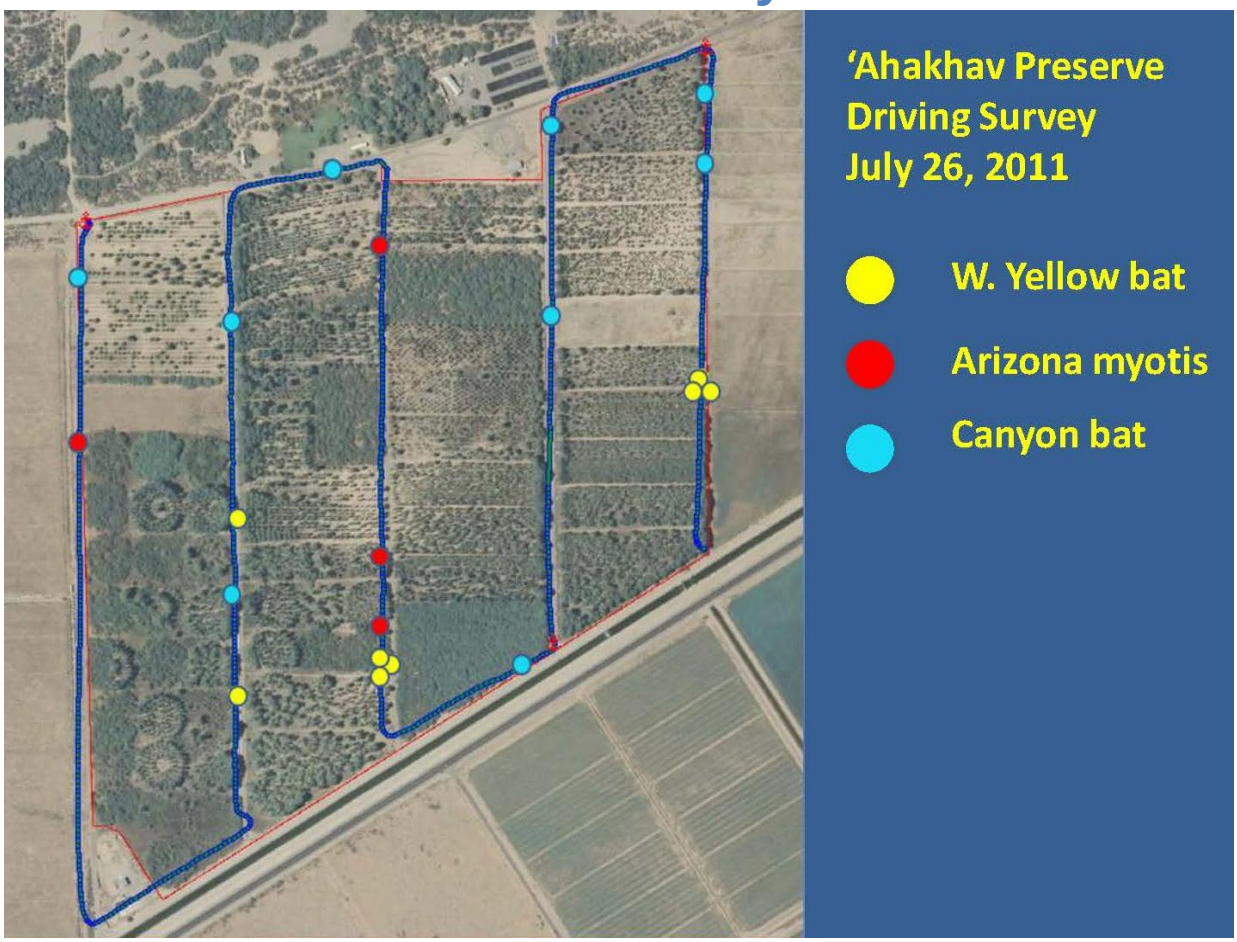
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Post-Development Bat Monitoring of Habitat Creation Areas along the Lower Colorado River – 2011 Acoustic Surveys



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April 2013

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Lower Colorado River Multi-Species Conservation Program

Post-Development Bat Monitoring of Habitat Creation Areas along the Lower Colorado River – 2011 Acoustic Surveys

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ACRONYMS AND ABBREVIATIONS

‘Ahakhav	Colorado River Indian Tribe’s ‘Ahakhav Tribal Preserve
Beal	Beal Lake Riparian Restoration Area
CNWR #1	Cibola National Wildlife Refuge Unit 1 Conservation Area
CVCA	Cibola Valley Conservation and Wildlife Area
FY	fiscal year
ha	hectare(s)
IPCA	Imperial Ponds Conservation Area
kHz	kilohertz
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LDCA	Laguna Division Conservation Area
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation

Symbols

%	percent

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ABSTRACT

Pre-development acoustic bat surveys were conducted at the Laguna Division Conservation Area (LDCA) to establish a baseline for comparison as construction will begin in fiscal year 2012 (FY12). There were 12 minutes of western red bat activity in August–September and 2 minutes in May. There were 10 minutes of western yellow bat activity recorded in late summer. California leaf-nosed bats had 12 minutes in late summer, 4 minutes in May, and 4 minutes in January. Compared to abundant species like the canyon bat and Mexican free-tailed bat, the four focal species represented a very small percentage of the bat community present at the pre-development LDCA. The Arizona myotis activity was similar, with 11 minutes in late summer, and the cave myotis had 1 minute in late summer.

The Beal Lake Riparian Restoration Area (Beal) bat monitoring station performed nearly flawlessly in FY11. Overall, there was less western red bat activity this year compared to FY10, which had a pulse of western red bat activity in October and November. Western yellow bat activity was similar to the two previous years at Beal, but showed winter activity in December, January, and February. The California leaf-nosed bat showed increased activity in FY11 from May through September. The new monitoring stations established at the Cibola Valley Conservation Area and the Cibola National Wildlife Refuge Unit 1 Conservation Area were beset with equipment problems and insect-related data losses. However, when insect activity temporarily ceased and equipment was functional, there were large numbers of western red and yellow bats present.

Mobile acoustic bat surveys were conducted at six habitat creation areas in May, July, and September. The Colorado River Indian Tribe's 'Ahakhav Tribal Preserve had the highest minutes of activity for western yellow bats in May, with 13 minutes and 23 minutes for the Arizona myotis. Minutes of bat activity for the four focal bat species and two riparian specialists overall was low at all habitat creation areas monitored.

INTRODUCTION

Fiscal year (FY) 2011 was a transition year for acoustic bat monitoring. Intensive surveys were conducted quarterly for seven habitat conservation areas starting with a pilot program in 2007, with 3 years of monitoring from 2008 through 2010. Annual reports were completed for all years, with a completion report analyzing and summarizing the results of this intensive post-development bat monitoring (Broderick 2012).

The goal of the FY11 effort was to develop a monitoring program that could be continued over the long term that was based in lessons learned from the first four years, was economical, and provided accurate and useful information for the adaptive management process established in the Lower Colorado River Multi-Species Conservation Program (LCR MSCP).

Post-development acoustic bat monitoring this fiscal year consisted of testing the usefulness of mobile acoustic bat surveys (driving surveys) and establishing two more permanent bat monitoring stations to be operated along with the existing station at Beal Lake Riparian Restoration Area (Beal).

Pre-development bat surveys were also conducted at the Laguna Division Conservation Area (LDCA) to establish baseline bat community data, including the four covered and evaluation bat species (western red bat, western yellow bat, Townsend's big-eared bat, and the California leaf-nosed bat). Site development and construction at LDCA will begin in FY12 with initial vegetation clearing. These baseline data will allow changes to the bat community to be documented as clearing and planting are implemented.

STUDY AREA

Mobile acoustic bat surveys were conducted in six LCR MSCP habitat creation areas: Beal, Colorado River Indian Tribe's 'Ahakhav Tribal Preserve ('Ahakhav), Cibola Valley Conservation and Wildlife Area (CVCA), Cibola National Wildlife Refuge Unit 1 Conservation Area (CNWR #1), and the Imperial Ponds Conservation Area (IPCA). Permanent bat monitoring stations were established at Beal in 2008, at CVCA in 2011, and at CNWR #1 in 2011. Pre-development acoustic bat monitoring was conducted at the LDCA in January, May, and August/September. The Pratt Restoration Demonstration Area was dropped from further acoustic bat monitoring. Figure 1 shows the study areas in the lower Colorado River (LCR).

Figure 1.—Map of the acoustic bat monitoring areas along the lower Colorado River.

The following sections briefly describe each area where monitoring activities occurred. Additionally, maps and habitat are shown for the three permanent bat monitoring stations, and driving survey route maps are shown for each of the habitat conservation areas where mobile surveys were conducted.

Beal Lake Riparian Restoration Area

Beal is located on the Havasu National Wildlife Refuge in Needles, California, (figure 2) within the historic flood plain of the LCR. It consists of over 100 acres (40 hectares [ha]) of cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii),* coyote willow (*S. exigua*), honey mesquite (*Prosopis glandulosa*), and screwbean mesquite (*Prosopis pubescens*) in a series of plantings that began in 2001 and were completed in 2005 (Bureau of Reclamation [Reclamation] 2010b).

Monitoring activities at Beal consisted of conducting mobile acoustic bat surveys (driving surveys) and operating a permanent bat monitoring station. Figure 2 is an aerial view of Beal with the driving survey route indicated. Figure 3 shows the location of the permanent bat monitoring station. Figure 4 shows the habitat immediately adjacent to the monitoring station.

The permanent bat monitoring station was initially installed in April 2008 and has been operating successfully through FY11. Figure 4 is an aerial view of the station showing the adjacent habitat.

'Ahakhav Tribal Preserve

The 'Ahakhav Tribal Preserve ('Ahakhav) encompasses 154 acres (62 ha) of a mix of intermediate stage cottonwood-willow and screwbean and honey mesquite stands (figure 5). Propagating and irrigating cottonwood-willow and mesquite began in 2001, converting out-of-production agricultural fields dominated by tumbleweed and sparse saltcedar to riparian habitat.

Long-term bat monitoring activity at 'Ahakav consisted of driving surveys. A long-term bat monitoring station was installed at 'Ahakhav, but bat monitoring was suspended at the request of the Colorado River Indian Tribe in 2010. The station was subsequently removed. Bat monitoring was once again permitted by the Tribe in FY11, allowing driving surveys to be conducted. Figure 5 is the driving survey route map used for 'Ahakav.

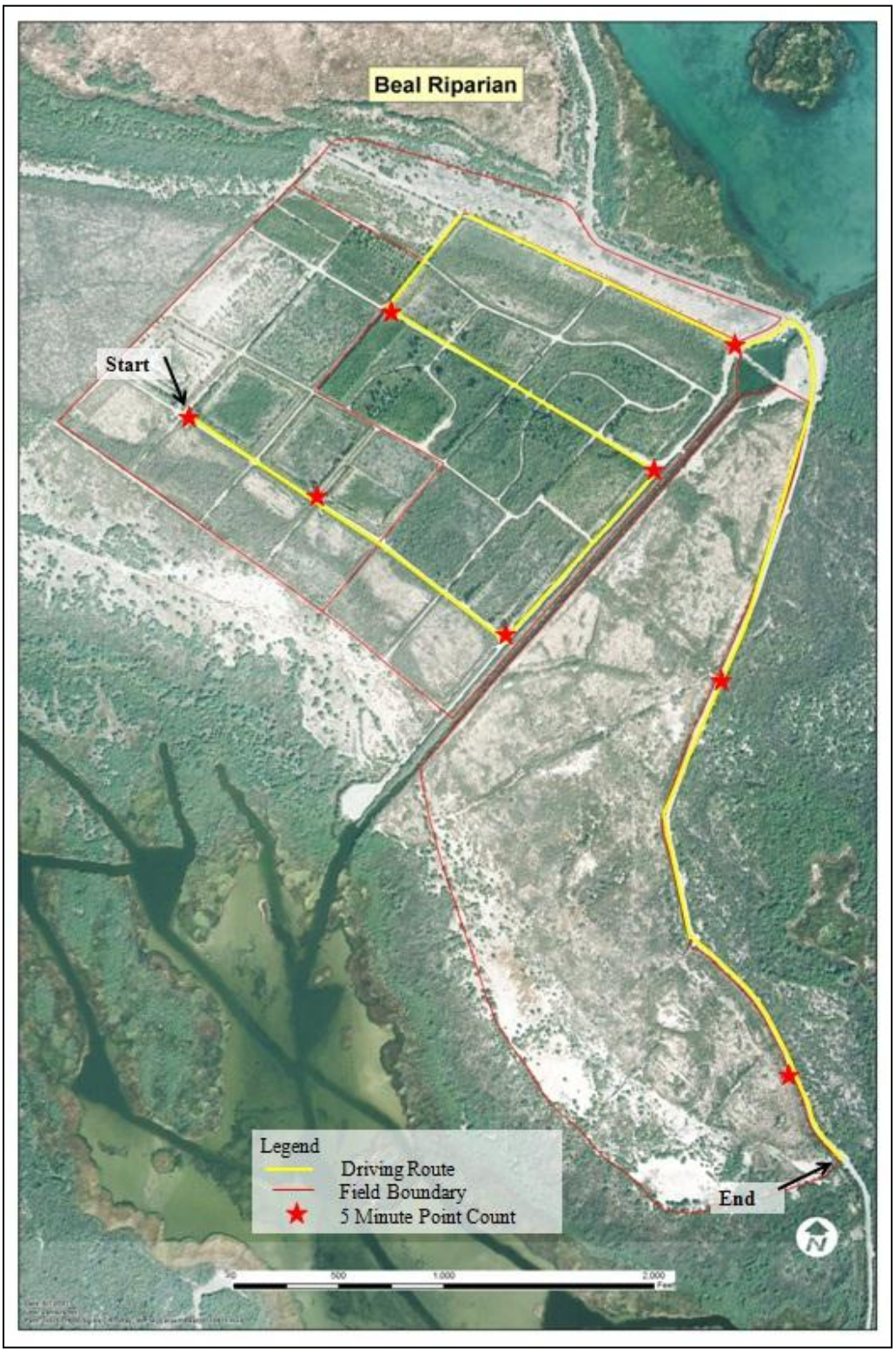

Figure 2.—Driving survey route map for the Beal Lake Riparian Restoration Area.

Figure 3.—Location of the permanent bat monitoring station at the Beal Lake Riparian Restoration Area.

Figure 4.—Aerial view of the Beal Lake Riparian Restoration Area permanent bat monitoring station showing the surrounding habitat.

Figure 5.—Driving survey route map for the ‘Ahakhav Tribal Preserve.

Palo Verde Ecological Reserve

PVER encompasses 1,352 acres (536 ha) of Colorado River historic flood plain near Blythe, California, of which 1,100 acres (445 ha) of active agricultural lands were identified for habitat restoration (Reclamation 2006). Through FY08, 323 acres of cottonwood-willow and mesquite land cover types have been established in Phases 1–4 and are being managed for the LCR MSCP covered species. In FY09, 100 acres of cottonwood-willow were planted in Phase 4. On the 84 acres in Phase 3, approximately 12 acres of cottonwood-willow land cover type was planted in the spring of 2009 as well as 22 acres of mesquite. In 2010, 216 acres of cottonwood-willow and mesquite were planted in Phase 5. Phase 6 was planted in FY11, and Phase 7 is scheduled to be planted in FY12 (Reclamation 2010a).

