Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Distribution and Roost Site Habitat Requirements of Western Yellow (*Lasiurus xanthinus*) and Western Red (*Lasiurus blossevillii*) Bats: 2011 Summary Findings

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

March 2012

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Multi-Species Conservation Program

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Prepared by:

Joel M. Diamond, PhD.
Arizona Game and Fish Department, Wildlife Contracts Branch
5000 West Carefree Highway
Phoenix, Arizona 85086

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

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ACRONYMS AND ABBREVIATIONS

ACP	Agua Caliente Park
AHAV	Ahakhav Tribal Preserve
BNWR	Bill Williams River National Wildlife Refuge
cm	centimeter(s)
CVCA	Cibola Valley Conservation Area
DBH	diameter at breast height
ESA	Endangered Species Act
g	gram(s)
HNWR	Havasu National Wildlife Refuge
INWR	Imperial National Wildlife Refuge
km	kilometer(s)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation
SPP	San Pedro River Preserve
THL	Three Links San Pedro River

Symbols

%	percent
°C	degrees Celsius

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ABSTRACT

The roosting ecology of western red bats (*Lasiurus blossevillii*) and western yellow bats (*Lasiurus xanthinus*) is poorly understood in the Southwestern U.S. and on the lower Colorado River (LCR) specifically. Red bats were not recorded on the lower Colorado River until after 1996 when a combination of biological contractors and a Bureau of Reclamation biologist began observing the species on the LCR. Similar to red bats, western yellow bats are believed to be a warm season migratory species in the Southwest. Yellow bats have also begun to be detected in increasing densities on the LCR. Both the western red and western yellow bat are listed as covered species on the LCR. The purpose of this project is to implement conservation measures identified within the Lower Colorado River Multi-Species Conservation Program that calls for the conservation of habitat that works toward the recovery of threatened and endangered species as well as reduces the likelihood of additional species being listed (i.e., the covered species). This project is the first stage and is directed at identifying habitat use by these two species. We radio tracked eight western red bats and nine western yellow bats today roosting habitat on the LCR and other riparian areas to determine the characteristics associated with individual tree roosts. This first year of data collection has provided us with patterns that will be more fully explored after additional seasons of data collection. For western red bats, these patterns indicate roost selection based on a tree patch or roosting neighborhood. In contrast, yellow bats appear to select roosts for the characteristics of individual trees. It is important to note that we are in the early stages of data analysis, and these patterns must be clarified with higher level data analysis.

INTRODUCTION

The roosting ecology of western red bats (*Lasiurus blossevillii*) and western yellow bats (*Lasiurus xanthinus*) is poorly understood (Adams 2003). Red bats were not recorded on the lower Colorado River (LCR) until after 1996 when a combination of biological contractors and a Bureau of Reclamation (Reclamation) biologist began observing the species on the LCR. Western red bats have primarily been observed adjacent to permanent water sources in cottonwood, oak, and sycamore communities (Adams 2003; Findley et al. 1975). The diet of red bats consists primarily of Lepidoptera it captures in flight at or near the canopy (Harvey et al. 1999). The ecology of the closely related eastern red bat (*Lasiurus borealis*) indicates that bats select roosts in mature deciduous riparian forest adjacent to open water and wetlands (Limpert et al. 2007). Whether western red bats respond to the same habitat types is unknown. Red bats were thought to be migratory throughout the Southwest, but recent winter captures indicate the presence of a wintering population on the LCR. Similar to western red bats, western yellow bats are believed to be warm season migratory species in the Southwest (Adams 2003). Yellow bats occurred historically throughout southern Arizona, extending as far north as Phoenix. However, recent observations of yellow bats north of Phoenix indicate that the range of this species is expanding northward in Arizona (Hoffmeister 1986). This expansion of the yellow bat range in the Southwest has been attributed to the planting of palm trees along riparian corridors (Adams 2003). Yellow bats have been detected as far north as Moapa, Nevada, adjacent to the impounded Colorado River at Lake Mead (Williams et al. 2006). This northern expansion of the range of this species has been attributed to the distribution of exotic palms (Williams 2006). The distribution of the species may also be associated with that of Yucca plants in the Southwestern U.S. (Higginbotham et al. 2000). Regardless of these associations, western yellow bats appear to exist in low densities throughout their range. Yellow bats had not been recorded on the LCR prior to 1996; however, researchers speculated that the species would expand into the LCR, and a Reclamation biologist confirmed this expansion (Adams 2003; A.Calvert pers. communication).

