Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2019 Post-Development Acoustic Monitoring of LCR MSCP Bat Species

March 2021

Work conducted under LCR MSCP Work Task F4

Lower Colorado River Multi-Species Conservation Program Steering Committee Members

Federal Participant Group

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

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The Nature Conservancy

Lower Colorado River Multi-Species Conservation Program

2019 Post-Development Acoustic Monitoring of LCR MSCP Bat Species

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ACRONYMS AND ABBREVIATIONS

ANPA	pallid bat *(Antrozous pallidus*)
BLCA	Beal Lake Conservation Area
BLCA1	Beal Lake Conservation Area acoustic station
CLNB	California leaf-nosed bat (*Macrotus californicus*)
CNU1	acoustic station initially deployed in 2011 at the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail
Crane Roost	Cibola National Wildlife Refuge Unit #1 acoustic station
CVCA	Cibola Valley Conservation Area
CVCA1	Cibola Valley Conservation Area acoustic station #1
CVCA2	Cibola Valley Conservation Area acoustic station #2
EPFU	big brown bat (*Eptesicus fuscus*)
EUMA	spotted bat (*Euderma maculatum*)
EUPE	greater mastiff bat (*Eumops perotis*)
i.e.	*id est*; that is
LACI	hoary bat (*Lasiurus cinereus*)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MYCA	California myotis (*Myotis californicus*)
MYOC	Arizona myotis (*Myotis occultus*)
MYVE	cave myotis (*Myotis velifer*)
MYYU	Yuma myotis (*Myotis yumanensis*)
PAHE	canyon bat (*Parastrellus hesperus*)
PVER	Palo Verde Ecological Reserve
PVER1	Palo Verde Ecological Reserve acoustic station #1
PVER2	Palo Verde Ecological Reserve acoustic station #2
PTBB	pale Townsend's big-eared bats (*Corynorhinus townsendii* also known as *Plecotus townsendii pallescens* and *Corynorhinus townsendii townsendii*)
TABR	Mexican free-tailed bat (*Tadarida brasiliensis*)
WRBA	western red bat (*Lasiurus blossevillii*)
WYBA	western yellow bat (*Lasiurus xanthinus* = *Dasypterus xanthinus*)

Symbols

%	percent
™	trademark

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Attachment

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EXECUTIVE SUMMARY

Acoustic bat call data were analyzed from six acoustic monitoring stations (Anabat™) along the lower Colorado River from June 1 to August 31, 2015–19. These stations were located within Lower Colorado River Multi-Species Conservation Program (LCR MSCP) conservation areas that consist of Fremont cottonwood-Goodding's willow (*Populus fremontii-Salix gooddingii*), honey mesquite (*Prosopis glandulosa*), marsh, and backwater habitats. The acoustic recordings were analyzed for the calls of four bat species for which habitat and/or conservation actions are being implemented by the LCR MSCP: western red bat (*Lasiurus blossevilli*) (LABL), western yellow bat (*Lasiurus xanthinus* = *Dasypterus xanthinus*) (LAXA), California leaf-nosed bat (*Macrotus californicus*) (CLNB), and pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* also known as *Plecotus townsendii pallescens* and *Corynorhinus townsendii townsendii*) (PTBB).[1] The acoustic recordings were also analyzed for the calls of western red and yellow bats, California leaf-nosed bats, pale Townsend's big-eared bats, and 11 additional bat species using the Kaleidoscope auto-classifier (Kaleidoscope Pro version 5.1.1) in order to compare the effectiveness of this software at detecting and distinguishing bat species along the lower Colorado River against the Analook Zero-Crossings Analysis using call filters (with visual verification method). In addition to documenting species presence, the project documents the variation in bat activity across time and space to inform LCR MSCP habitat credit accomplishments and habitat management. Calls were also analyzed at four exploratory locations at Planet Ranch to determine the optimal location for a future permanent acoustic station.

Western red bats, western yellow bats, and California leaf-nosed bats were detected at least once at all six permanent acoustic stations from 2015 through 2019. The only pale Townsend's big-eared bat call detected at any location from 2015 through 2019 occurred at the Cibola Valley Conservation Area CVCA2 station in August 2017. Activity and occupancy varied among monitoring sites, years, and species. Through the visual verification method, western red bats were recorded with the greatest activity at the Palo Verde Ecological Reserve PVER1 station, western yellow bats at CVCA1, and California leaf-nosed bats at CVCA2. Western red bat activity and occupancy stayed relatively stable from 2015 through 2019. Western yellow bat activity and occupancy dropped substantially after 2015, remained similar in 2016 and 2017, and dropped again in 2018 and 2019. California leaf-nosed bat activity and occupancy increased in 2017 and 2018, from 2015 and 2016 levels, and then decreased in 2019 from 2017 and 2018.

[1] Genetic analyses on the pale Townsend's big-eared bat indicate that the lower Colorado River 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 lower Colorado River will be referred 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.

Due to the quiet nature of their calls, Pale Townsend's big-eared bat activity was only detected with the Analook visual verification method at the CVCA2 area but were detected using the Kaleidoscope auto-classifier at CVCA1, CVCA2, PVER1, PVER2, and BLCA1, with the highest detections at CVCA1 during the reporting period of June – August 2015–19. The Kaleidoscope auto-classifier for pale Townsend's big-eared bats showed promising results compared with the Analook filters and may lead to more efficient processing of these calls. The Analook filters marked significantly more files as potential pale Townsend's big-eared bat and California leaf-nosed bat calls than the Kaleidoscope auto-classifier. The Kaleidoscope auto-classifier likely overestimated activity for western red and yellow bats and marked more potential calls as western red and yellow bats than the Analook filters. Activity and occupancy for LCR MSCP species and other species assessed with the Kaleidoscope auto-classifier were recorded at the highest levels at the largest, most mature, and complex conservation areas.

Acoustic calls were also analyzed at four exploratory locations on Planet Ranch to determine the future location of a permanent detector. A relatively substantial number of calls for pale Townsend's big-eared bats and California leaf-nosed bats were recorded at these locations.

INTRODUCTION

This document is a summary of acoustic bat call data collected at six acoustic monitoring stations (Anabat™) in six Lower Colorado River Multi-Species Conservation Program (LCR MSCP) conservation areas (Beal Lake Conservation Area, Palo Verde Ecological Reserve, Cibola Valley Conservation Area, and the Cibola National Wildlife Refuge Unit #1 Conservation Area along the lower Colorado River (LCR). The purpose of this project is to monitor the presence of bat species for the LCR MSCP. In addition to documenting species presence, the project documents the variation in bat activity across time and space to inform LCR MSCP habitat credit accomplishments and habitat management.

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. Two methods were compared for identifying bat acoustic calls recorded: the Analook Zero-Crossings Analysis using call filters (with visual verification method) used in prior years and a new method, the Kaleidoscope auto-classifier (Kaleidoscope Pro version 5.1.1). Activity and occurrence estimates using both methods were compared for the 2 covered and evaluation species (western red and western yellow bats) and 11 other species to assess the potential utility of auto-classification as a cost-effective means of call analyzation.

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. The LCR MSCP is required to create 765 acres of western red bat (*Lasiurus blossevillii*) (WRBA) roosting habitat and 765 acres of western yellow bat (*Lasiurus xanthinus* = *Dasypterus xanthinus*) (WYBA) roosting or foraging habitat (LCR MSCP 2004). The LCR MSCP is also evaluating the need to cover two additional species under the program permit: California leaf-nosed bats (*Macrotus californicus*) (CLNB) and pale Townsend's big-eared bats (*Corynorhinus townsendii* also known as *Plecotus townsendii pallescens* and *Corynorhinus townsendii townsendii*) (PTBB).[1]

[1] 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 referred 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.

STUDY AREA

The study area consists of six Anabat™ monitoring stations located along the LCR from the Havasu National Wildlife Refuge in the north to the Cibola National Wildlife Refuge (figure 1). The stations are located on conservation areas created by the LCR MSCP through their Habitat Conservation Plan (LCR MSCP 2004), which requires the creation of over 8,100 acres of various land cover types to provide habitat for targeted LCR MSCP covered species. Four land cover types are integrated in the LCR MSCP and include cottonwood-willow (*Populus fremontii-Salix gooddingii*) (5,940 acres), honey mesquite (*Prosopis glandulosa*) (1,320 acres), marsh (512 acres), and backwater (360 acres). Native species used in the conservation area plantings include coyote willow (*Salix exigua*), desert broom (*Baccharis sarothroides*), Fremont cottonwood, Goodding's willow, heliotrope (*Heliotropium curassavicum*), honey mesquite, mule fat (*Baccharis salicifolia*), quailbush (*Atriplex lentiformis*), and willow baccharis (*Baccharis salicina*). Conservation areas are planted in phases and contain a mixture of mature and maturing vegetation. In addition, some conservation areas, such as the Beal Lake Conservation Area on the Havasu National Wildlife Refuge, are taking longer to mature and have shorter canopy heights compared to sites at the Cibola Valley Conservation Area and Palo Verde Ecological Reserve.

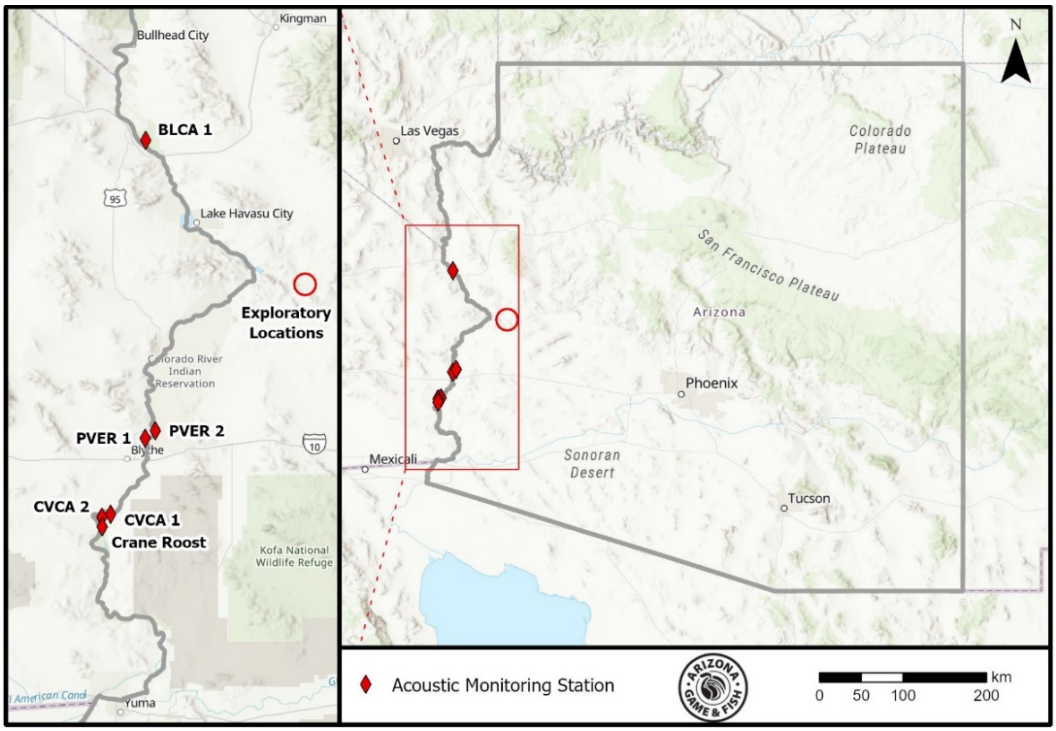

Figure 1.—Study area and location of acoustic monitoring stations.

Acoustic data collected from Planet Ranch in 2016 were also analyzed for this report to determine the optimal location for a future permanent acoustic monitoring station (figure 2).

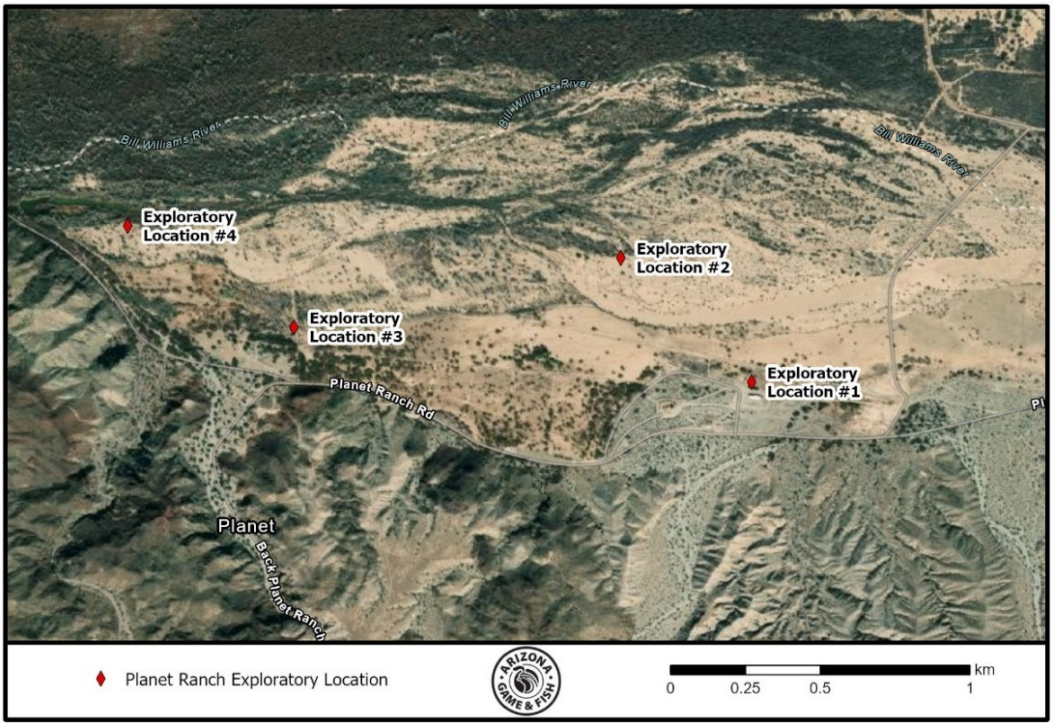

Figure 2.—Exploratory locations at Planet Ranch, 2016.

The Beal Lake Conservation Area is located on Havasu National Wildlife Refuge within the historic floodplain of the LCR. The Beal Lake Conservation Area is 119 acres in size and consists of cottonwood-willow, honey mesquite, and marsh habitat (figure 3). BLCA1 is located in cottonwood-willow habitat.

The Cibola National Wildlife Refuge Unit #1 Conservation Area is located in the Cibola National Wildlife Refuge near Cibola, Arizona. This conservation area is nearly 950 acres in size and consists of a mosaic of 843 acres of the cottonwood-willow and honey mesquite land cover types, with additional agriculture, wetland, native vegetation, and undeveloped land. The CNU1 acoustic station was initially deployed in 2011 at the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail area but was relocated to the Crane Roost area in 2013 because it was determined the Crane Roost site is more similar to other conservation area sites (figure 4). The station was renamed Crane Roost, as it is in a different location.