Long-term bat monitoring activity at PVER consisted of driving surveys. Figure 6 shows a driving survey route map.

Cibola Valley Conservation Area

CVCA encompasses 1,019 acres (412.4 ha) of active agricultural lands (see figure 6). Phase 1 implemented in 2006 converted approximately 64 acres (25.9 ha) of active agricultural fields to cottonwood-willow habitat (Reclamation 2007). For Phase 2, 71 acres of cottonwood-willow habitat were planted in FY08. In Phase 3, 103 acres of cottonwood-willow were planted in FY07. A total of 58 acres of honey mesquite was planted in FY09, 71 acres planted in FY10, and an additional 89 acres were planted in FY11 (Reclamation 2010a).

Long-term bat monitoring activity at CVCA consisted of driving surveys and the establishment of a permanent monitoring station. Figure 7 shows the driving survey route map used at CVCA. Figure 8 shows the location of the bat monitoring station. Figure 9 shows the habitat adjacent to the station.

Cibola National Wildlife Refuge Unit 1 Conservation Area

CNWR #1 consists of 16,600 acres (6,718 ha) along 12 miles (19.3 kilometers) of the LCR. It is divided into six management units numbered from 1 to 6. Reclamation has several ongoing and planned projects in Unit 1. To date,

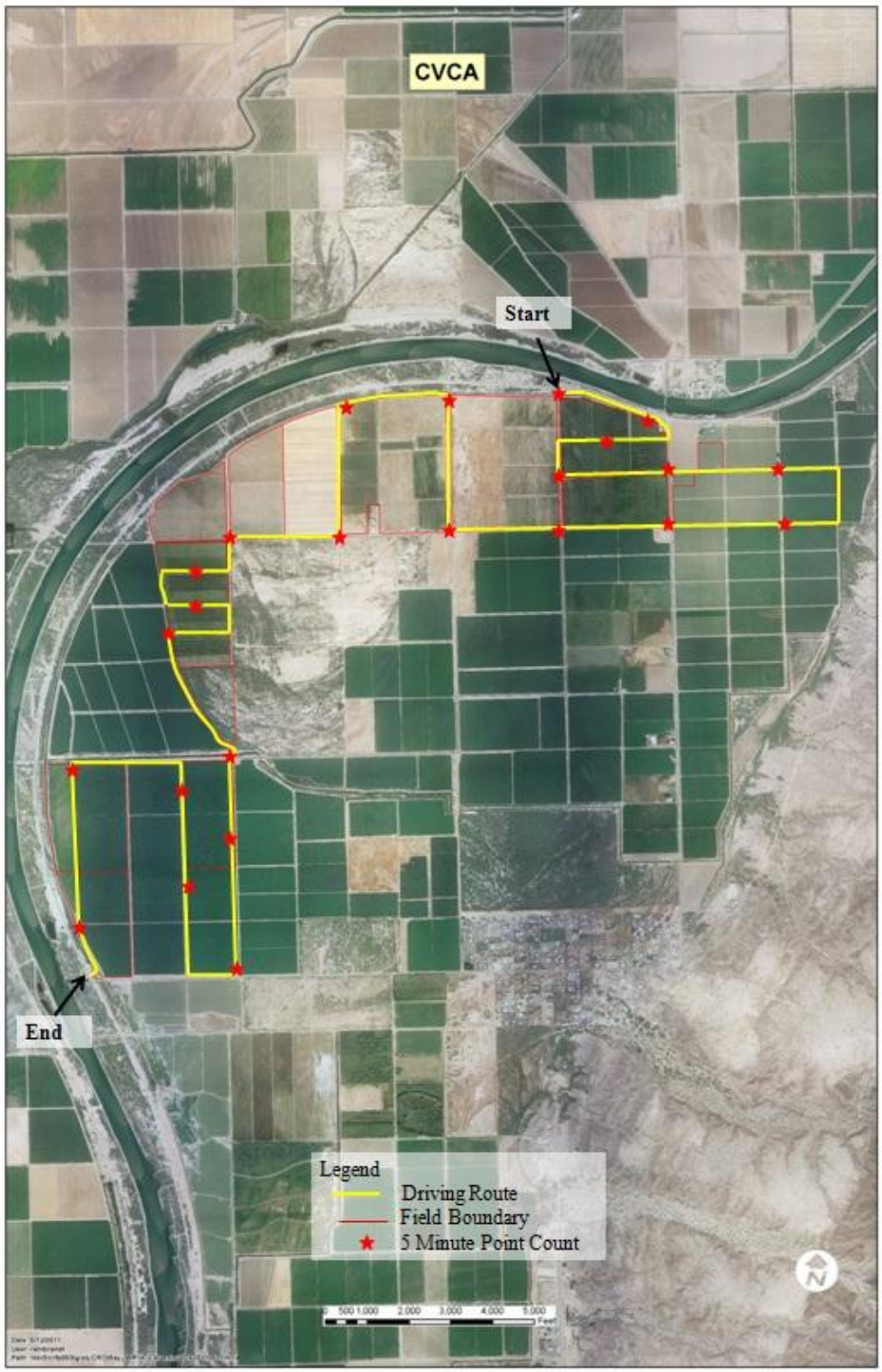

Figure 6.—Driving survey route map for the Palo Verde Ecological Reserve.

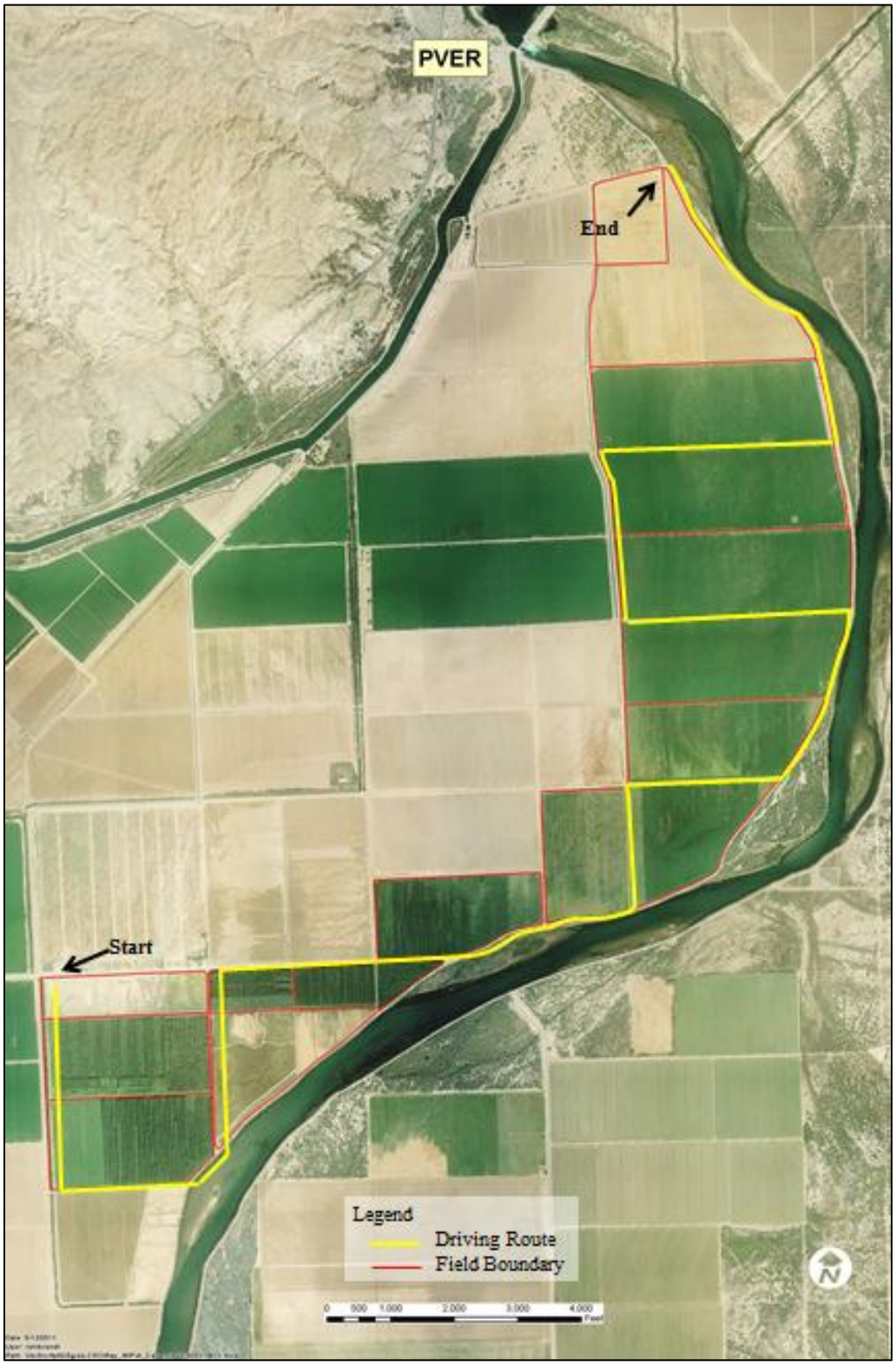

Figure 7.—Driving survey route map for the Cibola Valley Conservation Area.

Figure 8.—Permanent bat monitoring station at the Cibola Valley Conservation Area.

Figure 9.—Permanent bat monitoring station at the Cibola Valley Conservation Area showing adjacent habitat.

approximately 270 acres of cottonwood-willow and honey mesquite have been established. Additional acreage will be converted annually until 950 acres have been restored (figure 10).

Long-term bat monitoring at CNWR #1 consisted of driving surveys and the establishment of a permanent bat monitoring station. Figure 10 is the driving survey route map for CNWR #1. Figure 11 shows the location of the new permanent monitoring station. Figure 12 shows the habitat adjacent to the station.

Imperial Ponds Conservation Area

The ponds at IPCA, located on the Imperial National Wildlife Refuge, were originally constructed to provide a mixture of habitat types, including isolated backwater for native fish, marsh, and riparian land cover types. Those initial ponds were expanded to six ponds in 2007, creating an additional 80 acres of backwater habitat for native fish. Also present in the area is a mature cottonwood-willow stand planted in 1993 referred to as the "nursery" (Reclamation 2005). High soil salinity has impaired establishment of cottonwood, willow, and mesquite in this area. The soil removed from pond expansion was spread on adjacent fields. It was mostly bare dirt during bat monitoring in 2008, but in 2009 supported a grass cover crop. Eventually, 34 acres will be planted with cottonwood-willow adjacent to the nursery.

Long-term bat monitoring activity at IPCA consisted of driving surveys (figure 13).

Laguna Division Conservation Area

LDCA was a new initiative for the LCR MSCP in FY10. Three alternative designs for this area were prepared with input from the Laguna Division Planning Group. A final design was presented and approved as a new start project by the Steering Committee in October 2009. Monitoring began in FY11 to provide baseline wildlife presence and general vegetation information prior to construction (LCR MSCP 2012).

LDCA is a relatively wide, undeveloped area with a series of low linear depressions, which are remnants of former river meanders. The intent of this project is to create marsh and riparian land cover types by shaping and contouring multiple meandering channels. These land cover types would be maintained with a maximum base flow of 100 cubic feet per second from the Gila Gravity

Figure 10.—Driving survey route map for the Cibola National Wildlife Refuge Unit 1 Conservation Area.

Figure 11.—Location of permanent bat monitoring station at the Cibola National Wildlife Refuge Unit 1 Conservation Area.

Figure 12.—Permanent bat monitoring station at the Cibola National Wildlife Refuge Unit 1 Conservation Area showing adjacent habitat.

Canal sluicing gates. Open water areas could be created in the form of linear excavations aligned with historic river meanders east of lands identified as future stockpiling areas for dredged silt removed from the river (Laguna settling basin). To minimize earthwork, cuts and fills would follow the existing topography where feasible. Adjacent terraces would be graded to allow flooding and to promote the establishment of native riparian species, and water control structures would be created to manage water levels. Upland vegetation would receive water through flooding (LCR MSCP 2012). Figure 14 is a map of this conservation area.

Figure 13.—Driving survey route map for the Imperial Ponds Conservation Area.

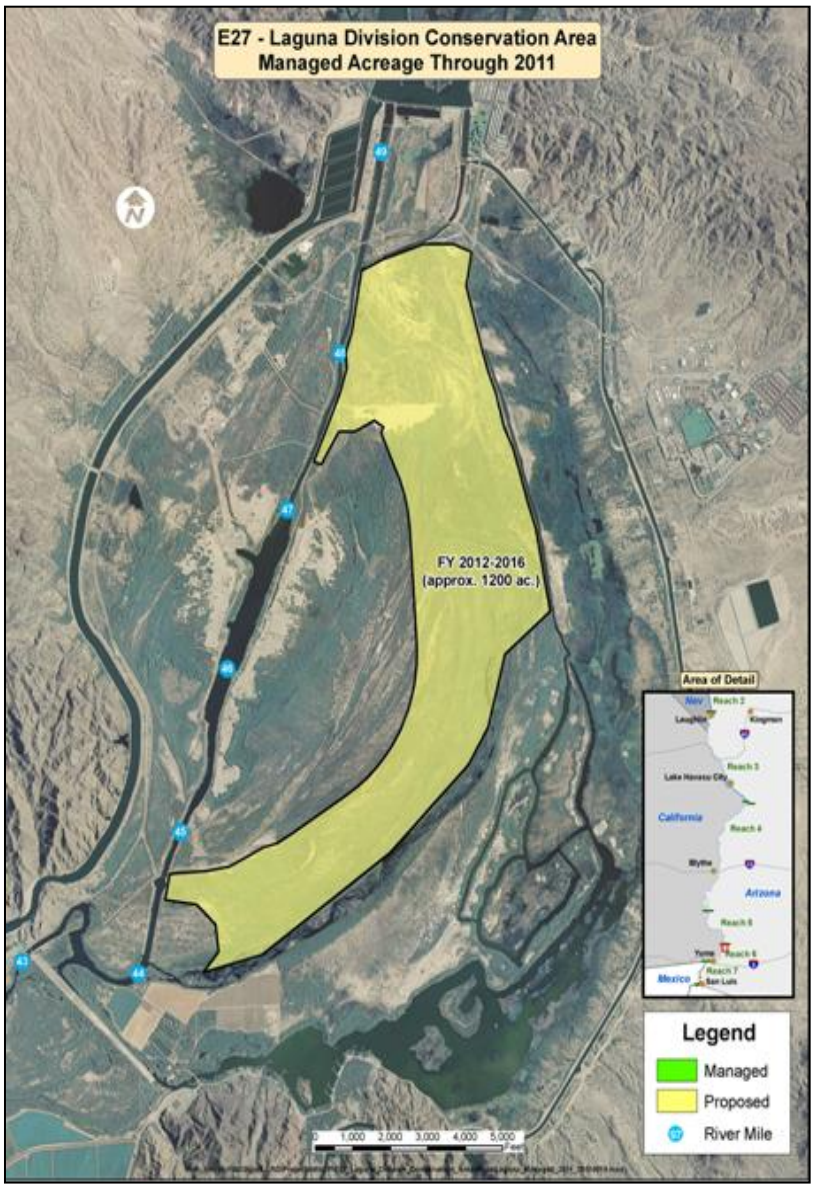

Figure 14.—Laguna Division Conservation Area as of FY11.

