaker et al. 1996). This is the species most likely to include a variety of agricultural pests in it's diet. Studies conducted in Texas have shown this species to be a significant predator on the corn earworm moth (*Heliothis zea*) (McCracken 1996), with the bats intercepting mass migrations of moths as they are carried from northern Mexico into Texas on northward flowing thermal currents several hundred meters above the ground. A study conducted in Yolo County indicated a correlation between activity patterns of codling moths (*Cydia pomonella* L.) and bats, with increasing numbers of moth scales occurring in the guano of Mexican free-tailed bats at the same time that increasing numbers of codling moths were captured in traps (Hogan 2000). Year-round diet studies conducted at Lemoore Naval Air Station showed that this species foraged primarily over cotton fields and other agricultural areas, and included flies, moths, true bugs (mostly plant hoppers) and beetles in their diet (Johnston 1998). Although this species is generally thought to forage at considerable height above the ground, both direct observations and diet studies in the Central Valley suggest that they can also be taking insects from close to water surfaces. D. Johnston (pers. comm.) has identified aquatic taxa in the diet of Mexican free-tailed bats: midges and/or mosquitoes (Chaoboridae and/or Culicidae) in the spring, and water boatmen (Corixidae) in the fall.

Suitable roosting habitat for this species occurs throughout the study area. It could be found in rock crevices of the Ione and Valley Springs formations. Colonies have been identified within the city of Merced and in several area bridges. This is also the species most likely to be found in ranch buildings in eastern Merced County.

10.5 DISCUSSION

Although the greatest species diversity for bats in central California occurs at somewhat higher elevation (1,000-2,000 meters [3,280-6,561feet]), in the mixed deciduous/coniferous forests and incised river canyons of the Sierra, maternity colonies for many species are concentrated at low elevation (Pierson et al. 2001). This is consistent with findings for other mountain ranges in the west, where it has been shown that reproductive females (and thus maternity colonies) for most species are concentrated at lower elevations, and animals captured at high elevations for many species are predominantly males (Cryan et al. 2000; Storz and Williams 1996). Thus it might be, given the patterns of land ownership in California, that much of the reproduction of bat populations on the western slope of the Sierra occurs on private land.

Available knowledge would suggest that roost sites in natural features are somewhat limited for bats in the open grasslands of eastern Merced County. The landscape features most likely to offer roosting habitat are exposures of resistant rock (Ione and Valley Springs formations) located along the Merced River corridor, and along the eastern county boundary. Rock crevices, solution cavities and caves could be used by up to 13 of the species that might occur in the area. Other potential roosts exist in numerous human-made structures in the area, particularly bridges and ranch buildings. The species most likely to occur in these structures are the pallid bat, the big brown bat, the Yuma myotis and the Mexican free-tailed bat. Tree roosts (flaking bark and bole cavities), available in oak savanna and riparian habitat (e.g., mature cottonwoods, large bole willows and sycamores in the Merced River, Chowchilla River and Bear Creek drainages) could be used by up to seven species. The hoary bat and red bat, both foliage-roosting species, likely find shelter under overhanging foliage and in vine tangles in mature cottonwood and sycamore. The red bat also roosts extensively in orchards. Additional more cryptic, but potentially widespread, diurnal roost sites for bats are swallow nests constructed of mud on natural and artificial surfaces (e.g, Pitts and Scharninghausen 1986; W.E. Rainey and E.D. Pierson unpublished observations) and crevices in semi-consolidated sediments on steep, eroding faces of stream or river banks. Voids in cobble/boulder tailing piles from historic mining can constitute another locally extensive year-round anthropogenic roosting habitat. Deep soil cracks following seasonal drying of vernal pools seem to offer roosting habitat similar to crevice locations occupied as maternity sites by several western species in the Dakota badlands (Barbour and Davis 1969; Tuttle and Heaney 1974).

Foraging habitat exists throughout eastern Merced County. Many bat species forage in association with water, and have been shown to use the Merced River drainage. Bat foraging also occurs along Bear Creek. Drinking and/or foraging also likely occur at stock ponds, vernal pools and other permanent or seasonal water retention sites. A number of species also feed away from water, in association with tree canopies or in the open air above grasslands. It is possible that these organisms provide ecological services of economic consequence due to the facts that some common bat species are known to forage in agricultural areas and smaller bats consume a substantial fraction of their body weight in insects per night (e.g., Whitaker 1995).

10.6 GAPS IN UNDERSTANDING AND RECOMMENDED STUDIES

In many temperate North American relatively natural habitats, bats constitute a large proportion of the potential mammalian species diversity (Pierson 1998). However, traditional neglect of this group in biodiversity inventories, lack of recognized sensitive or protected taxa, and the relatively specialized skills and equipment required for bat surveys propagates our ignorance of the local status and ecologic role of bats (relative to other more tractable and familiar vertebrates) through time. When diversity-oriented reconnaissance bat surveys are conducted with limited resources, efforts are generally concentrated in areas expected (based on prior work) to yield the most taxa per unit of time (e.g., water sources),

and tend to neglect previously unsampled habitats (e.g., grasslands and agricultural areas). Consequently, little is known about either the seasonal or spatial distribution of bat species in relation to the low relief habitats in eastern Merced County.

The opportunistic foraging habits of some common bats and their relative abundance in the Central Valley suggest they can be significant consumers of agricultural pests, but this interaction is still poorly documented. Diet studies are needed in agricultural areas to evaluate seasonally the extent to which various species include agricultural pests in their diet.

Research conducted along the Route 120 corridor suggested that some bat species can concentrate in the Central Valley in the spring and early summer, but abandon these sites, and possibly move upslope in the Sierra Nevada Mountains as habitats at lower elevation dry out (Pierson et al. 2001). Seasonal surveys that include capture efforts would help elucidate the significance of Central Valley habitat in the life cycle of these bat species, including which species are using the Central Valley for spring and/or fall migration, for raising their young, or for overwintering.

Research conducted in prairie habitat in southern Canada has shown that bat activity and species diversity are greater in association with riparian habitat (particularly cottonwoods) compared to grasslands (Holloway 1999, Holloway and Barclay 2000). Preliminary data collected along the Merced River near the S.R. 59 crossing also showed greater bat foraging activity and species diversity in areas with more extensive cottonwood riparian forest (Pierson 2000). More information is needed, however, to document the species assemblage using this habitat, and to evaluate the extent to which the bat community would benefit from restoration of riparian corridors.

Eastern Merced County has the highest density of vernal pools remaining in California. While research has been conducted on the use of vernal pools by birds (Baker et al. 1992; Silveira 1998), no information is available for bats. Vernal pools are extensive in eastern Merced County, and seasonally support a relatively diverse invertebrate community, which includes known bat prey (chironomids, mosquitoes, corixids, notonectids, and caddisflies). Consequently, it is likely that bats forage over these pools. The role that vernal pools might play in supporting local bat populations, particularly during the migration and early reproductive seasons, needs to be investigated.

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