# Lower Colorado River Multi-Species Conservation Program

*Balancing Resource Use and Conservation*

## Post-Development Acoustic Bat Monitoring 2012–2014 Results

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

October 2016

# Lower Colorado River Multi-Species Conservation Program Steering Committee Members

### Federal Participant Group

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

### Arizona Participant Group

Arizona Department of Water Resources
Arizona Electric Power Cooperative, Inc.
Arizona Game and Fish Department
Arizona Power Authority
Central Arizona Water Conservation District
Cibola Valley Irrigation and Drainage District
City of Bullhead City
City of Lake Havasu City
City of Mesa
City of Somerton
City of Yuma
Electrical District No. 3, Pinal County, Arizona
Golden Shores Water Conservation District
Mohave County Water Authority
Mohave Valley Irrigation and Drainage District
Mohave Water Conservation District
North Gila Valley Irrigation and Drainage District
Town of Fredonia
Town of Thatcher
Town of Wickenburg
Salt River Project Agricultural Improvement and Power District
Unit "B" Irrigation and Drainage District
Wellton-Mohawk Irrigation and Drainage District
Yuma County Water Users' Association
Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

### Other Interested Parties Participant Group

QuadState Local Governments Authority
Desert Wildlife Unlimited

### California Participant Group

California Department of Fish and Wildlife
City of Needles
Coachella Valley Water District
Colorado River Board of California
Bard Water District
Imperial Irrigation District
Los Angeles Department of Water and Power
Palo Verde Irrigation District
San Diego County Water Authority
Southern California Edison Company
Southern California Public Power Authority
The Metropolitan Water District of Southern California

### Nevada Participant Group

Colorado River Commission of Nevada
Nevada Department of Wildlife
Southern Nevada Water Authority
Colorado River Commission Power Users
Basic Water Company

### Native American Participant Group

Hualapai Tribe
Colorado River Indian Tribes
Chemehuevi Indian Tribe

### Conservation Participant Group

Ducks Unlimited
Lower Colorado River RC&D Area, Inc.
The Nature Conservancy

# Lower Colorado River Multi-Species Conservation Program

## Post-Development Acoustic Bat Monitoring 2012–2014 Results

*Prepared by:*

Susan Broderick, Denver Technical Service Center

**Lower Colorado River**
**Multi-Species Conservation Program**
**Bureau of Reclamation**
**Lower Colorado Region**
**Boulder City, Nevada**
**http://www.lcrmscp.gov**

**October 2016**

Broderick, S. 2016. Post-Development Acoustic Bat Monitoring, 2012–2014 Results. Annual report submitted to the Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada, by the Bureau of Reclamation, Technical Service Center, Denver, Colorado.

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AKTP | ‘Ahakhav Tribal Preserve acoustic station |
| BLCA 1 | Beal Lake Conservation Area acoustic station |
| Crane’s Roost | Cibola National Wildlife Refuge Unit #1 acoustic station |
| CVCA | Cibola Valley Conservation Area |
| CVCA 1 | Cibola Valley Conservation Area acoustic station #1 |
| CVCA 2 | Cibola Valley Conservation Area acoustic station #2 |
| FY | fiscal year |
| ha | hectare(s) |
| HHCA | Hunters Hole acoustic station |
| LCR | lower Colorado River |
| LCR MSCP | Lower Colorado River Multi-Species Conservation Program |
| PDA | personal digital assistant |
| PVER | Palo Verde Ecological Reserve |
| PVER 1 | Palo Verde Ecological Reserve acoustic station #1 |
| PVER 2 | Palo Verde Ecological Reserve acoustic station #2 |
| sp./spp. | species |
| Reclamation | Bureau of Reclamation |
| YEW 1 | Yuma East Wetlands acoustic station |

## Symbols

| | |
|---|---|
| °C | degrees Celsius |
| # | number |

# CONTENTS

Page

Abstract ..... v

Introduction ..... 1
Study Areas ..... 2
Beal Lake Conservation Area ..... 2
‘Ahakhav Tribal Preserve ..... 4
Palo Verde Ecological Reserve ..... 5
Cibola Valley Conservation Area ..... 6
Cibola National Wildlife Refuge Unit #1 Conservation Area ..... 7
Yuma East Wetlands ..... 8
Hunters Hole ..... 9
Methods ..... 10
Long-Term Bat Acoustic Monitoring Stations ..... 10
Insect Interference ..... 11
Bat Call Analysis ..... 18
Results ..... 20
Covered and Evaluation Species ..... 21
BLCA 1 Acoustic Station ..... 21
AKTP Acoustic Station ..... 25
PVER 1 Acoustic Station ..... 27
PVER 2 Acoustic Station ..... 31
CVCA 1 Acoustic Station ..... 32
CVCA 2 Acoustic Station ..... 35
Crane’s Roost Acoustic Station ..... 36
YEW 1 Acoustic Station ..... 39
HHCA Acoustic Station ..... 40
Species of Management Interest ..... 41
Cave Myotis ..... 43
Arizona Myotis ..... 43
Hoary Bat ..... 44
Western Mastiff Bat ..... 46
Pocketed Free-tailed Bat ..... 47
Site Comparisons of Bat Activity ..... 48
Discussion ..... 50
Western Red Bat ..... 50
Western Yellow Bat ..... 51
California Leaf-nosed Bat ..... 52
Pale Townsend’s Big-eared Bat ..... 53
Literature Cited ..... 55

## Tables

Table Page


1 Dates acoustic monitoring stations established..... 2
2 Total nights acoustic monitoring stations were operational and the total files recorded and processed ..... 20
3 Total call minutes for western red bats at BLCA 1, FY08–14 ..... 25
4 Total call minutes for western yellow bats at BLCA 1, FY08–14..... 25
5 Total call minutes for cave myotis in FY14 at the nine acoustic monitoring stations..... 43
6 Total call minutes for Arizona myotis in FY14 at the nine acoustic monitoring stations ..... 44
7 Total call minutes hoary bats in 2014 at the nine acoustic monitoring stations..... 45
8 Total call minutes for western mastiff bats in 2014 at the nine acoustic monitoring stations..... 46
9 Total call minutes for pocketed free-tailed bats in FY14 at the nine acoustic monitoring stations..... 47
10 Total call minutes per year by monitoring site for covered and evaluation bat species ..... 48
11 Total call minutes per year by monitoring site for selected species of interest..... 49


## Figures

Figure Page


1 Study area map showing locations of the six LCR MSCP conservation areas and the ‘Ahakhav Tribal Preserve where acoustic monitoring stations have been established..... 3
2 Beal Lake Conservation Area acoustic monitoring station..... 4
3 ‘Ahakhav Tribal Preserve acoustic monitoring station..... 5
4 Palo Verde Ecological Reserve acoustic monitoring stations PVER 1 and PVER 2. ..... 6
5 CVCA bat acoustic monitoring stations CVCA 1 and CVCA 2. ..... 7
6 Cibola National Wildlife Refuge Unit #1 Conservation Area original bat acoustic monitoring station location and new location..... 8
7 Yuma East Wetlands bat acoustic monitoring station. ..... 9
8 The HHCA acoustic bat acoustic monitoring station. ..... 9
9 Weather-resistant enclosure containing an Anabat™ bat detector, gel cell battery, and battery charger..... 11
10 Bat hat components consist of a protective covering, a microphone, a connecting bracket, and a reflector plate. ..... 12

## Figures (continued)

Figure Page


11 Crane's Roost bat acoustic monitoring station established on March 31, 2011, showing the layout of the components: National Electrical Manufacturers Association enclosure for the bat detector, battery and battery charger, solar panel, and bat hat. ..... 12
12 This file shows insect calls that have been recorded. ..... 13
13 An ideal acoustic bat call with no insect interference..... 13
14 Summary of data losses due to insect interference and other causes at BLCA 1, fiscal year 2012. ..... 14
15 Summary of data losses due to insect interference and other causes at AKTP, fiscal year 2012. ..... 15
16 Summary of data losses due to insect interference and other causes at PVER 2, fiscal year 2012. ..... 15
17 Summary of data losses due to insect interference and other causes at CVCA 1, fiscal year 2012..... 16
18 New fold-over pole installed in July 2012 at CVCA 1 replaced the original short post, seen left of center, which was increasingly susceptible to insect interference..... 17
19 The worm gear allows for maintenance of the bat hat and adjustment of the height of the bat hat and detector. ..... 17
20 Summary of data losses due to insect interference and other causes at Crane's Roost, fiscal year 2012. ..... 18
21 The new fold-over pole with the bat hat and reflector plate installed. ..... 19
22 Seasonal activity for western red bats and western yellow bats at BLCA 1, FY12–14. ..... 22
23 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at BLCA 1, FY12–14. ..... 24
24 Seasonal activity for western red bats and western yellow bats at the AKTP, FY12–14. ..... 26
25 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at the AKTP, FY12–14. ..... 28
26 Seasonal activity for western red bats and western yellow bats at PVER 1, FY12–14. ..... 29
27 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at PVER 1, FY12–14. ..... 30
28 Seasonal activity for western red bats and western yellow bats at PVER 2, FY13–14. ..... 31
29 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at PVER 2, FY13–14. ..... 32
30 Seasonal activity for western red bats and western yellow bats at CVCA 1, FY12–14. ..... 33

## **Figures** (continued)

Figure Page


31 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at CVCA 1, FY12–14. ..... 34
32 Seasonal activity for western red bats and western yellow bats at CVCA 2, FY13—14. ..... 35
33 Seasonal activity for California leaf-nosed bats and pale Townsend's Big-eared bats at CVCA 2, FY12–14..... 36
34 Seasonal activity for western red bats and western yellow bats at Crane's Roost, FY12–14..... 37
35 Seasonal activity for California leaf-nosed bats and pale Townsend's Big-eared bats at Crane's Roost, FY12–14..... 38
36 Seasonal activity for western red bats and western yellow bats at YEW 1, FY13–14. ..... 39
37 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at YEW 1, FY13–14. ..... 40
38 Seasonal activity for western red bats and western yellow bats at the HHCA, FY13–14. ..... 41
39 Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at the HHCA, FY13–14. ..... 42

# ABSTRACT

This report summarizes post-development acoustic bat monitoring for 2012 through 2014 for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). This period represents the first fully implemented program of acoustic monitoring stations following 5 years of intensive acoustic surveys that began in 2007. Nine acoustic monitoring stations were deployed in six LCR MSCP conservation areas and one area managed by the Colorado River Indian Tribes.

The four LCR MSCP covered and evaluation bat species include the western red bat (*Lasiurus blossevillii*), western yellow bat (*Lasiurus xanthinus*), California leaf-nosed bat (*Macrotus californicus*), and pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* also known as *Plecotus townsendii pallescens and Corynorhinus townsendii townsendii*). All four LCR MSCP bat species were detected at all seven study areas. The western red bat and western yellow bat showed the highest levels of activity at the Cibola Valley Conservation Area and the Palo Verde Ecological Reserve. The California leaf-nosed bat and pale Townsend's big-eared bat, while much more difficult to detect acoustically, were found throughout the study areas, with the Cibola Valley Conservation Area having the highest acoustic activity.

# INTRODUCTION

The Bureau of Reclamation (Reclamation) is the lead implementing agency for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a 50-year cooperative Federal, State, Tribal, county, and private effort to manage the natural resources of the lower Colorado River (LCR) watershed, provide regulatory relief for the use of water resources of the river, and create native habitat types along the LCR. The LCR MSCP was implemented in October 2005. To restore native habitats, the LCR MSCP will create the following cover types: (1) 5,940 acres (2,404 hectares [ha]) of cottonwood-willow (*Populus fremontii* and *Salix* spp.), (2) 1,320 acres (534 ha) of honey mesquite (*Prosopis glandulosa*), (3) 512 acres (207 ha) of marsh, and (4) 360 acres (146 ha) of backwaters (Reclamation 2004).

The western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) are covered species under the program. The California leaf-nosed bat (*Macrotus californicus*) and pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* also known as *Plecotus townsendii pallescens and Corynorhinus townsendii townsendii*) are evaluation species under the program. These four bat species are the focus of this report. Genetic analyses on the pale Townsend's big-eared bat indicate that the LCR is likely in the range of the Pacific Townsend's big-eared bat (*Corynorhinus townsendii townsendii)* rather than the pale Townsend's big-eared bat (Piaggio and Perkins 2005). The bats recorded along the LCR will be referred to as pale Townsend's big-eared bats in this report, as the nomenclature change has not yet been verified by U.S. Fish and Wildlife Service.

The year 2012 marked a transition from the intensive acoustic bat surveys conducted from 2007 through 2010 (Broderick 2012) to the use of long-term acoustic monitoring stations. The 3 years of intensive bat surveys, which included a large number of acoustic detectors, were conducted at LCR MSCP conservation areas and the Colorado River Indian Tribes' 'Ahakhav Tribal Preserve in various habitat types during all four seasons. This intensive sampling method allowed comparison of bat use by habitat type and by monitoring site. The year 2011 marked the first step in transitioning to a small number of long-term acoustic monitoring stations; two new stations were established in addition to the original station established at the Beal Lake Conservation Area in 2008. Additionally, the utility of using mobile acoustic surveys was tested and baseline acoustic surveys were conducted in the Laguna Division Conservation Area.

Five stations had been deployed in five monitoring sites by 2012, and by 2013, four additional stations were added, making a total of nine acoustic monitoring stations. The long-term monitoring strategy was to have one long-term station located in each LCR MSCP conservation area containing cottonwood-willow land cover in order to document western red bat and western yellow bat species

presence, with two stations located in the two largest conservation areas. The rationale for transitioning to long-term acoustic monitoring stations is to collect consistent and continuous data efficiently and reduce field labor and travel costs.

# STUDY AREAS

During the 3-year period of this report, 2012 through 2014, there were nine long-term acoustic monitoring stations deployed in six LCR MSCP conservation areas and one additional area managed by the Colorado River Indian Tribes (see figure 1). Four of those stations were established in 2013. Additional stations were placed in the two largest conservation areas: the Palo Verde Ecological Reserve (PVER) and the Cibola Valley Conservation Area (CVCA) to provide greater coverage. New acoustic monitoring stations were installed at Hunters Hole and Yuma East Wetlands. Table 1 summarizes the date each station was established.

Table 1.—Dates acoustic monitoring stations established

| Acoustic monitoring station | Date station established |
|---|---|
| BLCA 1 | April 9, 2008 |
| CVCA 1 | March 31, 2011 |
| Crane's Roost | April 1, 2011; relocated on July 17, 2013 |
| AKTP | April 9, 2012 |
| PVER 1 | April 10, 2012 |
| PVER 2 | March 15, 2013 |
| HHCA | April 8, 2013 |
| CVCA 2 | July 10, 2013 |
| YEW 1 | September 11, 2013 |

## Beal Lake Conservation Area

The Beal Lake Conservation Area is located on the Havasu National Wildlife Refuge in Needles, California, within the historic flood plain of the LCR. It consists of 107 acres (43 ha) of cottonwood, Goodding's willow (*Salix gooddingii),* coyote willow (*S. exigua*), honey mesquite, and screwbean mesquite (*Prosopis pubescens*) in a series of plantings that began in 2001 and were completed in 2005 (Reclamation 2005). An additional 9 acres (4 ha) (of willow marsh were established in 2012 (Reclamation 2015). No future plantings are

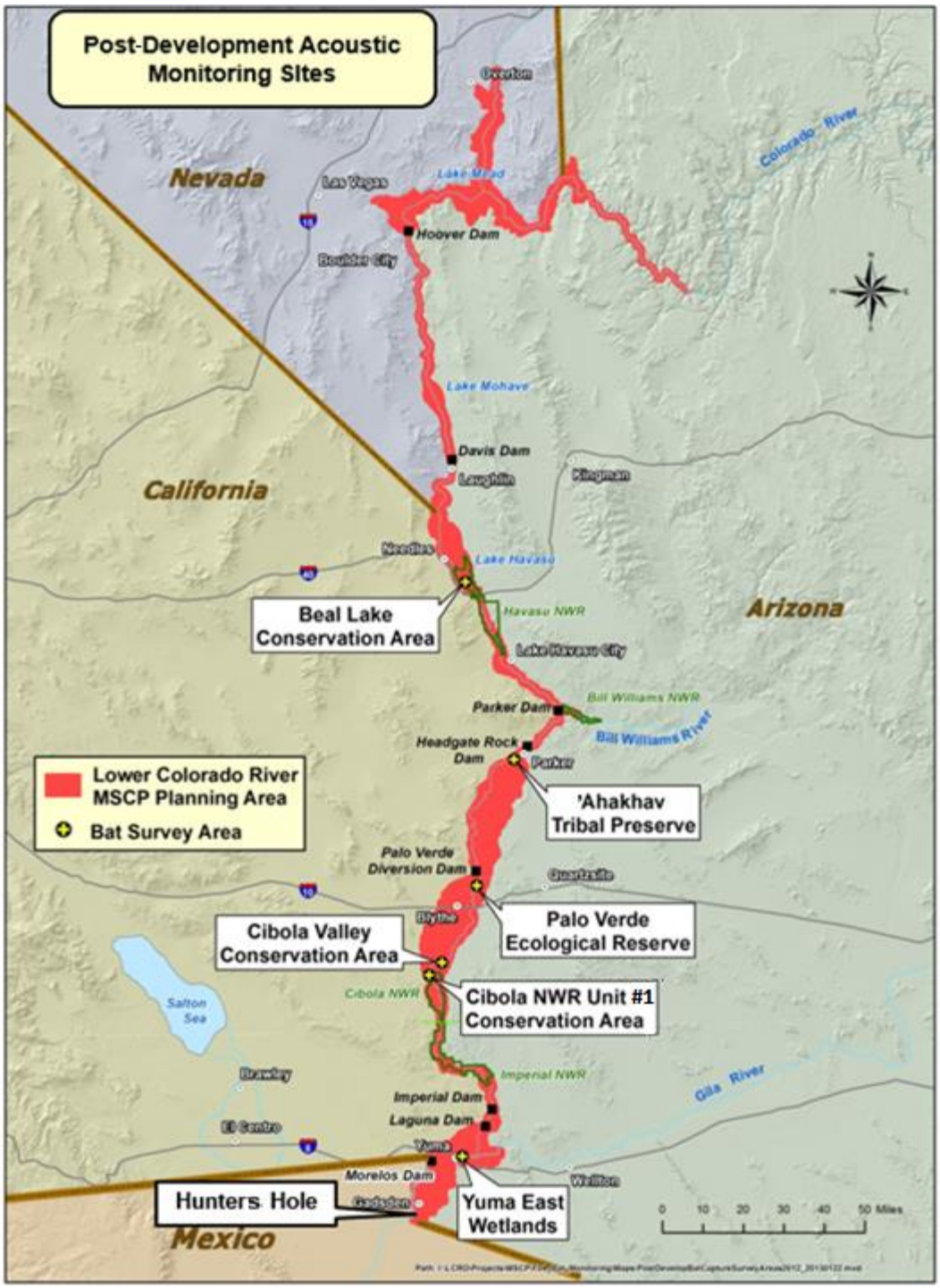


**Figure 1.—Study area map showing locations of the six LCR MSCP conservation areas and the 'Ahakhav Tribal Preserve where acoustic monitoring stations have been established.**

scheduled. Figure 2 shows the location of the first long-term bat acoustic monitoring station that was established on April 9, 2008. It has been running continuously since that time.

**Figure 2.—Beal Lake Conservation Area acoustic monitoring station.**

## ‘Ahakhav Tribal Preserve

The ‘Ahakhav Tribal Preserve is a 154-acre (62-ha) site located 3 miles (5 kilometers) southwest of Parker, Arizona, on Colorado River Indian Tribes’ land (figure 3). This site consists of a mosaic of cottonwood, willow, and honey mesquite fields planted in 2003 as part of an agreement between the Colorado River Indian Tribes and Reclamation in 2001. The long-term acoustic monitoring station (AKTP) was established at the ‘Ahakhav Tribal Preserve on April 9, 2012, near some of the largest trees of the site. The ‘Ahakhav Tribal Preserve is not an LCR MSCP conservation area; however, due to its similarity to other restoration sites and its proximity to mines and riparian habitat occupied by LCR MSCP covered and evaluation bat species, data from this site is currently analyzed with the LCR MSCP conservation areas to inform the LCR MSCP of covered and evaluation bat species at created cottonwood and willow habitat.

**Figure 3.—'Ahakhav Tribal Preserve acoustic monitoring station.**

## Palo Verde Ecological Reserve

The Palo Verde Ecological Reserve (PVER) encompasses 1,352 acres (547 ha) of Colorado River historic flood plain near Blythe, California (figure 4), of which 1,100 acres (445 ha) of active agricultural lands were identified for habitat restoration (Reclamation 2006). The PVER is on land owned by the California Department of Fish and Wildlife. Approximately 945 acres (382 ha) of cottonwood-willow and 78 acres (32 ha) of honey mesquite have been established in Phases 1–8. The final plantings consisting of honey mesquite and alkali sacaton (*Sporobolus airoides*) were made in Phase 8 in 2013. The PVER is now fully planted out with a total of about 1,023 acres (414 ha) (Reclamation 2015). This is an extensive area with more than 4 miles of the eastern boundary adjacent to the Colorado River; the western boundary is adjacent to agricultural fields. The first long-term acoustic monitoring station (PVER 1) was established on April 10, 2012, in well-established cottonwood-willow on the southwestern portion of the area in Phase 2. To provide adequate coverage of the extensive area along the LCR, a second station (PVER 2) was established on March 15, 2013, in recently planted cottonwood-willow in the northeast portion of the conservation area in Phase 7.