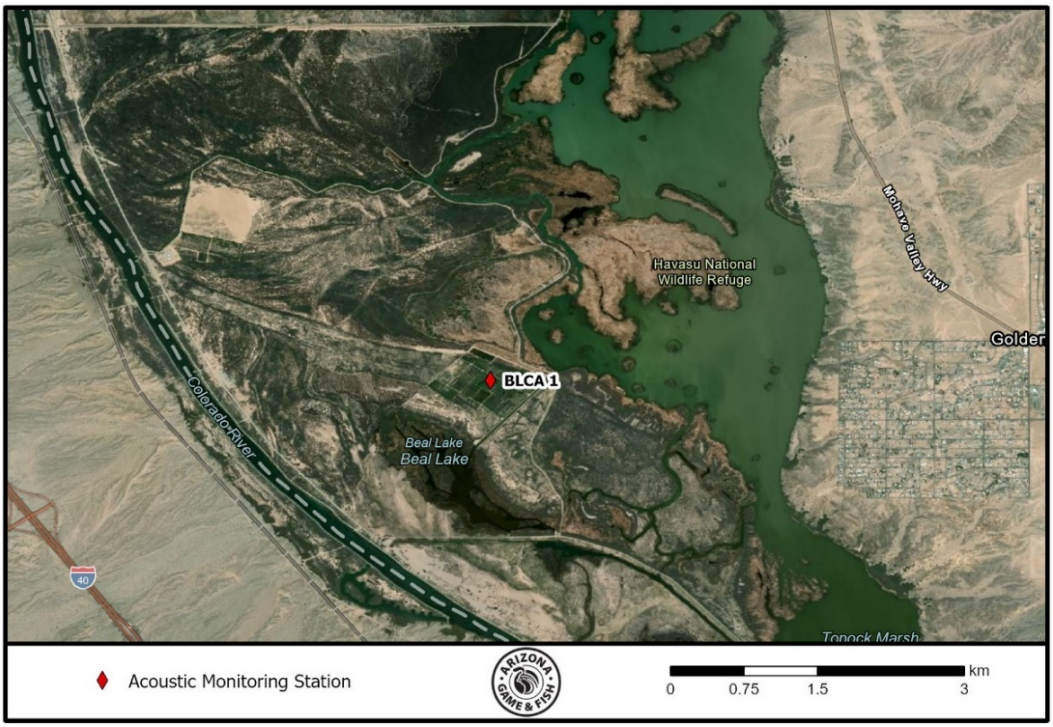

Figure 3.—Beal Lake Conservation Area acoustic monitoring station (BLCA1).

Figure 4.—Cibola Valley Conservation Area and Cibola National Wildlife Refuge Crane Roost location.

The Cibola Valley Conservation Area is located north of Cibola, Arizona, on Arizona Game and Fish owned lands. It consists of 929 acres of cottonwood-willow and honey mesquite. The first station (CVCA1) was deployed in mature cottonwood-willow habitat in 2011. The second station (CVCA2) was deployed in less dense cottonwood-willow habitat 2013 (figure 5). The habitat at both locations in the Cibola Valley Conservation Area has matured, and some trees have died near CVCA1, so it is now in a grassy clearing with a less dense stand of mature cottonwood-willow to the east.

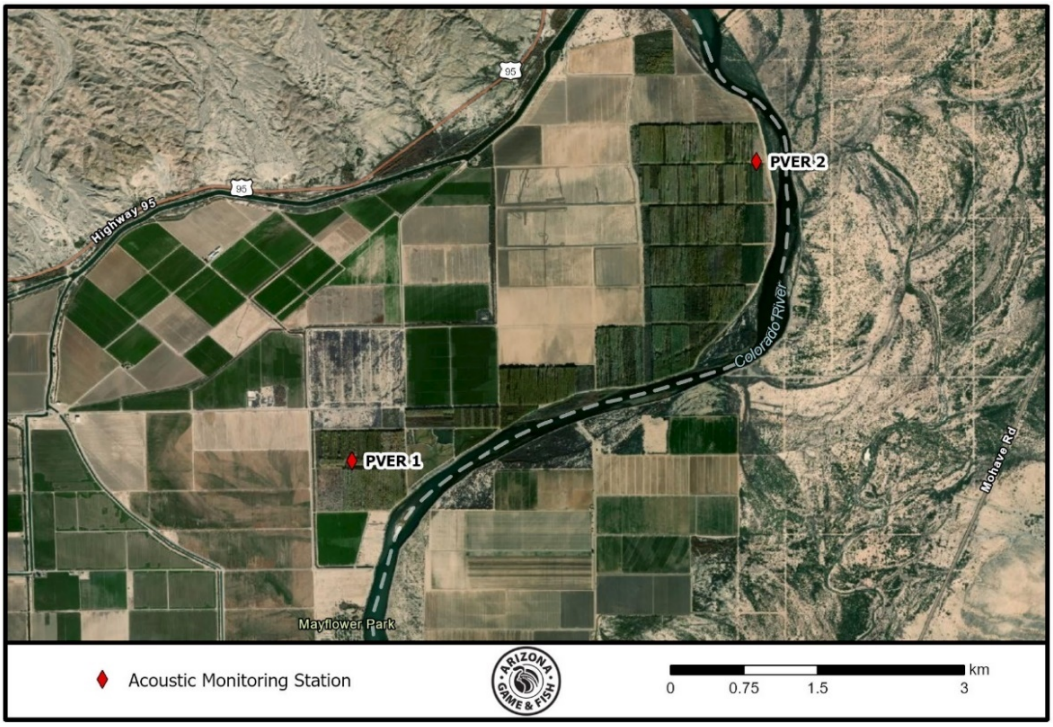

Figure 5.—Palo Verde Ecological Reserve acoustic monitoring stations (PVER1 and PVER2).

The Palo Verde Ecological Reserve is located northeast of Blythe, California, on California Department of Fish and Wildlife lands within the historic floodplain of the LCR. The Palo Verde Ecological Reserve is over 1,350 acres in size and consists of 1,023 acres of the cottonwood-willow and honey mesquite land cover types. The first station (PVER1) was deployed in mature cottonwood-willow habitat in 2012. The second station (PVER2) was deployed in 2013 in honey mesquite adjacent to cottonwood-willow habitat to provide sufficient coverage for this large conservation area (see figure 5).

METHODS

Data Collection Methods

Data were summarized from six permanent Anabat™ detectors in six LCR MSCP conservation areas and from four exploratory locations at Planet Ranch (table 1; see figures 1 and 2).

Table 1.—Conservation area, acronym, number of nights recorded during the sampling period, and year of station deployment

Conservation area (listed north to south)	Station acronym	Nights recorded (2015)	Nights recorded (2016)	Nights recorded (2017)	Nights recorded (2018)	Nights recorded (2019)	Year deployed
Beal Lake Conservation Area	BLCA1	92	92	92	92	92	2008
Palo Verde Ecological Reserve	PVER1	92	92	92	92	69	2012
Palo Verde Ecological Reserve	PVER2	26	77	43	82	92	2013
Cibola Valley Conservation Area	CVCA1	92	92	8	82	92	2011
Cibola Valley Conservation Area	CVCA2	92	92	91	92	92	2013
Cibola National Wildlife Refuge Unit #1 Conservation Area	Crane Roost	92	76	77	92	66	2011
Totals (percent of nights recorded)	**–**	**486 (88%)**	**521 (94%)**	**403 (73%)**	**532 (96%)**	**503 (91%)**	**–**

These six stations provide a temporal and spatial estimate of bat activity and daily occupancy. These stations consisted 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), 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 can provide approximately 4 months of data collection for the 4-gigabyte cards used. Data were recorded from June 1 through August 31 of each year to determine bat presence during summer. The stations were surveyed and data downloaded in June, July, and August, with an additional trip in May to address any maintenance issues. The four exploratory stations deployed at Planet Ranch collected data on the nights of June 9, 22, and 23 and on July 20 and 21, 2016.

During the 2015, 2016, 2017, 2018, and 2019 sampling seasons, several equipment malfunctions resulted in periods of data loss (attachment 1). The units were checked the day after they were installed for the season and then again the day after each card was downloaded or replaced to ensure the units collected data the first night. The units cannot be checked remotely to ensure they are functioning between site visits.

Analook Visual Verification Methods

The volume of call minutes was quantified for the four LCR MSCP species (western red bats, western yellow bats, California leaf-nosed bats, and pale 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 had been developed by a previous LCR MSCP acoustic monitoring project (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. Background and insect noise usually occurs at low frequencies and can be confused with bat calls. The "All bats" filter recognizes the patterns of background and insect noise and removes these files from consideration. Then, the remaining calls were run through species-specific filters and analyzed individually to sort out species with similar call shapes and frequencies 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 Bureau of Reclamation biologists (Broderick and Calvert 2011, personal communication) revealed they had recorded western red bat calls at higher frequencies along the LCR. Pale 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 Bureau of 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 reduced 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; Vizcarra et al. 2010; Williams et al. 2006). Bat minutes measure 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 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 the proportion of 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 activity and are not to be extrapolated to evaluate population dynamics or occupancy trends. It is believed that these methods provide a simple, standardized way of comparing activity across the stations and species.

Kaleidoscope Auto-Classifier Methods

All calls recorded were also analyzed using the Kaleidoscope Pro (version 5.1.1) auto-classifier to compare this method with the Analook filters and visual verification method. The Kaleidoscope software did not have classifiers for California leaf-nosed bats or western yellow bats until recently, and thus, calls for these species have only been analyzed for 2019. Western red bats and pale Townsend's big-eared bats were evaluated from 2015 through 2019 as well as other species the Kaleidoscope auto-classifier identified. The Kaleidoscope auto-classifier was used to assess the data in two ways: (1)as a comparison with LCR MSCP species verified calls and (2) as an index for overall bat activity at each station. The Kaleidoscope auto-classifier has 15 species classifiers for the study area: pallid bat *(Antrozous pallidus*) (ANPA), pale Townsend's big-eared bat, big brown bat (*Eptesicus fuscus*) (EPFU), spotted bat (*Euderma maculatum*) (EUMA), greater mastiff bat (*Eumops perotis*) (EUPE), western red bat, hoary bat (*Lasiurus cinereus*) (LACI), western yellow bat, California leaf-nosed bat, California myotis (*Myotis californicus*) (MYCA), Arizona myotis (*Myotis occultus*) (MYOC), cave myotis (*Myotis velifer*) (MYVE), Yuma myotis (*Myotis yumanensis*) (MYYU), canyon bat (*Parastrellus hesperus*) (PAHE), and Mexican free-tailed bat (*Tadarida brasiliensis*) (TABR). Output from the Kaleidoscope auto-classifier was not visually verified, and it is likely that many calls were misidentified because certain species can produce similar calls to others that can only be identified by visual verification. Species that have similar calls and can be misidentified by the classifier are big brown bats, hoary bats, and Mexican free-tailed bats, which all can have characteristics of each other's calls. Hoary bats are seasonally migratory and found at higher elevations during summer. They are most likely not present in conservation areas during the months of June,

July, and August. During the sampling period, calls identified as hoary bats are almost certainly big brown bats or Mexican free-tailed bats. California myotis and Yuma myotis can also produce similar calls. Arizona myotis calls can be similar to cave myotis (*Myotis velifer*); therefore, some Arizona myotis and cave myotis calls are almost certainly misidentified with each other. For the covered and evaluation species, western red bats and canyon bats produce similar calls, western yellow bats and Mexican free-tailed bats can be similar, and California leaf-nosed bats can be confused with California myotis and Yuma myotis. The Kaleidoscope activity index can be used as a quantitative measure of bat activity at each station, between stations and years, and it can be utilized to detect increases, decreases, or constant activity at acoustic stations.

RESULTS

Average nightly call minutes (activity) and proportion of nights occupied (occupancy) for the focal and evaluation species at each conservation area ranged widely across sites and years.

Western Red Bat

Analook Visual Verification Results

Western red bats were detected in 2015, 2016, 2017, 2018, and 2019 using the Analook visual verification method (table 2 and attachment 2). Average nightly call minutes (activity) and proportion of nights occupied (occupancy) of western red bats at each conservation area ranged widely across sites and years, with occupancy generally reflecting seasonal patterns of activity for visually verified results, while occupancy was 100% (or nearly 100%) at every site for the Kaleidoscope results. All results have been rounded to the nearest hundredth.

Table 2.—Western red bat detections in 2015, 2016, 2017, 2018, and 2019

Conservation area (listed north to south)	Station acronym	2015	2016	2017	2018	2019
Beal Lake Conservation Area	BLCA1	X	X	X	X	X
Palo Verde Ecological Reserve	PVER1	X	X	X	X	X
	PVER2	X	X	X	X	X
Cibola Valley Conservation Area	CVCA1	X	X	X	X	X
	CVCA2	X	X	X	X	X
Cibola National Wildlife Refuge Unit #1 Conservation Area	Crane Roost	X	X	X	X	X

Western Red Bat Yearly Comparison

2015

The greatest average nightly call minutes (2.85) and proportion of nights occupied (0.71) for western red bats during the 2015 season were recorded at PVER1 (figures 6 and 7).

2016

The greatest average nightly call minutes (1.72) recorded during the 2016 season were recorded at CVCA1, but the highest proportion of nights occupied (0.55) were recorded at PVER1 (figures 6 and 7).

2017

The greatest average nightly call minutes (2.26) and proportion of nights occupied (0.78) for western red bats during the 2017 season were recorded at PVER1 (figures 6 and 7).

2018

The greatest average nightly call minutes (1.41) and proportion of nights occupied (0.73) for western red bats during the 2018 season were recorded at PVER1 (figures 6 and 7).

2019

The greatest average nightly call minutes (0.71) and proportion of nights occupied (0.36) for western red bats during the 2019 season were recorded at PVER1 (figures 6 and 7).

Western Red Bat Station Comparison

BLCA1

Activity (0.45) and occupancy (0.27) were greatest at BLCA1 during 2015, and the lowest during 2016 (0.14 for activity and occupancy). The greatest activity (0.58) and occupancy (0.39) occurred during July 2015 (figures 6 and 7). In 2018, activity (0.31) and occupancy (0.23) were similar to those observed in 2017. The 2019 activity (0.16) and occupancy (0.15) were relatively low, and similar to 2016.

Crane Roost

At Crane Roost, bat activity (0.28) and occupancy (0.22) was highest in 2018, and the lowest during 2016 (0.03 for activity and occupancy) (figures 6 and 7). Station malfunctions in 2016, 2017 (0.10 activity and 0.09 occupancy), and 2019 (0.08 activity and 0.06 occupancy) may partly explain the lower activity recorded in these years. Activity (0.22) and occupancy (0.14) in 2015 were lower, but similar to 2018.