The purpose of this project is to implement conservation measures identified within the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a multi-stakeholder Federal and non-Federal partnership responding to the need to balance the use of the LCR water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act (ESA). This program works toward the recovery of listed species through habitat and species conservation and reduces the likelihood of additional species being listed under the ESA. This project specifically targets conservation measures that address the data gaps necessary to implement the conservation needs for the western yellow and western red bats. The following LCR MSCP conservation measures will be specifically addressed and aided through this project:

MRM1 = Conduct surveys and research to better identify covered and evaluation species habitat requirements

WRBA1 = Conduct surveys to determine species distribution of the western red bat

WRBA2 = Create 765 acres of western red bat roosting habitat

WYBA1 = Conduct surveys to determine species distribution of the western yellow bat

WYBA3 = Create 765 acres of western yellow bat roosting habitat

These specific conservation measures will be accomplished through the use of standard radio telemetry techniques to locate roost sites of western yellow and red bats. We will then describe the roost site characteristics used by western yellow and red bats within the LCR MSCP project area (as well as additional compatible riparian habitats outside the LCR MSCP project area). These data will be used to evaluate the potential distribution of yellow and red bat roosting habitat currently within the LCR MSCP project area. Finally, we will develop management guidelines for maintaining and creating roosting habitat for western yellow and red bats at the roost and stand level scale. These guidelines can be used by restoration project managers to create roosting habitat for these two covered species.

OBJECTIVES

To meet the project purpose as it pertains to western red and western yellow bat habitat management, we are addressing the following objectives:

1. Locate roost sites of western yellow and western red bats within the LCR MSCP project area.

2. Describe roost site characteristics used by western yellow and western red bats within the LCR MSCP project area and compatible riparian habitats.

3. Evaluate the current distribution of western yellow and western red bats in relation to determinate habitat associations currently within the LCR MSCP project area.

4. Develop management guidelines for maintaining and creating roosting habitat for western yellow and red bats within the LCR MSCP project area.

METHODS

We collaborated with a Reclamation biologist in December 2010 to identify potential sampling locations. We selected nine total sampling locations, five within the LCR, one in the Bill Williams River drainage adjacent to the LCR, two along the San Pedro River drainage, and one in a regional park in southeastern Arizona. The five sites within the LCR were selected to act as treatment plots. LCR plots are composed of densely planted, even-aged stands of cottonwood and willow species with little to no understory. Treatment plots include the Ahakhav Tribal Preserve (AHAV), Cibola Valley Conservation Area (CVCA), Havasu National Wildlife Refuge (HNWR), Imperial National Wildlife Refuge (INWR), and Palo Verde Ecological Reserve (PVER). Control sites were selected off of the LCR to accommodate for long-term ecological changes due to river channelization and tamarisk introduction, limiting areas of nonmanipulated habitat on the LCR. We initially selected three control sites and added an additional site as the sampling season progressed to increase sample size. These control sites are characterized by a cottonwood canopy and mixed native and invasive understory. The initial control sites included Bill Williams River National Wildlife Refuge (BNWR), San Pedro River Preserve (SPP), and Three Links San Pedro River (THL). The additional control site was located at Agua Caliente Park (ACP) and was sampled a single time during the warm season. Each sampling plot was centered on the BOR recommended netting location. Sample cells extend for 10 kilometers (km) in each direction along the riparian corridor and 5 km in each direction perpendicular to the riparian corridor. We allocated these cell sizes to correspond to the riparian obligate nature and daily range of western red bats (Adams 2003).

In order to locate roost sites of western yellow and western red bats within the sample cells, we focused on mist net and radio tracking methodologies. Within the nine sampling plots we attempted to capture a total of 10 red and 10 yellow bats during this first warm season sampling year and five western red bats during the cold season. We used 3.8 centimeter (cm) mesh size, 7.5-meter (m)-high mist net sets within foraging and traveling corridors. Where possible, we also set nets across and adjacent to available water sources (e.g., small pools, narrow river channels). Nets were set 0.5 hour before sunset and remained open for 4 hours. Captured red and yellow bats were fitted with VHS radio transmitters. The transmitters weigh 0.37 gram (g), less than 3 percent of the bat's body weight, and are glued onto their backs using surgical glue. The transmitters fall off the bats within approximately 15 days. We tracked bats roosting locations today using triangulation methods.

Once located, we described roost site characteristics used by western yellow and red bats within the sample cells. We mapped the location of all captured yellow and red bats and their roost sites. At each identified roost site, we collected both patch and tree roost site characteristics. To maintain consistency with other LCR

MSCP researchers (e.g., flycatcher and cuckoo biologists), we used LCR MSCP vegetation monitoring field methods (Bangle 2010) field protocol. In addition to the LCR MSCP methods, we measured appropriate roost tree characteristics of the four nearest trees to the roost tree. These characteristics included the tree heights, diameter at breast height, base height of the canopy, foliar width, temperature, tree roost species, number of live branches, live crown ratio, foliage condition, bat roost height, and distance the roosting bat is from the tree trunk. Tree heights, base height of canopy, and bat roost height were estimated with a Lecia Disto D330 laser distance meter and a stationary robel pole. Foliar width was estimated by stationing two robel poles at opposing canopy edges at 2 m, 4 m, 6 m, and 8 m. We then used the disto to measure canopy width. The temperature was recorded with a hand-held radiometer (Raytek MT4 Mini infrared thermometer) at 2 m, 4 m, 6 m, and 8 m. Live crown ratio was an ocular estimate of the percent of live foliage. The number of live branches was the number of live stems greater than 10 cm diameter at breast height (DBH) branching from 0–2 m from the tree base. In addition to recording these data at the location of a roost, this methodology supplied the covariates for habitat models created with objective three. We measured the same variables for the four trees nearest the roost tree to provide a basis for tree-specific comparisons. We performed a simple frequency analysis across a subset of variables to provide an initial estimate of roost tree characteristics. We also compared roost tree characteristics with those of the four adjacent trees to estimate variables associated with bat use. We used a series of two-tailed t-tests at a significance level of $p = 0.05$. These methods are focused on summarizing this first year's roost site data and not as a full model of bat distribution on the LCR and control sites.