**Figure 4.—Palo Verde Ecological Reserve acoustic monitoring stations PVER 1 and PVER 2.**

## Cibola Valley Conservation Area

The CVCA is approximately 2 miles (3 kilometers) north of Cibola, Arizona, on Arizona Game and Fish Department land. The CVCA is managed under a partnership between Reclamation and the Arizona Game and Fish Department. The habitat is being developed in the same way as the PVER. Through 2012, 265 acres (107 ha) of cotton-willow and 405 acres (164 ha) of honey mesquite habitat were planted. No additional plantings were made in 2013. When all phases have been planted, there will be over 1,000 acres (405 ha) of riparian habitat within the CVCA. The first long-term acoustic monitoring station (CVCA 1) was established in March 31, 2011, in well-established cottonwood-willow habitat in Phase 2 in the north-eastern portion (figure 5), and the second station (CVCA 2) was established on July 10, 2013, in Phase 3 on the southwestern portion of the conservation area.

**Figure 5.—CVCA bat acoustic monitoring stations CVCA 1 and CVCA 2.**

## Cibola National Wildlife Refuge Unit #1 Conservation Area

The Cibola National Wildlife Refuge Unit #1 Conservation Area is a 950-acre (384-ha) site located in the northern portion of the Cibola National Wildlife Refuge. It consists of about 270 acres (109 ha) of cottonwood-willow and honey mesquite. Reclamation has several planned projects in Unit #1. Additional acreage will be converted annually until 950 acres (384 ha) have been restored. The long-term acoustic monitoring station (Crane's Roost [previously referred to as CNU1) was established on April 1, 2011, but was subsequently relocated to a more representative site in the Cibola National Wildlife Refuge Unit #1 Conservation Area Crane's Roost phase on July 17, 2013 (figure 6).

**Figure 6.—Cibola National Wildlife Refuge Unit #1 Conservation Area original bat acoustic monitoring station location and new location.**

## Yuma East Wetlands

Yuma East Wetlands is a 350-acre (142-ha) site located on the north side of Yuma, Arizona, that has been restored to create a mosaic of marsh, honey mesquite, and cottonwood-willow. Restoration activities began in 2004 (figure 7). In 2013, the LCR MSCP entered into a partnership with the Quechan Indian Tribe, city of Yuma, Arizona Game and Fish Commission, and Yuma Crossing National Heritage Area (the landowners of the site) to support the long-term management of this area. The long-term bat acoustic monitoring station (YEW 1) was established on September 11, 2013.

**Figure 7.—Yuma East Wetlands bat acoustic monitoring station.**

## Hunters Hole

Hunters Hole is a 44-acre (18-ha) site located near San Luis, Arizona. Earthwork and irrigation infrastructure was installed in February 2012, and in March 2012, the site was planted with bulrush (*Schoenoplectiella* sp.) and willows in marsh cells and willows, honey mesquite, cottonwoods, and native grasses planted in flood-managed fields (figure 8). The long-term bat acoustic monitoring station (HHCA) was established on April 8, 2013.

**Figure 8.—The HHCA acoustic bat acoustic monitoring station.**

# METHODS

## Long-Term Bat Acoustic Monitoring Stations

Long-term acoustic monitoring stations are the main components of the LCR MSCP Post-Development Bat Monitoring Program along with seasonal mist netting. Each station consists of a 40-foot metal pole securely anchored in the ground upon which a rugged National Electrical Manufacturers Association type 4 enclosure is secured. Inside the enclosures are the Anabat™ SD1 or SD2 bat detector, a rechargeable gel cell battery, and battery charger (figure 9). The detector is connected to an EME Systems bat hat mounted further up the pole, which consists of a reflector plate and microphone mounted in a protective covering. Within the protective covering is a preamplifier to prevent data loss due to cable length (figure 10). The detectors were calibrated using a bat chirper with standardized recordings. The microphone is aimed at the reflector plate, which reduces the sensitivity of the bat call recordings somewhat, but it allows bat calls to be recorded in poor weather conditions. The Anabat™ detector is programmed to turn on at dusk and off at dawn. A small solar panel keeps the battery charged (figure 11). The poles are designed to be lowered with a worm gear, which allows maintenance of the bat hat and adjustment of the height of the bat hat and detector.

Bat stations were visited regularly, usually monthly during spring and summer, and less frequently during the cool late fall, winter, and early spring months. On each visit, data were downloaded from the compact flash card in each bat detector, equipment was maintained, and any problems were diagnosed and resolved, if possible. Maintenance included cleaning the reflector plates of accumulated dirt and bird droppings, removing wasp nests, and checking wires and microphones. Data were checked immediately and any corrective measures taken if necessary.

The long-term stations are not randomly located within monitoring areas. The sites were selected to be generally in the interior of the habitat, near cottonwood stands and adjacent to a field opening or a road that can serve as flyways. Insect interference is a significant factor that can adversely impact bat call recordings, so microphones and reflector plates are located to minimize this interference by facing them toward a road or open field or positioning them on the pole slightly above canopy level.

**Figure 9.—Weather-resistant enclosure containing an Anabat™ bat detector, gel cell battery, and battery charger.**

It is assumed that bat activity at the station is similar to the bat activity throughout these relatively small cottonwood-willow habitat patches. Bats are highly mobile and will freely fly through all areas to forage and do not have territories that tie them to particular areas of the habitat patches.

## Insect Interference

As the vegetation in the monitoring sites has begun to mature, insect noise has increasingly become a source of acoustic bat call data loss. Katydid (Tettigoniidae), cricket (Gryllidae), and cicada (Cicadoidea) calls can reach higher decibel levels than bat echolocation calls, resulting in only insect calls being recorded (figure 12). This effectively results in the loss of acoustic bat call data during periods of intense insect activity. The problem was first identified and discussed with staff in 2011. Insect interference became a serious issue in 2012, as insect activity in the riparian plantings continued to increase.

**Figure 10.—Bat hat components consist of a protective covering, a microphone, a connecting bracket, and a reflector plate.**

**Figure 11.—Crane's Roost bat acoustic monitoring station established on March 31, 2011, showing the layout of the components: National Electrical Manufacturers Association enclosure for the bat detector, battery and battery charger, solar panel, and bat hat.**

It is essential in acoustic bat monitoring to record clean bat calls (figure 13). This ensures that bats that are present in a monitoring area can be recorded and it is also essential for the ability to correctly identify a call to species by allowing call filters to work properly and for visual identification to be made.

During the intensive acoustic surveys from 2007 through 2010, Anabat™ detectors were placed on LongArm poles (Mr. LongArm, Greenwood, Missouri) to extend the detector microphone to the tops of the canopy and thereby avoid most insect interference (Broderick 2012). However, a permanent durable solution was needed. Plans for a folding pole were obtained and modified to suit the needs of the long-term bat monitoring program. The Yuma Area Office agreed to finalize the design and to build enough monitoring poles for the foreseeable future and also agreed to install the structures. The following figures show the amount of the insect interference at the acoustic monitoring stations that occurred in 2012 to illustrate the extent of the problem.

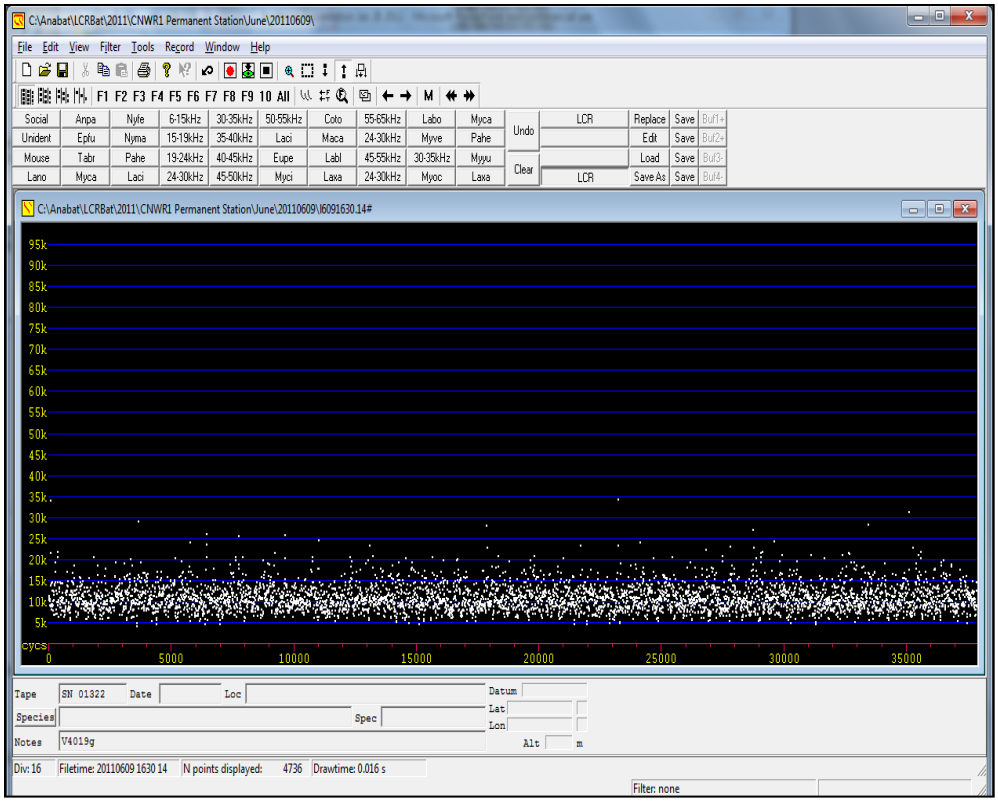


**Figure 12.—This file shows insect calls that have been recorded.**
This insect interference is preferentially recorded by the bat detector. This can preclude any bat from being recorded.

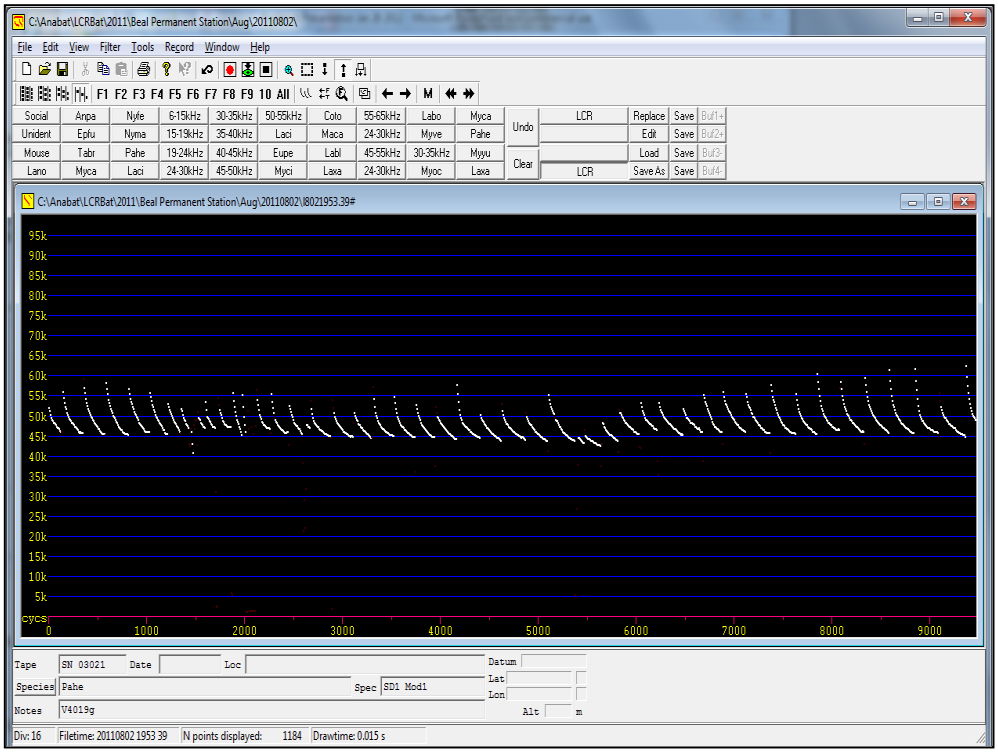


**Figure 13.—An ideal acoustic bat call with no insect interference.**

The station at the Beal Lake Conservation Area typically experiences reduced acoustic data collection during the cold winter months when bats are inactive (blue shaded area) (figure 14). The station also malfunctioned during a nearly 3-month period from late February through mid-May (red shaded area). Such equipment malfunctions are not uncommon in acoustic bat data collection, as the sensitive wiring and equipment are exposed to the elements. The faulty wiring was replaced. Insect interference became increasingly problematic as vegetation surrounding the station grew in density and height.

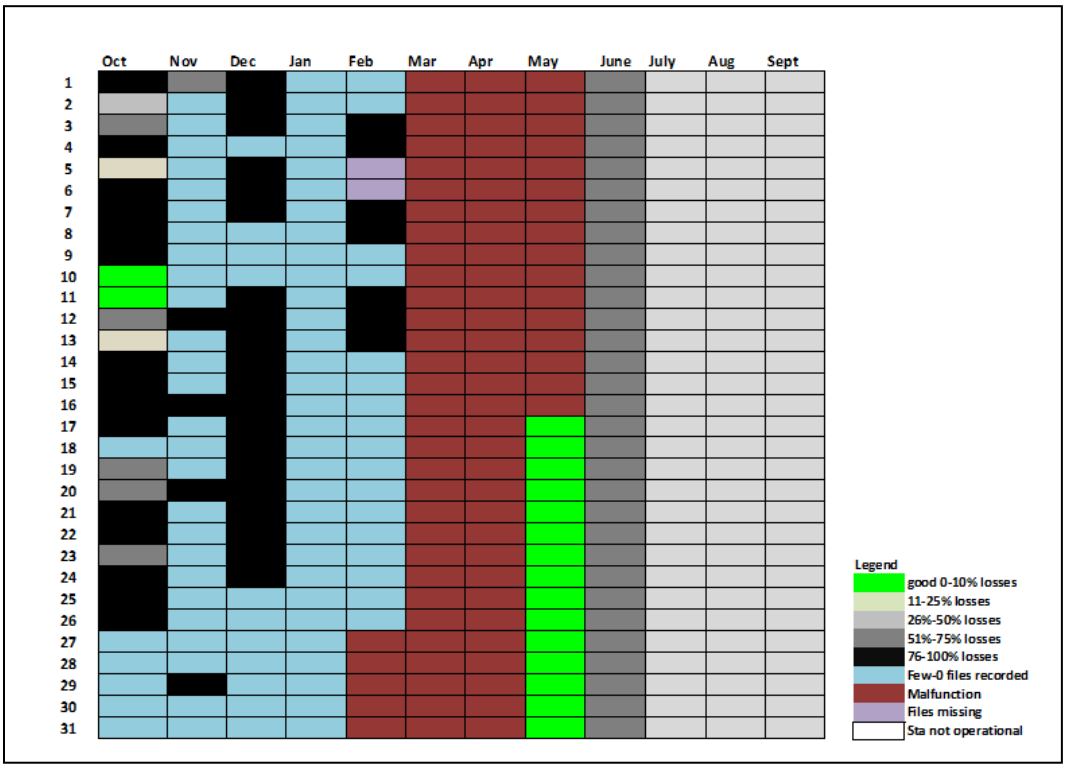


**Figure 14.—Summary of data losses due to insect interference and other causes at BLCA 1, fiscal year 2012.**

Data losses at the AKTP (figure 15) occurred as vegetation matured around the station in summer. Vegetation was cut back in July, and the microphone was extended on a LongArm pole to help reduce insect losses.

PVER 2 (figure 16) experienced very little insect losses, as it was located further out into the open grassy area. The station was installed on April 9, 2012.

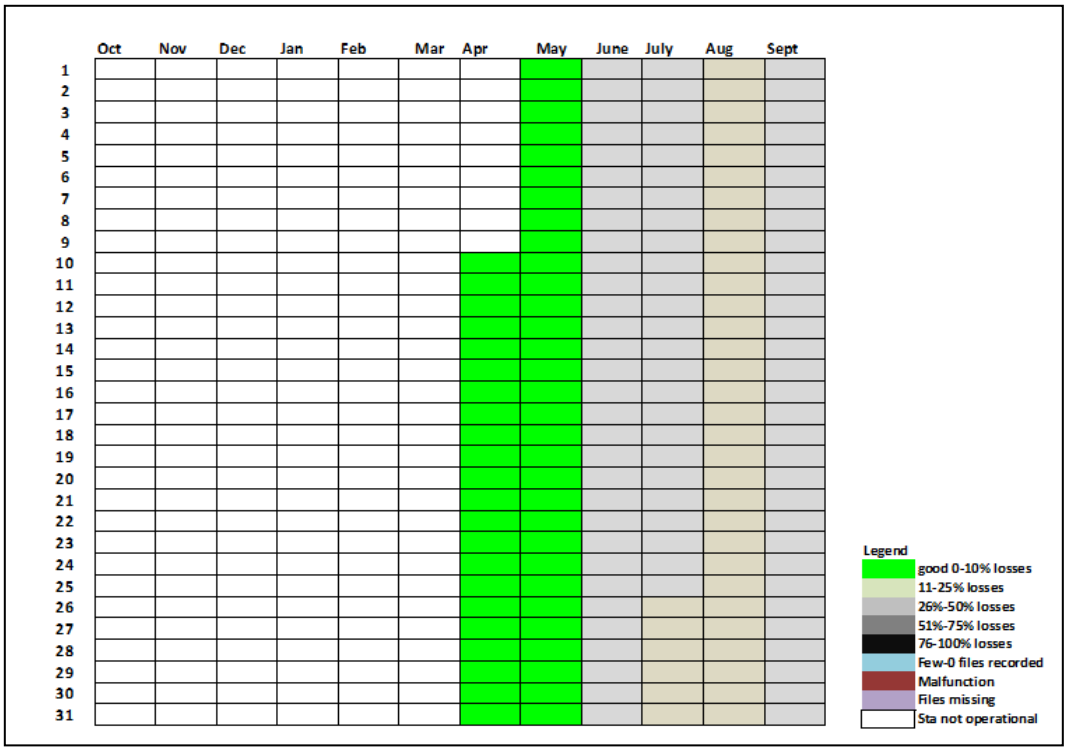


**Figure 15.—Summary of data losses due to insect interference and other causes at AKTP, fiscal year 2012.**

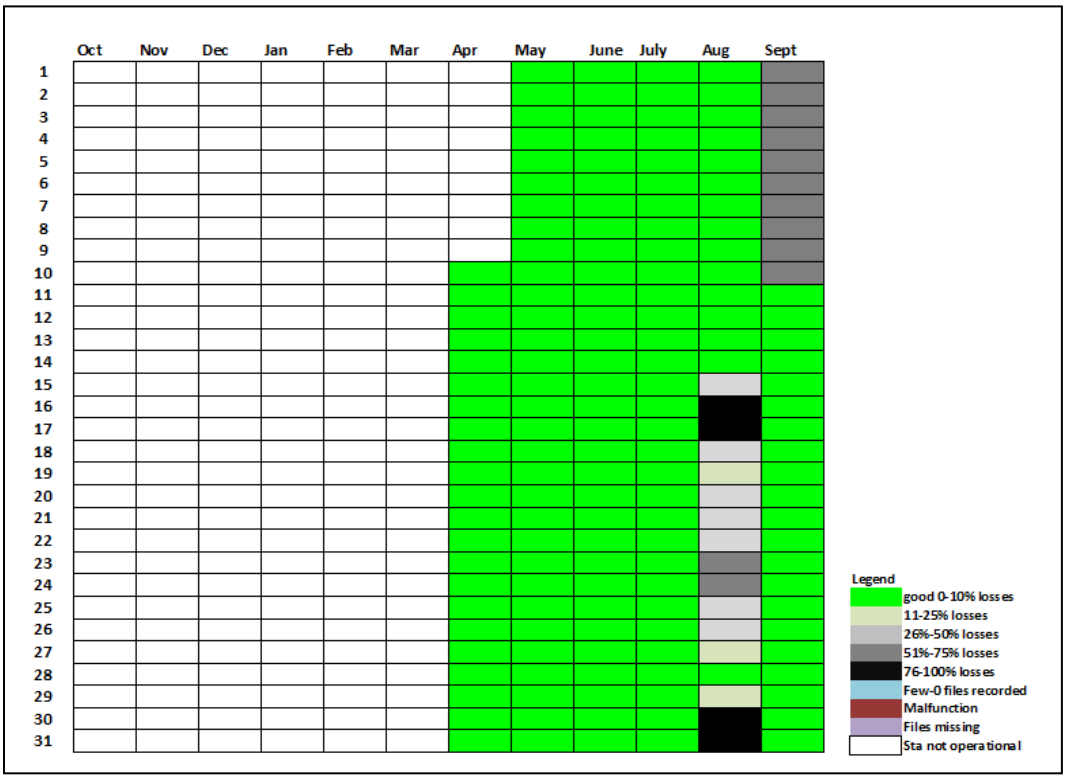


**Figure 16.—Summary of data losses due to insect interference and other causes at PVER 2, fiscal year 2012.**

CVCA 1 (figure 17) experienced 11 to 25 percent insect-related data losses during April through September 2012. A 40-foot pole was installed in July 2012. The microphone height was adjusted to minimize insect interference. This station typically has very few calls during the winter months (blue shaded area).

