REPORT 2021: Study of Bat Populations on BCPOS Properties, Seasonal Migrations, Overwintering Activity, High Elevation Roost Sites, and Effects of the Cal-Wood Burn at Heil Valley Ranch

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(66 Pages, 49 Figures, 2 Tables)

Abstract

In 2021, major emphasis was placed on understanding how bats would react to the Cal-Wood burn at Heil Valley Ranch. Thirty-one SMU Mini detector sites were established and run for four nights at each location. Analyses showed that in general, bats foraged more in moderate to severely burned ponderosa pine stands that retained needles than in either low to nonburned areas or severely burned stands lacking needles. The fringed myotis (*M. thysanodes*) maternity colony located in a rock crevice roost in Geer Canyon appeared to be active and productive in 2021 despite the severely burned stands most proximate to their roost site. Ingersol Quarry was highly active in 2021 and continues to be a highly important drinking and foraging site, especially for myotis species. In addition, small-footed myotis (*M. ciliolabrum*) continue to be over-wintering at the site in winter 2020-2021. At the eastern property of Twin Lakes tricolored bats continued to increase exponentially, whereas at Walden Ponds, number of passes per night decreased from 2020 numbers. The South St. Vrain elevational transect showed different patterning than in 2020, with much higher activity the highest elevation and almost zero activity at the mid-elevation. The lowest elevation site at Hall II in 2021 was not surveyed in 2020, so not comparable to 2020 dats. A new elevational transect along Left Hand Canyon Creek was begun in 2021 and also showed high activity at the highest elevation near Brainard Lakes. High-elevation building sites, Rocky Mountain Mammoth, Cardinal Mill, and Blue Jay Mine showed high activity in 2021 and showed clear indication of large maternity colonies for little brown myotis and long-legged myotis.

Introduction

The main emphasis of the 2021 grant was to survey for bats at Heil Valley Ranch (HVR) after the Cal-Wood Burn of October 2020 affected more than 10,000 acres that included much of HVR (Fig. 1). Although the landscape burned as a mosaic of intensities, much of HVR underwent intense burning that removed all ground cover and severely torched ponderosa pine trees and other vegetation (Fig. 2). Other areas were less severely burned or even untouched (Fig. 3) thus generating the question of how bats would forage among different forest stands.

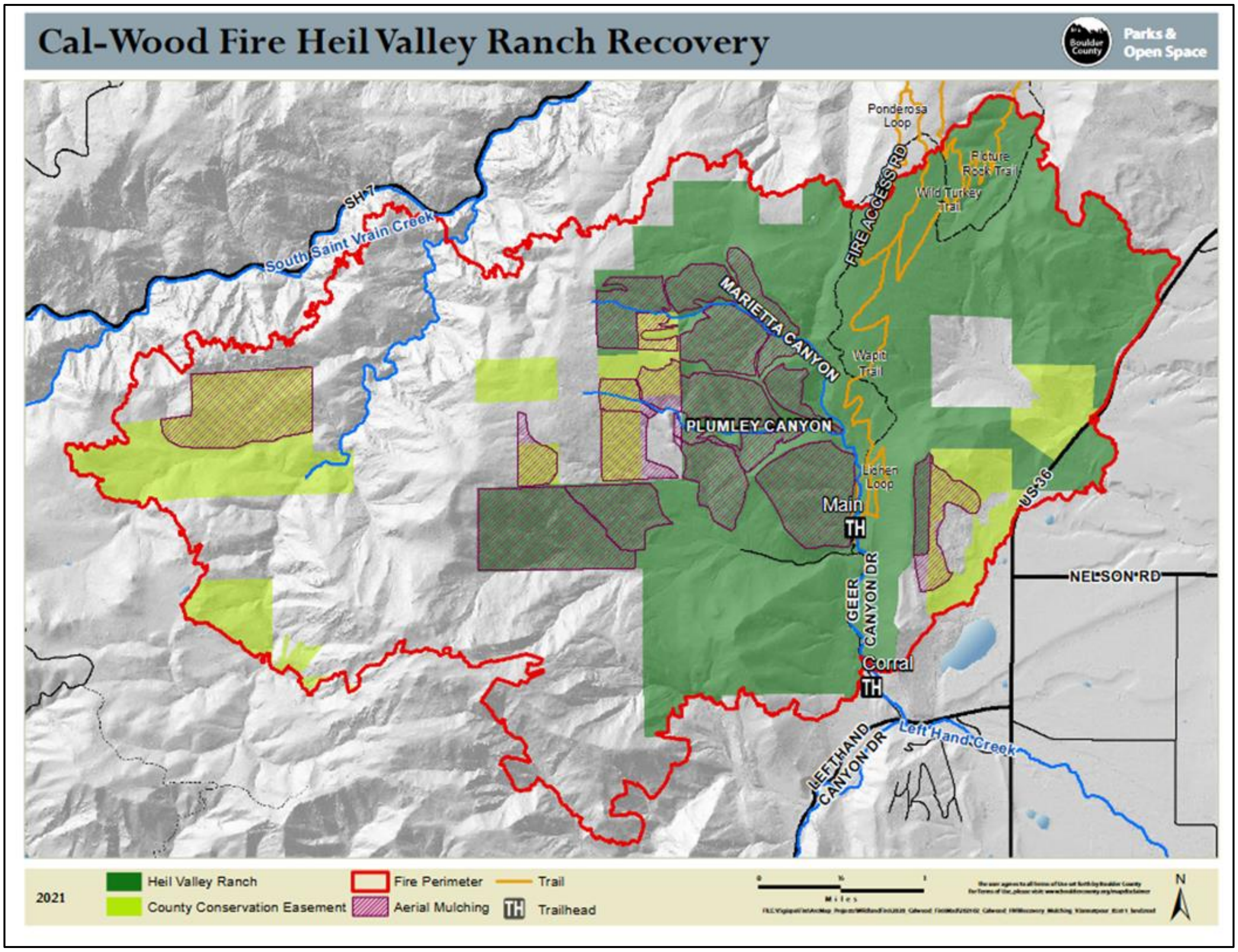


Figure 1. Map showing areas burned at Heil Valley Ranch (HVR) in October 2020. Map legend depicts fire perimeter in relation to HVR. Fire burn intensity varied but much of HVR underwent severe intensity burning.

Figure 2. Photograph exemplifying severe-intensity burn at HVR. (credit R. Adams).

Figure 3. Photographs showing other stand burn intensities excluding the severe state illustrated in Fig. 2. From left to right: from no damage to ponderosa pine trees to lower limb damage to entirely burned trees that still retain needles. (credit R. Adams)

Fire and Bats

Fire may affect bats directly through heat, smoke, and carbon monoxide, or indirectly through modifications in habitat and changes in their food base (Dickinson et al. 2009, Perry 2012). With increasing use of prescribed burns as a land management tool and contemporary increasing fire intensity and frequency in the West due to climate change, understanding the effects of fire (prescribed or natural) on bat populations have just begun. A study conducted in an oak-hickory forest in Kentucky, Lacki et al. (2016) found that bat activity did not differ with burn severity for high-frequency (clutter-adapted or closed-space foragers) or low-frequency (edge or open-space foragers) bats. Differing degrees of burn severity from prescribed fires conducted between 2007 and 2017 produced spatial variation in canopy structure within stands; however, bats demonstrated no shifts in activity levels to this variation in canopy structure, suggesting prescribed fire during the dormant season, season, used as a management practice targeting desired changes in vegetation, is compatible with sustaining foraging habitat of insectivorous bats. Buchalski et al. (2013) found that bat activity in burned areas one year later was either equivalent or higher than in unburned stands for all six phonic groups measured, with four groups having significantly greater activity in at least one burn severity level. Evidence of differentiation between fire severities was observed with some *Myotis* species having higher levels of activity in stands of high-severity burn. Larger-bodied bats, typically adapted to more open habitat, showed no changes in foraging area in response to fire. Extent of high-severity fire damage in the landscape had no effect on activity of bats in unburned sites suggesting no landscape effect of fire on foraging site selection and emphasizing stand-scale conditions driving bat activity. Results from this fire in mixed-conifer forests of California suggest that bats are resilient to landscape-scale fire and that some species preferentially select burned areas for foraging. A more recent study in the Sierra Nevada mountains that analyzed megafire areas from 2014 and 2017 found very similar results (Mirts et a. 2021).

Tricolored Bats in Boulder County

Until 2017, there had been only two individuals of the tricolor bat (*Perimyotis subflavus*) documented in Boulder County (Armstrong et al. 2006, RA Adams personal observation 2013). However, the finding of a grounded female with two pups along South Boulder Creek in eastern Boulder County by a wildlife rehabilitator in 2017 provided evidence that this species is reproducing along the Front Range (Adams et al. 2018). Sonar evidence gathered in 2020 showed that tricolored bats are increasing in numbers at Twin Lakes and Walden Ponds and this increase is either due to reproduction and survivorship of young, increased migration into the county, or both. Tricolored bats have been devastated by white-nose syndrome in the eastern US and a petition has been submitted for listing this species as endangered. A recent survey in the Guadalupe Mountains National Park and Culberson County extended the range of this species into the Trans-Pecos region of Texas (Hannttula and Valdez 2021). Although movement patterns of this species are poorly known, some evidence indicates that at least some individuals may undergo long-distance seasonal migrations latitudinally (Fraser et al. 2012).

