Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2015 System-Wide Acoustic Monitoring of LCR MSCP Bat Species

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

September 2016

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Lower Colorado River Multi-Species Conservation Program

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Multi-Species Conservation Program
Bureau of Reclamation
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ACRONYMS AND ABBREVIATIONS

BWRNWR	Bill Williams River National Wildlife Refuge acoustic station
CNWR-Island	Cibola National Wildlife Refuge-Island Unit acoustic station
HNWR-Pintail	Havasu National Wildlife Refuge acoustic station in Pintail Slough
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MLWA	Mittry Lake Wildlife Area acoustic station
PSRA	Picacho State Recreation Area acoustic station

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ABSTRACT

Acoustic bat call data were analyzed from five acoustic monitoring stations (Anabat™) along the lower Colorado River from June 1 through August 31, 2010, through 2015. These stations were located within system-wide monitoring sites that consist of existing habitat along the lower Colorado River, with vegetation species composition, area, and canopy height varying across sites. The calls of four species were monitored: western red bat (*Lasiurus blossevilli*), western yellow bat (*Lasiurus xanthinus*), California leaf-nosed bat (*Macrotus californicus*), and pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* also known as *Plecotus townsendii pallescens and Corynorhinus townsendii townsendii*). Sites and species were evaluated based on relative activity (average nightly call minutes and proportion of nights occupied). Relative activity was found to vary widely among sites, years, and species. Western red and yellow bats were recorded with the greatest relative activity at the Bill Williams River National Wildlife Refuge, while California leaf-nosed bats were recorded with the greatest relative activity at the Picacho State Recreation Area. Pale Townsend's big-eared bat relative activity was recorded at low levels due to the quiet nature of their calls and was greatest at the Bill Williams River National Wildlife Refuge.

INTRODUCTION

This document is a summary of acoustic bat call data collected at five acoustic monitoring stations (Anabat™) along the lower Colorado River (LCR). The purpose of this project is to monitor the presence of bat species to inform 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 LCR water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act. This program works toward the recovery of listed species through habitat and species conservation and reduces the likelihood of additional species listings under the Endangered Species Act.

Bats have been proposed as indicators of the integrity of natural communities and an excellent taxa for monitoring habitats because they integrate a number of resource attributes (e.g., roosting, watering, and foraging habitats) and thus a change in bat detections may indicate if habitat is declining in quantity or quality (Hutson et al. 2001; Miller et al. 2003; Miller 2010; Williams et al. 2006; Rainey et al. 2006, 2009; Jones et al. 2009). Acoustic sampling is an effective and economical means to monitor bat populations. Analyses of recordings from ultrasonic bat detectors are now widely applied when assessing bat distribution and activity over a range of temporal scales in various landscape contexts. Changes in bat species activity that suggest declining population trends or reveal limited ranges may warrant targeted investigation and shape the allocation of conservation funding support (Rainey et al. 2009). Alternatively, populations demonstrating stable or increasing population trends may require limited monitoring and funding support in the future. A key component of understanding and effectively managing bat communities is gaining a basic understanding of the inherent variation in species composition across spatial and temporal scales (Morris 1990). Understanding the variation in bat communities across time and space is fundamental for conservation efforts because managers must decide whether changes in species richness warrant management efforts.

This project targets the presence of the western red bat (*Lasiurus blossevillii*), western yellow bat (*Lasiurus xanthinus*), pale Townsend's big-eared bat (*Corynorhinus townsendii*), and California leaf-nosed bat (*Macrotus californicus*) within system-wide monitoring sites. Genetic analyses on the pale Townsend's big-eared bat indicate that the LCR is likely in the range of the Pacific Townsend's big-eared bat (*Corynorhinus townsendii townsendii)* rather than the pale Townsend's big-eared bats (Piaggio and Perkins 2005). Bats recorded along the LCR will be refered to as the pale Townsend's big-eared bat in this report, as the name change has not yet been verified by the U.S. Fish and Wildlife Service. The LCR MSCP is required to create 765 acres of western red bat roosting habitat and 765 acres of western yellow bat roosting or foraging habitat by creating suitable habitat for these covered species.

Acoustic bat call data were collected and analyzed to document activity trends from the five permanent stations located in riparian habitat along the LCR that have not been restored by the LCR MSCP (system-wide monitoring sites) for future comparison with activity trends at LCR MSCP conservation areas.

STUDY AREA

The study area consists of five Anabat™ stations located along the LCR from the Havasu National Wildlife Refuge in the north to the Mittry Lake Wildlife Area located near Yuma, Arizona (see figure 1). System-wide monitoring sites are generally located in areas containing a mixture of native and non-native riparian vegetation that is remnant or where older small-scale planting occurred but there is no active management or irrigation of the site. The extent of the canopy cover and overall composition varies across sites. The system-wide monitoring stations are located at Pintail Slough in the Havasu National Wildlife Refuge (HNWR-Pintail), the Bill Williams River National Wildlife Refuge (BWRNWR), the Cibola National Wildlife Refuge-Island Unit (CNWR-Island), the Picacho State Recreation Area (PSRA), and the Mittry Lake Wildlife Area (MLWA) (figure 1).

METHODS

Data were summarized from permanent Anabat™ detectors in five locations along the LCR. These stations were deployed in system-wide monitoring sites in 2008, with HNWR-Pintail added in May 2014 (table 1).

Table 1.—Station name, acronym, treatment, number of nights recorded during the sampling period, and year of station deployment

Station	Station acronym	Treatment	Nights recorded	Year deployed
Havasu National Wildlife Refuge-Pintail Slough	Havasu-Pintail	System-wide monitoring	65	2014 (May)
Bill Williams River National Wildlife Refuge	BWRNWR	System-wide monitoring	92	2008
Cibola National Wildlife Refuge-Island Unit	CNWR-Island	System-wide monitoring	92	2008
Picacho State Recreation Area	PSRA	System-wide monitoring	92	2008
Mittry Lake Wildlife Area	MLWA	System-wide monitoring	92	2008

These five stations provide a temporal and spatial estimate of bat species diversity and presence. These stations consist of Anabat™ II detectors with associated ZCAIM (a device that takes a frequency signal from an Anabat™ detector, detects the zero-crossings in the signal, and stores the signals on a compact flashcard),

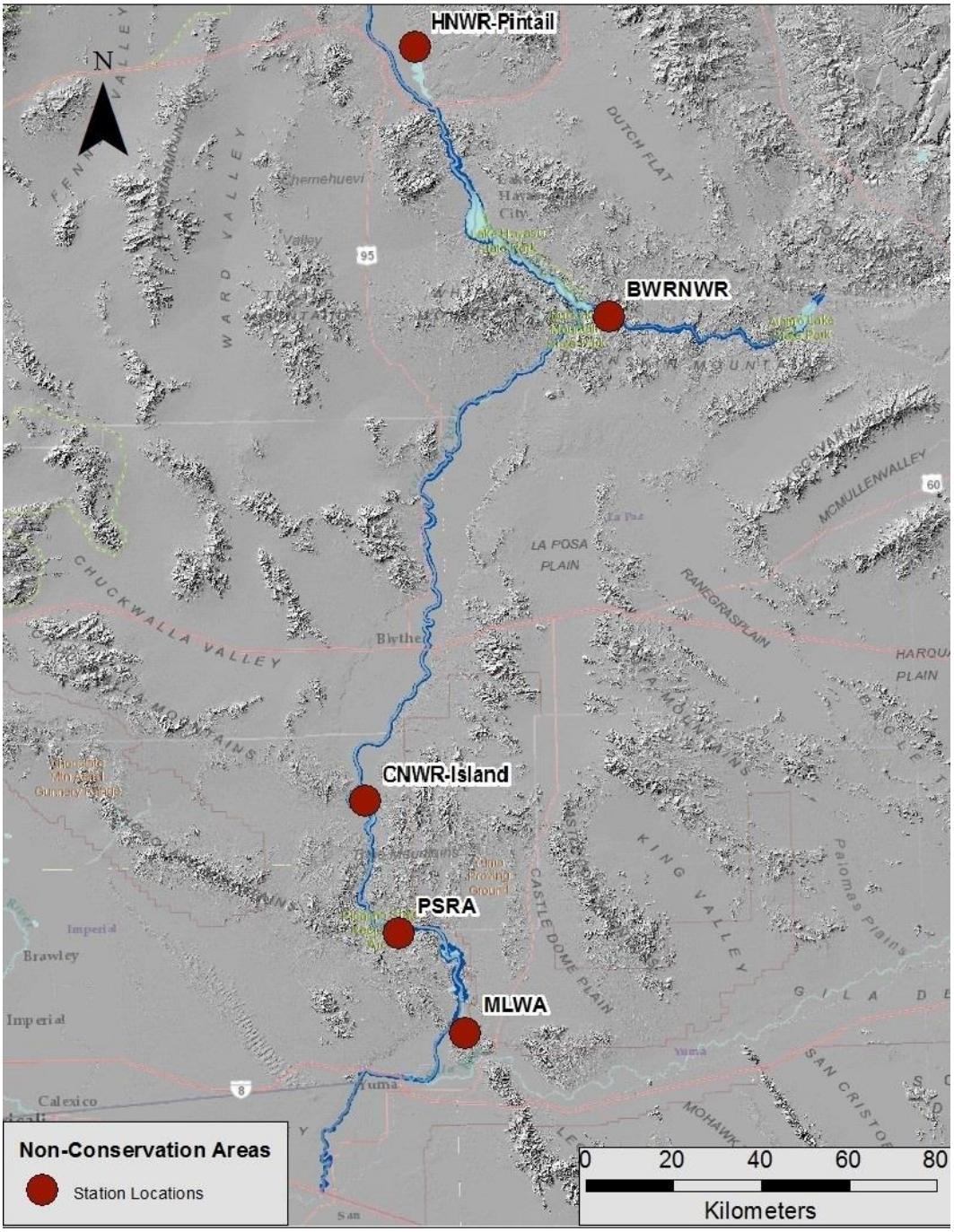

Figure 1.—Study area system-wide monitoring sites.