The habitat in 2011 consisted of an extensive stand of decadent saltcedar (*Tamarisk* spp.) with areas that had been burned in the past. There were extensive stands of baccharis scattered throughout as well as relatively open sandy areas.

The proposed restoration of LDCA provides an excellent opportunity to monitor the changes to the bat community. The LDCA project encompasses 1,050 acres with up to 100 acres of open water created along with more than 200 acres of cottonwood-willow and 500 acres of mesquite. This site has the potential to provide outstanding habitat for the two covered bat species (western red bat and western yellow bat) and the two evaluation bat species (California leaf-nosed bat and Townsend's big-eared bat) as well as the other species in the LCR bat

community. The juxtaposition of cottonwood-willow and open water as visualized in the Task 4 Final/Preferred Habitat Restoration Concept PowerPoint presentation are likely to react synergistically to provide some of the best bat habitat found on the LCR. The timing of the project is also ideal in that we would have the opportunity to sample pre-construction as well as post-construction and utilize our experience with acoustic monitoring conducted in six habitat creation areas from 2007 through 2010.

Figures 15 through 20 show the habitats at each of six acoustic sampling sites.

METHODS

Mobile Acoustic Bat Surveys

Mobile acoustic bat surveys were conducted using an Anabat SD2 bat detector connected to an Anabat PDA kit with a compact flash Global Positioning System (GPS) unit (figure 21). A high-mount extension cable and microphone was connected to an Anabat car mount (Titley Scientific, USA, Columbia, Missouri).

The survey protocol consisted of establishing driving transects for each habitat conservation area (figures 2, 5, 6, 7, 10 and 13). The routes were designed to be wide enough to avoid encountering the same bat twice. The routes were driven at about 15 miles per hour. From one to three transects were conducted for each night sampled. We also experimented with conducting point counts along the driving routes as well as conducting a straight driving route with no stops. Driving surveys began 30 minutes after sunset on evenings that were over 50 degrees Fahrenheit with low wind and no rain. Surveys were repeated across the season (May, July, and August/September).

Survey routes and waypoints for bat recordings were mapped using GPS Utility Version 5.10 software.

Permanent Bat Monitoring Stations

Permanent monitoring stations form the core of the long-term acoustic bat monitoring program along with seasonal mist-netting (Calvert 2012). Permanent stations produce large sample sizes and are statistically robust in comparing season-to-season and year-to-year bat activity at the same site and among sites.

Figure 15.—CW1 typical dense, mature saltcedar.

Figure 16.—WAT2 showing bathat and reflective plate.

Figure 17.—WAT3 – Old burn with open sandy areas.

Figure 18.—CW2 – Old burn with extensive stand of knapweed.

Figure 19.—WAT1 – Dense stand of baccharis.

Figure 20.—CW3 – Decadent saltcedar stand.

Figure 21.—Equipment used to conduct mobile bat surveys consisted of a car mount with a high-mount microphone that connected to an Anabat SD2 through a PDA with an attached compact flash GPS unit.

The Beal permanent monitoring station was established in April 2008 and has operated continuously with few problems through FY11. There were some minor data losses due to insect interference in 2009. Anabat bat detectors cannot record bat calls when insects such as cicadas, crickets, and katydids are calling unless the bat flies and calls directly over the microphone. Most of the other data loss events occurred during the early evening hours principally in July and August, affecting Canyon bat calls the most, as this species emerges to forage early in the evening. Overall, data loss due to insects was relatively minor. A more extensive data loss occurred from July 29 through September 2010 when an internal battery in the bat detector expired. The station performed flawlessly throughout FY11.

The CVCA permanent monitoring station was established on March 31, 2011. It functioned properly for most of the time period, but data losses occurred due to insect interference and an internal bat detector battery that expired.

The CNWR #1 permanent monitoring station was established on March 31, 2011, and as with the CVCA station, functioned properly, but experienced data losses due to insect interference.

Pre-Development Acoustic Bat Surveys – Laguna Division Conservation Area

Six Anabat detectors were set out during three different periods across the site for acoustic bat monitoring (figure 22). Dates of deployment were January 24–31, May 18–31, and August 19–September 8 for a total of 43 nights. The six sites were sampled 8 to 20 nights simultaneously.

Bat activity was sampled remotely using Anabat SD1 bat detectors (Titley Electronics, New South Wales, Australia). Prior to deployment, each detector was calibrated manually using an Anabat chirper (Titley Scientific, Lawnton QLD). The typical sensitivity was set around 7 depending on the detector, and the standard division ratio was set at 16. Bat detectors recorded continuously from dusk to dawn directly onto compact flash cards. Detectors were placed in waterproof tackle boxes on the ground. Microphones were housed in weatherproof "bathats" mounted on posts (see figures 15 and 16).

Sampling of multiple nights provides an assessment of the level of temporal variation within and among habitats (Williams et al. 2006). Sampling all sites within a habitat creation area simultaneously also ensures that any variation in conditions that affect bat activity is consistent among sampling sites.

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 on the LCR following the method outlined in Thomas et al. (1987). Analook version 3.9.c. 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 milliseconds and consisting of more than two individual calls (Thomas 1988; O'Farell and Gannon 1999). Although feeding buzzes frequently occurred throughout surveys, they were not quantified in this study.

Call minutes 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 (i.e., presence-absence of a species per 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 2001; Miller 2001).

Figure 22.—Location of pre-development bat monitoring stations at Laguna Division Conservation Area.

A total of 15 bat species is known to occur along the LCR (Snow 2007). An additional species, the Arizona myotis (*Myotis occultus*), was thought to have been extirpated, but has been confirmed from genetic analysis of an individual captured at ‘Ahakhav (Calvert 2009). This finding was supported by correlation of diagnostic acoustic calls with the genetics. Eleven bat species were identified based on the presence of characteristic, diagnostic calls in the recordings. In addition, species groups were created consisting of overlapping, similar call characteristics as done by Betts (1998); Rainey et al. (2003); and the Western Bat Working Group (2004). The 45–55 kilohertz (kHz) species group includes California myotis (*Myotis californicus*), Yuma myotis (*Myotis yumanensis*), and some calls of the canyon bat (*Parastrellus hesperus*) and California leaf-nosed

bat. The 35–40 kHz species group consists of overlapping calls of the cave myotis (*Myotis velifer*) and the Arizona myotis. The 25–30 kHz group includes big brown bat (*Eptesicus fuscus*), Mexican free-tailed bat (*Tadarida brasiliensis*), and the pallid bat (*Antrozous pallidus*). The 19–24 kHz species group includes overlapping calls of pocketed free-tailed bat (*Nyctinomops femorosaccus*), big free-tailed bat (*Nyctinomops macrotis*), hoary bat (*Lasiurus cinereus*), and some calls of the Mexican free-tailed bat.

There are four abundant "flagship" species: canyon bat, Mexican free-tailed bat, California myotis, and Yuma myotis (Brown and Berry, personal communication 2007). These flagship species (a term coined by Pat Brown, personal communication, which refers to their abundance along the lower Colorado River) are widespread in a large array of habitats along the LCR and are considered to have stable or increasing populations. While they are important members of the mammalian community, the focus of habitat creation efforts is on restoring habitat for the two covered species, western red bat and western yellow bat, as well as for the two evaluation species, the California leaf-nosed bat and the pale Townsend's big-eared bat. Calls of these abundant, common species were placed in species groups.

RESULTS

Mobile Acoustic Bat Surveys

A representative set of mapped results are displayed for three habitat conservation areas below. All data recorded during mobile surveys are shown in tables by month and habitat conservation area. All bat species names and codes can be found in table 1.

Beal Lake Riparian Restoration Area

Driving surveys were conducted during May, July, and September. Figure 23 displays the results of Transect 1, May 19, 2011. Since it was the first survey of the evening, most of the bats recorded were the early emerging canyon bats. Table 2 shows the total minutes of bat activity for each survey period. Western red bat minutes (LABL) were recorded in July (1 minute), and 1 minute was recorded for the California leaf-nosed bat in May. The most abundant bat species recorded was the canyon bat (PAHE) with 83 minutes recorded in July.

Overall, this was one of the easiest and most consistent survey routes. The route was on dry, firm roadways, and no difficulties were encountered. It also traversed the habitats thoroughly.

Table 1.—Bat species and species groups identified in the lower Colorado River habitat creation areas

Common name	Scientific name	Species code
Individual species		
Arizona myotis	*Myotis occultus*	MYOC
Big free-tailed bat	*Nyctinomops macrotis*	NYMA
California leaf-nosed bat	*Macrotus californicus*	MACA
Canyon bat	*Parastrellus hesperus*	PAHE
Cave myotis	*Myotis velifer*	MYVE
Hoary bat	*Lasiurus cinereus*	LACI
Mastiff bat	*Eumops perotis*	EUPE
Pocketed free-tailed bat	*Nyctinomops femorosaccus*	NYFE
Townsend's big-eared bat	*Corynorhinus townsendii*	COTO
Western red bat	*Lasiurus blossevillii*	LABL
Western yellow bat	*Lasiurus xanthinus*	LAXA
Phonic groups		
19–24 kHz	Overlapping calls of NYFE, NYMA, LACI, TABR	
25–30 kHz	All calls of EPFU, TABR, ANPA	
30–35kHz	Overlapping calls of EPFU, TABR, ANPA	
35–40 kHz	Overlapping calls of MYOC, MYVE	
45–55 kHz	All calls of MYCA, MYYU, and overlapping calls of PAHE	
Species included in the species groups listed above		
Big brown bat	*Eptesicus fuscus*	EPFU
California myotis	*Myotis californicus*	MYCA
Mexican free-tailed bat	*Tadarida brasiliensis*	TABR
Pallid bat	*Antrozous pallidus*	ANPA
Yuma myotis	*Myotis yumanensis*	MYYU

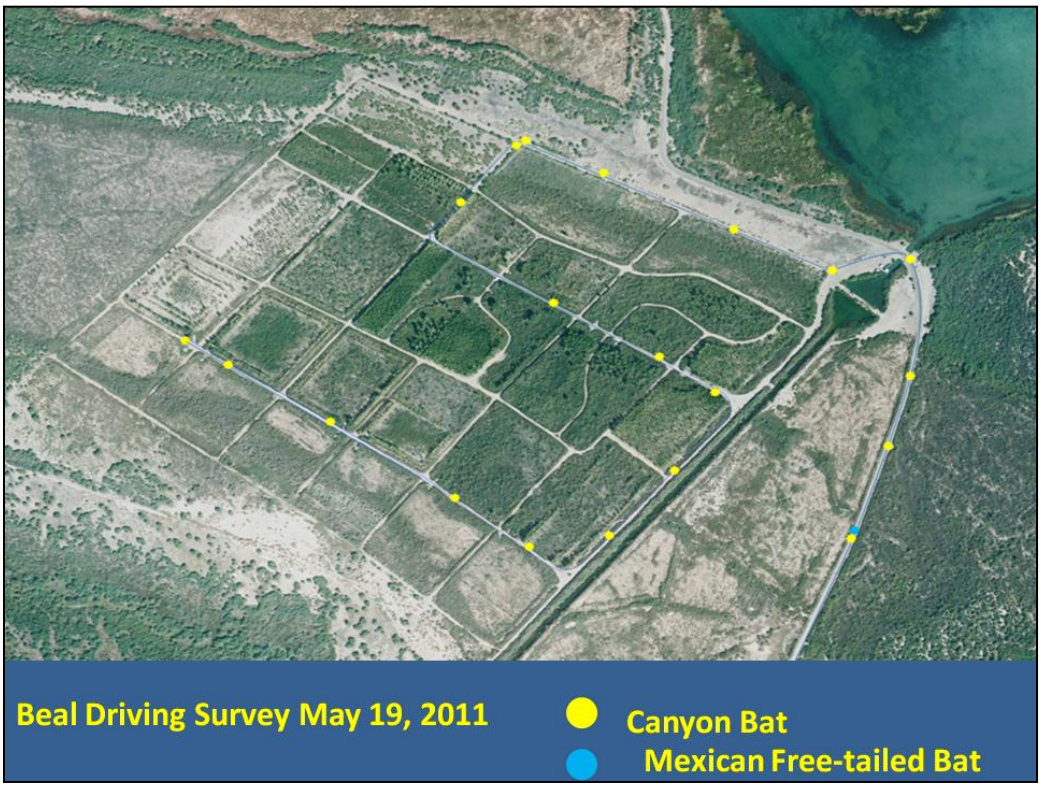

Figure 23.—Driving survey map of Transect 1, May 19, 2011, at the Beal Lake Riparian Restoration Area.

‘Ahakhav Tribal Preserve

Figure 24 shows a map of species encountered during driving Transect 1 on July 26, 2011, at ‘Ahakhav. Eight western yellow bats were encountered during this brief survey (5 minutes) along with canyon bats and Arizona myotis. Table 3 summarizes the results of all transects for the three survey periods. Fourteen minutes of western yellow bat activity were recorded during May along with 23 minutes of Arizona myotis activity. There were no western red bats or California leaf-nosed bats recorded.

This driving route was also one of the most consistent and easy routes to survey because of the excellent condition of the road and excellent access throughout the riparian habitats.

Palo Verde Ecological Reserve

Figure 25 shows the result of one transect driven through PVER on July 26, 2011. Seven minutes of western yellow bat activity were recorded. This survey route proved difficult to consistently survey because of impassable road conditions when irrigation was occurring, which resulted in confining the survey to the main road and, therefore, missing a good deal of the habitat.