Elevational Migrations and Bats

Outside the general patterns that our local bat species move among different elevations seasonally, the relationship of these local migratory movements to annual weather patterns or more long-term changes in climate remain unclear. It has been presumed that myotis bats and big brown bats overwintering in Boulder County move between higher elevation underground hibernacula and summer foraging areas at lower elevations seasonally. Adams and Hayes (2018) analyzed capture data over the last 23 years and found that the long-legged myotis (*M. volans*) were not as prevalent at lower elevations in the spring and early-summer months as was documented previously. They infer climate change and the well-known fact that this species is sensitive to heat stress at lower elevations during mid-late summer and typically moves to higher elevations during these months. If this species is no longer descending to lower elevations in years where springtime temperatures are above average, this would be the first bat species for which climate change is disrupting its seasonal migration patterns. In 2019, we began tracking seasonal movements of bats using sonar detectors across elevations in South St. Vrain Canyon and in fall 2021 we replicated this along Lefthand Canyon Creek. Quantifying elevational migrations in Boulder County will help with understanding how various bat species may react to regional climate warming.

Winter Bat Activity

Gilbert White (1777) noted in his journal the observation of bats aerially emerging from their hibernaculum in winter. Moffat (1904); Barrett-Hamilton (1910-11); Venables (1943) and Vesey-Fitzgerald (1949) noted occasional occurrences of winter feeding by pipistrelle bats in Britain as did, later, Avery (1985).

Winter activity by bats in temperate North America was made clear by at least 1989 (Whittaker and Rissler 1992, Indiana). In the western US, winter bat activity has been noted in New Mexico (Geluso 2007), Yellowstone National Park (2017) and Montana 2014). In arid regions such as New Mexico (Geluso 2007), Utah (Ruffner 1979), and Colorado (Adams unpub. data) such activity appears restricted along water sources that provide winter water due to surface-melt on warmer days. Rather than humid underground caverns, bats are using unconventional hibernation sites that require regular arousal and water replenishment. More understanding of these behavioral patterns should prove important for proper management of these unique locales.

Methods

HVR Burn: Sonar surveys for bats in various burn intensities based upon post-fire damage levels to ponderosa trees (*Pinus ponderosa*) caused by the Cal-Wood fire at Heil Valley Ranch (HVR) were conducted based upon four categorical criteria (Table 1) similar to those used by Lacki et al. (2016) for bats but derived to HVR burn-specific conditions in ponderosa pine woodlands within 30m of each detector. Wildlife Acoustic SMU Mini Bat Detectors were deployed for four-five nights (five if weather was significantly different on one of the nights) in each sonar zone. Recorded sonar sequences were analyzed with SonoBat 4.4 version software to identify bat species. Bat activity was defined as the cumulative sum of sonar call sequences recorded regardless of species or if the call sequence was indefinable to species. In some cases, these data were converted to Passes per Night (PNN) to compare different sites if the number of survey nights differed. In addition, an SM4 sonar unit was placed in a severe burn with no needles site below the known maternity roost of friend myotis (*Myotis thysanodes*) and maintained throughout the summer and fall months to track their fidelity as well as other bat species activity in Geer Canyon. In addition, an SM4 sonar detector was maintained at Ingersol Quarry through the spring, summer, and fall months to better understand the importance of this site to bats for drinking, foraging, and overwintering.

Table 1. Classification of ponderosa pine tree stands within bat sonar detection areas. Because burns create a mosaic of effects on individual trees in a given area, categories are based upon a range of effects within each sonar zone similar to those used by Lacki et al. (2016) but specific to within 30m of each detector placement at HVR.

Burn Intensity	Definition	Example
None-Low	No clear damage to trunk or branches of trees- damage to trunk or most trees restricted to lower trunk and lower 1/3rd branches burned	
Moderate-Severe with needles	More than ½ branches burned or entire tree burned but supporting needles	
Severe with needles	Nearly all or all of trees entirely burned but supporting needles	
Severe with no needles	Nearly all or all trees severely burned and not supporting needles	

Results

Heil Valley Ranch

Cal-Wood Burn Analyses: SMUs were deployed for a total of 167 detector nights across 31 sites from 8 July – 7 September 2021 (Fig. 4). Access to sites was limited due to post-fire recovery mitigation efforts. A total of 39,144 call sequences were recorded with 22,047 being identified to species. On average 234.4 bat passes per night across all sites occurred. Table 2 provides descriptions of each site as well as specific GPS locations in degrees, decimal minutes, and graphs depicting bat species activity patterns at each site. Number of sites surveyed relative to burn severity were as follows: none-low (N = 10), moderate-severe N = (5), severe with needles (N = 11), severe without needles (N = 5).

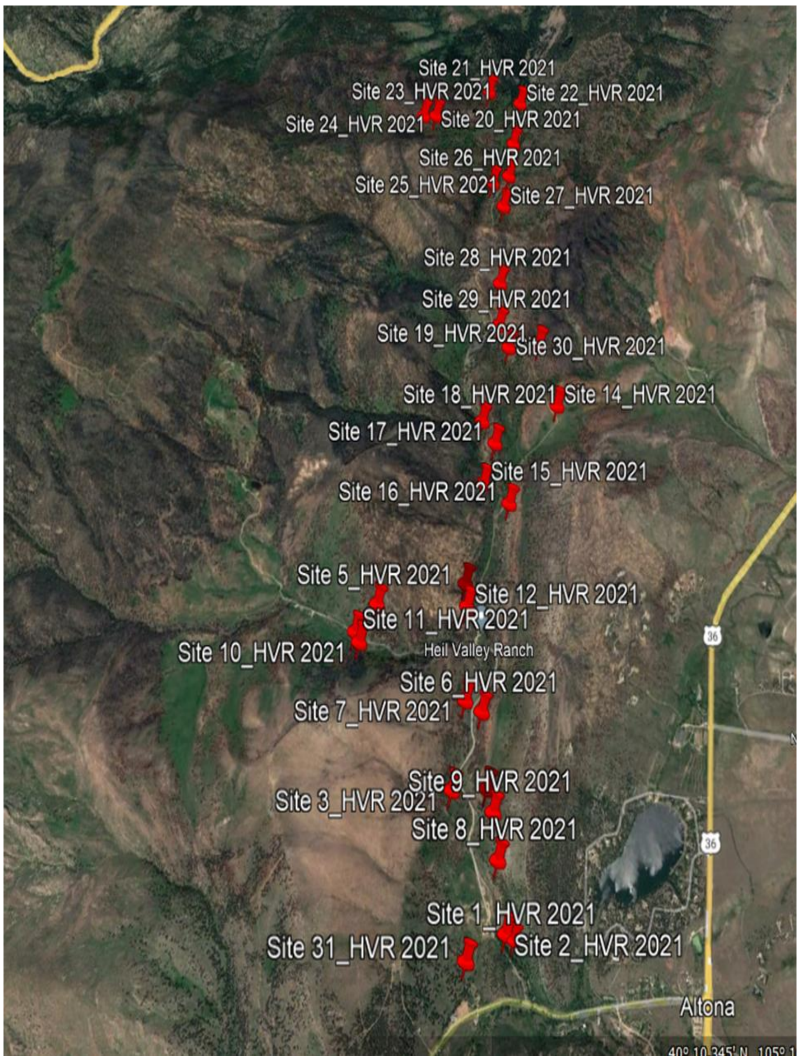
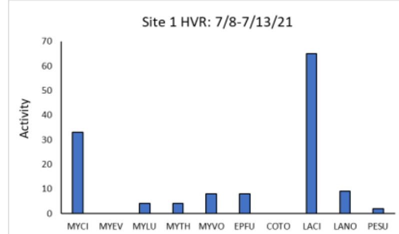
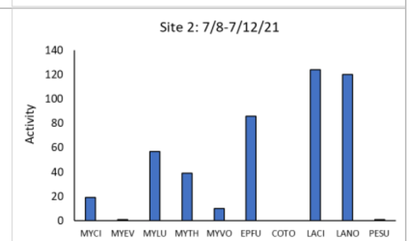
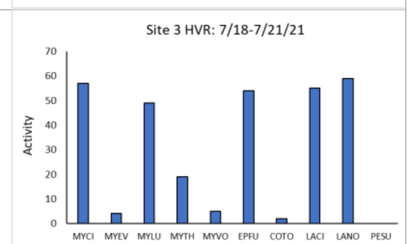
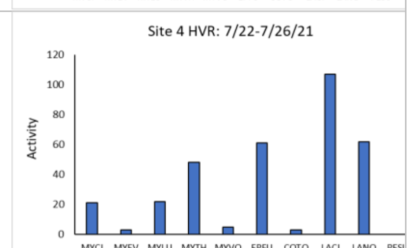
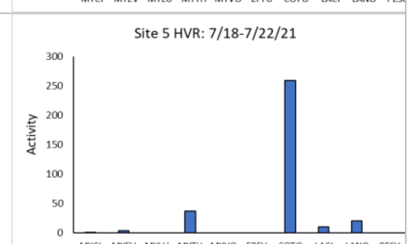
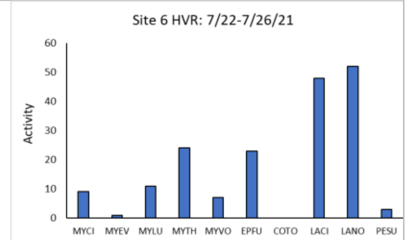
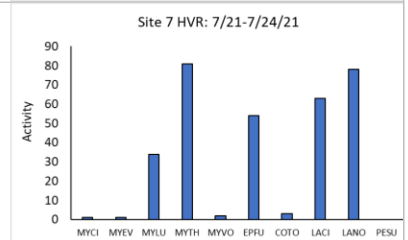
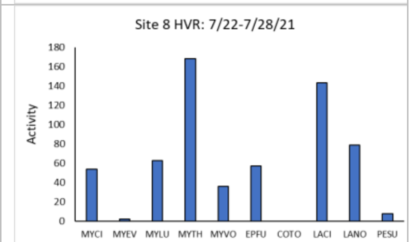
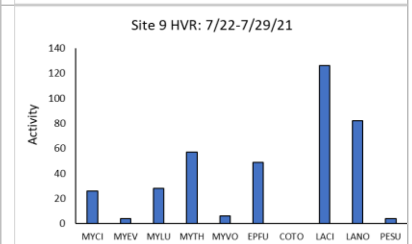
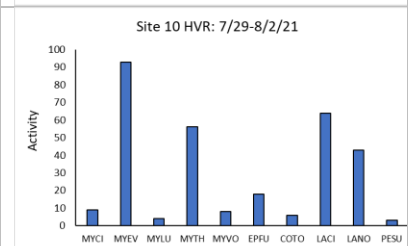
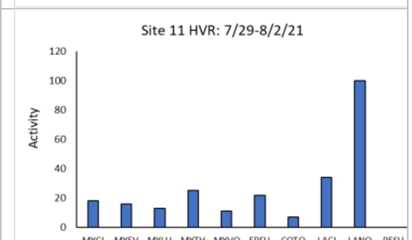
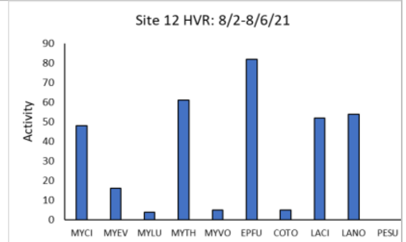
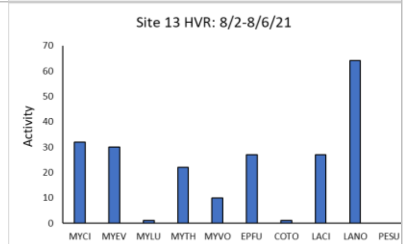
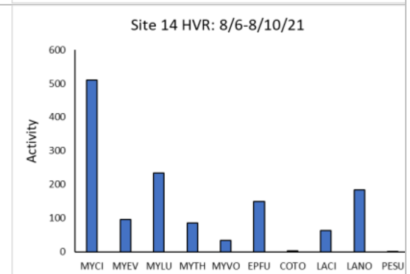
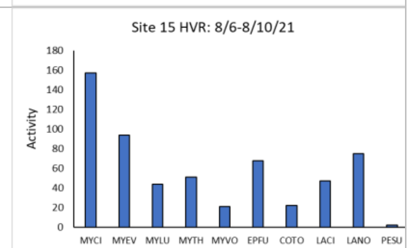
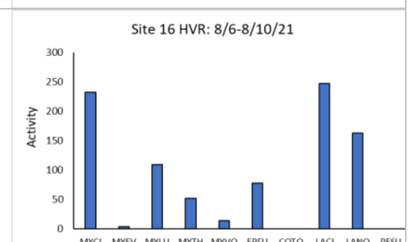
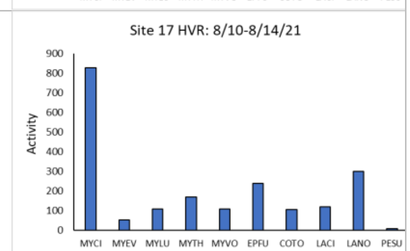


