Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Post-Development Bat Monitoring of Habitat Creation Areas along the Lower Colorado River – 2010 Capture Surveys

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

March 2012

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Lower Colorado River Multi-Species Conservation Program

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ACRONYMS AND ABBREVIATIONS

‘Ahakhav	‘Ahakhav Tribal Preserve
BWRNWR	Bill Williams River National Wildlife Refuge
CNTR	Cibola National Wildlife Refuge Nature Trail
CRIT	Colorado River Indian Tribe
CVCA	Cibola Valley Conservation and Wildlife Area
ft	foot/feet
ha	hectare(s)
HCA	habitat creation area
in	inch(es)
km	kilometer(s)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
mi	mile(s)
mm	millimeter(s)
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation

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ABSTRACT

This was the fourth year of bat capture surveys within habitat creation areas (HCAs) for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). There are two covered and two evaluation bat species listed under the program. The western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) are both tree-roosting species, and the California leaf-nosed bat (*Macrotus californicus*) and Townsend's big-eared bat (*Corynorhinus townsendii*) are both mine- and cave-roosting species that utilize riparian areas as foraging habitat. Five sites were surveyed in 2010, one of which was a natural riparian area along the Bill Williams River, as a comparison to the HCAs. One HCA was only surveyed during the winter season. The other three HCAs were surveyed along with the natural site once a month from May through September. A total of 709 bats of 13 species were captured during the summer survey period. Species richness was similar across sites, but species diversity was higher at the natural site compared to the HCAs. This was mainly due to the big brown bat (*Eptesicus fuscus*) that dominated captures at the HCAs. The Townsend's big-eared bat was only captured at the natural site, and the California leaf-nosed bat was captured at the natural site and at two HCAs. Red and yellow bats were captured at two of the HCAs, but not at the natural area, and winter activity of red bats was confirmed at two sites. It is thought that as HCAs mature, species diversity will become more similar to natural areas. Surveys will continue in 2011 at four HCAs, and data will be compiled with previous years to give better recommendations for HCAs for LCR MSCP bat species.

INTRODUCTION

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

The western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) are covered species under the program. The California leaf-nosed bat (*Macrotus californicus*) and Townsend's big-eared bat (*Corynorhinus townsendii*) are evaluation species under the program. The LCR MSCP uses a variety of methods to monitor covered bat species in these habitat creation areas (HCAs). In the fall of 2006, a post-development bat survey using acoustic bat detectors was initiated by the Bureau of Reclamation, Denver Technical Service Center (Broderick 2008). During these acoustic surveys in July and October 2007, a preliminary capture survey began at three of the locations in which acoustic data had been collected (Calvert 2009). In September, a fourth site was surveyed in which only exploratory acoustic work had been done. In 2008, a full-season capture survey was conducted. The survey protocol was refined in 2009, and surveys continued in 2010. Riparian HCAs along the LCR have only minimally been surveyed for bats in the past (Brown 2006). This new survey is an attempt to increase effort and thus increase the capture of bats to discover whether LCR MSCP covered species are utilizing HCAs.

There are a variety of reasons why bat surveys should include both acoustic and capture techniques. Not all species are successfully surveyed using only one of the two methods (O'Farrell and Gannon 1999). Species such as Townsend's big-eared bats and California leaf-nosed bats are known to echolocate at low intensities, which are often missed using acoustic detectors. If there is a species identification question using acoustic data, then captures may confirm the presence of a species. Capturing bats allows for acoustic voucher calls to be made when releasing bats near a bat detector so that additional calls can be included in the reference call library, which allows easier identification of species recorded using bat detectors. The design of future HCAs may also be aided by capturing bats. The location of mist-nets at current sites may allow a better understanding of how bats use riparian areas. Acoustic data show that most bats avoid cluttered areas and forage along edges of riparian forests, in corridors, and in openings in forest canopies that create "flyways" for bats (Broderick 2008).

Capture techniques may allow for more refined specifications on how to create corridors and flyways in future sites. This will allow bats to use a larger area of these sites as well as allow biologists to more easily find locations to capture bats during future surveys.

STUDY AREAS

Palo Verde Ecological Reserve

The Palo Verde Ecological Reserve (PVER) is a large-scale LCR MSCP project approximately 6 miles (mi) (10 kilometers [km]) north of Blythe, California. Habitat is being created by replacing cultivated crops with native riparian plant species on agricultural fields, utilizing existing irrigation infrastructure. In the last 5 years, over 500 acres (202 ha) of habitat were created. Species that were planted included: Fremont cottonwood, Goodding's willow (*Salix gooddingii*), coyote willow (*Salix exigua*), honey mesquite, mule-fat (*Baccharis salicifolia*), desert broom (*Baccharis sarothroides*), and quailbush (*Atriplex lentiformis*). Most of the habitat is dominated by cottonwood and willow trees, including the area where surveys were conducted.

Cibola Valley Conservation and Wildlife Area

The Cibola Valley Conservation and Wildlife Area (CVCA) is just over 2 mi (3 km) north of Cibola, Arizona, and is also a large-scale LCR MSCP project. The habitat is being developed in the same way and with the same species as PVER. In the last 4 years, over 500 acres (202 ha) of habitat were created. Once all phases have been planted, there will be over 1,000 acres (405 ha) of riparian habitat within CVCA. The capture survey area was an 86-acre (35-ha) section with cottonwood and willow that were planted in 2006.

Cibola National Wildlife Refuge Nature Trail

The Cibola National Wildlife Refuge Nature Trail (CNTR) is a 34-acre (13.8-ha) site located on the Cibola National Wildlife Refuge Unit 1 Conservation Area, 1 mi (1.6 km) south west of Cibola, Arizona (figure 1). Capture surveys took place in areas of the CNTR that were lined with tall cottonwood trees. Goodding's willow, mule-fat, screwbean mesquite (*Prosopis pubescens*), and honey mesquite are additional species found within the site.

Figure 1.—Bat capture survey areas.