RESULTS

We netted for western red and yellow bats for a total of 42 sample nights (table 1). We sampled seven of the nine sites twice in the cold season and an eighth sites three times to compensate for an increased sampling effort established after the first netting date at the AHAV site. During the warm season, eight of the sample locations were sampled three times, while a ninth site was sampled a single time to increase sample size. Western yellow and/or red bats were captured at four Reclamation treatment sites and two control sites. We observed 17 species at control sampling sites and 12 species at the treatment sites (table 2). During cold season surveys, we detected five bat species at the control sites and six at the treatment sites. We observed 17 bat species at the control sites and 11 at the treatment sites during the warm season (table 2). Shannon-wiener diversity indices indicated that diversity and evenness did not vary between the treatment and control sites ($p = 0.48$).

Table 1.—Sampling dates by sample site across the cold and warm season for western red and western yellow bats

Sampling location	Cold season sampling dates	Warm season sampling dates
Havasu National Wildlife Refuge	3-9-2011 and 3-14-2011	5-30-2011, 6-27-2011, and 7-11-2011
Ahakhav Tribal Preserve	2-24-2011, 2-28-2011, and 3-16-2011	5-23-2011, 6-23-2011, and 7-21-2011
Palo Verde Ecological Reserve	2-23-2011 and 3-8-2011	5-24-2011, 6-22-2011, and 7-20-2011
Cibola Valley Conservation Area	2-22-2011 and 3-7-2011	5-25-2011, 6-21-2011, and 7-19-2011
Imperial National Wildlife Refuge	3-1-2011 and 3-23-2011	6-06-2011, 6-29, 2011, and 7-18-2011
Bill Williams River National Wildlife Refuge	3-8-2011 and 3-15-2011	5-31-2011, 6-28-2011, and 7-12-2011
San Pedro River Reserve	2-17-2011 and 3-3-2011	6-03-2011. 7-01-2011, and 7-14-2011
Three Links San Pedro River	2-16-2011 and 3-2-2011	6-02-2011, 6-30-2011, and 7-13-2011
Agua Caliente Park		6-16-2011

Ahakhav Tribal Preserve

At the AHAV control site, we captured and tracked one western red bat and three western yellow bats. The single western red bat was captured in the cold season and the western yellow bats were tracked in the warm season. We located roosts for all four bats:

- The male western red bat captured at AHAV in the cold season was only tracked for 2 days. The AHAV red bat foraged north of the capture site for 10 minutes and then headed directly upriver. We were unable to relocate the bat the night of March 16 or the morning of the 17th pre-sunrise. However, we did locate this bat the afternoon of the 17th roosting in a Mexican fan palm located within an RV park in Parker, Arizona. We searched the adjacent area and from the INWR survey site to the HNWR site along the length of the LCR for the next 2 weeks, and the bat was not detected again. Given the late cold season capture date (March 16) and the direct northern movements of this bat, it was likely a migrant and or a cold season resident moving to its warm season range.

- A female western yellow bat was captured at AHAV on May 23. It was tracked to a Mexican fan palm in a backyard near Parker, Arizona. The bat was observed day roosting in the palm on May 24, 25, and June 1. This repeated use of the same roosting site indicates that it is a warm season resident on the LCR.

Table 2.—Bat species diversity at each study site in the cold season, warm season, and both

	Treatment sites					Control sites			
	AHAV	CVCA	HNWR	INWR	PVER	BNWR	SPP	THL	ACP
Townsend's big-eared bat									
Western red bat									
Western yellow bat									
California leaf-nosed bat									
California myotis									
Pallid bat									
Canyon bat									
Mexican free-tailed bat									
Big brown bat									
Yuma myotis									
Arizona myotis									
Cave myotis									
Pocketed free-tailed bat									
Silver-haired bat									
Mexican long-tongued bat									
Western small-footed bat									
Southwestern myotis									
Number of Bats (Cold Season)	7	1	1	31	2	13	0	11	N/A
Number of Bats (Warm Season)	43	59	12	25	21	67	31	113	6
Number of Species (Cold Season)	5	1	1	4	2	5	0	2	N/A
Number of species (Warm Season)	7	7	4	7	4	10	9	11	3
Shannon-Wiener diversity index (Cold Season)	4.71	N/A	N/A	3.63	2.00	4.12	N/A	1.79	N/A
Shannon-Wiener diversity index (Warm Season)	4.56	2.60	3.13	6.33	2.71	7.19	6.74	4.81	1.09
Shannon-Wiener diversity index (Combined Warm and Cold Season)	5.23	3.15	3.26	6.08	3.76	5.60	6.74	4.79	3.00

Note: Light grey represents bat species captured only during the cold season, medium grey represents species captured only during the warm season, and black represents species captured in both the cold and warm seasons.

