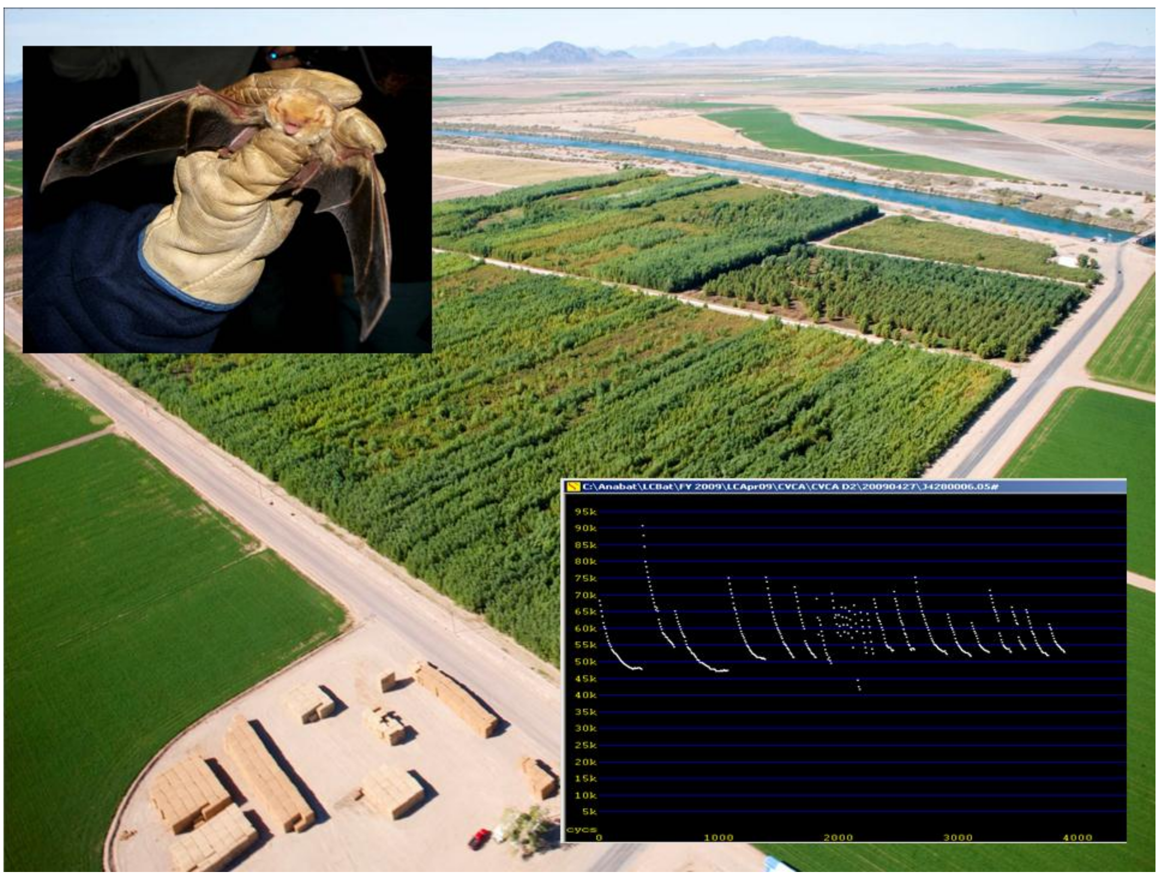
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Post-Development Bat Monitoring 2007–2010 Intensive Acoustic Surveys Completion Report



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

June 2012

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Lower Colorado River Multi-Species Conservation Program

Post-Development Bat Monitoring 2007–2010 Intensive Acoustic Surveys Completion Report

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Multi-Species Conservation Program
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June 2012

ACRONYMS AND ABBREVIATIONS

AGFD	Arizona Game and Fish Department
ANOVA	analysis of variance
B-A-C-I	before-after-control-impact
Beal	Beal Lake Riparian Restoration Area
cm	centimeter(s)
CNWR #1	Cibola National Wildlife Refuge Unit 1 Conservation Area
CRIT	Colorado River Indian Tribe's 'Ahakhav Tribal Preserve
CVCA	Cibola Valley Conservation and Wildlife Area
db	decibel
dbh	diameter breast height
ft	foot/feet
FY	fiscal year
GLM	generalized linear model
ha	hectare(s)
HCA	habitat creation area
in	inch(es)
IPCA	Imperial Ponds Conservation Area
kHz	kilohertz
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
Pratt	Pratt Restoration Demonstration Area
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation

Symbols (if any)

°C	degrees Celsius
%	percent

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ABSTRACT

Acoustic bat monitoring was conducted at seven habitat creation areas (HCAs) along the lower Colorado River (LCR) during October, February, April, and July 2008 through 2010 using a before-after-control-impact study design following a 1-year pilot program in 2007. Anabat bat detectors were deployed remotely in intermediate cottonwood, sapling cottonwood, and mesquite stands established as part of the Lower Colorado Multi-Species Conservation Program, as well as in adjacent untreated agricultural fields and salt cedar stands. The primary focus of post-development bat monitoring was on two covered bat species: western red bat *(Lasiurus blossevillii)* and western yellow bat (*Lasiurus xanthinus)*, and two evaluation species, Townsend's big-eared bat (*Corynorhinus townsendii)* and California leaf-nosed bat (*Macrotus californicus).* A total of 2,024 detector nights, operated dusk to dawn, were conducted, collecting a total of 615,736 bat call files during the 4 years of this monitoring program. During the initial years when plantings were becoming established, western red and western yellow bat calls were recorded infrequently and were often associated with migration along the LCR or foraging over ponds during the winter in the most southerly of the HCAs. As habitats began to rapidly mature and become more complex, particularly during 2010, significant increases in minutes of bat activity were recorded for these two focal species. Additionally, as habitats began to mature, western red and western yellow bat calls were obtained year round, most notably in the more northerly HCA.

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 western yellow bat activity. Overall canopy complexity can be increased by planting different tree and shrub species in juxtaposition to each other (such as Goodding's willow next to Fremont cottonwood). Bats forage intensely along edges created by different canopy heights. In areas of uniform habitats, the number of flyways can be increased by allowing natural events such as wind throw or small areas of die-outs to persist uncorrected and by deliberately planting rows further apart than the usual road or canal width.

INTRODUCTION

Bats are being positively affected by riparian habitat development projects taking place along the lower Colorado River (LCR) in Arizona and California through the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). This 50-year multi-agency effort is designed to protect the LCR while ensuring the certainty of existing river water and power operations. The program's goal is to create more than 7,260 acres of riparian, marsh, and backwater habitat for four threatened and endangered species and 16 other species that potentially could be listed as threatened or endangered. The western red bat *(Lasiurus blossevillii)* and western yellow bat (*Lasiurus xanthinus)* are not listed currently, but as with the other 14 species, could become listed. The California leaf-nosed bat (*Macrotus californicus)* and Townsend's big-eared bat (*Corynorhinus townsendii)* are among the evaluation species that could become listed in future years and could be added to the covered species list during the 50-year period, but which have insufficient information to determine their status in the planning area, assess potential effects of Program activities, or develop specific conservation measures.

Conservation measures for the covered bat species include conducting surveys and research to better identify covered habitat requirements and species distribution as well as monitoring and adaptively managing covered and evaluation species habitats. Of the 7,260 acres of cottonwood-willow and honey mesquite to be created as covered species habitat, at least 765 acres will be designed and created to provide western red and western yellow bat roosting habitat. Conservation measures for the two evaluation bat species include conducting surveys to locate roost sites and creating covered species habitat near roost sites (Bureau of Reclamation [Reclamation] 2004).

Quarterly post-development acoustic bat monitoring was conducted from 2008 through 2010 following a pilot sampling program in 2007 using Anabat bat detectors in seven LCR MSCP habitat creation areas (HCAs). These sites ranged from the northernmost site at the Beal Lake Riparian Restoration Area near Needles, California, to the southernmost site at the Imperial Ponds Conservation Area near Yuma, Arizona. The principal goal of this 4-year post-development monitoring program is to assess the responses of the two covered bat species, the western red and western yellow bat, and the two evaluation species, the Townsend's big-eared bat and the California leaf-nosed bat, to the creation of cottonwood-willow and mesquite habitats. Monitoring data also provide an increased understanding of what habitats are used by the focal bat species, the seasonal use of those habitats, as well as what habitat and landscape features are most influential to bat use of created habitats.

The cave myotis (*Myotis velifer*) and Arizona myotis (*Myotis occultus*) are two riparian specialists that occur in all HCAs. Data from these species were also used along with the four focal bat species in analyzing habitat use.

In addition to the quarterly acoustic surveys, a long-term acoustic bat station was installed at the Beal Lake Riparian Restoration Area (Beal) in April 2008, and it collected data every night unless technical difficulties occurred.

STUDY AREA

Quarterly post-development acoustic bat monitoring was conducted in seven LCR MSCP HCAs from 2007 through 2010. These areas included Beal Lake Riparian Restoration Area (Beal), Palo Verde Ecological Reserve (PVER), Colorado River Indian Tribe's 'Ahakhav Tribal Preserve (CRIT), Cibola Valley Conservation and Wildlife Area (CVCA), Cibola National Wildlife Refuge Unit 1 Conservation Area (CNWR #1), Imperial Ponds Conservation Area (IPCA), and the Pratt Restoration Demonstration Area (Pratt) (figure 1).

Beal Lake Riparian Restoration Area

Beal is located on Havasu National Wildlife Refuge in Needles, California, (figure 2) within the historic flood plain of the LCR. It consists of over 200 acres (81 hectares [ha]) of cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii),* coyote willow (*S. exigua*), honey mesquite (*Prosopis glandulosa*), and screw bean mesquite (*Prosopis pubescens*) in a series of plantings that began in 2001 and were completed in 2005 (Reclamation 2005a).

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) (figure 3). Through fiscal year (FY) 2008, 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. Phases 6 and 7 are scheduled to be planted in FY11 and FY12, respectively (Reclamation 2010).

Figure 1.—Location of study area.

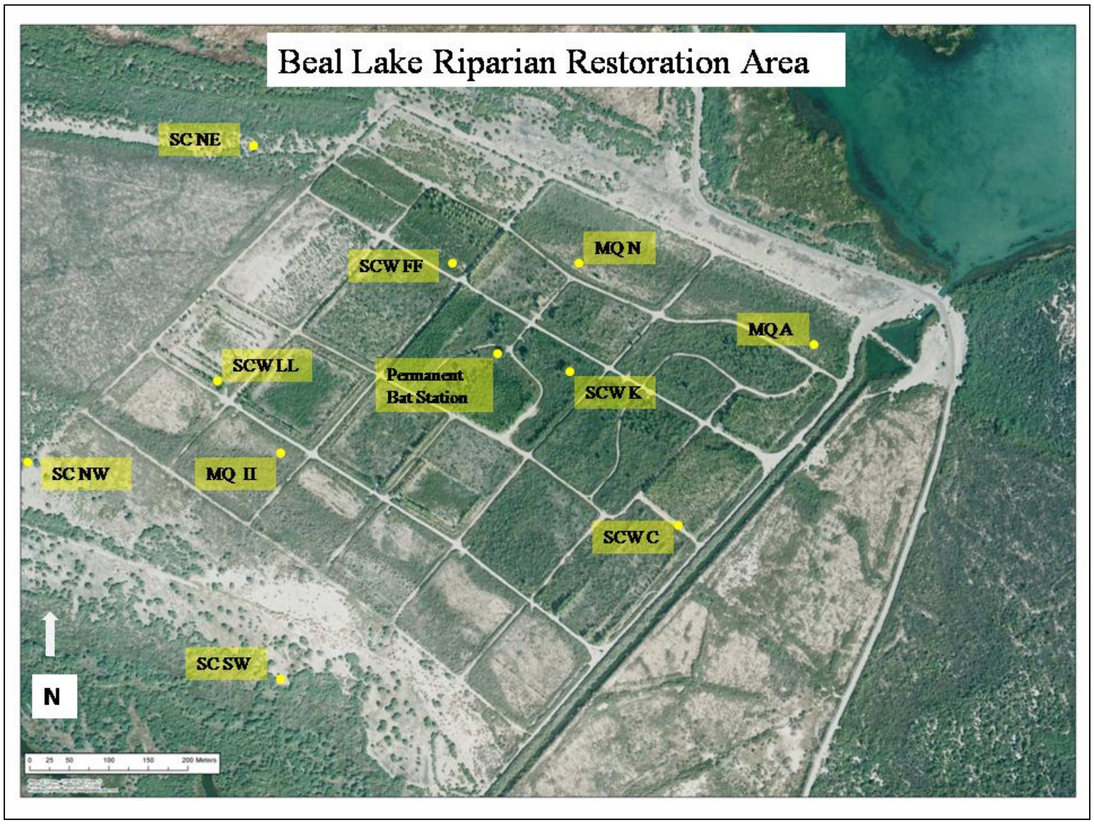

Figure 2.—Beal Lake Riparian Restoration Area.

‘Ahakhav Tribal Preserve

The Colorado River Indian Tribe’s ‘Ahakhav Tribal Preserve (CRIT) encompasses 154 acres (62 ha) of a mix of intermediate stage cottonwood and screw bean and honey mesquite stands (figure 4). Propagating and irrigating cottonwood-willow and mesquite began in 2001, converting out-of-production agricultural fields dominated by tumbleweed and sparse salt cedar to riparian habitat.

Cibola Valley Conservation and Wildlife Area

CVCA encompasses 1,019 acres (412.4 ha) of active agricultural lands (figure 5). Phase 1, implemented in 2006, converted approximately 64 acres (25.9 ha) of active agricultural fields into 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. Fifty-eight acres of honey mesquite were planted in FY09, 71 acres planted in FY10, and an additional 89 acres is scheduled to be planted in FY11 (Reclamation 2010).

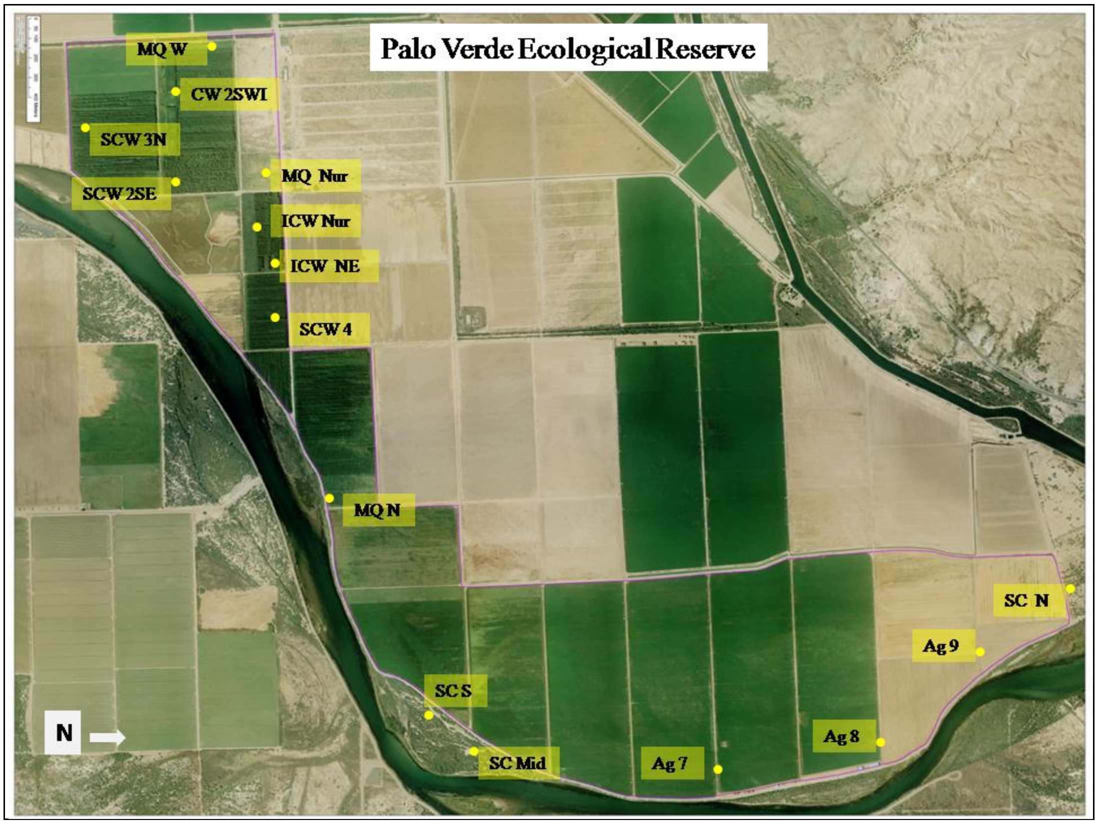

Figure 3.—Palo Verde Ecological Reserve bat sampling locations.

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, 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 6).