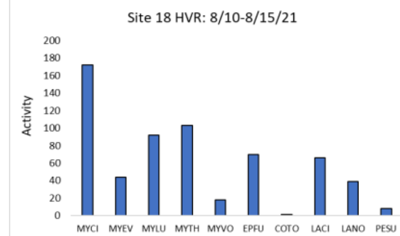
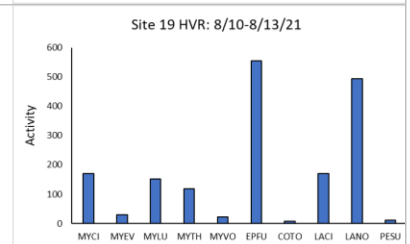
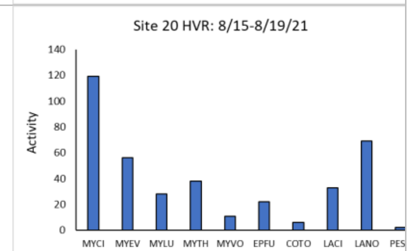
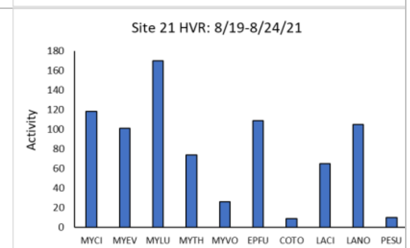
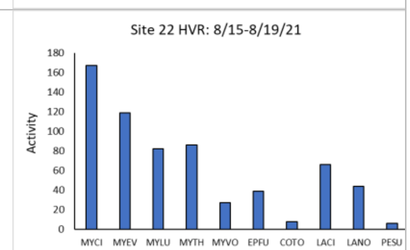
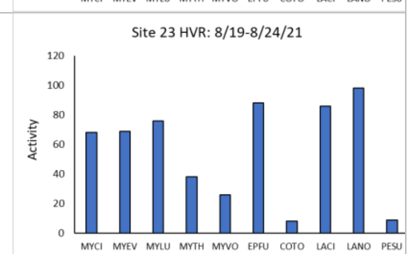
Figure 4. Map showing the locations of 31 sites sampled at Heil Valley Ranch (HVR) in 2021.

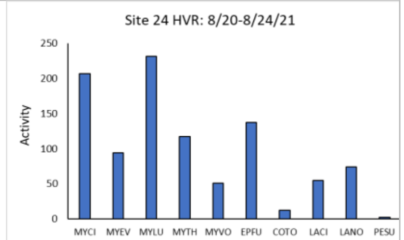
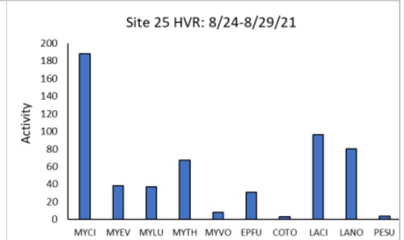
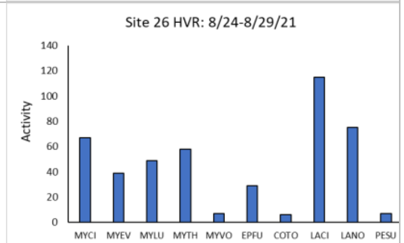
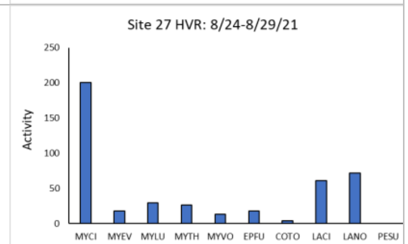
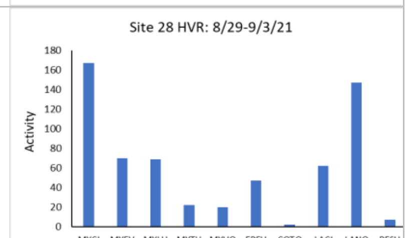
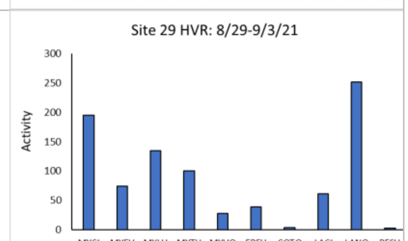
Table 2. Site descriptions including GPS coordinates (degrees, decimal minutes), survey dates, habitat type, burn level and species-specific bat activity for the 31 sites surveyed at HVR. All graphs are organized from left to right using the following species codes: MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, LANO = *Lasionycteris noctivagans*, and PESU = *Perimyotis subflavus*.

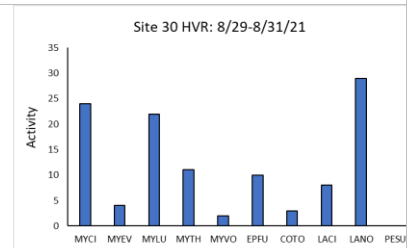
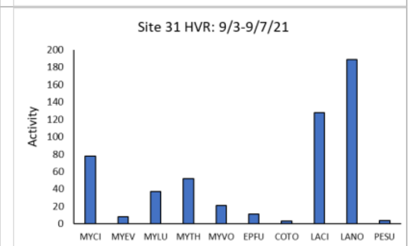
SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 1	40 8 52 105 17 802 1735m	7/8-7/12 2021	Riparian	None-Low	
 Site 2	40 8 49 105 17 763 1753m	7/8-7/12 2021	Ponderosa Pine Woodlands	None-Low	
 Site 3	40 8 378 105 18 84 1776m	7/18-7/21 2021	Ponderosa Pine Woodlands	Moderate -Severe	
 Site 4	40 8 396 105 17 932 1766m	7/21-7/24 2021	Ponderosa Pine Woodlands	None-Low	
 Site 5	40 8 831 105 18 505 1873m	7/18-	Ponderosa Pine Woodlands -below MYTH roost	Severe, no needles	

SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 6	40 8 594 105 17 984 1779m	7/21-7/25/21	Ponderosa Pine Woodlands	Severe, with needles	
 Site 7	40 8 617 105 18 63 1781m	7/21-7/25/21	Ponderosa Pine Woodlands	Moderate -Severe	
 Site 8	40 8 222 105 17 859 1759m	7/21-7/25/21	Ponderosa Pine Woodlands	None-Low	
 Site 9	40 8 338 105 17 896 1771m	7/21-7/25/21	Ponderosa Pine Woodlands	Low-Moderate	
 Site 10	40 8 717 105 18 563 1893m	7/29-8/2/21	Ponderosa Pine Woodlands	Severe, with needles	
 Site 11	40 8 747 105 18 590 1884m	7/29-8/2/21	Ponderosa Pine Woodlands	Moderate -Severe	

SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 12	40 8 872 105 18 94 1819m	8/2/-8/6/21	Ponderosa Pine Woodlands	Severe, no needles	
 Site 13	40 8 935 105 18 112 1838m	8/2-8/6/21	Ponderosa Pine Woodlands	Severe, no needles	
 Site 14	40 9 526 105 17 744 1862m	8/6-8/10/21	Grassland-Pdog colony	Severe, no needles	
 Site 15	40 9 244 105 18 73 1850m	8/6-8/10/21	Ponderosa Pine Woodlands	Severe, no needles	
 Site 16	40 9 198 105 17 941 1831m	8/6-8/10/21	Ponderosa Pine Woodlands	Severe, with needles	
 Site 17	40 9 381 105 18 36 1839m	8/10-8/15/21	Ponderosa Pine Woodlands, Lower Plumley Canyon	Severe, with needles	

SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 18	40 9 446 105 18 109 1849m	8/10-8/15/21	Ponderosa Pine Woodlands, Annual-Site, Plumley Canyon	Severe, with needles	
 Site 19	40 9 711 105 17 858 1908m	8/10-8/15/21	Ponderosa Pine Woodlands with meadows	Low-Moderate	
 Site 20	40 10 403 105 18 81 2057m	8/15-8/19/21	Ponderosa Pine Woodlands	None	
 Site 21	40 10 602 105 18 241 2068m	8/19-8/24/21	Ponderosa Pine Woodlands MYEV thinned	Severe, with needles	
 Site 22	40 10 573 105 18 66 2060m	8/15-8/19/21	Ponderosa Pine Woodlands	Low-Moderate	
 Site 23	40 10 454 105 18 581 2103m	8/19-8/24/21	Ponderosa Pine Woodlands	None	

SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 24	40 10 467 105 18 516 2091m	8/19-8/24/21	Ponderosa Pine Woodlands	Severe, with needles	
 Site 25	40 10 270 105 18 88 2055m	8/24-8/29/21	Ponderosa Pine Woodlands	Low-Moderate	
 Site 26	40 10 243 105 18 171 2044m	8/24-8/29/21	Ponderosa Pine Woodlands	None	
 Site 27	40 10 156 105 18 101 2036m	8/24-8/29/21	Ponderosa Pine Woodlands	Severe, with needles	
 Site 28	40 9 882 105 18 81 1990	8/29-9/3/	Ponderosa Pine Woodlands with meadows	Severe, with needles	
 Site 29	40 9 750 105 18 67 1946m	8/29-9/3/	Ponderosa Pine Woodlands with meadows	None-Low	

SITE	LOCATION	DATES	HABITAT	BURN LEVEL	Bat Species Activity by Site
 Site 30	40 9 685 105 18 9 1945m	8/29-9/3/	Ponderosa Pine Woodlands	None-Low	
 Site 31	40 7 975 105 17 958 1747m	9/3-9/7/21	Ponderosa Pine Woodlands with meadows	None	

Bat Activity: Individual sites varied in terms of bat activity with Site 19 (low to moderate severity) recording the highest number of passes per night (891 PPN) and Site 1 (unburned riparian area along Geer Creek) with 64.8 PPN (Figure 5).

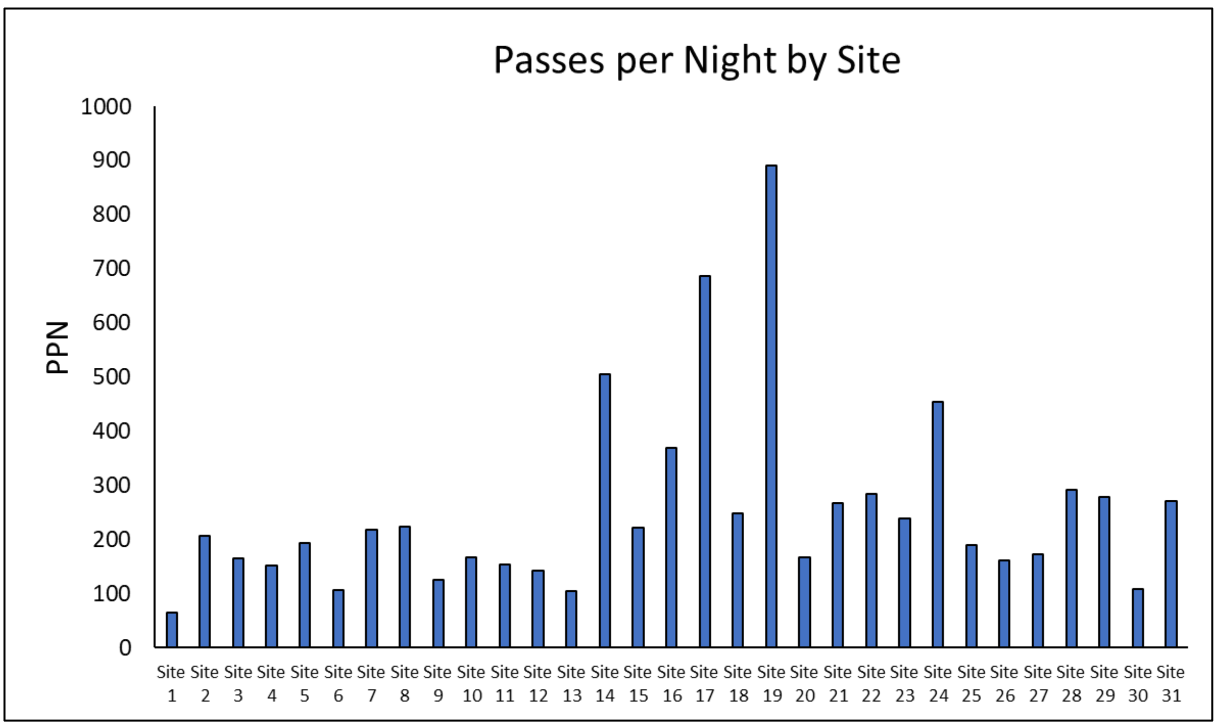


Figure 5. Passes per night calculations indicated that whereas most sites averaged around 200-400 passes per night, Site 19 (moderate-severe) was particularly active with nearly 900 passes per night. Sites 17 (severe with needles) and 14 (severe without needles) were also much higher than other sites in activity.

Mean bat activity in relation to burn severity indicated wide variation in usage of each burn type. However, all burned sites had more activity than did the none-low severity sites with moderate-severe burned sites having the highest mean, but also the highest standard deviation. None-low burn sites had the lowest average activity and also the least amount of variation (standard deviation) (Fig. 6)

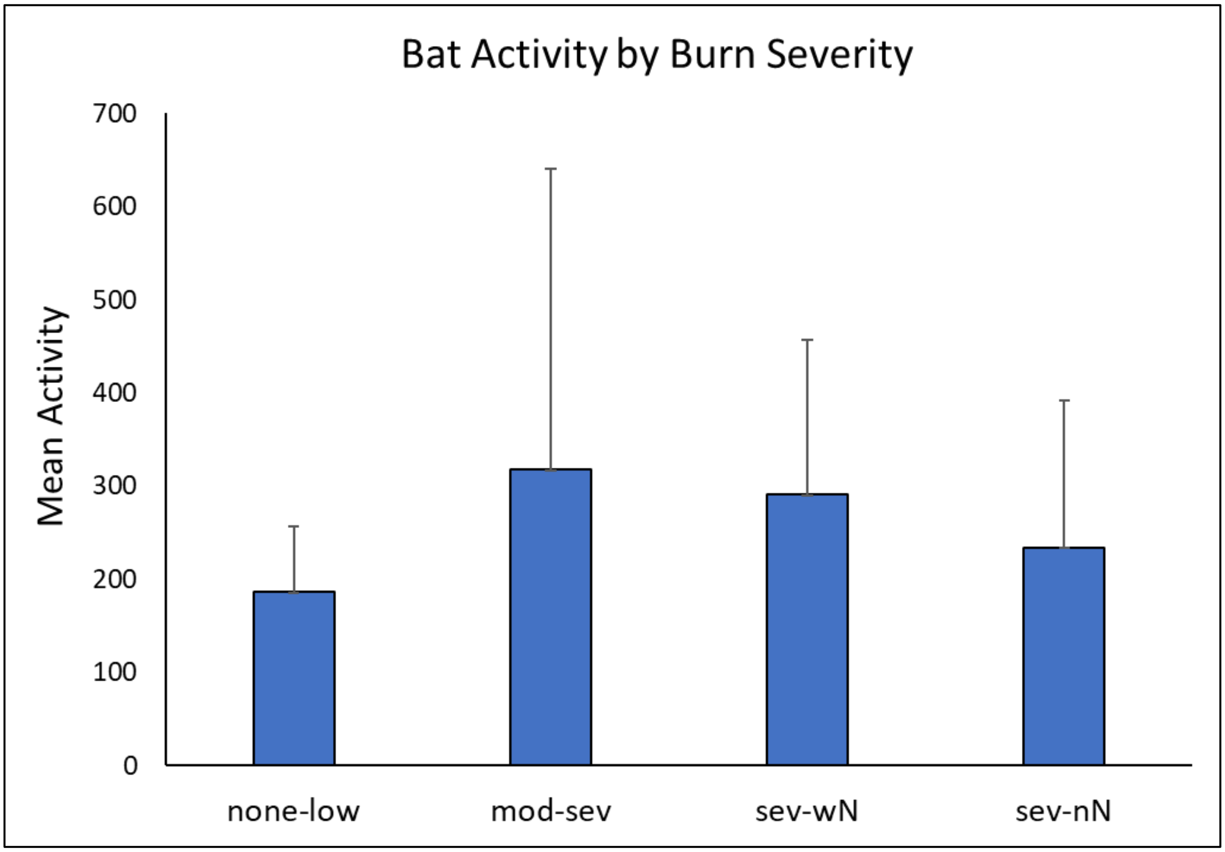


Figure 6. Mean bat activity plotted against burn severity. Moderate-severe burns had most activity whereas none-low severity had the least.