Bill Williams River National Wildlife Refuge

The Bill Williams River National Wildlife Refuge (BWRNWR) is located approximately 12 mi (19 km) north east of Parker, Arizona. The Bill Williams River is a tributary of the Colorado River, flowing over 25 mi (40 km) from Alamo Dam west into Lake Havasu. The flow of water is controlled by releases from Alamo Dam, and at times the river can be intermittent, flowing underground in certain areas. High pulse flows are occasionally conducted when Alamo Reservoir is high. When possible, these flows are timed with when natural flooding would have taken place in order to mimic historic conditions to maintain riparian habitat. Because of this, the BWRNWR contains large areas dominated by native cottonwood and willow trees, usually with an understory of Tamarisk (*Tamarix* spp.) and native shrubs (*Baccharis* spp.). This area was selected for surveys in 2010 to compare bat captures at the HCAs to a more natural site.

‘Ahakhav Tribal Preserve

The ‘Ahakhav Tribal Preserve (‘Ahakhav) is a 150-acre (61-ha) site located 3 mi (5 km) south west of Parker, Arizona, on Colorado River Indian Tribe (CRIT) land (figure 1). This site consists of fields of cottonwood, willow, and mesquite planted as part of an agreement between the CRIT and the Bureau of Reclamation. The capture survey area was planted in 2001 and has the largest trees of the site. Cottonwood, Goodding’s willow, and coyote willow were planted in the area.

METHODS

Mist-netting was the only technique used to capture bats during the 2010 surveys. The number and size of mist-nets varied between sites depending on habitat. The optimum number of nets used at each site corresponded to what could be handled by the number of personnel available. Four net lengths were used, including 6-meter (m) (19.7-feet [ft]), 9-m (29.5-ft), 12-m (39.4-ft), and 18-m (60-ft) Avinet Inc., nets, which were all 2.6-m (8.5-ft) tall with a 38-millimeter (mm) (1.5-inch [in]) mesh size. High net setups were used at all of the sites. These high nets were constructed by stacking regular nets (8.5 ft [2.6 m] tall) on top of each other using poles in which a pulley system had been made to reach the higher stacked nets. The setup used three nets stacked on top of each other, known hereafter as a triple (figure 2). Depending on the width of the corridor, either 6-m, 9-m, 12-m, or 18-m-long nets were used in this system.

Figure 2.—Triple high net setup used at the BWRNWR.

Nets were set up at a site in areas where bats were most likely using as a flyway. Usually this involved natural corridors within a site or roadways and trails that divided areas of habitat, which created artificial corridors. Netting perpendicular to an edge was also attempted at one site (PVER). The size of the net or trap used was determined by the width of the corridor, maximizing the area where bats could be captured. In some areas where it appeared that one single net may be easily avoidable by a bat, nets were placed together to make avoidance of one of the nets by the bat less likely. Nets were set up in a V or L formation, where a bat might be funneled from one net into the other. These techniques have been used successfully by Bat Conservation International. The triple high net was used in corridors to capture bats that fly higher and where single nets are easily avoided.

During netting, two types of bat detectors were used in order to obtain reference calls of captured bats when released as well as to discover whether bat activity in the area was changing over the course of the evening. Bat detectors record the high frequency calls of bats, which are above the audible range of humans. Software was later used to analyze each call for species-specific characteristics such as frequency, length and slope. The Anabat SD-1 bat detector (Titley Electronics) was connected to an HP iPAQ pocket PC running AnaPocket software. The AR-125 bat detector (Binary Acoustics Technology), which records bat calls as full spectrum wav files, was tested in 2010, to determine if new analyzing software would improve species identification. It was connected

to a Samsung Q1 Ultra tablet PC running SPECTR Mobile software. These acoustic data were also used later on to determine whether any LCR MSCP covered species were in the survey area, but not captured.

Once a bat was captured, species, age, sex, and reproductive status were determined. Measurements such as forearm and ear length andwere also taken if it was necessary to identify species. If the species was one for which acoustic reference calls were needed, a small 1-in (2.5-centimeter) long glow stick was glued onto the ventral fur to be used as a light tag. Once the bat was released, it was followed with the bat detector until it flew too far to be recorded. All acoustic file names saved on the HP iPAQ or the Samsung Q1 Ultra were written on the data sheet for species confirmation and then added to the acoustic reference library.

Genetic sampling was also conducted on some captured bats if needed for future genetic studies or for species identification. If a species was found in a new locality, a voucher specimen may have been taken and deposited into an accredited museum. Genetic samples were taken from the wing using a 2-mm or 3-mm biopsy punch. All tissues were stored in 95 percent ethanol.

Surveys began at sunset and continued for 4.5 hours (weather permitting). Each site was surveyed once a month from May to September for a total of five survey sessions. If covered species were recorded acoustically during other times of the year, an exploratory survey was conducted. A minimum of one triple high setup was used at each site. These standardizations were taken from an unpublished protocol that was created using data from the 2007 and 2008 LCR MSCP bat surveys.

In 2010, total net hours of effort were calculated for each site. One 6-m net set for 1 hour equals 1 net hour of effort. If a total of one 6-m, one 9-m, and one 12-m net were set for 4.5 hours on a given night, a total of 20.25 net hours would be calculated. This allows better comparisons between sites when the total net effort varies.

Species diversity was calculated at each site using the Shannon-Weaver index (Krebs 1989 in Nur et. al 1999), using the formula:

$$H^2 = \sum_{i\,1}^{i\,s} = (p_i)(\ln p),\ I = 1, 2 \ldots S$$

where:

S = The number of species in a sample
H^2 = The species diversity index
p_i = The proportion of all birds detected belonging to the *i*th species

The index was then transformed using the formula $N_1 = e^H$. N_1 gives a value that expresses diversity in terms of species, giving a value that represents what the species richness (number of species detected) is when data are statistically transformed to represent even detection numbers for all species (Macarthur 1965 in Nur et al. 1999), which gives a more useful value to use for site comparison in the analysis.