Imperial Ponds Conservation Area

The ponds at IPCA, located on Imperial Ponds 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 (figure 7). Also present in the area is a mature cottonwood-willow stand planted in 1993 referred to as the "nursery"

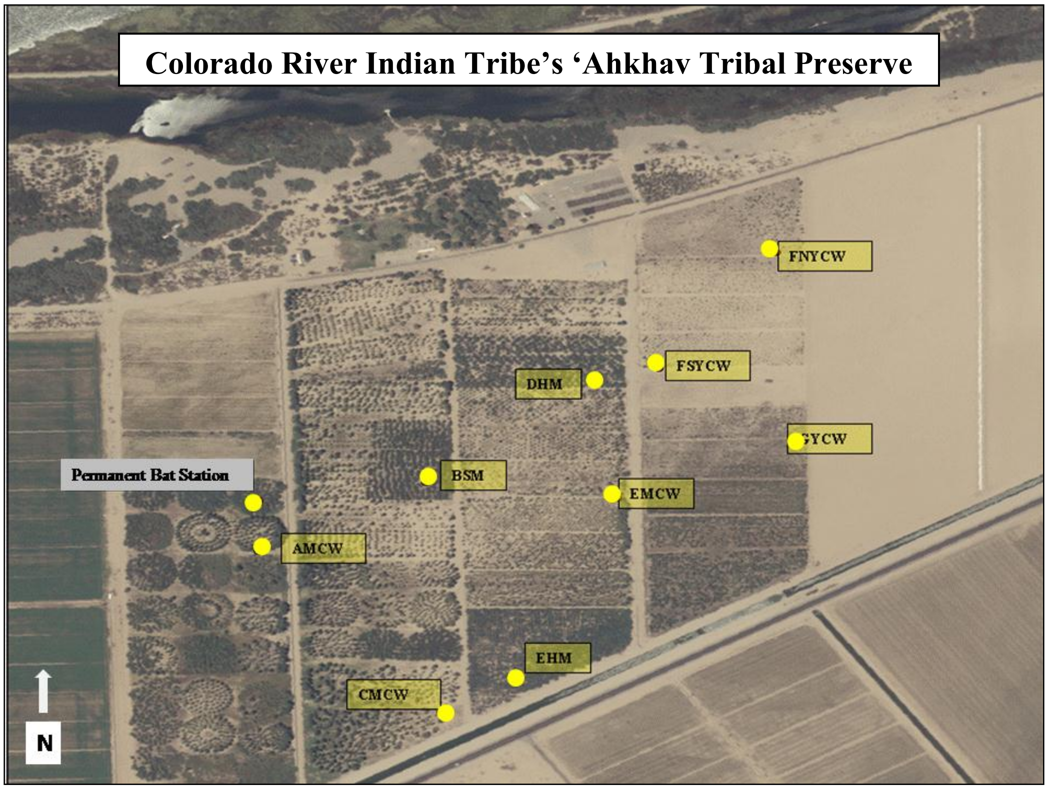

Figure 4.—Colorado River Indian Tribe's 'Ahakhav Tribal Preserve bat sampling locations.

(Reclamation 2005b). 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.

Pratt Restoration Demonstration Area

Pratt, a 12-acre (4.9-ha) site, was planted with cottonwood and willow in 1999 (Reclamation 2003). At present, this has matured into a gallery forest that is drought-stressed but overall mostly functional as of 2010. The Bureau of Land Management also planted cottonwood-willow immediately adjacent to the original stand, and this habitat is rapidly maturing. Some selective thinning was conducted in 2005, 2006, and 2007 to create a mosaic of uneven aged, structurally diverse habitat. This site (figure 8) was selected for bat monitoring because it is a restoration site that contains mature cottonwood-willow habitat that is potentially suitable for the western red and western yellow bat.

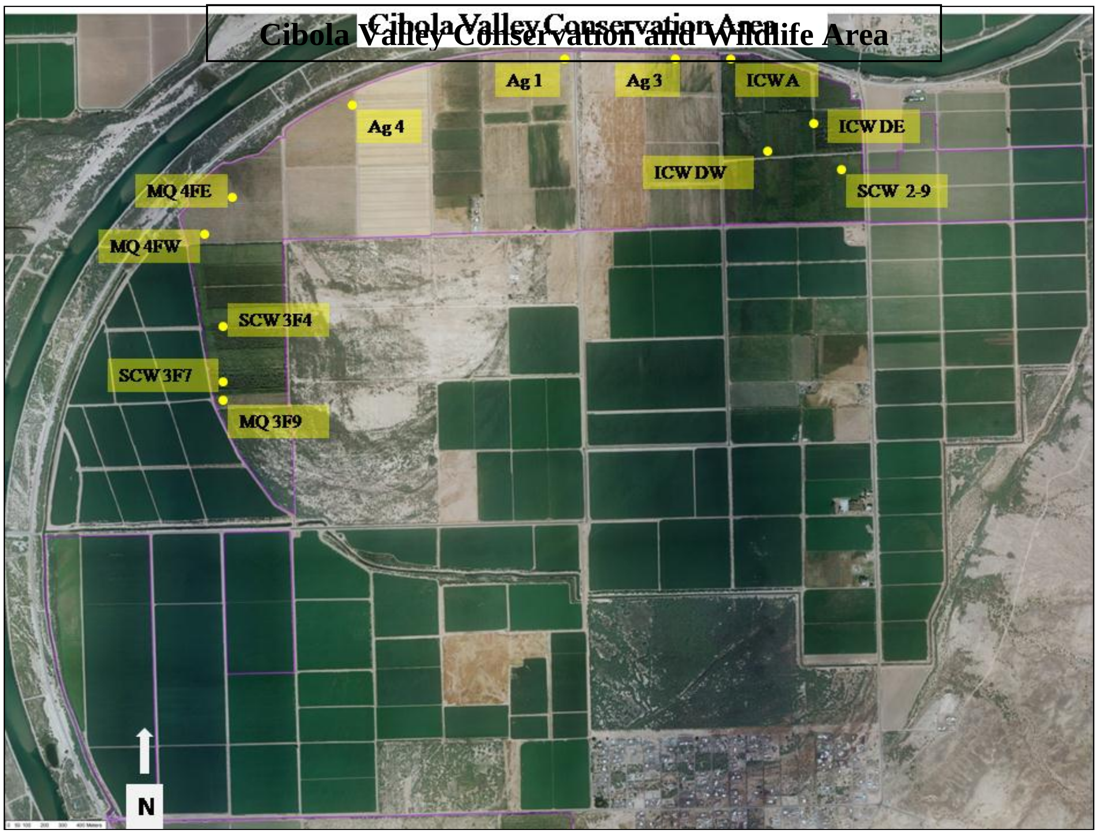

Figure 5.—Cibola Valley Conservation and Wildlife Area bat sampling locations.

METHODS

Acoustic Bat Surveys

Bat activity was sampled remotely using Anabat SD1 bat detectors (Titley Electronics, Ballina, 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 on posts at approximately 1-meter (m) high at a 45-degree (^{o}) angle in most habitats.

In rapidly growing sites at several of the restoration areas, it was necessary to elevate the detector to the canopy level on extendable poles (Mr. Long Arm 3-section extension poles 8 feet (ft) to 23 ft [2.4 m to 7 m] Model 6924). The detector was mounted on the top of the pole and positioned either vertically or at a 45^{o} angle and faced away from taller vegetation edges. This was done to reduce exposure to excessive insect noise, which prevents the detector from recording bat

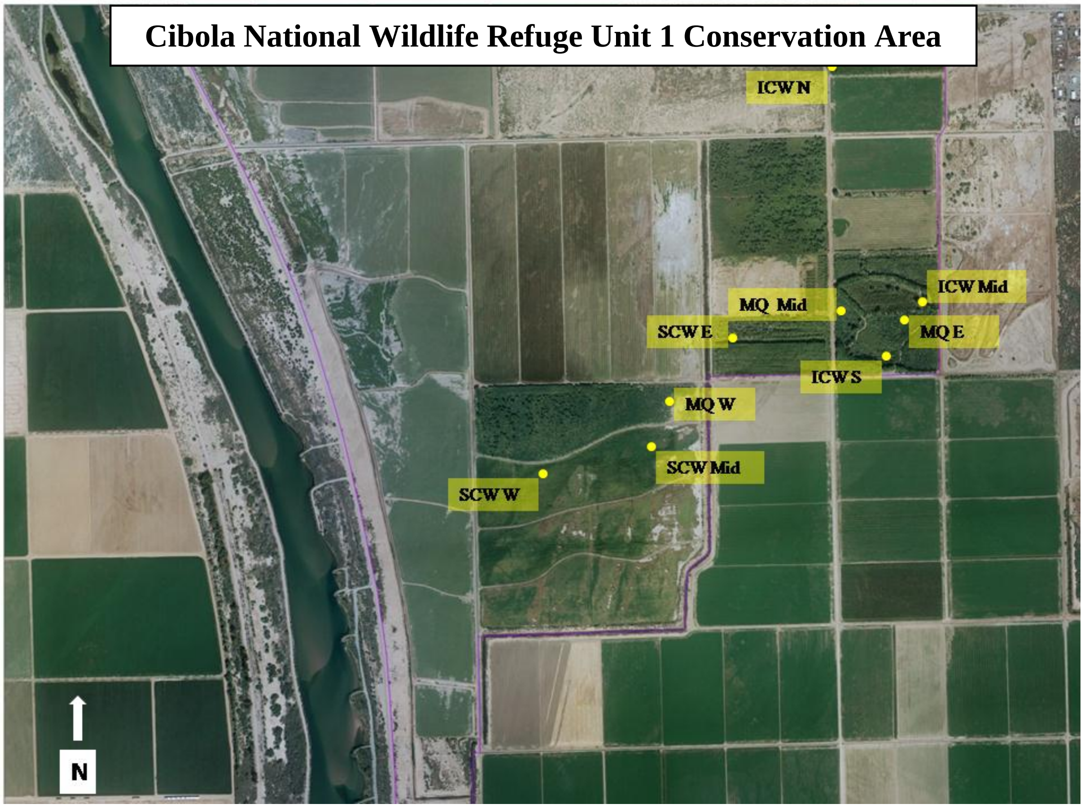

Figure 6.—Cibola National Wildlife Refuge Unit 1 Conservation Area bat sampling locations.

calls. Insect noise from primarily katydids as well as crickets and cicadas was a significant issue at all of the HCAs from April through July, and extensive data loss could occur unless appropriate steps were taken to locate the detector properly. Another reason for locating the detector above the canopy in dense, rapidly growing habitats was to allow acoustic sampling of the habitat. In many instances, the rapidly growing cottonwoods and willows were extremely dense, preventing aerial access to foraging or commuting bats in the habitat; hence, no bat activity would be recorded from detectors mounted on 1-m-tall poles. Locating the bat detector on an extendable pole within the stand allowed sampling to be conducted in accessible airspace in and very near the habitats even during the peak of insect activity. As much as possible, detectors were located within stands rather than on the outside of stands along field edges or roads as detectors at these locations would also pick up calls from bats flying over a different habitat type.

To protect detectors from rain and dust, each detector was placed in a tightly sealed plastic bag with the microphone exposed. During cloudy periods with

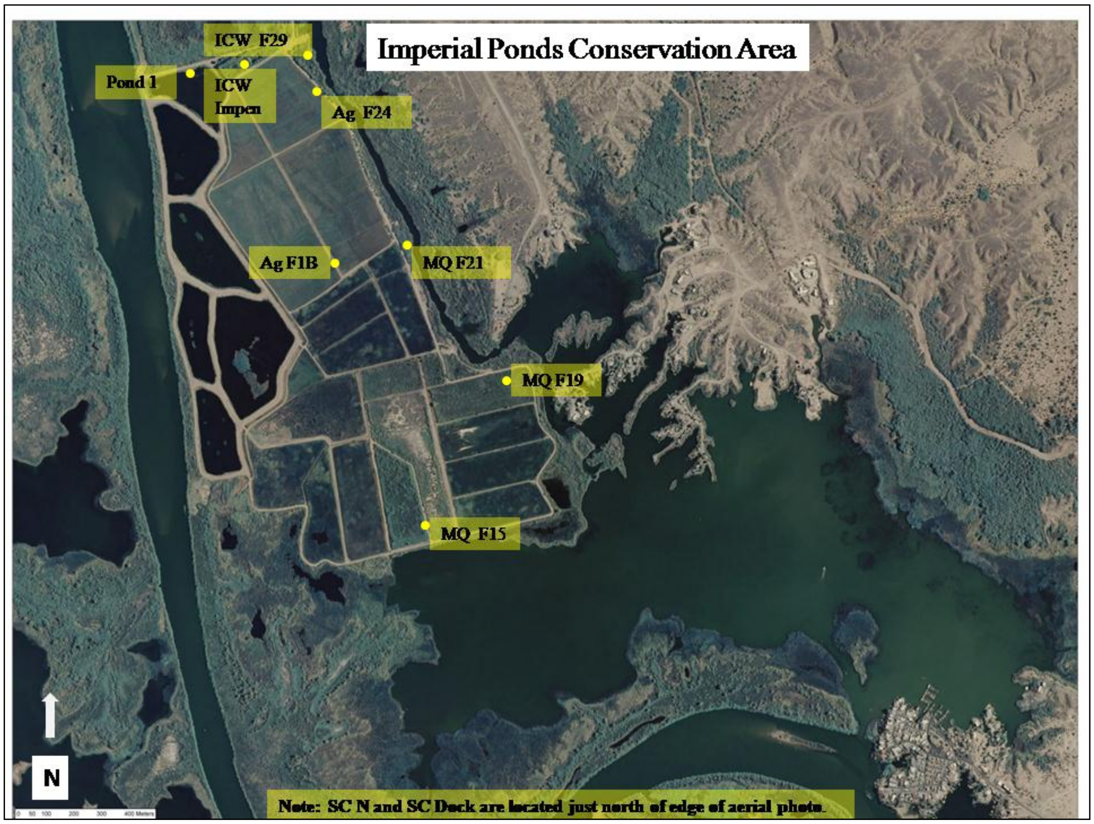

Figure 7.—Imperial Ponds Conservation bat sampling locations.

storm activity likely (summer thunderstorms were common occurrences), a rain guard was mounted on the detector (a flat thin metal shield placed on top of the detector extending slightly over the microphone). The shield protected the microphone from storm events, but also allowed good exposure of the microphone for bat calls. Standard bat hats were not utilized in this study to allow maximum sensitivity to bat calls and to allow the unit to be camouflaged to minimize exposure to theft or vandalism, as most of the sites were open to public use.

Each HCA was sampled quarterly during the months of October, February, April, and July. As between-night and between-site variation can be significant (Williams et al. 2006), each site was sampled twice during the quarterly surveys either consecutively or within 4 nights. Within each HCA, up to15 detectors were deployed simultaneously in 3 to 5 adjacent habitats with 3 replicates for each habitat type. Each area was sampled for 2 nights, then the next HCA was sampled until all HCAs were sampled during a 12-day period.

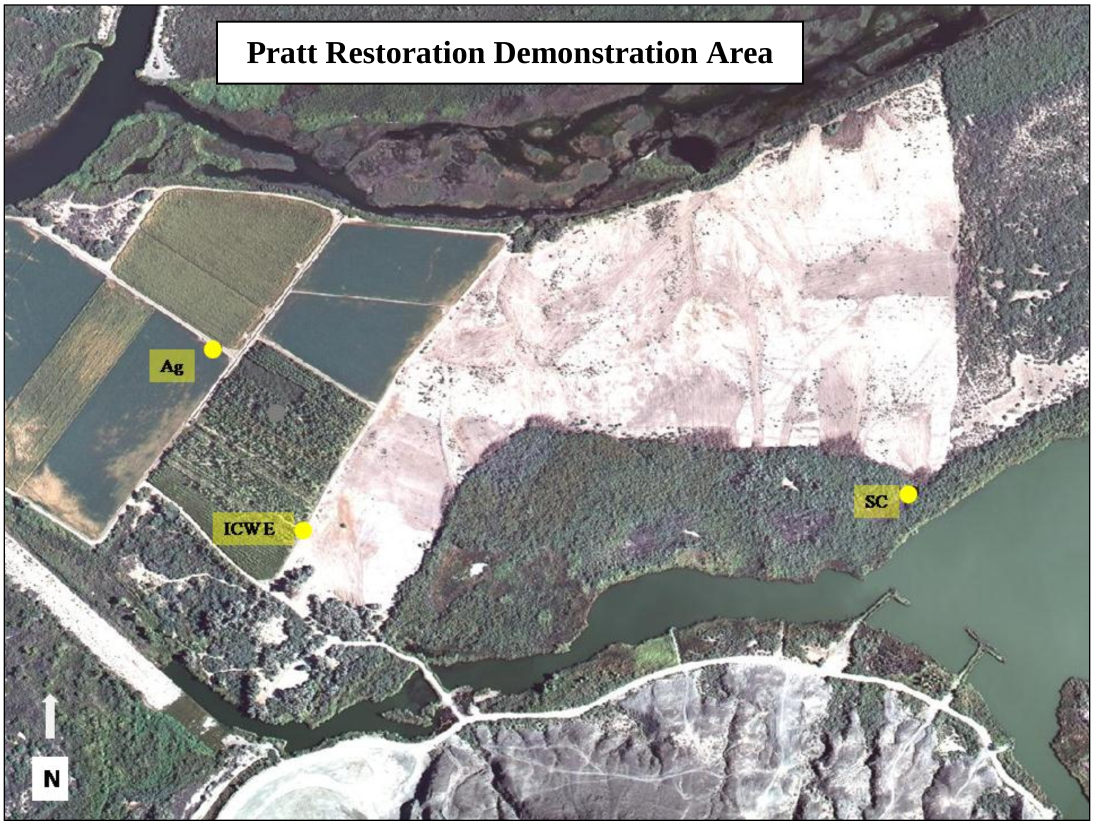

Figure 8.—Pratt Restoration Demonstration Area bat sampling locations.

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). 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.

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 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).

One of the most challenging aspects to bat call identification is the frequent overlap of call characteristics among bat species. Depending on the habitat the bat is flying over, wind, humidity, presence of ponded water, decibels of calls (shouters such as big brown bats produce 110-decibel [db] calls versus whisperers such as the pallid bat produce 60 db calls), and presence of other bats of the same species or other species in the same airspace may all play a role in call identification. This has been well documented by many bat researchers and summarized by the Western Bat Working Group (2004). A detailed analysis of these overlaps and guidelines for determining species identity was developed for each of the four focal bat species and is included in appendices 1 through 4 of the 2008 Annual Report (Broderick 2009). These call guidelines serve as documentation for how each call was identified. Efforts to further refine the call guidelines was continued in 2009 and 2010 as new positively identified reference calls were obtained from mist-netting efforts in HCAs (Calvert 2008, 2010).