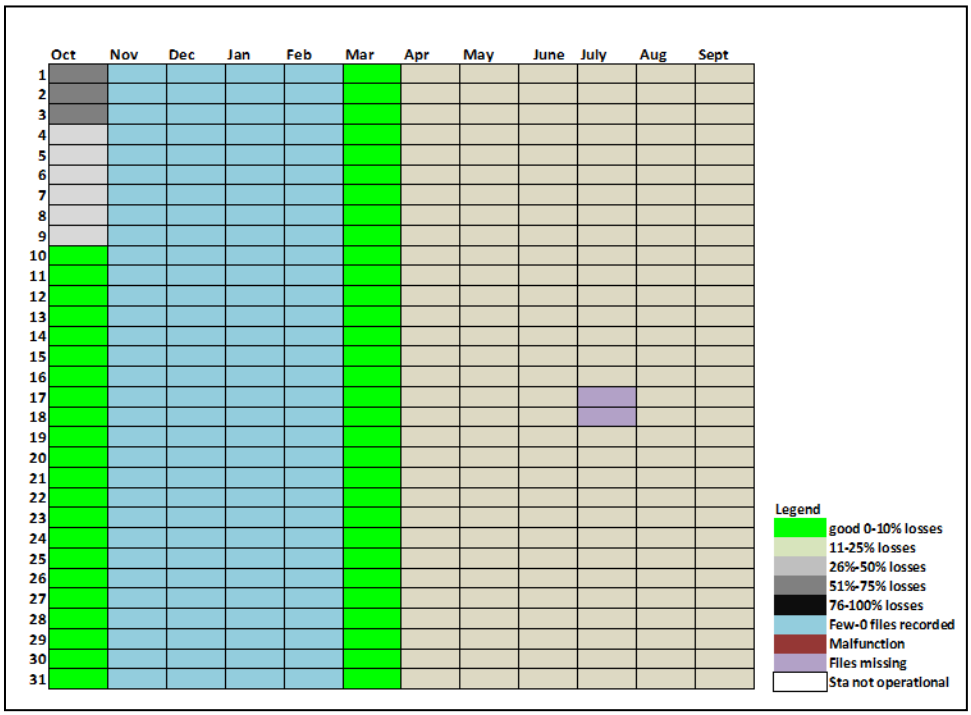


**Figure 17.—Summary of data losses due to insect interference and other causes at CVCA 1, fiscal year 2012.**

The first 40-foot pole was installed at CVCA 1 in July 2012, replacing the short pole (figure 18). The ability to crank the pole down using the worm gear (figure 19) allowed for the installation of the bat hat and reflector plate at a level just high enough to avoid insect interference. Currently, the bat hat and reflector plates are at 25 feet at seven of the stations, while at two stations (PVER 2 and Crane's Roost) the bat hat and reflector plates had to be raised to the very top of the pole to adequately reduce insect interference.

The original Cibola National Wildlife Refuge Unit #1 Conservation Area station (CNU1) performed poorly due to a suboptimal location (detector position low enough that vegetation clutter became an issue as the site matured). Figure 20 shows the insect-related losses that occurred from April through September. The station was moved to a permanent site on July 10, 2013, in the Crane's Roost phase, which has improved data collection significantly.

**Figure 18.—New fold-over pole installed in July 2012 at CVCA 1 replaced the original short post, seen left of center, which was increasingly susceptible to insect interference.**

**Figure 19.—The worm gear allows for maintenance of the bat hat and adjustment of the height of the bat hat and detector.**

All of the long-term acoustic monitoring stations, except the AKTP and PVER 1, were retrofitted with the 40-foot pole. The AKTP was modified with a LongArm telescoping extension pole hose clamped to the main post, which sets the bat hat

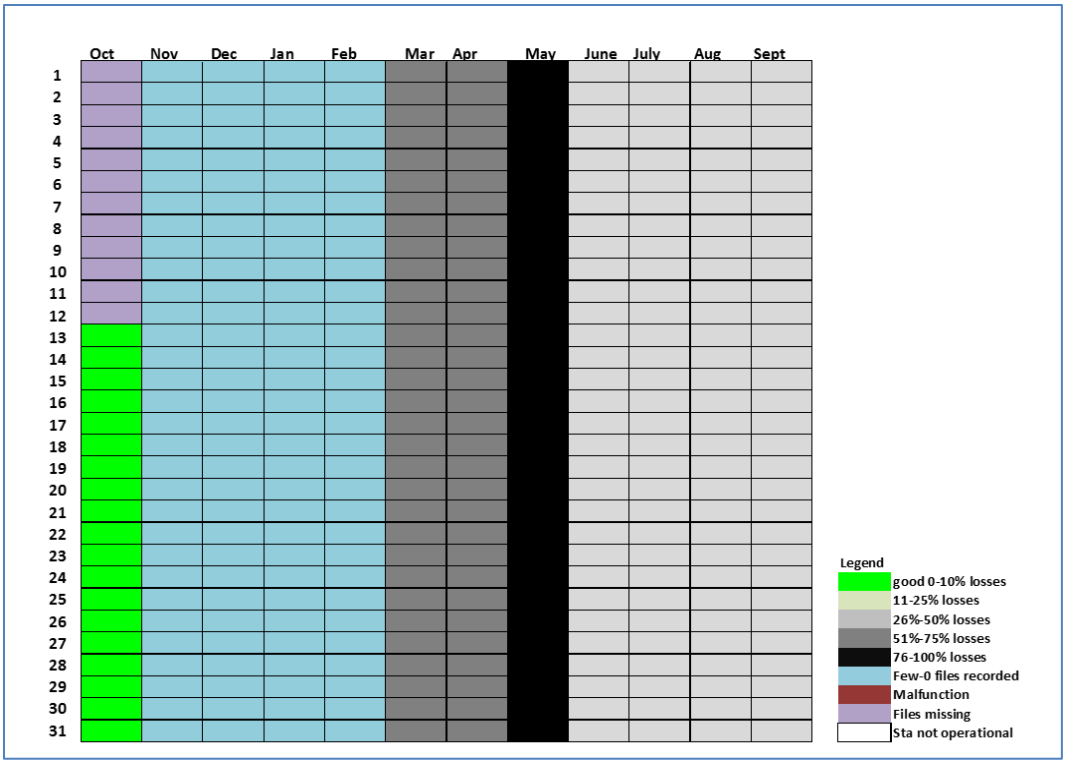


**Figure 20.—Summary of data losses due to insect interference and other causes at Crane's Roost, fiscal year 2012.**

at just above 20 feet in the air. A permanent concrete pad and shorter pole was installed at PVER 1 in 2012. The station was also located away from the edge of tall cottonwoods far enough to have little issue with insect interference.

Figure 21 shows the entire bat station. The original station had not been removed as of yet and appears on the left of the new station, providing a comparison view. The solar panel and bat detector/battery enclosure were installed at a lower level to allow cleaning, maintenance, and data download. The pole is 40 feet tall.

## Bat Call Analysis

The minimum frequency, duration, and shape of each call sequence (bat pass) was compared with reference calls from libraries of positively identified bats from throughout the Western United States as well as reference calls recorded along the LCR following the method outlined in Thomas et al. (1987). AnalookW version 4.1t was used to analyze the bat calls and summarize call data. A bat pass is defined as a call sequence of duration greater than 0.5 millisecond and consisting of more than two individual calls (Thomas 1988; O'Farrell and Gannon 1999). Although feeding buzzes frequently occurred throughout surveys, they were not quantified in this study.

**Figure 21.—The new fold-over pole with the bat hat and reflector plate installed.**

A call minute is a relative activity index that eliminates the bias of overestimating bat relative abundance if multiple files of the same individual were recorded in a short period of time or underestimating bat abundance because of multiple individuals recorded within a single file (Kalcounis et al 1999; Brown 2006). A call minute indicates that a given species is present if it was recorded at least once within a 1-minute period regardless of the number of call sequences recorded within that minute. The highest rating a bat species can have is 60 in an hour, indicating that the species (but not necessarily the same individual) is recorded continuously during the hour (Brown 2006; Williams et al. 2006; Miller 2001).

All monitoring results are discussed in terms of call minutes rather than total call files for a given species. The terms "call minutes," "bat minutes," or "minutes" all refer to this relative activity index.

Additional reference calls were collected during bat mist netting effort to add to the library of known species calls in habitats specific to the LCR MSCP. These were collected using an Anabat™ SD2 bat detector coupled to a personal digital assistant (PDA). When captured bats were released, the detector was used to record calls. In some instances, particularly when a species' call library was small, a light stick was attached to the chest fur of the bat using a non-toxic kid's glue stick. The light stick provides a longer period of time in which to record calls of the bat, particularly as it gets into the nearby habitats, and after a brief period of time has passed. This allows the bat to calm down a bit, resulting in recordings that are more natural. The light sticks fall off sometime within the night, usually 3 to 4 hours.

The California leaf-nosed bat and pale Townsend's big-eared bat are whispering bats, echolocating at lower intensity levels. Their low whispers must occur close to the bat detector microphone, within 15 feet or possibly less for Townsend's, in order to be recorded. In comparison, western red and western yellow bats emit high-intensity echolocations, and their calls are readily recorded. Overall minutes of western red and western yellow bat activity will be much higher than the whispering bats. While mean minutes of bat activity for whispering bats generally do not show seasonal peaks and year to year variability, they do show presence of the species at monitoring areas.

# RESULTS

The 9 stations were operational for 6,004 nights, recording 2,134,214 call files (table 2). Of those, 74,866 call files were identified to species or species groups. These identified files included the four covered and evaluation bat species and five additional species of management interest for 2014. However, due to time and budget limitations, not every bat call recorded during the 3-year period was identified, particularly those of the more common and abundant species.

Table 2.—Total nights acoustic monitoring stations were operational and the total files recorded and processed

| Fiscal year | Total number of acoustic monitoring stations | Total nights operational | Total number of files | Total number of calls identified to spp. or spp. group |
|---|---|---|---|---|
| 2012 | 5 | 1,326 | 474,813 | 27,835 |
| 2013 | 9 | 2,054 | 657,625 | 18,824 |
| 2014 | 9 | 2,624 | 1,001,776 | 28,207 |
| | **Total** | **6,004** | **2,134,214** | **74,866** |

Some of the files were insect calls or calls with both bats and insects recorded. Because insect calls were pervasive in the recorded files, filters were used to identify the presence of bat calls rather than eliminating calls with large amounts of insect clutter. The use of the poles to elevate detectors above most of the insect noise was successful in reducing insect interference to the point that bats in the area were readily recorded rather than being completely drowned out by loud insect calls. One of the dilemmas in acoustic bat detection at the habitat conservation areas versus the adjacent salt cedar (*Tamarix* sp.), agricultural, and other areas was that the lush riparian vegetation growing in the conservation areas attracted insects, which in turn attracted foraging bats. A balance had to be struck between adequately sampling the bats while not getting excessive insect interference.

While the stations operated well for the bulk of the 3-year period, some data losses did occur due to mechanical issues. This is not an uncommon problem for acoustic monitoring equipment, and is it widely reported in the bat literature (Skalak et al. 2012; Barnett 2014; Hendricks 1999; Thomas and West 1989; Duff 2004). Corrective measures were taken to minimize losses as much as possible. The CVCA 1, CVCA 2, and HHCA stations operated flawlessly during this monitoring period. The AKTP, PVER 2, and Crane's Roost stations experienced relatively minor data losses. Significant data losses occurred at the PVER 1 and YEW 1 stations.

# Covered and Evaluation Species

The results of acoustic monitoring in mean call minutes per month for the covered and evaluation species are displayed by monitoring station and year (figures 22 and 23). The first graphs show western red bats on the left side and western yellow bats on the right side (figure 22). The second set of graphs show the California leaf-nosed bat and pale Townsend's big-eared bat results (figure 23). Note that the scales on the y-axes are different for each species. Also displayed are periods of time that data losses occurred to provide a better sense of the data (lightly shaded areas). These figures show the level of bat activity at each of the monitoring sites and the seasonal differences in bat activity through the 3-year period. All data displayed are based on the fiscal year (FY) beginning in October of the previous year and ending in September rather than on the normal calendar year.

## BLCA 1 Acoustic Station

The acoustic station at the Beal Lake Conservation Area operated well during the monitoring period with the exception of data losses during January and April 2012. Red bats were detected year round for 2013 and 2014, and were recorded nearly every month in 2012, with the exception of December and March (figure 22 – charts A, B, and C). The highest overall monthly mean minutes of

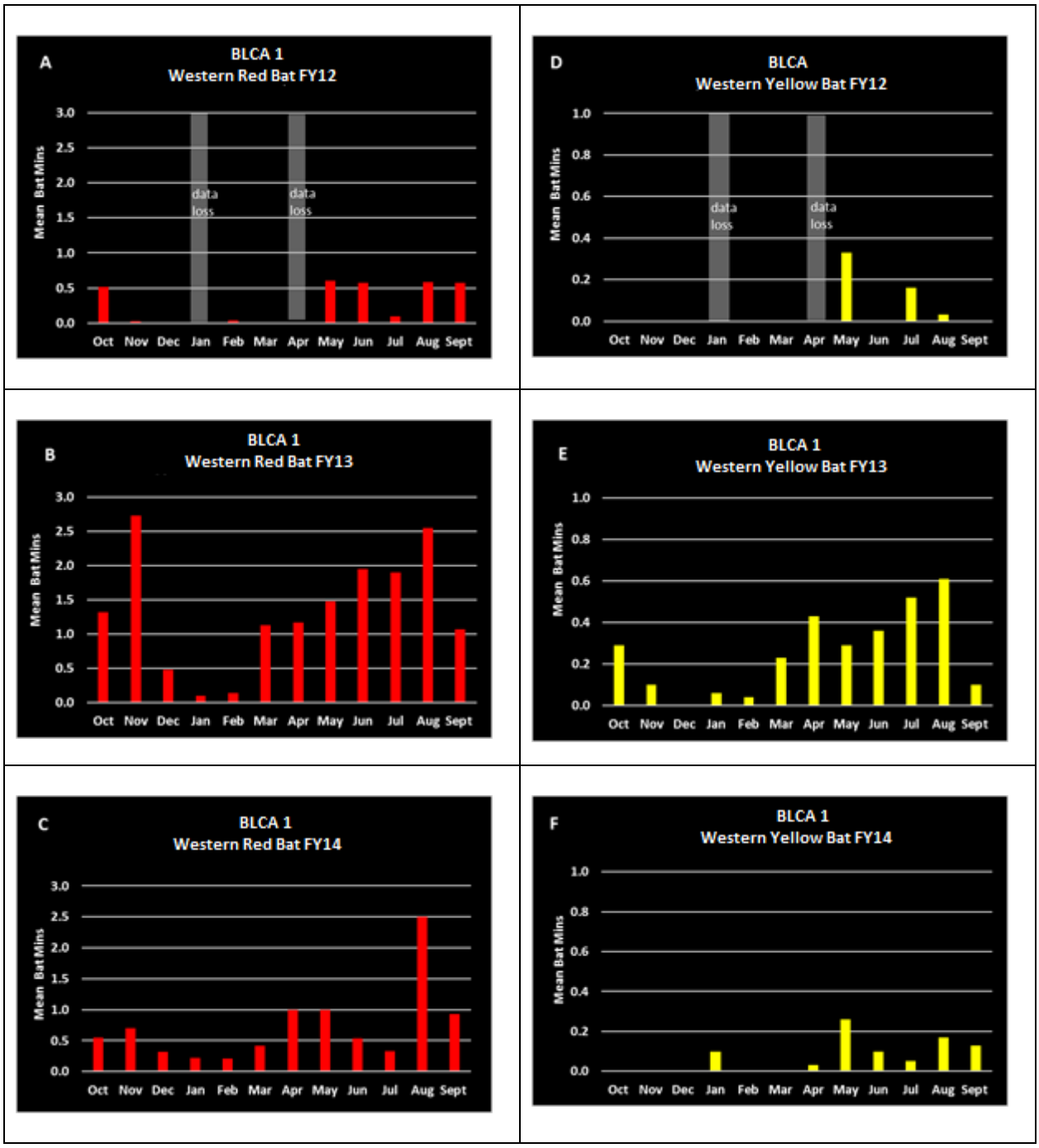


**Figure 22.—Seasonal activity for western red bats and western yellow bats at BLCA 1, FY12–14.**
Note: The scales are different between western red and western yellow bats.

bat activity occurred in 2013, with pronounced seasonal peaks occurring in October and November and again during the summer months. The lowest overall activity was recorded in 2012. Winter activity was low during all three years. The overall activity for the 3-year period is modest compared to the large amount of bat activity observed at PVER 1 and CVCA 1.

Western yellow bats were detected year round in 2014, except December. Peak activity occurred during spring and summer. Western yellow bat detections at BLCA 1 is more sporadic in 2012 and 2014 (see figure 22 – charts D, E, and F). Overall activity is relatively low at BLCA 1 compared to high western yellow bat activity recorded at PVER 1 and CVCA 1.

Figure 23 – charts A, B, and C show mean call minutes per night for each month for California leaf-nosed bat, indicating that this species is sporadically present during July through September for all three years, though the mean call minutes per night are low. This is expected given the difficulty in recording whispering bat calls. In 2014, California leaf-nose bats were detected at BLCA 1 every month except December, January, and August. There is also a small pulse in activity in October for all years.

Pale Townsend's big-eared bat activity is extremely low but indicates this species was present during spring and summer 2014. Sporadic calls were recorded in July and September for 2012 and April, June, and July for 2013 (figure 23 – charts D, E, and F). Mist netting was used to capture pale Townsend's big-eared bats in 2013 at the Beal Lake Conservation Area. This is the only site where low but consistent captures are occurring (Calvert, in press).

BLCA 1 is the longest running acoustic monitoring station since its establishment in April 2008. It provides a 7-year view of western red and western yellow bat activity. Table 3 summarizes western red bat total monthly minutes of activity detected at BLCA 1 (blank cells indicate periods when the station was not operational). The largest activity peaks occurred during October and November in 2010 (268 and 150 minutes, respectively), possibly a result of migrants passing through. Overall fall activity has been consistent across the years. Winter activity overall has been light, with periodic pulses of activity (February 2010 with 18 call minutes and December 2011 with 9 call minutes). Recently, winter activity increased and became more consistent, with call minutes recorded for all winter months in 2013 and 2014. March and April activity was sporadic, ranging from no calls in 2009 to pulses of activity in 2010. Activity has increased in 2013 and 2014. The May through September period has shown the most consistent activity, with the largest increases occurring most recently in 2013 and 2014.

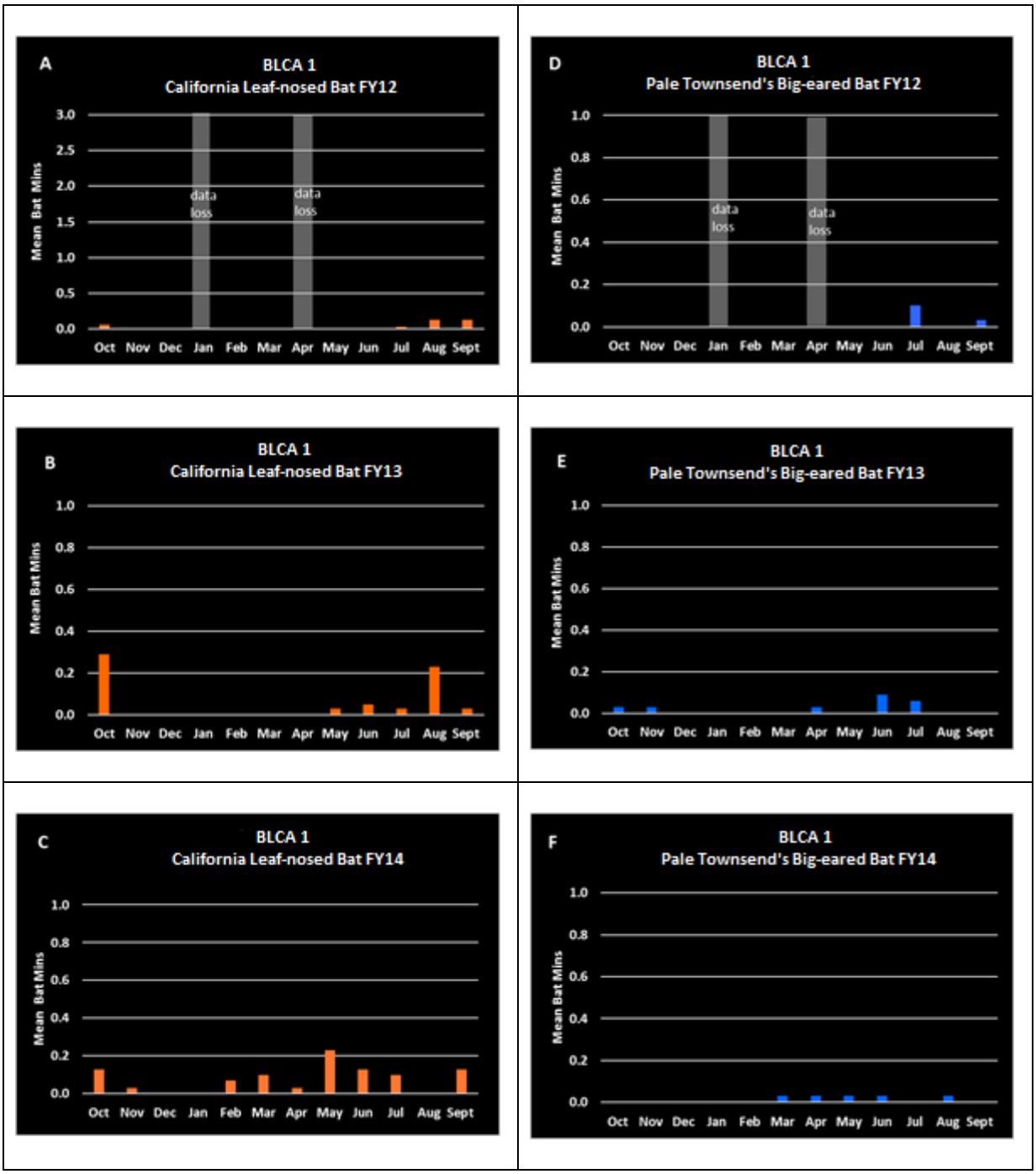


**Figure 23.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at BLCA 1, FY12–14.**

Table 3.—Total call minutes for western red bats at BLCA 1, FY08–14

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2008** | | | | | | | 0 | 0 | 1 | 3 | 0 | 0 |
| **2009** | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 2 | 3 | 22 |
| **2010** | 268 | 150 | 0 | 0 | 18 | 10 | 19 | 13 | 5 | 3 | | 5 |
| **2011** | | 1 | 9 | 1 | 1 | 1 | 0 | 10 | 16 | 5 | 10 | 12 |
| **2012** | 16 | 11 | 0 | 0 | 1 | 0 | 0 | 9 | 17 | 13 | 18 | 17 |
| **2013** | 41 | 82 | 15 | 3 | 4 | 35 | 35 | 46 | 43 | 50 | 79 | 32 |
| **2014** | 17 | 21 | 10 | 7 | 6 | 13 | 32 | 31 | 17 | 7 | 15 | 28 |

Table 4 summarizes western yellow bat total monthly minutes of activity at BLCA 1. This station has consistently shown the presence of western yellow bats during the winter period (December through February), with activity recorded from 2010 through 2014. Activity pulses in October were recorded for 2012 and 2013, possibly associated with fall migration. Western yellow bat activity has been recorded for the May through September period during all years, increasing in total call minutes in 2012 and 2013. However, there were declines in overall western yellow bat activity in 2014.