RESULTS

See appendix 1 for a list of common and scientific names of all species captured.

Palo Verde Ecological Reserve

The year 2010 was the first year that capture surveys were conducted at PVER. Three triple high net sets and one single net set were used for each survey, for a total of 427.5 net hours of effort in 2010. Table 1 lists all species captured across months. The big brown bat (*Eptesicus fuscus*) was the most commonly captured species. Western red and western yellow bats were the only LCR MSCP species captured. The highest captures and species richness were found during the last three surveys (figure 3). While July had the highest capture rate, August had the highest species diversity (table 2).

Table 1.—Species captured at PVER for each survey month
(LCR MSCP species in bold)

Species	May	June	July	August	September	Total
Eptesicus fuscus	5	4	57	29	59	154
Myotis velifer	0	0	24	4	3	31
Myotis yumanensis	0	2	7	2	5	16
Lasiurus xanthinus	**4**	**1**	**1**	**6**	**0**	**12**
Antrozous pallidus	1	0	3	2	1	7
Lasiurus blossevillii	**0**	**0**	**0**	**2**	**1**	**3**
Myotis californicus	0	0	2	1	0	3
Nyctinomops femorosaccus	0	0	0	0	4	4
Tadarida brasiliensis	0	0	0	0	2	2
Unknown species	0	0	1	0	0	1
Total	10	7	95	46	75	233

Western yellow bats had an equal sex ratio, while all western red bats were males (table 3). Juvenile western yellow bats were found in July and August. Reproductive signs were found for two western yellow bats: a pregnant female captured in May and a scrotal male captured in August. The two western red bats captured in August were considered almost reproductive.

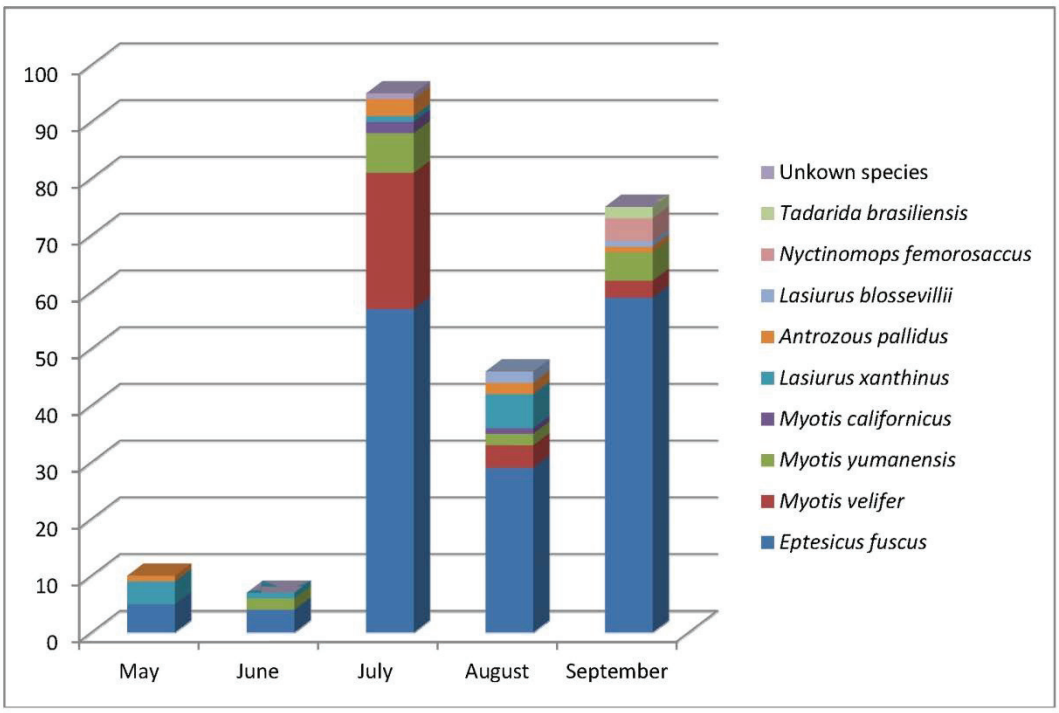

Figure 3.—Species composition for each survey month at PVER.

Table 2.—Transformed N_1 value of the Shannon-Weaver diversity index for each survey month at PVER

Month	Diversity index
May	2.57
June	2.60
July	2.96
August	3.53
September	2.38
All surveys	3.34

Table 3.—Sex and age ratios for LCR MSCP species for all months at PVER

Species	Sex (male:female)	Age (adult:juvenile)
Lasiurus xanthinus	6:6	10:2
Lasiurus blossevillii	3:0	3:0

Cibola Valley Conservation and Wildlife Area

This was the second year that capture surveys were conducted at CVCA. Two triple high net sets and one double high net set were used for the February survey, for a total of 57 net hours of effort. Three triple high net sets were used at each of the five summer surveys, for a total of 405 net hours of effort. Table 4 lists all species captured across months. The big brown bat was the most commonly captured species. The Townsend's big-eared bat was the only LCR MSCP species not captured. The highest captures and species richness were found during the last three surveys (figure 4). While July had the highest capture rate, May and August had the highest species diversity (table 5). Western yellow bats had an equal sex ratio, while all western red bats were males (table 6). All but one of the California leaf-nosed bats were females (table 6). A juvenile western yellow bat was found in May, and a reproductively active male was found in September.