In cases in which there are significant portions of the call envelope (all the characteristic calls of a species) that overlap with other bat species, a species group was assigned. Table 1 shows the species and species groups used for post-development bat monitoring.

Bat Species

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 as being present at the CRIT (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.

Table 1.—Bat species and species groups identified in the LCR HCAs

Common name	Scientific name	Species code
Individual species		
Townsend's big-eared bat	*Corynorhinus townsendii*	COTO
Western red bat	*Lasiurus blossevillii*	LABL
Yellow bat	*Lasiurus xanthinus*	LAXA
California leaf-nosed bat	*Macrotus californicus*	MACA
Mastiff bat	*Eumops perotis*	EUPE
Hoary bat	*Lasiurus cinereus*	LACI
Arizona myotis	*Myotis occultus*	MYOC
Cave myotis	*Myotis velifer*	MYVE
Pocketed free-tailed bat	*Nyctinomops femorosaccus*	NYFE
Big free-tailed bat	*Nyctinomops macrotis*	NYMA
Canyon bat	*Parastrellus hesperus*	PAHE
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		
Pallid bat	*Antrozous pallidus*	ANPA
Big brown bat	*Eptesicus fuscus*	EPFU
Mexican free-tailed bat	*Tadarida brasiliensis*	TABR
California myotis	*Myotis californicus*	MYCA
Yuma myotis	*Myotis yumanensis*	MYYU

There are four abundant "flagship" species: canyon bat, Mexican free-tailed bat, California myotis, and Yuma myotis (Brown and Berry 2007, personal communication). These flagship species (a term coined by Pat Brown, personal communication, which refers to their abundance along the LCR) 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, the western red 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.

Species Emphasized in Data Analyses

The primary focus of post-development bat monitoring is on the two covered bat species, western red bat (LABL) and western yellow bat (LAXA), and the two evaluation species, Townsend's big-eared bat (COTO) and California leaf-nosed bat (MACA). While western red and western yellow bat activity is increasing at the LCR MSCP HCAs as documented in this report, their numbers are extremely small compared to more abundant species.

To supplement our understanding of how these focal bat species are responding to cottonwood-willow and mesquite plantings, I also included cave myotis (*Myotis velifer*) (MYVE) and the Arizona myotis (*Myotis occultus*) (MYOC) in the analyses. In the desert habitats along the LCR, these two species are riparian specialists (Arizona Game and Fish Department [AGFD] 2009; Reid 1997). Arizona myotis are primarily found over or near water or in riparian forest in desert areas (AGFD 2009). In lower elevations, the cave myotis is found in riparian habitats near desert scrub (Reid 1997). At some habitat conservation areas, activity as measured by the number of bat minutes is very high for both of these riparian specialists, and they provide good quality additional data.

These riparian specialists were present in all of the habitat conservation areas, in some cases in large numbers for FY10 (table 2). The are two exceptions: there were no positively identified cave myotis (MYVE) calls at either IPCA or the nearby Pratt. There were only 3 minutes of activity for the Arizona myotis (MYOC) at Pratt, which is the lowest for this species of any of the HCAs. The CRIT appears to be the stronghold for both the cave myotis (1,470 minutes) and the Arizona myotis (1,864 minutes). PVER also appears to be a stronghold for cave myotis, with 1,503 minutes of activity.

Table 2.—Total minutes of bat activity for cave myotis (MYVE) and Arizona myotis (MYOC) in each habitat creation area in FY10

Habitat creation area	MYVE	MYOC
BEAL	218	8
CRIT	1,470	1,864
PVER	1,503	206
CVCA	432	194
CNWR #1	65	36
IPCA	0	60
PRATT	0	3

Study Design

Acoustic monitoring of HCAs began with an initial pilot study in 2007 and continued from 2008 through 2010. Sample sites were not randomly located within the habitats, but rather were selected to optimize acoustic recording of bat calls within each of the habitat types. As much as possible, sample locations remained consistent from year to year, with minor adjustments to minimize insect interference and to allow acoustic sampling in rapidly growing stands. Additionally, these HCAs were being planted in phases lasting a period of several years. During the 4-year monitoring program, newly established habitats became available for sampling, and other habitats matured enough to be categorized as a different habitat type (i.e., from sapling cottonwood to intermediate cottonwood). The initial sampling in 2007 corresponded to the initial plantings of cottonwood, willow, and mesquite, where plantings were little more than seedlings.

The overall intensive acoustic bat monitoring program uses an optimal impact study design (Green 1979; Underwood 1993) – also referred to as a B-A-C-I design (before-after-control-impact). The B-A-C-I study design allowed us to examine the effect of establishment and maturation of riparian vegetation at HCAs along the LCR on bat activity. In this approach, time or period is viewed as the unit of replication (Stewart-Oaten et al. 1986). Riparian vegetation is established in the habitat conservation areas by first clearing agricultural fields or mature stands of saltcedar. Riparian vegetation is then established by planting cottonwood, willow, or mesquite seedlings.

It is rare that treatments can be randomly assigned in a B-A-C-I study. In this monitoring program, treatments corresponded to riparian planting sites. Three techniques recommended by McDonald et al. (2000) were employed in the study design to strengthen the B-A-C-I study interpretation: (1) collect multiple years of data both before and after the disturbance (in this case, the conversion of agricultural fields and saltcedar stands to cottonwood-willow and mesquite stands), (2) select multiple reference areas (in this case agriculture and/or saltcedar sites at most of the HCAs, and (3) collect information on covariates that could influence results (see table 3). The study design incorporates 4 years of data collection. The first year coincides with the initial establishment of cottonwood-willow and mesquite stands, while years 2 through 4 measure the changes in bat activity as the stands mature. Additionally, data on bat activity and habitat variables were collected at multiple areas corresponding to each HCA.

There are two habitat types that are considered the “before” component: agricultural fields that are essentially bare dirt in the winter and early spring, supporting low growing crops such as alfalfa, sorghum, or corn in the spring, summer, and fall (figure 9); and extensive stands of mature saltcedar (figure 10).

Figure 9.—Agricultural fields with alfalfa, corn, sorghum, etc.

Figure 10.—Saltcedar – height ≥3 ft.

The agricultural fields and saltcedar stands are also referred to as the "untreated" fields. There are three habitat types that are considered the "after" component: intermediate cottonwood-willow plantings in which the average cottonwood diameter breast height (dbh) is greater than 8 centimeters (cm) and the overall height greater than 40 ft (figure 11); sapling cottonwood-willow in which the average dbh is < 8 cm (3.1 inches [in]) and overall height is < 40 ft (7 m) (figure 12); and screwbean or honey mesquite with an overall canopy height greater than or equal to 3 ft (0.9 m) (figure 13). These three habitats are considered the "treated" fields. At some sites, small cottonwood-willow plantations had been established prior to 2007. These pre-existing sites were included in the study.

Figure 11.—Intermediate cottonwood average dbh > 8 cm; height > 40 ft.

Figure 12.—Sapling cottonwood average dbh < 7 cm; height < 40 ft.

Figure 13.—Screwbean or honey mesquite – height ≥ 3ft.

At least three of the five habitat types were monitored per HCA depending on habitats present. Three bat detectors were deployed in each habitat type so that at least nine detectors were being deployed on any given night. Some HCAs had all 5 habitat types being monitored, for a total of 15 detectors deployed on a given sampling night. Acoustic surveys were conducted for 2 days every quarter at each study area so that all seasons were sampled each year. This study design is scalable, providing information on bat habitat use within individual restoration sites. The primary focus is on habitat use of the four focal bat species using an index of bat activity. Bat activity levels were compared among habitat types as well as over time as plantings matured.

The following assumptions are made for this monitoring study (Hayes 2000; Sherwin et al 2000): all habitats are equally accessible to all bats. Any particular species is equally detectable from each habitat type. It is also assumed that all acoustic equipment has an equal ability of detecting bat echolocation calls. Sampling multiple nights provides an assessment of the level of temporal variation within and among habitats (Williams et al. 2006). Sampling all sites within a HCA simultaneously also ensures that any variation in conditions that affect bat activity is consistent among sampling sites. Sampling simultaneously in a HCA for a minimum of 2 nights per quarter is adequate to account for nightly variations in activity patterns of bats.

The installation of a permanent bat monitoring station at Beal provides continuous year-round nightly sampling. The nonrandom nature of the bat detector location is done to select sites for optimum recording of bat calls either along habitat edges or in openings within habitats. All field studies have some degree of spatial autocorrelation risk, and this study is no exception. Sample sites within a habitat restoration area are located as far apart as possible (at least 100 m [328 ft] and usually >250 m [820 ft] to reduce the risk that bats foraging in one area are not also recorded foraging in nearby areas. However, as with all acoustic bat studies, this is difficult to assess. Data from this monitoring effort are intended to apply to the habitat restoration sites rather than to the broader LCR ecosystem. Data from the permanent bat monitoring stations are not part of the B-A-C-I study design.

Statistical Analysis

Discrete response variables such as counts of individuals or species, particularly with acoustic bat data, are often log-transformed or square-route transformed to satisfy parametric test assumptions or to deal with outliers. Count data often contains many zero observations with a few large numbers and are unlikely to be normally distributed. These data are typically referred to as overdispersed. O’Hara and Kotze (2010) suggest that for count data, transformations perform poorly, and they recommend generalized linear models (GLM) that are designed to deal specifically with count data (McCullagh and Nelder 1989). The poor performance of transformations was evident in the data collected in this monitoring study, particularly for the relatively rare focal bat species. Data transformations were ineffective in achieving a normal distribution, and thus, the common parametric statistical tests were not valid.

Additionally, McDonald et al. (2000) recommend use of the generalized linear mixed model (rather than an untransformed additive model or log-transformed multiplicative models) for analysis of count data from B-A-C-I studies because underlying assumptions of the model are likely satisfied and interpretation of estimated parameters is straightforward. The generalized mixed linear model approach assumes only that the mean and variance of the raw count data exist. This approach eliminates the erroneous normal distribution assumption of the untransformed analysis and problems with parameters and zeros inherent in the log-transformed analysis.

I, thus, adhered to the recommendations of O’Hara and Kotze (2010) and McDonald et al. (2000) and utilized GLMs whenever appropriate; and in some cases, utilized nonparametric methods such as Kruskal-Wallis or Mann-Whitney tests to analyze data sets when appropriate. Analyses were conducted utilizing July 2010 data, as these data represented the most fully mature habitats of the 4-year monitoring study.

The complete results of FY10 acoustic bat monitoring are summarized below by seasonal habitat use. The mean number bat of minutes per sample site for restoration habitats (cottonwood-willow and mesquite) were compared graphically to the untreated habitats (agriculture and saltcedar habitats for the four focal bat species beginning with the most northerly site [Beal] and continuing downstream. The following metrics and statistical analyses were utilized:

Year-to-Year Comparisons of Bat Minutes in Treatment Sites Versus Control Sites – Repeated Measures Analysis of Variance

To determine how focal bat species are responding to riparian plantings, year-to-year comparisons of bat minutes in treatment sites versus control sites, a repeated measures analysis of variance (ANOVA) was used to analyze changes in the number of bat minutes for the four focal bat species and the riparian specialists. Treatment sites are the riparian plantings that include cottonwood-willow and mesquite, which are at least 1 m tall; and control sites include agricultural fields either in bare dirt, fallow field, or growing commercial crops such as corn, sorghum, alfalfa, melons, and saltcedar stands, which are located adjacent or near the HCAs. Data for both western red bats and western yellow bats were pooled to provide an adequate sample size for analysis.

Minutes of bat activity for each habitat type (mesquite, sapling cottonwood, intermediate cottonwood) in each HCA was compared using a Kruskal-Wallis analysis to test the following hypotheses:

H_o = No difference in bat activity among the five habitat types
H_a = Bat activity varies by species depending on habitat type

Comparison of Bat Activity among the Five Habitat Types Sampled Acoustically – Kruskal-Wallis One-Way Analysis of Variance

To determine how bat activity compares among the five broad habitat types sampled (intermediate cottonwood, sapling cottonwood, mesquite, agriculture, and saltcedar), the Kruskal-Wallis one-way ANOVA by ranks test was performed on minutes of bat activity by species recorded for focal bat species for July 2010 data. This is a nonparametric method for testing whether samples originate from the same distribution.

Habitat Variables Influencing Bat Activity – Poisson Regression

GLM was used to determine the habitat variables that influence bat activity in riparian plantings at the HCAs. GLM was also used to develop habitat models for 6 of the 15 bat species that occur along the LCR as done by Milne et al. (2006). The particular GLM used was a Poisson regression, which is particularly suited to count data and especially data with a large number of 0s, as is the case with acoustic data collected along the LCR. It is often used to model rare events.

Eight variables (covariates), table 3, were measured at each acoustic sample site. Three variables captured the amount of canopy complexity in a stand: canopy edge, canopy layers, and number of flyways. Two variables were landscape features that can influence bat activity: distance to the Colorado River and distance to the nearest canal with consistently flowing water. The remaining

Table 3.—Variables measured at each acoustic sample site

Variable	Description
Canopy layer	Number of canopy layers that consist of either different species or ages of tree species.
Canopy edge	Linear distance (m) of canopy edges formed by different tree and shrub species or ages of stands within 100 m of the acoustic sample point.
Number of flyways	Number of flyways (linear openings in habitat such as roads, rows between vegetation, field edges, or naturally created openings that bats will fly along within 100 m of the acoustic sample point.
Colorado River	Distance (m) to Colorado River. Bats use rivers as migratory corridors as well as sources of water and aquatic insects.
Canals with water	Distance (m) to nearest canal with consistently flowing water.
Nearest edge	Distance to nearest edge (i.e., road, canal, field edge) from the sample point). This measures how close potential flyways are to the detector.
Stand edge	Distance to stand edge – not just the nearest edge. This provides a measure of the size of the stand and the location of the detector within that stand.
Patch size	Number of acres of contiguous uniform habitat immediately surrounding the acoustic sample point.

variables, distance to stand edge and distance to nearest edge, helped characterize the size and relative position of the habitat relative to other features. These variables are defined as follows in table 3. Measurements for these variables were obtained from current geographic information system images of the HCAs.

Relationship between Total Number of Acres of Cottonwood-Willow Habitat and Bat Minutes – Linear Regression

Linear regression was used to determine if the overall size of a riparian restoration area influences bat activity. The independent variable was the number of acres of cottonwood-willow habitat at each HCA, and the dependent variable was the number of bat minutes for the four focal bat species and two riparian bat species. There is considerable variation in the overall size of riparian plantings. For example, the total amount of cottonwood-willow habitat at PVER was 499 acres (202 ha), whereas in smaller areas such as Beal, there was only 107 acres (43 ha).

Data for FY10 were utilized for the repeated measures ANOVA, Poisson regression, and linear regression analyses, as this time period represents the maximum extent of habitat growth monitored during the 4-year study period.

Monthly bat activity at the Beal permanent bat station was compared from 2009 to 2010 using a Mann-Whitney test. This is a nonparametric test used to determine if there is a significant difference between two groups – in this case, mean monthly bat minutes for the focal and riparian specialist bat species.

RESULTS

Fiscal Year 2010 Acoustic Bat Surveys

The complete results of the FY10 acoustic bat monitoring are contained in appendix A of this report. The results for FY09 acoustic monitoring are found in Broderick (2010); FY08 results are in Broderick (2010), and FY07 results are in Broderick (2008).

The total number of call minutes recorded for the four focal species for FY07 through FY10 in restoration sites only (cottonwood-willow and mesquite) are summarized in tables 4 through 10. These summaries do not include bat minutes for agricultural and saltcedar sites (untreated sites).

Slight increases in bat activity were recorded for all four focal bat species in 2010 for Beal, table 4, while total call minutes for all species declined somewhat.

Table 4.—Beal Lake Riparian Restoration Area

Species	FY07	FY08	FY09	FY10	All years
Western red bat	3	3	3	14	23
Western yellow bat	5	2	1	5	13
California leaf-nosed bat	4	4	7	4	19
Townsend's big-eared bat	1	0	4	2	7
All other species	2,040	3,012	3,782	2,910	11,744
Total call minutes	2,053	3,021	3,797	2,935	11,806

In table 5, note that only October and February were sampled in FY10. April and July 2010 were not sampled at the request of the Colorado River Indian Tribe. In spite of the loss of April and July monitoring data, western red bats had 136 bat minutes for 2010 compared to 180 for all four seasons in 2009. The CRIT may offer good habitat for this species.

Table 5.—Colorado River Indian Tribe's 'Ahakhav Tribal Preserve

Species	FY08	FY09	FY10	All years
Western red bat	2	180	136	182
Western yellow bat	69	203	4	272
California leaf-nosed bat	37	67	13	104
Townsend's big-eared bat	1	1	0	2
All other species	7,238	11,372	1,253	18,610
Total call minutes	7,347	11,823	1,406	19,170

Note that only 2 quarters were sampled in 2008, as sampling at this site was initiated in April, and only 2 quarters were sampled in 2010 (October and February).

Western red bats and yellow bats showed large increases in FY10 compared to the three previous years at PVER (table 6). Much of the statistical analyses described further in this report are centered on determining the significance of these increases shown here for PVER as well as CVCA (table 7) and CNWR (table 8), and how habitat variables are influencing these apparent increases in bat activity.