CVCA1

A large peak in activity (3.77) and occupancy (0.74) was observed at CVCA1 in July 2016 (figures 6 and 7). This peak led to overall activity (1.72) being highest in 2016, but the greatest annual occupancy was documented in 2015 (0.44). The lowest activity (0.12) and occupancy (0.09) was recorded in 2019. Station malfunctions resulted in missing data for June 2017 and 2018 and reduced data in July and August 2017.

CVCA2

The greatest activity (0.94) and occupancy (0.48) was observed at CVCA2 in August 2018. However, the greatest overall activity (0.50) was recorded during 2019 and the greatest occupancy (0.29) during the 2017 season at CVCA2 (figures 6 and 7). The least amount of activity (0.18) was recorded during 2016, with the least amount of occupancy (0.15) documented equally in 2015 and 2016. Only 1 night of data was missing due to station malfunction in June 2017.

PVER1

The highest activity (2.85 in 2015) and occupancy (0.78 in 2017) from any site were noted at PVER1, with activity at its highest in July 2015 (4.13) and occupancy at its' greatest in August 2017 (0.90). The lowest activity (0.71) and occupancy (0.36) were documented in 2019 (figures 6 and 7).

PVER2

Bat activity and occupancy were lower at PVER2, and station malfunctions impacted data collection from 2015 through 2018. Activity (0.41) and occupancy (0.27) were highest at PVER2 in 2019 (figures 6 and 7). The greatest activity (0.45) was recorded in August 2019, and occupancy (0.33) in June 2019. Activity and occupancy had been very low at PVER2 from 2015 to 2017 but saw an increase in 2018 and another increase in 2019.

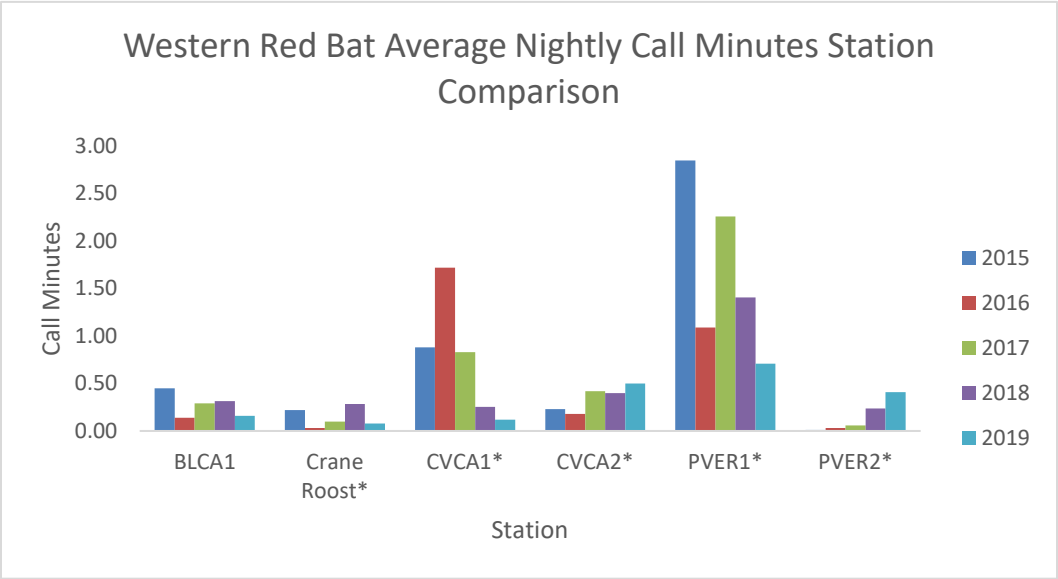

Figure 6.—Western red bat average nightly call minutes station comparison.
* Station malfunction occurred at the site.

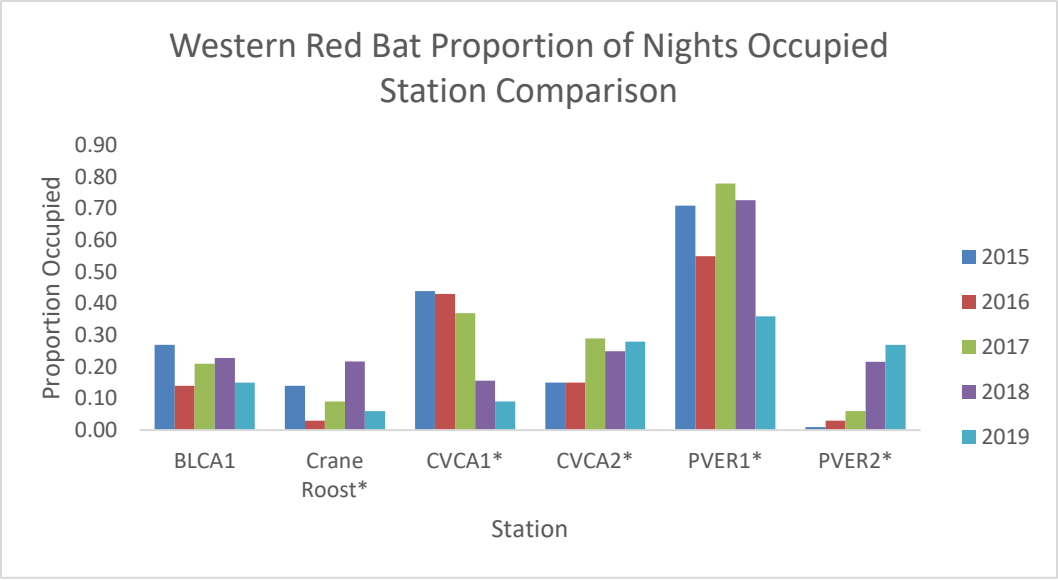

Figure 7.—Western red bat proportion of nights occupied station comparison.
* Station malfunction occurred at the site.

Kaleidoscope Results

The Kaleidoscope auto-classifier produced different results than the visual verification methods. Considerably more average nightly call minutes and proportion of nights occupied were recorded by the Kaleidoscope auto-classifier. The Kaleidoscope auto-classifier consistently identified more occupancy than the visual verification methods, with over 90% occupancy (and often 100%) at most stations from 2015 through 2019, with the exceptions of CVCA1 in 2018 and PVER2 during 2016 and 2018. BLCA1 had the highest average nightly call minutes during the 2015, 2016, 2017, and 2019 seasons, followed by PVER1 (figure 8). Crane Roost had the highest average nightly call minutes during the 2018 season, followed by BLCA1. The lowest average nightly call minutes were recorded at PVER2, which matches results from the visual verification methods.

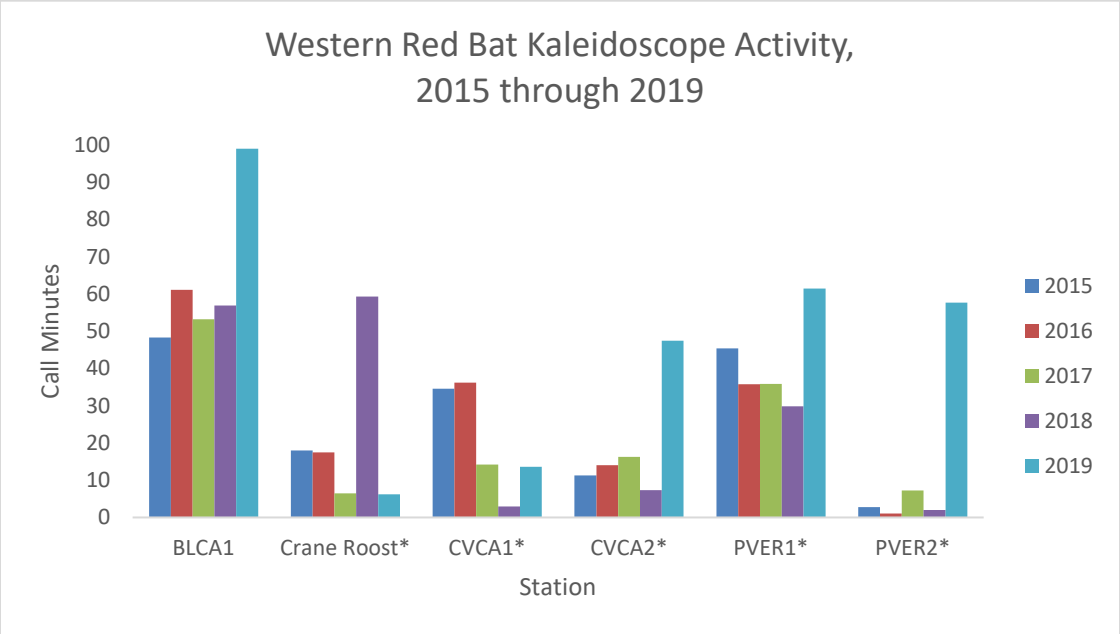

Figure 8.—Western red bat Kaleidoscope results station comparison.
* Station malfunction occurred at the site.

Western Yellow Bat

Analook Visual Verification Results

Western yellow bats were detected at all stations during the 2015, 2016, 2017, 2018 and 2019 seasons using the Analook visual verification method with the exception of PVER2 during the 2016 season and Crane Roost during the 2019 season (table 3 and attachment 2). Average nightly call minutes (activity) and proportion of nights occupied (occupancy) of western yellow bats at each conservation area ranged widely across sites and years, with occupancy generally reflecting seasonal patterns of activity for visually verified results (figures 9 and 10).

Table 3.—Western yellow bat detections in 2015, 2016, 2017, 2018, and 2019

Conservation area (listed north to south)	Station acronym	2015	2016	2017	2018	2019
Beal Lake Conservation Area	BLCA1	X	X	X	X	X
Palo Verde Ecological Reserve	PVER1	X	X	X	X	X
	PVER2	X	None detected	X	X	X
Cibola Valley Conservation Area	CVCA1	X	X	X	X	X
	CVCA2	X	X	X	X	X
Cibola National Wildlife Refuge Unit #1 Conservation Area	Crane Roost	X	X	X	X	None detected

Western Yellow Bat Yearly Comparison

2015

The greatest average nightly call minutes (16.81) and proportion of nights occupied (0.97) for western yellow bats during the 2015 season occurred at CVCA1 (figures 9 and 10).

2016

The greatest average nightly call minutes (4.22) and proportion of nights occupied (0.91) for western yellow bats during the 2016 season occurred at CVCA1 (figures 9 and 10).

2017

The greatest average nightly call minutes (5.3) and proportion of nights occupied (0.8) for western yellow bats during the 2017 season occurred at CVCA1 (figures 9 and 10).

2018
The greatest average nightly call minutes (0.93) and proportion of nights occupied (0.35) for western yellow bats during the 2018 season occurred at PVER1 (figures 9 and 10).

2019
The greatest average nightly call minutes (0.83) and proportion of nights occupied (0.42) for western yellow bats during the 2019 season occurred at PVER1 (figures 9 and 10).

Western Yellow Bat Station Comparison

BLCA1
Activity and occupancy were consistently low at BLCA1 from 2015 to 2019. The greatest activity (0.09) was recorded in 2016 and the greatest occupancy in 2015 (0.08). The least amount of activity (0.03) and occupancy (0.03) were recorded in 2018 (figures 9 and 10).

Crane Roost
Activity and occupancy were the lowest at Crane Roost from 2015 through 2019 compared to all other conservation areas, with the greatest activity (0.05) and occupancy (0.05) recorded in 2017 and the least in 2019, when no activity was recorded (figures 9 and 10). Activity (0.5) and occupancy (0.04) in 2018 were similar to those recorded in 2017, and activity (0.03) and occupancy (0.03) were equal in 2015 and 2016. Station malfunctions in 2016, 2017, and 2019 may partly explain the lower activity recorded in these years.

CVCA1
A large peak in activity (16.81) and occupancy (0.97) was observed at CVCA1 in 2015, with the highest activity recorded in July (25.81) and August (20.48) and occupancy remaining constant throughout 2015 for each month (0.97). Activity and occupancy were the highest at CVCA1 from 2015 through 2017 compared to all other conservation areas (figures 9 and 10). CVCA1 had much lower activity and occupancy in 2018 (0.55 and 0.18) and 2019 (0.32 and 0.15) compared to 2015–17. The station malfunctioned in June 2018; however, this minor malfunction (10 nights) does not explain the precipitous drop in activity and occupancy in 2018. Station malfunctions resulted in missing data for June 2017 and reduced data in July and August 2017. The station recorded without incident in 2019.

CVCA2

Much like CVCA1, a peak in activity (1.3) and occupancy (0.45) was also observed at CVCA2 during 2015 compared to 2016 (0.41 and 0.22) and 2017 (0.4 and 0.3). Like CVCA1, the highest activity and occupancy occurred during July and August, with little recorded in June (figures 9 and 10). Like CVCA1, a drop in activity (0.10) and occupancy (0.09) was documented in 2018 compared to 2015 through 2017. A further decline in occupancy (0.05) was observed in 2019, but there was the same amount of activity (0.10) from 2018 to 2019. Only 1 night of data was not recorded due to station malfunction in June 2017.

PVER1

A high amount of activity and occupancy was recorded at PVER1, with a peak in 2015 (6.12 and 0.68). While activity varied from 2015 through 2017, occupancy remained relatively stable in 2015 (0.68), 2016 (0.63), and 2017 (0.58). The greatest activity was recorded in July from 2015 through 2017, but the highest occupancy was recorded in August (figures 9 and 10). The greatest activity and occupancy were recorded at PVER1 during 2018 and 2019 compared to all other stations. However, 2018 represented the lowest occupancy (0.35) and 2019 the lowest activity (0.83) recorded at PVER1 from 2015 through 2019.

PVER2

Activity and occupancy were much lower at PVER2, with none recorded in 2016. The greatest activity (0.27) and occupancy (0.15) were recorded during 2015. Activity and occupancy in 2018 were both 0.12. The greatest activity and occupancy were recorded during August, with only 2018 seeing activity across all months (figures 9 and 10). Station malfunctions impacted data collection from 2015 through 2018.