Table 4.—Species captured at CVCA for each month (LCR MSCP species in bold)

Species	February	May	June	July	August	September	Total
Eptesicus fuscus	0	0	3	39	35	24	101
Myotis yumanensis	0	1	0	21	13	2	37
Myotis velifer	0	0	3	7	6	0	16
Myotis californicus	0	0	2	2	4	2	10
Antrozous pallidus	0	1	1	2	3	1	8
Macrotus californicus	4	0	0	0	0	0	4
Lasiurus xanthinus	0	1	0	0	1	2	4
Parastrellus hesperus	0	1	0	1	1	0	3
Lasiurus blossevillii	2	0	0	0	0	0	2
Myotis occultus	0	0	0	1	1	0	2
Unknown species	0	1	1	0	0	0	2
Total	6	5	10	73	64	31	189

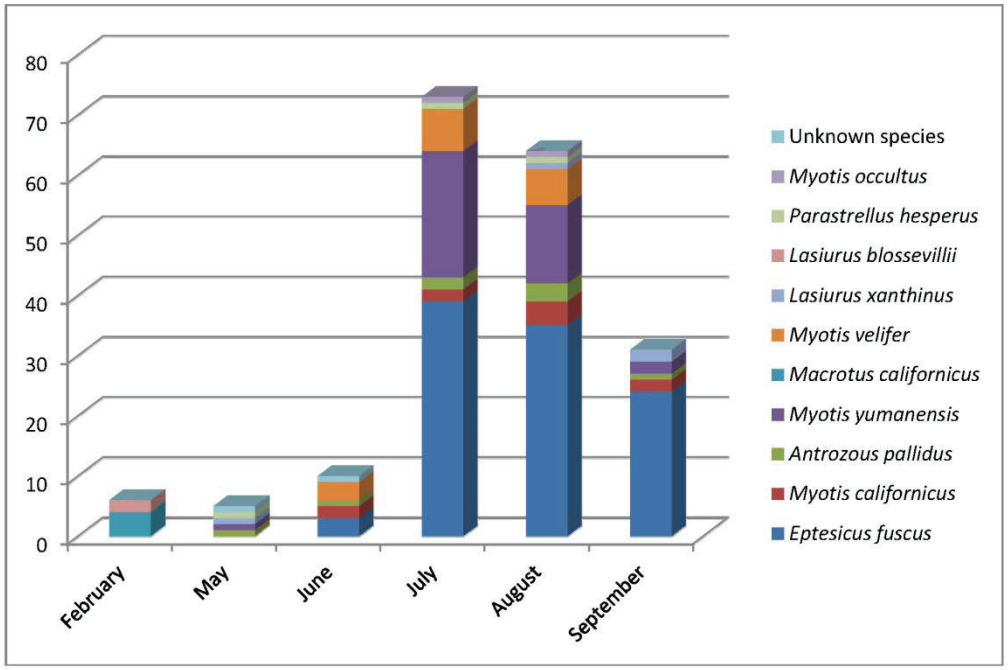

Figure 4.—Species composition for each survey month at CVCA.

Table 5.—Transformed N_1 value of the Shannon-Weaver diversity index for each survey month at CVCA

Month	Diversity Index
May	4.00
June	3.71
July	3.43
August	4.00
September	2.31
All surveys	3.91

Table 6.—Sex and age ratios for LCR MSCP species for all months at CVCA

Species	Sex (male:female)	Age (adult:juvenile)
Lasiurus xanthinus	2:2	3:1
Lasiurus blossevillii	2:0	2:0
Macrotus californicus	1:3	4:0

Between the 2 years of surveys, a total of 12 species have been captured (table 7). The big brown bat was the most common capture during both years of surveys. Two species captured in 2009 were not captured in 2010. One new species, the Arizona myotis (*Myotis occultus*) was captured in 2010. The western red bats captured in 2009 were captured during the late summer season, while both captures in 2010 were during the February survey (there was no survey in February 2009), though acoustic data did show them present during the summer. Species diversity increased from 3.29 in 2009 to 3.91 in 2010.

Table 7.—Comparison between the 2 years at CVCA (LCR MSCP species in bold)

Species	2009 N[1] = 5	2010 N = 6	All years N = 11
Eptesicus fuscus	86	101	187
Myotis californicus	2	10	12
Antrozous pallidus	9	8	17
Myotis yumanensis	7	37	44
Macrotus californicus	**1**	**4**	**5**
Tadarida brasiliensis	2	0	2
Myotis velifer	4	16	20
Lasiurus xanthinus	**5**	**4**	**9**
Lasiurus blossevillii	**3**	**2**	**5**
Lasiurus cinereus	1	0	1
Parastrellus hesperus	1	3	4
Myotis occultus	0	2	2
Total	121	187	302

[1] N = Number of survey nights.

Cibola National Wildlife Refuge Nature Trail

This was the fourth year that capture surveys were conducted at the CNTR. Three triple high net sets were used for each survey, for a total of 407 net hours of effort. Table 8 lists all species captured across months. The big brown bat was the most commonly captured species. The California leaf-nosed bat was the only LCR MSCP species captured. The highest captures and species richness were found during the July and August surveys (figure 5). While July had the highest capture rate, August had the highest species diversity (table 9).

Table 8.—Species captured at CNTR for each month (LCR MSCP species in bold)

Species	May	June	July	August	September	Total
Eptesicus fuscus	1	1	25	9	1	37
Myotis yumanensis	0	0	1	3	0	4
Myotis californicus	1	0	2	2	1	6
Myotis velifer	0	0	0	3	0	3
Macrotus californicus	**0**	**1**	**1**	**1**	**2**	**5**
Antrozous pallidus	0	4	0	3	0	7
Parastrellus hesperus	0	0	1	0	0	1
Total	2	6	30	21	4	63