Table 2.—Total bat minutes recorded for all bat species during driving surveys at the Beal Lake Riparian Restoration Area

Beal driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**2**	**5**	**2**
24–30 kHz	5	11	
30–35 kHz		8	
35–40 kHz		1	
40–45 kHz		4	
45–55 kHz	13	13	
EPFU		2	
EUPE			1
LABL		1	
MACA	1		
MYOC	1	2	
MYVE	3	3	
NYFE			1
PAHE	17	83	
TABR	5	2	2
Grand total all species	45	130	4

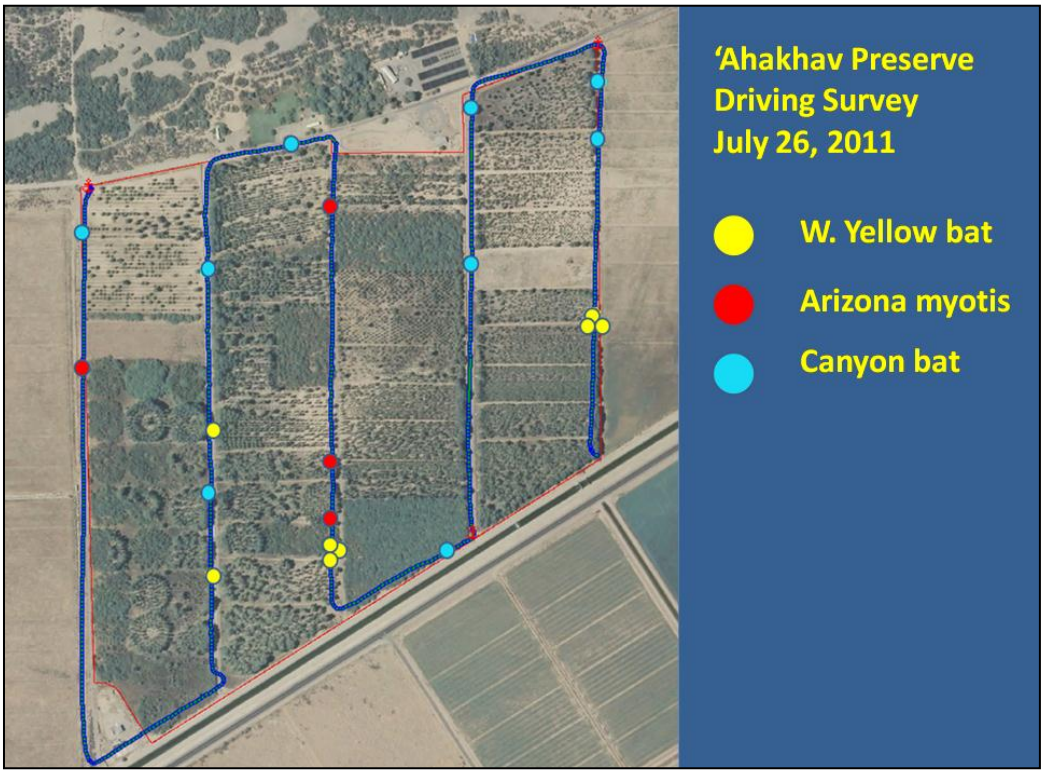

Figure 24.—Map of bat species encountered during Transect 1 on July 26, 2011, at the 'Ahakhav Tribal Preserve.

Table 3.—Total bat minutes recorded during driving surveys at the ‘Ahakhav Tribal Preserve

‘Ahakav driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**2**	**1**	**1**
24–30 kHz	1		
30–35 kHz	2	1	
35–40 kHz	1		
45–55 kHz	7		
ANPA	2		
EPFU	3		
EUPE			1
LACI			1
LAXA	14	4	
MYOC	23	4	2
MYVE	9		1
NYFE			3
PAHE		14	10
TABR			7
Grand total all species	62	23	25

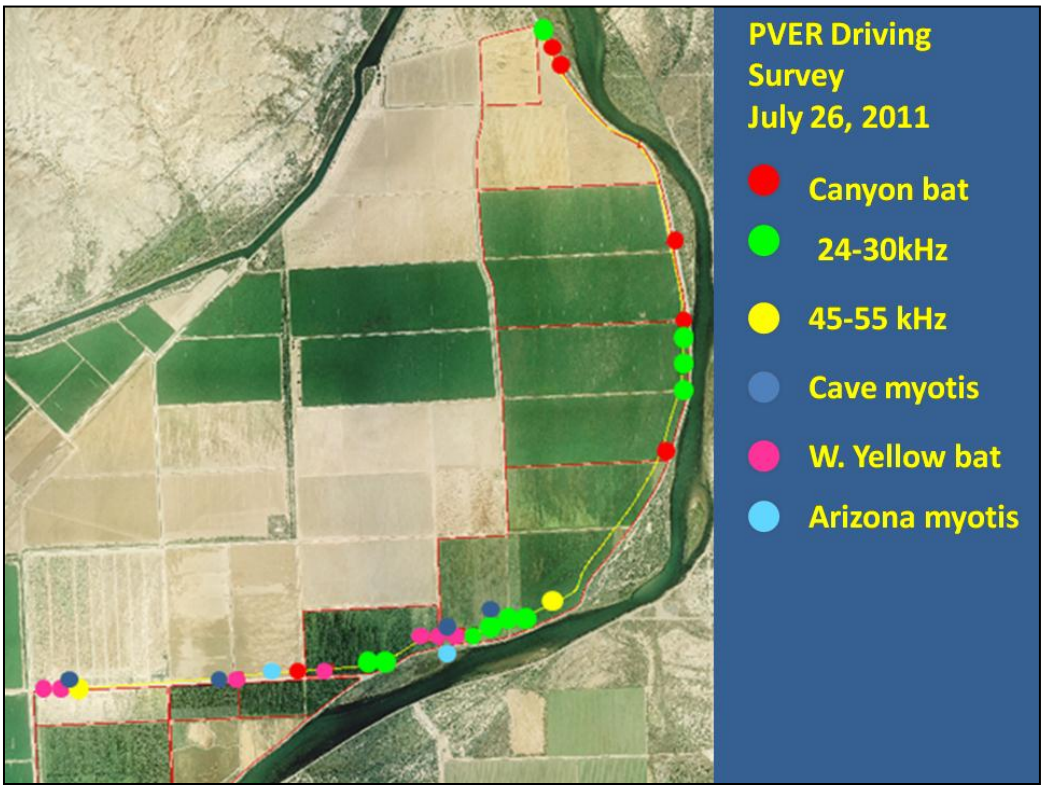

Figure 25.—Map of the Palo Verde Ecological Reserve driving survey showing locations of bat species recorded during two transects on July 26, 2011.

Table 4 shows the total minutes of bat activity for the 3 nights of surveys. There was 1 minute of western red bat activity recorded in May along with 5 minutes of western yellow bat activity recorded in July and 3 minutes in September.

Table 4.—Total bat minutes recorded during driving surveys at the Palo Verde Ecological Reserve

PVER driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**2**	**2**	**2**
19–24 kHz		3	
24–30 kHz		5	16
30–35 kHz		2	9
45–55 kHz	6	3	7
LABL	1		
LAXA		5	3
MYOC		2	2
MYVE		6	7
NYFE		2	4
PAHE	1	5	1
TABR		1	9
Grand total all species	8	34	59

Cibola Valley Conservation Area

Table 5 shows the total bat minutes recorded during driving surveys at CVCA. Western red bat minutes were recorded during May (3) and July (1), and western yellow bat minutes were recorded during July (2) and September (1). The canyon bat was the most numerous species with 55 minutes recorded in July and 39 minutes recorded in September. Some difficulties were encountered in conducting the driving surveys at CVCA due to periodically impassable portions of the route during irrigation activities.

Cibola National Wildlife Refuge Unit 1 Conservation Area

Table 6 shows the total minutes of bat activity during the three survey periods at CNWR #1. No focal bat species was encountered during any survey period. The most numerous were the 24–30 kHz species group (primarily big brown and Mexican free-tailed bats and the Mexican free-tailed bats). For the most part, this route presented only minor difficulties in some sandy field edges.

Table 5.—Total bat minutes recorded during mobile bat surveys at the Cibola Valley Conservation Area

CVCA driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**2**	**2**	**2**
19–24 kHz		1	
24–30 kHz	1	20	13
30–35 kHz		14	2
45–55 kHz	5	12	2
ANPA	1	1	
EPFU		3	1
EUPE			5
LABL	3	1	
LACI			1
LAXA		2	1
MACA		1	
MYVE		1	3
NYFE	1		2
PAHE	4	55	39
TABR		4	24
Grand total all species	15	115	93

Table 6.—Total bat minutes recorded during mobile bat surveys at the Cibola National Wildlife Refuge Unit 1 Conservation Area

CNWR #1 driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**2**	**1**	**2**
19–24 kHz			
24–30 kHz	1	3	15
30–35 kHz		1	2
35–40 kHz			1
45–55 kHz		5	3
ANPA		1	
EPFU	2	1	
EUPE	1		
NYFE	1		
PAHE	8	12	3
TABR			13
Grand total all species	13	23	37

Imperial Ponds Conservation Area

Table 7 summarizes the minutes of bat activity recorded during the three survey periods at IPCA. There were 3 minutes of western red bat activity recorded in July, 1 minute of western yellow bat activity in May, and for the first time, a Townsend's big-eared bat minute was recorded in July. Canyon bats and the 24–30 kHz species group were the most frequently recorded bats at IPCA. The survey route at IPCA for the most part was adequate for surveying, with good access to the habitats.

Table 1.—Total bat surveys recorded during mobile bat surveys at the Imperial Ponds Conservation Area

IPCA driving surveys 2011			
Species/species group	**May**	**July**	**September**
Number of transects	**3**	**4**	**3**
19–24 kHz			
24–30 kHz	6	31	8
30–35 kHz	2	15	1
35–40 kHz			
40–45 kHz			1
45–55 kHz	17	24	
ANPA			7
COTO		1	
EPFU	2		
EUPE		3	
LABL		3	
LAXA	1		
MYOC		1	
NYFE	7		
PAHE	10	104	30
TABR	20	2	3
Grand total all species	65	184	50

Permanent Bat Monitoring Stations

Beal Lake Riparian Restoration Area

The minutes of bat activity for the four focal species are displayed on figures 26–29. In FY11, western red bat activity was recorded year round, with the most consistent activity occurring from May through September. Western red bat minutes were also recorded in October and November and sporadically throughout the winter months.

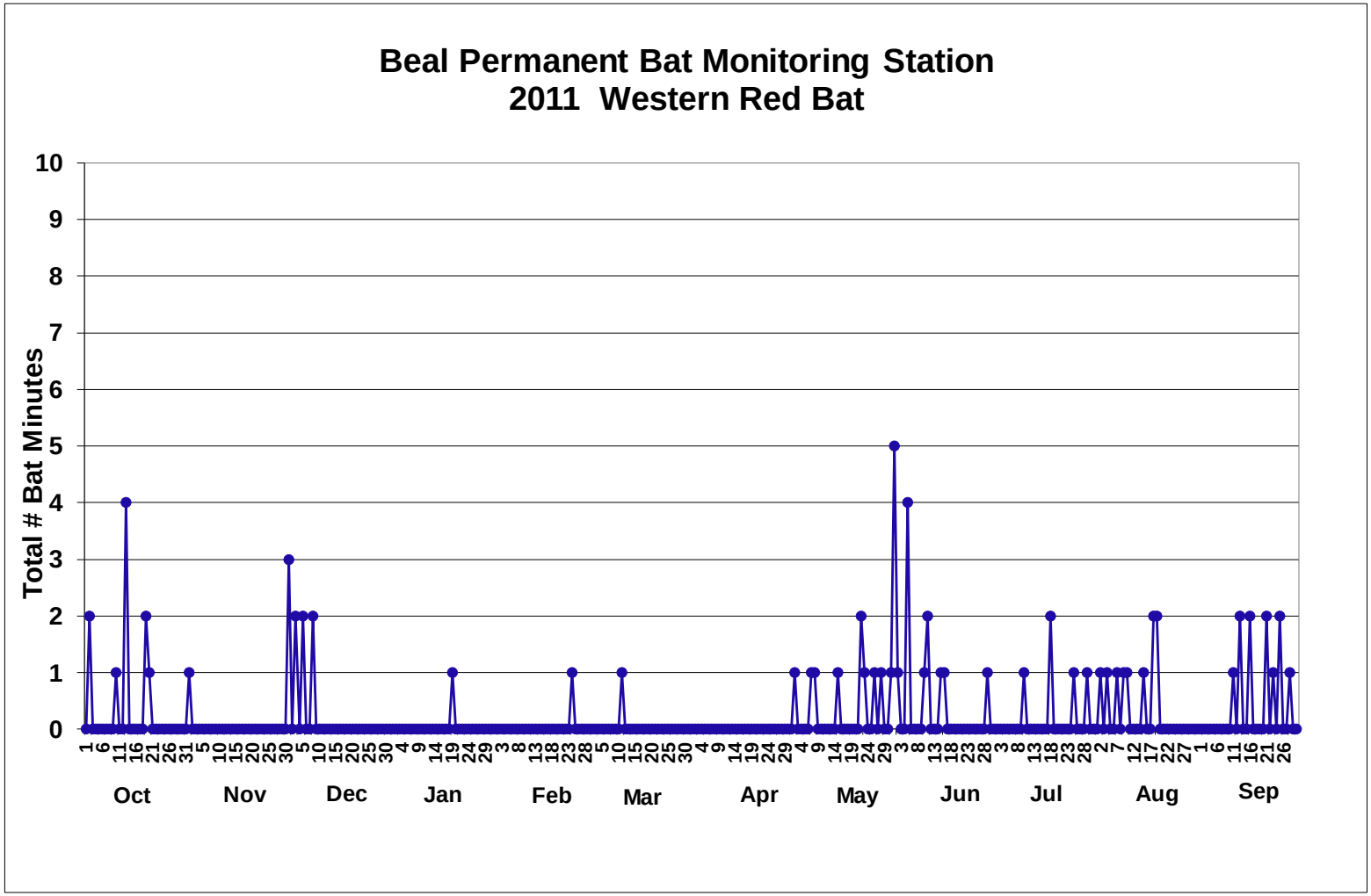

Figure 26.—Total minutes of western red bat activity recorded at the Beal Lake Riparian Restoration Area permanent monitoring station in 2011.

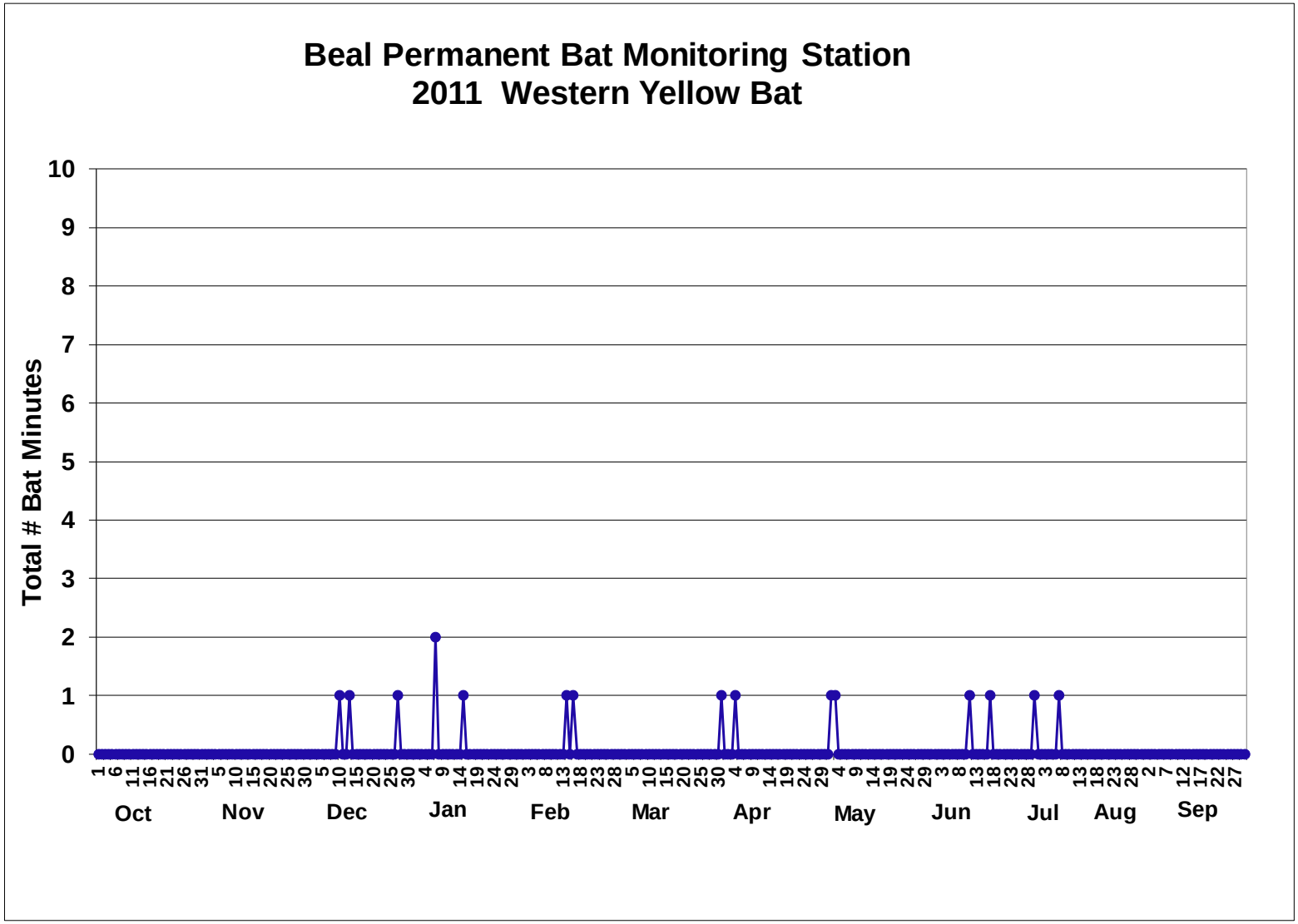

Figure 27.—Total western yellow bat minutes recorded at the Beal Lake Riparian Restoration Area permanent monitoring station in 2011.