Table 4.—Total call minutes for western yellow bats at BLCA 1, FY08–14

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2008** | | | | | | | 0 | 1 | 0 | 9 | 2 | 2 |
| **2009** | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 1 | 0 | 0 |
| **2010** | 1 | 0 | 0 | 0 | 7 | 0 | 7 | 2 | 3 | 4 | | 0 |
| **2011** | | 0 | 0 | 3 | 1 | 2 | 0 | 2 | 2 | 2 | 1 | 0 |
| **2012** | 16 | 1 | 1 | 0 | 1 | 0 | 0 | 9 | 17 | 3 | 18 | 17 |
| **2013** | 9 | 3 | 0 | 2 | 1 | 7 | 13 | 9 | 8 | 16 | 19 | 3 |
| **2014** | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 8 | 3 | 0 | 1 | 4 |

## AKTP Acoustic Station

The station at the ‘Ahakhav Tribal Preserve was established on April 4, 2012. Data losses occurred in April 2013 and October and November 2014. The most complete dataset was for 2013 (figure 24 – charts A, B, and C). During 2013, western red bats were detected at the AKTP during October through March, with peaks in activity occurring in December and February. Note the y-axis scale differences between 2012 and 2014 compared to 2013. There was also winter western red bat activity in December through March for 2014, with a seasonal peak occurring in January. Western red bats were detected during the spring and summer months at the AKTP but at very low levels. No activity was recorded for September 2013 or 2014.

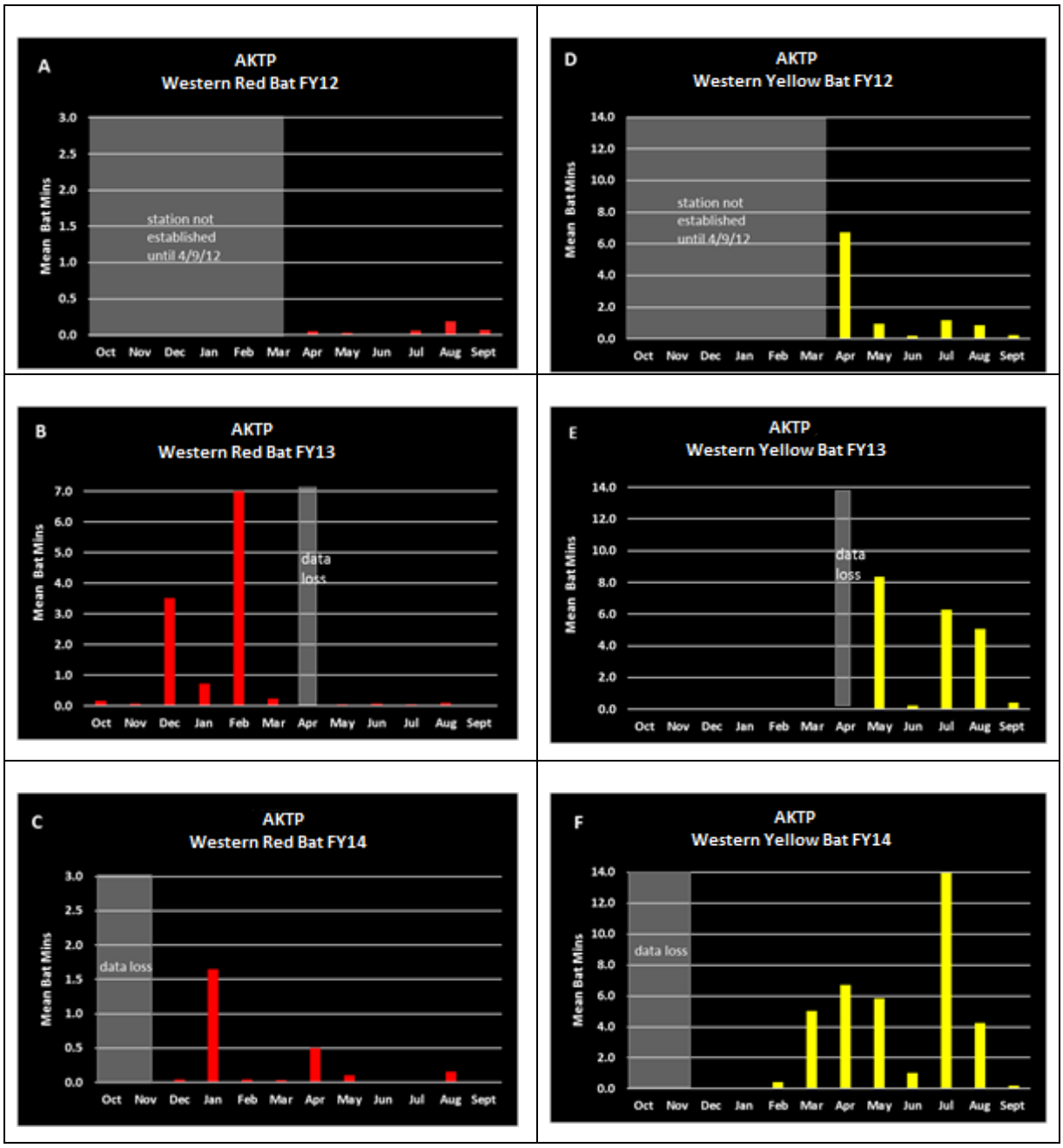


**Figure 24.—Seasonal activity for western red bats and western yellow bats at the AKTP, FY12–14.**

Note: The scales are different among the three years for western red bats.

Western yellow bats were detected at the AKTP during the spring and summer months of 2012 through 2014, with peak levels occurring in July 2014 (see figure 24 – charts D, E, and F). Western yellow bats were not recorded from October 2012 through March 2013 or December 2013 and January 2014, though one call was recorded during February 2014.

Figure 25 – charts A, B, and C show mean call minutes per night for 2012 through 2014 for California leaf-nosed bats. Mean call minutes were low but indicate that this species was present at the ‘Ahakhav Tribal Preserve from April through September 2012, 2013, and 2014, though the numbers are sporadic for August 2013 and 2014. California leaf-nosed bats were detected at the AKTP during winter, with low mean call minutes for December and February 2013. No calls were recorded in January 2013 or 2014. California leaf-nosed bats were detected during October and November 2013 at the AKTP.

Pale Townsend’s big-eared bats were detected sporadically at the AKTP from April through September for 2012 through 2014 (figure 25 – charts D, E, and F). There was no winter activity recorded during the 3-year period.

## PVER 1 Acoustic Station

Equipment malfunctions occurred during the October to March period for 2012 and the May through September period for 2014. The most complete dataset is from 2013, and it is the best indicator of western red and western yellow bat response to habitat growth at PVER 1, with the exception of the data loss in February 2013 (figure 26 – charts A, B, and C). Western red bats appear to be present year round at PVER 1. The overall amount of mean bat minutes are among the highest recorded for western red bats, only exceeded by CVCA 1. Western red bats showed an increase in mean call minutes for April through September between 2012 and 2013. Overwintering detections of western red bats remained fairly consistent from 2012 through 2013. Peak activity occurred in November and March 2013.

There was a large increase in activity for western yellow bats during the breeding season from 2012 to 2013. It was not possible to determine if these increases extended into 2014 due to equipment malfunction. There were slightly more detections in April 2014 compared to the previous 2 years.

Call minutes were sporadic for California leaf-nosed bats, with activity recorded only for August and September 2012. For 2013, only November, December, June, August, and September had calls detected. In 2014, October, November and March had light levels of activity (figure 27 – charts A, B, and C). Common patterns were the August and September activity period recorded for both 2012 and 2013 and the November period recorded in 2013 and 2014.

Call minutes were also sporadic for pale Townsend’s big-eared bats, with call minutes recorded for late spring through summer for 2012 and 2013 and February and April recorded for 2014 (figure 27 – charts D, E, and F).

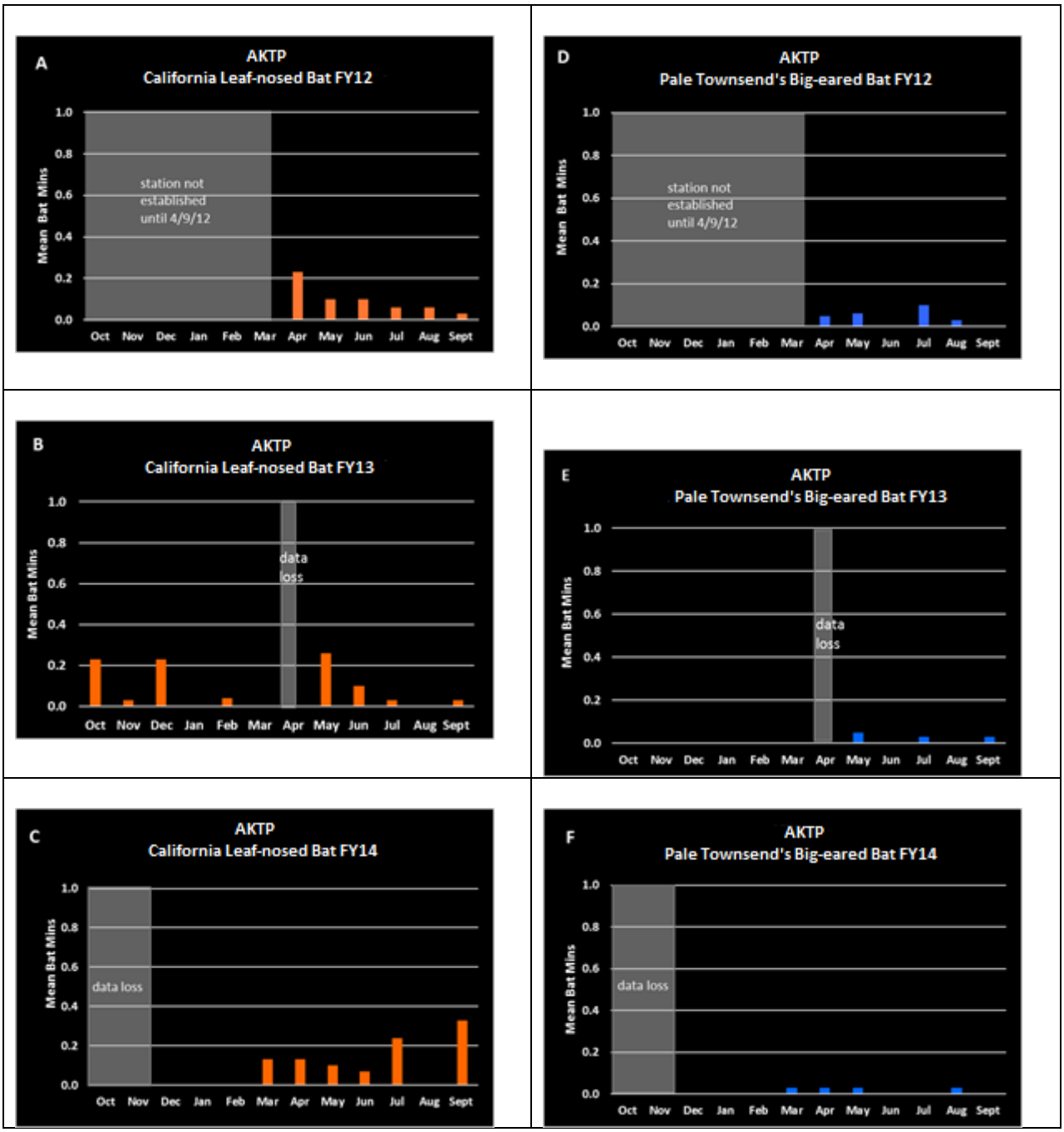


**Figure 25.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at the AKTP, FY12–14.**

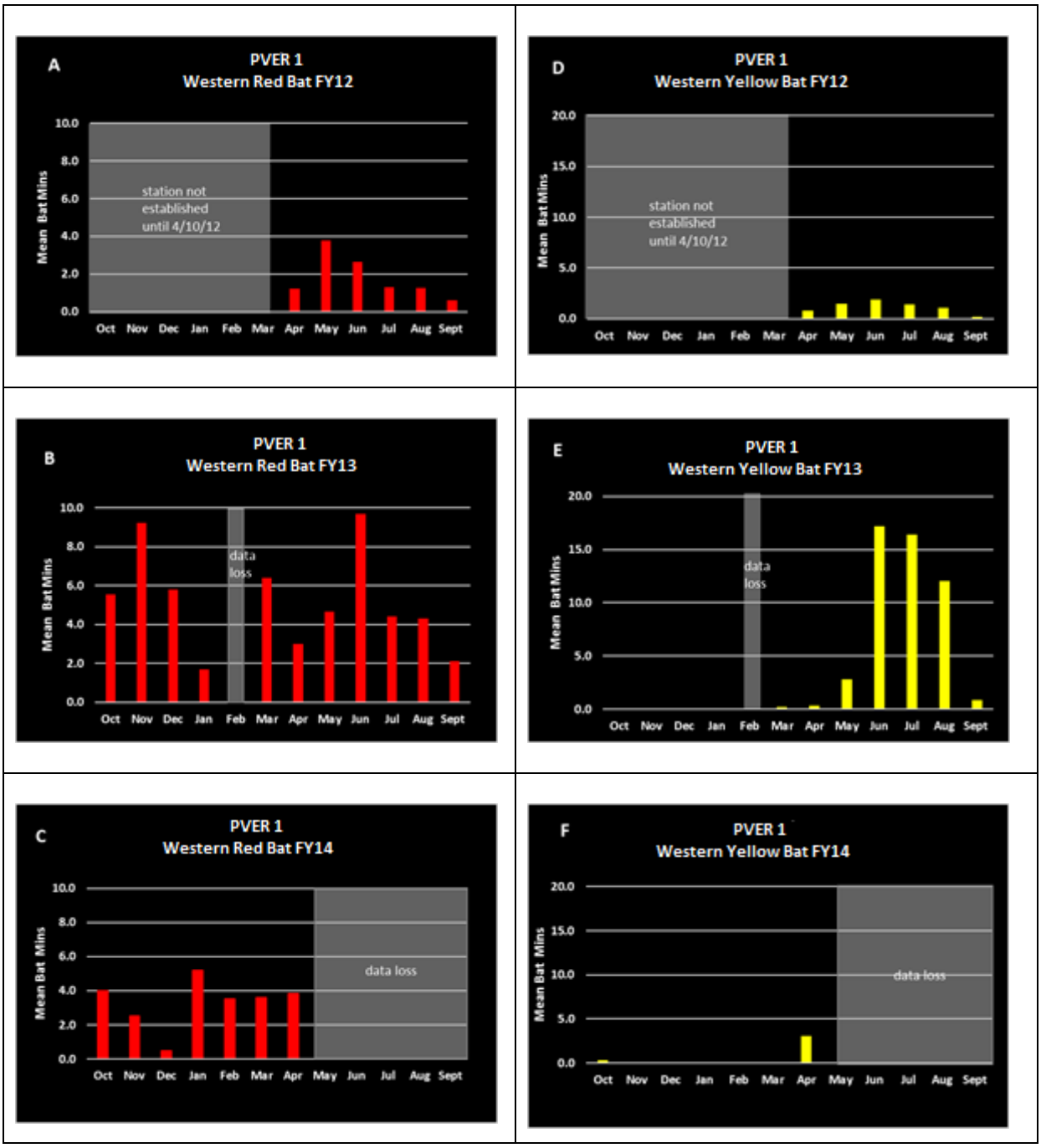


**Figure 26.—Seasonal activity for western red bats and western yellow bats at PVER 1, FY12–14.**

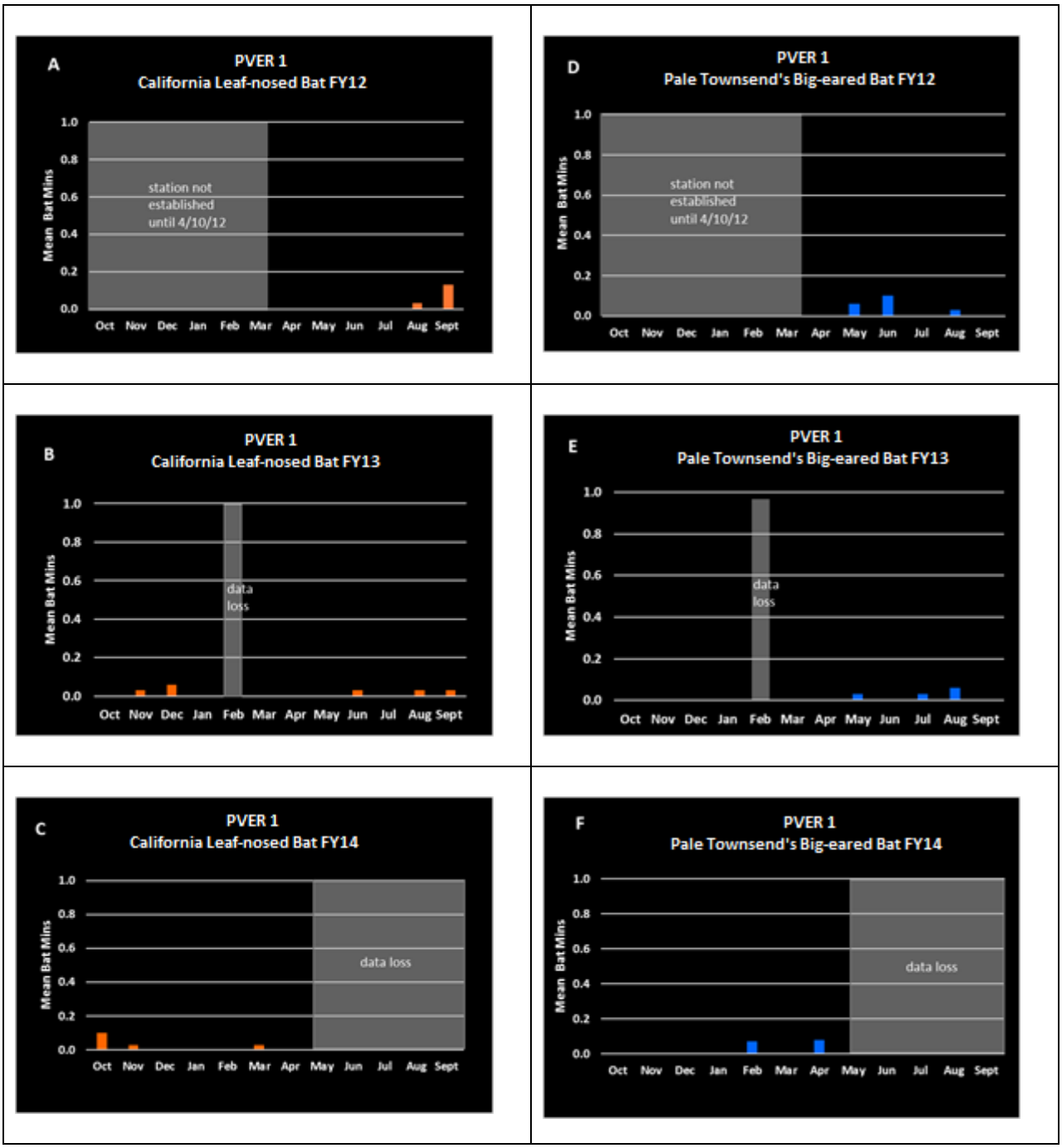


**Figure 27.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at PVER 1, FY12–14.**

## PVER 2 Acoustic Station

PVER 2, established on March 15, 2013, operated well, with the exception of data losses in October 2014. In 2013, both western red and western yellow bat activity was similar, beginning at a low level in March and continuing through the spring and summer months at a very low level (figure 28 – charts A–D).