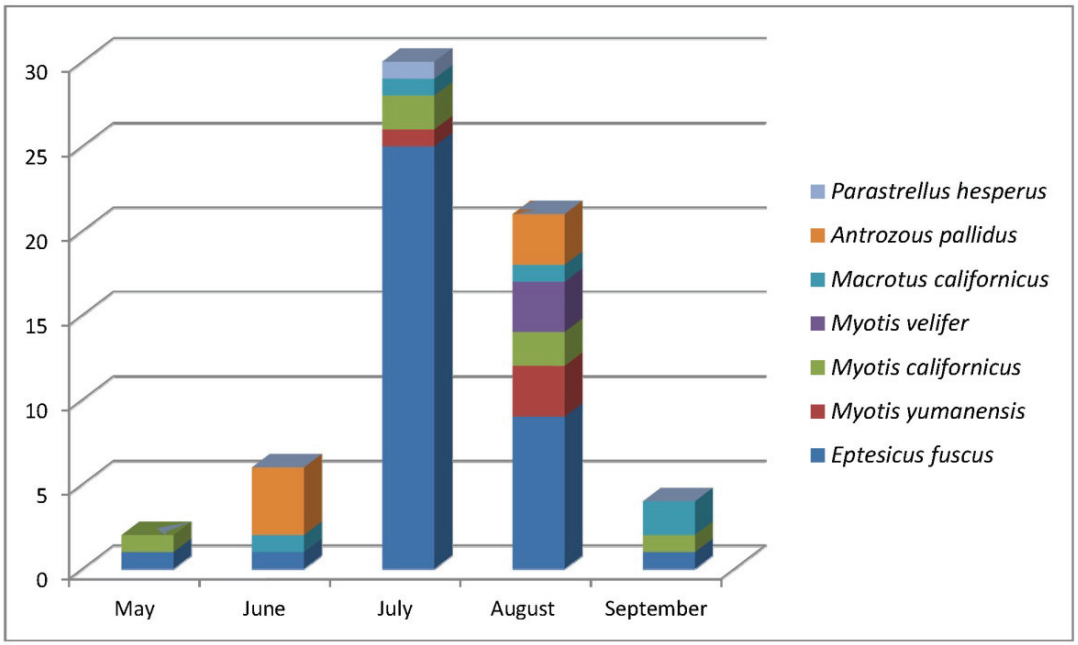

Figure 5.—Species composition for each survey month at CNTR.

Sex and age ratios for California leaf-nosed bats captured in 2010 can be found in table 10. The California leaf-nosed bat captured in June was a pregnant female; all others were non-reproductive.

Between the 4 years of surveys, a total of 10 species have been captured (table 11). Total captures decreased considerably compared to 2009, though rates were still higher than in 2007 and 2008. The cave myotis (*Myotis velifer*) and canyon bat (*Parastrellus hesperus*) were new species captured in 2010. Three

Table 9.—Transformed N_1 value of the Shannon-Weaver diversity index for each survey month at CNTR

Month	Diversity index
May	2
June	2.38
July	1.96
August	4.79
September	2.83
All surveys	3.93

Table 10.—Sex and age ratios for LCR MSCP species for all months at CNTR

Species	Sex (male:female)	Age (adult:juvenile)
Macrotus californicus	3:2	5:0

Table 11.—Comparison between all years at CNTR (LCR MSCP species in bold)

Species	2007 N = 2[1]	2008 N = 5	2009 N = 5	2010 N = 5	Total N = 17
Eptesicus fuscus	2	13	121	37	173
Myotis californicus	0	3	27	6	36
Antrozous pallidus	1	13	8	7	29
Macrotus californicus	14	4	4	5	27
Myotis yumanensis	1	0	4	4	9
Myotis velifer	0	0	0	3	3
Lasiurus cinereus	1	2	0	0	3
Lasiurus xanthinus	0	2	0	0	2
Tadarida brasiliensis	0	0	1	0	1
Parastrellus hesperus	0	0	0	1	1
Myotis species	0	0	1	0	1
Total	19	37	166	63	285

[1] N = Number of survey nights.

species, including the western yellow bat, that were captured in previous years were not captured in 2010. Species diversity increased from 2009, though 2008 was the highest diversity year (table 12).

Table 12.—Transformed N_1 value of the Shannon-Weaver diversity indices across years at the CNTR

Year	Diversity index	Species richness
2007	2.52	5
2008	4.46	6
2009	2.42	6
2010	3.93	7
All years	3.95	11

Bill Williams River National Wildlife Refuge

This was the first time that a capture survey had been conducted at the same location across the summer months within the BWRNWR. One triple high net set and 2–3 single net sets were used for each survey, for a total of 206.25 net hours of effort in 2010. Table 13 lists all species captured across months. During the May and June surveys, water was flowing through the netting corridor; by July, the flow had reduced so that the river was only flowing underground in that area. The California leaf-nosed bat was the most commonly captured species. The California leaf-nosed bat and Townsend's big-eared bat were the only LCR MSCP species captured. The highest captures and species richness were found during the June and July surveys (figure 6). While July had the highest capture rate, June had the highest species diversity (table 14). The Townsend's big-eared bat showed an equal sex ratio, while the California leaf-nosed bat had slightly more females than males captured (table 15). All of the Townsend's big-eared bats and most of the California leaf-nosed bats were adults. Eighteen of the California-leaf nosed bat females were pregnant, lactating, or post-lactating, including one that was captured carrying a juvenile pup. None of the Townsend's big-eared bats showed any reproductive signs.

During the surveys, 11 of the 53 total California leaf-nosed bats that were captured had been banded. Patricia Brown (personal communication) had been banding bats at the Californian Mine, just south of Parker Dam, on the California side of the river for over 40 years. Band numbers were recorded for 10 of the 11 bats. Seven of the bats had been banded on February 6, 2010. The other three had originally been banded on January 30, 2004, and had been recaptured by Patricia Brown when the others where banded in February 2010. The Californian Mine is approximately 6.3 mi from the capture site and is known to be a winter roost for California leaf-nosed bats, but only a small maternity colony exists

Table 13.—Species captured at the BWRNWR for each month
(LCR MSCP species in bold)

Species	May	June	July	August	September	Total
Macrotus californicus	**5**	**8**	**22**	**10**	**8**	**53**
Myotis yumanensis	3	15	27	1	2	48
Parastrellus hesperus	1	17	14	1	0	33
Eptesicus fuscus	0	10	13	3	0	26
Myotis velifer	9	4	9	2	0	24
Antrozous pallidus	3	8	9	2	2	24
Myotis californicus	2	10	3	0	0	15
Corynorhinus townsendii	**0**	**1**	**3**	**0**	**0**	**4**
Tadarida brasiliensis	0	2	0	0	0	2
Nyctinomops femorosaccus	0	0	0	0	1	1
Total	23	75	100	19	13	230