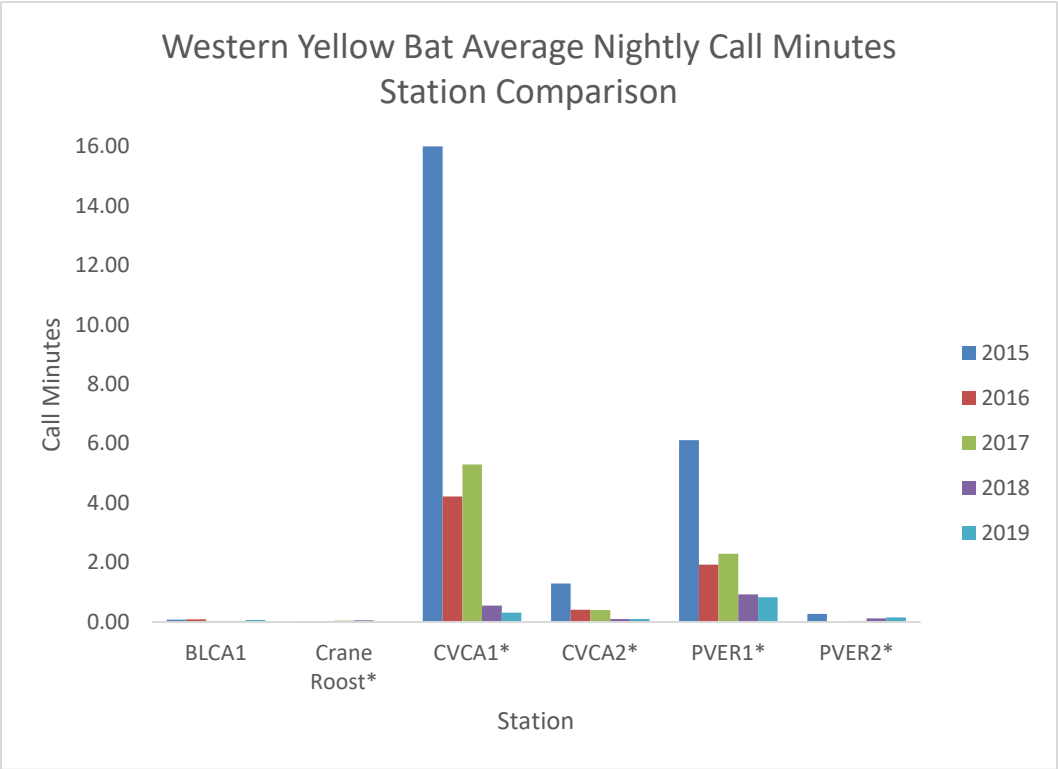

Figure 9.—Western yellow bat average nightly call minutes station comparison.
* Station malfunction occurred at the site.

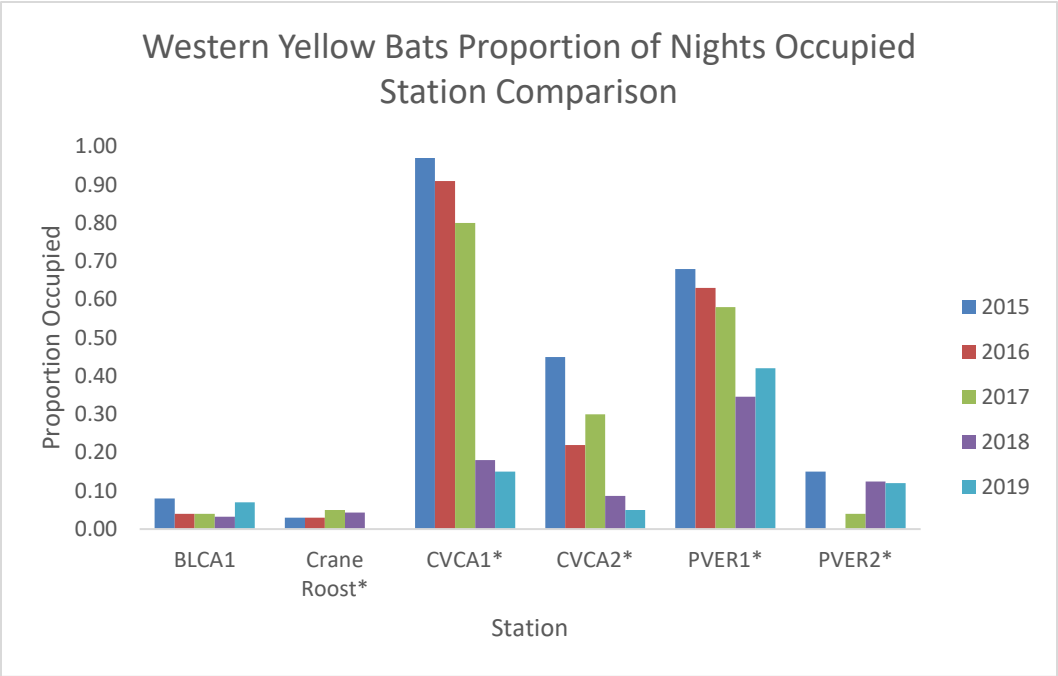

Figure 10.—Western yellow bat proportion of nights occupied station comparison.
* Station malfunction occurred at the site.

Kaleidoscope Results

The Kaleidoscope auto-classifier for western yellow bats has recently become available and displays some differences and similarities to the visual verification results. It classifies far greater calls as western yellow bats than the Analook visual verification methods. The least amount of activity was detected at Crane Roost for both methods, but the greatest activity differed with PVER1 displaying the most with visual verification and CVCA2 with the Kaleidoscope auto-classifier. CVCA2 had the fourth highest activity levels with visual verification, and PVER1 had the second highest levels through the Kaleidoscope auto-classifier (figure 11).

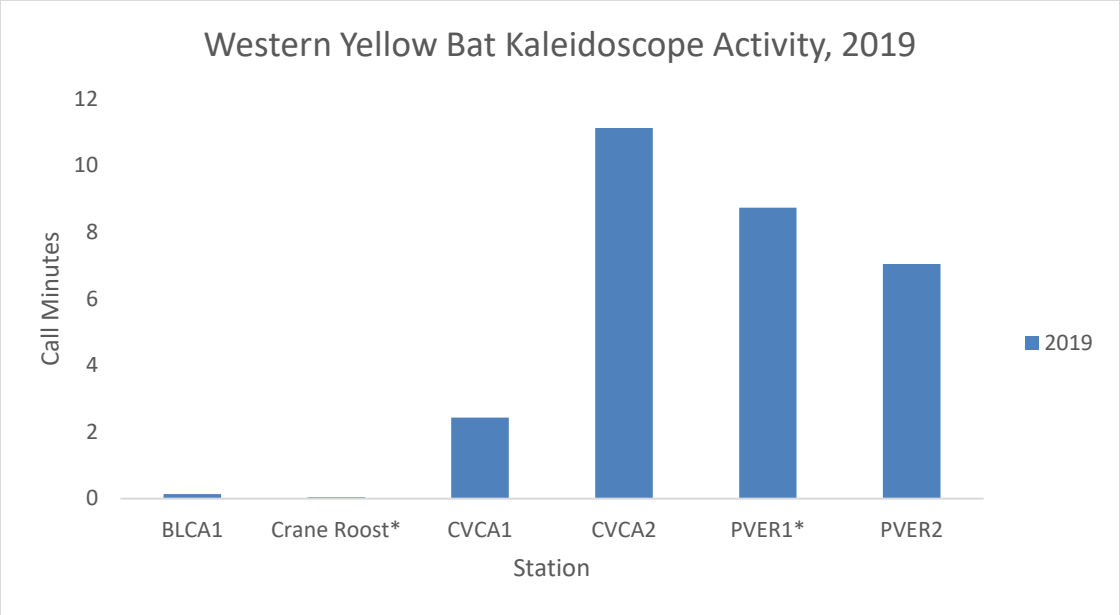

Figure 11.—Western yellow bat Kaleidoscope activity, 2019.
* Station malfunction occurred at the site.

California Leaf-nosed Bat

Analook Visual Verification Results

California leaf-nosed bats were detected in 2015, 2016, 2017, 2018, and 2019 using the Analook visual verification method. None were detected at BLCA1 or PVER1 during the 2015 season, but they were detected annually starting in 2016 at those sites. No California leaf-nosed bats were detected at Crane Roost or CVCA2 during the 2016 season, but they were detected in 2015 and subsequent years. California leaf-nosed bats were detected at CVCA1 during 2015 but were not detected from 2016 through 2019. No California leaf-nosed bats were detected at PVER2 during the 2015, 2016, 2017, or 2018 seasons, but they were detected in 2019 (table 4 and attachment 2). Average nightly call minutes (activity) and proportion of nights occupied (occupancy) of California leaf-nosed bats at each conservation area generally ranged widely across sites and years. California leaf-nosed bat activity and occupancy were recorded sporadically and in low numbers due to the low-amplitude calls this species produces.

Table 4.—California leaf-nosed bat detections in 2015, 2016, 2017, 2018, and 2019

Conservation area (listed north to south)	Station acronym	2015	2016	2017	2018	2019
Beal Lake Conservation Area	BLCA1	None detected	X	X	X	X
Cibola National Wildlife Refuge Unit #1 Conservation Area	Crane Roost	X	None detected	X	X	X
Cibola Valley Conservation Area	CVCA1	X	None detected	None detected	None detected	None detected
	CVCA2	X	None detected	X	X	X
Palo Verde Ecological Reserve	PVER1	None detected	X	X	X	X
	PVER2	None detected	None detected	None detected	None detected	X

California Leaf-nosed Bat Yearly Comparison

2015

The greatest average nightly call minutes (0.14) and proportion of nights occupied (0.11) for California leaf-nosed bats during the 2015 season occurred at CVCA2 (figures 12 and 13).

2016
The greatest average nightly call minutes (0.02) and proportion of nights occupied (0.02) for California leaf-nosed bats during the 2016 season occurred equally at BLCA1 and PVER1 (figures 12 and 13).

2017
The greatest average nightly call minutes (0.38) and proportion of nights occupied (0.25) for California leaf-nosed bats during the 2017 season occurred at CVCA2 (figures 12 and 13).

2018
The greatest average nightly call minutes (0.38) and proportion of nights occupied (0.22) for California leaf-nosed bats during the 2018 season occurred at Crane Roost (figures 12 and 13).

2019
The greatest average nightly call minutes (0.15) and proportion of nights occupied (0.13) for California leaf-nosed bats during the 2019 season occurred at BLCA1 (figures 12 and 13).

California Leaf-nosed Bat Station Comparison

BLCA1
Activity (0.16) and occupancy (0.15) were greatest at BLCA1 during 2017, followed by 2019 (0.15 and 0.12). Activity and occupancy were only recorded in June 2016, and none recorded during 2015 (figures 12 and 13). The greatest monthly activity (0.26) was documented equally in August 2017 and 2018. The greatest monthly occupancy (0.26) was documented in August 2018.

Crane Roost
The greatest activity and occupancy at any site in 2018 occurred at Crane Roost. Activity (0.38) and occupancy (0.22) were the greatest at Crane Roost in 2018 compared to 2015 through 2017 and 2019. Activity and occupancy were only recorded in June 2015, with none recorded during 2016. Activity and occupancy were documented across all months in 2017 and 2018, and only in July for 2019 (figures 12 and 13). Station malfunctions in 2016, 2017, and 2019 may partly explain the lower activity recorded in these years.

CVCA1
Activity and occupancy were lowest at CVCA1, with the greatest recorded in 2015 (0.04 and 0.04), and none recorded in 2016, 2017, 2018, or 2019 (figures 12 and 13). Station malfunctions resulted in missing data for June 2017, reduced data in July and August 2017, and reduced data in June 2018.

CVCA2

The greatest activity and occupancy for any site occurred at CVCA2 from 2015 to 2017. The greatest activity (0.38) and occupancy (0.25) occurred during 2017, with none recorded during 2016 (figures 12 and 13). The greatest activity (0.58) was documented in July 2017, and the greatest occupancy (0.39) occurred in August 2017. Only 1 night of data was missing due to a station malfunction in June 2017. Activity and occupancy were 0.11 and 0.10 in 2018 and 0.10 and 0.10 in 2019.

PVER1

Activity (0.16) and occupancy (0.12) were highest at PVER1 during 2018. Activity and occupancy were recorded in July and August 2017, very little recorded in 2016 (0.02 and 0.02) and 2019 (0.03 and 0.03), and none recorded in 2015 (figures 12 and 13).

PVER2

Activity and occupancy at PVER2 were extremely low, with 2019 being the only season in which activity (0.02) and occupancy (0.02) were recorded. No activity or occupancy were recorded at PVER2 from 2015 to 2018 (figures 12 and 13). Station malfunctions impacted data collection at PVER2 from 2015 through 2018.

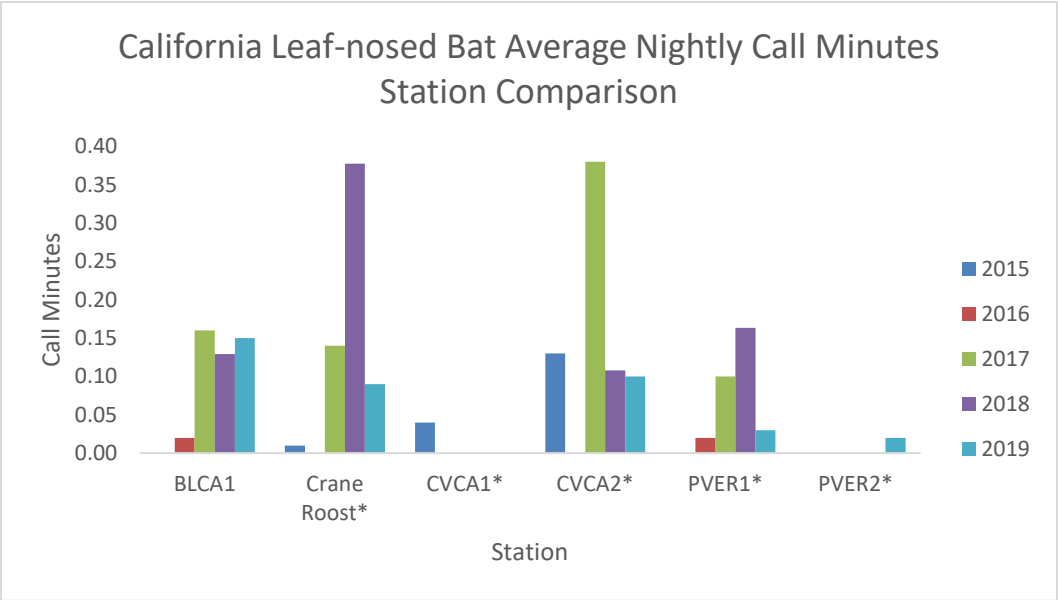

Figure 12.—California leaf-nosed bat average nightly call minutes station comparison.
* Station malfunction occurred at the site.