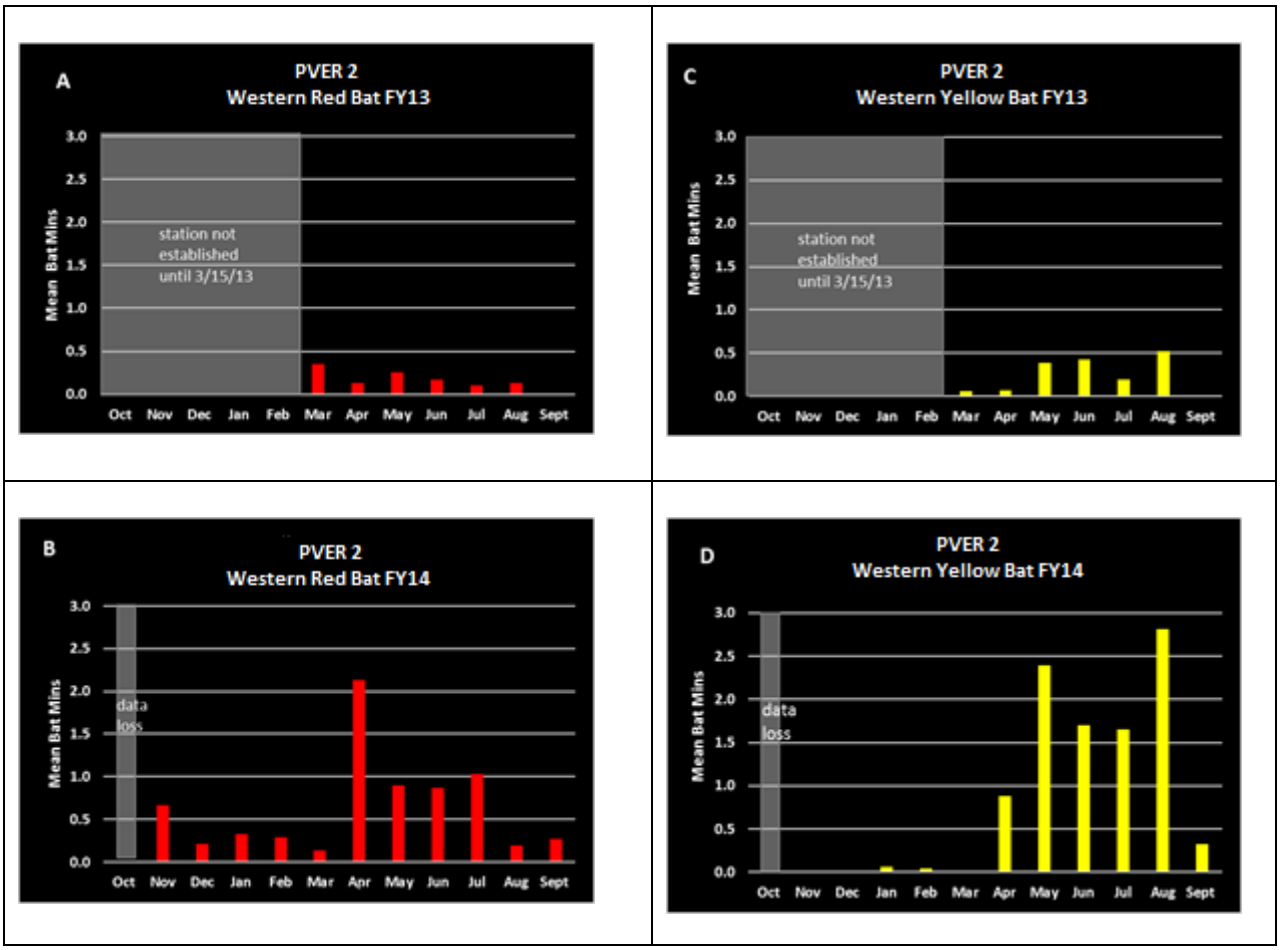


**Figure 28.—Seasonal activity for western red bats and western yellow bats at PVER 2, FY13–14.**

There was increased bat activity April through September 2014 for both western red and western yellow bats. As at PVER 1, there was a low level of overwintering western red bat activity. There was an indication of wintering western yellow bat activity during January and February.

Low levels of California leaf-nosed bat were detected at PVER 2 during May and July 2013. Call minutes increased in 2014, with detections recorded for April and May, and July, and August (figure 29 – charts A and B). A single call minute was recorded in June 2013 for pale Townsend's big-eared bat at PVER 2, and two call minutes were recorded in 2014 – one in May and one in June (figure 29 – charts C and D).

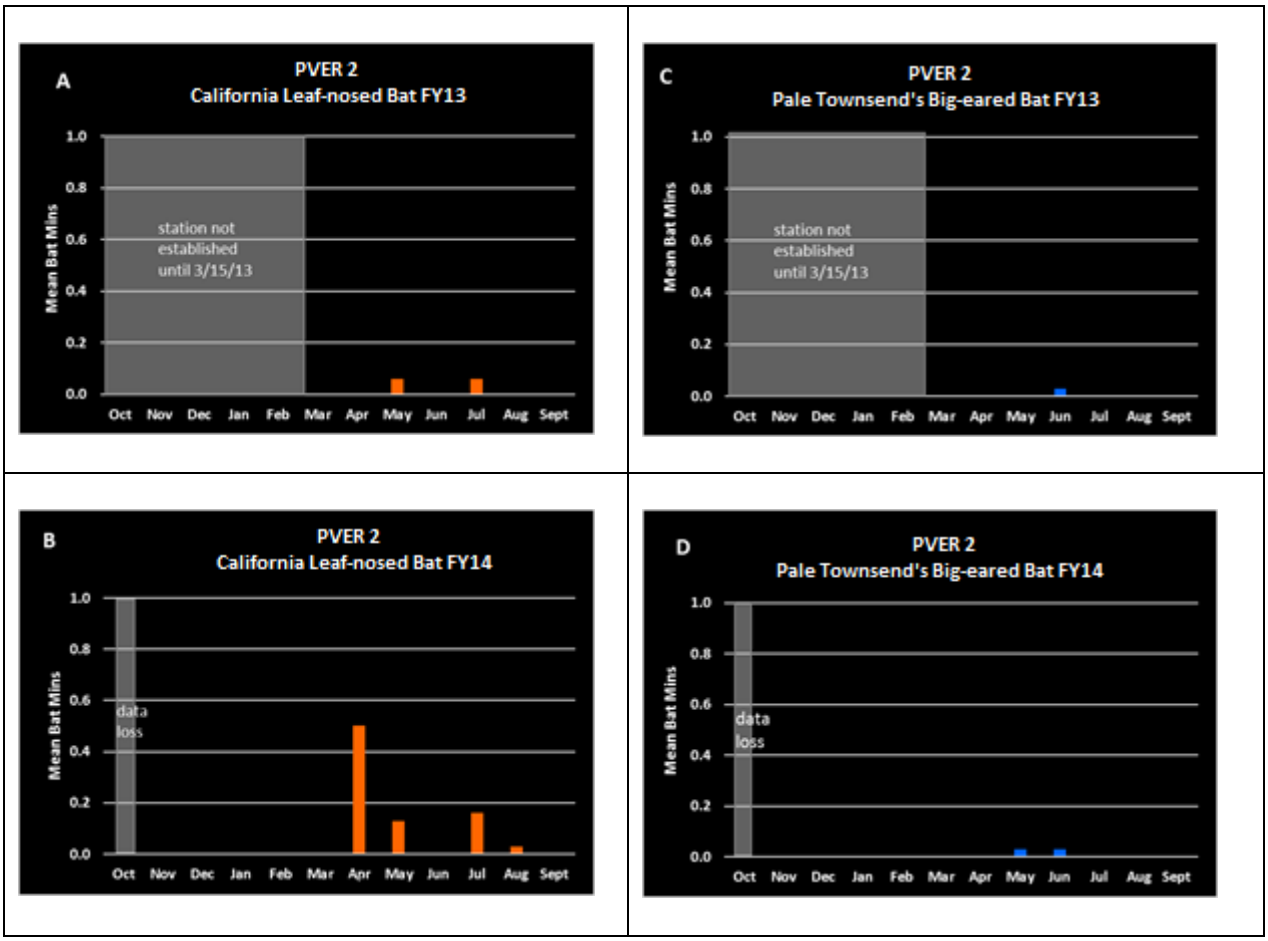


**Figure 29.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at PVER 2, FY13–14.**

## CVCA 1 Acoustic Station

CVCA 1 operated well during the 3-year monitoring period, providing an excellent dataset. Overall, western red bats were detected year round at CVCA 1, with peak activity occurring during February and March 2012 and March 2013. Western red bat activity during the spring, summer, and fall months was fairly consistent from 2012 to 2013; however, overall year-round activity declined in 2014 (figure 30 – charts A, B, and C).

Western yellow bats were consistently detected at CVCA 1 from April through September during all three years. A small amount of activity was also recorded for October for this 3-year period. A consistent pattern observed for 2013 and 2014 consisted of relatively low mean bats per minutes in April, May, and June, followed by a very large increase in mean minutes for July and August. September was lower for both years. Overall spring and summer bat activity increased in 2013 and 2014 over 2012 levels (figure 30 – charts D, E, and F).

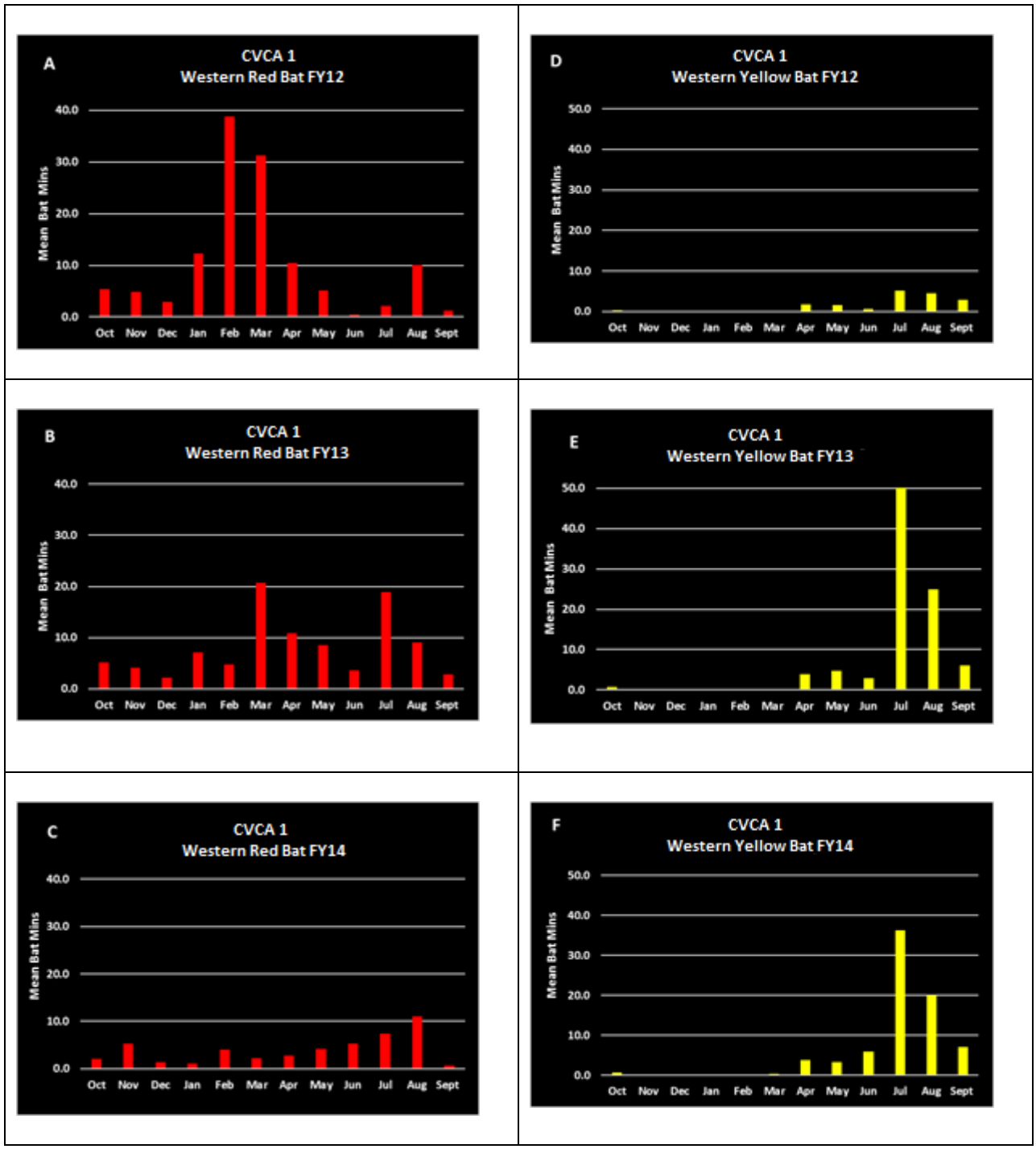


**Figure 30.—Seasonal activity for western red bats and western yellow bats at CVCA 1, FY12–14.**

California leaf-nosed bats were detected year round at CVCA 1 in 2012. This pattern continued in 2013 and 2014, though call minutes were more sporadic. There were no call minutes for January and February 2013, and no call minutes for December and April to June, 2014. Activity in 2013 and 2014 was more sporadic, with no calls detected January and February 2013 and December, April, May, and June for 2014 (figure 31 – charts A, B, and C).

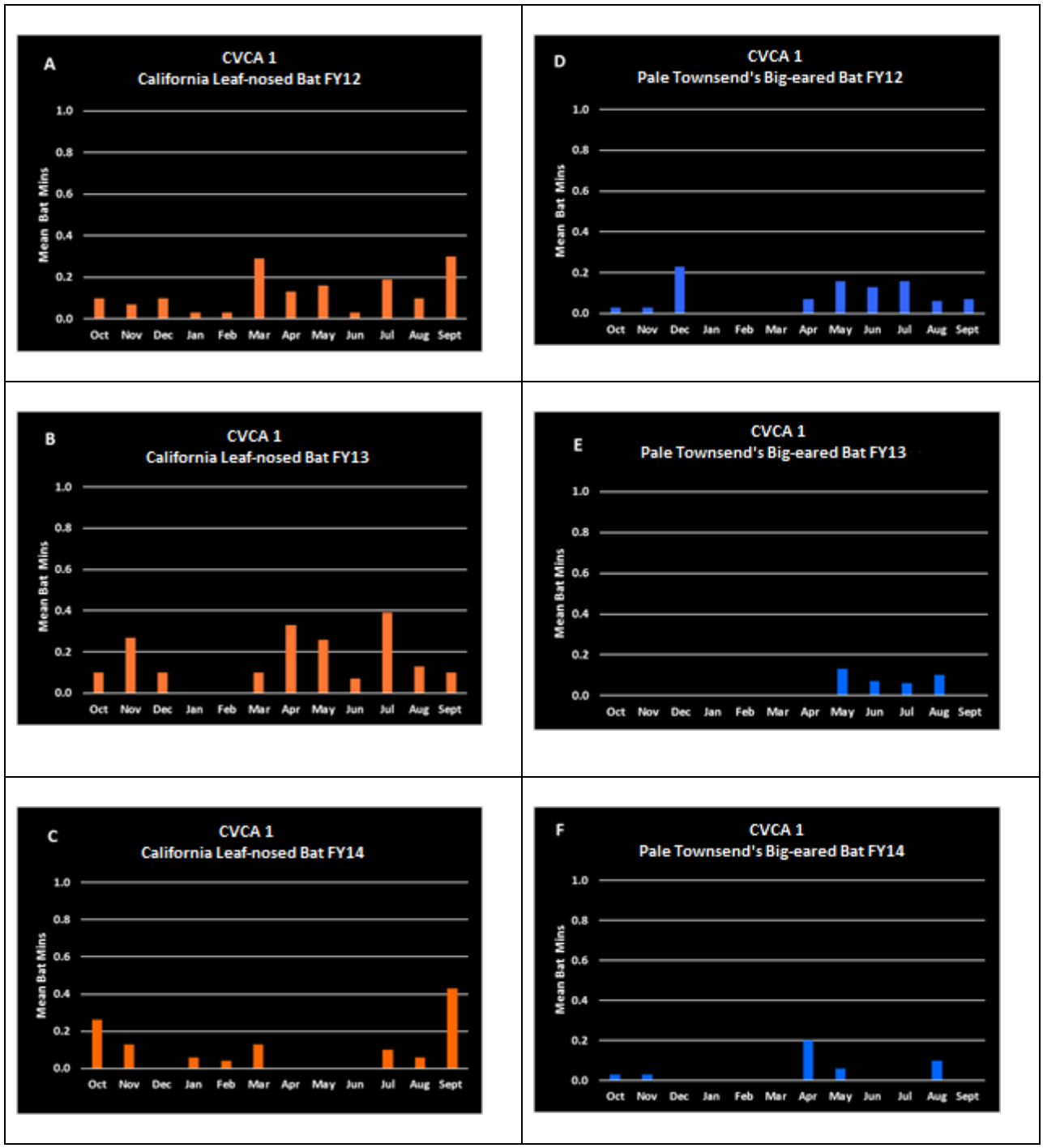


**Figure 31.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at CVCA 1, FY12–14.**

Pale Townsend's big-eared bats were detected at CVCA 1 year round in 2012. Activity became somewhat more sporadic in 2013 and 2014, with no calls recorded in winter (see figure 31 – charts D, E, and F).

## CVCA 2 Acoustic Station

CVCA 2 was established in July 2013, operating well through the end of 2014. Western red bats were detected year round at CVCA 2, with call minutes recorded for every month that the station was running. The lowest activity occurred in January and February and again in June and July. Peak activity occurred in October 2014 (figure 32 – charts A and B).

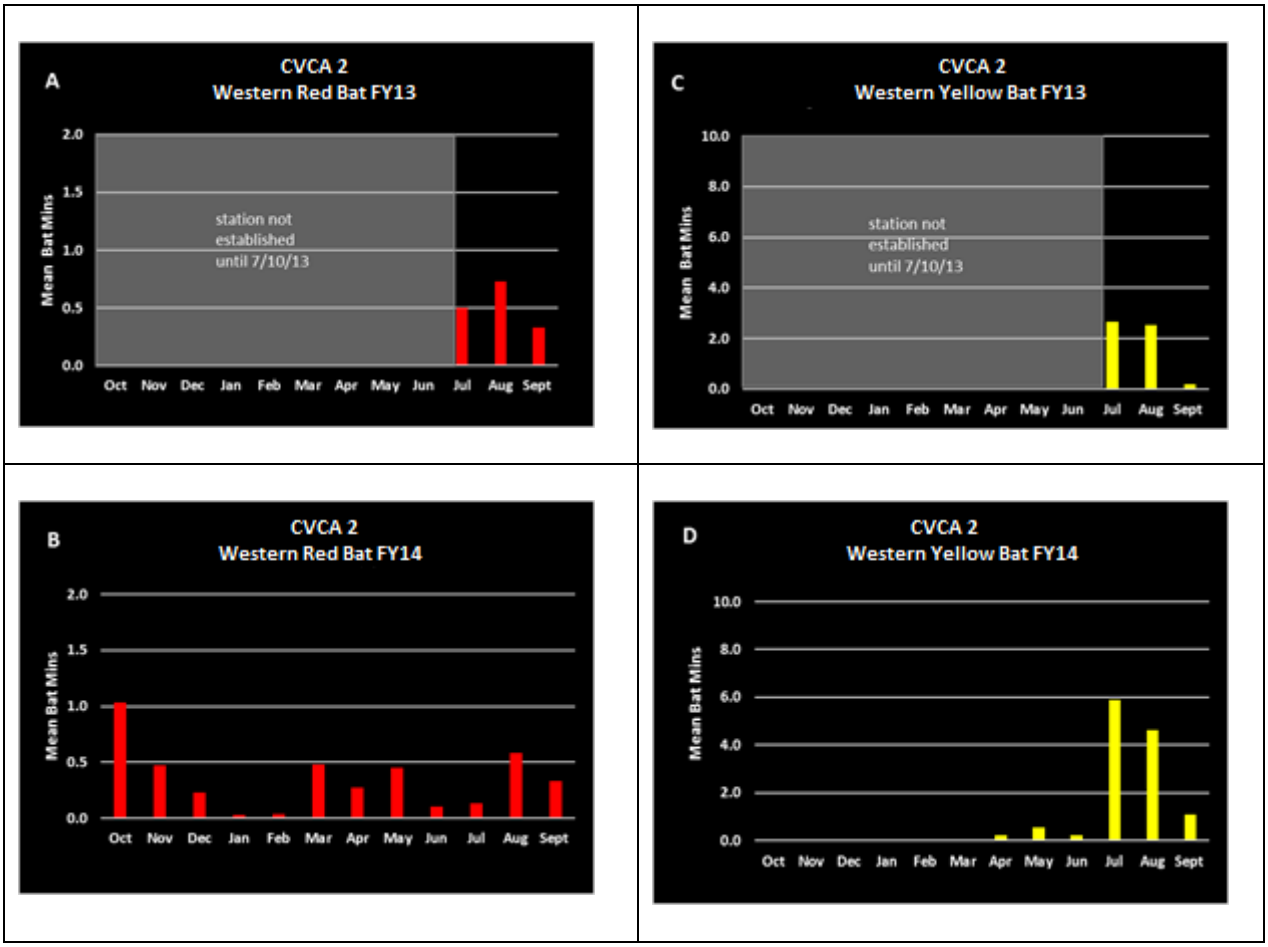


**Figure 32.—Seasonal activity for western red bats and western yellow bats at CVCA 2, FY13—14.**
Note: The scales are different between western red and western yellow call minutes.