- We netted two female western yellow bats at AHAV on the night of July 21. We tracked one of the bats to a Mexican fan palm near a home south of the trapping site. We monitored this bat foraging over the agricultural fields south of AHAV after its release and found it roosting in the palm at approximately 2300 hours. The bat was observed day roosting in this palm on July 22, but was not found again, suggesting it may have been a migrant moving through the LCR corridor or a resident outside of our study area.

- We found the other female western yellow bat day roosting in a Mexican fan palm on the California side of the LCR. This palm was on private property. We observed the bat day roosting in this palm on July 22 and July 25, leading us to believe the bat is most likely a warm season resident along the LCR.

Cibola Valley Conservation Area

We captured and tracked three western red bats and two western yellow bats at CVCA. All captures and tracking at CVCA occurred during warm season surveys. We located roosts for all western red bats and one of the western yellow bats at CVCA. The first western yellow bat was tracked into California and lost. All three western red bats were detected moving around the cottonwood patch after being released.

- The first male western red bat captured was located roosting in a Fremont cottonwood tree on June 22 and 23. He was approximately 4 m above the ground on the north side of the tree under a live leaf. This bat was located again on June 24 in a different Fremont cottonwood, 11 m above the ground on the southwest side of the tree under a live leaf. This second roost was approximately 100m from its previous roost. The bat's transmitter was recovered, likely due to grooming on June 27 near the June 24 roost. The repeated detection of this bat within the CVCA site indicates it is a warm season resident.

- The second male western red bat caught at CVCA was detected on June 22, 23, 24, and 27 in a Fremont cottonwood on the north side of the cottonwood grove where the netting site was. The bat was found roosting each time 4 m above the ground on the south side of a Fremont cottonwood in dense live foliage. The repeated observation of this bat in the CVCA site indicates that it is a warm season resident.

- The third western red bat was a female and was located in a single roost. She was located roosting within a dense stand of coyote willows approximately 15 cm off the ground at the base of a coyote willow on June 22 and 23.

- A female western yellow bat was captured at CVCA on May 25. This bat was fitted with a transmitter and, almost immediately upon release, flew north and out of range of our telemetry gear. An intensive search ensued, with four people searching for 5 days. North and south along the LCR and into California was searched, but the signal was never picked up. Due to this bats movement, it was most likely a migrant or resident on the LCR outside of our survey area.

- We followed a second female western yellow bat captured at CVCA on July 19 to a Mexican fan palm on the bank of the LCR. We observed the bat day roosting on the northeast side of the palm on July 20, 21, and 22. The repeated observation of this western yellow bat suggests it is a warm season resident on the LCR.

Havasu National Wildlife Refuge

We captured and tracked a single western yellow bat at HNWR during the warm season.

- This male western yellow bat was captured at HNWR on June 27. The bat was having trouble flying upon release, so he was placed 2 m above the ground in a nearby Fremont cottonwood and found at the same location on the 28th. He was observed attempting to shed his transmitter with his foot. His transmitter signal was picked up again on June 29, 10 m from the previous roost. The signal appeared to be coming from the ground, but an exhaustive search of the leaf litter yielded nothing. This bat most likely shed his transmitter while roosting in the cottonwood above where the signal was received. Given that this bat was placed in the roosting tree, it was treated as a nonselected roosting site in the analysis.

Palo Verde Ecological Reserve

We captured and tracked three western red bats and two western yellow bats to roosts at the PVER sample site. We captured one red bat in the cold season and two in the warm season. Western yellow bats were tracked to roosts in the warm season. We attached transmitters to a female and male western yellow bat at PVER on July 20.

- We were able to follow the male western red bat captured at PVER during the cold season for 14 days before the transmitter battery life concluded. The initial capture of this western red bat occurred on February 23. The night of the 23rd we observed the bat moving north into the agricultural fields adjacent to PVER, most likely foraging. The bat foraged above these fields for approximately 1 hour. We then observed the bat returning to PVER and night roosting in a Fremont cottonwood 50 m from the trapping site on February 23. This western red bat was located day roosting in a Fremont cottonwood at PVER on February 24 and in the same tree on the 28th. We tracked the bat to an athel tamarix and honey mesquite hedge row stand on March 2, and the bat was roosting in an Athel tree. We detected the bat a second time at the Athel roost on March 7. We located the bat back at PVER on March 8, roosting two trees north of its original roost in a cottonwood. Our final location for this bat was in the Athel roost on March 9. This bat moved between two roosting locations repeatedly. Movement between the same roosts repeatedly indicates that it is a cold season resident on the LCR.

- The first western red bat captured in the warm season was a male captured on May 24, and it was tracked for only 2 days before he was presumably able to groom his transmitter off. The bat was observed over the agricultural fields bordering PVER after being released, most likely foraging. The bat was found day roosting on May 25 in a Fremont cottonwood approximately 5 m above the ground on the southwest side of the tree under a live leaf. The bat was detected on May 26 approximately 100 m from the previous roost in a Fremont cottonwood 5 m above the ground on the west side of the tree again under a live leaf. Its transmitter was found directly below on the ground. The repeated locations in the same roosting area indicates this bat is a warm season resident.