Species-specific Activity Patterns: All 10 species known to have reproductive populations in Boulder County were found active at Heil Valley Ranch. The most active species were small-footed myotis (*Myotis ciliolabrum*) and the least active was tricolored bats (*Perimyotis subflavus*) (Fig. 7).

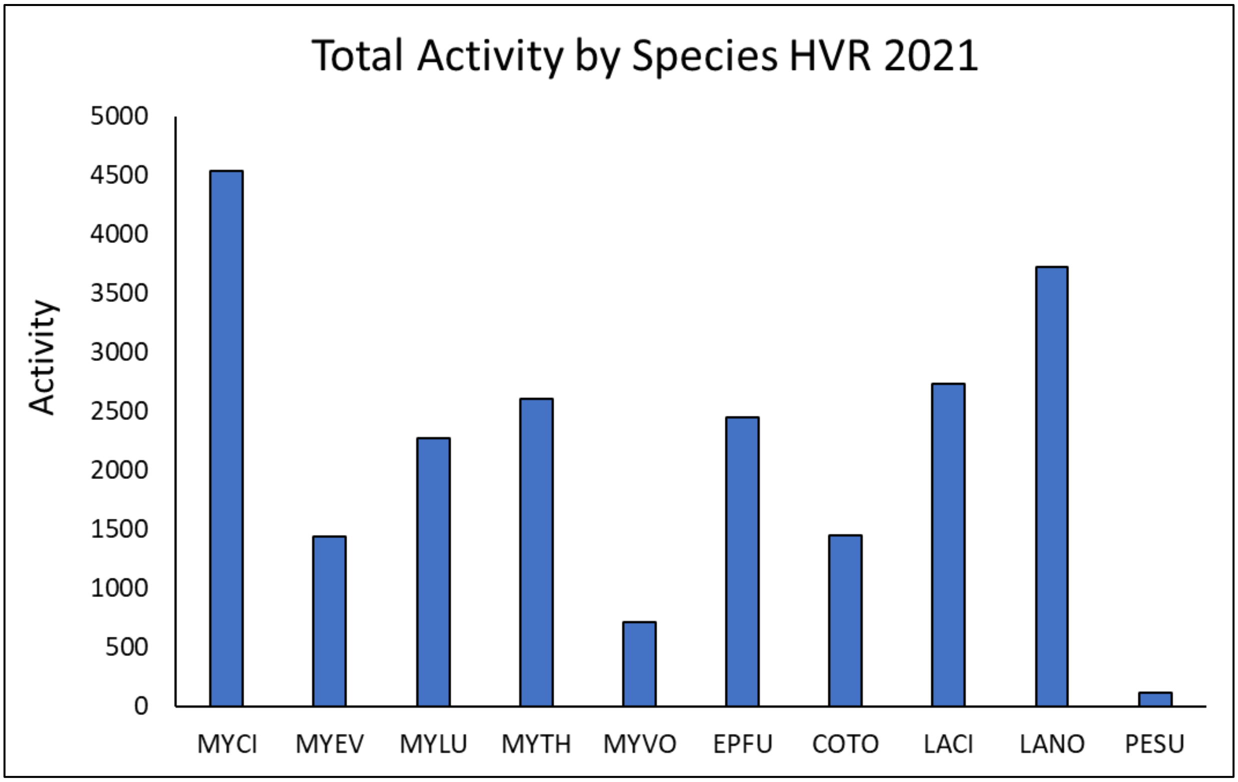


Figure 7. Distribution of bats based on number of passes (Activity) recorded throughout the summer at the 31 HVR sites. Small-footed myotis (MYCI) were the most active and tricolored bats were the least (PESU). MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, LANO = *Lasionycteris noctivagans*, and PESU = *Perimyotis subflavus*.

Species distributions within different burn severities showed that although much of the bat activity recorded at HVR was in none-low and moderate-severe burns, these were mostly open aerial foragers such as big brown bats (*Eptesicus fuscus*), hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*). In severe burn sites retaining needles, myotis species were prolific, especially the small-footed myotis (*M. ciliolabrum*) and in severe-burns with no needles Townsend's big-eared bats (*Corynorhinus townsendii*) were very active (Fig. 8A). However, most of this activity occurred at a single site (Site 5) just below the *M. thysanodes* maternity colony between 7/18 and 8/2 2021 (Fig. 8B)

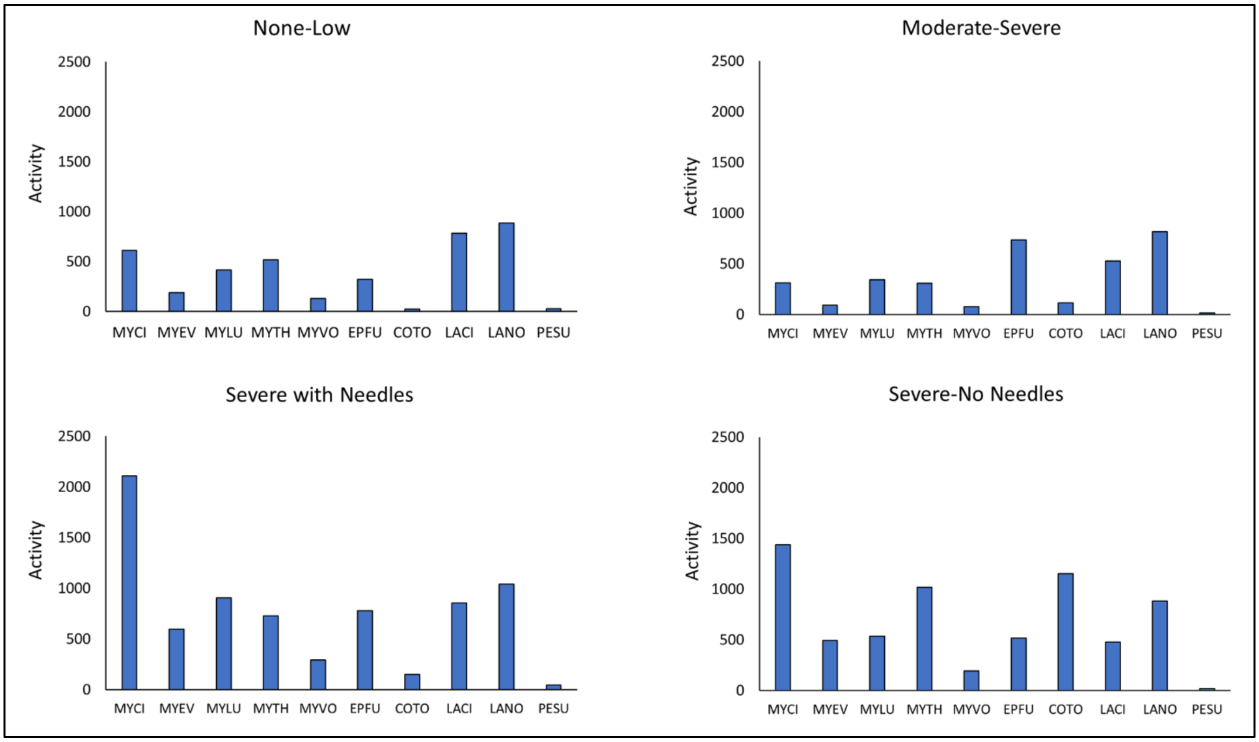


Figure 8A. Distribution of bat species activity in each of the burn severity categories. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, LANO = *Lasionycteris noctivagans*, and PESU = *Perimyotis subflavus*.