Overall, there was higher bat activity for western yellow bats during the July through September 2013 period than for western red bats at CVCA 2. Similar to CVCA 1, there was no wintering western yellow bat activity from October through March (see figure 32 – charts C and D).

California leaf-nosed bat calls were consistently recorded every month that the station was operational, with the exception of December 2014 (figure 33 – charts A and B).

Pale Townsend's big-eared bat calls were detected sporadically in 2013 (July and August) and in 2014 (October, May and July) (figure 37 – charts C and D).

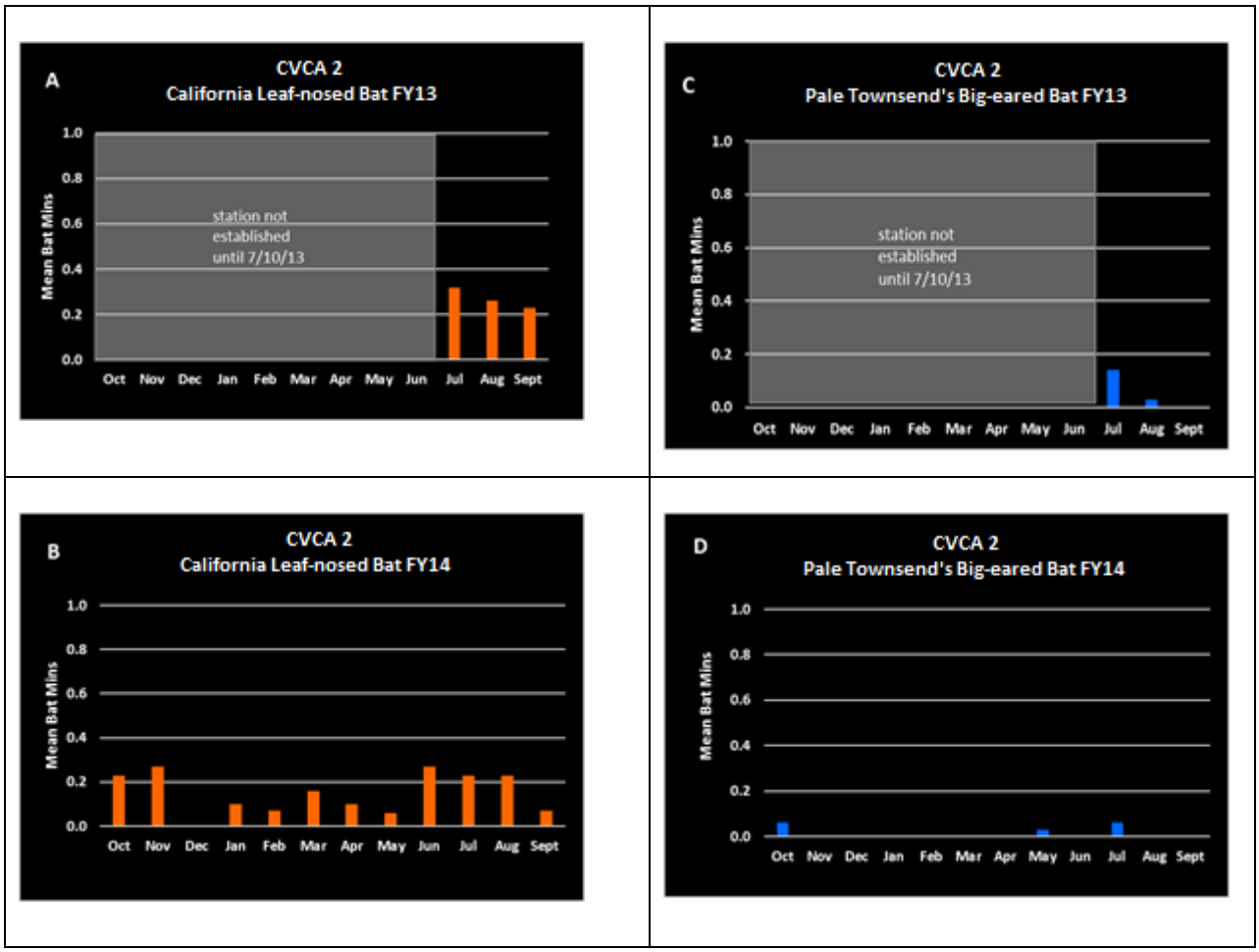


**Figure 33.—Seasonal activity for California leaf-nosed bats and pale Townsend's Big-eared bats at CVCA 2, FY12–14.**

## Crane's Roost Acoustic Station

Western red bat acoustic activity was extremely low for 2012 (figure 34 – charts A, B, and C). This relatively poor performance prompted the idea that possibly the station's location was contributing to the low bat call recordings. An ideal site was selected in a flyway adjacent to a maturing stand of cottonwoods. This site had a greater number of canopy layers and number of small openings than the relatively even-age monoculture at the original location. The station was relocated in July 2013. However, in 2013, western red bat calls picked up substantially, with mean call minutes per night peaking in February and March – well before the station was relocated.

In retrospect, it appears that both station sites were in adequate locations to capture western red bat activity that occurred at this conservation area. For example, high numbers of red bat minutes and lower numbers of western yellow bat minutes were recorded in 2011 as soon as the station was established on April 1, 2011 (Broderick 2013). Regardless of the location history of the acoustic monitoring station, red bats calls were recorded year round in 2013 and in 2014. Peak activity occurred in February and March 2013 and in April 2014.

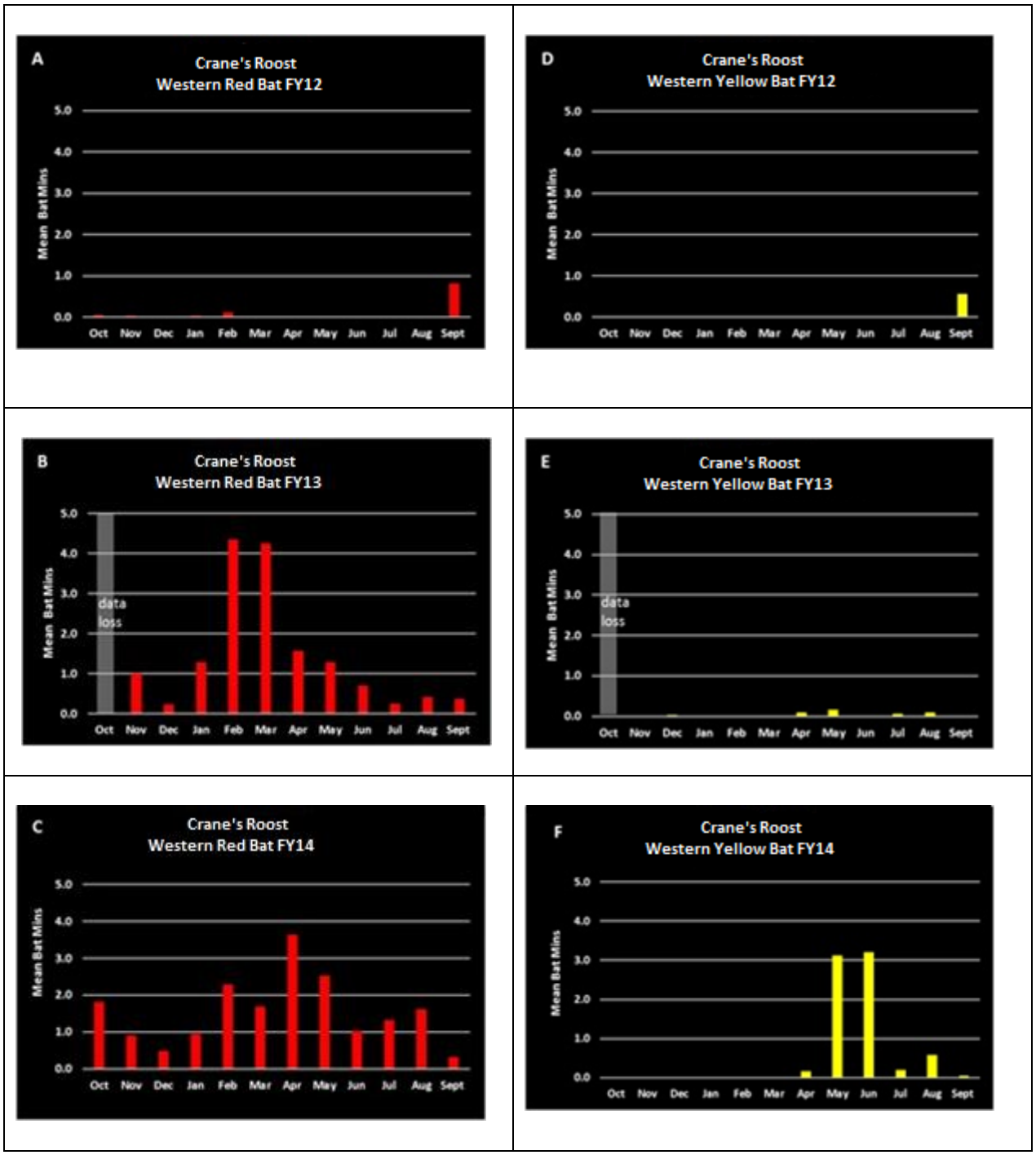


**Figure 34.—Seasonal activity for western red bats and western yellow bats at Crane's Roost, FY12–14.**

Western yellow bats present a completely different scenario (see figure 34 – charts D, E, and F). There were extremely low levels of western yellow bat activity in both 2012 and 2013. Overall activity increased in 2014, with calls recorded April through September. Peak activity occurred in May and June.

Low levels of activity occurred sporadically throughout 2012 for California leaf-nosed bats. Activity increased in 2013 and 2014, with activity occurring year round, except for November and December of both years (figure 35 – charts A, B, and C).

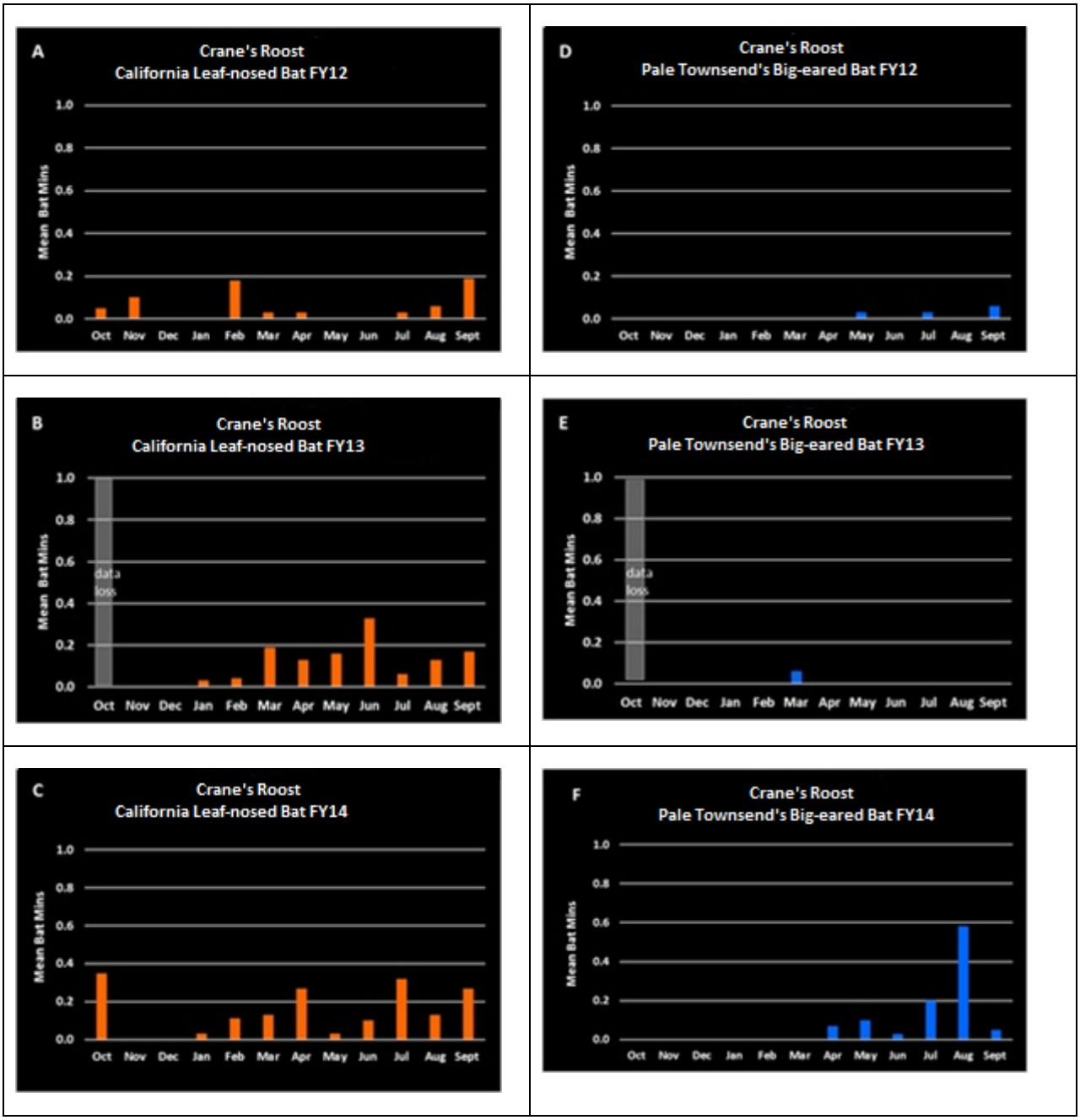


**Figure 35.—Seasonal activity for California leaf-nosed bats and pale Townsend's Big-eared bats at Crane's Roost, FY12–14.**

There were very low levels of pale Townsend's big-eared bat activity in 2012 for May, July, and September. Activity in 2013 consisted of a single call minute recorded in March. Activity in 2014 increased slightly, with call minutes recorded for April through September (see figure 35 – charts D, E, and F).

## YEW 1 Acoustic Station

YEW 1, established in September 11, 2013, worked well for that month, but persistent equipment malfunctions resulted in data losses from October 2013 through April 2014 (figure 36).

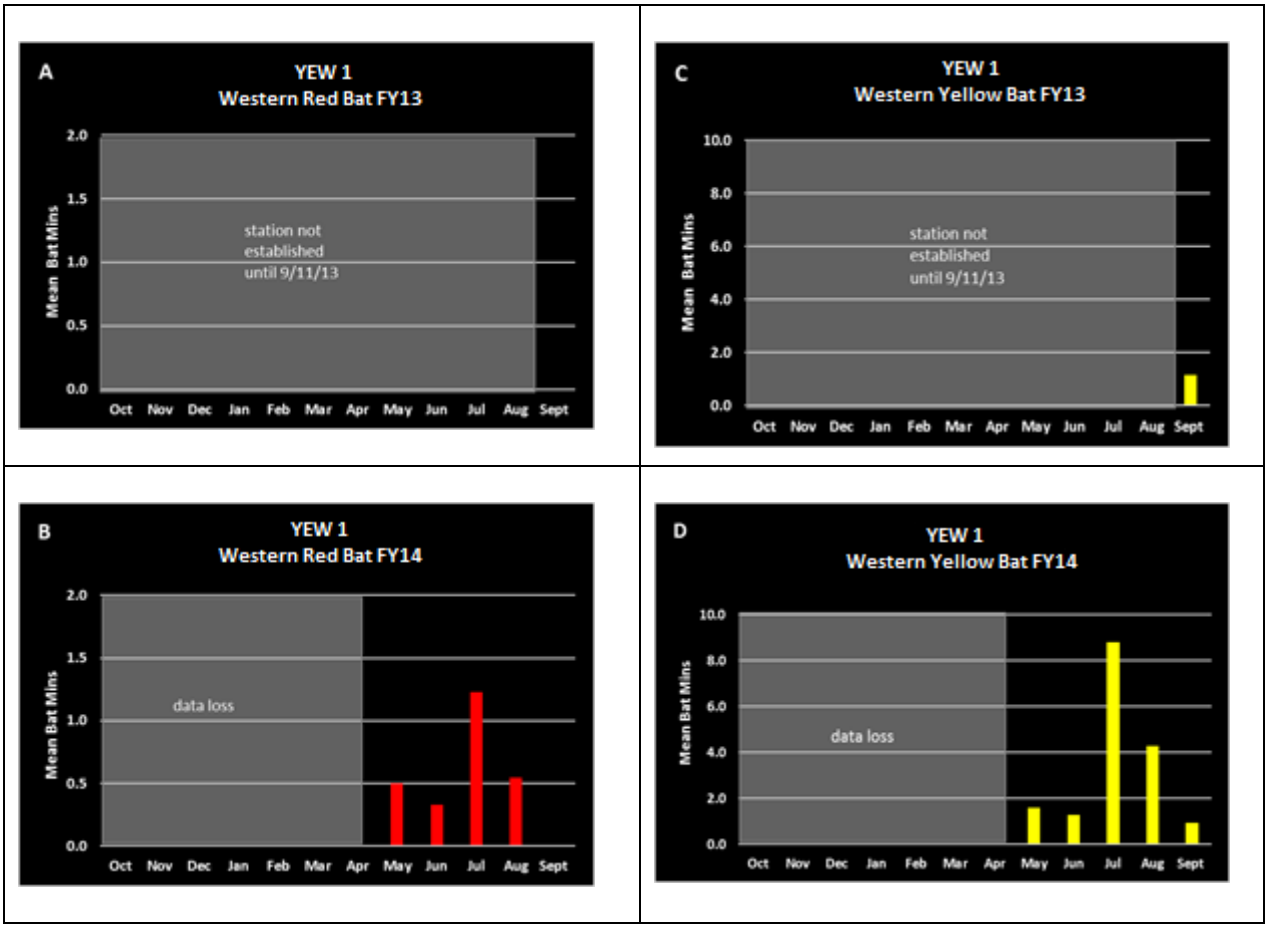


**Figure 36.—Seasonal activity for western red bats and western yellow bats at YEW 1, FY13–14.**
Note: The scales are different between western red and western yellow bats.

No western red bat calls were recorded in September 2013. When the station was repaired, a low level of red bat activity was detected for May through August 2014 (see figure 36 – charts A and B).

An overall higher level of activity was recorded for western yellow bats (note the differences in the y-axis scales.) Western yellow bats were recorded at Yuma East Wetlands during September 2013 and were recorded again in 2014 as soon as the station was repaired. Western yellow bats were present from May through September, with peak activity occurring in July (see figure 36 – charts C and D).

Bat calls were recorded for California leaf-nosed bats and pale Townsend's big-eared bats every month that the station was operational except September 2013

and September 2014 (figure 37). Peak activity for California leaf-nosed bats occurred in September 2013 and in July 2014. Peak activity for pale Townsend's big-eared bat occurred in September 2014. A low level of activity was recorded June through September 2014.