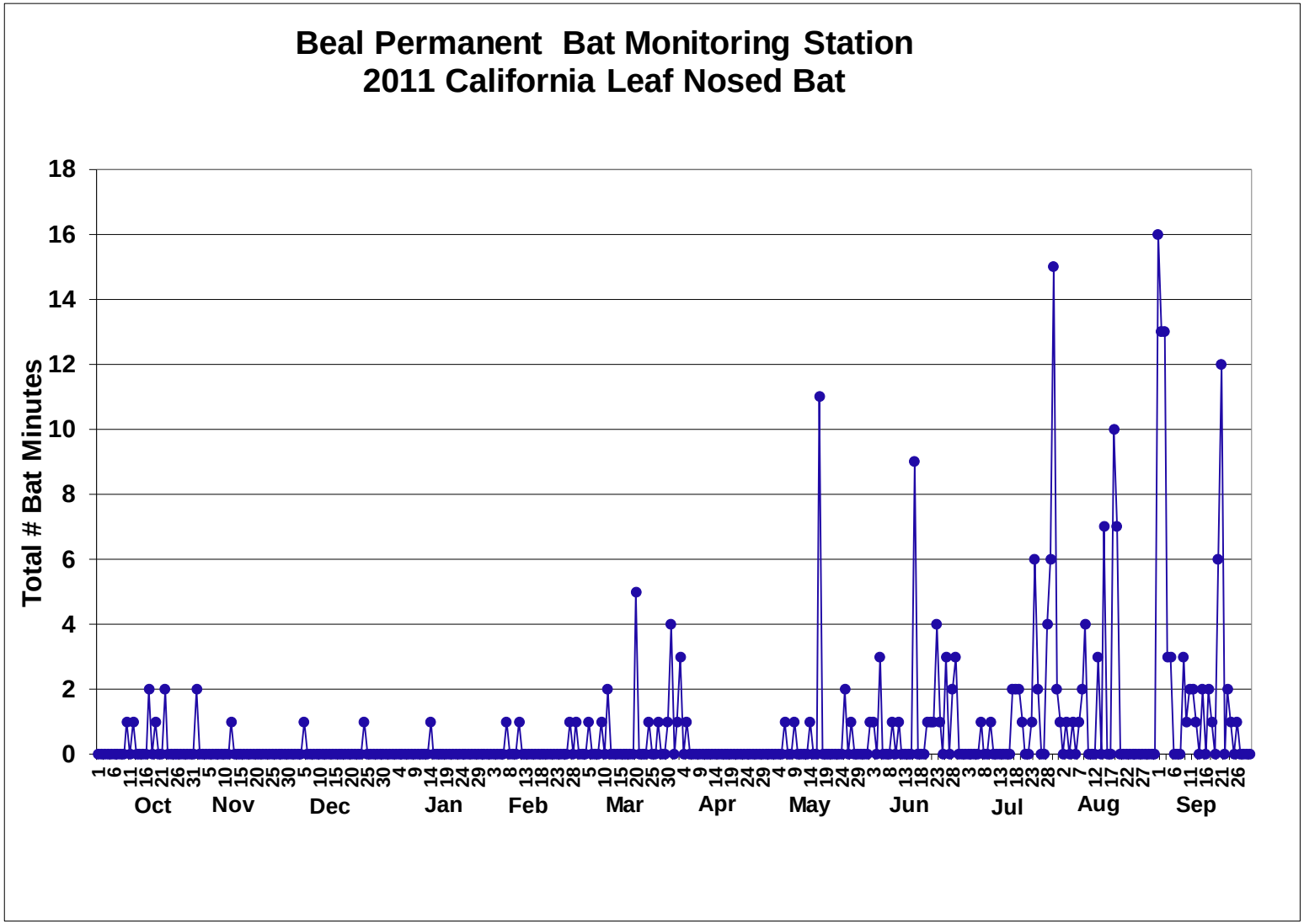

Figure 28.—Total minutes of California leaf-nosed bat activity at the Beal Lake Riparian Restoration Area permanent bat monitoring station in 2011.

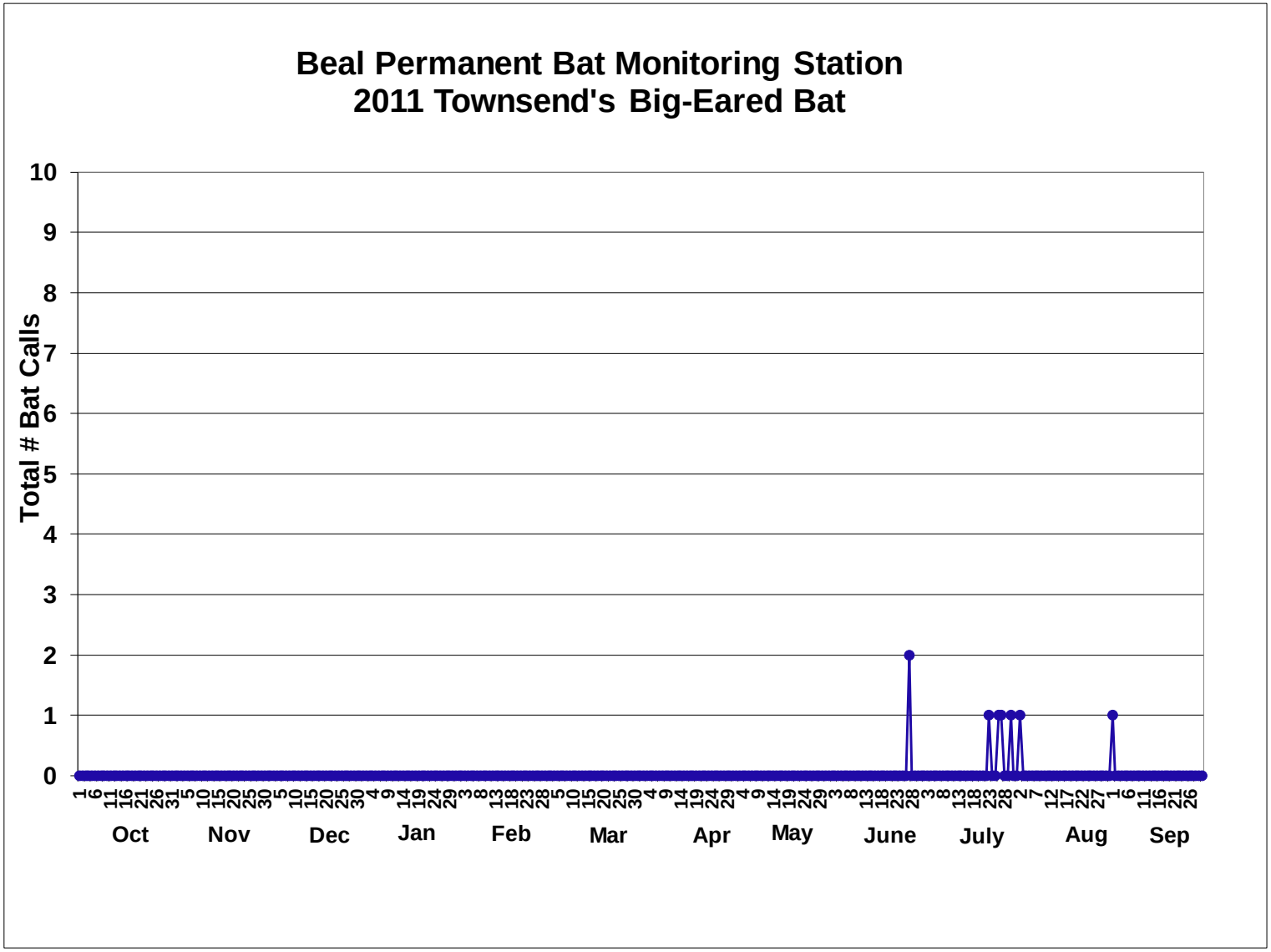

Figure 29.—Total minutes of Townsend's big-eared bat activity at the Beal Lake Riparian Restoration Area permanent bat monitoring station in 2011.

Figure 27 shows light but consistent western yellow bat activity December through the first part of August.

California leaf-nosed bat activity is shown occurring year-round at Beal, with the greatest amount of activity May through September (figure 28).

Figure 29 shows the Townsend's big-eared bat is utilizing the habitat Beal as well, with activity recorded from late June through early September.

This next section shows the results of year-to-year comparisons for western red and yellow bats, with figures 30 and 31 showing 3 years of bat activity and tables 8 and 9 summarizing the results of statistical analyses comparing activity.

The Kruskal-Wallis test is a non-parametric procedure that tests the null hypothesis that the medians within each of the three columns of data corresponding to years 2009 through 2011 are the same. The data from all the columns are first combined and ranked from smallest to largest. The average rank is then computed for the data in each column. If *p*-values are less than 0.05, there is a statistically significant difference among the medians at the 95-percent (%) confidence level. To determine which medians are significantly different from which others, a Tukey's Honestly Significant Difference procedure was conducted. Table 8 summarizes the results for western red bat activity, and table 9 summarizes the results for western yellow bat activity.

A large pulse of western red bats occurred during the 2010 migration period (figure 30). This was significantly higher than migration during 2009 and 2011 (table 8). It was speculated in 2010 that this influx of western red bats might indicate the habitat at Beal was maturing sufficiently to attract red bat use; however, this simple explanation may not be adequate to explain why the large influx of western red bats occurred in the fall of 2010 and not in the fall of 2011.

Western red bats appear to be expanding into Beal during the winter season, with 2011 having significantly higher bat activity than in 2009 or 2010.

Cibola Valley Conservation Area

Minutes of western red bat activity recorded at the permanent monitoring station at CVCA is plotted on figure 32. In spite of the poor quality files that were recorded from station startup in March 31 through July due to insect interference, a large amount of activity was recorded for this species in April, with slightly lower activity recorded May through July. A period of data loss occurred in mid- July through August due to internal battery failure in the bat detector. A large pulse of western red bat activity is seen in early September.

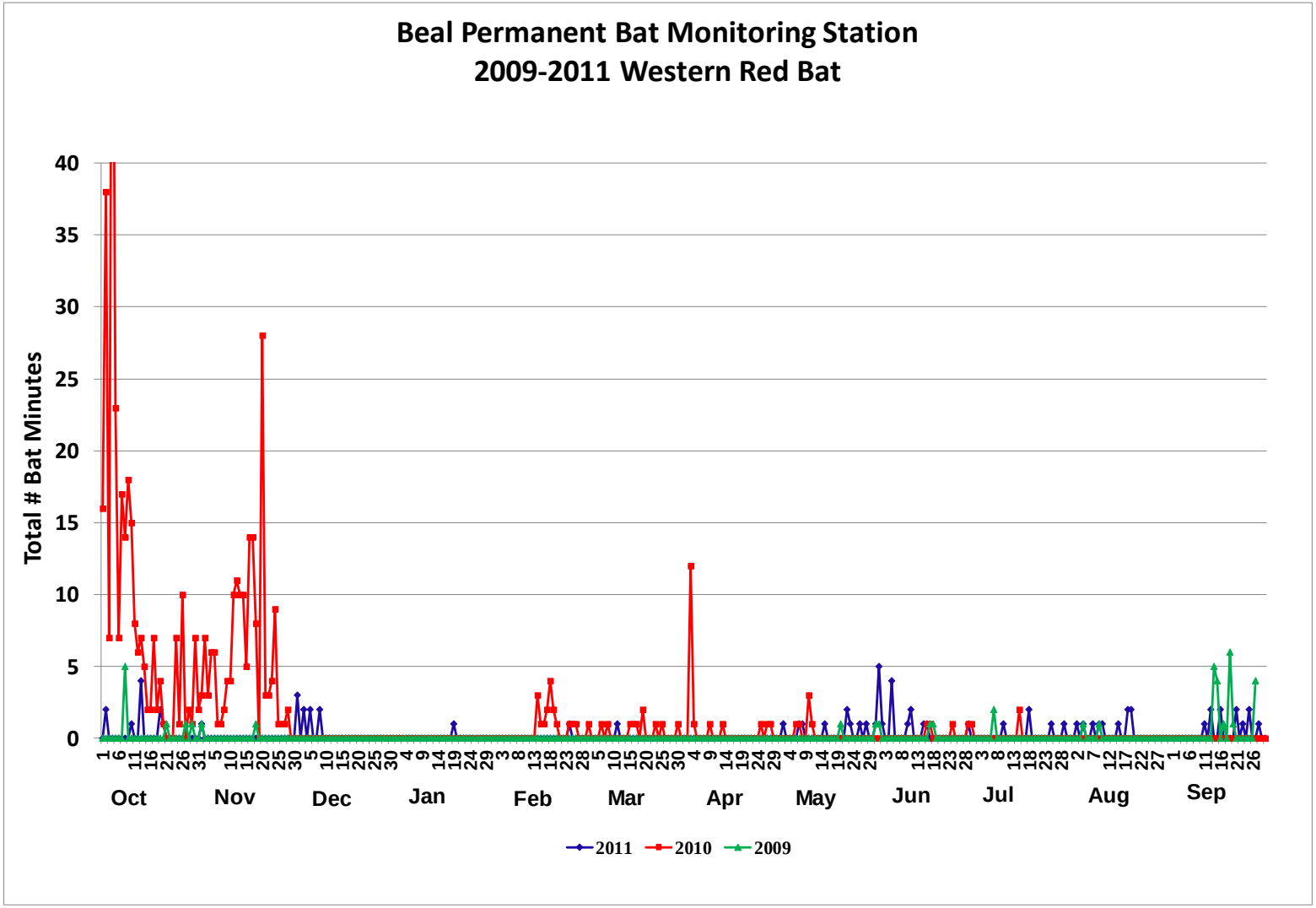

Figure 30.—Comparison of total bat minutes for the western red bat from 2009 to 2011.