Table 6.—Palo Verde Ecological Reserve

Species	FY07	FY08	FY09	FY10	All years
Western red bat	6	1	11	208	226
Western yellow bat	0	0	1	159	160
California leaf-nosed bat	22	3	23	66	114
Townsend's big-eared bat	0	0	1	6	7
All other species	1,380	1,898	2,005	11,689	16,972
Total call minutes	1,408	1,902	2,041	12,128	17,479

Similar to the 2010 increases in western red and yellow bat activity at PVER, CVCA also showed a 2010 increase in western red and yellow bat activity compared to previous years (table 7).

Table 7.—Cibola Valley Conservation and Wildlife Area

Species	FY07	FY08	FY09	FY10	All years
Western red bat	4	0	91	197	292
Western yellow bat	0	0	3	55	58
California leaf-nosed bat	36	18	14	55	123
Townsend's big-eared bat	1	0	1	5	7
All other species	1,294	1,426	1,687	7,643	12,050
Total call minutes	1,335	1,444	1,796	7,955	12,530

In table 8, note that there were two restoration samples sites in 2007; 2008 was a transition year with five new restoration sites added in April and July; 2009 had six restoration sites; and nine restoration sites were sampled in 2010. The total minutes of bat activity showed large increases for western red bat at CNWR #1 in FY10, most likely reflecting the increased number of sample sites.

Table 8.—Cibola National Wildlife Refuge Unit 1 Conservation Area

Species	FY07	FY08	FY09	FY10	All years
Western red bat	0	1	2	56	59
Western yellow bat	0	0	4	7	11
California leaf-nosed bat	12	67	11	68	158
Townsend’s big-eared bat	0	0	7	1	8
All other species	433	2,066	5,715	8,352	16,566
Total call minutes	445	2,134	5,739	8,484	16,802

Western yellow bat activity increased in FY10 at the IPCA as did overall bat activity for all species combined (table 9).

Table 9.—Imperial Ponds Conservation Area

Species	FY07	FY08	FY09	FY10	All years
Western red bat	1	0	8	8	17
Western yellow bat	0	4	6	42	52
California leaf-nosed bat	41	60	34	81	216
Townsend’s big-eared bat	4	0	0	1	5
All other species	2,534	3,075	4,175	9,271	19,055
Total call minutes	2,580	3,139	4,223	9,403	19,345

Note that there were two restoration sample sites in 2007; 2008 was a transition year with two sites in November and January, which were replaced with one site in 2008; and 2009 and 2010 had one restoration sample site. Acoustic bat monitoring at Pratt showed relatively little change in bat activity in FY10; however, for the first time, western red bats were recorded in FY10 (table 10).

Table 10.—Pratt Restoration Demonstration Area

Species	FY07	FY08	FY09	FY10	All years
Western red bat	0	0	0	3	3
Western yellow bat	0	0	7	4	11
California leaf-nosed bat	0	6	1	1	8
Townsend's big-eared bat	0	0	0	0	0
All other species	1,617	788	1,260	1,271	4,936
Total call minutes	1,617	794	1,268	1,279	4,958

Seasonal Habitat Use – Fiscal Year 2010

The seasonal habitat use (mean number of bat minutes per sample site) for treated habitats (cottonwood-willow and mesquite) compared to untreated habitats (agriculture and saltcedar) for the four focal bat species for each habitat conservation area is shown on figures 14 and 15.

Overall, western red bats (LABL) were either not recorded or had a very low mean number of bat minutes in untreated agricultural/saltcedar habitats for all of the HCAs. The two most rapidly maturing habitats with the complex canopy habitats, PVER and CVCA, had the highest number of mean bat minutes during all four seasons. These two areas were the only HCAs to host wintering red bats (CRIT also hosts winter red bats, but is not currently being managed as an LCR MSCP HCA), which were recorded in the intermediate cottonwood habitats.

Wintering western yellow bats (LAXA) were recorded only at IPCA, nearly all of which were in the intermediate cottonwood habitats, with a small number also recorded in the adjacent untreated agriculture habitat. Overall, western yellow bats were recorded mostly in cottonwood-willow and mesquite habitats at Beal, PVER, CVCA, CNWR #1, and IPCA, with the highest mean number of bat minutes (41) occurring at CNWR #1 during the summer. The exception to this general trend was observed at PVER during the summer, with 12.8 mean bat minutes per site in the adjacent agricultural habitat. LAXAs were also recorded in small numbers in untreated agriculture habitat at CVCA during the summer as well as at IPCA during the winter, spring, and summer.

California leaf-nosed bats (MACA) were recorded in untreated agricultural/ saltcedar habitats at all HCAs, with the highest mean number of bat minutes recorded during the fall at CNWR #1 (4.0) and during the winter at CVCA.

Townsend's big-eared bats (COTO) were rarely recorded because of their low intensity "whispering" calls. This reflects only the difficulty of detecting them acoustically – not because this species is not present on the HCAs. Very low numbers of mean bat minutes/site were recorded in both treated and untreated sites primarily during the summer.

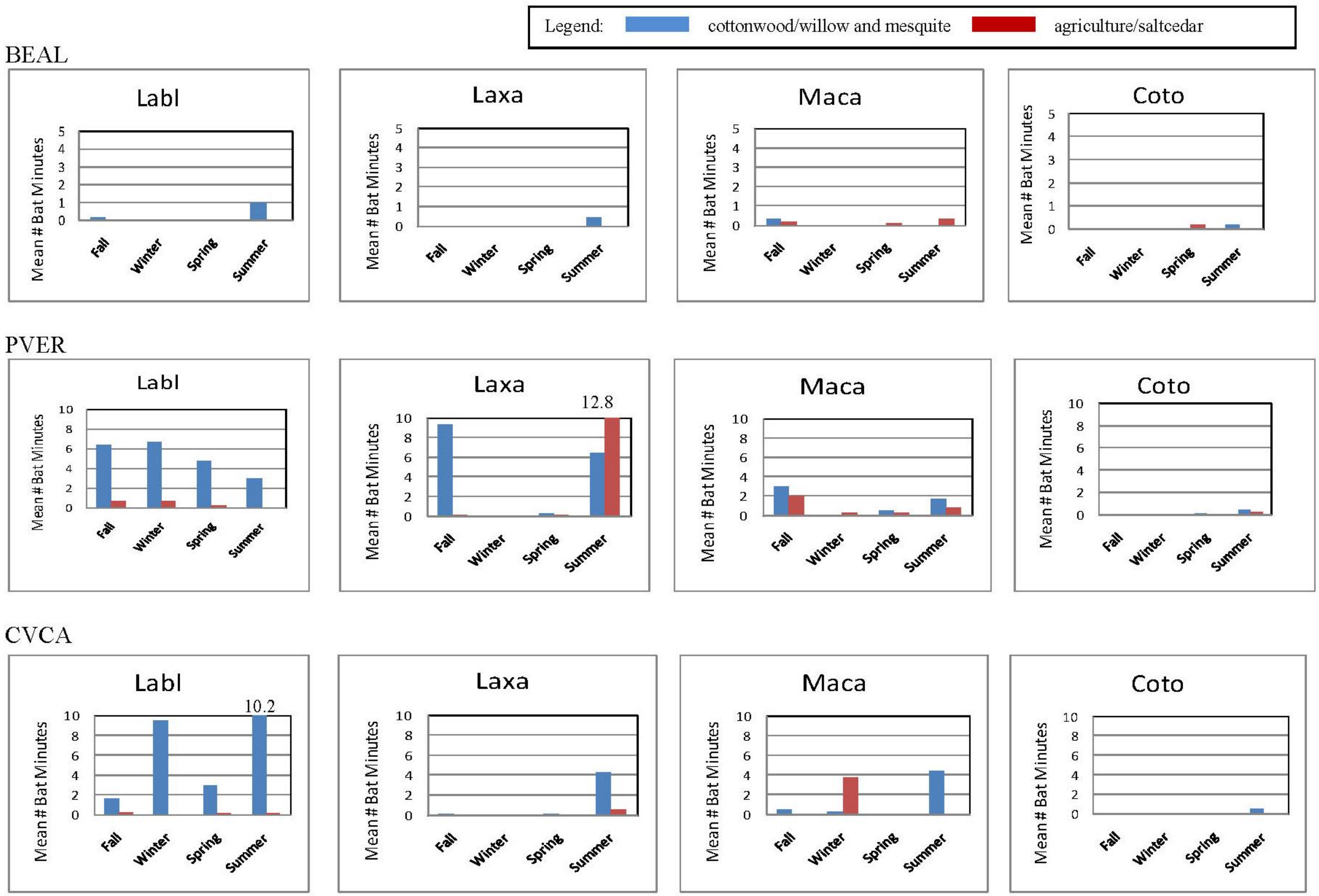

Figure 14.—Seasonal use of cottonwood-willow/mesquite and agriculture/saltcedar habitats (mean number bat minutes) for western red and western yellow bat and the two evaluation species, California leaf-nosed bat and Townsend's big-eared bat, for Beal, PVER, and CVCA.

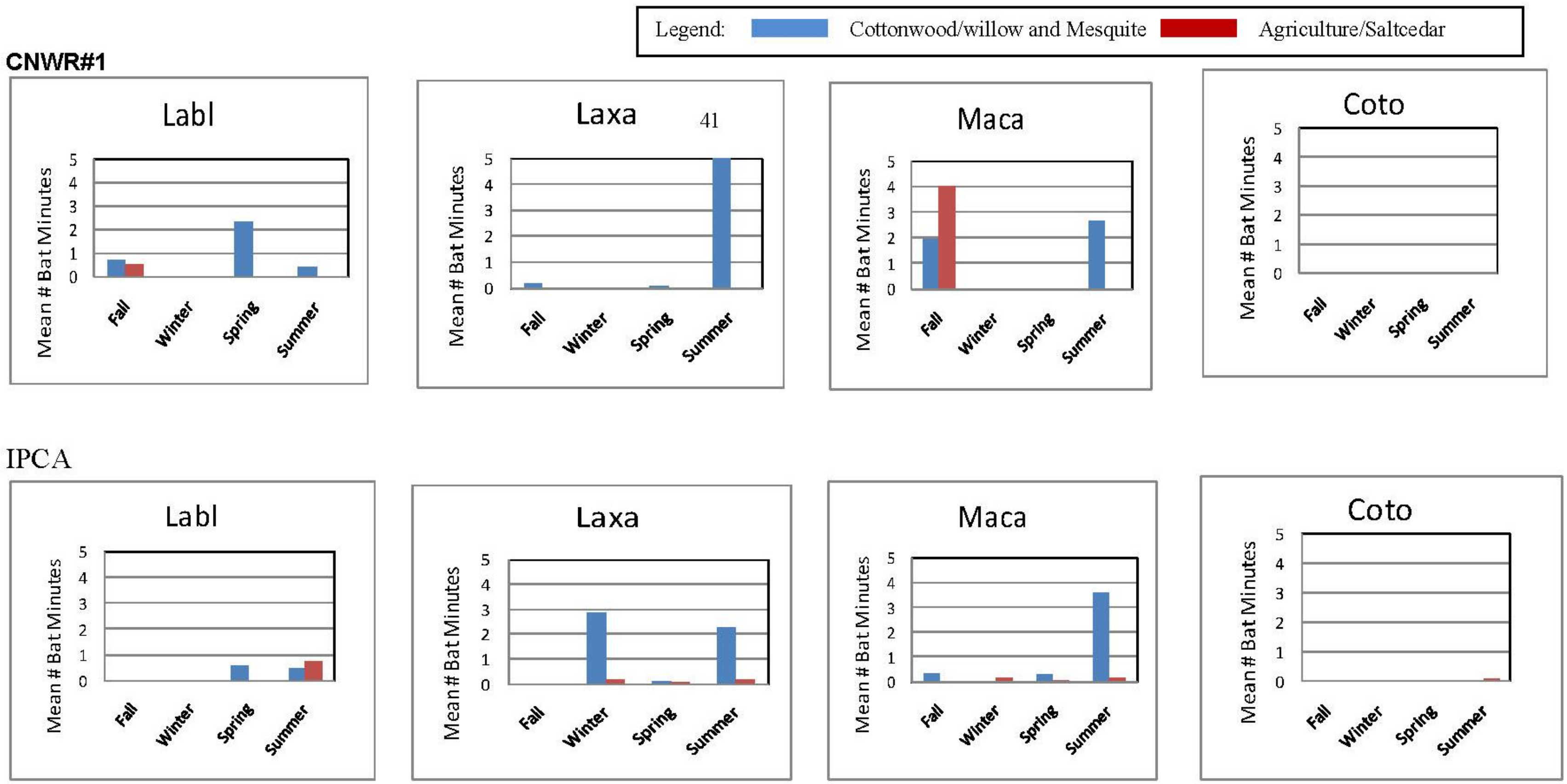

Figure 15.—Seasonal use of cottonwood-willow/mesquite and agriculture/saltcedar habitats (mean number bat minutes for western red and western yellow bat and the two evaluation species, California leaf-nosed bat and Townsend's big-eared bat, for CNWR #1 and IPCA.

The seasonal habitat use for the two riparian specialists as represented by the mean number of bat minutes per acoustic sample location per sample night is shown on figure 16. Both the cave myotis (MYVE) and Arizona myotis (MYOC) are migratory, leaving the LCR as the nights begin to cool down in October and returning in April to the LCR, with one exception, CNWR #1, with a mean of 1.3 bat minutes in October, with all of the bat minutes recorded in the spring and summer. The CRIT had very high bat activity during July for cave myotis (80 minutes) and Arizona myotis (97 mean minutes) of activity. PVER also had very high bat activity for cave myotis (100 mean minutes) of activity. CVCA had high levels of activity for cave myotis at a mean of 65 minutes recorded during July. Most of the activity occurred in treated habitats (cottonwood-willow and mesquite) for all HCAs.

Year-to-Year Comparisons of Bat Minutes in Treatment Sites Versus Control Sites

A repeated measures ANOVA (figures 17 A–E) showed significant increases in bat minutes for western red and western yellow bats from 2009 to 2010 at PVER ($p = 0.0434$) and at CVCA ($p = 0.0080$). This increase appeared to correspond to a period of extremely rapid growth of cottonwood-willow habitats at these two sites from 2009 to 2010. Western red and western yellow bat minutes increased in cottonwood-willow habitats at CNWR #1 ($p = 0.2734$), IPCA ($p = 0.4747$), and Beal ($p = 0.1126$) from 2009 to 2010, but the increases were not significant. Habitats at the latter three sites showed steady growth although at much slower rates than at PVER and CVCA.

Data for California leaf-nosed bats and Townsend's big-eared bats were insufficient to analyze using a repeated measures ANOVA. Repeated measures ANOVA results for riparian specialists, cave myotis, and Arizona myotis in cottonwood-willow versus agriculture-saltcedar at PVER and CVCA showed an increase in number of bat minutes from 2009 to 2010 in cottonwood-willow habitats, but these increases were not significant ($p = 0.3065$ for PVER and $p = 0.2624$ for CVCA) (figures 18 A–B).

Comparison of Bat Activity among the Five Habitat Types Sampled Acoustically

Bat activity for western red bats (LABL) and western yellow bats (LAXA) was significantly higher in intermediate cottonwood habitats at PVER and CVCA compared to sapling cottonwood, mesquite, agriculture, or saltcedar (table 11).

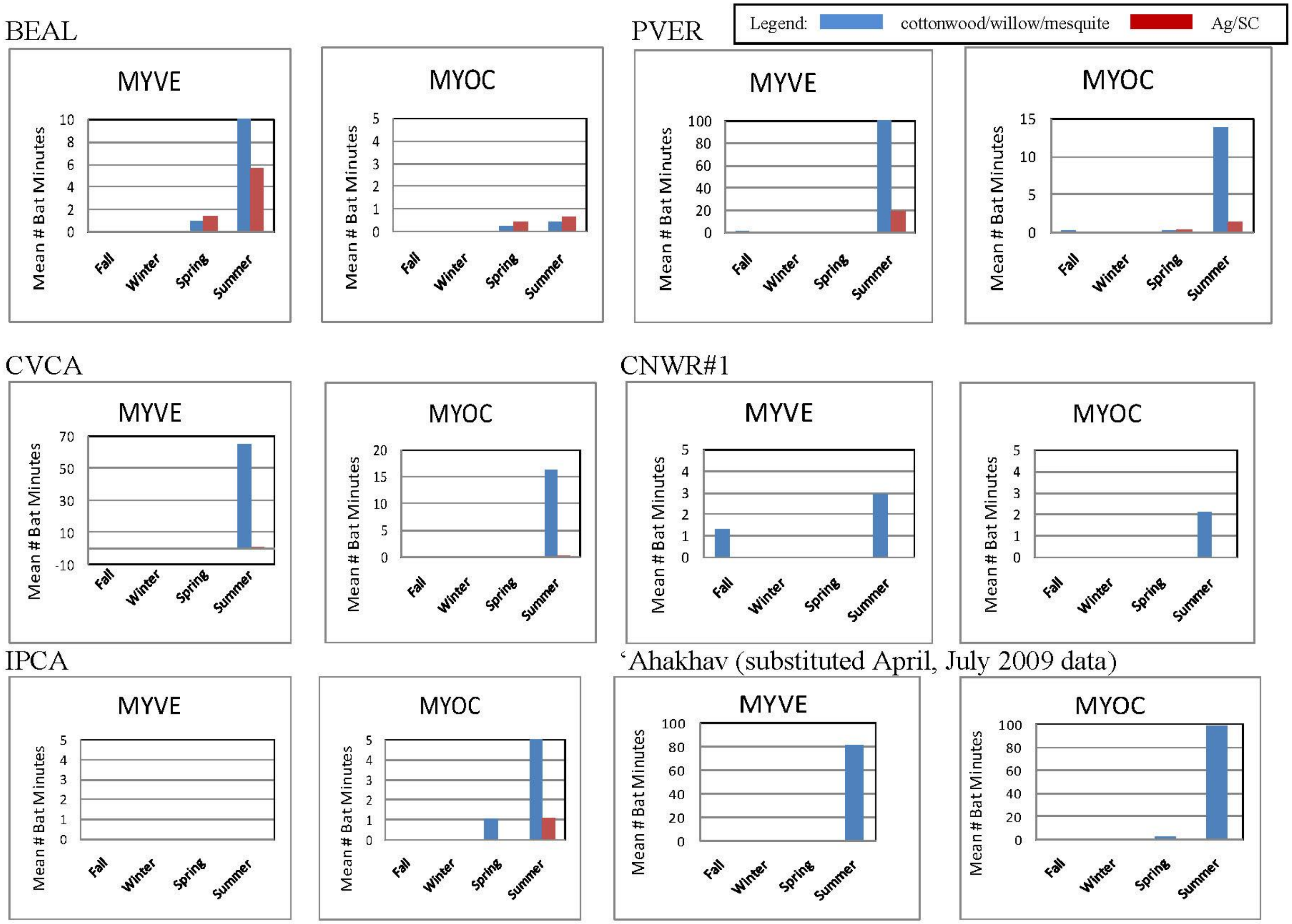

Figure 16.—Seasonal use of cottonwood-willow/mesquite and agriculture/saltcedar habitats for cave myotis and Arizona myotis for six habitat creation areas.