and Anabat™ SD1 and SD2 detectors. Compact flashcards at the stations accumulated data at the rate of about 12 megabytes per night during periods of very high bat activity (about 1,500 calls per night). This is about 4 months for the 1-gigabyte cards used. Data from June 1 through August 31 of each year, coinciding with the peak in summer activity, were used to determine summer residency. We surveyed and downloaded data from the stations during the months of June, July, and August and made an additional trip in May in order to address any maintenance issues. All stations, with the exception of HNWR-Pintail, recorded data and operated correctly from June 1 through August 31. HNWR-Pintail malfunctioned, and no data were recorded from June 18 through July 14.

The volume of call minutes was quantified for the four LCR MSCP species: western red bats, western yellow bats, California leaf-nosed bats, and Townsend's big-eared bats. Acoustic bat calls were recorded nightly from sunset to sunrise, and the files were processed using filters and methods that have been used on previous LCR MSCP acoustic monitoring projects (Broderick 2008). Using Analook software, a series of acoustic filters were created for the focal bat species. The analysis was based on first running files through an "All bats" filter to eliminate any files with significant background and insect noise. Then, the remaining calls were run through species-specific filters and analyzed individually to sort out species with similar call envelopes to the four focal species. Western red bat calls were then run through two species-specific filters (a low frequency and a high frequency). The low-frequency filter detected bat calls ending between 40–47.5 kilohertz, while the high-frequency filter detected bat calls ending between 52–80 kilohertz. The high-frequency filters were applied after discussions with Reclamation biologists (Broderick and Calvert 2011, personal communication) revealed they had recorded western red bat calls at higher frequencies along the LCR. Townsend's big-eared bats are known to emit low-intensity vocalizations in an attempt to capture their Lepidopteran prey, which makes them difficult to detect with acoustic methods (O'Farrell and Gannon 1999). Pale Townsend's big-eared bats produce a dual harmonic and cannot be positively identified unless the presence of this diagnostic harmonic is detected. The calls were compared and the filters tested on hand-release reference calls recorded along the LCR provided by Reclamation biologists (Broderick and Calvert 2011, personal communication) and reference calls from across the Southwestern United States. All calls that were flagged as a species of interest were visually analyzed, and only those calls that fit all of the call parameters for the given species and that could confidently be identified are presented.

Call minutes were used in order to reduce bias in estimating bat activity at Anabat™ stations. A call minute is defined as a 1-minute interval in which a particular species is recorded at least once, regardless of the number of call sequences, or the number of files for that species recorded within that minute (Broderick 2010; Brown 2006; Kalcounis et al. 1999). The call minutes index reduces the bias associated with the tendency for individual bats to be detected multiple times or for multiple bats of a single species to be detected within an individual file (Miller 2001; Williams et al. 2006; Vizcarra et al. 2010). Bat

minutes give a relative measure of activity while reducing the tendency to classify calls as the result of one bat making multiple calls or many bats making a single call. Therefore, data were also analyzed using a presence/absence framework as the measure of occupancy and are presented as nights occupied and proportion of nights occupied at the permanent stations. The approach is based on naïve occupancy (i.e., if the species is present and within range of the stations, it will be detected). Therefore, detection probabilities are not taken into account (i.e., imperfect detections). It should be noted that detection is indicative of presence, but non-detection of the species is not equivalent to absence (MacKenzie et al. 2002). Monitoring was limited to the distance in which the station could record reliable bat calls, and it is not known if a bat was present or absent just beyond the range of the station. Stations were compared based on average nightly call minutes per species per station as well as total nights a species occupied the station area during the year. Because results may be biased based on station malfunctions, data based on average nightly call minutes per month were also compared, which removed nights when a station was not recording. As such, the comparisons among stations represent a qualitative measure of relative activity and are not to be extrapolated to evaluate population dynamics or occupancy trends. There is no best way to deal with stations that have malfunctioned, but it is believed that the methods provide a simple, standardized way of comparing relative activity across the stations and species.

RESULTS

Western Red Bat

The greatest average nightly call minutes and proportion of nights occupied for western red bats were detected at the BWRNWR, followed by HNWR-Pintail, the MLWA, and the PSRA. No western red bat activity was recorded at CNWR-Island (table 2 and figures 2 and 3). The greatest average nightly call minutes and proportion of nights were recorded for the BWRNWR, HNWR-Pintail, and the PSRA during the month of July and during the month of August for the MLWA (figures 2 and 3). Two peaks in recorded activity were recorded throughout the night. The first peak occurred between 20:00–20:59 and the second occurring from 04:00–05:59 (figure 4).

Table 2.—Western red bat activity and nights occupied at system-wide monitoring sites in 2015

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
BWRNWR	0.52	31	0.34
PSRA	0.02	2	0.02
MLWA	0.13	11	0.12
CNWR-Island	0	0	0
HNWR-Pintail	0.18	9	0.14

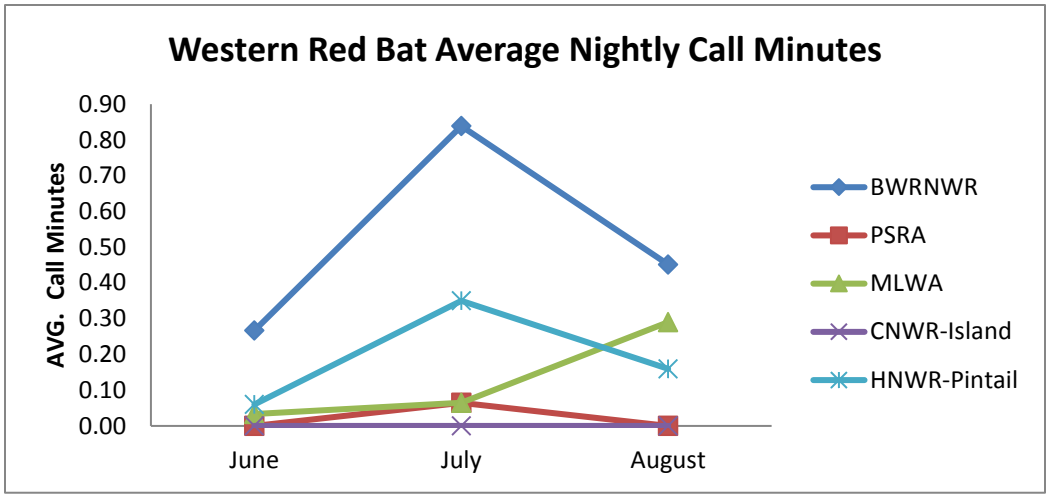

Figure 2.—Western red bat average nightly call minutes.

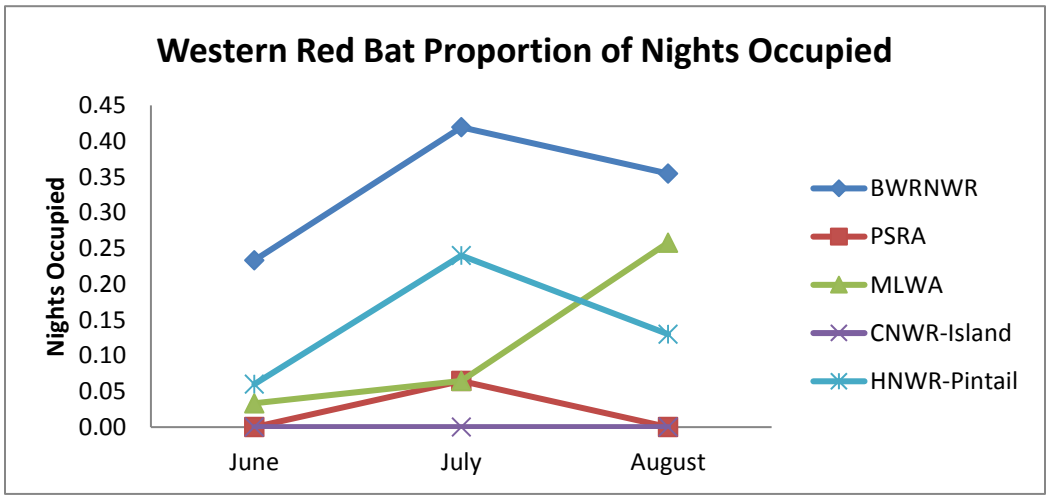

Figure 3.—Western red bat proportion of nights occupied.