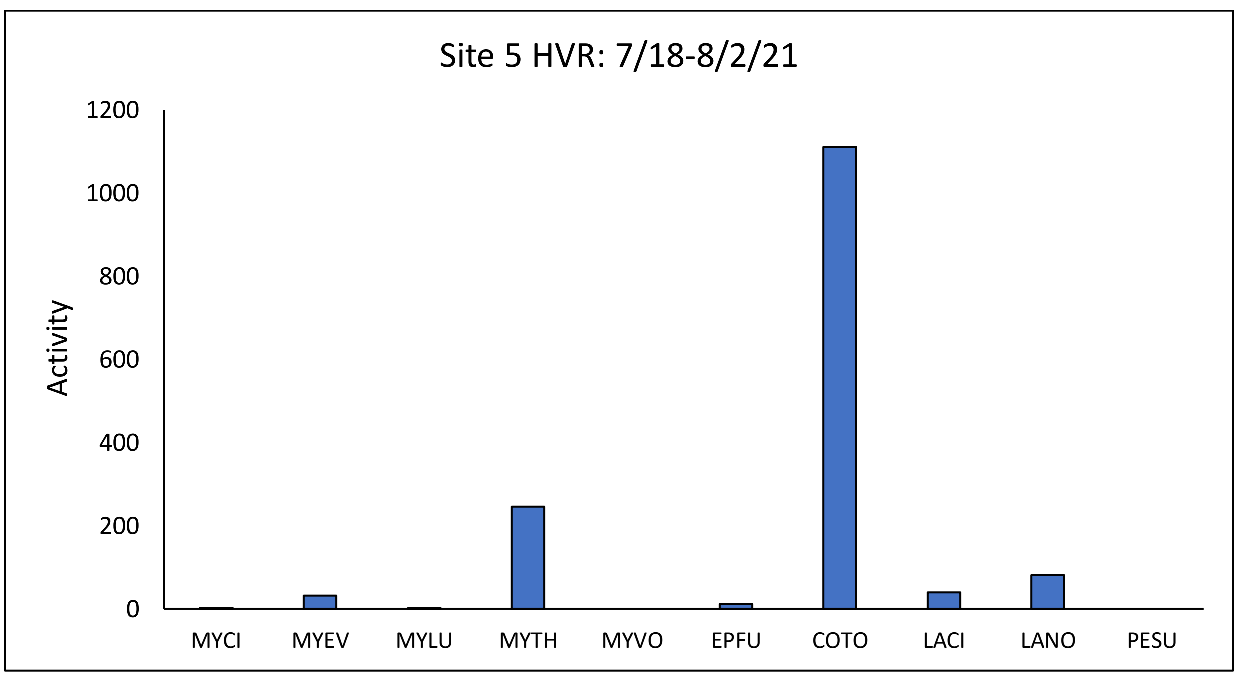
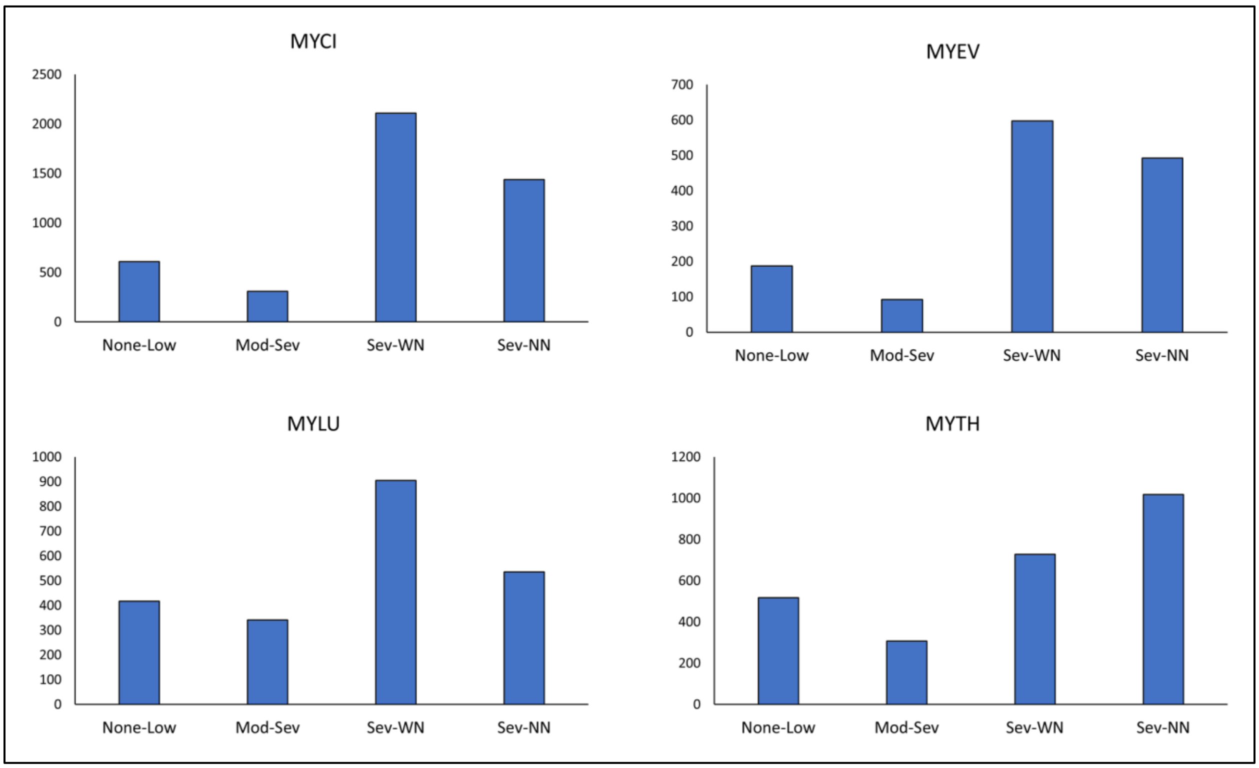


Figure 18B. Species activity at Site 5 below the *M. thysanodes* maternity roost in Geer Canyon. 2021. Note high activity of Townsend's big-eared bats (*Corynorhinus townsendii*) during this period.

Species-specific activity in each of the burn severity types showed that four of the five myotis species preferred severely burned sites in which trees had needles. The exception was the fringed myotis (*M. thysanodes*), a clutter aerial pursuit predator which preferred severely burned stands lacking needles (Fig. 9). Big brown bats (*E. fuscus*) foraged mostly over moderate-severe and severe with needles stands, whereas Townsend's big-eared bats (*C. townsendii*) clearly preferred severe burns with no needles. Hoary bats (*L. cinereus*) were nearly equally present over none-low and severe with needles stands, whereas silver-haired bats (*L. noctivagans*) were more or less equally distributed among stand types. Tricolored bats (*P. subflavus*) foraged predominately in severe burns having needles (Fig. 10A).



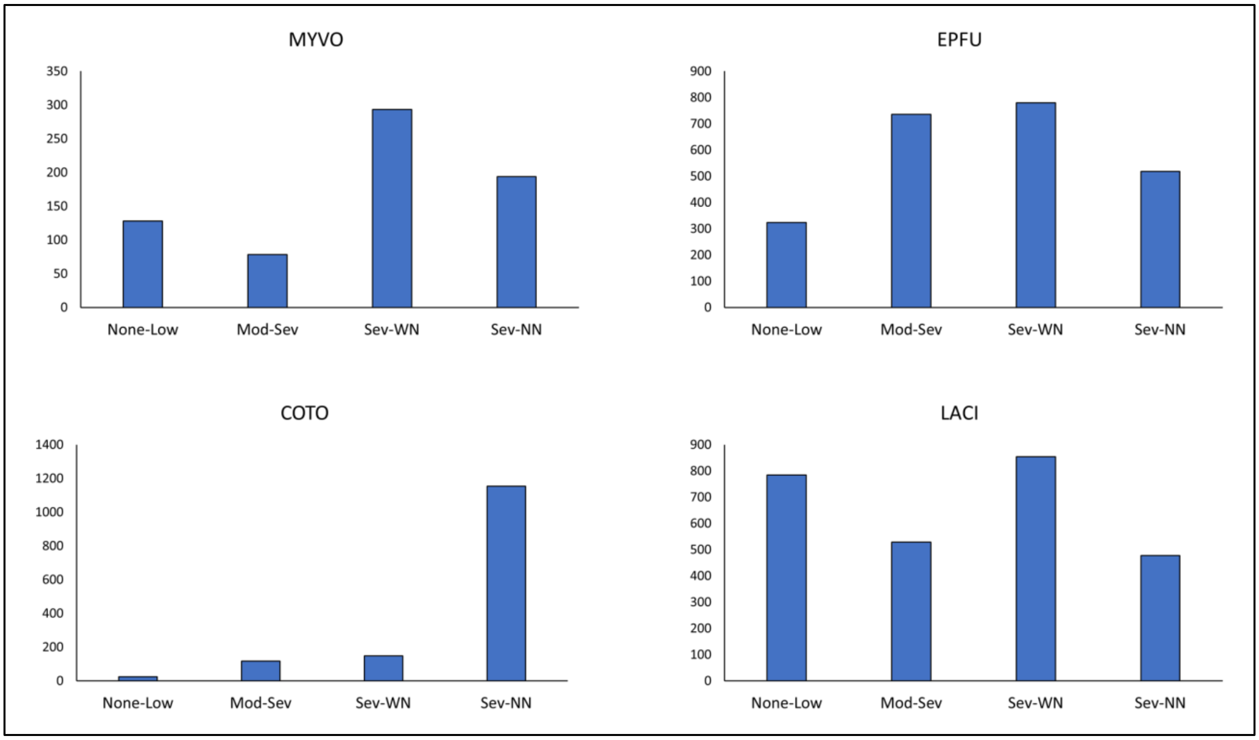


Figure 9. Species-specific usage of different burn types. Distribution of bat species activity in each of the burn severity categories. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*.

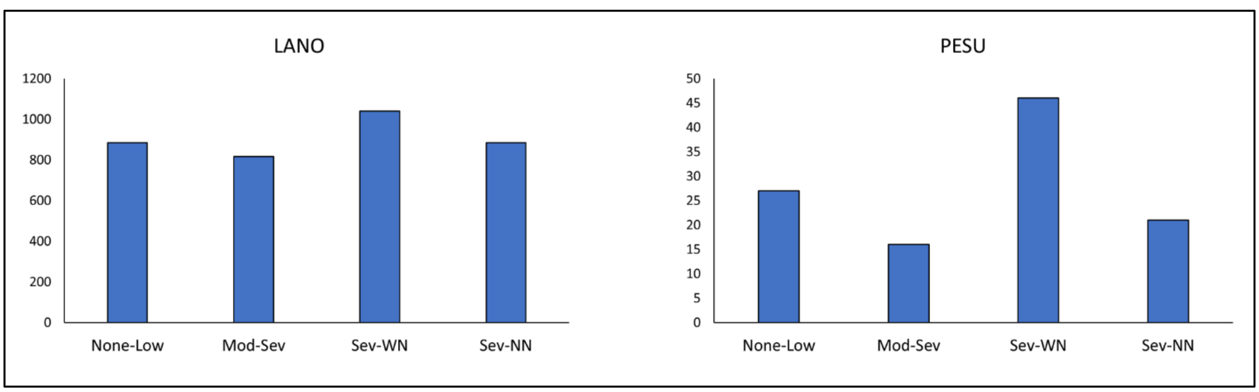


Figure 10. Species-specific usage of different burn types. Distribution of bat species activity in each of the burn severity categories. LANO = *Lasionycteris noctivagans*, and PESU = *Perimyotis subflavus*.