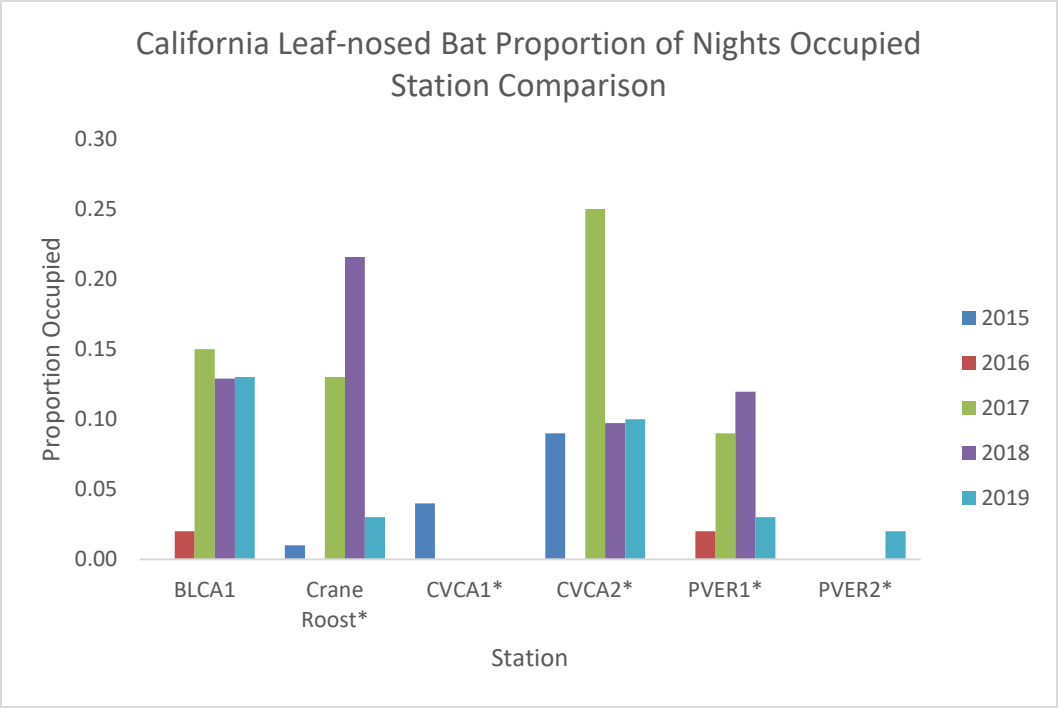

Figure 13.—California leaf-nosed bat proportion of nights occupied station comparison.
* Malfunction occurred at the station.

Kaleidoscope Results

The Kaleidoscope auto-classifier for California leaf-nosed bats has recently become available and displays some differences and similarities to the visual verification results. The highest activity was detected at BLCA1 and CVCA2 for both methods, but the greatest activity through Analook visual verification was observed at BLCA1, while the greatest through the auto-classifier was at CVCA2. The lowest activity for both methods was recorded at CVCA1 and PVER2; however, the least activity for Analook visual verification was observed at CVCA1, and the least for the auto-classifier at PVER2 (figure 14).

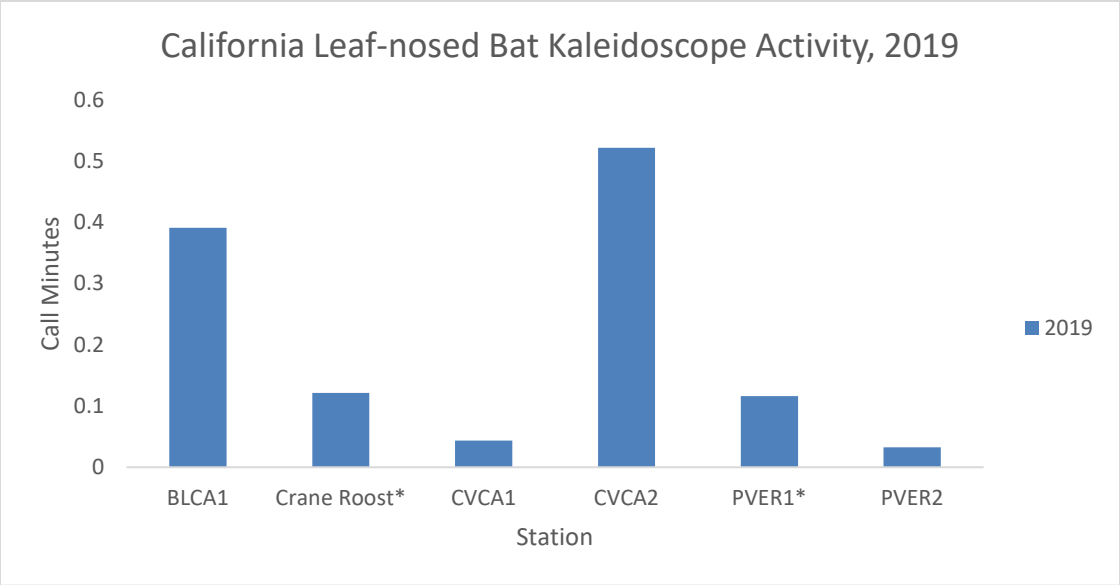

Figure 14.—California leaf-nosed bat Kaleidoscope activity, 2019.
* Station malfunction occurred at the site.

Pale Townsend's Big-eared Bat

Analook Visual Verification Results

Because of the conservative method of identifying Townsend's big-eared bat (*Corynorhinus townsendii*) calls to species and subspecies using the Analook verification method and the nature of their whispering calls, no pale Townsend's big-eared bat calls were detected during 2015, 2016, 2018, or 2019 at any location. One pale Townsend's big-eared bat call was recorded at CVCA2 during August 2017.

Kaleidoscope Results

Kaleidoscope results showed average nightly call minutes (activity) and proportion of nights occupied (occupancy) of pale Townsend's big-eared bats at each conservation area ranged widely across sites and years, with occupancy generally reflecting seasonal patterns of activity (figures 15 and 16). The Kaleidoscope auto-classifier results indicated the greatest average nightly call minutes during the 2015 season were recorded at CVCA1, followed by BLCA1 and Crane Roost (figure 15). The greatest average nightly call minutes during the 2016 season were recorded at CVCA1, followed by PVER1 and CVCA2. The greatest average nightly call minutes recorded during the 2017 season were recorded at BLCA1, followed by CVCA1 and PVER1. No activity for pale Townsend's big-eared bats was recorded at CVCA2 and PVER2 during the 2017 season. The greatest average nightly call minutes during the 2018 season were recorded at BLCA1, followed by PVER1, Crane Roost, CVCA2, and PVER2. No activity was recorded at CVCA1 in 2018. The greatest average nightly call minutes during the 2019 season were recorded at BLCA1, followed by PVER1. No activity for pale Townsend's big-eared bats was recorded at Crane Roost during the 2019 season. The greatest average nightly call minutes were recorded during the 2016 season for pale Townsend's big-eared bats and the least during 2018.

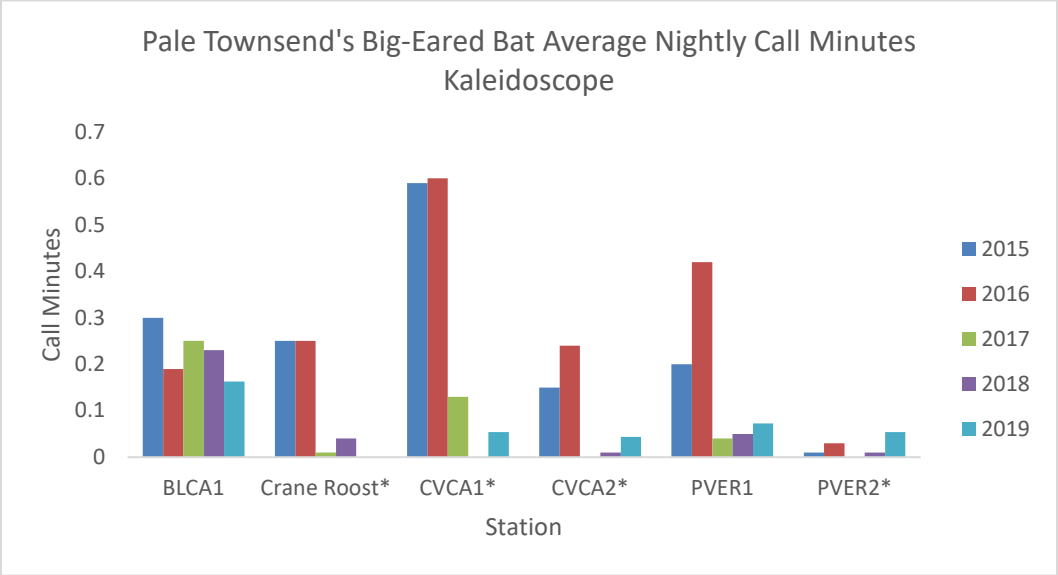

Figure 15.—Pale Townsend's big-eared bat activity Kaleidoscope results station comparison.
* Station malfunction occurred at the site.

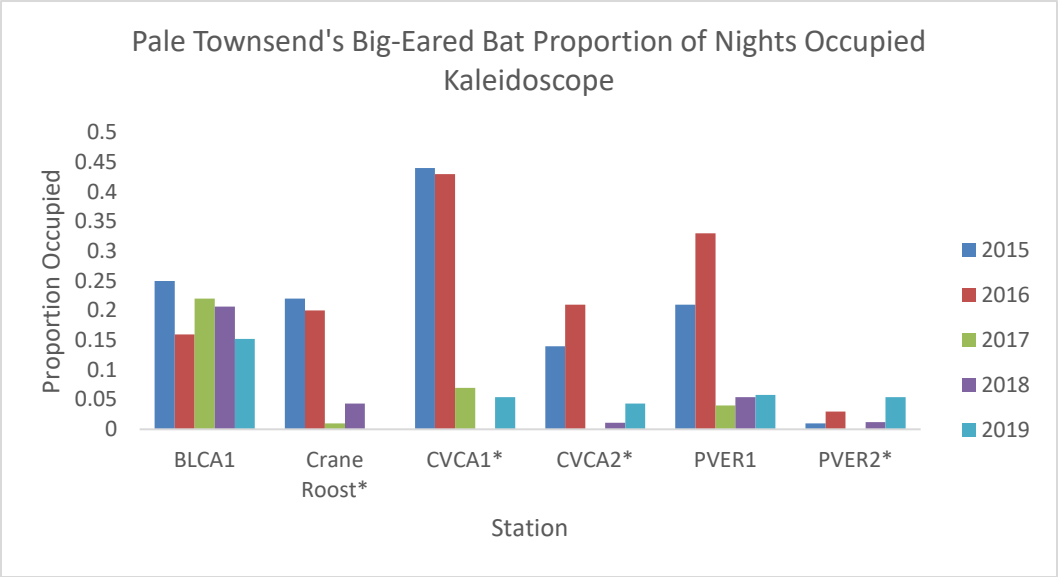

Figure 16.—Pale Townsend's big-eared bat occupancy Kaleidoscope results station comparison.
* Station malfunction occurred at the site.

Yearly Comparison Across All Post-Development Stations

Analook Visual Verification Results

Western Red Bat

Western red bat activity varied across all post-development stations from 2015 through 2018, ranging from 0.77 call minutes in 2018 to 0.33 in 2019. The proportion of nights occupied were relatively stable, ranging from 0.20 in 2019 to 0.30 in 2017 and 2018 (figure 17).

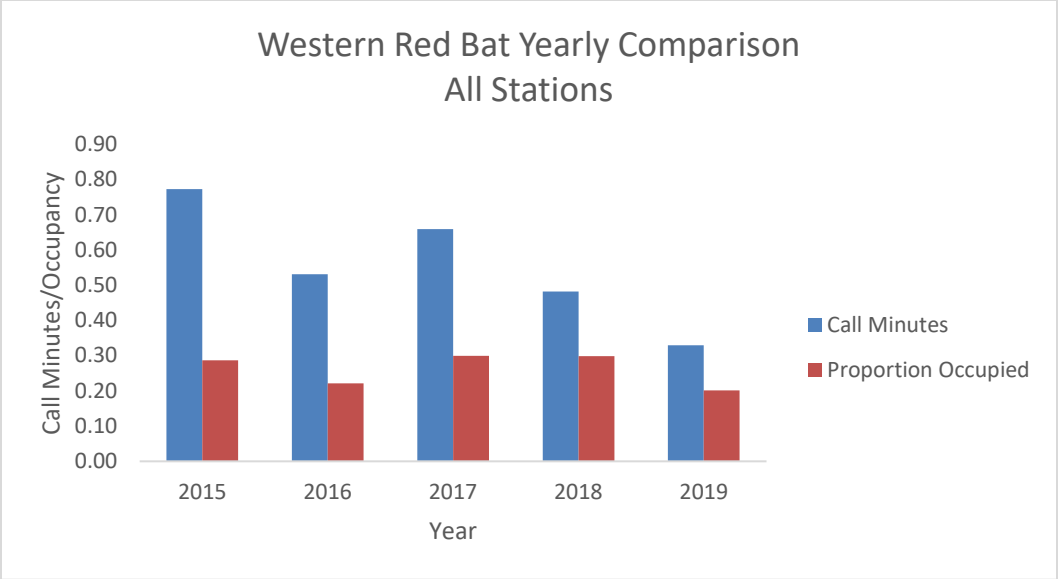

Figure 17.—Western red bat verified call results across all post-development stations.

Western Yellow Bat

Western yellow bat activity has dropped precipitously since 2015 (4.10). Activity was similar from 2016 (1.11) to 2017 (1.36) before dropping to 0.30 in 2018 and 0.25 in 2019. Occupancy was relatively stable in 2015 (0.39), 2016 (0.31), and 2017 (0.30), but it dropped in 2018 (0.14) and 2019 (0.14) (figure 18).

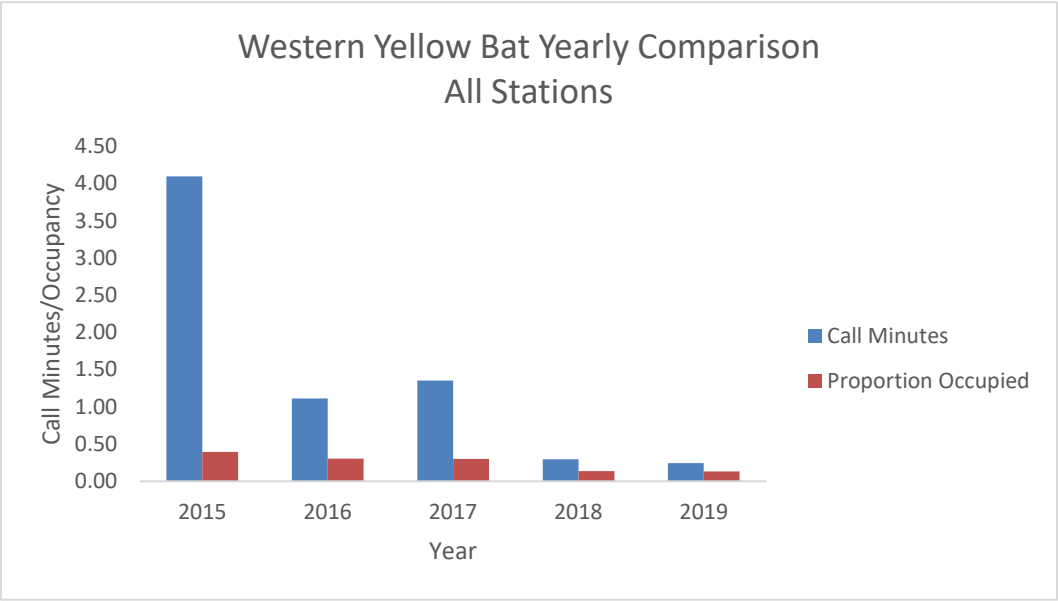

Figure 18.—Western yellow bat verified call results across all post-development stations.