- We captured and tracked a second male western red bat moving up the LCR to the area around the Palo Verde Dam. This bat was most likely foraging and stayed in the area for approximately 2 hours before returning to PVER. We tracked the western red bat to a cottonwood within the gallery planted at PVER (Phase I). We detected the bat day roosting in the same cottonwood on July 21, 22, and 25. The repeated detection of this bat on the LCR indicates that it is a warm season resident.

- We captured a female western yellow bat on July 20. We tracked the female to a Mexican fan palm near a home on the west side of N Intake Blvd. We found the female day roosting in the palm on July 21, 22, and 25. Due to the repeated detection within the LCR study area, we believe this bat is a warm season resident.

- We captured and tracked a male western yellow bat to a stand of Mexican fan palms within a locked residential yard on July 20. We were not able to determine the specific tree the bat was roosting in, but all trees within the grouping shared similar characteristics as far as height and dead skirt length. We observed the bat day roosting in the palm on July 21, 22, and 25. Due to the repeated detection within the LCR study area, we believe this bat is a warm season resident

San Pedro River Preserve

We detected two western red bats at the SPP control site during the warm season.

- The male western red bat was captured at SPP on June 3. The bat proved elusive after being netted and was not located again until June 7, when it was found day roosting in a Mexican fan palm in Dudleyville, Arizona. The bat was detected again on June 8 in the same roost. The repeated detection of this bat in the same roost indicates that this bat is a warm season resident.

- A lactating female western red bat was also captured at SPP on July 1. Due to the bat's weight (9.5 g) and reproductive status, it was determined not fit for a transmitter and was then released.

Agua Caliente Park

Two western yellow bats were captured at ACP on June 16 during warm season surveys. The first western yellow bat captured was a nonreproductive female, and the other was a male.

- We captured and tracked the nonreproductive female western yellow bat on June 16. This bat was observed day roosting in a Mexican fan palm adjacent to the netting site. On June 18, the female was observed in the same tree. The female was detected again at her original roosting site on June 22. The repeated detection of this bat within the same general area indicates that it is a warm season resident.

- We also captured and tracked a male western yellow bat on June 16. The male was located on June 22 roosting south of the park in a Mexican fan palm on private property. The detection of this bat within the same general area indicates that it is a warm season resident.

We did not capture either western red or yellow bats at one treatment site (INWR) or two control sites (BNWR and THL). We captured western red bats in February, March, May, June, and July. Western yellow bats were observed in May, June, and July.

Western Yellow Bat – Roost Characteristics

We captured and radio tagged a total of nine western yellow bats during 2011. Bats were captured at four of the Reclamation treatment sites and a single control site. We detected a mean of 1.1 roosts per bat, and only two bats were observed using multiple roosts. We were unable to locate the roost of a single bat, which we pursued into California to the limit of our jurisdictional abilities. We observed bats a mean of twice with a maximum of three observations. Western yellow bats were detected at 11 distinct roosts, 9 of which were palm trees. Mean roost tree height was 11.63 m and varied from 0 to 18.2 m. Roost trees varied in from 36 to 104 cm, with a mean value of 65 cm. The beginning of the live crown for roost trees had a mean value of 7.3 m from the ground and varied from 0.5 m to 17 m. Roosting locations were consistently below the live crown within the dead palm frond skirt. A mean of 43 percent (%) of the total crown consisted of dead material and varied from 35% to 75% dead crown. Bat roosting height within the tree varied from 0 m to 17 m and a mean roost height of 6.4 m. Palm skirt widths

varied from 1 m to 4 m wide, with a mean of 2.5 m wide. Temperatures on the surface of the roosting tree palm skirts varied from 30.4 degrees Celsius (°C) to 44.9 °C, with a mean value of 37 °C. Roosting trees were characterized by 1 to 5 apical meristems and a mean of 1.4 meristems. Comparison of roosting tree characteristics to those of adjacent trees indicates patterns of roost use. Adjacent trees had a mean height of 10.8 m, while the roost trees had a mean of 11.6 m and were not significantly different ($p = 0.668$) (figure 1). Tree DBH was also not significantly ($p = 0.514$) different across trees (figure 2). The height of the beginning of the live crown was significantly ($p = 0.013$) higher in the roost trees when compared to neighboring trees (figure 3). Roosting trees had a significantly higher percentage of dead crown vegetation than that of adjacent trees ($p = 0.046$) (figure 4). Crown width did not vary significantly ($p = 0.292$) between roost trees and neighboring trees (figure 5).

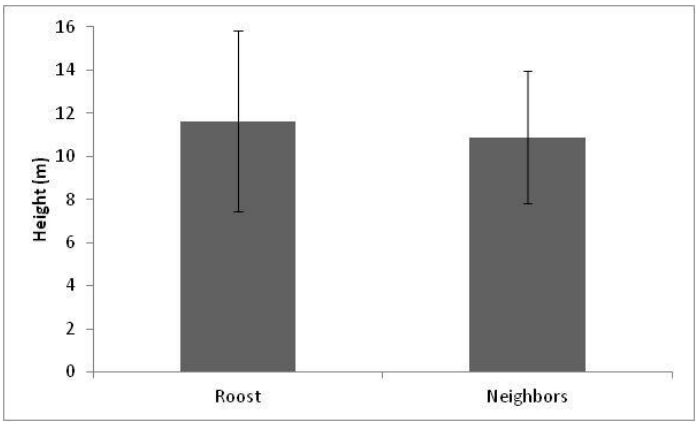

Figure 1.—Comparison of mean and standard deviation of tree height between the roosting tree and the four adjacent neighbor trees.