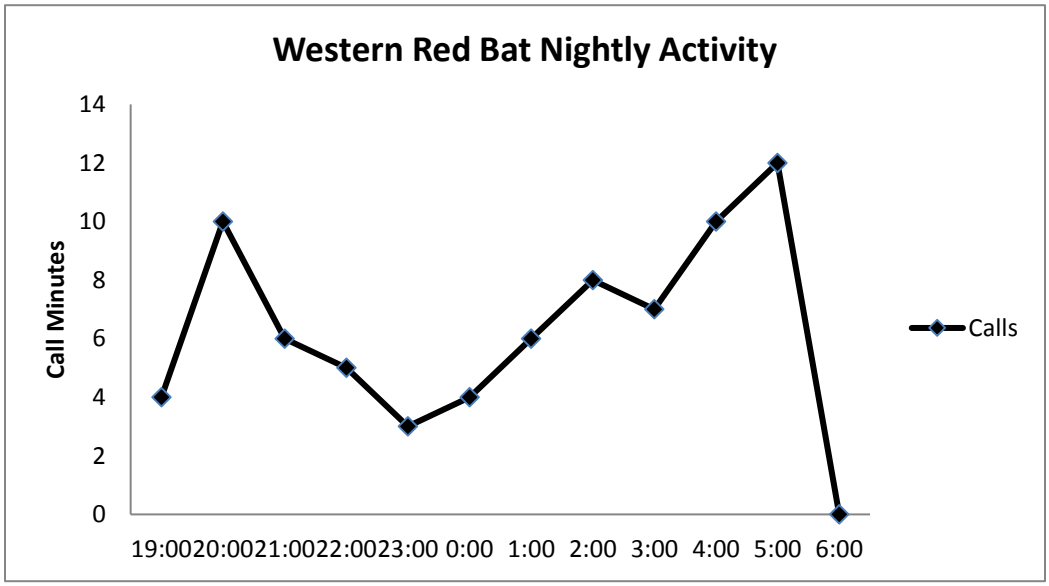

Figure 4.—Western red bat nightly activity patterns at all stations.

Western Yellow Bat

The greatest average nightly call minutes and proportion of nights occupied for western yellow bats were recorded at HNWR-Pintail, followed by the MLWA and BWRNWR. No western yellow bat activity was recorded at CNWR-Island or the PSRA (table 3, figures 5 and 6). The greatest average nightly call minutes and proportion of nights occupied were recorded at the MLWA and HNWR-Pintail during the month of August and during the month of June for the BWRNWR (figures 5 and 6). Two peaks of recorded activity were recorded throughout the night. The first peak occurred between of 23:00–23:59 and the second from 03:00–03:59 (figure 7).

Table 3.—Western yellow bat activity and nights occupied at system-wide monitoring sites in 2015

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
HNWR-Pintail	0.06	3	0.05
BWRNWR	0.01	1	0.01
CNWR-Island	0	0	0
PSRA	0	0	0
MLWA	0.05	3	0.03

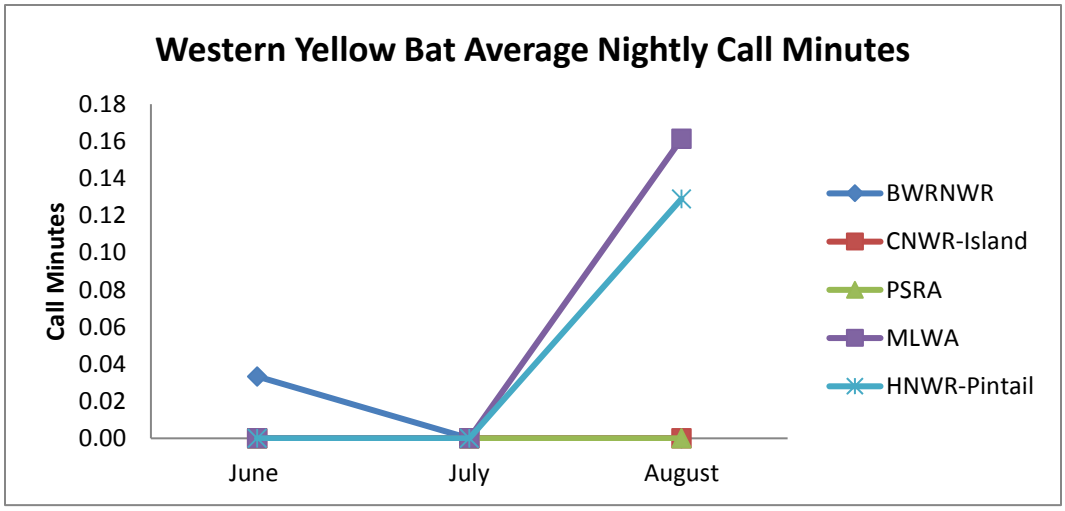

Figure 5.—Western yellow bat average nightly call minutes.

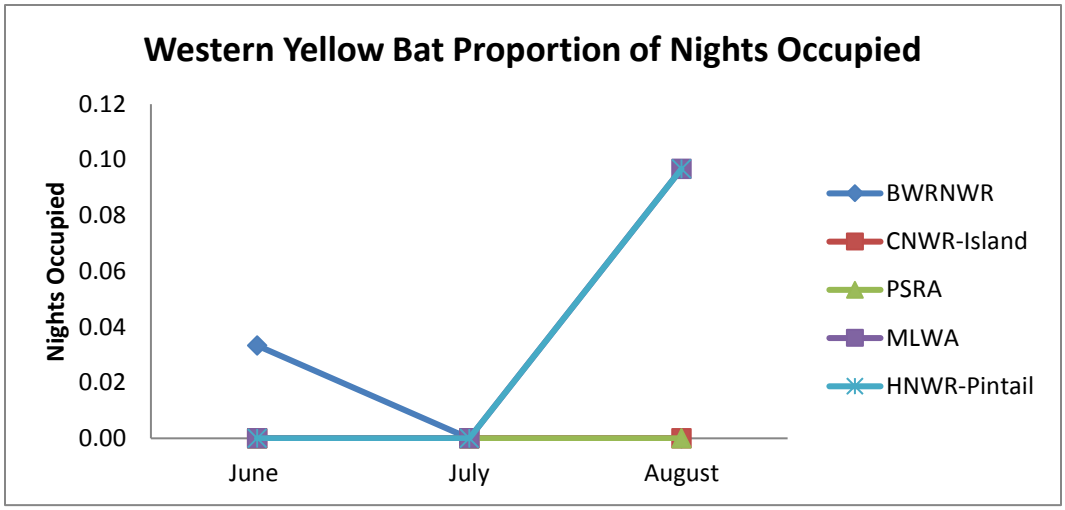

Figure 6.—Western yellow bat proportion of nights occupied.

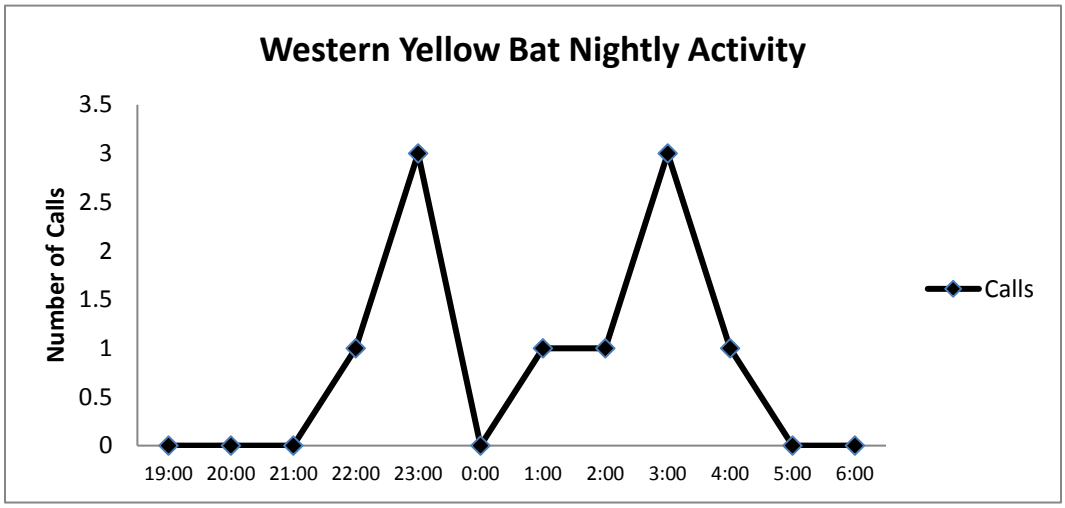

Figure 7.—Western yellow bat nightly activity patterns at all stations.