California Leaf-nosed Bat

California leaf-nosed bat activity and occupancy across all stations increased from 2017 through 2019 from 2015 and 2016 levels. Activity and occupancy remained above 2015 and 2016 levels in 2019 but was lower than 2017 and 2018. Activity and occupancy remain relatively low due in part to the quiet nature of their calls. Activity and occupancy ranged from a low in 2016 (0.01 and 0.01) to a high in 2017 (0.13 and 0.10) (figure 19).

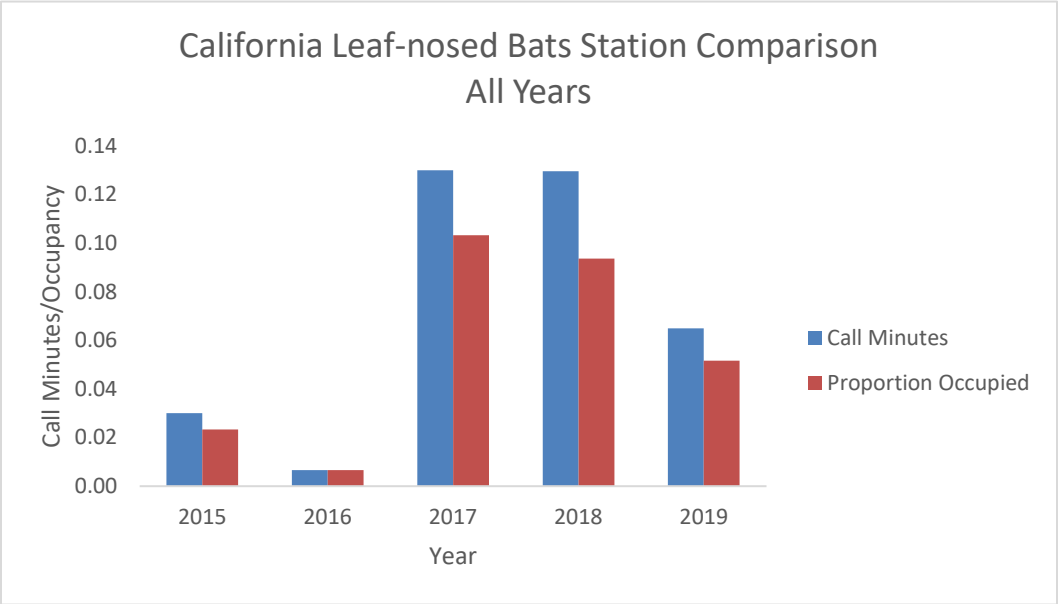

Figure 19.—California leaf-nosed bat verified call results across all post-development stations.

Kaleidoscope 15 Species Results

As stated above, the Kaleidoscope auto-classifier has 15 species classifiers for the study area: pallid bat, pale Townsend's big-eared bat, big brown bat, spotted bat, greater mastiff bat, western red bat, hoary bat, western yellow bat, California leaf-nosed bat, California myotis, Arizona myotis, cave myotis, Yuma myotis, canyon bat, and Mexican free-tailed bat.

BLCA1

Canyon bats had the greatest average nightly call minutes from 2015 through 2019 (118.17) for any species detected at BLCA1 by the Kaleidoscope auto-classifier (figure 20). Other species with high activity levels at BLCA1 were Arizona myotis, western red bats, Yuma myotis, big brown bats, and Mexican free-tailed bats. The greatest average nightly call minutes at BLCA1 occurred during 2016, followed by 2015, 2017, 2018, and 2019.

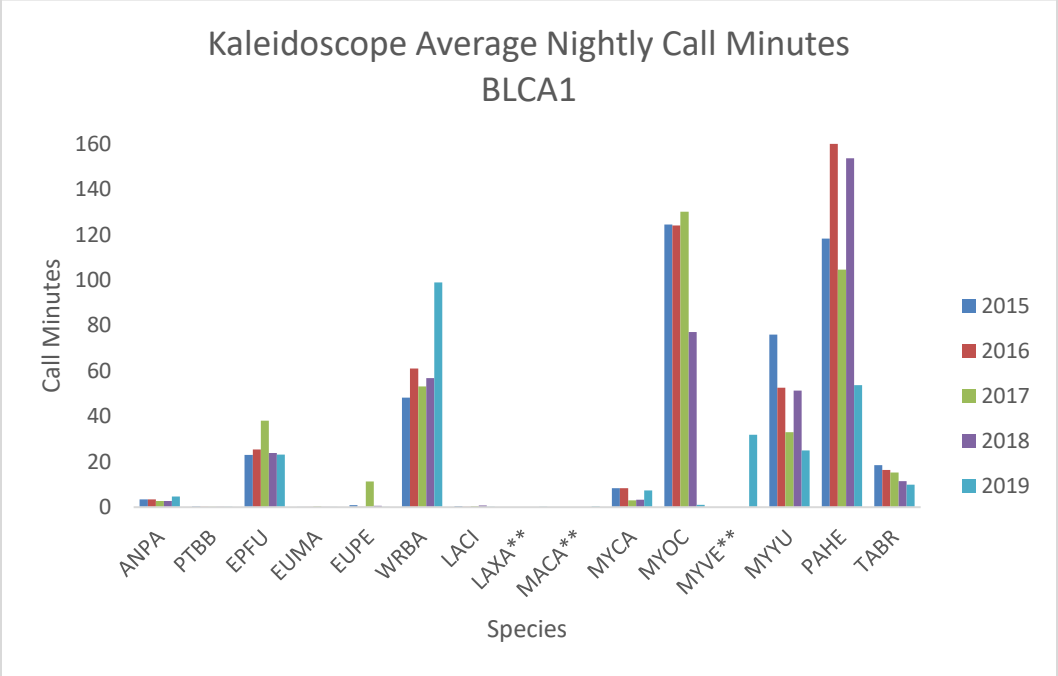

Figure 20.—Kaleidoscope results for 2015, 2016, 2017, 2018, and 2019 at BLCA1.
** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

Crane Roost

Canyon bats also had the greatest average nightly call minutes from 2015 through 2019 (80.59) for any species detected at Crane Roost by the Kaleidoscope auto-classifier (figure 21). Other species with high activity levels at Crane Roost were Yuma myotis, big brown bats, western red bats, and Arizona myotis. Big brown bats, spotted bats, greater mastiff bats, western red bats, and Mexican free-tailed bats all had substantial increases in activity during 2018 compared to 2015 through 2017. The greatest average nightly call minutes at Crane Roost occurred during 2018, followed by 2016, 2017, 2015, and 2019.

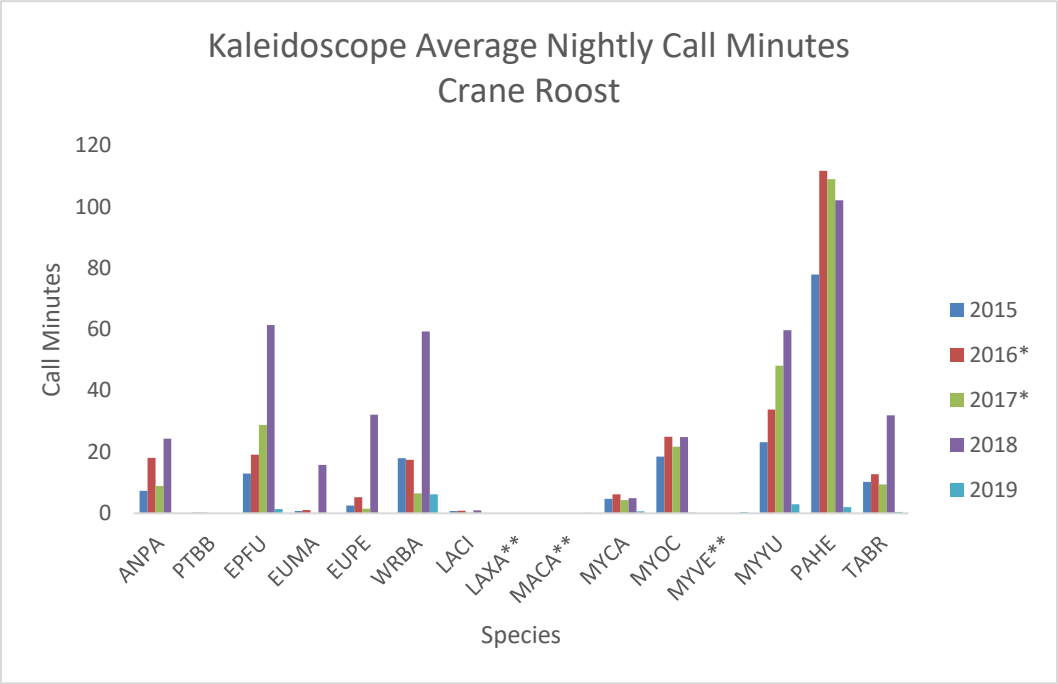

Figure 21.—Kaleidoscope results for 2015, 2016, 2017, 2018, and 2019 at Crane Roost.
* Station malfunction leading to partial monthly data collected in June 2016 and June and July 2017.
** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

CVCA1

Mexican free-tailed bats had the greatest average nightly call minutes from 2015 through 2019 (167.56) for any species detected at CVCA1 by the Kaleidoscope auto-classifier (figure 22). Other species with high activity levels at CVCA1 were big brown bats and canyon bats. The greatest average nightly call minutes at CVCA1 occurred during 2016, followed by 2015. A sharp drop in acoustic activity at CVCA1 for all species occurred in 2017 through 2019.

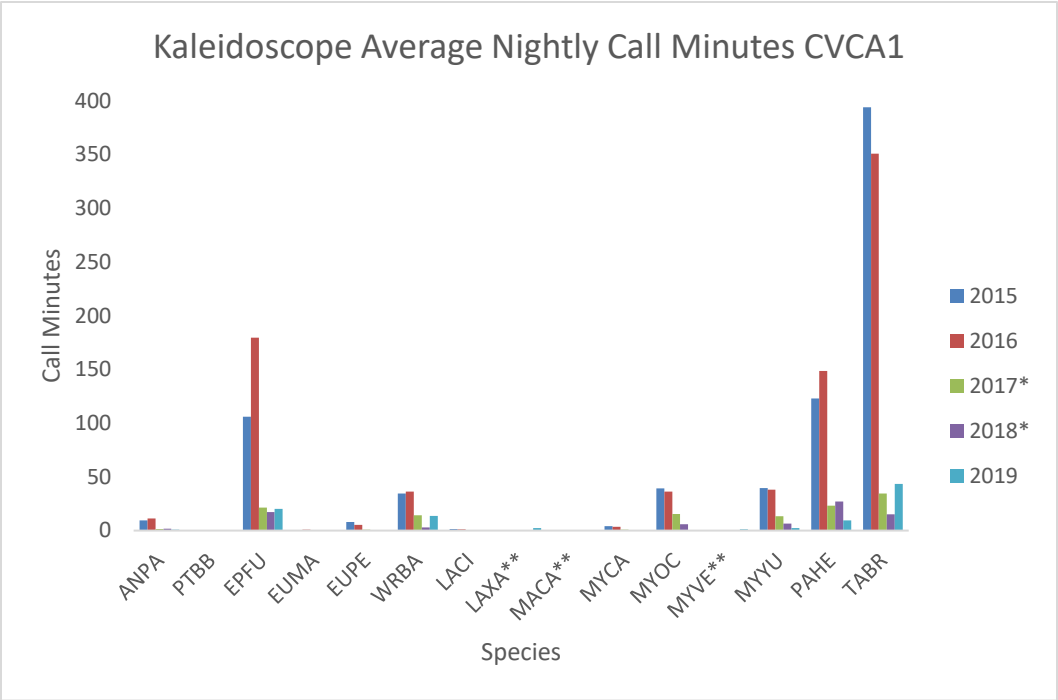

Figure 22.—Kaleidoscope results for 2015, 2016, 2017, 2018 and 2019 at CVCA1.
* Station malfunction leading to no data collected in June 2017 and partial monthly data collected in July and August 2017. Partial monthly data also collected in June 2018.
** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

CVCA2

Yuma myotis had the highest average nightly call minutes from 2015 through 2019 (98.22) for any species detected at CVCA2 by the Kaleidoscope auto-classifier (figure 23). Other species with high activity levels at CVCA2 were big brown bats, canyon bats, Mexican free-tailed bats, and Arizona myotis. The greatest average nightly call minutes at CVCA2 occurred during 2018, followed by 2017, 2016, 2019, and 2015.

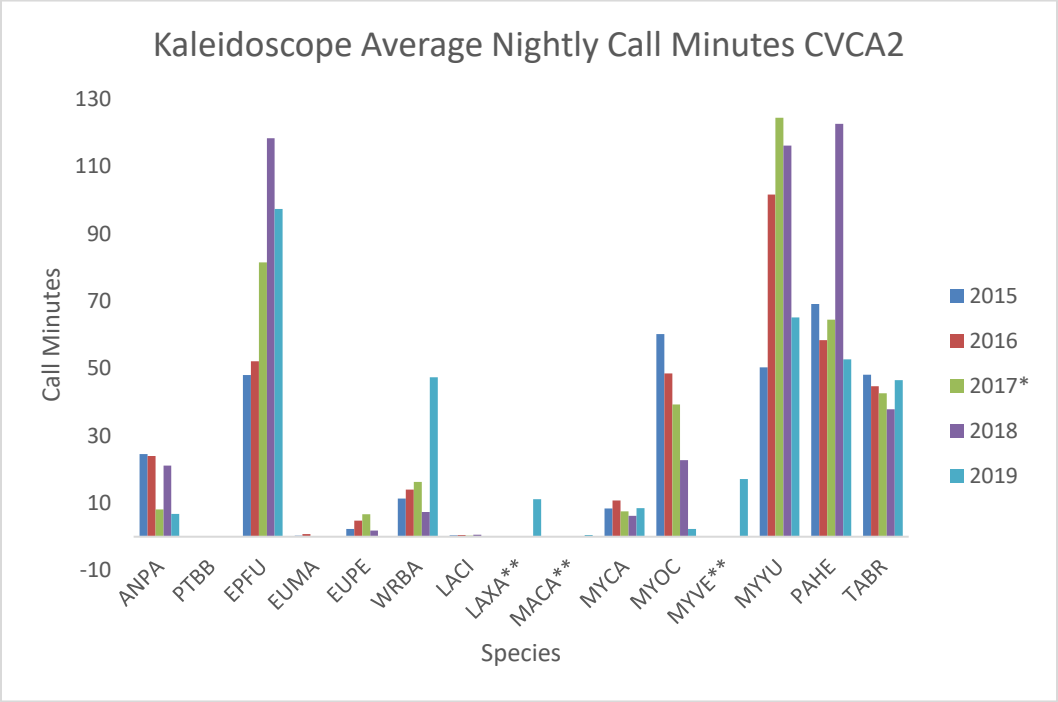

Figure 23.—Kaleidoscope results for 2015, 2016, 2017, 2018, and 2019 at CVCA2.
* Station malfunction led to partial monthly data collected in June 2017.
** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

PVER1

The TABR had the highest average nightly call minutes from 2015 through 2019 (177.52) for any species detected at PVER1 by the Kaleidoscope auto-classifier (figure 24). Other species with high activity levels at PVER1 were big brown bats, canyon bats, and western red bats. The greatest average nightly call minutes at PVER1 occurred during 2016, followed by 2017, 2015, 2019, and 2018.