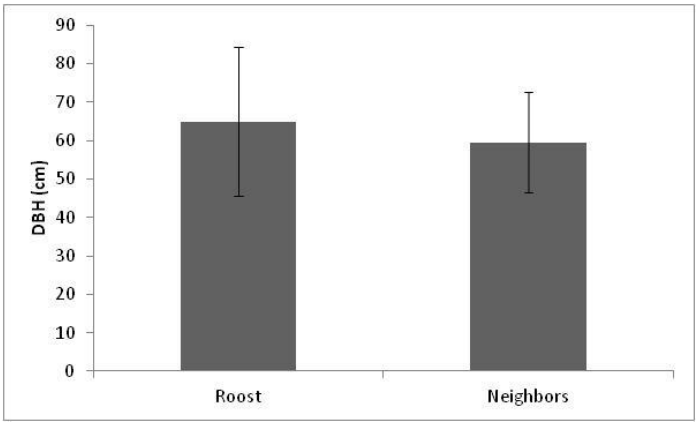

Figure 2.—Comparison of mean and standard deviation of DBH between the roosting tree and the four adjacent neighbor trees.

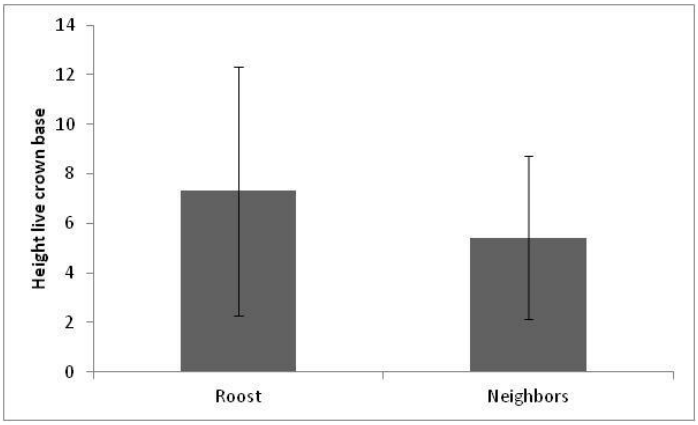

Figure 3.—Comparison of mean and standard deviation of height of the base of the live crown between the roosting tree and the four adjacent neighbor trees.

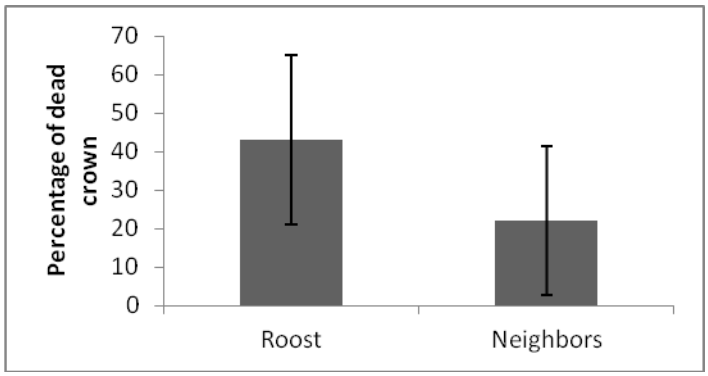

Figure 4.—Comparison of mean and standard deviation of the percent of dead crown between the roosting tree and the four adjacent neighbor trees.

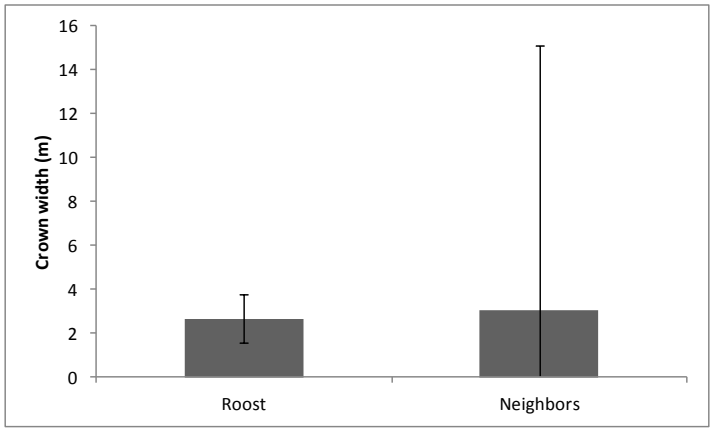

Figure 5.—Comparison of mean and standard deviation of the crown width between the roosting tree and the four adjacent neighbor trees.