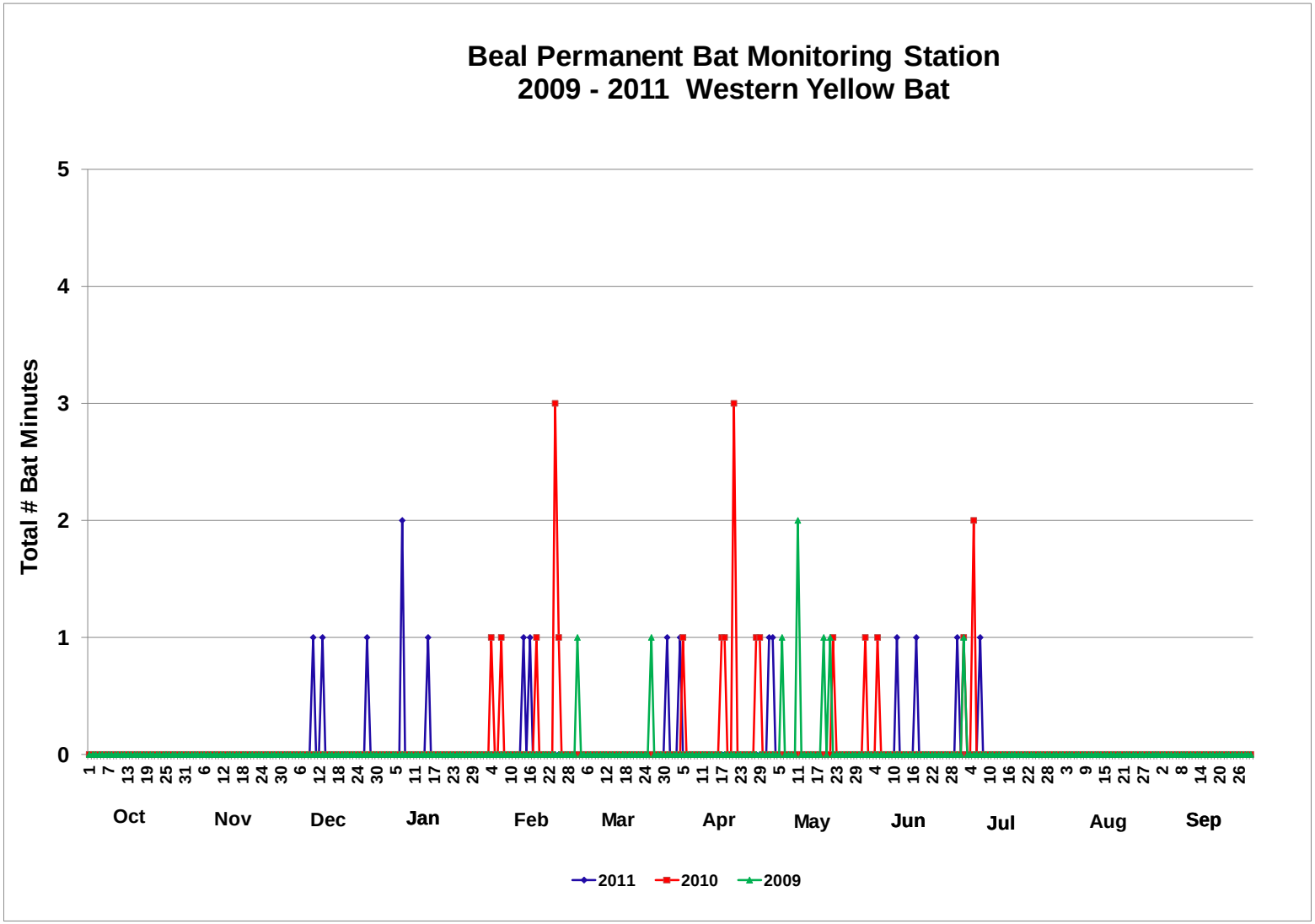

Figure 31.—Comparison of total bat minutes for western yellow bat from 2009 to 2011.

Table 8.—Comparison of bat activity during key time periods for western red bat at the Beal Lake Riparian Restoration Area permanent monitoring station for 2009 through 2011

Comparison of western red bat activity 2009 through 2011			
Months	**Biological period**	***p*-value**	**Results**
Oct – Nov	Migration	$p = 0.00$	FY10 had significantly higher minutes of western red bat activity than 2009 or 2011.
Dec – Jan	Wintering	$p = 0.01$	FY11 had significantly higher minutes of western red bat activity than 2009 or 2010.
Feb – Mar	Late winter/early spring	$p = 6.28$	No significant differences in western red bat activity among years.
Apr	Migration	$p = 0.00$	FY10 had significantly higher minutes of western red bat activity than 2009 or 2011.
May – July	Breeding	$p = 0.00$	FY11 had significantly higher western red bat activity during the breeding season than 2009 or 2010.
Aug – Sept	Late summer/early migration	$p = 0.00$	FY11 had significantly higher minutes of western red bat activity than 2009 or 2010.

Table 9.—Comparison of bat activity during key time periods for western yellow bats at the Beal Lake Riparian Restoration Area permanent monitoring station for 2009 through 2011

Comparison of western yellow bat activity 2009 through 2011			
Months	**Biological period**	***p*-value**	**Results**
Oct – Nov	Fall migration	$p = 0.00$	No minutes of western yellow bat activity for any year during this period.
Dec – Jan	Wintering	$p = 0.01$	2011 had significantly higher minutes of western yellow bat activity in winter than 2009 or 2010.
Feb – Mar	Late winter/early spring	$p = 6.28$	No significant differences among years.
Apr	Spring migration	$p = 0.00$	2010 had significantly higher minutes of western yellow bat activity in April than 2009 or 2010.
May – July	Breeding	$p = 0.62$	No significant differences among years.
Aug – Sept	Late summer/ early migration	$p = 0.00$	No significant differences among years.

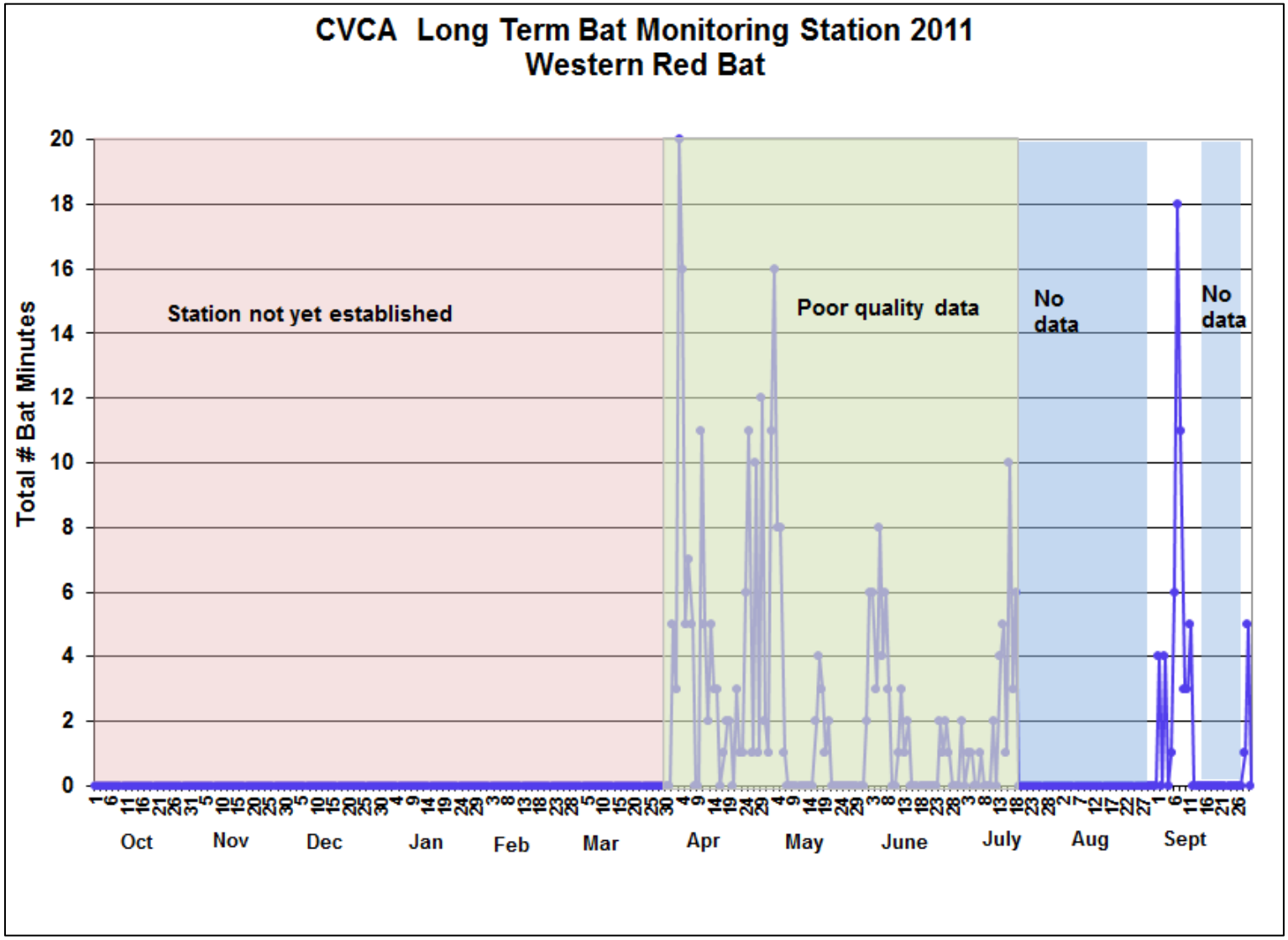

Figure 32.—Total minutes of western red bat activity at the Cibola Valley Conservation Area permanent bat monitoring station in 2011.

In spite of technical difficulties with insects and the bat detector, it appears that western red bats are actively utilizing the habitat in CVCA, at least during the breeding season, as well as during late summer.

This pattern is repeated for the western yellow bat (figure 33). The window of time that the station was operating, in spite of poor quality recorded calls, shows that western yellow bats are actively using the habitats at CVCA.

Figure 34 shows that California leaf-nosed bats are utilizing the CVCA habitat, and a relatively high level of activity was recorded for the brief periods of time that the station was operating properly.

Figure 35 shows Townsend's big-eared bat activity in the habitat at CVCA primarily during April as well as in June and September.

Cibola National Wildlife Refuge Unit 1 Conservation Area

The new permanent bat monitoring station established at CNWR #1 on March 31, 2011, had a brief window of normal operation in April (figure 36). That was soon negated as insect interference became a major source of data loss. The microphone for this station must be raised to just slightly above the canopy to prevent the detector from recording only insect calls. However, the little window of time when the station was operating properly showed a good deal of western red bat activity in April. Some western red bat calls were recorded through the din of insect interference in May and June, and a pulse of activity appears in September when insects were not calling.

This pattern is repeated with the western yellow bat (figure 37) with light activity recorded in April, some through the insect interference May and June, and a spike in activity as insect calling stopped. The California leaf-nosed bat showed a similar pattern, figure 38, as did the Townsend's big-eared bat (figure 39).

Laguna Division Conservation Area Pre-Development Bat Surveys

The total number of bat minutes and relative abundance by bat species and species group for the pre-development acoustic bat surveys for three survey

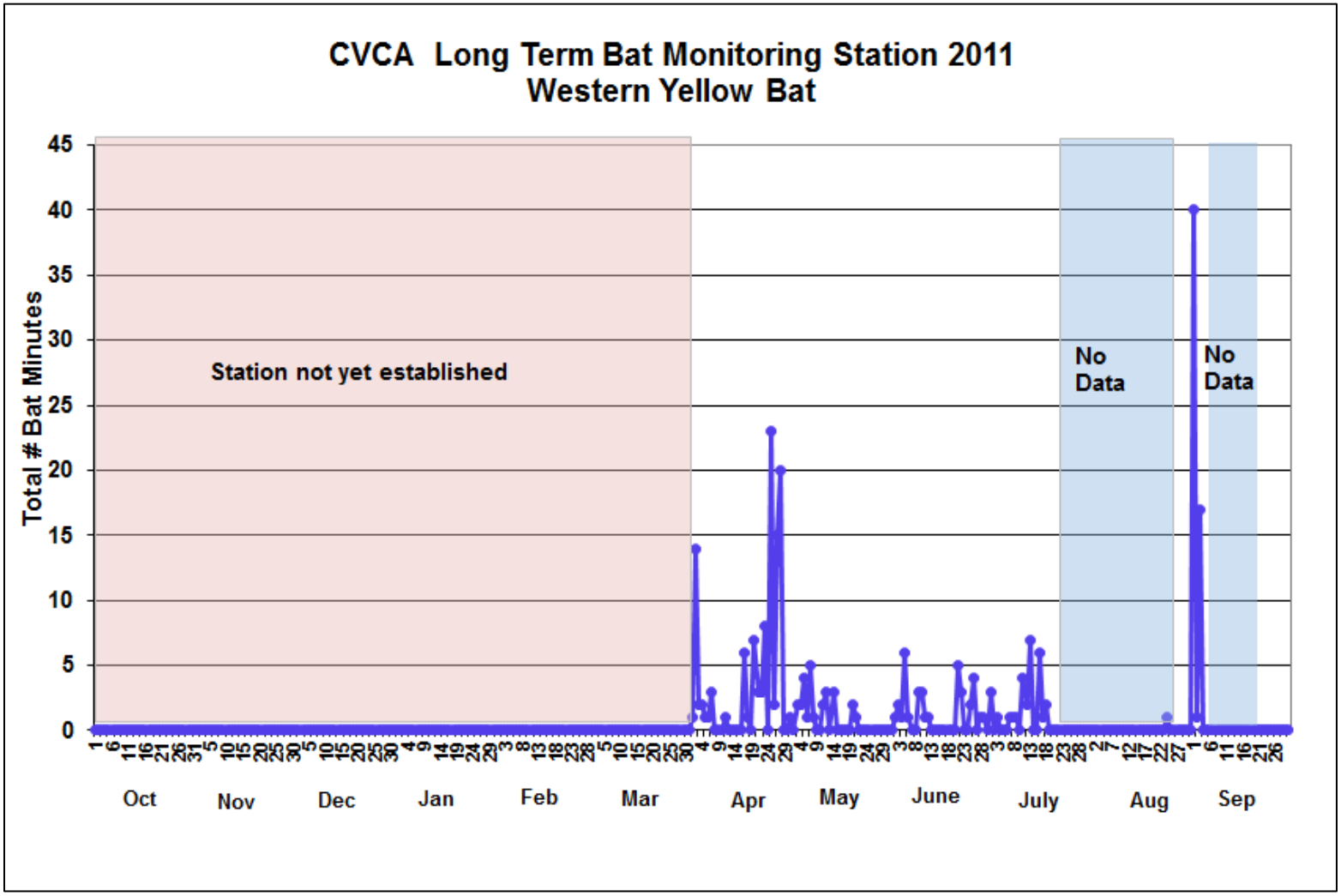

Figure 33.—Total minutes of western yellow bat activity at the Cibola Valley Conservation Area permanent bat monitoring station in 2011.