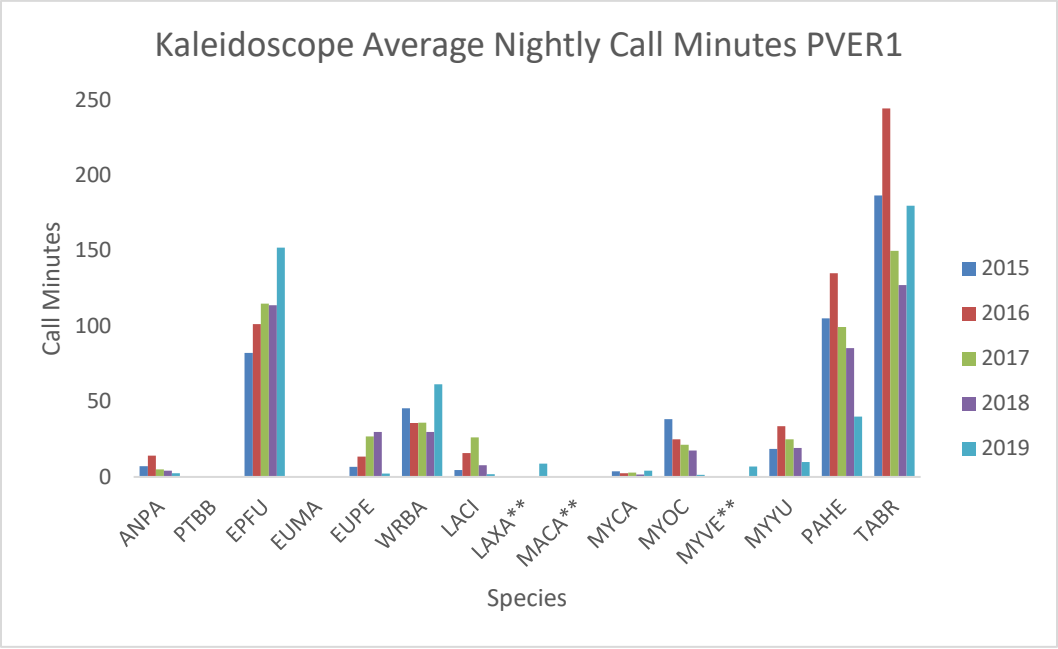

Figure 24.—Kaleidoscope results for 2015, 2016, 2017, 2018, and 2019 at PVER1. ** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

PVER2

Canyon bats had the highest average nightly call minutes from 2015 through 2019 (41.70) for any species detected at PVER2 by the Kaleidoscope auto-classifier (figure 25). The other species with high activity levels at PVER2 were TABR, western red bats, and big brown bats. Pallid bats, big brown bats, greater mastiff bats, hoary bats, and canyon bats all saw large increases in acoustic activity in 2018 compared to the 2015 through 2017 seasons. Western red bats had a large increase in activity in 2019 compared to 2015 through 2018. The greatest average nightly call minutes at PVER2 occurred during 2018, followed by 2019, 2017, 2015, and 2016.

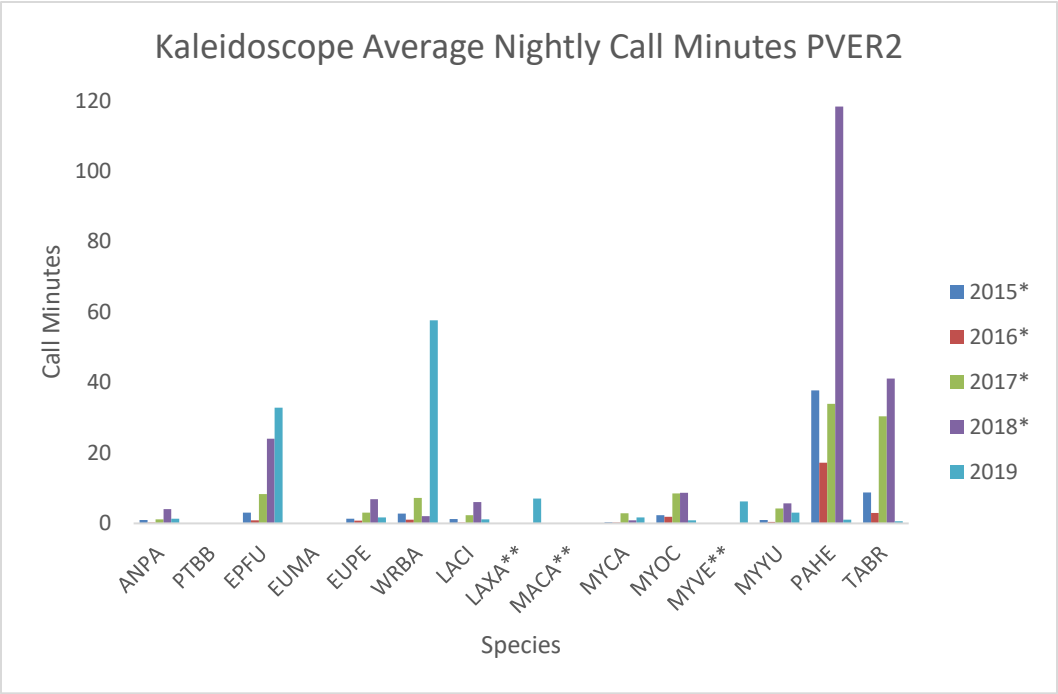

Figure 25.—Kaleidoscope results for 2015, 2016, 2017, 2018, and 2019 at PVER2.
* Station malfunction leading to partial monthly data collected in June and August 2015, June 2016, July 2017, and June 2018. No data collected July 2015 or June 2017.
** Classifiers first made available for these species in 2019. No data reported for 2015 through 2018.

Note: ANPA = pallid bat; PTBB = pale Townsend's big-eared bat; EPFU = big brown bat; EUMA = spotted bat; EUPE = greater mastiff bat; WRBA = western red bat; LACI = hoary bat; LAXA = western yellow bat; MACA = California leaf-nosed bat MYCA = California myotis; MYOC = Arizona myotis; MYVE = cave myotis; MYYU = Yuma myotis (*Myotis yumanensis*); PAHE = canyon bat; and TABR = Mexican free-tailed bat.

Planet Ranch

Acoustic detectors recorded calls in 2016 on the nights of June 9, 22, and 23, and July 20 and 21. The detectors were placed at four locations to examine an optimal site for the future placement of a permanent station. At exploratory location 1, one western yellow bat call was recorded through visual verification methods and no calls for western red bats, California leaf-nosed bats, or pale Townsend's big-eared bats. At exploratory location 2, one western red bat call and four California leaf-nosed bat calls were documented. At exploratory location 3, two pale Townsend's big-eared bat calls, and one California leaf-nosed bat call were recorded. At exploratory location 4, one western red bat call, three pale Townsend's big-eared bat calls, and 11 California leaf-nosed bat calls were recorded (figure 26).

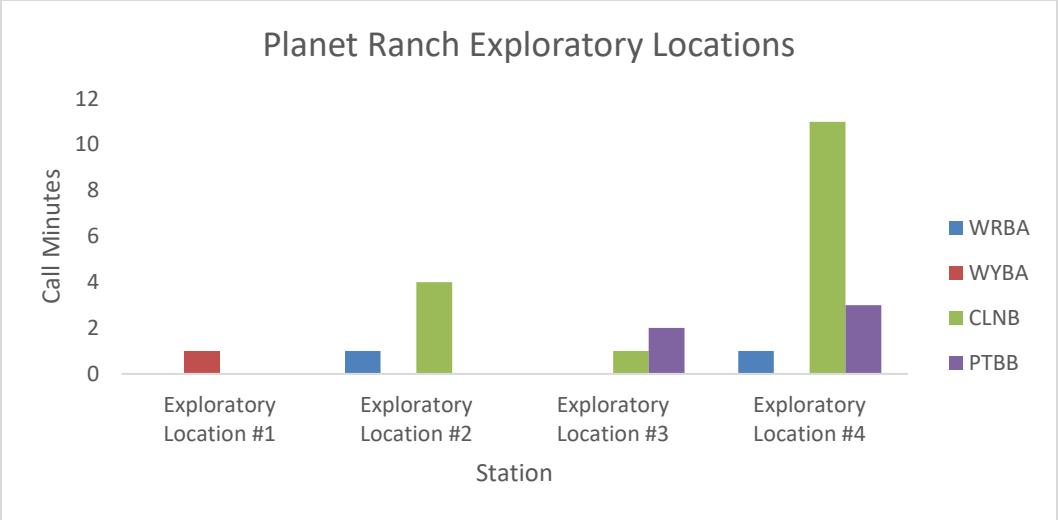

Figure 26.—Planet Ranch exploratory location acoustic results, 2016.
Note: WRBA = western red bad; WYBA = western yellow bat; CLNB = California leaf-nosed bat; and PTBB = pale Townsend big-eared bat.

Discussion

Through the Analook visual verification method, the greatest activity and occupancy for western red and yellow bats from 2015 through 2019 were detected at CVCA1 and PVER1 and at CVCA2 and Crane Roost for California leaf-nosed bats. One pale Townsend's big-eared bat call was detected through the visual verification methods at CVCA2 in 2017, and they were recorded with the greatest activity and occupancy with the Kaleidoscope auto-classifier at CVCA1 from 2015 to 2016 and at BLCA1 from 2017 through 2019. The Kaleidoscope auto-classifier overestimated western red bat, western yellow bat, and California

leaf-nosed bat activity and occupancy, but it has the potential to be useful for pale Townsend's big-eared bat calls. The greatest activity across all species for the auto-classifier was detected at PVER1, followed by BLCA1 and CVCA2. The auto-classifier results have shown a precipitous drop in activity at CVCA1 from 2017 through 2019 for all species from the highs recorded in 2015 and 2016. The drop in activity may be the result of changing vegetation characteristics as the site matures. CVCA1, which had been surrounded by cottonwood trees, now sits in a grassy clearing with some snags after trees around it died. In contrast, the CVCA2 and PVER2 detectors, which were deployed in less mature vegetation, have seen an increase in activity from 2017 through 2019 with the Kaleidoscope auto-classifier, which may be reflective of the maturing of the vegetation.

Western Red Bat

Western red bat average nightly call minutes and proportion of nights occupied were recorded to be highest at PVER1 and CVCA1 from 2015 through 2019, though, these stations have shown declines in 2018 and 2019. While CVCA1 had the second highest activity and occupancy from 2015 through 2019, a large decrease in activity and occupancy was documented from 2017 (0.83 and 0.37) to 2018 (0.25 and 0.16), to 2019 (0.12 and 0.09), making CVCA1 the acoustic station with just the second lowest activity and the lowest occupancy in 2018 and the second lowest activity and occupancy in 2019. A station malfunction in June 2018 led to 10 nights of down time for the recorder, but it does not explain the precipitous drop in activity at this site in 2018. The station operated without incident in 2019. While activity and occupancy have declined at PVER1, this station has still recorded the greatest activity and occupancy in 2018 and 2019. CVCA1 and PVER1 are located in the most mature vegetation of the conservation areas. The Palo Verde Ecological Reserve and Cibola Valley Conservation Area are also the largest continuous tracts of conservation area habitat and provide important foraging area and roosting locations for western red bats along the LCR. While CVCA1 and PVER1 saw declines in activity in 2018 and 2019, CVCA2 and PVER2 had an increase in activity. It is difficult to assess what may be causing this shift in activity, but CVCA2 and PVER2 are located in areas with maturing vegetation, while CVCA1 and PVER1 are located in areas containing the oldest vegetation. Something about the vegetation structure at maturing vegetation plantings may make the habitat more suitable for roosting and foraging than the older, more mature sites. For example, the vegetation around the detector at CVCA1 now sits in a grassy clearing with some snags, as the trees surrounding the detector have died. Western red bats often forage along edge habitat and roost in habitat with limited understory. Because this detector now sits in a clearing, western red bats have certainly shifted roosting behaviors in the area and are less likely to forage in this open clearing.

The highest average nightly call minutes were recorded across all sites in 2015, but the 2017 and 2018 seasons contained the greatest proportion of nights occupied for western red bats. Thus, activity was higher but concentrated over less nights in 2015 (0.77) near the acoustic stations compared to 2017 (0.66) and 2018 (0.48). The 2019 season contained the lowest activity (0.33) and proportion of nights occupied (0.20) across all sites from 2015 through 2019. In assessing average nightly call minutes and proportion of nights occupied, it was found that average nightly call minutes fluctuate and display greater variations (0.33 low to 0.77 high) between years than proportion of nights occupied (0.20 low to 0.30 high). In a given year, habitat near a detector may be optimal for a roost, maternity roost, or foraging, leading to an increase in average nightly call minutes but not necessarily nights occupied. Vegetation structure or prey base may change the following season, becoming less optimal near the detector but perhaps more optimal elsewhere in the conservation area, leading to a decrease in average nightly call minutes near the detector site that does not reflect a true decrease in bat use across the entire conservation area. Therefore, proportion of nights occupied may be the best way to describe bat use through acoustic detectors at conservation areas.

While the Kaleidoscope auto-classifier results were similar to the visual verification method (in that they generally identified the sites with the highest and lowest activity levels), they considerably overestimated western red bat activity at the conservation areas. If only the Kaleidoscope results were relied upon to assess bat use, BLCA1 would have been the conservation area with the greatest western red bat activity from 2015 through 2019. Through the verification method, BLCA1 had the fourth highest activity and occupancy for western red bats, behind CVCA1, CVCA2, and PVER1 from 2015 to 2019. Crane Roost would have the greatest activity in 2018 based on Kaleidoscope results. Through visual verification, Crane Roost had the fourth highest activity and occupancy in 2018, behind PVER1, CVCA2, and BLCA1. Previous capture surveys also support the verification methods, as captures for western red bats were highest at the Palo Verde Ecological Reserve and Cibola Valley Conservation Area. The Kaleidoscope auto-classifier works much like the Analook filters but is considered to be more sophisticated in terms of analyzing call parameters for identification of each species. The Kaleidoscope auto-classifier identified more potential western red bat calls than our Analook filters overall, but differences between the results from these methods varied among monitoring sites, with the Analook filters identifying more potential calls at several locations. The greater potential western red bat calls identified by the Kaleidoscope auto-classifier likely represent misidentified calls from other species (canyon bats), but we cannot discount that the Kaleidoscope auto-classifier may have identified some western red bat calls the Analook filters did not detect. An indepth comparative analysis between these two methods was not an objective for this report but could prove to be useful as a management tool as its fit is improved in the future. Because these

methods identify a different number of calls, which could potentially impact the verified results, it would be useful to determine which method identifies the greater number of verified calls.