Conclusions: The ensembles of bat species throughout HVR varied, but some patterns are discernable. Myotis species, in general, were more active in the northern section of the park, especially around Ingersol Quarry (Fig. 11A, B). The small-footed myotis (*M. ciliolabrum*) was widely distributed throughout the park and was the most abundant myotis species present.

Although, as previously mentioned (Fig. 5), Site 19 (Fig. 11C), moderate to severe intensity, was the most active site during the survey. However, this was due to predominately high activity of big brown bats (*E. fuscus*) and silver-haired bats (*L. noctivagans*) relative to any other of the eight species. Site 17, located at the mouth of Plumley Canyon (Fig. 11C), was the second most active site, was also relatively high in bat activity driven predominately by small-footed myotis (*M. ciliolabrum*). The third highest activity site was Site 14, located in the black-tailed prairie dog colony (*Cynomys ludovicianus*) and this was also driven by a high activity of *M. ciliolabrum*. The least number of species recorded at any sites was Site 5 (N = 4), severe with no needles, where *E. fuscus* dominated (Fig. 11D). Tricolored bats (*P. subflavus*) were generally low in activity but were a bit more active near Ingersol Quarry than in other parts of HVR, similar to myotis species (Fig. 11A). Overall, burned areas were active with bats. Although overall activity for bats was highest in low-med burned areas, for myotis species, highest activity clearly trended towards severe burns with and without needles. Curiously, the fringed myotis (*M. thysanodes*), typically an aerial pursuit predator in cluttered habitats, greatly preferred to forage in severe burns with no needles as did Townsend's big-eared bat (*C. townsendii*) which is a gleaning forager typically of cluttered habitats. The small-footed myotis (*M. ciliolabrum*) preferred to forage in severe burns having needles present as did the long-eared myotis (*M. evotis*) who, like *C. townsendii*, is primarily a gleaner within cluttered habitats.

Overall, the bat activity and species richness at HVR was much higher than expected. The propensity for bats to use severely burned stands was somewhat surprising, but one can only surmise these areas contained high prey densities. As mentioned in the introduction section, other studies on bats and burn severity, mostly conducted in deciduous forests showed similar patterns to our findings but the patterns were mixed among these studies. However, in no cases did bats avoid burned areas regardless of severity. Buchalski et al. (2013) in California one year after the burn event that showed some myotis species, such as *M. thysanodes* having higher affinity for high-burn-severity stands, as did Mirts et al. (2021). No studies have been conducted in ponderosa pine woodland habitat previously, but it appears that bats continue to forage in all areas of the park and do not appear affected by severely burned stands.

Assessment of Fringed Myotis Maternity Colony in Geer Canyon: This colony was of particular concern as its position on the south-facing cliff face in Geer Canyon was just above a stand that sustained the highest-level burn severity. An SM4 sonar detector was placed in the burned stand just below the roost from 18 July-25 August 2021. Evidence showed that the maternity colony was present and gave birth to young in 2021 (Fig. 10B). Unfortunately, the detector could not be placed until July due to post-fire recovery mitigation efforts and flash-flooding with mudslides in Geer Canyon. In July, some young of the year would likely already be volant. However, activity did increase between July and end of August. Standardized for passes per night (PPN) there is also an increase from 16.4 to 25.1 possibly indicating an increase in the number of bats leaving the roost, possibly newly-volant young. Because the Cal-Wood burn did not occur until late October 2020, it is likely that most if not all of the fringed myotis in the maternity colony had already departed on their higher elevation hibernacula by late October.

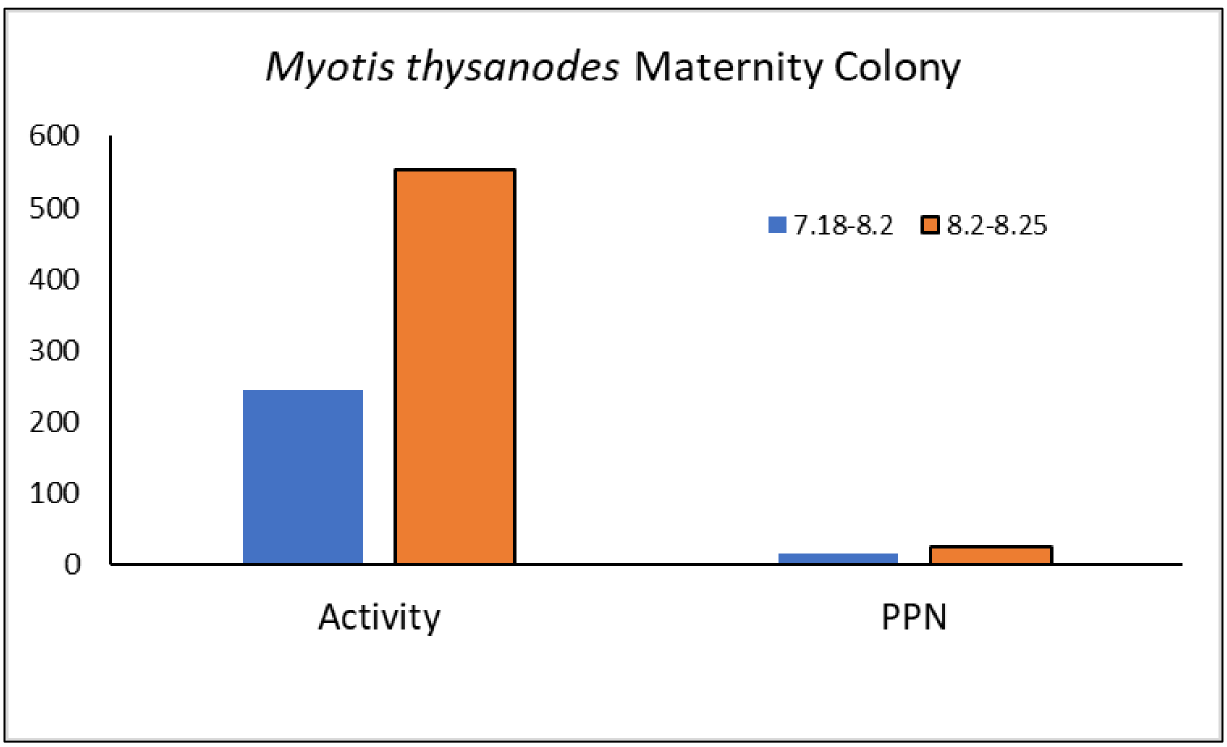


Figure 10B. Activity and adjusted activity (i.e., passes per night, PPN) from a sonar detector placed in a severe burn stand below the cliff face housing a fringed myotis (*M. thysanodes*) maternity colony from 18 July – 25 August 2021.

Recommendations: There appears to be no negative effects on bat activity patterns or species richness at HVR post-Cal-Wood burn. However, mitigation efforts should take into consideration any south- and/or east-facing cliff faces most of which likely house maternity colonies of various bat species. Roost sites have been documented in Geer Canyon but have not been specifically searched for in other canyons at HVR. Therefore, any mitigation that involves excessive human disturbance (such as loud noises via machinery or other sources) should be avoided near cliff faces throughout HVR. In addition, water availability and quality are important for maintaining bat maternity colonies on-site and therefore any mitigation to restore, or even enhance, water availability would be strongly encouraged. In addition, water quality should be monitored, especially any runoff in severely burned areas.