California Leaf-Nosed Bat

The greatest average nightly call minutes and proportion of nights occupied were recorded at the PSRA, followed by the BWRNWR and CNWR-Island. No activity was recorded at HNWR-Pintail or the MLWA (table 4 and figures 8 and 9). The greatest average nightly call minutes and proportion of nights occupied during the month of June were recorded at the PSRA and CNWR-Island and during the month of August for the BWRNWR (figures 8 and 9). California leaf-nosed bat nightly activity was sporadic throughout the night, with the peak in activity occurring between 0:100–0:159 (figure 10).

Table 4.—California leaf-nosed bat activity and nights occupied at system-wide monitoring sites in 2015

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
HNWR-Pintail	0	0	0
BWRNWR	0.12	10	0.11
CNWR-Island	0.02	2	0.02
PSRA	0.26	19	0.21
MLWA	0	0	0

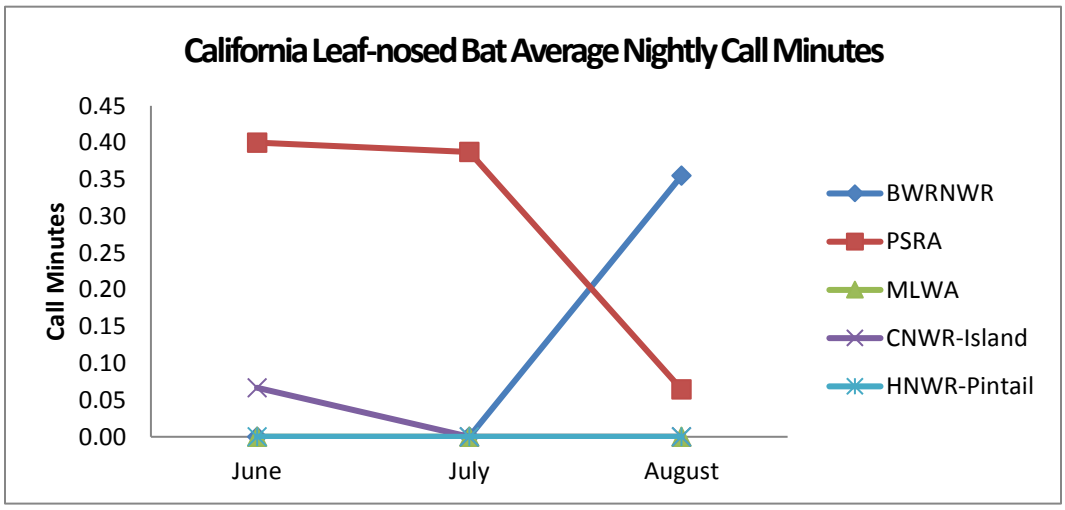

Figure 8.—California leaf-nosed bat average nightly call minutes.

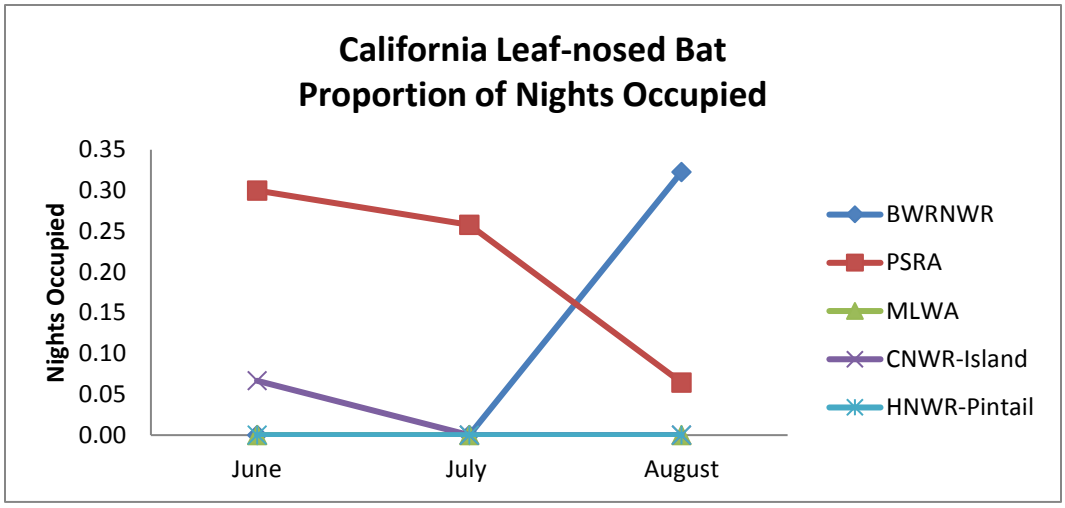

Figure 9.—California leaf-nosed bat proportion of nights occupied.

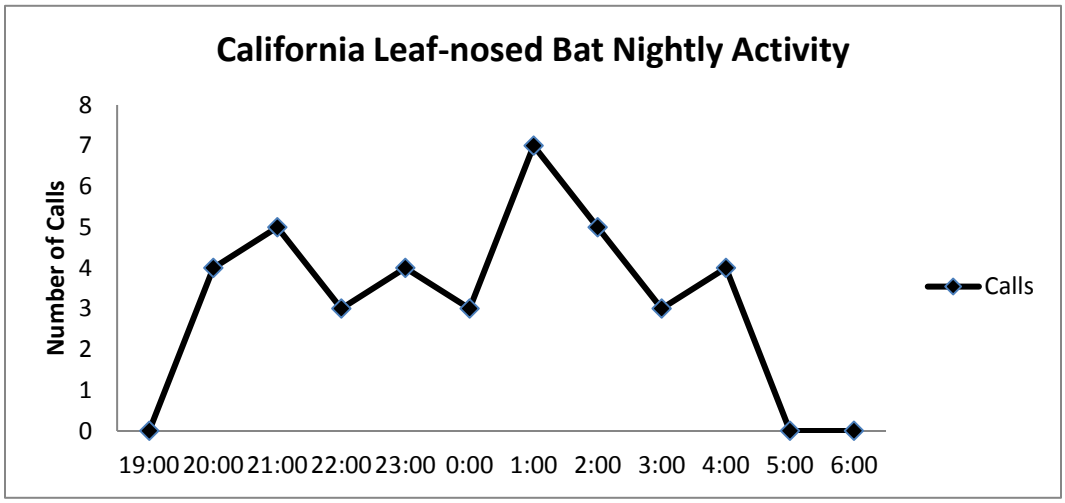

Figure 10.—California leaf-nosed bat nightly activity patterns at all stations.

Yearly Activity

Western Red Bat

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at the BWRNWR during the 2010 season, followed by 2014, 2015, 2011, 2012, and 2013. A decrease in average nightly call minutes and proportion of nights occupied from 2010 through 2013 was recorded. An increase in detections in the 2014 and 2015 seasons from the low in 2013 was noted (figure 11). From 2010 through 2015, the greatest average nightly call minutes and proportion of nights occupied for western red bats were recorded at the BWRNWR among all system-wide monitoring stations.

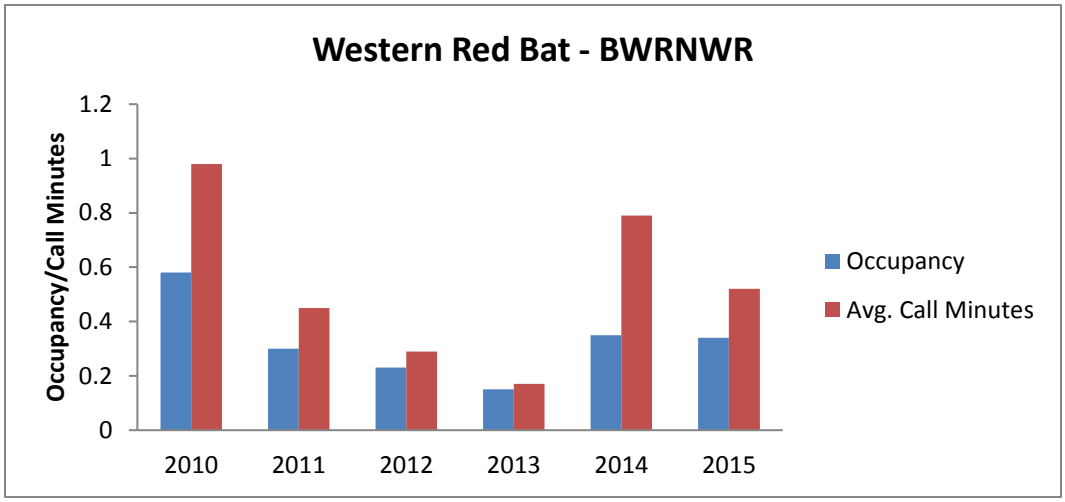

Figure 11.—Western red bat average call minutes and proportion of nights occupied at the BWRNWR.

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at CNWR-Island during the 2010 season, followed by 2011, 2014, 2012, 2013, and 2015. The only season no call minutes were recorded for western red bats at CNWR-Island was in 2015. A decrease was recorded starting in 2010 through 2013, with an increase in 2014, followed by no activity in 2015 (figure 12). The fourth greatest average nightly call minutes and proportion of nights occupied were recorded at CNWR-Island from 2010 through 2015.