Year-to-year comparison of western red and western yellow bat minutes for treated versus untreated habitats

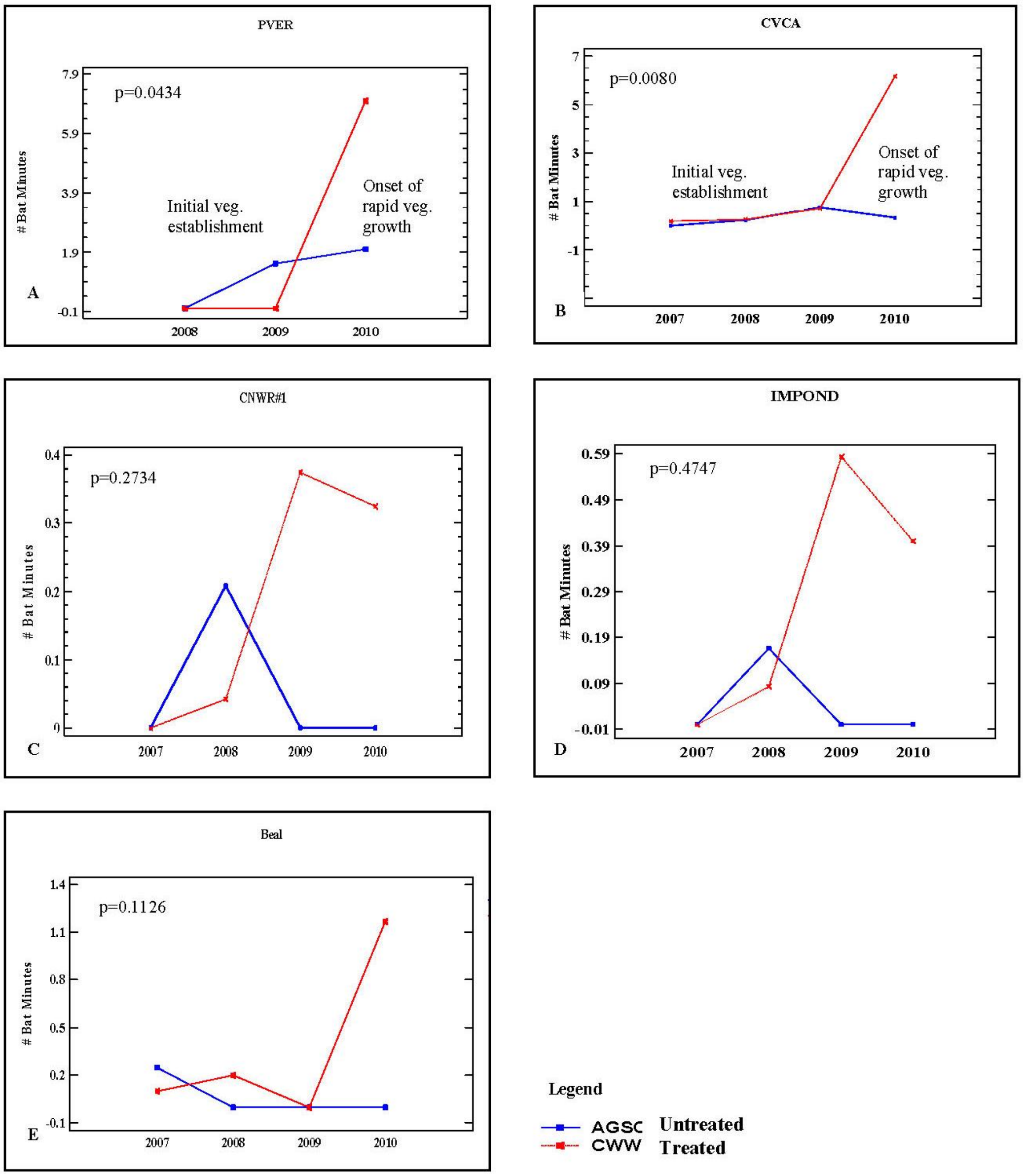

Figure 17.—Repeated measures ANOVA shows that the number of bat minutes pooled for western red and western yellow bat increased significantly from 2009 to 2010 at PVER and CVCA.
The blue line (solid) representing agriculture/saltcedar is untreated, and the red line (dashed) representing cottonwood-willow is treated.

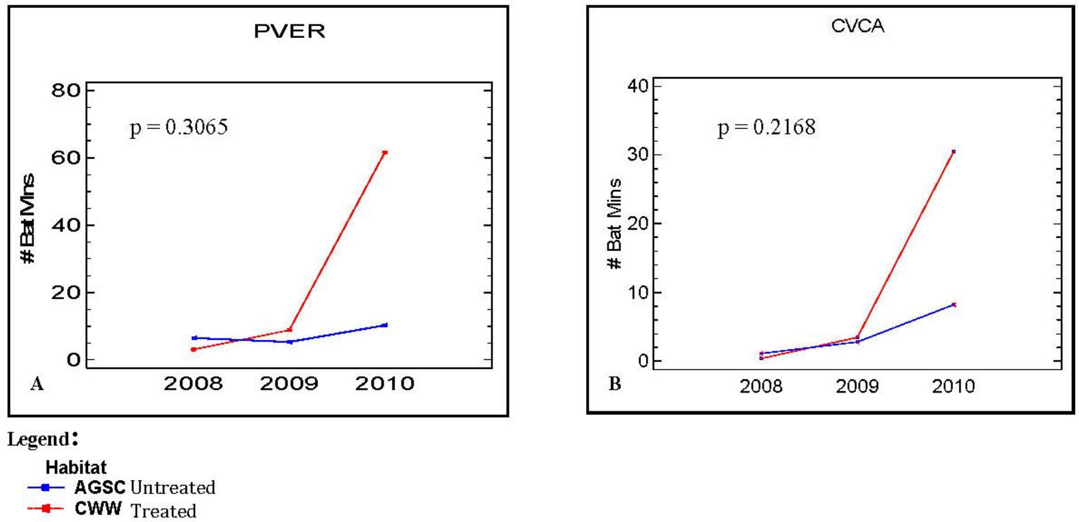

Figure 18.—Repeated measures ANOVA for riparian specialists MYVE and MYOC at PVER and CVCA.
The blue line represents agriculture and saltcedar and is untreated, while the red line represents cottonwood-willow plantings (treated).

This also held true for cave myotis and Arizona myotis at PVER and CVCA. Western yellow bat minutes were significantly higher in only one habitat type, intermediate cottonwood, at IPCA.

Significantly higher bat activity in sapling cottonwood occurred in CVCA and Beal for MYVE. Bat activity comparisons were also made for canyon bat (PAHE), one of the abundant flagship species commonly considered to be a habitat generalist, with agricultural habitat at PVER being the only habitat with significant higher bat activity compared to other adjacent habitats. Overall for all species combined, five HCAs had significantly higher bat activity for intermediate cottonwood (all except IPCA), with CVCA and Beal being significantly higher for sapling cottonwood.

Habitat Variables Influencing Bat Activity

Habitat analyses were conducted for western red bats, western yellow bats, California leaf-nosed bats, as well as the riparian specialists cave myotis and Arizona myotis. The Townsend's big-eared bat is a "whispering bat" and had too few minutes to conduct analyses. These analyses were designed explore what habitat variables are important in determining whether focal and riparian bat species utilize riparian plantings. From the results of this analysis, management recommendations can be made that can enhance the created habitats for the focal bat species and riparian bat species.

Table 11.—Comparison of bat activity by habitat for each habitat creation area for July 2010 (Kruskal-Wallis)

Significant p values are shown in red along with the habitat types with significantly high bat activity. Note that CRIT was not monitored in July 2010 (2009 data were substituted for this analysis). CW = intermediate cottonwood; SCW = sapling cottonwood; MESQ = mesquite, and AG = agricultural fields.

Species	Habitat conservation area	P value	Habitats	Species	Area	P value	Habitats
LAXA	PVER	0.4774		MYOC	PVER	0.0247	ICW
	CVCA	0.0865			CVCA	0.0026	ICW
	BEAL	0.1203			BEAL	0.6351	
	CNWR #1	0.3525			CNWR #1	0.1053	
	IPCA	0.0051	ICW		IPCA	0.4556	
	CRIT	0.0549			CRIT	0.0273	ICW
LABL	PVER	0.0084	ICW	PAHE	PVER	0.0314	AG
	CVCA	0.0355	ICW		CVCA	0.4304	
	BEAL	0.3283			BEAL	0.7722	
	CNWR #1	0.9509			CNWR #1	0.2716	
	IPCA	0.0703			IPCA	0.1760	
	CRIT	0.6703			CRIT	0.0664	
MACA	PVER	0.0138	ICW	Total spp.	PVER	0.0123	ICW
	CVCA	0.0428	ICW		CVCA	0.0167	ICW & SCW
	BEAL	0.0773			BEAL	0.0145	SCW
	CNWR #1	0.1072			CNWR #1	0.0418	ICW
	IPCA	0.0052	MESQ		IPCA	0.2192	
	CRIT	0.5914			CRIT	0.0273	ICW
MYVE	PVER	0.0012	ICW				
	CVCA	0.0015	ICW & SCW				
	BEAL	0.0057	SCW				
	CNWR #1	0.2337					
	IPCA	0.3916					
	CRIT	0.1133					

The results of fitting a Poisson regression model to describe the relationship between each species and eight habitat variables are shown in table 12. Habitat modeling was not possible in instances in which the minutes of bat activity were very sparse (many 0s and 1s in the data), and those results are not included in the Poisson regression modeling. Table 3 summarizes those with adequate data.

Table 12.—Poisson regression analyses for habitats with sufficient bat minutes for the species to conduct the analyses

CL = Canopy layer, CE = Canopy edge, CR = Distance to Colorado River; CWW = Canals with water; PS = Patch size; FW = Flyway; NE = Nearest edge. See discussion of variables on page 19.

Area	Species	Equation of the fitted model	Percent deviance[1]	Model variables	P value model
PVER	LABL	LABL = exp(-1.19769 + 0.876513*CL)	34.8	# canopy layers,	0.0001
PVER	LAXA	LAXA = exp(1.05148 + 0.00201824*CE + 0.465895*CL - 0.0019968*CR)	45.3	Canopy edge, length, distance to Colorado River	0.0001
PVER	MYVE	MYVE = exp(0.829257 + 1.15196*CL + 0.000479548*CWW + 0.0108703*PS)	80.4	# canopy layers, distance to canals w/water, patch size	0.0000
PVER	MYOC	MYOC = exp(-1.56238 + 0.93571*CL + 1.21187*FW - 0.0122837*NE)	86.5	# canopy layers, # flyways, distance to nearest edge	0.0000
CVCA	LABL	LABL = exp(0.71571 - 0.105841*NE + 1.45972*CL)	68.9	# canopy layers, distance to nearest edge	0.0000
CVCA	LAXA	LAXA = exp(1.171 + 0.0190633*CE + 1.30013*CL - 0.216365*NE - 0.0350382*SE)	88.7	# canopy layers, canopy edge, length, distance to nearest edge, distance to stand edge	0.0000
CVCA	MYVE	MYVE = exp(-0.139566 + 0.0212529*CE + 1.12709*CL + 0.00527935*CR - 4.11083*FW)	85.8	# canopy layers, canopy edge, length, distance to Colorado River, # flyways	0.0000
CVCA	MYOC	MYOC = exp(-3.28827 + 0.0380733*CE + 2.29798*CL + 0.00894013*CR - 7.41667*FW - 0.00977238*SE)	86.7	# canopy layers, canopy edge, length, distance to Colorado River, # flyways, distance to stand edge	0.0000
CNWR	MYOC	MYOC = exp(-2.39269 + 3.45707*CL - 0.785898*FW - 0.0463415*NE)	88.5	# canopy layers, # flyways, distance to nearest edge	0.0000
IPCA	LABL & LAXA	Tree Bats = exp(-1.18189 + 0.889245*FW)	32.7	# flyways	0.0005
IPCA	MACA	MACA = exp(5.75354 - 2.35987*CL - 0.00171865*CR - 0.0537399*PS)	80.0	# canopy layers, distance to Colorado River, hatch size	0.0000
IPCA	MYOC	MYOC = exp(-3.42782 + 0.00578204*CE + 1.57561*CL)	49.1	# canopy layers, canopy edge, length	0.0001

[1] Percent deviance is similar to r-squared.

Habitat models were developed for five bat species, including western red bat, western yellow bat, California leaf-nosed bat, cave myotis, and Arizona myotis. Almost all of the models identified a unique combination of environmental variables. Reliability of the models was variable. Based on model variances, two of the species models were considered to be moderately weak (<35 percent [%] of the deviance captured), whereas 10 models were robust (>40% of the deviance captured). The modeling revealed one variable to be particularly important in determining habitat use of riparian plantings: the number of canopy layers. The canopy layer was identified as a significant variable in 11 of the 12 species habitat models, which is in keeping with the work of Milne et al. (2006) who demonstrated the importance of canopy layers to bats in an Australian forest. The canopy edge was a significant variable in 5 of the 12 species habitat models, while distance to nearest edge and number of flyways were significant variables in 4 of the 12 species habitat models. The distance to the Colorado River was significant in 4 of the 12 models.

Canopy Complexity

Tree-roosting and riparian specialist bats, such as western red and western yellow bats, and Arizona myotis and cave myotis show increased activity in HCAs that exhibit canopy complexity. Complexity increases as trees and shrubs mature, creating canopy edges with different vegetation heights. A photo (figure 19) was taken in October 2009 at PVER Nursery. At this site, a coyote willow stand with an average height of 18 ft (5.5 m) is growing next to a Goodding’s willow stand with an average height of 35 ft (10.7 m). These, in turn, are immediately adjacent to a cottonwood stand with an average canopy height of 50 ft (15.2 m). Bats forage along edges that form between stands of different species such as tree willows adjacent to coyote willow and/or ages. Additionally, stochastic events such as wind throw or morning glory infestations that smother saplings create openings in otherwise dense, uniformly planted habitats. Bats also forage along edges created by roads, canals, field edges, and deliberately created wide spaces between plantings.

Relationship between Total Number of Acres of Cottonwood-Willow Habitat and Bat Minutes

The relationship between the total number of acres of cottonwood-willow habitats and bat minutes was explored using linear regression analysis. This was designed to answer the question, “Does the overall size of a riparian restoration area affect bat activity?” The metric tested was the overall total number of acres of cottonwood-willow habitat at each HCA, and it was used to measure the importance of the overall size of this habitat type to bat activity. This contrasts to the patch size variable discussed above, which measures the size of the

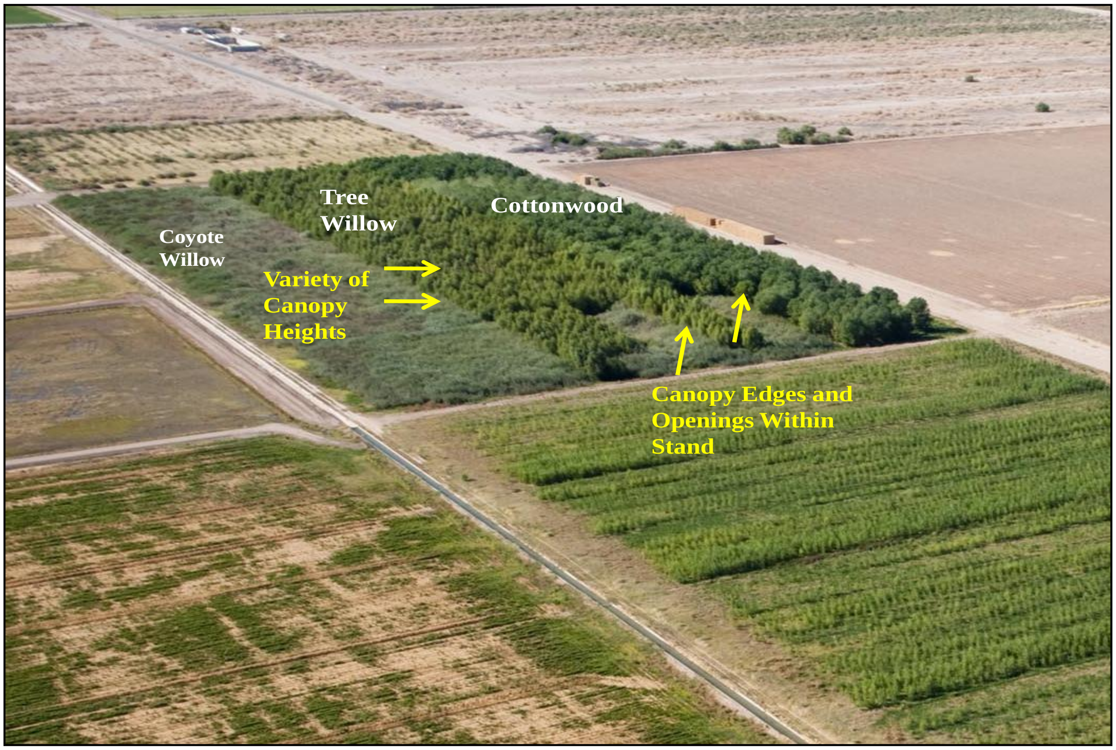

Figure 19.—Components of canopy complexity shown in a riparian planting site at the PVER Nursery.

immediate patch in the vicinity of the detector as opposed to totaling all acres of cottonwood-willow for the entire HCA. Linear regression was conducted for the relationship between number of bat minutes for each species and the number of acres of cotton-willow habitat for each HCA.