Western Yellow Bat

Like western red bats, western yellow bats were recorded with the greatest average nightly call minutes and proportion of nights occupied at CVCA1 and PVER1 from 2015 through 2019. The Cibola Valley Conservation Area and Palo Verde Ecological Reserve are large, complex conservation areas that provide important edge habitat for foraging western yellow bats. Like western red bats, larger fluctuations and disparities among average nightly call minutes (0.25 low to 4.10 high) were noted versus proportion of nights occupied (0.14 low to 0.39 high) from 2015 through 2019. The largest disparity occurred at CVCA1, with 16.81 average nightly call minutes being recorded during the 2015 season versus 0.32 during the 2019 season. The difference in proportion of nights occupied between the two seasons was 0.97 in 2015 versus 0.15 in 2019. PVER1 differed between years, with average nightly call minutes during 2015 (6.12) greatly surpassing 2016 (1.93) and 2017 (2.3). The proportion of nights occupied between 2015 (0.68), 2016 (0.63), and 2017 (0.58) did not show such a large disparity. Activity and occupancy declined at PVER1 and CVCA1 after 2017. Western yellow bat activity and occupancy aggregated across all sites decreased substantially after the 2015 season, remained stable from 2016 through 2017, then dropped again from 2018 to 2019. Activity dropped by roughly 25% from 2016–17 to 2018–19, and occupancy dropped by more than 50%. The reasons for this decrease are unknown at this time. Western yellow bat activity has not been recorded in greater magnitudes at the system-wide acoustic detectors from 2015 through 2019, so they have not shifted their activity to these areas. It may be that as more conservation area habitat becomes suitable, western yellow bats are foraging in different parts of the conservation areas as they mature, or it may be a true decrease in activity and occupancy along the LCR. The presence of suitable roost trees in the area may be a factor as well; any removal of palms (Arecaceae) or the trimming of palm skirts, where western yellow bats prefer to roost, would limit their numbers in a given area.

The majority of western yellow bat activity and occupancy occurs later in summer during the months of July and August, with no station documenting its highest activity in June. Like western red bats, western yellow bat young typically become volant in July, which would lead to the increased activity observed in July and August. Western yellow bats are also believed to be migratory along the LCR.

A Kaleidoscope auto-classifier was recently developed and used to analyze western yellow bat calls in 2019. The Kaleidoscope auto-classifier overestimates western yellow bat activity and occupancy. The classifier identified the greatest activity at CVCA2, followed by PVER1, PVER2, and CVCA1. These results conflict with the visual verification methods for 2019, which identified the greatest activity at PVER1, followed by CVCA1, PVER2, and CVCA2.

California Leaf-nosed Bat

California leaf-nosed bats were recorded in low numbers across all sites during the 2015 and 2016 seasons. These bats produce a low-amplitude call that is difficult to detect through acoustic methods. California leaf-nosed bats were not detected at PVER2 from 2015 through 2018 or CVCA1 from 2016 through 2019. The greatest average nightly call minutes and proportion of nights occupied occurred at CVCA2, followed by Crane Roost and BLCA1 from 2015 through 2019. Crane Roost had slightly higher activity than BLCA1, but BLCA1 had slightly higher occupancy. The 2017 and 2018 seasons displayed a considerable increase in activity and occupancy over 2015 and 2016; however, a decrease in 2019 from 2017 and 2019 was observed, though still staying above 2015 and 2016 levels. The increase is difficult to attribute to any one factor, but it may be that these conservation areas are maturing and harboring a favorable prey base for California leaf-nosed bats, and they are beginning to rely on these sites for a larger portion of their diet.

A Kaleidoscope auto-classifier was recently developed and used to analyze California leaf-nosed bat calls in 2019. The greatest activity recorded by the auto-classifier during the 2019 season was observed at CVCA2, followed by BLCA1 and Crane Roost. These results were similar to the visual verification results that documented the greatest activity at BLCA1, followed by CVCA2 and Crane Roost during the 2019 season. While the auto-classifier did identify more calls as California leaf-nosed bats than the visual verification methods, it did not identify the magnitude of calls the western red and yellow bat auto-classifiers and the Anabat filters did. It may prove useful for streamlining the analysis process, as tens of thousands of calls are identified by the Anabat filter annually and must be individually verified. A visual verification of the Kaleidoscope auto-classifier calls could be conducted to determine if this method identifies all potential calls for this species.

Pale Townsend's Big-eared Bat

Pale Townsend's big-eared bats were not recorded at any conservation area with visual verification methods during the 2015, 2016, 2018, or 2019 seasons, with a

single call verified at CVCA2 in August 2017. These bats emit an extremely low-amplitude call that is difficult to detect using acoustic methods alone. The Kaleidoscope auto-classifier results recorded CVCA1, BLCA1, and PVER1 as having the greatest average nightly call minutes and proportion of nights occupied from 2015 through 2019. The auto-classifier recorded pale Townsend's big-eared bat activity at every conservation area during 2015 and 2016. A lower number of calls were identified by the auto-classifier in 2017, with no activity recorded at CVCA2, or PVER2. The auto-classifier identified the lowest number of calls in 2018, with no activity recorded at CVCA1. There was a slight increase in the number of calls detected in 2019, with no calls recorded at Crane Roost.

The Kaleidoscope auto-classifier identified an extremely low number of calls compared to the Analook filters. Where the Analook filters identified tens of thousands of calls as potential pale Townsend's big-eared bat calls, the Kaleidoscope auto-classifier identified hundreds. Given that a considerable amount of time is dedicated to visually verifying calls identified as potential pale Townsend's big-eared bat calls with little to no calls actually verified, the Kaleidoscope auto-classifier may be an efficient way to analyze these calls. A visual verification of the Kaleidoscope auto-classifier calls could be conducted to assess this method; however, such a change in methods may not be warranted, as the continuity of data analysis for this long-term acoustic monitoring study may be compromised.

Planet Ranch

The acoustic calls recorded at Planet Ranch in 2016 suggest the permanent station would best be placed at exploratory location 4. At this site over only 5 nights, 11 California leaf-nosed bat calls, 3 pale Townsend's big-eared bat calls and 1 western red bat call were recorded. An additional two pale Townsend's big-eared bat calls were recorded at exploratory location 3. Only one pale Townsend's big-eared bat call has been documented at the six permanent locations from 2015 through 2019. Planet Ranch is located in close proximity to a California leaf-nosed bat and pale Townsend's big-eared bat maternity roost, and this location may allow for the monitoring of these species to a greater degree than other sites located farther from known roosts.

Other Species Analyzed with the Kaleidoscope Auto-Classifier

The species identified by the auto-classifier across all monitoring sites as having the greatest average nightly call minutes are the canyon bat, Mexican free-tailed bat, big brown bat, and Yuma myotis. The greatest total average nightly call

minutes identified by the auto-classifier for all species combined from 2015 through 2019 were recorded at PVER1, followed by BLCA1, CVCA2, CVCA1, Crane Roost, and PVER2. The results at CVCA1 for all species mirror the drop in activity and occupancy detected through visual verification methods for western red and yellow bats.

Assessing the four LCR MSCP bat species, it was found that western yellow bats were most prevalent, with the highest activity recorded across all conservation areas from 2015 through 2019, while western red bats had the highest proportion of nights occupied. Western yellow bats are highly dependent on non-native palms for use as roosts, and as the acoustic data seem to indicate, planted conservation areas for foraging along the LCR. Western red bats are dependent on conservation sites for roosting, foraging, and as maternity roosts. Their activity and occupancy fluctuates a bit between years and sites, but overall occupancy has remained relatively stable from 2015 through 2019, while activity has decreased. California leaf-nosed bat activity and occupancy had increased in 2017 and 2018 (with a slight decline in 2019), and they are foraging at conservation areas. Although pale Townsend's big-eared bats are difficult to detect acoustically, they are most likely relying on conservation areas as foraging sites. The majority of activity and occupancy for all species occurred during July and August, with larger, more complex monitoring sites generally seeing higher average nightly call minutes and proportion of nights occupied.

It is important to note that average nightly call minutes and proportion of nights occupied are two indexes of bat activity and do not translate to population estimates. A correlation of the acoustic and capture data being collected by Bureau of Reclamation biologists at LCR MSCP conservation areas would further inform natural resource managers on bat activity and diversity at these sites, as it has been recorded that a combination of the methods was more successful in detecting bat species than either method alone (O'Farrell and Gannon 1999). Examining the capture data would be especially informative for California leaf-nosed bats and pale Townsend's big-eared bats, both of which emit low-amplitude calls and are difficult to detect acoustically. Acoustic activity and occupancy are also being collected at system-wide sites along the LCR, which are located in habitat that has not been restored. A comparison between these sites and the conservation area sites would inform land managers on broader trends of bat activity and occupancy along the LCR. It also appears that western red and yellow bat acoustic activity and occupancy have been declining at sites that historically supported the greatest activity and occupancy (CVCA1 and PVER1). It is difficult to determine the reason for this decline, and more data are needed to confirm. These bats may prefer sites with emerging and maturing vegetation, and after vegetation reaches a certain age class, it is no longer suitable. It is also possible that their prey may prefer these vegetation characteristics. An examination of vegetation characteristics and acoustic activity at these sites may further a land manager's understanding of optimal planting designs for conservation and restoration practices in the Southwest.

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ATTACHMENT 1

Station Malfunctions

During the 2015, 2016, 2017, 2018, and 2019 sampling seasons, several equipment malfunctions resulted in periods of data loss. The units were checked the day after they were installed for the season and then again a day after each card was downloaded or replaced to ensure the units collected data the first night. The units cannot be checked remotely to ensure they are functioning between site visits.

- The Palo Verde Ecological Reserve PVER2 station had multiple issues during the 2015 season (June 24 – August 12, and August 16–31) and the Anabat unit had to be replaced. PVER2 also malfunctioned during the 2016 season (June 1–15) due to corrupted compact flashcards. The station also had a kinked microphone cable, which may have led to a reduced amount of calls being detected for the recording period. PVER2 malfunctioned during the 2017 season as well (June 1 – July 19) due what was first thought to be a malfunctioning unit but ultimately was determined to be a broken microphone cable. The Anabat unit used in this station in 2016 had burn marks, and it is possible that the tower and equipment was damaged by a lightning strike. PVER2 was also inoperable from June 1through June 10, 2018.

- The Crane Roost station malfunctioned during the 2016 season (June 1–16), also due to corrupted compact flashcards. The station also malfunctioned during the 2017 season (June 1 and July 4–17). The battery had to be replaced on June 2, 2017. No reason could be determined for the data loss in July 2017; the unit functioned properly through August. The station malfunctioned during the 2019 season from June 6 to July 1.

- The Cibola Valley Conservation Area CVCA1 station malfunctioned during the 2017 season, resulting in only 8 nights of recorded data (June 1 – July 28 and August 6–31). Equipment was swapped out and the cause of malfunction could not be determined. The station was inoperable from June 1 through June 10, 2018.

- CVCA2 malfunctioned during the 2017 season (no data for June 1). A different compact flash card was installed on June 2, and no further issues were encountered.

- PVER1 malfunctioned during the 2019 season from August 9 through August 31.

- The Beal Lake Conservation Area BLCA1 station functioned properly throughout the recording period.

Data collected at these six stations was used to evaluate bat use magnitude and diversity.

ATTACHMENT 2

Station Monthly Summaries for 2019 – Analook Visual Verification Method

WESTERN RED BAT

Table 2-1.—Western red bat 2019 summary data for BLCA1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	3	0.10	3	0.10
July	31	9	0.29	10	0.32
August	31	2	0.06	2	0.06

Table 2-2.—Western red bat 2019 summary data for Crane Roost

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	5	1	0.20	1	0.20
July	30	3	0.10	4	0.13
August	31	0	0.00	0	0.00

Table 2-3.—Western red bat 2019 summary data for CVCA1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	2	0.07	4	0.13
July	31	4	0.13	5	0.16
August	31	2	0.06	2	0.06

Table 2-4.—Western red bat 2019 summary data for CVCA2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	4	0.13	4	0.13
July	31	9	0.29	19	0.61
August	31	13	0.42	23	0.74

Table 2-5.—Western red bat 2019 summary data for PVER1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	7	0.23	15	0.50
July	31	14	0.45	22	0.71
August	8	4	0.50	12	1.50

Table 2-6.—Western red bat 2019 summary data for PVER2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	10	0.33	12	0.40
July	31	8	0.26	12	0.39
August	31	7	0.23	14	0.45

WESTERN YELLOW BAT

Table 2-7.—Western yellow bat 2019 summary data for BLCA1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	1	0.03	1	0.03
July	31	4	0.13	4	0.13
August	31	1	0.03	1	0.03

Table 2-8.—Western yellow bat 2019 summary data for CVCA1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	1	0.03	2	0.07
July	31	7	0.23	16	0.52
August	31	6	0.19	11	0.35

Table 2-9.—Western yellow bat 2019 summary data for CVCA2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	0	0.00	0	0.00
July	31	5	0.16	9	0.29
August	31	0	0.00	0	0.00

Table 2-10.—Western yellow bat 2019 summary data for PVER1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	2	0.07	2	0.07
July	31	22	0.71	44	1.42
August	8	5	0.63	11	1.38

Table 2-11.—Western yellow bat 2019 summary data for PVER2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	0	0.00	0	0.00
July	31	5	0.16	5	0.16
August	31	6	0.19	9	0.29

No calls were detected at Crane Roost using the Analook visual verification method.

CALIFORNIA LEAF-NOSED BAT

Table 2-12.—California leaf-nosed bat 2019 summary data for BLCA1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	6	0.20	7	0.23
July	31	6	0.19	7	0.23
August	31	0	0.00	0	0.00

Table 2-13.—Western yellow bat 2019 summary data for Crane Roost

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	5	0	0.00	0	0.00
July	30	2	0.07	6	0.20
August	31	0	0.00	0	0.00

Table 2-14.—Western yellow bat 2019 summary data for CVCA2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	2	0.07	2	0.07
July	31	3	0.10	3	0.10
August	31	4	0.13	4	0.13

Table 2-15.—Western yellow bat 2019 summary data for PVER1

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	0	0.00	0	0.00
July	31	2	0.06	2	0.06
August	8	0	0.00	0	0.00

Table 2-16.—Western yellow bat 2019 summary data for PVER2

Month	Days recorded	Days occupied	Proportion of nights occupied	Call minutes	Average call minutes
June	30	0	0.00	0	0.00
July	31	1	0.03	1	0.03
August	31	1	0.03	1	0.03

No calls were detected at CVCA1 using the Analook visual verification method.

PALE TOWNSEND'S BIG-EARED BAT

No calls were detected at any of the stations in 2019 using the Analook visual verification method.