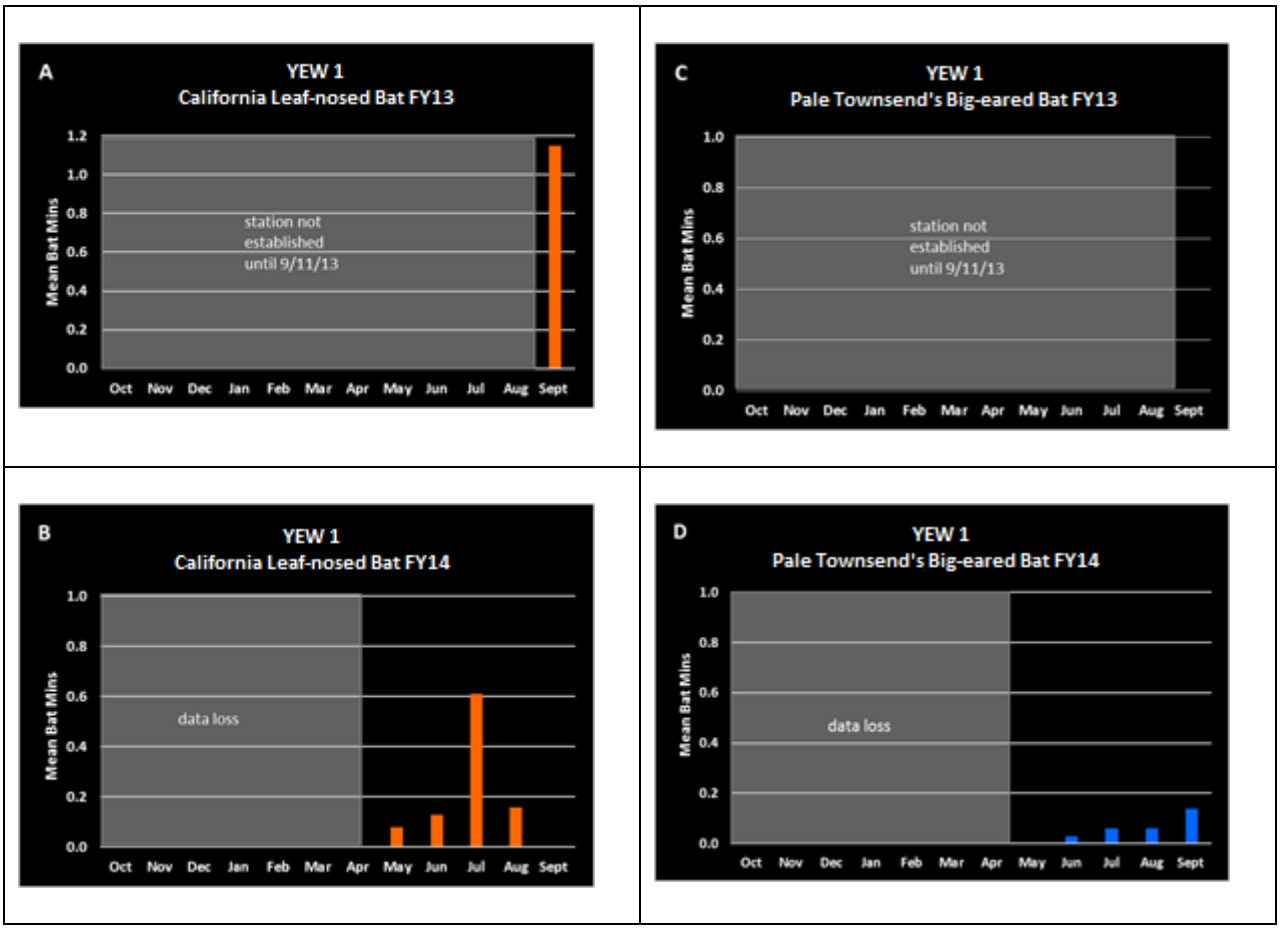


**Figure 37.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at YEW 1, FY13–14.**

## HHCA Acoustic Station

The station at Hunters Hole, established April 8, 2013, operated well through the 2-year monitoring period. In 2013, western red bats were detected at low levels during the spring and summer months, with the exception of August, when no activity was recorded (figure 38 – charts A and B).

Western yellow bat activity was recorded as soon as the station became operational in April 2013 and continued through September 2013. A similar pattern of western yellow bat activity was recorded during spring and summer 2014. There was no western yellow bat activity from November 2013 through January 2014. Activity picked up at very low levels in February and March. Spring and summer activity increased beginning in April and peaked in August (figure 38 – charts C and D).

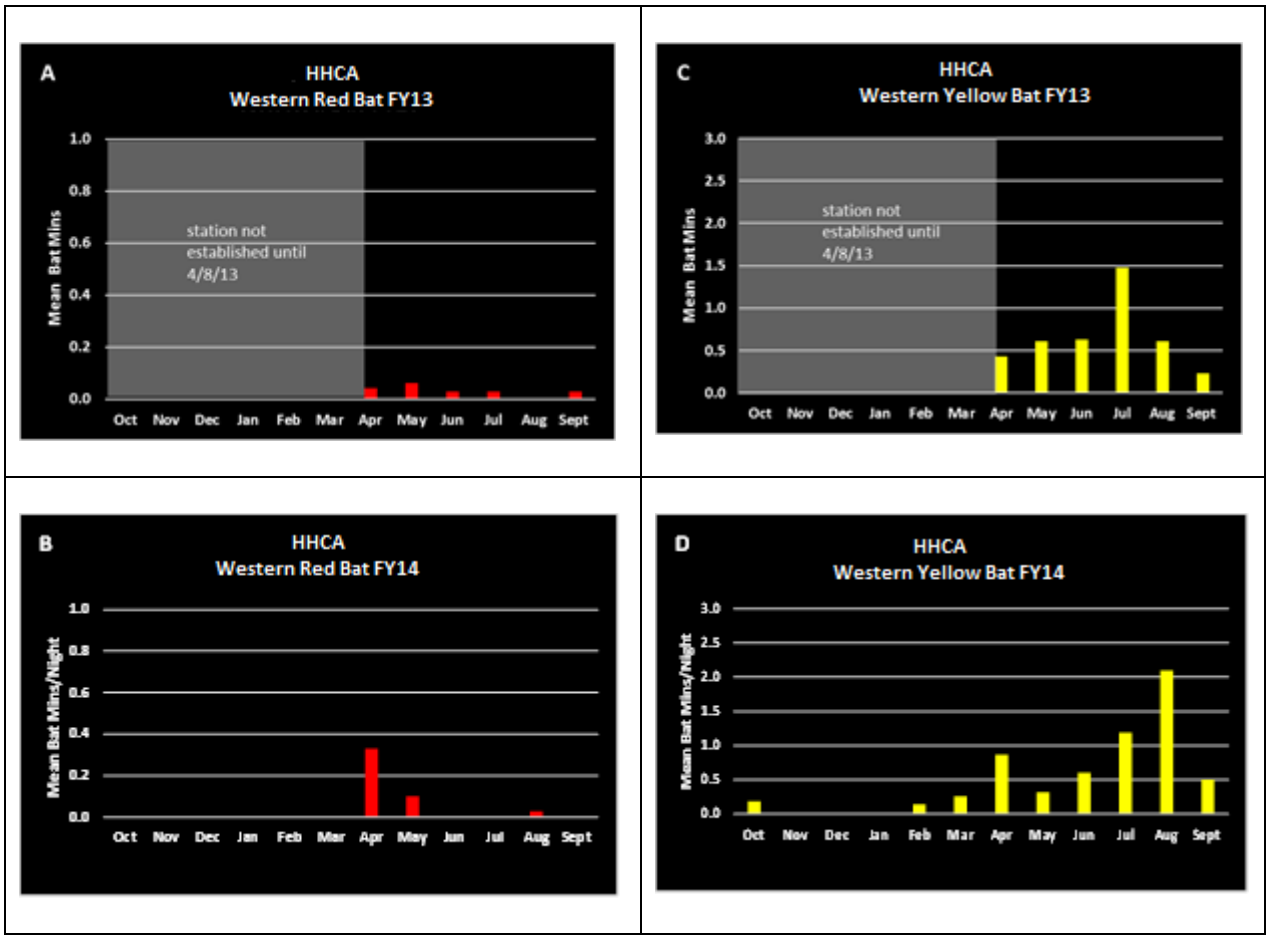


**Figure 38.—Seasonal activity for western red bats and western yellow bats at the HHCA, FY13–14.**

Acoustic monitoring at Hunters Hole resulted in no California leaf-nose bat activity detected for 2013 or 2014 (figure 39 – charts A and B). Only one pale Townsend's big-eared bat call was recorded at Hunters Hole in July (figure 39 – charts C and D).

## Species of Management Interest

To supplement the understanding of how the covered and evaluation species are responding to cottonwood-willow and honey mesquite plantings, five additional bat species are included in the results for 2014, including: Arizona myotis (*Myotis occultus*), cave myotis (*Myotis velifer*), hoary bat (*Lasiurus cinereus*), western mastiff bat (*Eumops perotis*), and pocketed free-tailed bat (*Nyctinomops femorosaccus*).

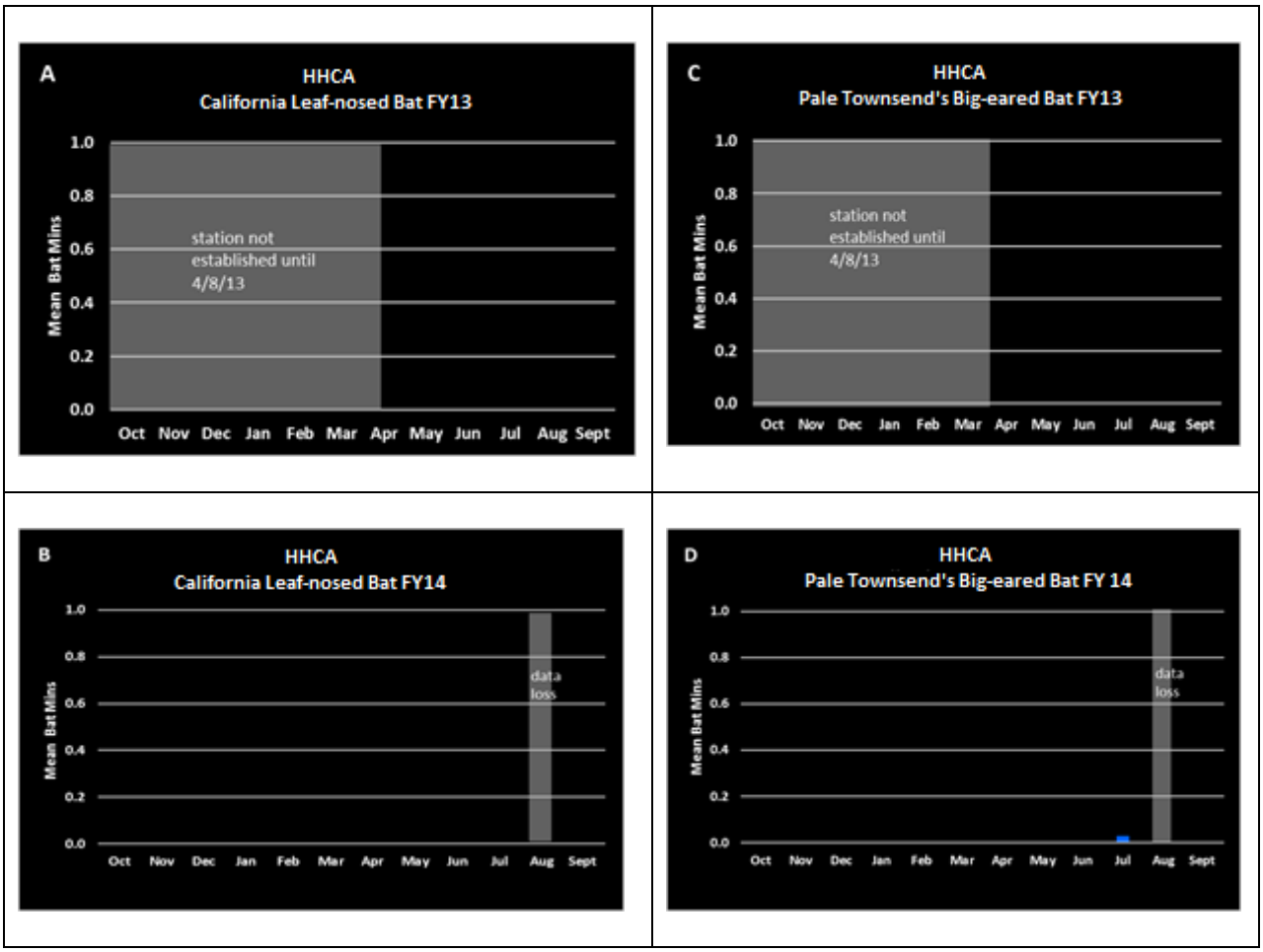


**Figure 39.—Seasonal activity for California leaf-nosed bats and pale Townsend's big-eared bats at the HHCA, FY13–14.**

In the desert habitats along the LCR, Arizona myotis and cave myotis are riparian specialists (Arizona Game and Fish Department 2016; Reid 1997; Calvert and Neiswenter 2012). Arizona myotis are primarily found over water or near water or in riparian forests in desert areas. This species, long thought to be extirpated from the LCR, was captured during mist netting during 2007–10 (Calvert and Neiswenter 2012). Cave myotis are found in riparian habitats near desert scrub in lower elevations (Reid 1997). At some habitat monitoring areas, activity (as measured by the number of call minutes) is very high for both of these riparian specialists, and monitoring these bats can provide good quality additional data for looking at whether riparian specialist bat species are active in the monitoring areas.

Results are presented in the following tables. The total minutes of bat activity are shown for each species for all nine monitoring areas for each month for 2014. Note that blank cells within the tables indicate equipment malfunction resulting in data loss for that month.

## Cave Myotis

Table 5 summarizes the total call minutes for cave myotis for FY14. The cave myotis is detected throughout the monitoring sites, with the exception of YEW 1 and the HHCA. The highest activity levels were recorded at CVCA 1 (735 total minutes), the AKTP (615 total minutes), CVCA 2 (511 total minutes), and the BLCA 1 (477 total minutes). Peak activity occurred in July and August. The cave myotis is a migratory species and is absent during mid-October through late April. The cave myotis is considered to be an indicator species of good cottonwood riparian habitat. This species is included in roost surveys to provide another measure of the success of the LCR MSCP revegetation projects (Brown 2010).

Table 5.—Total call minutes for cave myotis in FY14 at the nine acoustic monitoring stations

| | BLCA 1 | AKTP | PVER 1 | PVER 2 | CVCA 1 | CVCA 2 | Crane's Roost | YEW | HHCA |
|---|---|---|---|---|---|---|---|---|---|
| Oct. | 4 | | 6 | | 3 | 0 | 0 | | 0 |
| Nov. | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| Dec. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Jan. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Feb. | 4 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Mar. | 7 | 0 | 0 | 0 | 0 | 1 | 0 | | 0 |
| Apr. | 11 | 21 | 5 | 3 | 0 | 4 | 1 | | 0 |
| May | 69 | 119 | | 28 | 25 | 25 | 16 | 0 | 0 |
| June | 236 | 153 | | 25 | 37 | 129 | 61 | 0 | 0 |
| July | 99 | 212 | | 50 | 316 | 295 | 9 | 0 | 0 |
| Aug. | 11 | 102 | | 25 | 288 | 1 | 2 | 0 | 0 |
| Sept. | 36 | 8 | 0 | 15 | 66 | 56 | 1 | 0 | 0 |
| **Total** | **477** | **615** | **11** | **146** | **735** | **511** | **90** | **0** | **0** |

## Arizona Myotis

Table 6 summarizes total monthly call minutes for the Arizona myotis for FY14. A new and rigorous set of call identification guidelines were developed to reduce and hopefully eliminate misidentification with the similar calls of the cave myotis. The Arizona myotis calls at the 'Ahakhav Tribal Preserve are very characteristic and provide a good baseline from which to compare similar calls at other sites. This species was long thought to be extirpated from the LCR, but the use of mist netting conducted as part of the post-development bat monitoring program routinely resulted in the capture of this species. This is the only location along the LCR where this species is regularly captured (Calvert and Neiswenter 2012).

Table 6.—Total call minutes for Arizona myotis in FY14 at the nine acoustic monitoring stations

| | BLCA 1 | AKTP | PVER 1 | PVER 2 | CVCA 1 | CVCA 2 | Crane's Roost | YEW 1 | HHCA |
|---|---|---|---|---|---|---|---|---|---|
| Oct. | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| Nov. | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| Dec. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Jan. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Feb. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Mar. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Apr. | 0 | 45 | 0 | 0 | 0 | 0 | 0 | | 0 |
| May | 0 | 248 | | 0 | 0 | 0 | 0 | 0 | 0 |
| June | 0 | 99 | | 0 | 0 | 1 | 0 | 0 | 0 |
| July | 0 | 194 | | 0 | 0 | 1 | 0 | 0 | 0 |
| Aug. | 0 | 203 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Sept. | 1 | 6 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **1** | **795** | **2** | **1** | **0** | **2** | **0** | **0** | **0** |

This unique location for the Arizona myotis is further confirmed by acoustic monitoring. A large number of minutes of bat activity (795 total minutes) were recorded for this species at the AKTP. On the other hand, BLCA 1, PVER 1, PVER 2, and CVCA 2 only had 1 to 2 minutes of activity during the same time period. Peak Arizona myotis activity at the AKTP occurred late spring through August. The Arizona myotis is also migratory and is not present at sites along the LCR from October through March. Migrants begin being detected at the station in April.

Though the Arizona myotis is not an LCR MSCP species, it may be a good indicator of foraging and potentially roosting habitat quality. In other parts of its range, the Arizona myotis roosts under loose bark in mature cottonwoods and other tree species (Chung-MacCoubrey 1999). Historically, it was found along the LCR and was regularly captured by Grinnell (1914). With the increase of habitat conservation areas along the river, this species may begin to use other areas (Calvert, in press).

## Hoary Bat

The hoary bat is one of four lasurine tree-roosting bats in Arizona along with the western yellow bat, western red bat, and silver-haired bat (*Lasionycteris noctivans)*. The hoary bat prefers forests and woodlands, roosting primarily

among foliage in trees. Its response to riparian habitat plantings can help to clarify how lasurine bats in general respond to increasing acreage of cottonwood-willow and honey mesquite.

Table 7 summarizes the total call minutes for the hoary bat for FY14. This species was detected at all of the monitoring stations except YEW. The most activity was recorded at CVCA 1 (2,080 total minutes), with peak activity focusing on the months of October, November, and December.

Table 7.—Total call minutes hoary bats in 2014 at the nine acoustic monitoring stations

| | BLCA 1 | AKTP | PVER 1 | PVER 2 | CVCA 1 | CVCA 2 | Crane's Roost | YEW 1 | HHCA |
|---|---|---|---|---|---|---|---|---|---|
| Oct. | 12 | | 244 | | 614 | 27 | 49 | | 0 |
| Nov. | 0 | | 92 | | 759 | 4 | 2 | | 0 |
| Dec. | 27 | 1 | 40 | 1 | 346 | 0 | 2 | | 40 |
| Jan. | 11 | 0 | 14 | 25 | 9 | 4 | 2 | | 1 |
| Feb. | 1 | 3 | 22 | 7 | 8 | 0 | 0 | | 3 |
| Mar. | 4 | 14 | 21 | 2 | 35 | 0 | 11 | | 3 |
| Apr. | 21 | 28 | 16 | 2 | 135 | 5 | 8 | | 10 |
| May | 8 | 18 | | 6 | 19 | 1 | 6 | 0 | 0 |
| June | 0 | 1 | | 5 | 9 | 0 | 0 | 0 | 0 |
| July | 1 | 1 | | 0 | 6 | 1 | 0 | 0 | 0 |
| Aug. | 1 | 4 | | 3 | 58 | 7 | 0 | 0 | 0 |
| Sept. | 11 | 17 | | 4 | 82 | 4 | 1 | 0 | 0 |
| **Total** | **97** | **87** | **449** | **55** | **2,080** | **53** | **81** | **0** | **57** |

It appears that CVCA 1 serves both as migration habitat as well as wintering habitat for the hoary bat for at least the early part of winter. A few minutes of activity was recorded for January through March at this site. Hoary bats at PVER 1 also had a high level of bat activity (449 total minutes), with peak activity occurring in October and November. Data losses occurred from May through September. Moderate activity levels were recorded at the BLCA 1 (97 total minutes), the AKTP (87 total minutes), PVER 2 (55 total minutes), CVCA 2 (53 total minutes), Crane's Roost (81 total minutes), and the HHCA (57 total minutes).

Peak winter activity was recorded at the BLCA 1 and HHCA in December. Activity pulses possibly linked to migration were recorded in October at BLCA 1, PVER 1, CVCA 1, CVCA 2, and Crane's Roost and in spring in April at BLCA 1, the AKTP, PVER 1, CVCA 1, Crane's Roost, and the HHCA.

## Western Mastiff Bat

The western mastiff bat is one of four molossid bat species in California and Arizona along with the pocketed free-tailed bat, Mexican free-tailed bat (*Tadarida brasiliensis*), and the big free-tailed bat (*Nyctinomops macrotis*). Molossids have long, slender wings adapted for rapid, prolonged flight in open areas and are the fastest flying bat species in North America (Best et al. 1996; Western Bat Working Group 2016). Much of the western mastiff bat's foraging is within 1 meter (3.3 feet) of the ground to treetop level, but it can also forage on insects carried as high as 1,000 meters (3,280 feet) by air currents (Best et al. 1996). Although it can enter daily torpor, the western mastiff bat does not hibernate and may be active year round (Best et al. 1996; Leitner 1966). Monitoring data on this species as well as the pocketed free-tailed bat discussed below can provide insights on how fast, open habitat foragers respond to the riparian plantings.

Table 8 summarizes the total call minutes for the western mastiff bat in FY14. This species is active throughout all monitoring areas. The highest overall activity levels were recorded at the AKTP (1,283 total minutes), followed by CVCA 1 (394 total minutes) and YEW 1 (325 total minutes). Moderate levels of activity were detected at Crane's Roost (204 total minutes), CVCA 2 (192 total minutes), PVER 2 (147 total minutes), and BLCA 1 (84 total minutes). The lowest activity levels were at PVER 1 (50 total minutes) due to the late spring and summer data losses. Activity levels were observed for all months, with the highest use generally occurring in summer.