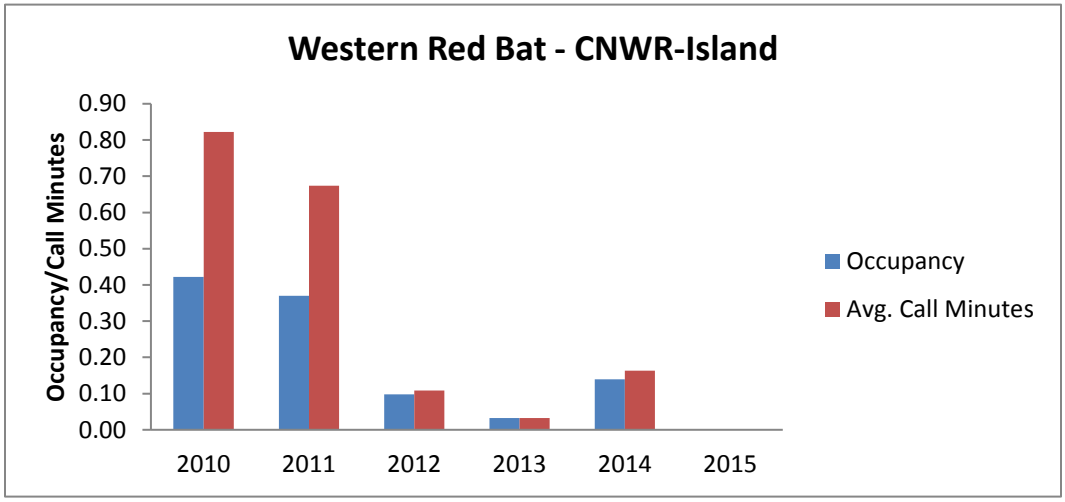

Figure 12.—Western red bat average call minutes and proportion of nights occupied at CNWR-Island.

The greatest average nightly call minutes at the MLWA were recorded during the months of June, July, and August during the 2011 and 2014 seasons, followed by 2013, 2012, 2010, and 2015. The greatest proportion of nights occupied at the

MLWA was recorded during the 2014 season, followed by 2011, 2013, 2012, 2010, and 2015. The average nightly call minutes and proportion of nights occupied varied among seasons and showed no trends (figure 13). From 2010 through 2015, the second greatest average nightly call minutes were at MLWA and NWR-Pintail, and the second greatest proportion of nights occupied for western red bats were recorded at the MLWA.

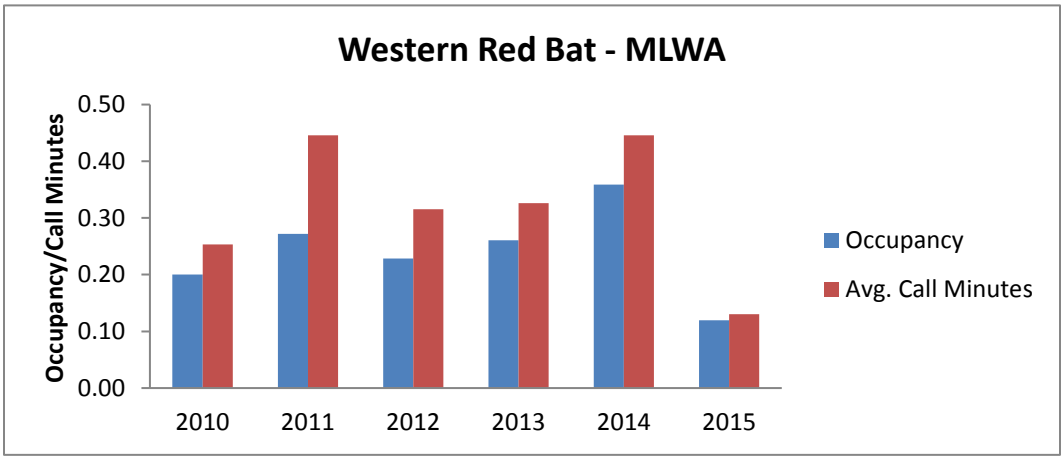

Figure 13.—Western red bat average call minutes and proportion of nights occupied at the MLWA.

The greatest average nightly call minutes and proportion of nights occupied at the PSRA were recorded during the months of June, July, and August during the 2011 season, followed by 2013, 2012, 2014, and 2015. No call minutes were recorded during the 2010 season. A decrease in detections was recorded at the PSRA from 2013 through 2015 (figure 14). The lowest average nightly call minutes and proportion of nights occupied for western red bats were recorded at the PSRA from 2010 through 2015.

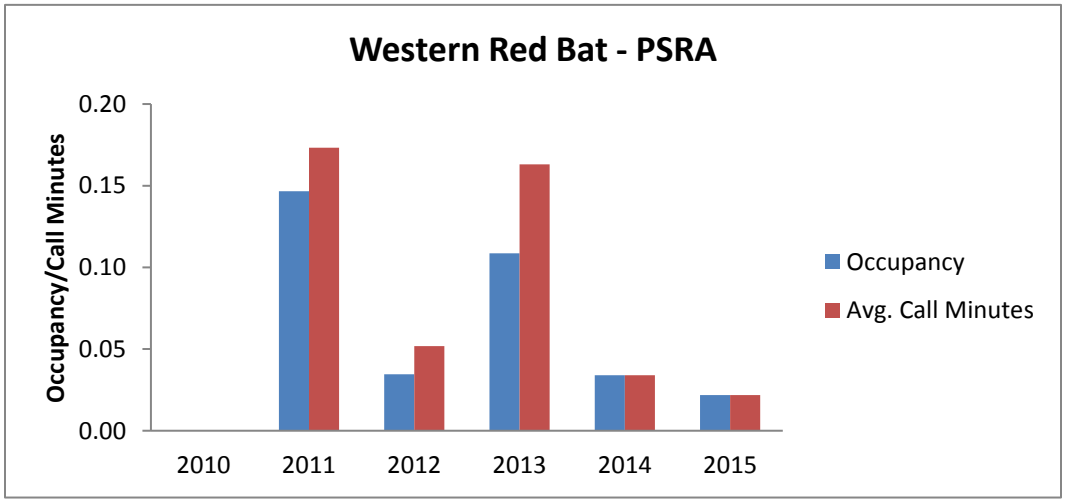

Figure 14.—Western red bat average nightly call minutes and proportion of nights occupied at the PSRA.

The greatest average nightly call minutes and proportion of nights occupied at HNWR-Pintail were recorded during the months of June, July, and August during the 2014 season, followed by 2015 (figure 15). No real trends have emerged, as this station has only been recording since 2014. The pattern for average call minutes from 2014 through 2015 is similar to what was observed at other sites, with more relative activity occurring in 2014 than 2015. From 2010 through 2015 (2014–15 for HNWR-Pintail), the second greatest average nightly call minutes were at HNWR-Pintail and MLWA, and the third greatest proportion of nights occupied for western red bats were recorded at HNWR-Pintail.

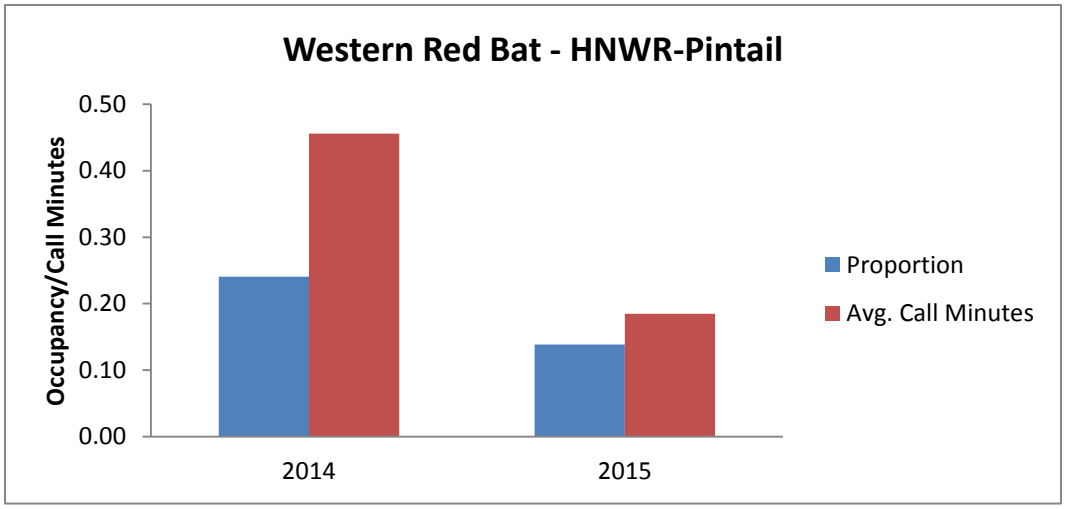

Figure 15.—Western red bat average nightly call minutes and proportion of nights occupied at HNWR-Pintail.

Western Yellow Bat

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at the BWRNWR during the 2010 season, followed by 2014, 2012 and 2013, 2011, and 2015. The average nightly call minutes and proportion of nights occupied varied among seasons and showed no trends (figure 16). The greatest average nightly call minutes and greatest proportion of nights occupied for western yellow bats were recorded at the BWRNWR from 2010 through 2015.