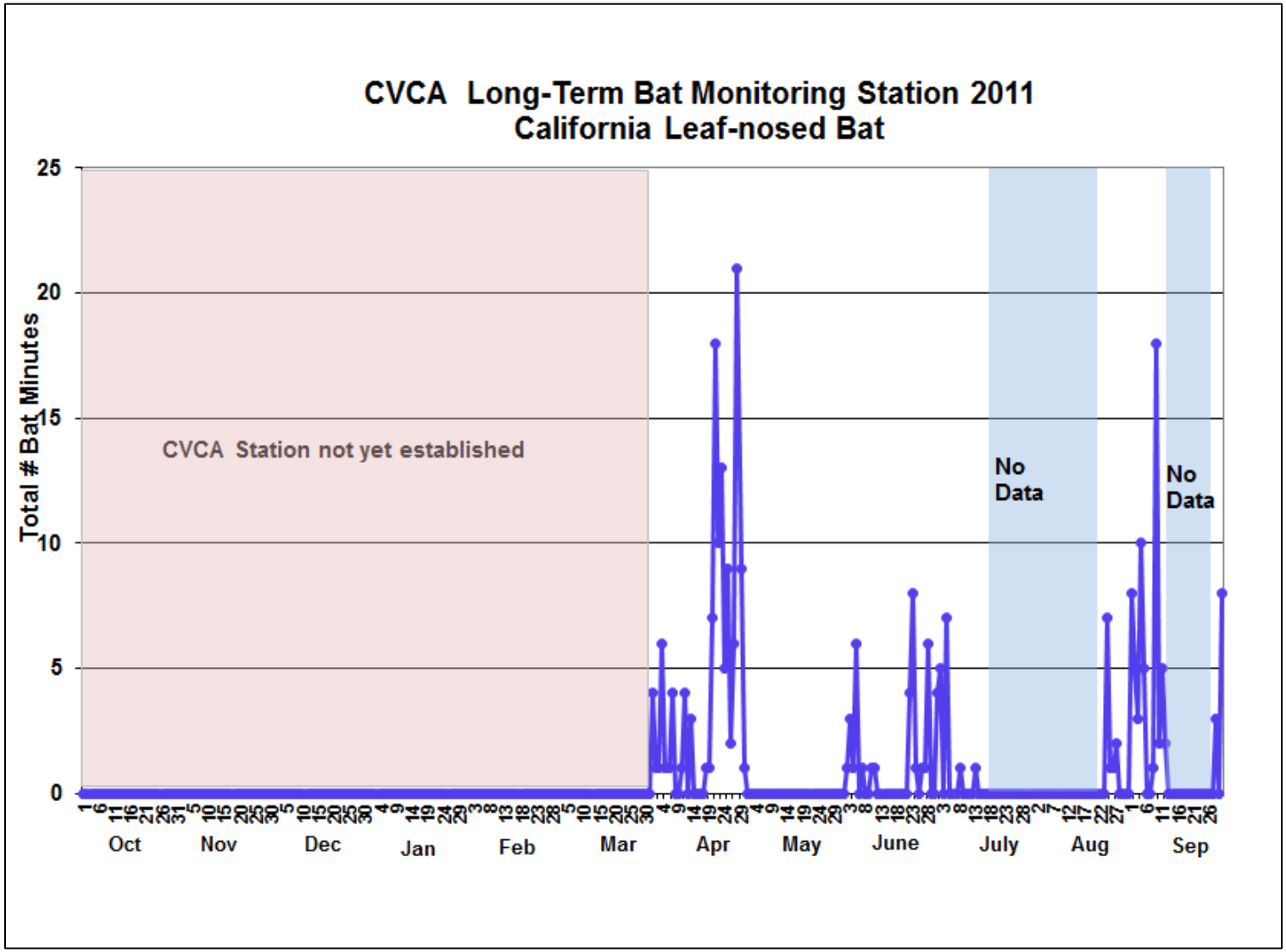

Figure 34.—Total minutes of California leaf-nosed bat activity at the Cibola Valley Conservation Area permanent bat monitoring station in 2011.

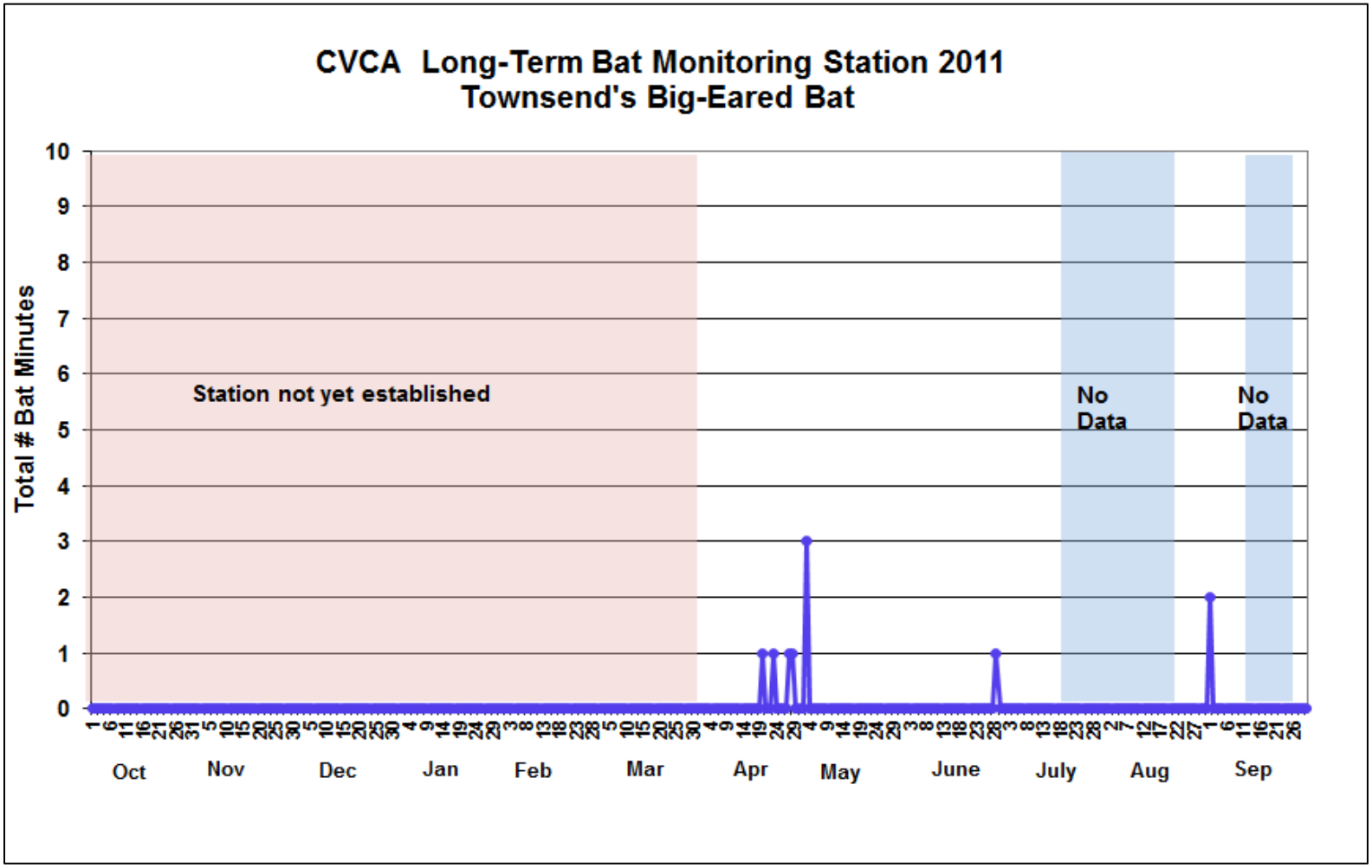

Figure 35.—Total bat activity for Townsend's big-eared bat at the Cibola Valley Conservation Area permanent bat monitoring station in 2011.

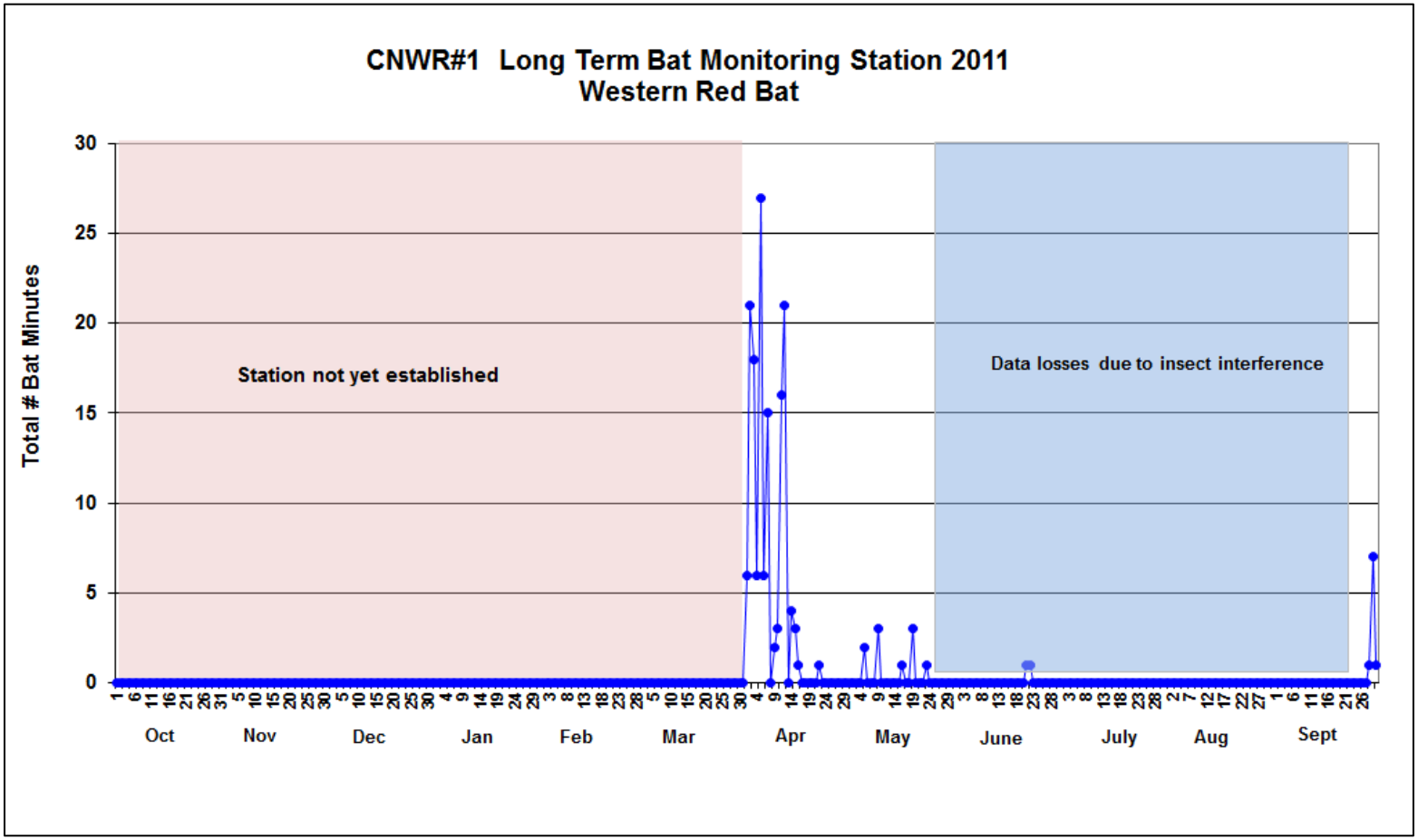

Figure 36.—Total minutes of western red bat activity at the Cibola National Wildlife Refuge Unit 1 Conservation Area permanent bat monitoring station in FY11.

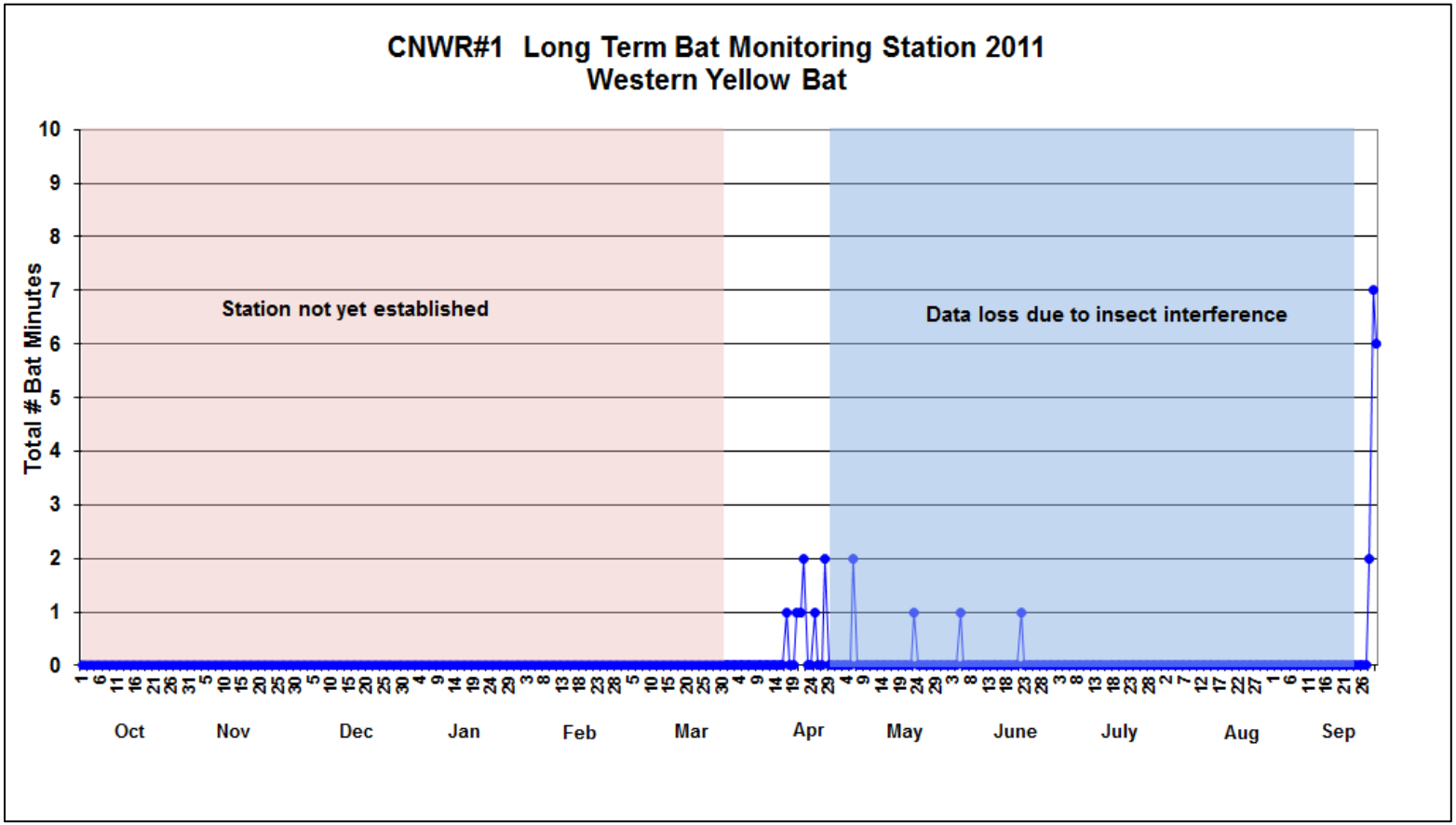

Figure 37.—Total minutes of western yellow bat activity at the Cibola National Wildlife Refuge Unit 1 Conservation Area permanent bat monitoring station in FY11.