Western Red Bat – Roost Characteristics

We radio tagged a total of eight western red bats during 2011. We captured and tracked two western red bats in the cold season and six in the warm season. We pooled the analysis of roosting locations across warm and cold season due to the small sample size of cold season roosts. We detected western red bats roosting within three of the Reclamation treatment sites and one control site. We observed red bats using a total of 12 distinct roosting trees: eight of these roosts were cottonwoods, two athel tamarisk, one willow, and a single palm (the single migrant red bat from AHAV was excluded). Red bats used a mean of 1.5 roosting locations with a maximum of three roosts. We detected red bats a mean of three separate times and a maximum of six across days. We detected bats roosting in trees with a mean height of 14.3 m, and it varied from 7–21 m. The red bat roosting in a litter 10 cm from the base of a coyote willow was treated as an outlier and removed from the analysis. The mean DBH for roost trees was 45 cm and varied from 6 to 83 cm. The live crown began at a mean of 2.7 m from the ground and varied from 0.1–11 m. A mean of 17% of the live crown was dead in roost trees, and it varied from 5–75%. The foliar width of the roost trees was a mean of 3.7 m, and it varied from 0.1–8 m. The mean temperature of the roosting trees was 27.4 °C, and it varied from 17.1–39.6 °C. Comparisons between roost tree and nearest neighbor trees' characteristics indicated highly variable roost use patterns. Roost tree height was not significantly ($p = 0.825$) different from neighboring trees (figure 6). DBH was also not significantly different ($p = 0.419$) between the roost and adjacent trees (figure 7). The height of the base of the live crown was not significantly different ($p = 0.806$) between the roost tree and adjacent trees (figure 8). The percent of dead crown did not differ significantly ($p = 0.342$) between roost and adjacent trees (figure 9). The crown width was also not significantly different ($p = 0.539$) between the roost tree and the four adjacent trees (figure 10).

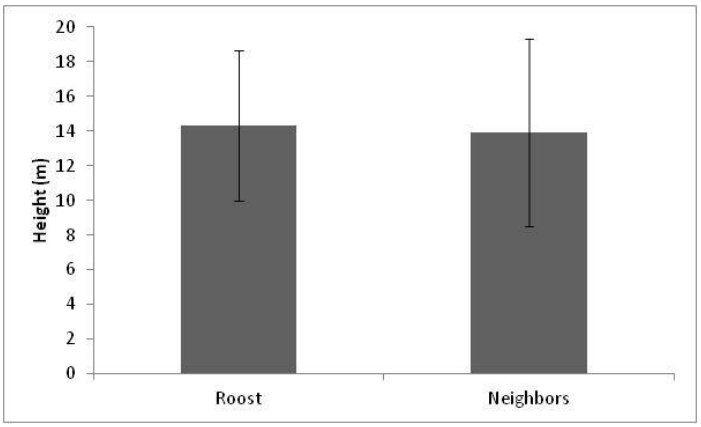

Figure 6.—Comparison of mean and standard deviation of tree height between the roosting tree and the four adjacent neighbor trees.

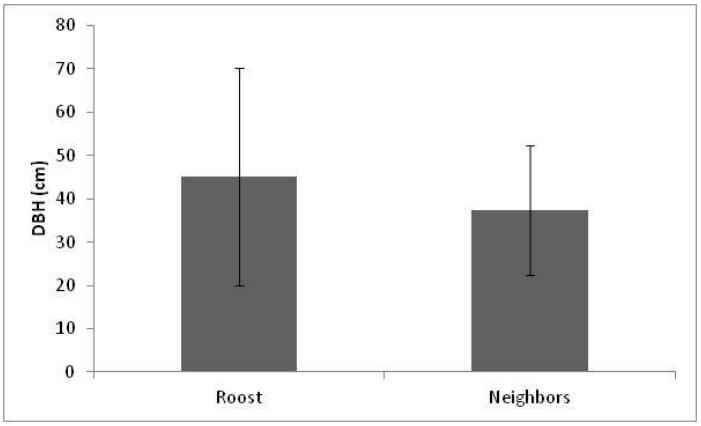

Figure 7.—Comparison of mean and standard deviation of DBH between the roosting tree and the four adjacent neighbor trees.

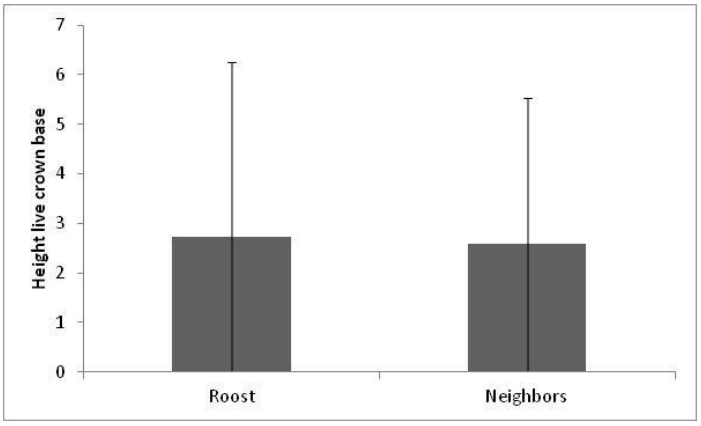

Figure 8.—Comparison of mean and standard deviation of height of the base of the live crown between the roosting tree and the four adjacent neighbor trees.