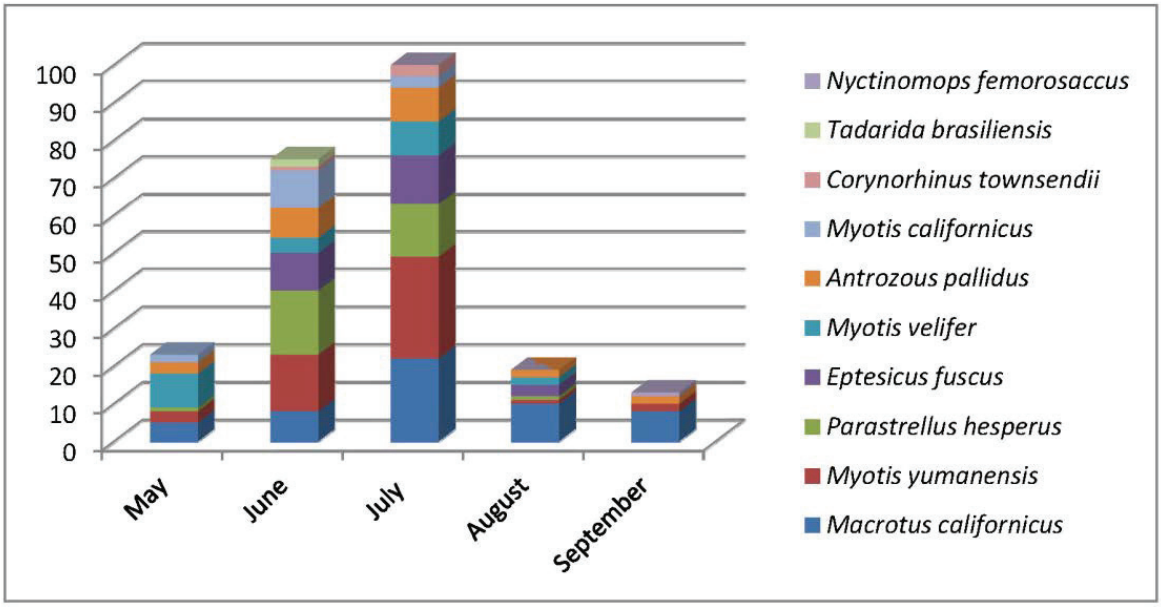

Figure 6.—Species composition for each survey month at BWRNWR.

during the summer season (figure 7). Larger maternity and bachelor colonies are known from the Planet Ranch area, which is less than 2 mi from the capture site and is likely the roosting area these bats came from.

Table 14.—Transformed N_1 value of the Shannon-Weaver diversity index for each survey month at BWRNWR

Month	Diversity index
May	4.85
June	7.27
July	6.49
August	4.11
September	2.92
All surveys	7.21

Table 15.—Sex and age ratios for LCR MSCP species for all months at BWRNWR

Species	Sex (male:female)	Age (adult:juvenile)
Macrotus californicus	19:30[1]	46:3[1]
Corynorhinus townsendii	2:2	4:0

[1] Four *Macrotus californicus* escaped before sex and age could be determined.

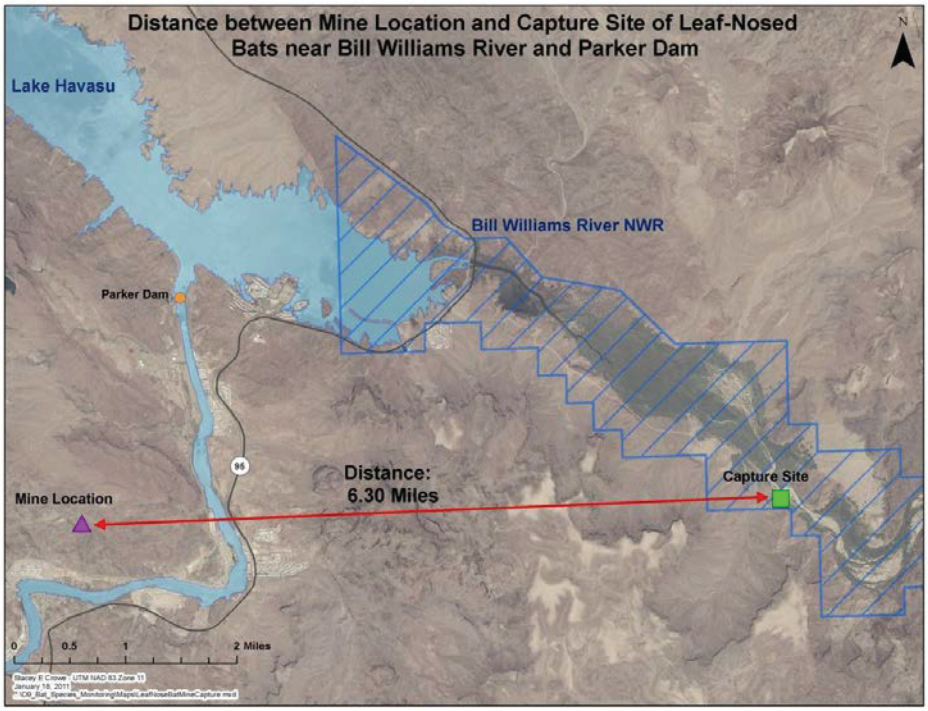

Figure 7.—Distance between the capture site and banding site of California leaf-nosed bats.

‘Ahakhav Tribal Preserve

The year 2010 was the fourth year that capture surveys were conducted at ‘Ahakhav. Only one survey was conducted in early February, making it the second year in a row that a winter season survey was conducted. Three triple high net sets were used for the survey, for a total of 58.5 net hours of effort. Table 16 lists all species captured across all years. The western red bat captured in 2010 was a nonreproductive adult male. This was the second western red bat captured during a winter survey. Additional surveys were not conducted due to issues with access.