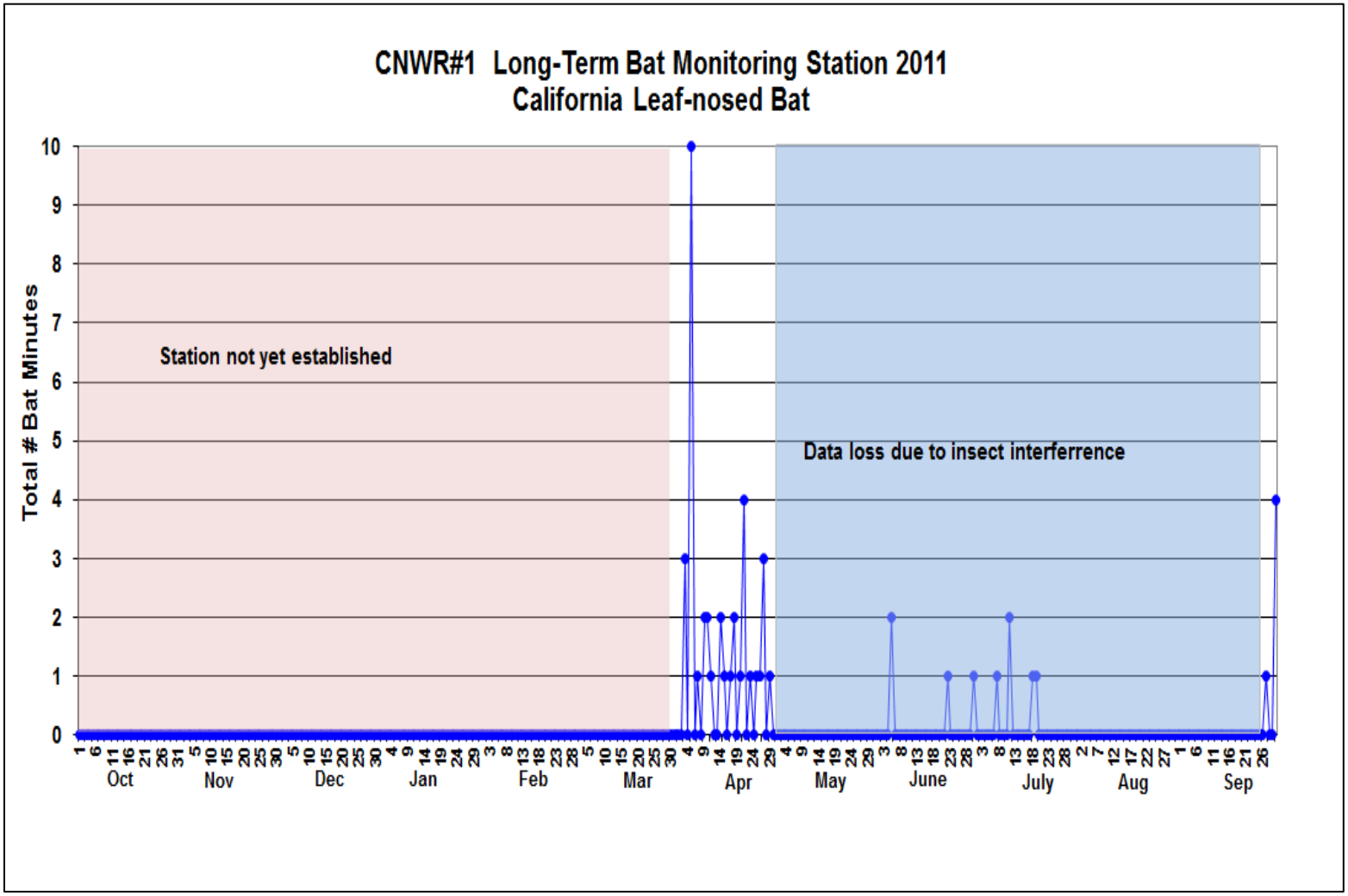

Figure 38.—Total bat minutes of California leaf-nosed bat activity at the Cibola National Wildlife Refuge Unit 1 Conservation Area permanent bat monitoring station in FY11.

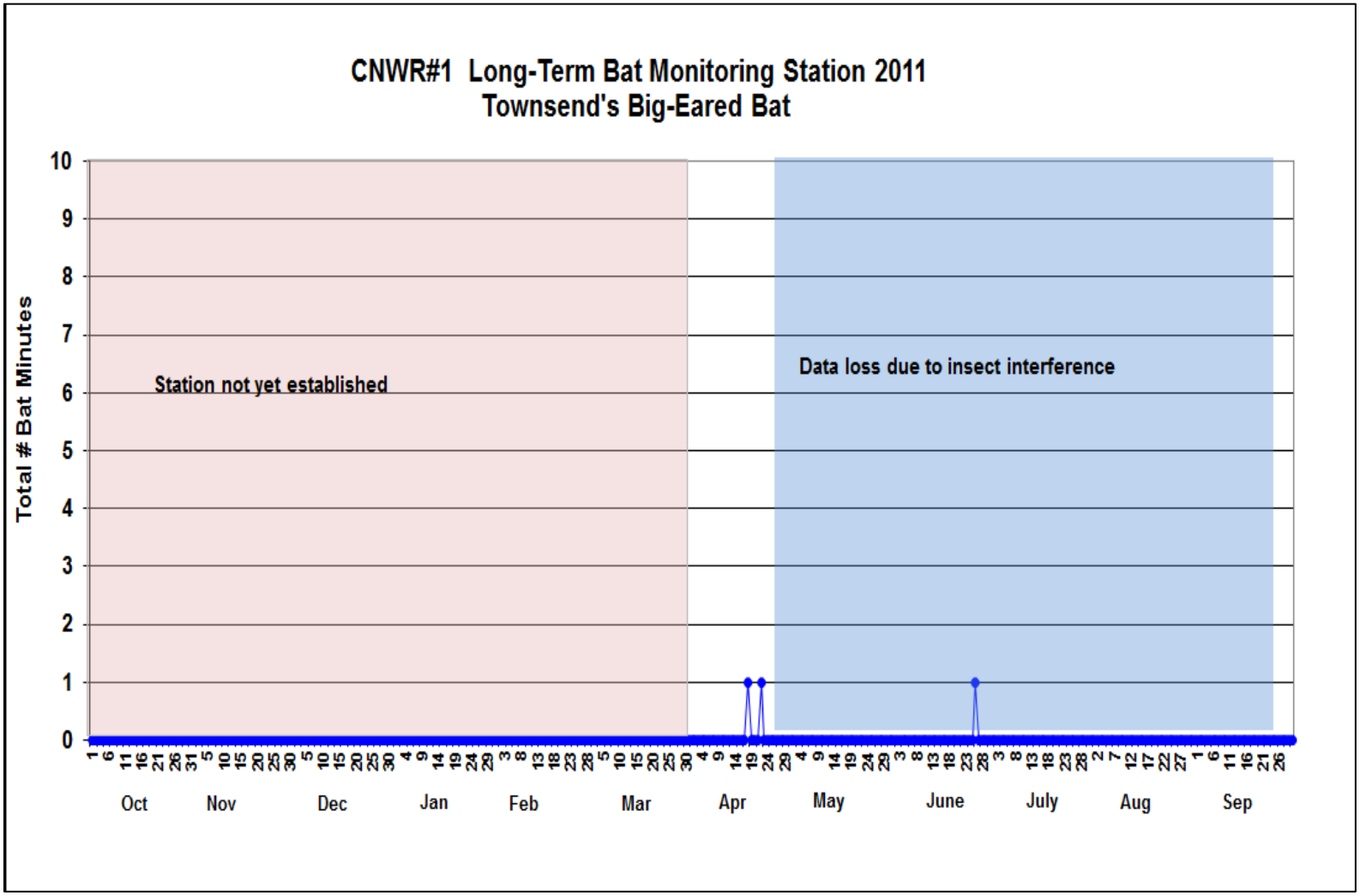

Figure 39.—Total bat minutes of Townsend's big-eared bat activity at the Cibola National Wildlife Refuge Unit 1 Conservation Area permanent bat monitoring station in FY11.

periods (January, May, and August/September 2011) are displayed in table 10. May had the greatest total number of bat minutes (10,785) with the Mexican free-tailed bat activity being the highest at 56.9% relative abundance. The second highest total bat activity was recorded during the August–September sample period with the canyon bat having the highest activity at 49.8% relative abundance. January sampling resulted in far lighter bat activity at 1,289 minutes total with Mexican free-tailed bats at 88% relative abundance. The four focal bat species were recorded during the three sample periods but overall formed a miniscule part of the bat activity recorded (< 1% relative abundance). Western red bats were present during the August/September period with 12 minutes of activity and 0.14% relative abundance and May periods (2 minutes bat and 0.02% relative abundance), but were absent in the January surveys. Western yellow bats were recorded in the late summer period (10 minutes of activity and 0.1% relative abundance). California leaf-nosed bats were present during all sample periods, with a late summer total of 12 minutes (0.1% relative abundance), 4 minutes recorded in May (0.04% relative abundance), and 4 minutes in January (0.3% relative abundance).

Table 10.—Relative abundance of bat activity based on total bat minutes for three survey periods in FY11

Species/ species groups	January		May		August – September	
	Total # bat minutes	% relative abundance	Total # bat minutes	% relative abundance	Total # bat minutes	% relative abundance
PAHE	3	0.23	1,613	15.0	4,431	49.82
TABR	1,137	88.21	6,135	56.9	1,834	20.62
45–55 kHz	14	1.09	2,528	23.4	1,778	19.99
24–30 kHz	95	7.37		0.00	459	5.16
30–35 kHz	27	3.00	337	3.10	203	2.28
NYFE	1	0.08	138	1.30	56	0.63
EUPE		0.00	20	0.19	36	0.41
19–24 kHz	1	0.08	2	0.02	23	0.26
40–45 kHz		0.00		0.00	14	0.16
MACA	4	0.31	4	0.04	12	0.14
LABL		0.00	2	0.02	12	0.14
MYOC		0.00		0.00	11	0.12
LAXA		0.00	2	0.02	10	0.11
LACI	2	0.16	2	0.02	5	0.06
ANPA		0.00		0.00	5	0.06
COTO		0.00		0.00	2	0.02
MYVE		0.00		0.00	1	0.01
EPFU	5	0.39		0.00	1	0.01
Totals	1,289	100%	10,785	100%	8,894	100%

DISCUSSION

Driving Surveys

Driving surveys were conducted during three time periods at six of the habitat creation areas. We found that the equipment performed well and that data and mapped locations of species recorded could be obtained. Overall however, the amount of time surveyed was relatively small with roughly 5 minutes surveyed during a typical transect. Transects were repeated two to five times depending on weather and other circumstances. This is a relatively miniscule sampling effort upon which to base long-term monitoring. Driving surveys ideally are suited for surveying large geographic areas with transects ranging from 20 to 30 miles. The transects in the habitat creation areas were a small fraction of the typical driving survey.

The survey route also was difficult to use at PVER and CVCA during the frequent irrigation periods, which made the road impassable. This cut short the survey route and prevented sampling in all of the habitats. In other cases, weather turned adverse during the scheduled time periods. This was unfortunate since people's schedules were done in advance and the sample sites are quite a distance from the office. Basically, the flexibility to adapt to changing weather and irrigation conditions was non-existent.

Overall, as a regular monitoring tool, mobile acoustic bat surveys do not yield robust monitoring results that can be used to track changes in bat use. On rare occasions, this technique could be used to survey large areas including the habitat creation areas and the adjacent agriculture and saltcedar. This would likely show "hot spots" of bat activity around the habitat creation areas compared to the extensive agricultural and saltcedar areas. But generally, for the amount of time preparing for the surveys, traveling to the survey sites, conducting the surveys, and subsequent mapping and data analysis for this method, far more efficient and statistically robust monitoring efforts can be used.

Permanent Stations

Data results for permanent bat monitoring stations can be striking. Visually, the daily plots of bat activity by species show a complete record of bat activity in a particular habitat creation area, including migration pulses, winter use, and breeding season activities. Data are readily useable in statistical analysis programs, and sample sizes are very large. When operating optimally, the stations are an excellent monitoring tool. However, intense insect noise resulted in severe data losses for the two new stations established at CVCA and CNWR #1

this year. These data losses were unfortunate, because during small windows of time when insects were not causing interference, it was evident that the four focal bat species were very active in these habitat creation areas.

The most severe and unexpected equipment problem encountered was the failure of the internal battery in the Anabat detectors. This was readily fixed by sending the affected detectors to the manufacturer for replacement and substituting for detectors with still functioning batteries. In the future, this type of problem can be minimized by routine detector checks when downloading data as well as periodically servicing detectors by the manufacturer.

Laguna Division Conservation Area Pre-Development Monitoring

Pre-development bat surveys were successfully conducted during January, May, and August/September. In one case, a coyote damaged a detector wire and microphone, resulting in some data loss in August, and in another case, a detector malfunctioned during the May sample. A fire that started near Betty's Kitchen on the same day that we deployed the units caused a great deal of concern; however, the fire was controlled before it could destroy our equipment. The equipment worked well for the most part. A large data set was collected, resulting in establishment of a good baseline for the bat community at LDCA from which comparisons can be made as the habitat work is initiated.

RECOMMENDATIONS

Driving surveys are not suitable for statistically robust long-term monitoring. This technique is best used for special applications – public and Steering Committee demonstrations and very broad-scale pictures of how the habitat creation areas differ from the surrounding farmland and saltcedar habitats.

Permanent stations should be installed at PVER, and 'Ahakhav in FY12.

Insect interference and subsequent data losses must be addressed as soon as possible to reduce or eliminate the potential for excessive data losses. The use of tilt-over tower designs to raise the Anabat microphones above intense insect activity should be explored. In the short term, Long-Arms can be used to elevate the microphones as much as possible in problem areas such as CVCA and CNWR #1 as well as to remove brush near the bat monitoring station.

Equipment should be cleaned and maintained regularly, especially the reflector plate, which can accumulate bird droppings and dirt, adversely affecting call quality.

Logbooks for each station should be used to document losses in data or causes for poor quality calls and equipment malfunctions.

We should explore the use of short, intensive sampling at a given site to answer site-specific questions either using point counts or by deploying several bat detectors at a site for a few days.

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