The results of linear regression show there is a statistically significant relationship between the number of acres and number of western red bat minutes at the 95.0% confidence level. A plot of the fitted model is shown on figure 20. The r-squared statistic is 71.9%. The correlation coefficient equals 0.85, indicating a moderately strong relationship between the variables. There were no significant relationships between size (number of acres) of the cottonwood habitat and bat activity for any of the other species.

Monthly Bat Activity at Beal Permanent Bat Station

A permanent bat monitoring station was established at the Beal Lake Riparian Restoration Area in April 2008. After a short adjustment period, the monitoring station performed flawlessly until July 29, 2010, when the internal battery in the

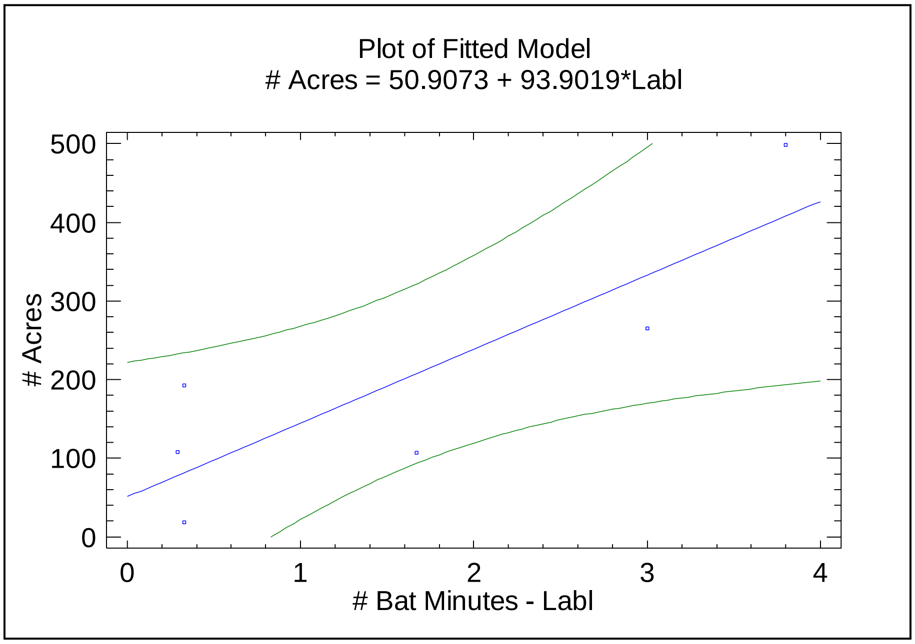

Figure 20.—Plot of fitted model for the relationship between amount of cottonwood-willow habitat in an HCA and the number of bat minutes for the western red bat.

Anabat SD1 detector expired. Data loss occurred for the months of August and September 2010. Figures 21 and 22 show the daily monitoring results for western red and western yellow bat for October 1, 2009, through July 29, 2010.

An increased pulse of bat activity occurred during October and November 2009. A Mann-Whitney test was run on the number of bat minutes recorded for western red and western yellow bat during October and November 2009 compared to 2010. There was a significant difference between years at the 95.0% confidence level (W = 879.5, p = 0.0001). The presence of large numbers of western red bats at Beal during October and November is likely associated with fall migration. Western red bat activity ceases during December and January. Activity picks up again as the weather warms in February and continues at light levels throughout the spring and summer months. A Mann-Whitney test indicated that bat activity during 2010 compared to 2009 for the months of February through July had a significant increase in western red bat activity in 2010 compared to the same period in 2009 at the 95.0% confidence level (W = 532.0 p = 0.0007). Further monitoring should be continued to determine if a trend toward increasing western red bat use of cottonwood-willow habitats at Beal may be developing.

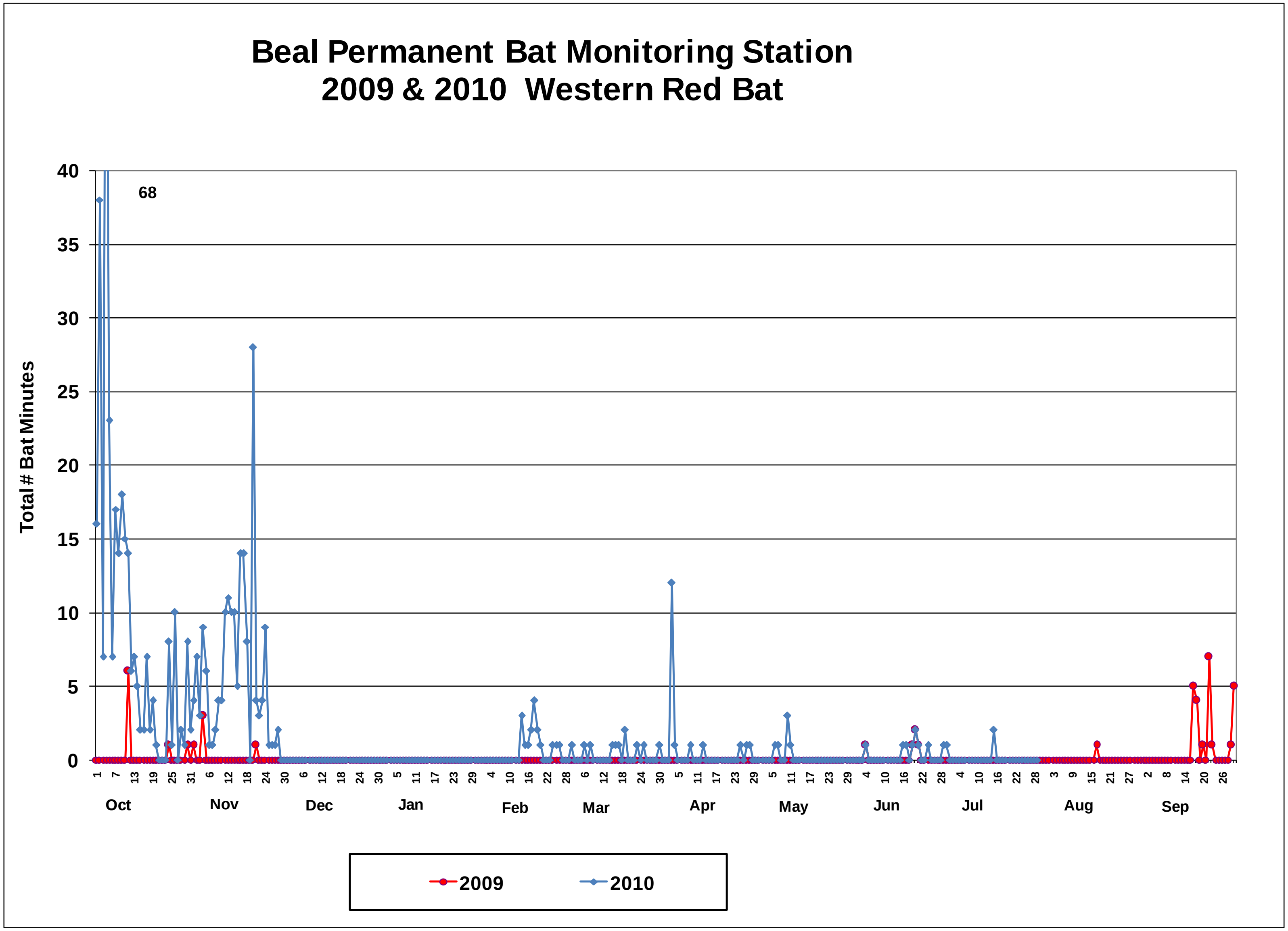

Figure 21.—Beal permanent bat station monitoring results during 2009 and 2010, which show the number of minutes of bat activity for the western red bat. Note that data collection for 2010 ended on July 29.

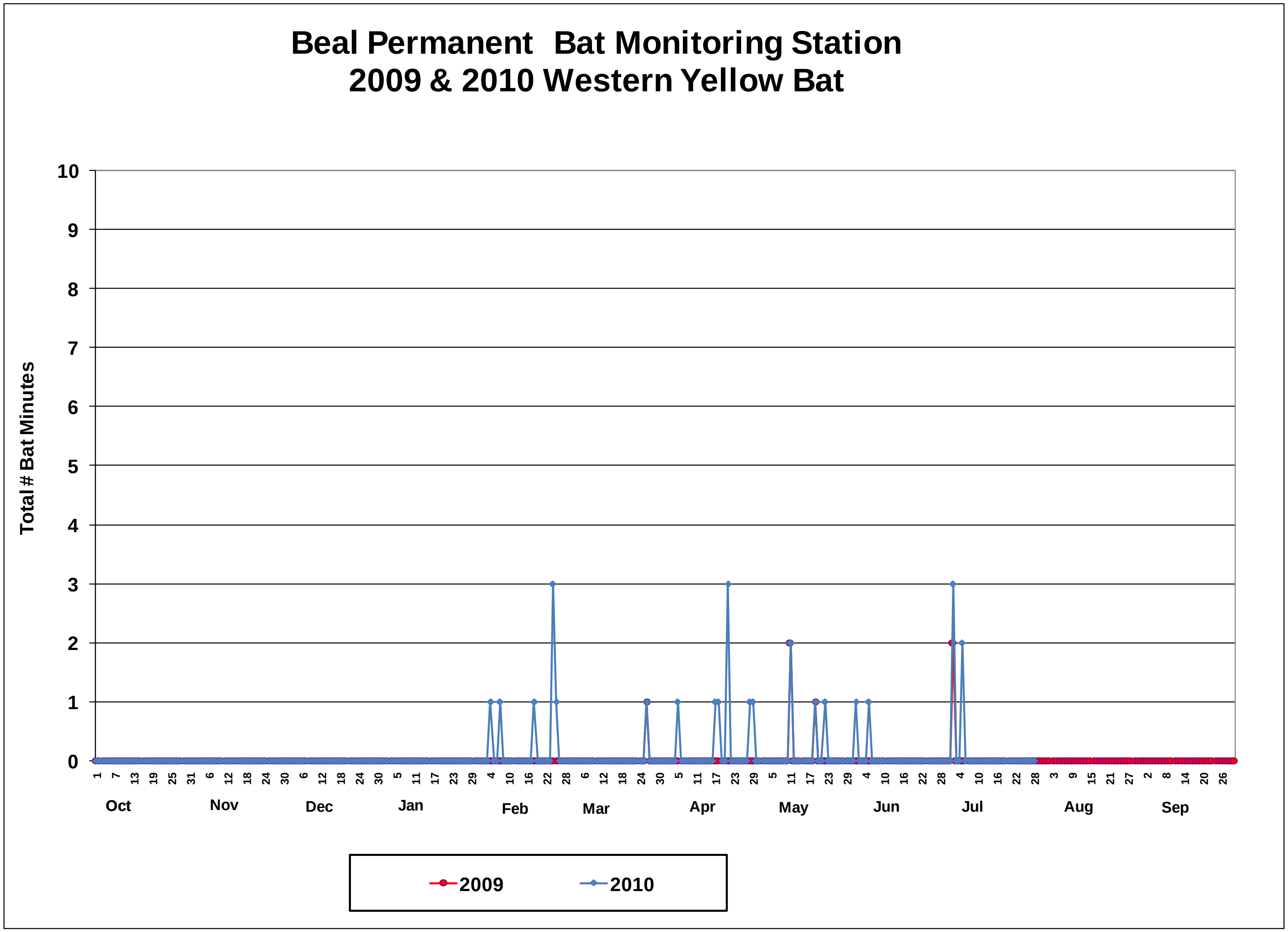

Figure 22.—Beal permanent bat monitoring station results during 2009 and 2010, which show the number of minutes of bat activity recorded nightly for the western yellow bat. Note that data collection ended on July 29, 2010.

DISCUSSION

This discussion addresses a series of questions frequently raised about bat use of HCAs along the LCR.

Does bat activity vary by season? One of the most important findings of this 4-year monitoring effort was the documentation of winter use by western red bats in the rapidly developing intermediate cottonwood habitats at PVER and CVCA. Forty red bat minutes were recorded in PVER in February 2010, and 38 bat minutes were recorded at CVCA in February 2010. Light winter activity for western red bats was also recorded at the permanent monitoring station at Beal. Habitats are also maturing at Beal, with cottonwoods becoming taller and denser with more canopy complexity, though at a smaller scale than at PVER and CVCA.

Winter use of the CRIT was documented in 2009 (Broderick in press) when 168 western red bat minutes were recorded in intermediate cottonwood during February 2009 sampling, and 45 bat minutes were recorded during February 2010 also in intermediate cottonwood. Nineteen bat minutes of western red bat activity were also recorded in mesquite in February 2009 (Broderick in press). However, the riparian plantings at CRIT had been established in 1995 and, thus, were more mature and fully developed than the other HCAs. It is likely that as cottonwood-willow habitats matured during 2009 and 2010 at PVER and CVCA, the habitat became suitable for wintering western red bats.

IPCA appears to be providing winter habitat for western yellow bats (19 total bat minutes in February 2010 sampling). Nearly all of the western yellow bat activity during the February sample was recorded in cottonwood-willow habitat. This site is approximately 23 miles from the International Boundary with Mexico and is warmer than the more northerly HCAs upstream. Interestingly, however, the permanent monitoring station at Beal also recorded western yellow bat activity during the winter and early spring months. Routine intensive acoustic monitoring has not recorded western yellow bats during the winter or early spring at PVER, CVCA, CNWR #1, or Pratt, though more intensive monitoring through the installation of permanent monitoring stations may reveal more extended winter/early spring western yellow bat use that previously suspected.

In one anecdotal observation during a wind storm in April 2010 with accompanying cooler temperatures, I continued acoustic bat monitoring at CVCA in spite of the high winds (40 to 50 miles per hour) and intense dust storms that occurred overnight just to see what bat species, if any, would be active. I found that the only species active that night was western red bats, with 40 minutes of activity as well as 180 minutes of activity for Yuma myotis and California myotis. These bats were active only in the densest, most complex habitat (multiple canopy layers, with various openings). As the riparian plantings mature and the complexity increases (number of canopy layers, edges, and overall tree density), habitat may become more suitable for wintering bats and bats subjected to intense weather events such as wind and dust storms.

Western red bats also show relatively high levels of activity year round at PVER and during the winter and summer at CVCA. Activity is lighter at CNWR, IPCA, and Beal. Western yellow bats tend to be found in cottonwood-willow habitats as at PVER and CNWR #1 during the summer, but also utilize agriculture and saltcedar habitats as seen at PVER during the summer.

Are focal bat species responding to riparian plantings? What about riparian specialist bats? Significant increases in western red and western yellow bat activity (the number of bat minutes) occurred in cottonwood-willow habitats at PVER and CVCA from 2009 to 2010. This surge in activity coincided with the onset of rapid growth of cottonwood and willow at these two HCAs. In contrast, bat activity for western red and western yellow bats in the adjacent agriculture and saltcedar habitats remained at a fairly steady low level, with only a slight year-to-year increase. Bat minutes increased in cottonwood-willow habitats at CNWR #1, IPCA, and Beal from 2009 to 2010, but the increases were not significant. Cottonwood-willow habitats at these three areas showed steady growth, but at much slower rates than at PVER and CVCA. Bat activity in agricultural fields and saltcedar remained at low levels throughout the study period.

Bat activity for the riparian specialists, cave myotis and Arizona myotis, showed increases in the number of bat minutes from 2009 to 2010 in cottonwood-willow habitats at PVER and CVCA, but these increases were not significant. Activity in adjacent agriculture and saltcedar remained at very low levels throughout the study period.

How does bat activity compare among the five habitat types sampled? Comparisons of bat minutes for the focal bat species and two riparian specialist bat species for each of the broad habitat categories at HCAs showed that the intermediate cottonwood habitat had significantly higher bat activity for western red bats, California leaf-nosed bats, cave myotis, and Arizona myotis at PVER and CVCA. Intermediate cottonwood at IPCA was significantly higher for western yellow bats – in fact, intermediate cottonwood was the only habitat type for this species with significantly high levels of bat activity. Intermediate cottonwood was also important for the total bat community when all species were considered. For the overall bat community, intermediate cottonwood was significantly higher at PVER, CVCA, CNWR #1, and CRIT. Agricultural habitat had significantly high numbers of bat activity at only one HCA, PVER, and that was for the abundant generalist, the canyon bat (PAHE).