Table 16.—Comparison between all years at ‘Ahakhav
(LCR MSCP species in bold)

Species	2007 N[1] = 2	2008 N = 5	2009 N = 6	2010 N = 1	Total N = 14
Antrozous pallidus	4	35	52	0	91
Eptesicus fuscus	0	9	35	0	44
Myotis yumanensis	4	12	23	1	40
Macrotus californicus	**1**	**4**	**13**	**0**	**18**
Myotis occultus	5	0	12	0	17
Lasiurus xanthinus	**4**	**4**	**6**	**0**	**14**
Myotis velifer	6	0	5	0	11
Myotis californicus	1	1	1	0	3
Lasiurus blossevillii	**0**	**0**	**2**	**1**	**3**
Lasiurus cinereus	0	0	1	0	1
Tadarida brasiliensis	1	0	0	0	1
Myotis species	0	0	2	0	2
Total	26	65	152	2	245

[1] N = Number of survey nights.

Site Comparisons

A total of 706 bats were captured during the summer season (table 17). All four LCR MSCP species were captured. Species composition varied at each site, with only four species overlapping across all sites surveyed during the summer season. Capture rates were highest at the BWRNWR and lowest at the CNTR (figure 8). Species diversity across each month for the restoration sites showed an increase in the last two surveys, but an opposite pattern was found for the BWRNWR (figure 9).

Table 17.—Total captures at all summer survey sites (LCR MSCP species in bold)

Species	BWRNWR	PVER	CVCA	CNTR	Totals
Eptesicus fuscus	26	154	101	37	318
Myotis yumanensis	48	16	37	4	105
Myotis velifer	24	31	16	3	74
Macrotus californicus	53	0	0	5	58
Antrozous pallidus	24	7	8	7	46
Parastrellus hesperus	33	0	3	1	37
Myotis californicus	15	3	10	6	34
Lasiurus xanthinus	0	12	4	0	16
Nyctinomops femorosaccus	1	4	0	0	5
Tadarida brasiliensis	2	2	0	0	4
Corynorhinus townsendii	4	0	0	0	4
Lasiurus blossevillii	0	3	0	0	3
Myotis occultus	0	0	2	0	2
Unknown species	0	1	2	0	3
Totals	230	233	183	63	709

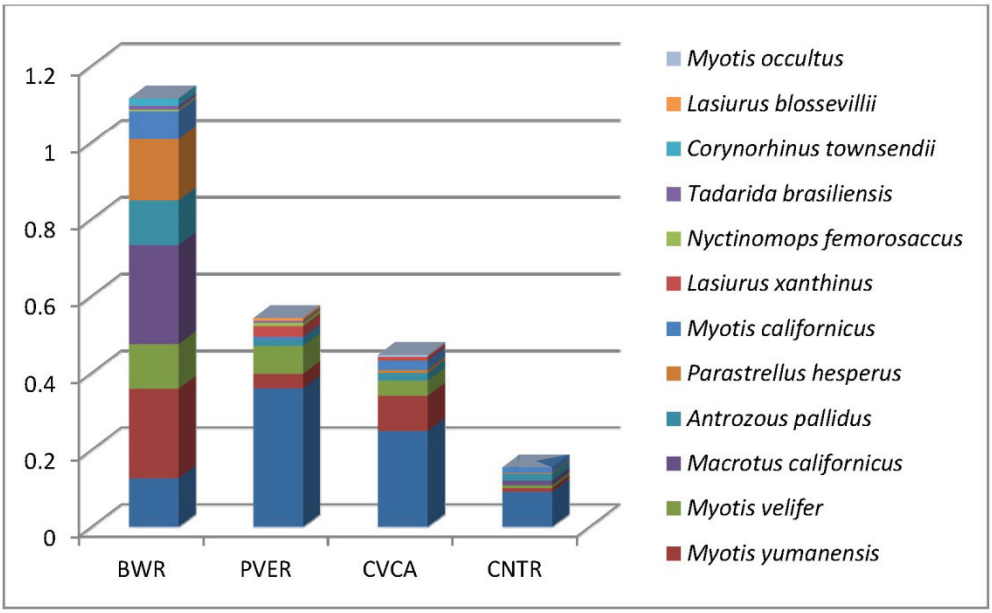

Figure 8.—Species composition based on capture rates per net hour at each site.

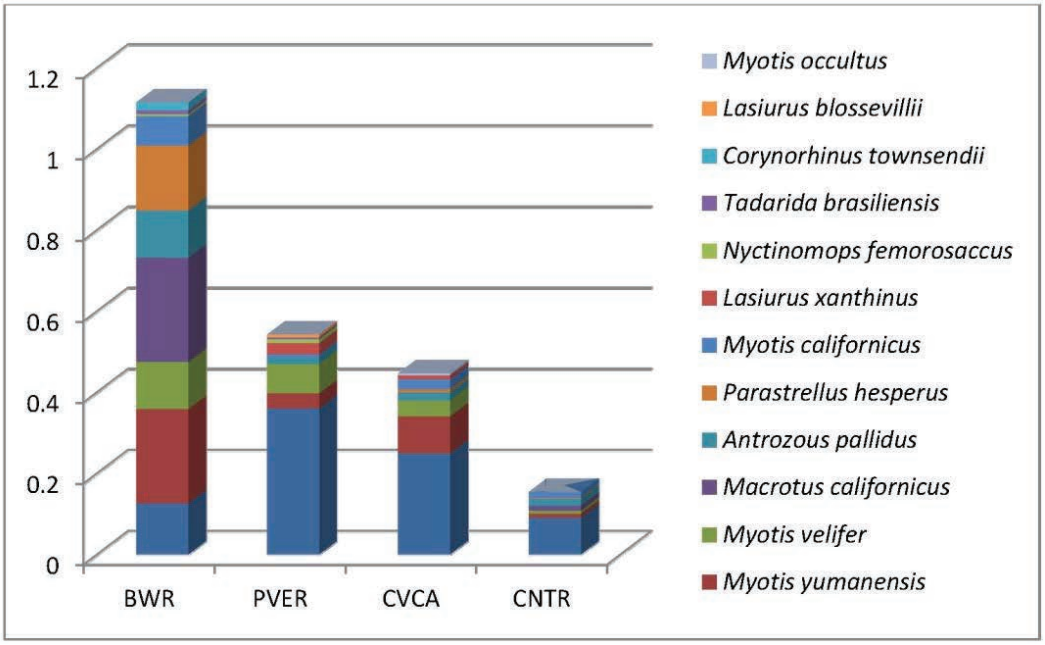

Figure 9.—Species diversity across summer months at each site.