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at the CNWR-Island during the 2011 season, followed by 2010, 2011, and 2014. No call minutes were recorded at the CNWR-Island during the 2013 and 2015 season. An overall downward trend in average call minutes and proportion of nights occupied was recorded from 2011 through 2015 (figure 17). From 2010 through 2015, the greatest average nightly call minutes were recorded at CNWR-Island and BWRNWR, and second greatest proportion of nights occupied for western yellow bats were recorded at CNWR-Island and the MLWA.

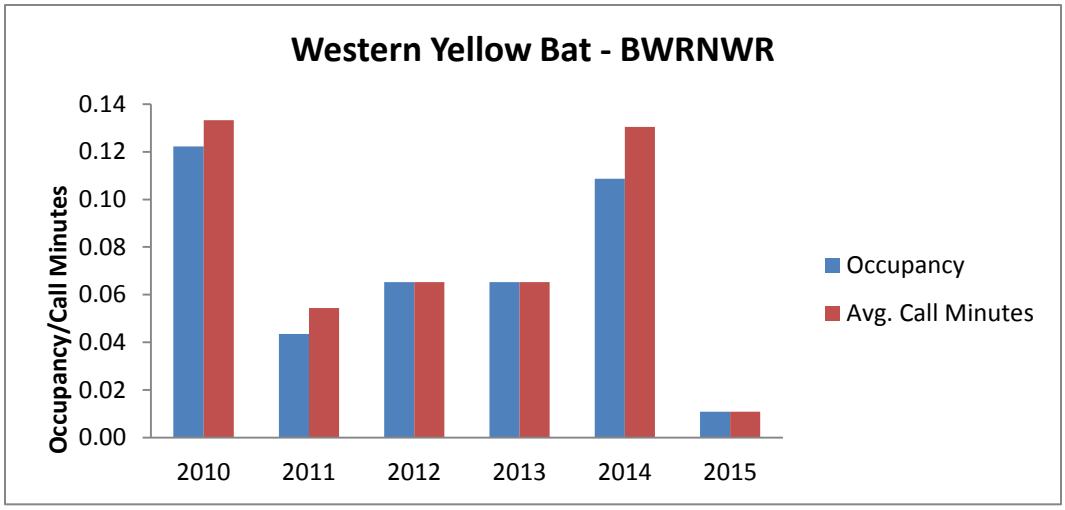

Figure 16.—Western yellow bat average nightly call minutes and proportion of nights occupied at the BWRNWR.

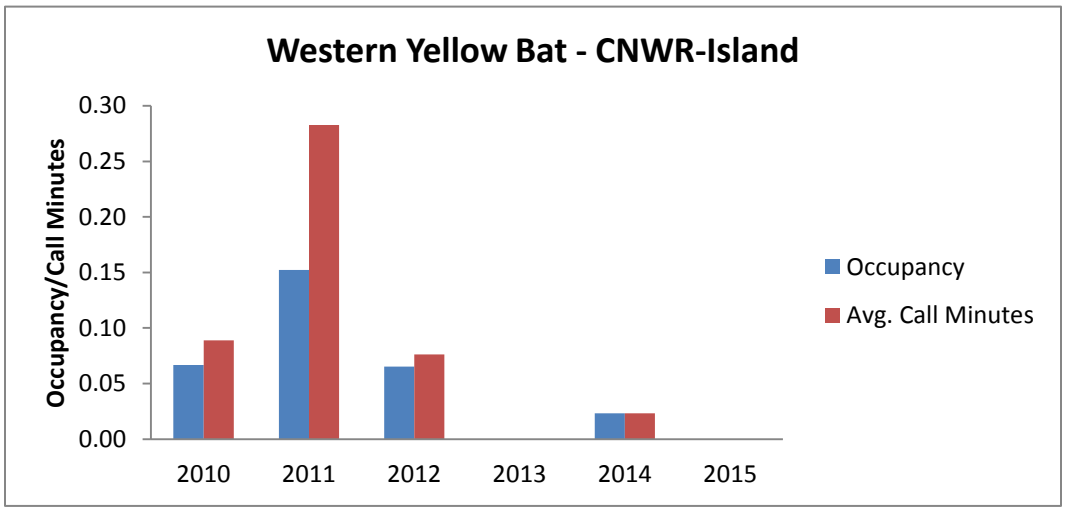

Figure 17.—Western yellow bat average nightly call minutes and proportion of nights occupied at CNWR-Island.

The greatest average nightly call minutes were recorded at the MLWA during the 2010 season, followed by 2012, 2013, 2015, 2011, and 2014. The greatest proportion of nights occupied were recorded during the 2010 season, followed by 2012 and 2013, 2015, 2011, and 2014. The average nightly call minutes and proportion of nights occupied varied among seasons, but an overall decrease since 2010 has emerged (figure 18). The third greatest average nightly call minutes were recorded at the MLWA, and the second greatest proportion of nights occupied for western yellow bats were recorded at the MLWA and CNWR-Island from 2010 through 2015.

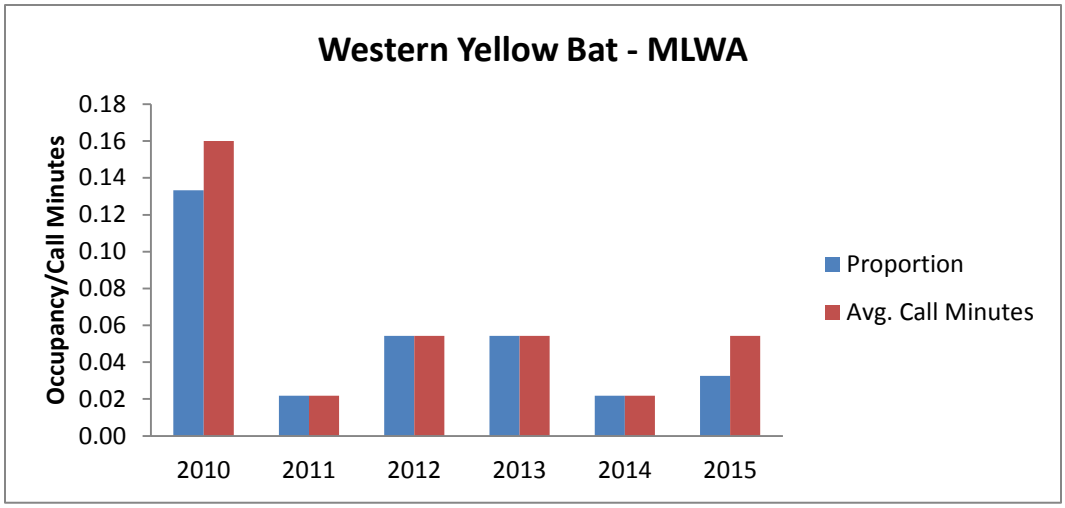

Figure 18.—Western yellow bat average nightly call minutes and proportion of nights occupied at the MLWA.

The greatest average nightly call minutes and proportion of nights occupied were recorded at the PSRA during the months of June, July, and August during the 2011 season, followed by 2012, 2014, and 2013. The average nightly call minutes and proportion of nights occupied varied among seasons and showed no trends (figure 19). From 2010 through 2015, the lowest average nightly call minutes and proportion of nights occupied for western yellow bats were recorded at the PSRA.

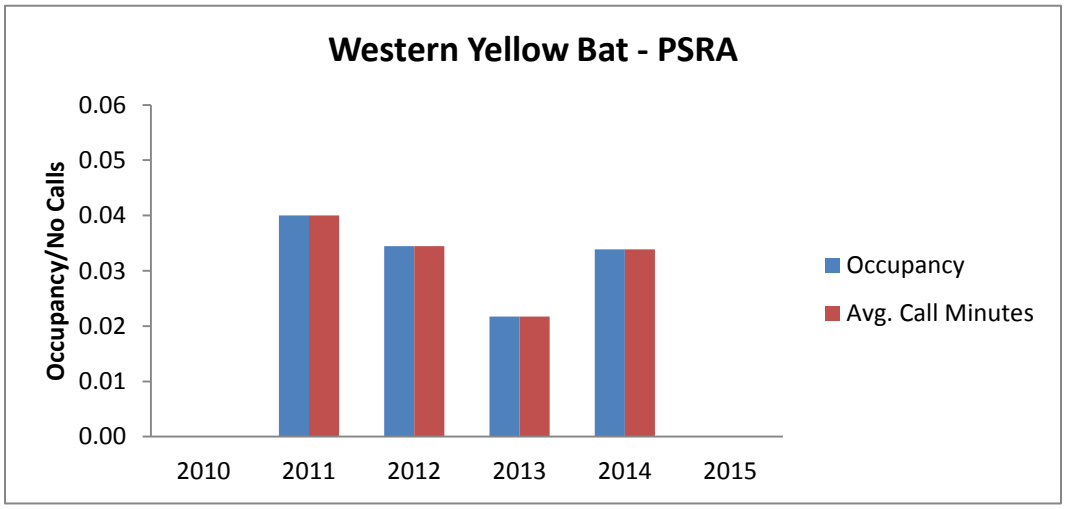

Figure 19.—Western yellow bat average nightly call minutes and proportion of nights occupied at the PSRA.