Mesquite had significantly high bat activity for California leaf-nosed bats at IPCA, which corresponded to a particularly robust, fully mature mesquite stand.

Mesquite, both screwbean and honey, tend to be much more slow growing than cottonwood-willow and usually are not irrigated. Mesquite stands at PVER and CVCA were established and growing, but were not dominant components of the vegetation at these HCAs. The most fully developed mesquite was present at CRIT. This habitat was fully utilized by the bat community along with ICW and SCW and thus did not result in significantly higher bat activity. Mesquite at Beal was also established and growing fairly well, as of 2010, but it did not show significantly higher bat activity than the adjacent sapling cottonwood or saltcedar habitats.

California leaf-nosed bats show an affinity for the agriculture/saltcedar habitats, more so than the other three focal bat species, with some activity recorded in these untreated habitats year round at PVER, during the winter at CVCA, and during the fall for CNWR #1. California leaf-nosed bats are also well dispersed in cottonwood-willow habitats during the summer period, with moderately high levels of bat activity recorded at CVCA, CNWR, and IPCA.

What habitat variables are important in determining whether focal bat species utilize riparian plantings? Can management recommendations be made based on what we know so far? 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 bat activity. This demonstrates the need to design for these features in subsequent habitat plantings. Overall canopy complexity can be increased by planting different tree and shrub species in juxtaposition to each other. For example, Goodding's willows do not grow as tall as Fremont cottonwood, and when planted adjacent to a cottonwood stand, they can provide an edge that bats can forage along. Also, the number of flyways can be increased by allowing stochastic events such as wind throw or small areas of die-outs to persist uncorrected and by deliberately planting rows further apart than the usual road or canal width.

Does the overall size of a riparian restoration area affect bat activity? Linear regressions showed that there was a significant relationship between the size of cottonwood-willow habitats (number of acres) in a given area and the number of bat minutes for the western red bat. This confirms the observations that habitat creation areas with the most extensive stands of cottonwood-willow also have the highest activity. It is thus very likely that as the areas are fully planted and the habitats mature, the overall activity for western red bats will increase significantly.

It has also been shown that including the riparian specialists, cave myotis (MYVE) and Arizona myotis (MYOC), in subsequent monitoring analyses can provide valuable insight into the response of riparian bat specialists to HCA development. These two species are easily recorded acoustically and readily identified. They are relatively abundant at some HCAs. Additionally, these species have declined in response to riparian habitat loss and degradation throughout the Southwest and thus are important riparian species to manage for in their own right. Finally, these two riparian specialists have responded dramatically to habitat creation as part of the LCR MSCP.

How does monthly bat activity vary at the Beal permanent bat station? Do permanent bat stations provide useful data for management purposes? Permanent bat monitoring stations collect nightly data year round, providing a very large sample size. This large data set allows robust statistical analyses to be conducted on a variety of metrics, the most common being month-to-month comparisons and year-to-year comparisons of various bat species. It also shows pulses of activity associated with spring and fall migrations, providing insight into how bats are using the habitat. In the case of Beal, it appears that the primary use, at least during 2009 and 2010, is as migratory habitat. Collection of multiple years of nightly data will allow the establishment of trends in bat use as the habitats mature and HCAs become fully established.

Conclusion. Based on the results of 4 years of post-development bat monitoring at these HCAs, it is evident that western red bats and western yellow bats are increasingly utilizing the created habitats and are now routinely recorded acoustically in all of the HCAs. Significant increases in bat minutes for both species occurred at PVER and CVCA, and overall increases (though not significant) were shown for Beal, CNWR #1, and IPCA. It can thus be stated with some degree of confidence that the LCR MSCP is in fact moving toward its goal of creating cottonwood-willow habitat for western red and western yellow bats, though it is not confirmed that they are using the habitat for roosting. As monitoring in the form of permanent bat stations continues, and as areas become fully developed and habitats mature, this trend toward increasing use by these two covered species will likely continue to increase.

RECOMMENDATIONS

As planting phases are completed at the HCAs and cottonwood-willow and mesquite habitats become mature within the next 3 to 5 years, intensive acoustic surveys should be repeated. This can be done one time during an intensive sampling period during July. The following questions should be addressed: What is the synergistic effect of having the entire habitat creation site fully planted and matured? Is there an overall increase in the numbers of focal bat species throughout the LCR as all of the HCAs become fully developed and mature? Does species composition, relative abundance, and overall bat activity as measured by bat minutes increase significantly over levels present in 2008 through 2010? Does seasonal use change? (e.g., does western red and western yellow bat activity increase during winter?) Does a particular species remain in a HCA after fully developing the site compared with just migrating through – as observed during the initial years of the restoration program?

Acoustic sampling was not the optimum survey method for the evaluation species. Both the Townsend's big-eared bat and California leaf-nosed bat are whispering bats and are poorly surveyed by acoustic methods. Leaf-nosed bats are fairly well represented in mist-net capture efforts; however, Townsend's big-eared bats are rarely captured. Radio-tracking studies would allow individuals from adjacent mines where colonies are present to be fitted with radio transmitters and tracked as they commute and forage in nearby riparian areas.

Mobile monitoring can provide a large-scale spatial emphasis and can identify where and which bats are found. It is good for identifying hot spots of bat activity (such as the restoration sites). It can provide actual numbers of bats, as there is little chance of encountering the same individual twice. Mobile monitoring is well suited to regular transects for temporal coverage. This could be a logical way to transition from the intensive seasonal acoustic monitoring that has been conducted since 2007 in the restoration habitats. A pilot study should be conducted in FY11 to determine the efficacy of this monitoring method.

Permanent bat monitoring stations operating at six HCAs would provide year-round nightly monitoring in the center of mature, complex canopies. They will provide excellent data on (1) seasonal use of the habitat, (2) migration patterns of various species, and (3) overall bat activity of the entire bat community as well as the focal bat species.

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 bat activity. These features should be included in future habitat plantings. Canopy complexity can be increased by planting different tree and shrub species in juxtaposition to each other, such as Goodding's willows adjacent to Fremont cottonwood. Resulting differences in canopy height create an edge that bats can forage along. Also, flyways within otherwise uniform stands can increase bat use. Allowing natural events such as wind throw or small areas of die-outs to persist uncorrected and designing occasional wider spaces between tree rows that can serve as a flyway will be beneficial to increasing bat use.

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APPENDIX A

Data Sheets – Quarterly Bat Monitoring

Table A1. – Quarterly summary of bat minutes recorded simultaneously in monitoring sites and one exploratory site at Beal, first and second samples, October 2009 and February 2010.

October 2009	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Myyu	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 1																								
A		1	7				40			1									42	5			96	
N			8	1			11										2		30	1			53	
II			7				12												32	3			54	
C		1	12		1		59						3						40	2			118	
K			5	2		1	50			1			1						39	1			100	
FF			7				11												19	1			38	
LL			3				13												37				53	
SCNE			6				14						1						24	1			46	
SCNW			3				10												18				31	
SCSW			8				31												42	1			82	
Beal Lake Habitat Restoration Post Development Bat Monitoring FY2010 Sample 2																								
A			3				11										2		2	1			19	
N							3			1									1				5	
II			2				8										2		1	1			14	
C																							0	ok
K		1	5				14		1								1	1	1	1			25	
FF			1				3										1						5	
LL			1				3												2	1			7	
SCNE			2				4										1			3			10	
SCNW			3				4										1						8	
SCSW			3				11		1										1				16	
February 2010	**15-19kHz**	**19-24kHz**	**24-30kHz**	**30-35kHz**	**35-40kHz**	**40-45kHz**	**45-55kHz**	**Coto**	**Eupe**	**Labl**	**Laci**	**Laxa**	**Maca**	**Myoc**	**Myve**	**Myyu**	**Nyfe**	**Nyma**	**Pahe**	**Tabr**	**Social**	**55-65kHz**	**Site Total**	**Status**
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 1																								
A		1	3								1									6			11	
N																							0	ok
II																				1			1	ok
C																							0	ok
K			2				1				1									1			5	ok
LL		2	1				1														7		11	
SCNE																							0	ok
SCNW																							0	ok
SCSW		5	5																	2			12	ok
PumpSta		2	28	2			5		1											7			45	
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 2																								
A		2	11				3													1			17	
N		2	9				2				2									2			17	
II			5				1													6			12	ok
C																							0	ok
K		4	7				1													1			13	
LL		1	3																	1			5	
SCNE		1	5																	1			7	
SCNW																							0	ok
SCSW																							0	ok
PumpSta			26				12													5	2		45	

Legend: Saltcedar Mesquite Sapling Cottonwood Water

Table A2.—Quarterly summary of bat minutes recorded simultaneously at Beal, first and second samples, April and July 2010

Apr 2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Myyu	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 1																								
A		2					10													16			28	
N		8	1				2								1				1	9			22	
II		7	6				3							1	1				1	2			21	
C	1	2					1				1				2					11			18	
K		6	1																1	7			15	
LL																							0	No data
SCNE	1	8					3							1	3					9			25	
SCNW	1						4						1		1					13			19	
SCSW		2	6				6				3				1					10			28	
Beal Pump			5				85										1			18			109	
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 2																								
A		1	1				9								2				6	8			27	
N		2	6				4												4	4			20	
II		7	6				3							1	1				1	2			21	
C			6				8		1						3				6	3			27	
K	1	3	4				8		3										3	4			26	
LL		2	5				6							1	1				4	2			21	
SCNE			1			2	4	1						1	1					4			14	
SCNW		4					5										1			1			11	
SCSW		6	8				5				1				1				3				24	
Beal Pump		1	4				101								2				20	2			130	

July 2010		19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Myyu	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 1																								
A			26	13	1	1	34	1		2					6				94				178	
N			13	5		2	12		1						4				89				126	
II			15	8	1	1	16		4						2				87				134	
C			25	17		3	31	1	1						18				111				207	
K			30	21	2	6	38			4		3		1	67				73				245	
LL		10	12		1	4	21		5						10				79				142	
SCNE			5		8	3	24		1					2	11				58				112	
SCNW		1	23	8	2	3	24		5				1		2				101	1			171	
SCSW			16	1	1		14		2					1	3				101	1			140	
Beal Lake Habitat Restoration Post Development Bat Monitoring FY 2010 Sample 2																								
A			13	1			13								2				67				96	
N		1	9	7		1	26								3				93				140	
II			4	7		1	12		1					1	3				91				120	
C			10	27		2	25								14				113				191	
K			15	16		7	37			5		2		3	56				75				216	
LL			5	26		9	38								22				114			1	215	
SCNE			24	11	3	2	44								10				113				207	
SCNW																							0	malfx
SCSW			5	6			17		2				1		2				79				112	

Legend: Saltcedar (red), Mesquite (orange), Sapling Cottonwood (purple), Water (blue)

Table A3. Quarterly summary of bat minutes recorded for nine monitoring sites at CRIT, first and second samples, October 2009 and February 2010

October 2009	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Anpa	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc
COLORADO RIVER INDIAN TRIBE 2010 SAMPLE 1															
AMCW			4	2			54			1	5			1	
CMCW		1	11				96				8			3	
EMCW		2	7	1			17				3			2	
BSM		1		2			16								
DHM			20	6	3		3								
EHM		1	13	1			10				1			2	
FNYCW		2	4				39				12				
FSYCW			6	1			16						1		
GYCW			10	1			31			1	8		3		
COLORADO RIVER INDIAN TRIBE 2010 SAMPLE 2															
AMCW							30				8			1	
CMCW		1	5				77				5			2	
EMCW															
BSM		3	4	1			13								
DHM		1	23	3			38							1	
EHM			9				9			1					
FNYCW		3	2				12				13				
FSYCW		5	6				21							1	
GYCW		1					5				8				

February 2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Anpa	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc
COLORADO RIVER INDIAN TRIBE 2010 SAMPLE 1															
AMCW							1			2	13				
CMCW							1			1					
EMCW											1				
BSM															
DHM															
EHM															
FNYCW							2				4				
FSYCW							32				9				
GYCW															
COLORADO RIVER INDIAN TRIBE 2010 SAMPLE 2															
AMCW							9			5	26				
CMCW		1	1				18				5				
EMCW			1							2					
BSM															
DHM		1								8					
EHM		1								1	1				
FNYCW			1				3			1	4				
FSYCW			1							2					
GYCW										1	2				

Legend: Intermediate Cottonwood (green); Mesquite (orange); Sapling Cottonwood (purple). Apr & Jul not sampled at Tribes' request.

Table A4.—Quarterly summary of bat minutes recorded simultaneously in nine monitoring sites at PVER, first and second samples, October 2009 and February 2010

Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 1																							
Oct 2009		19-24kHz	24-30Khz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Anpa	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyma	Nyfe	Pahe	Tabr	Social	Site Total	Status
2NW			1	1			9											2	25	1		39	ok
2SE		3	19	15	6		4				1		16		1			3	49	9		126	
NUR2		1	13	43	29	1	62	1		2	19	2	4	5		4		17	51			254	
7		5	2	1			218							9				7	73	2		317	
8			1	1			180			1								16	75	6		280	
9		3	5	2			119						1	5			1	53	48	9		246	
SCN				3	3		36										1	13	56	2		114	
SCM		1	1	3			23				1							13	62	3		107	
SCS			7				2			1	1			1				6	65	1		84	
RIV2		3	42	30	3		42			1	1		3					15	65	2		207	
Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 2																							
2NW			2	3			7							10					35			57	ok
2SE		2	15	39	22	1	4				2		29			1		12	51	1		179	
NUR		2	18	34	40		60				61		7	3		1		12	67		3	308	
7		2	9	1			130			1				2				17	55	5		222	
8		1	13	2			188							2				12	48	12		278	
9		1	9	2			48							5		2		20	41	8		136	
SCN		1	3	1	1		21											12	37	1		77	ok
SCM			4	3	1		15				1					1		13	50	1		89	
SCS			13	2			2				5		1					13	69	6		111	
RIV2		13	52	38	5	1	22				5		17					49	66	22		290	

Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 1																							
Feb 2010		19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45-kHz	45-55kHz	Anpa	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyma	Nyfe	Pahe	Tabr	Social	Site Total	Status
2NW							6			1	5	1						6		2		21	
2SE			2															2				4	
NUR							1				27									1		29	
7			2				43											7	13			65	
8							19											2				21	
9							17											1		1		19	
SCN							1			1									1	1		4	
SCM							6															6	
SCS			15				8											4				27	
Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 2																							
2NW										2	3							3	1	2		11	
2SE																		1		1		2	
NUR							1				5							2		3		11	
7			1				48											1	1	2		53	
8							17							1				3		1		22	
9							27			1								1	12			41	
SCN							7												2	4		13	
SCM			2				2											1		1		6	
SCS		8	4				8							2				4	1	11	7	45	

Legend:												
	(yellow)	Agriculture	(red)	Saltcedar	(green)	Intermed Cottonwood	(purple)	Sapling Cottonwood	(blue)	Water		

Table A5.—Quarterly summary of bat minutes recorded simultaneously at 15 monitoring sites at PVER, first and second samples, April and July 2010

Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 1																							
Apr 2010	**15-19kHz**	**19-24kHz**	**24-30kHz**	**30-35kHz**	**35-40kHz**	**40-45-kHz**	**45-55kHz**	**Anpa**	**Coto**	**Eupe**	**Labl**	**Laci**	**Laxa**	**Maca**	**Myoc**	**Myve**	**Nyma**	**Nyfe**	**Pahe**	**Tabr**	**Social**	**Site Total**	**Status**
2SW			**2**	**1**			**13**				**2**					**1**		**6**	**9**	**1**		**35**	
Nur2			**5**	**4**			**20**			**1**	**15**	**1**		**1**				**3**	**7**	**1**		**58**	
NurNE			**3**	**3**	**1**		**19**		**1**		**4**		**2**					**4**	**6**	**2**		**45**	
2SE																						0	not sampled
3N			2	3			1											5	8	2		21	
4		1	4		2		1				1	1						2	4	3		19	
7		1	3	1			104				2			1	1			1	8	2		124	
8			4	2	1		80												14	3		104	
9		1	4				32												16			53	
MQW																							not deployed
SCN		1	4	3			19			1						1			17			46	
SCMid																						0	malfx*
SCS			4	1			17				1								10	2		35	
Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 2																							
2SW			**3**	**1**	**1**		**34**				**2**		**1**	**2**	**1**			**1**	**7**			**53**	
Nur2		**1**	**11**	**3**	**1**		**20**				**8**		**1**	**1**		**1**		**4**	**20**			**71**	
NurNE		**1**	**5**	**6**	**1**		**30**			**1**	**5**							**4**	**8**			**61**	
2SE			5	3		1								1	1	1		3	7			22	
3N		1		1			3				1								7			13	
4			10	6			14								1				5	2		38	
7			4	2			97											1	19			123	
8			3	2			85									1		2	16			109	
9		1	3			1	34			1			1	1				5	44	1		92	
MQW			1				3							1					5	1		11	malfx*
SCN			4	1			29							1				3	52	2		92	
SCMid																						0	malfx*
SCS		1	9				9												9		1	29	

Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 1																							
July 2010	**15-19kHz**	**19-24kHz**	**24-30kHz**	**30-35kHz**	**35-40kHz**	**40-45-kHz**	**45-55kHz**	**Anpa**	**Coto**	**Eupe**	**Labl**	**Laci**	**Laxa**	**Maca**	**Myoc**	**Myve**	**Nyma**	**Nyfe**	**Pahe**	**Tabr**	**Social**	**Site Total**	**Status**
2SW		**1**	**194**	**109**	6	3	157		3	5	1		**1**	**6**	**27**	**128**		**4**	**75**			**720**	
Nur2	**1**	**22**	**58**	**99**	1	13	156		1	5	6		**3**	**1**	**2**	**196**		**12**	**74**			**650**	
NurNE		**25**	**136**	**328**	21	28	226			7	3	1	**33**	**2**	**43**	**138**	**1**	**18**	**91**			**1101**	
2SE		15	113	47	8	7	42			10	1		3	2	2	40		15	137			442	
3N																							malfx*
4		7	32	89	16	28	104	1		6	4		19	5	32	172		12	80			607	
MesqN																						0	malfx*
MesqNur		27	116	22	3		38			18			3		1	7		107	125			467	
MesqW		2	51	26	4	2	50			23			2		9	8		11	109			297	
7		4	103	19	2	1	85			6			1	1	1	30		13	259	3		528	
8		4	44	22	3	3	142		1	2		1	9	1		60		5	207	3	1	508	
9		2	47	24		1	67			1			2		2	12	1	6	169	3		337	
SCMid																						0	malfx*
SCN			27	12			42			2		1	1		3	5		17	143			253	
SCS		1	117	69	4	30	73			1				1		30			81	1		408	
Palo Verde Ecological Reserve Post Development Bat Monitoring Sample Period 2																							
2SW		**2**	**77**	**98**	16	22	109		1	1			**1**	**3**	**44**	**72**		**2**	**110**			**558**	
Nur2		**2**	**20**	**44**	2	4	91			29	2		**4**	**1**	**2**	**143**		**4**	**135**			**483**	
NurNE		**1**	**277**	**195**	5	6	175			9	4		**11**	**1**	**1**	**90**		**3**	**517**	**2**		**1297**	
2SE			82	32	5	6	35			3			6	2	5	47	4	11	177			415	
3N																						0	malfx*
4			20	18	15	5	59	4		1	14			1	4	44		3	77			265	
MesqN																						0	malfx*
MesqNursery		7	86	24	2		27			15	3		4		2	5		60	149	1		385	
MesqW		3	21	25	6	3	48			9					3	7		7	119			251	
7			95	21	2	2	64		1	7			6	1		17		1	344	1		562	
8		1	49	44	1	2	95			6			3		1	15		3	257	2		479	
9		3	56	17	2	1	48			1			2			5	1	4	199	1		340	
SCMid		2	131	45	2	2	54			2			5	3	1	19		11	268	2		547	
SCN			25	8		2	40			4			2		3	7		17	159	3		270	
SCS	1		203	56	4	5	19						10	1		14		1	57			371	

Legend: Agriculture (yellow), Saltcedar (red), Intermed Cottonwood (green), Sapling Cottonwood (purple), Water (blue)

*Internal batteries were beginning to die in the detectors -- no warning.

Table A6.—Quarterly summary of bat minutes recorded simultaneously at five monitoring sites at CVCA, first and second samples, October 2009 and February 2010

October 2009	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Cibola Valley Conservation Area Post Development Bat Monitoring FY 2010 Sample 1																							
3F4		3	16	2	3		21		17	2		1				43		34	1			143	
A		4	62	12			15		2							16		42	4			157	
D	1		15	3			32		3	2			1			7		6				70	
Wat 1		1					4		10							9		20				44	
Wat 2							10		5	1						8		28				52	
Cibola Valley Conservation Area Post Development Bat Monitoring FY 2010 Sample 2																							
3F4		4	62	12			15		2	1						15		42	4			157	
A		2	22	1			15		1	3						7		24	9			84	
D							42			2						2		14				60	
Wat 1							11		1							2		38				52	
Wat 2			2				27				1					3		44	2			79	

February 2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	65kHz	Site Total	Status
Cibola Valley Conservation Area Post Development Bat Monitoring FY 2009 Sample 1																							
3F4			2				1															3	
A							5			11			1									17	
D																						0	malfx
Wat1																						0	ok
Wat 2																						0	ok
Cibola Valley Conservation Area Post Development Bat Monitoring FY 2009 Sample 2																							
3F4							4			6												10	
A							5			21												26	
D																						0	malfx
Wat 1													2									2	ok
Wat 2							61						13									74	

Legend: Agriculture (yellow) | Sapling Cottonwood (purple)

Table A7.—Quarterly summary of bat minutes recorded for 9 to 12 monitoring sites at the CVCA, first and second samples, April and July 2010

April	Cibola Valley Conservation Area Post Development Bat Monitoring FY 2010 Sample 1																					
2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	65kHz	Site Total	Status
A-1							131															131	
D-2							1															1	ok
B		1	2	1	1	1	49			37		2							3			97	
2F9			1				4		1	3												9	
3F4																						0	ok
3F7			1				25															26	
3F9																						0	ok
4F2E							2															2	ok
4F2W							2															2	ok
Wat 1							2															2	ok
Wat 3																						0	ok
Wat 4																						0	ok
	Cibola Valley Conservation Area Post Development Bat Monitoring FY 2010 Sample 2																						
A-1							4			4												8	ok
D-2							1															1	ok
B						1			1	8									1			11	ok
2F9							5		2													7	
3F4																						0	ok
3F7							25			1												26	ok
3F9																						0	ok
4F2E																			1			1	ok
4F2W							1												1			2	ok
Wat 1																						0	ok
Wat 3							1												1			2	
Wat 4							2			1									1			4	

July	Cibola Valley Conservation Area Post Development Bat Monitoring FY 2009 Sample 1																					
2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	65kHz	Site Total	Status
A-1			39	104	20	7	168		1	3		5	1	28	41			95				512	
D-2			17	61	3	11	93							4	30			49		1		269	
B	1		88	256	28	53	329	3		41		4	21	57	51			125		3		1060	
2F9				62	3		71		1	9		3			8			78	1	2		238	
3F4			45	311	42	22	116			1			5	23	16			88		6		675	
3F7		1	79	303	23	19	182					6	1	8	22	3		89		1		737	
Wat 1				22	19	2	111		1	1		1			1			159		1		318	
Wat 3			33	6	2		41		2								1	129				214	
Wat 4			8	30	3		50		5			2			4			60				162	
	Cibola Valley Conservation Area Post Development Bat Monitoring FY 2009 Sample 2																						
A-1			45	109	12	14	210		2	3		5		37	55			95			1	588	
D-2			56	65	6	3	114			1		1	4	11	37			80			4	382	
B	2		95	244	21	50	312	2	2	34		25	16	16	80			115			2	1016	
2F9			33	17	1		87		1	3		2		2	11			71				228	
3F4			25	178	15	32	94						1	4	51			97			3	500	
3F7			54	242	6	39	199			1		1	4	4	50	2		93			4	699	
Wat 1			38	21		4	112							1	2	1		117			1	297	
Wat 3			19	4	1		38							1		2		122				187	
Wat 4			10	26			35								4			70				145	

Legend: Agriculture (yellow), Sapling Cottonwood (purple), Intermed. Cottonwood (green), Mesquite (orange)

Table A8.—Quarterly summary of bat minutes recorded for seven monitoring sites at CNWR #1, first and second samples, October 2009 and February 2010

October	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2009 Sample 1																						
2009	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Ag		2	5	1			411		12				5		17			48	5			506	
MQ2			12				46		7	6			7		4			9	9			100	
MQ4			6	1			101		1				3		1			10				123	
MQ3			2				16		3	1		1	1		9			11	2			46	
CWN			2				17		1									4				24	
CWMid							13		2			1	1		1			2	1			21	
CWS							51						5									56	
	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2009 Sample 2																						
Ag		8	33	3		1	412		7	1			3			12		64	16			560	
MQ3		2	9				59		2	1			1			7		19	11			111	
MQ2			3	3			213						1			2		20				242	
MQ4		1	13				52		1				2			3		9	4			85	
CWN			3				31				1		1			1		2	1			40	
CWMid		1	4				7											16				28	
CWS							30						1									31	

February	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 1																						
2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
Ag							2															2	
MQMid																						0	ok
MQE							4															4	
MQW			4																			4	
CWN							1		2													3	
CWMid																						0	ok
CWS	1	2	4	2			7													45		61	wild social ca
	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 2																						
Ag							17															17	
MesqMid			1																			1	
MesqE			1				3															4	
MesqW		3	6	1			11															21	
CWN																						0	ok
CWMid																						0	ok
CWS	1	1	3	1			24		1											70		101	social calls w

Legend		Agriculture		Mesquite		Intermediate Cottonwood

Table A9.—Quarterly summary of bat minutes recorded for nine monitoring sites at CNWR #1, first and second samples, April and July 2010

April	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 1																						
2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
MQMid			21	1			15											3				40	
MQCrane		1	13	2			25		1		1							16	3			62	
MQW		1	54	5			60		13									20	2			155	
CWN			2				23											3				28	
CWMid			5	1			14											10				30	
CWS			80				97											10				187	
CWCrane																							not sampled
YCWE			2		1		9		1									4				17	
YCWW			2		1		9		1									4				17	
YCWMass			56				64			20								9				149	
	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 2																						
MQMid	1		33	4			28				2							3				71	
MQCrane		1	28	3			17		2	1	3					1		11				67	
MQW		3	61	23			50		18							1		10				166	
CWN			3				10											3				16	
CWMid	1		33	4			28				2							3				71	
CWS			200	6			121											24				351	
CWCrane			16				5		2							1		2				26	
YCWE			5				7		2							1						15	
YCWW			7				5			1						1		1				15	
YCWMass			56				32			19		1						1				109	

July	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 1																						
2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Total	Status
MQMid																						0	malfx
MQW	1		7	25	1	1	171							1		2		18				227	
MQCrane			35	19		1	44			5								106			1	211	
CWN			88	85	14		291	1	2	1			4	2	2			56			2	548	
CWMid			121	31			18							2				97				269	
CWS		2	11	150	65		209		1			1	13	14		3		5			1	475	
YCWE			20	13	0		42											90			4	169	
YCWW			11	18	1		51											89			3	173	
YCWMass			72	296	7	3	229		1			1	17		2			142			35	805	
	Cibola NWR Conservation Unit #1 Post Development Bat Monitoring FY 2010 Sample 2																						
MesqMid			13	18			23											111				165	
MesqW			3	15	1		51											59		2		131	
MQCrane			37	11			32		2									122				204	
CWN			107	115	8	10	144						2		15	1		74				476	
CWMid			104				7											158				269	
CWS			27	115	29	2	287						3	13	2			13				491	
YCWE			18	12			54											92	1			177	
YCWW			8	22		1	91						3			1		99	8			233	
YCWMass			67	260	11	7	210			1		2	3	4	29	1		159	9			763	

Legend							
Legend	(orange)	Mesquite	(green)	Intermediate Cottonwood		(purple)	Sapling Cottonwood

Table A10.—Quarterly summary of bat minutes recorded in 6 monitoring sites and 1 exploratory site at IPCA, first and second samples, October 2009 and February 2010

October 2009	Imperial Ponds Conservation Area Post Development Bat Monitoring 2010 Sample 1																						
	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40Khz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Totals	Status
F1			15				30									1		74	2			122	
F24		1	5	1			38									9		98	9			161	
Impen1		1					11									1		9	2			24	
F29	1		18				53											33	1			106	
SCDock		1	11				96		1				1			10		86	6		1	213	
SCN																						0	Malfx
Pond1A		1	36				68		1							9		85	3			203	
	Imperial Ponds Conservation Area Post Development Bat Monitoring 2010 Sample 2																						
F1			16				34		1							6		74	3			134	
F24			9	1			112									10		86	14			232	
Impen1			2				13		1				1			2		19	1			39	
F29			14	2			74		1				1			10		77	16		1	196	
SCDock		1	11	2			94						2			37		83	10		1	241	
SCN																						0	Malfx
Pond1A		1	29				121									5		85	3			244	

February 2010	Imperial Ponds Conservation Area Post Development Bat Monitoring 2010 Sample 1																						
	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40Khz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Totals	Status
F1		1	4				19				1					2		1	22			50	
F24		1	38				20						1					2	4			66	
F29		10	41				12									1			1			65	
Impen1		4	54				13									1		2	3			77	
SCDock		6	54	1			21									1		2	3			88	
SCN		4	9				17									1		5	3			39	
				Imperial Ponds Conservation Area Post Development Bat Monitoring 2009 Sample 2																			
F1		5	30				149					1			1			3				189	
F24		3	42				105		1			1										152	
F29		10	40	3	1		99				1	7						1			3	165	
Impen1			25				123		1			10						1				160	
SCDock		7	58				42															107	
SCN		2	22				13				1											38	

Legend:			
Agriculture (yellow)	Saltcedar (red)	Intermed. Cottonwood (green)	Water (blue)

Table A11.—Quarterly summary of bat minutes recorded simultaneously in nine monitoring sites at IPCA, first and second samples, April and July 2010

April 2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Totals	Status
Imperial Ponds Conservation Area Post Development Bat Monitoring 2009 Sample 1																							
F1b						1	24			1						1		47	3			77	
F24			2				70		1	1	2					2		60	3			141	
F29		3	3	2	1		48				1			1		1		46				106	
Impen1			5				19							5				20				49	
F15Mesq		1	2		1		92		1	1			1			2		52	4			157	
F19Mesq		2	1				57			2						2		44	5			113	
F22Mesq																						0	malfx
SCDock			1				81		1				2			2		40				127	
SCN			1	1			58				1					2		51				114	
Imperial Ponds Conservation Area Post Development Bat Monitoring 2009 Sample 2																							
F1b																						0	malfx
F24		1	2				79		1									21	1			105	
F29		1	2				47					1	1					12				64	
Impen1		1	2	1			26						1	2				1				34	
F15Mesq		3	13	2			112		1							2		21				154	
F19Mesq							51				1					3		25	3			83	
F22Mesq																						0	malfx
SCDock		1	2				111		1				9					25	1			150	
SCN		1	1				26									1		7	1			37	

July 2010	15-19kHz	19-24kHz	24-30kHz	30-35kHz	35-40kHz	40-45kHz	45-55kHz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	55-65kHz	Site Totals	Status
Imperial Ponds Conservation Area Post Development Bat Monitoring 2010 Sample 1																							
F1b		1	7	5			72									1		228				314	
F24		3	56	38	1	1	198		7		2		1	2	1	1		238	6		1	556	
F29		6	49	35	1		128		9					14		6		225	2			475	
Impen1		7	31	44	1		22						1					16				122	ok
F15Mesq		1	61	37	2	1	244		10			1	22			1		206			1	587	
F19Mesq			246	177	7	1	103		14			2	2			4		231	6			793	
F22Mesq		5	33	14			74		19	1		1	1					152			2	302	
SCDock	1		34	52	2	1	174	1					12	2		1		160			7	447	
SCN			38	27	1		82		1					1		3		138				291	
Imperial Ponds Conservation Area Post Development Bat Monitoring 2010 Sample 2																							
F1b			16	5			59						2					211				293	
F24			44	12			355		7				1			1		261			8	689	
F29		1	123	74	12	1	244		6	1		1		23		4		295	1			786	
Impen1		1	146	137	9	1	62						1					23				380	
F15Mesq		2	65	41	3		143		5			4	9	4				224				500	
F19Mesq		2	273	205	16	1	154		41	2		13	1	9				224	1		4	946	
F22Mesq		1	39	12			58		5	1		2	5			1		171				295	
SCDock			25	21	1	1	141						8	2				215			3	417	
SCN			35	20			67							2		1		191				316	

Legend: Agriculture (yellow), Saltcedar (red), Intermed. Cottonwood (green), Mesquite (orange)

Table A12.—Quarterly summary of bat minutes recorded simultaneously in three monitoring sites at Pratt, first and second samples, all quarters

October 2009	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 1																				
	19-24kHz	25-30Khz	30-35kHz	35-40kHz	40-45kHz	45-55Khz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	Site Total	Status
AG	3	9				24									3		30	8		77	
E		5	2			16		1							1		26	4		55	
SC																				0	malfx
	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 2																				
AG	2	24	1			21							1		2		27	3		81	
E	10	14	3		24												16	1		68	
SC																				0	malfx

February 2010	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 1																				
	19-24kHz	24-30Khz	30-35kHz	35-40kHz	40-45kHz	45-55Khz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	Site Total	Status
AG	5	14			1			1										2	27	50	
E																				0	not sampled
SC	1	9				2														12	
	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 2																				
AG	2	3				2													9	16	
E		16				1												1		18	
SC	4	4		1		3													2	14	

April 2010	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 1																				
	19-24kHz	24-30Khz	30-35kHz	35-40kHz	40-45kHz	45-55Khz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	Site Total	Status
AG		5		1		37			4	3					9		10	4		73	
E	4	14	2			47		1	2	1	1		1		3		16	7		99	
SC	1	4				31		6	3						5		20	1		71	
	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 2																				
AG	2	5				32		1							2		15			57	
E	6	15	1			39		1	1	1					4		16	11	6	101	
SC		4				23		11	2						2		13	9		64	

July 2010	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 1																				
	19-24kHz	24-30Khz	30-35kHz	35-40kHz	40-45kHz	45-55Khz	Coto	Eupe	Labl	Laci	Laxa	Maca	Myoc	Myve	Nyfe	Nyma	Pahe	Tabr	Social	Site Total	Status
AG		14	7	1		154		1									148			325	
E		50	45	4		299					1	1	2		1		152	1		556	
SC		5	9			87		2			1	1			3		116	3	1	228	
	Pratt Restoration Post Development Bat Monitoring FY 2010 Sample 2																				
AG		21	18	2		131		1									160			333	
E	2	28	26	3		207		3			2				6		102	3		382	
SC		39	6			116		1			1	2			3		86	2		256	

Legend: Agriculture (yellow), Intermed Cottonwood (green), Saltcedar (red)