Table 8.—Total call minutes for western mastiff bats in 2014 at the nine acoustic monitoring stations

| | BLCA 1 | AKTP | PVER 1 | PVER 2 | CVCA 1 | CVCA 2 | Crane's Roost | YEW 1 | HHCA |
|---|---|---|---|---|---|---|---|---|---|
| Oct. | 6 | | 17 | | 20 | 6 | 6 | | 7 |
| Nov. | 6 | | 1 | | 5 | 1 | 7 | | 5 |
| Dec. | 0 | 2 | 4 | | 2 | 3 | 1 | | 2 |
| Jan. | 1 | 1 | 4 | 4 | 6 | 1 | 7 | | 2 |
| Feb. | 4 | 2 | 10 | 4 | 6 | 0 | 2 | | 2 |
| Mar. | 3 | 8 | 13 | 1 | 25 | 3 | 14 | | 1 |
| Apr. | 11 | 13 | 1 | 1 | 23 | 7 | 23 | | 6 |
| May | 20 | 47 | | 28 | 28 | 11 | 36 | 66 | 5 |
| June | 2 | 71 | | 48 | 28 | 8 | 18 | 210 | 25 |
| July | 8 | 733 | | 26 | 106 | 27 | 14 | 45 | 37 |
| Aug. | 0 | 392 | | 20 | 92 | 62 | 13 | 4 | 8 |
| Sept. | 23 | 14 | | 13 | 53 | 63 | 63 | 0 | 9 |
| **Total** | **84** | **1,283** | **50** | **147** | **394** | **192** | **204** | **325** | **109** |

## Pocketed Free-tailed Bat

As discussed above, the pocketed free-tailed bat is also a molossid bat species. With its long, narrow wings, it is a fast flier of open areas. It is found primarily in arid lowland areas in desert shrub and river flood plains (Pierson and Rainey 1998). It has been detected at all of the conservation area acoustic monitoring stations.

Table 9 summarizes the total call minutes for the pocketed free-tailed bat in FY14. The pocketed free-tailed bat is active throughout all of the monitoring areas, with the highest amount of activity at CVCA 1 (1,277 total minutes), followed by Crane's Roost (853 total minutes), YEW 1 (633 total minutes), the HHCA (490 total minutes), and the AKTP (356 total minutes). Even with data losses, PVER 1 had 559 total minutes, and YEW 1 had 633 total minutes of activity. These sites very likely would have received a large amount of pocketed free-tailed bat activity during these periods as well. Relatively high levels of winter activity occurred throughout the monitoring areas, with the highest amounts recorded at PVER 1, CVCA 1, and Crane's Roost.

Table 9.—Total call minutes for pocketed free-tailed bats in FY14 at the nine acoustic monitoring stations

| | BLCA 1 | AKTP | PVER 1 | PVER 2 | CVCA 1 | CVCA 2 | Crane's Roost | YEW 1 | HHCA |
|---|---|---|---|---|---|---|---|---|---|
| Oct. | 6 | | 60 | | 92 | 27 | 71 | | 30 |
| Nov. | 20 | | 32 | 5 | 536 | 115 | 274 | | 6 |
| Dec. | 6 | 16 | 65 | 35 | 307 | 80 | 188 | | 26 |
| Jan. | 4 | 12 | 140 | 90 | 48 | 50 | 144 | | 38 |
| Feb. | 4 | 26 | 121 | 55 | 32 | 11 | 27 | | 48 |
| Mar. | 10 | 52 | 108 | 0 | 56 | 27 | 59 | | 33 |
| Apr. | 13 | 28 | 33 | 25 | 0 | 22 | 42 | | 60 |
| May | 2 | 29 | | 12 | 26 | 8 | 37 | 35 | 48 |
| June | 3 | 3 | | 16 | 31 | 6 | 8 | 203 | 108 |
| July | 0 | 13 | | 4 | 45 | 6 | 0 | 306 | 63 |
| Aug. | 0 | 113 | | 22 | 43 | 11 | 0 | 52 | 19 |
| Sept. | 10 | 34 | | 7 | 61 | 31 | 3 | 37 | 11 |
| **Total** | **78** | **326** | **559** | **271** | **1,277** | **394** | **853** | **633** | **490** |

The highest summer activity was recorded in June and July at YEW 1, followed by the HHCA. The lightest level of pocketed free-tailed bat activity was recorded at BLCA 1, with low activity levels occurring throughout the year.

# Site Comparisons of Bat Activity

The total minutes of bat activity for covered and evaluation species for 2012 through 2014 are compared in table 10. Table 11 compares the total minutes of bat activity for species of management interest for 2014. Data are sorted from highest to lowest total call minutes to facilitate comparisons of sites and species. Caution must be used in interpreting data because dates of station initiation and periods of data loss vary from site to site and year to year, greatly affecting the total call minutes.

Table 10.—Total call minutes per year by monitoring site for covered and evaluation bat species (Values sorted from highest activity to least activity. Total minutes do not account for periods of data loss but provide an overview of bat activity.)

| Station | Western red bat | Western yellow bat | Pale Townsend's big-eared bat | California leaf-nosed bat |
|---|---|---|---|---|
| **2012** | | | | |
| CVCA 1 | 3,766 | 430 | 29 | 47 |
| PVER 1 | 319 | 251 | 7 | 17 |
| BLCA 1 | 82 | 200 | 7 | 16 |
| Crane's Roost | 19 | 11 | 5 | 11 |
| AKTP | 12 | 9 | 3 | 5 |
| **2013** | | | | |
| CVCA 1 | 2,838 | 2,920 | 14 | 56 |
| PVER 1 | 1,611 | 1,526 | 7 | 38 |
| BLCA 1 | 474 | 533 | 3 | 26 |
| Crane's Roost | 440 | 143 | 3 | 22 |
| AKTP | 353 | 101 | 2 | 20 |
| CVCA 2 | 43 | 90 | 0 | 10 |
| PVER 2 | 30 | 50 | 0 | 4 |
| HHCA | 6 | 23 | 0 | 1 |
| YEW 1 | 0 | 14 | 0 | 0 |
| **2014** | | | | |
| CVCA 1 | 1,433 | 2,400 | 13 | 54 |
| PVER 1 | 636 | 680 | 7 | 50 |
| Crane's Roost | 551 | 476 | 6 | 37 |
| BLCA 1 | 201 | 389 | 5 | 31 |
| PVER 2 | 141 | 283 | 5 | 14 |
| CVCA 2 | 127 | 222 | 4 | 9 |
| YEW 1 | 71 | 189 | 3 | 5 |
| AKTP | 54 | 56 | 2 | 0 |
| HHCA | 14 | 21 | 1 | 0 |

Table 11.—Total call minutes per year by monitoring site for selected species of interest (Values are sorted from highest activity to least activity. Total minutes do not account for periods of data loss but provide an overview of bat activity.)

| Station | Cave myotis | Arizona myotis | Hoary bat | Western mastiff bat | Pocketed free-tailed bat |
|---|---|---|---|---|---|
| **2014** | | | | | |
| CVCA 1 | 753 | 795 | 2,080 | 1,283 | 1,277 |
| AKTP | 615 | 2 | 449 | 394 | 853 |
| CVCA 2 | 511 | 2 | 97 | 325 | 633 |
| BLCA 1 | 477 | 1 | 87 | 204 | 559 |
| PVER 2 | 146 | 1 | 81 | 192 | 490 |
| Crane's Roost | 90 | 0 | 57 | 147 | 394 |
| PVER 1 | 11 | 0 | 55 | 109 | 356 |
| HHCA | 0 | 0 | 53 | 84 | 271 |
| YEW 1 | 0 | 0 | 0 | 50 | 0 |

Western red bat and western yellow bat activity occurred in every monitoring area, with the highest overall levels occurring at CVCA 1 and PVER 1. BLCA 1 and Crane's Roost recorded large amounts of red bat activity, with Crane's Roost increasing in activity over the 3-year period. The most recently deployed stations, CVCA 2, PVER 2, YEW 1, and the HHCA, all recorded substantial red bat activity. The total minutes of red bat activity at the AKTP reflects a large pulse in winter activity in 2012.

California leaf-nosed bats and pale Townsend's big-eared bats were recorded at all nine monitoring areas, with the highest amount of activity for both species at the CVCA (based on both CVCA 1 and CVCA 2). The most recently established stations at CVCA 2, PVER 2, YEW 1, and the HHCA received the lightest activity levels.

Acoustic detectors with the highest call minutes of activity for cave myotis included CVCA 1, the AKTP, CVCA 2, and BLCA 1. PVER 1 likely did not appear in this group due to data losses during spring and summer 2014. There were moderate activity levels at PVER 2 and Crane's Roost. No activity was recorded for cave myotis at the HHCA or YEW 1.

Arizona myotis activity is focused on at the 'Ahakhav Tribal Preserve. This is confirmed by capture surveys (Calvert, in press). Very light activity levels were recorded at PVER 1, CVCA 2, BLCA 1, and PVER 2.

Hoary bat activity tracked well with the other tree-roosting bats – the red bat and the western yellow bat. The highest activity levels were recorded at CVCA 1 and PVER 1. Moderate activity levels were recorded at the BLCA 1, AKTP, Crane's Roost, HHCA, PVER 2, and CVCA 2 stations. YEW 1 was the exception, with no acoustic activity recorded in 2014.

Western mastiff bat activity was concentrated at the AKTP, with the highest number of total call minutes recorded. Substantially lower call minute were received at CVCA 1 and YEW 1, followed by Crane's Roost, CVCA 2, PVER 2, the HHCA, and BLCA 1. The lightest activity was at PVER 1 probably due to data losses during spring and summer.

Pocketed free-tailed bat activity was concentrated at CVCA 1, followed by Crane's Roost. Slightly lower levels of call minutes were recorded at PVER 1, the HHCA, CVCA 2, the AKTP, and PVER 2. The lowest activity level was at the BLCA 1.

# DISCUSSION

During the 3-year period of this report from 2012 through 2014, there were nine long-term acoustic monitoring stations deployed in six LCR MSCP conservation areas and the 'Ahakhav Tribal Preserve managed by the Colorado River Indian Tribes. All four covered and evaluation bat species were detected acoustically in all of the monitoring areas.

## Western Red Bat

For red bats, CVCA 1 and PVER 1 had consistently the most amount of bat activity as measured by mean call minutes per month of any of the monitoring areas. Red bat calls were detected year round at both CVCA 1 and PVER 1. These are the largest monitoring areas, with complex cottonwood-willow habitat. Canopy complexity, as measured by the number of canopy layers, linear amount of canopy edges, and number of flyways, was shown by habitat modeling to be significantly related to increased western red and yellow bat activity (Broderick 2012). Overall canopy complexity is increased when different tree and shrub species are planted in juxtaposition to each other (such as Goodding's willows next to Fremont cottonwoods). Bats forage intensely along edges created by different canopy heights.

Seasonally, the highest red bat activity was at CVCA 1 during February and March 2012 and March 2013. Spring and summer activity increased in 2013, peaking in July. In 2014 however, red bat activity declined year round from

the levels recorded in 2012 and 2013. PVER 1 followed a similar pattern, with year-round bat activity peaking in 2013 and then declining somewhat in 2014. A clear picture of the full seasonal responses is hampered by fall and winter data losses in 2012 and spring and summer data losses in 2014. Insights provided during periods when the station was operational indicated red bat activity occurred year round at some of the highest levels observed in any of the monitoring areas beside CVCA 1. The declines from 2013 to 2014 for both CVCA 1 and PVER 1 may be normal variation in response to weather or insect abundance or other factors.

Acoustic stations with relatively high levels of mean call minutes included Crane's Roost and the AKTP, followed by BLCA 1 and PVER 2. In 2012, Crane's Roost had only a trace amount of red bat activity in February and slightly higher activity in September. Mean call minutes increased dramatically in 2013 and 2014 in every month with the exception of October 2013. Unlike the pattern seen at CVCA 1 and PVER 2, red bat activity remained at similar levels between 2013 and 2014. Peaks in red bat activity occurred during February and March 2013 and in April 2014. Activity recorded at BLCA 1 was low and sporadic in 2012 for months when data were collected, (data losses occurred in January and April). Overall activity increased in 2013 and 2014. Activity peaked in fall and summer 2013 and in summer 2014. Red bats were consistently detected year round at the BLCA 1.

The 'Ahakhav Tribal Preserve is the exception among monitoring areas – red bat activity is highest December through February and declines dramatically in spring and summer. PVER 2 and CVCA 2 show year-round red bat presence at low levels. Red bat activity at PVER 2 increased from 2013 to 2014, with activity peaking in spring. YEW 1 only operated a few months in spring and summer 2014, but red bats were detected from May through August. In spite of its small size, red bats were active at the HHCA for both years from April through September at very low levels.

## Western Yellow Bat

Both CVCA 1 and PVER 1 experienced the highest mean call minutes for western yellow bats, though for different reasons. There was an extraordinary July activity peak at CVCA 1 in both 2013 and 2014, but generally the spring and summer months had relatively light western yellow bat activity levels. The high activity levels at PVER 1 for 2013 spread across multiple months during summer, while the spring and late summer months were at much lower levels. The station was operational during spring and summer for both 2013 and 2014 and clearly showed an increase in activity from 2012 to 2013.

With the summer data losses in 2014, it is not possible to speculate at this time whether the high summer western yellow bat activity seen in 2013 at PVER 1 will repeat itself. What can be concluded is that western yellow bats were present at the PVER consistently from April through September for 2 years. As discussed for the red bat previously, both the CVCA and PVER are large conservation areas with complex riparian habitat. It is reasonable to expect western yellow bats to appear in subsequent acoustic bat monitoring efforts at the CVCA and PVER.

Other stations with relatively high levels of mean call minutes include the AKTP, YEW 1, and CVCA 2. Western yellow bats were detected at the AKTP May through September 2012 through 2014. Mean call minutes increased each year from 2012, with peak activity occurring in July 2013 and 2014 that approach the high levels seen at PVER 1, CVCA 1, and CVCA 2. There is only one complete spring and summer season of data from YEW 1, but it shows that western yellow bats are present from May through September, with peak activity occurring in July. There was a modest increase in mean call minutes at CVCA 2 for July and August from 2013 to 2014.

Relative low mean call minutes were recorded for the April through September period at PVER 2, the HHCA, and BLCA 1. While fairly low activity levels were recorded, western yellow bats were present during the entire spring and summer period. Overall bat activity increased at PVER 2 from 2013 to 2014. The Beal Lake Conservation Area is unique among the monitoring areas in that winter activity was recorded for January and February 2013 and January 2014. Winter activity was also recorded in December, January, and February 2011 (Broderick 2013) and in February 2010 (Broderick 2012). Western yellow bats were also detected at the HHCA in 2014 from February through September. Call minutes have been sporadically recorded at Crane's Roost. Overall seasonal mean bat minutes increased from sporadic low levels during spring and summer 2013 to a solid presence in 2014. Peak activity peaked at moderate levels May and June 2014.

## California Leaf-nosed Bat

California leaf-nosed bats were detected year round at CVCA 1 in 2012. Calls were also recorded 10 months of the year, usually with the exception of December and January at CVCA 1 in 2013, CVCA 2 in 2014, Crane's Roost in 2013 and 2014, and the BLCA 1 in 2014. They were recorded sporadically for the other monitoring areas and years and not detected at the HHCA.

## Pale Townsend's Big-eared Bat

Pale Townsend's big-eared bats were recorded sporadically throughout the nine monitoring areas.

Acoustic monitoring stations where this whispering bat was detected in blocks of several months include Crane's Roost in 2014 for 6 months (April through September), CVCA 1 for 6 months (April through September 2012) and for 4 months (May through August 2013), and YEW 1 for 4 months (June through September 2014).

# LITERATURE CITED

Arizona Game and Fish Department 2016. Mammal Abstracts, Distribution Maps & Illustrations. http://www.azgfd.gov/w_c/edits/hdms_abstracts_mammals.shtml

Barnett, J.K. 2014. Region 1 Acoustic Bat Inventory: National Wildlife Refuges in Eastern Oregon, Eastern Washington, and Idaho. U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon. 69 p.

Best, T.L., W.M. Kiser, and P.W. Freeman. 1996. *Eumops perotis*. American Society of Mammalogists. Mammalian Species 534:1–8.

Broderick, S. 2012. Post-Development Bat Monitoring 2007–2010 Intensive Acoustic Surveys Completion Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada. 66 p.

_____. 2013. Post-Development Bat Monitoring of Habitat Creation Areas Along the Lower Colorado River – 2011 Acoustic Surveys. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada. 52 p.

Brown, P. 2006. Bat Monitoring Protocol. Prepared for the Lower Colorado River Multi-Species Conservation Program. Submitted to the Bureau of Reclamation, Boulder City, Nevada.

Brown, P.E. 2010. Roost Surveys and Monitoring for Lower Colorado River Bat Species. Reported submitted to the Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

Bureau of Reclamation (Reclamation). 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan, Final. Sacramento, California.

_____. 2005. Beal Lake Habitat Restoration. Lower Colorado Region, Boulder City, Nevada.

_____. 2006. Palo Verde Ecological Reserve Restoration Development Plan: Phase I. Lower Colorado River Multi-Species Conservation Program, Lower Colorado Region, Boulder City, Nevada.

_____. 2015. Draft Implementation Report, Fiscal Year 2016 Work Plan and Budget, Fiscal Year 2014 Accomplishment Report. Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada. 475 p.

Calvert, A. (in press). Post-Development Bat Monitoring of Conservation Areas and ‘Ahakhav Tribal Preserve Along the Lower Colorado River – 2013-2014 Capture Surveys. Annual report prepared by the Bureau of Reclamation, Boulder City, Nevada.

Calvert, A. and S.W. Neiswenter. 2012. Bats in riparian-restoration sites along the lower Colorado River, Arizona. Southwestern Naturalist 57(3):340–342.

Chung-MacCoubrey, A.L. 1999. Maternity roosts of bats at the Bosque del Apache National Wildlife Refuge: a preliminary report. Pages 187–190 *in* D.M. Finch, J.C. Whitney, J.F. Kelly, and R.S. Loftin (editors). Rio Grande Ecosystems: Linking Land, Water and People – Toward a Sustainable Future for the Middle Rio Grande Basin. June 2–5, 1998. Albuquerque, New Mexico. Proceedings RMRS-P-7. Ogden, Utah. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 245 p.

Duff, A. 2004. Distribution and Relative Abundance of Bat Species in Crater Lake National Park, Redwood National and State Parks, and Oregon Caves National Monument, 2004 Annual Report for Bat Inventories in the Klamath Lakes Monitoring Network. Southern Oregon University, Ashland, Oregon.

Grinnell, J. 1914. An account of the mammals and birds of the lower Colorado Valley with especial reference to the distributional problems represented. University of California Publication of Zoology 12:51–294.

Hendricks, P. 1999. Bat Survey Along the Norris-Madison Junction Road Corridor, Yellowstone National Park, Wyoming. Montana National Heritage Program, Helena. 15 p.

Kalcounis, M.C., K.A. Hobson, R.M. Brigham, and K.R. Hecker. 1999. Bat activity in the boreal forest: importance of stand type and vertical strata. Journal of Mammalogy 80:673–682.

Leitner, P. 1966. Body temperature, oxygen consumption, heart rate and shivering in the California mastiff bat, *Eumops perotis*. Comparative Biochemistry and Physiology 19(2):431–143.

Miller, B.W. 2001. A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring. Acta Chiropterologica 3(1):93–105.

O’Farrell, M.M. and W.J. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammalogy 80:11–23.

Pierson, E.D. and W.E. Rainey. 1998. Distribution, Habitat Associations, Status and Survey Methodologies for Three Molossid Bat Species (*Eumops perotis*, *Nyctinomops femorosaccus*, *Nyctinomops macrotis*) and the Vespertilionid (*Euderma maculatum*). Final report prepared for the California Department of Fish and Game, Sacramento. 61 p.

Piaggio, A.J. and S.L. Perkins 2005. Molecular phylogeny of North American long-eared bats (Vespertilionidae: *Corynorhinus*); inter- and intraspecific relationships inferred from mitochondrial and nuclear DNA sequences. Molecular Phylogenetics and Evolution 37:762–775.

Reid, F.A. 1997. A Field Guide to the Mammals of Central America and Southeast Mexico. Oxford University Press, Inc., New York, New York. 334 p.

Skalak, S.L., R.E. Sherwin, and R.M. Brigham. 2012. Sampling period, size and duration influence measures of bat species richness from acoustic surveys. Methods in Ecology and Evolution 3:490–502.

Thomas, D.W., G.P. Bell, and M.B. Fenton. 1987. Variation in echolocation call frequencies recorded from North American verspertilionid bats: a cautionary note. Journal of Mammalogy 68:842–847.

Thomas, D.W. 1988. The distribution of bats in different ages of Douglas-fir forest. Journal of Wildlife Management 52:619–626.

Thomas, D.W. and S.D. West. 1989. Sampling methods for bats *in* A.B. Carey and L.F. Ruggiero (technical editors). Wildlife-Habitat Relationships: Sampling Procedures for Pacific Northwest Vertebrates. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland Oregon. General Technical Report PNW-GTR-243.

Western Bat Working Group. 2016. Western Bat Species, *Eumops perotis*. www.wbwg.org/western-bat-species/

Williams, J.A., M.J. O'Farrell, and B.R. Riddle. 2006. Habitat use by bats in a riparian corridor of the Mojave desert in Southern Nevada. Journal of Mammalogy 87(6):1145–1153.