The greatest average nightly call minutes and proportion of nights occupied were recorded at HNWR-Pintail during the 2015 season, followed by 2014 (figure 20). No real trends have emerged, as this station has only been installed since 2014. From 2010 through 2015 (2014–15 for HNWR-Pintail), the fourth greatest average nightly call minutes and proportion of nights occupied for western yellow bats were recorded at HNWR-Pintail.

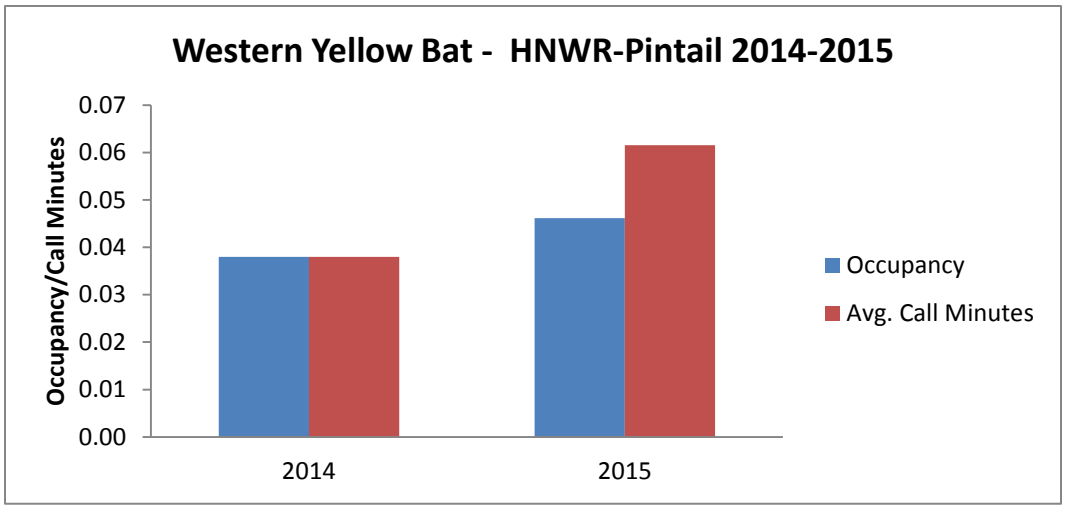

Figure 20.—Western yellow bat average nightly call minutes and proportion of nights occupied at HNWR-Pintail.

California Leaf-Nosed Bat

The greatest average nightly call minutes and proportion of nights occupied were recorded at the BWRNWR during the months of June, July, and August during the 2013 season, followed by 2015, 2012, 2014, and 2010. No call minutes were recorded during the 2011 season. The average nightly call minutes and proportion of nights occupied varied among seasons and showed no trends, with the exception of the spike during the 2013 season (figure 21). The second greatest average nightly call minutes and proportion of nights occupied for California leaf-nosed bats were recorded at the BWRNWR from 2010 through 2015.

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at CNWR-Island during the 2010 season, followed by 2012, 2011, 2015, and 2013. No call minutes were recorded during the 2014 season. An overall downward trend from 2012 through 2015 (figure 22) has been noted. From 2010 through 2015, the third greatest average nightly call minutes were recorded at CNWR-Island and the MLWA, and fourth greatest proportion of nights occupied for California leaf-nosed bats were recorded at CNWR-Island.

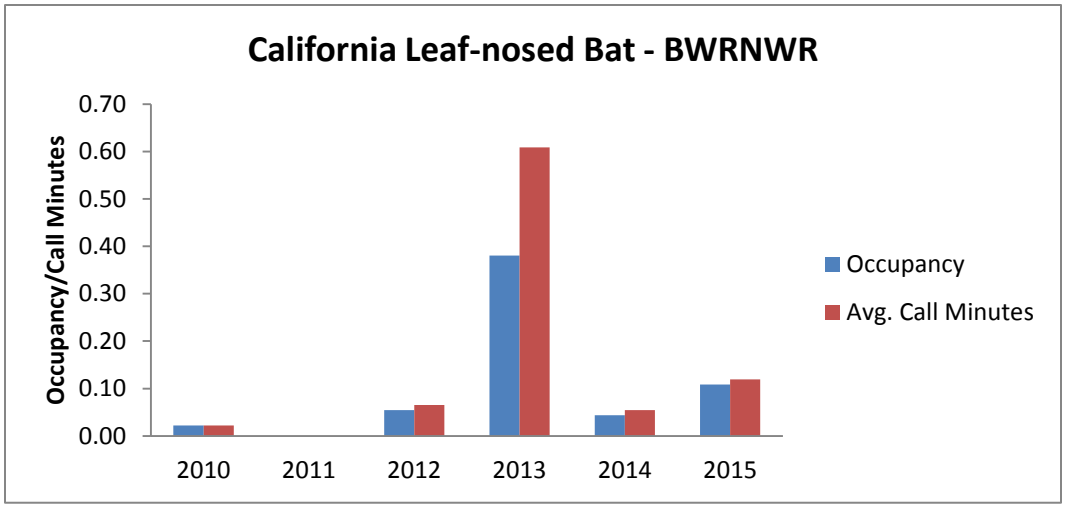

Figure 21.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at the BWRNWR.

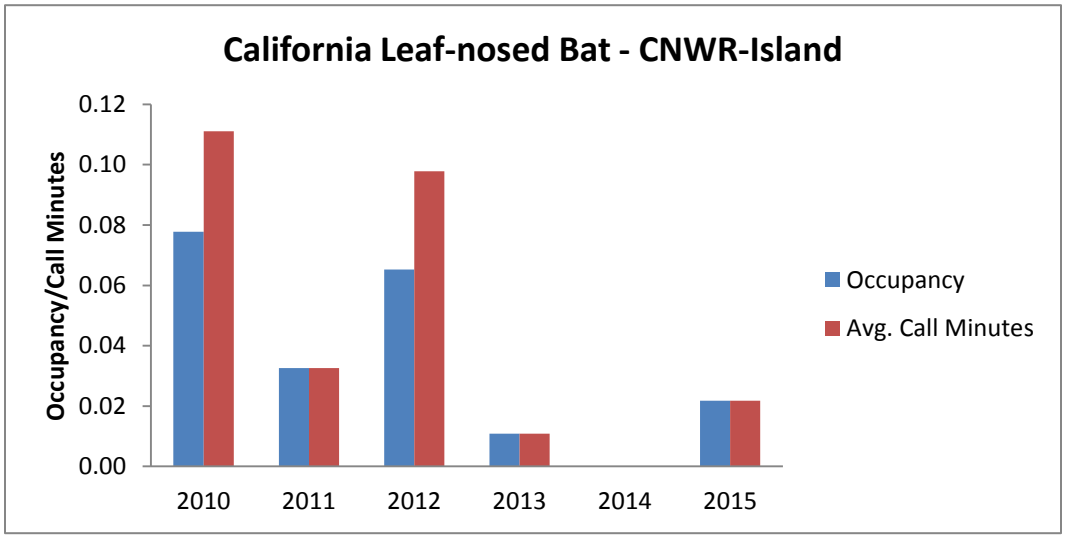

Figure 22.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at CNWR-Island.

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at the MLWA during the 2010 season, followed by 2013, 2011, and 2012. No call minutes were recorded during the 2014 and 2015 seasons. The average nightly call minutes and proportion of nights occupied varied among seasons, but a decrease has been documented from 2010 to 2015 (figure 23). From 2010 through 2015, the third greatest average nightly call minutes were recorded at the MLWA and CNWR-Island, and the third greatest proportion of nights occupied for California leaf-nosed bats were recorded at the MLWA.

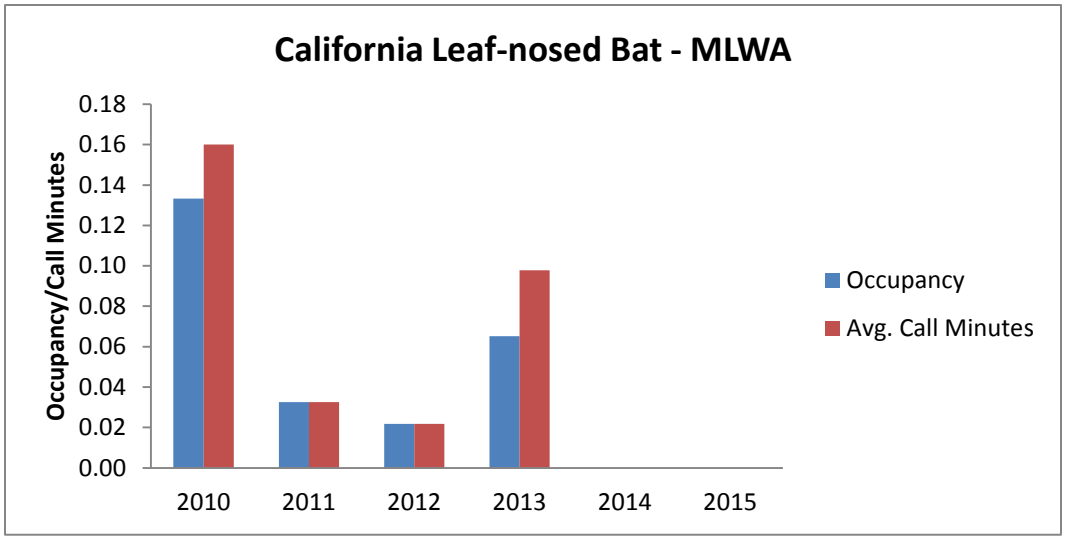

Figure 23.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at the MLWA.