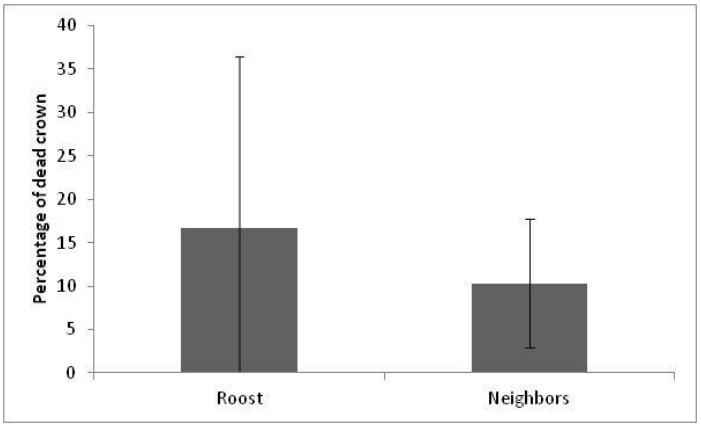

Figure 9.—Comparison of mean and standard deviation of the percent of dead crown between the roosting tree and the four adjacent neighbor trees.

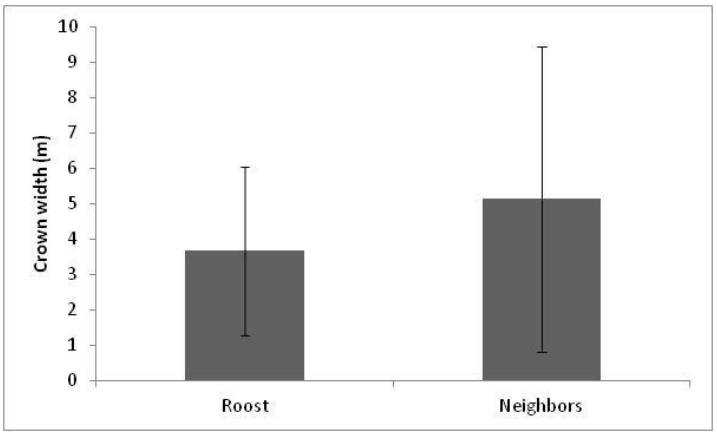

Figure 10.—Comparison of mean and standard deviation of the crown width between the roosting tree and the four adjacent neighbor trees.

DISCUSSION

These findings indicate patterns of western yellow and western red bat habitat use. At this early stage in the project, these patterns should be evaluated with a high degree of caution and be re-evaluated as additional data are collected across the next field season. Our preliminary analysis of these data was focused on a single spatial scale, that of the individual roost tree. This small spatial scale does not appear to account for the roost selection by western red bats. Red bat roost trees were not significantly different from the adjacent trees, indicating a larger scale response to roosting sites. This pattern of patch level selection of tree roosts was also noted with eastern red bats (Higginbotham et al. 2000). A single variable, crown width, was borderline significant, indicating a possible relationship between canopy structure and bat use. Therefore, it is likely that red bats are responding to patch scale habitat characteristics rather than tree-specific characteristics. In contrast, western yellow bats appear to be associated with roost tree specific characteristics. Yellow bat tree roosts had a significantly higher live crown base and percentage of dead crown. Roost trees with a high live crown base and a high percentage of dead crown indicate the presence of a wide and deep dead palm frond skirt. These palm skirts likely provide a suitable microclimate that is not found in those palms lacking a large dead frond skirt. This first year of data collection has provided us with patterns that will be more fully explored after additional seasons of data collection. For red bats, these patterns indicate roost selection based on a tree patch or roosting neighborhood. In contrast, yellow bats appear to select roosts for the characteristics of individual trees. It is important to note that we are in the early stages of data analysis and that these patterns must be clarified with higher level data analysis. This tree scale analysis will be used as the basis in scaling up to patch and landscape scale analyses after the second year data collection period. It is important to note that the majority of western red and western yellow bats were captured and tracked

within the treatment sites on the LCR. While we have not yet made any comparisons across the treatment and control sites, patterns are beginning to emerge. The treatment sites consist of homogeneous patches of cottonwood habitat, while the control sites consist of linear tracts of often fragmented habitat. Thus, we may be observing selection of habitat based on the patch size. Further data collection and analysis may help us define these emerging patterns. We also require further data in order to analyze the relationship between distances from capture location to roosting site. We will use our patch scale and sample cell scales to analyze these distance relationships once more samples have been collected.

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ATTACHMENT A

Photos to be Included for Future Presentation

Western yellow bat (*Lasiurus xanthinus*) caught at Havasu National Wildlife Refuge fitted with a transmitter.

Male western red bat (*Lasirurs blossevilli*) caught at Cibola Valley Conservation Area with the transmitter attached.

Western red bat *(Lasirurs blossevillii)* caught at Palo Verde Ecological Reserve was found roosting in this Fremont cottonwood.

The Mexican fan palm to the right of the person is where the Arizona myotis (*Myotis lucifugus occultus*) was tracked to and where the maternity colony was discovered. Western yellow bat was observed roosting in the palm to the left of the person.