While all sites were compared to each other, it should be noted that the BWRNWR had much lower net hours of effort compared to the HCAs. The PAST: Paleontological Statistics Software Package for Education and Data Analysis program was used to perform a bootstrap analysis comparing Shannon-Weaver diversity values between each site. One thousand replicates with replacement were produced, each with the same total number of individuals as in each original sample, and a 95-percent confidence interval was then calculated (Hammer et al. 2001). The BWRNWR had statistically higher species diversity compared to the three HCAs, while none of the HCAs were statistically different from one another (table 18). Due to the differences in net effort, any significant differences between the BWRNWR and the other sites should be viewed with caution.

Table 18.—Species diversity bootstrap comparisons

Site comparison	*p* value
BWRNWR vs. PVER	<0.001
BWRNWR vs. CVCA	<0.001
BWRNWR vs. CNTR	<0.001
PVER vs. CVCA	=0.178
PVER vs. CNTR	=0.439
CVCA vs. CNTR	=0.987

DISCUSSION

The PVER and CVCA sites were the only sites to have red or yellow bats captured in 2010. The CNTR has had two yellow bat captures in the past, but these are so infrequent that it is likely that they were transients. Yellow bats were captured across multiple months, indicating probable summer residency. Red bats were captured during the winter season and, in addition to winter captures in 2009, indicate that red bats are probably winter residents on the LCR. Red bats were recorded acoustically throughout the summer, though only captured during late summer. Red bats, along with others of their genus, are thought to begin breeding during migration. Recent evidence of red bats and other tree-roosting species using large landmarks to congregate for breeding has been implicated as a reason for the high number of bat fatalities during the late summer and early fall at wind energy farms (Cryan 2008).

Potentially this same hypothesis can account for increases in red and yellow bats within the HCAs, which generally contain the largest trees on a landscape dominated by agriculture. It is possible that during the early to mid-summer, red bat abundance is low on the LCR and within HCAs, but as migration begins, these sites are being used as migration and breeding stopover areas that would increase their abundance and likelihood of being captured. It is unknown if red or yellow bats are actually roosting within the HCAs, but they can be considered residents of the area during the times they were captured. A red and yellow bat roosting study is being implemented in 2011, which will entail capturing both species and radio tracking them back to their roosts both in the winter and summer months. Not only will this give us specific roosting characteristics for future habitat creation projects, but will also allow us to determine if current HCAs can be considered roosting habitat for both species.

The CNTR had much lower captures than the other two HCAs in 2010. Acoustic activity at this site also appeared to be less than at the other sites. It is unknown why so few bats were captured. Net locations were generally in slightly narrower areas than the other sites. One of the triples will be moved for the 2011 surveys to another part of the trail that is lined with a dense mesquite and *Baccharis* spp. This will also be the first attempt at mist-netting within a mesquite-dominated area. The CNTR site is also much smaller than PVER and CVCA, though additional habitat has been planted nearby in recent years.

The disparity in species diversity between the HCAs and the BWRNWR is mainly due to the high capture rates of the big brown bat that dominate the results within those sites. Big brown bats are not the dominant species captured at the BWRNWR, and in general, there was much more evenness of captures for all species. Big brown bats are generalists that will forage anywhere that is reasonably close to their roost. They also utilize multiple roost types, including buildings and other manmade structures (Kurta and Baker 1990). Potentially,

there are more roosting opportunities for them within the highly modified landscape of the LCR compared to the more natural areas of the Bill Williams River. As the HCAs continue to mature and vegetative structure becomes more heterogeneous, species diversity may become more similar to natural areas like the BWRNWR. It is optimistic though, that the tree-roosting red and yellow bats appear to be responding quickly to the large-scale HCAs of the LCR MSCP. These data concur with the recent habitat use and occupancy modeling study conducted by the Arizona Game and Fish Department that showed a very high correlation between red and yellow bat occupancy and cottonwood-willow habitat along the LCR (Vizcarra et al. 2011). In 2011, surveys will be continued at PVER, CVCA, and the CNTR. Access was again granted to ‘Ahakhav, and as such, it will be surveyed instead of the natural site. Capture surveys will be conducted along a different area of the Bill Williams River as part of the red and yellow bat roosting study, and data may be used to compare what is found at the four HCAs. Data will continue to be compiled for all years in the hopes that better recommendations can be given to habitat creation project managers so that more bat-specific specifications can be included when creating habitat.

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APPENDIX 1

Common and Scientific Names of All Species Captured

Common name	Scientific came
California leaf-nosed bat	*Macrotus californicus*
Pallid bat	*Antrozous pallidus*
Hoary bat	*Lasiurus cinereus*
Western yellow rat	*Lasiurus xanthinus*
Western red bat	*Lasiurus blossevillii*
Canyon bat[1]	*Parastrellus hesperus*
Big brown bat	*Eptesicus fuscus*
California myotis	*Myotis californicus*
Yuma myotis	*Myotis yumanensis*
Cave myotis	*Myotis velifer*
Arizona myotis	*Myotis occultus*
Unknown myotis	*Myotis* spp.
Mexican free-tailed bat	*Tadarida brasiliensis mexicana*
Pocketed free-tailed bat	*Nyctinomops femorosaccus*

[1] *Parastrellus hesperus* is formerly known as *Pipistrellus hesperus*, the western pipistrelle.