The greatest average nightly call minutes and proportion of nights occupied during the months of June, July, and August were recorded at the PSRA during the 2013 season, followed by 2014, 2012, 2015 and 2011. No call minutes were recorded during the 2010 season. The average nightly call minutes and proportion of nights occupied varied among seasons, with an increase occurring through 2014, with a slight decrease in 2015 (figure 24). The greatest average nightly call minutes and greatest proportion of nights occupied for California leaf-nosed bats were recorded at the PSRA from 2010 through 2015.

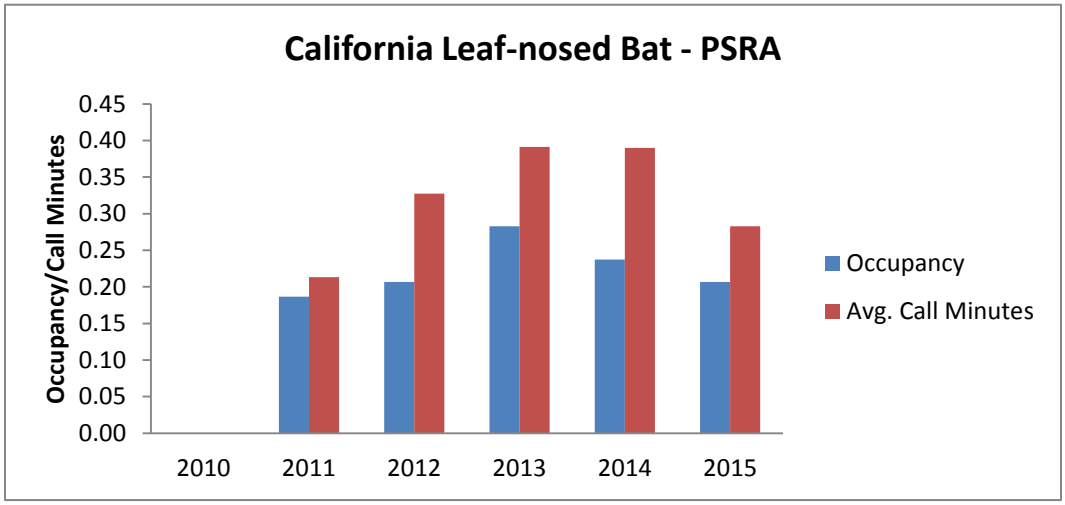

Figure 24.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at the PSRA.

Townsend's Big-Eared Bat

The only calls recorded from 2010 through 2015 during the months of June, July, and August were two calls and 2 days of occupancy at the BWRNWR in 2013 and one call and 1 day of occupancy at CNWR-Island in 2013.

DISCUSSION

During 2015 monitoring, the greatest average call minutes and proportion of nights occupied for western red bats were recorded during the month of July. July is the month when western red bat young become volant, most likely leading to the increase in activity. The sites exhibiting the greatest activity during July were the BWRNWR and HNWR-Pintail. These sites or adjacent areas most likely contain suitable roosting habitat for this species. Activity at the BWRNWR and HNWR-Pintail decreased in August, which suggests these bats were beginning to migrate out of that area during that month. There was an increase in average call minutes and proportion of nights occupied during August at the MLWA. The MLWA is the most southern site, and this increase may also be attributed to the start of migration. No activity was recorded at CNWR-Island, which may still be experiencing the effects of the fire that burned this area in August 2011.

Western red bat average nightly call minutes and proportion of nights occupied has varied widely across and within sites from 2010 through 2015, with the exception of CNWR-Island. A clear downward trend is present at CNWR-Island beginning in 2012. The fire at CNWR-Island occurred on August 29, 2011, and burned the entire cottonwood-willow (*Populus fremontii*, *Salix gooddingii*) habitat surrounding the station. Cottonwoods, and to a lesser extent willows, are the preferred roosting trees for western red bats along the LCR (Diamond et al. 2015). To date, this vegetation has not recovered in the area surrounding the station.

The greatest average call minutes and proportion of nights occupied for western yellow bats during 2015 monitoring were recorded in August. Overall, low activity for western yellow bats was recorded at the sites, with HNWR-Pintail and the MLWA recording the greatest average nightly call minutes and proportion of nights occupied. No activity for western yellow bats was recorded at CNWR-Island or the PSRA. Western yellow bats roost almost exclusively in the skirts of non-native palm trees. Western yellow bats were documented using Mexican fan palms (*Washingtonia robusta*) and date palms (*Phoenix dactylifera*) along the LCR in 2011–13. The lack of these palms in the vicinity of the PSRA explains why no activity was recorded at this site. There are palms surrounding the CNWR-Island site, and the absence of activity may be the result of habitat lost in the fire in August 2011.

Across and within all sites from 2010 through 2015, western yellow bat average nightly call minutes and proportion of nights occupied has varied widely, again

with the exception of CNWR-Island. As was recorded with western red bats, western yellow bat average nightly call minutes and proportion of nights occupied at CNWR-Island has displayed a downward trend beginning in 2012 (the year after the fire). There seems to be an abundance of suitable palm tree roosts within the vicinity of CNWR-Island, so it may be that the fire disturbed the prey base in the area, resulting in the bats going elsewhere to forage.

During 2015 monitoring, the greatest average call minutes and proportion of nights occupied for California leaf-nosed bats were recorded during August, but June and July displayed similar levels of activity. The greatest average nightly call minutes and proportion of nights occupied were recorded at the PSRA and BWRNWR. California leaf-nosed bats are limited by the distance they can travel from their cavern roosts to forage, suggesting there are roosts near the PSRA and BWRNWR. Low activity levels were recorded at CNWR-Island, which is surprising because it is close to a known California leaf-nosed bat roost. This low level of activity may also be the result of habitat lost in the August 2011 fire.

California leaf-nosed bat average nightly call minutes and proportion of nights occupied varied widely, as well as across and within sites from 2010 through 2015, but displayed a decrease at CNWR-Island (2013–15) and the MLWA (2014–15). These decreases in nightly call minutes and proportion of nights occupied are relatively small and may be a cyclical natural pattern of activity for this species rather than a true decrease. The decrease at CNWR-Island did not coincide with the fire but started the following year. The reason for the downward trend at the MLWA is unknown but may be attributed to two fires that burned in the vicinity of the station in December 2014 and August 2015. California leaf-nosed bat calls are difficult to detect in that they emit low-frequency calls, which are not always picked up by the microphone, and their calls resemble two common species of *myotis* found along the LCR. Their calls were recorded in low numbers (with the exception of the PSRA), and the downward trends at CNWR-Island and the MLWA may be a result of this species biology/ecology and not an actual decline in activity.

No diagnostic calls for Townsend's big-eared bats were recorded during 2015 monitoring using the conservative method of identifying calls to species. The only calls recorded from 2010 through 2015 during the months of June, July, and August were two calls and 2 days of occupancy at the BWRNWR in 2013 and one call and 1 day of occupancy at CNWR-Island in 2013.

A fire at HNWR-Pintail started on August 8, 2015. The area surrounding the station burned, but left it operational, and a large patch of cottonwoods was also left unburned. Western red and yellow bat calls were detected after the fire, but it will be interesting to monitor the impacts this fire may have on bat activity into the future.

While summer residency is an important activity to monitor, the greatest activity for western red and yellow bats have been recorded at system-wide monitoring stations during migration periods (Mixan and Diamond, in press). This trend lends support to these areas providing important foraging and possibly roosting habitat as these species migrate along the LCR. At the BWRNWR, the majority of activity for western red bats was detected during the months of October, November, December, March, and April. At the MLWA, the greatest activity was detected during April and May. For western yellow bats, the greatest activity was detected during March and April at the BWRNWR, and the greatest activity was recorded at the MLWA during February, March, and April. These activity patterns suggest these two tree-roosting species are using system-wide monitoring sites mainly during migration. The opposite trend for activity was seen at LCR MSCP conservation areas, with these species exhibiting the greatest average nightly call minutes and proportion of nights occupied during the summer months (Mixan and Diamond 2014). This trend lends support to LCR MSCP conservation areas providing significant foraging and roosting habitat for these species. It is plausible that before these LCR MSCP conservation areas existed, western red bats utilized the LCR as mainly a migratory corridor, with minimal suitable habitat to provide the resources needed to support a larger resident population. These LCR MSCP conservation areas also seem to be providing increased foraging opportunities for western yellow bats, California leaf-nosed bats, and Townsend's big-eared bats as documented by acoustic and capture surveys.

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