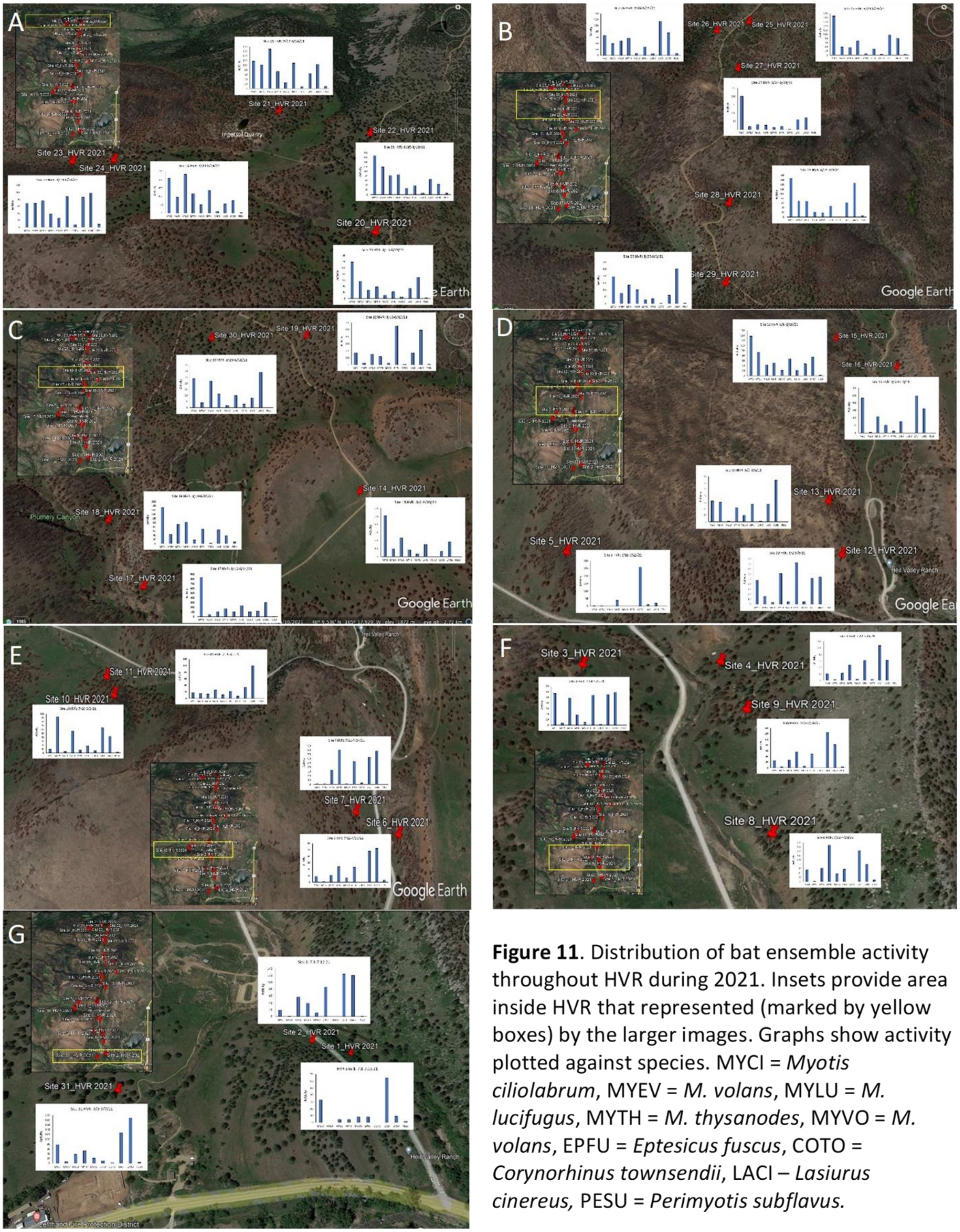


Figure 11. Distribution of bat ensemble activity throughout HVR during 2021. Insets provide area inside HVR that represented (marked by yellow boxes) by the larger images. Graphs show activity plotted against species. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus,* PESU = *Perimyotis subflavus.*

Ingersol Quarry: The SM4 detector recorded bats at Ingersol Quarry from 8 December 2020 to 11 October 2021. Unfortunately, I was not able to access the recorder in July due to post-fire recovery mitigation efforts at HVR, thus creating a data gap. In addition, somehow the microphone cord was disconnected after one night of recording on 15 August but was not discovered until 29 August leaving another longer data gap. However, trends in bat activity at the site were apparent with increasing activity throughout the summer and decreasing in the fall (Fig. 12).

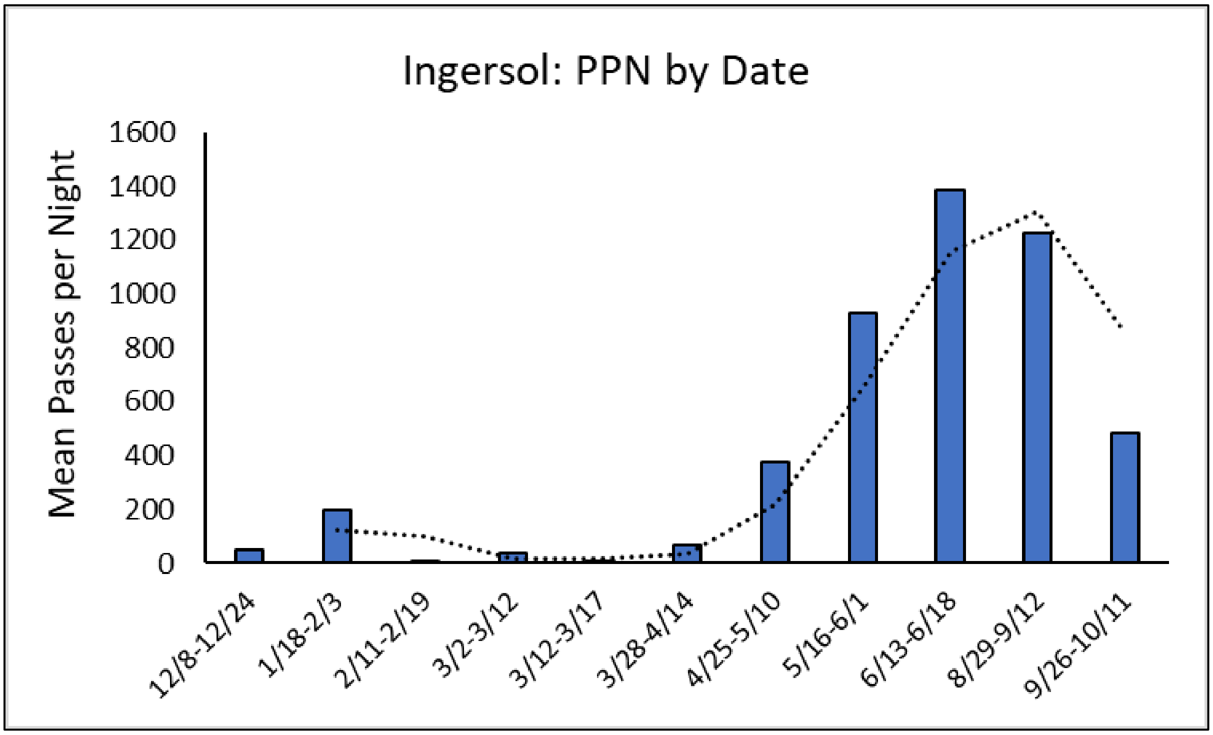
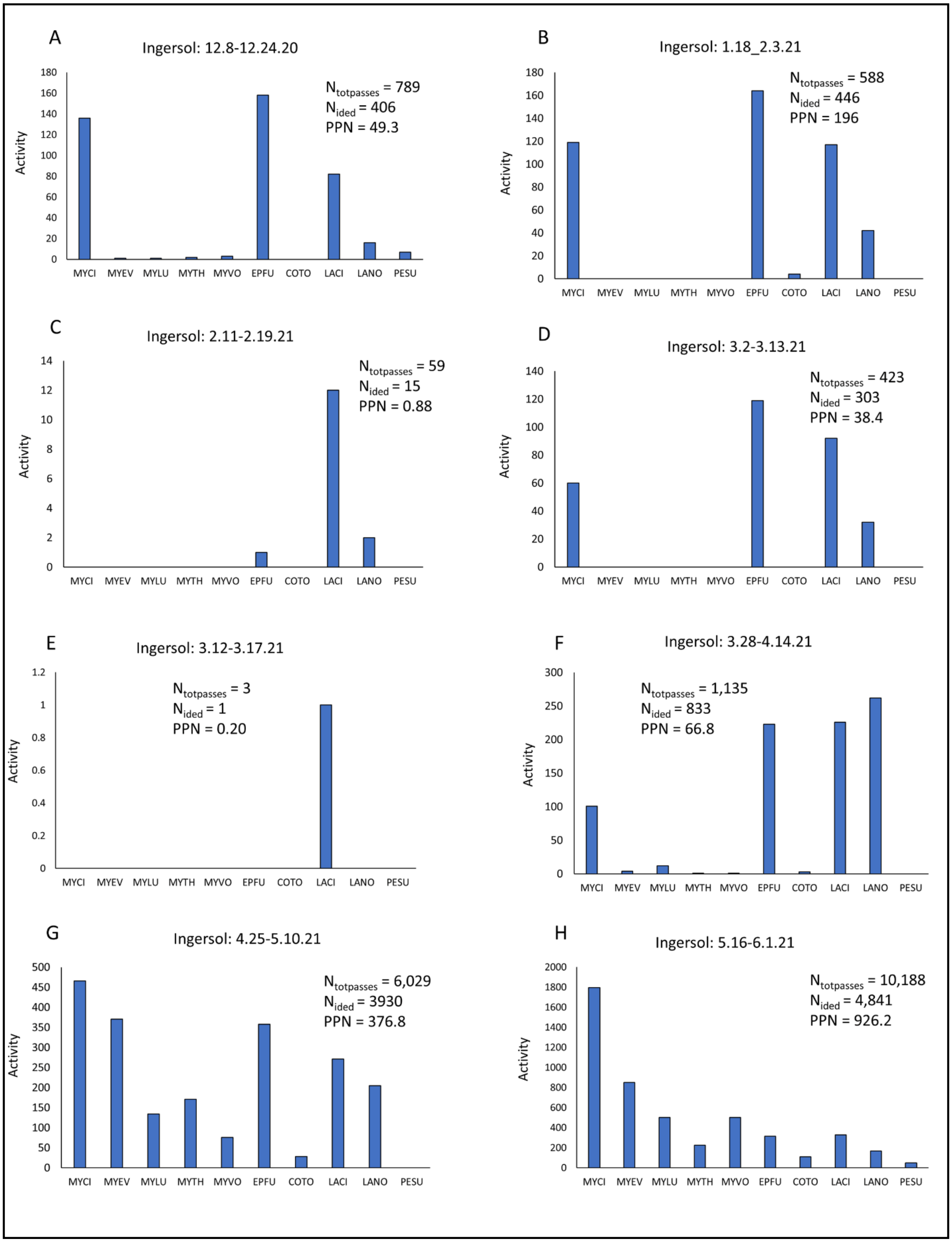


Figure 12. Mean passes per minute (PPN) of bat at Ingersol Quarry from 8 December 2020- 11 October 2021.

Species-specific activity December 2020 (Fig. 13A), most activity was from small-footed myotis (*M. ciliolabrum*), big brown bats (*E. fuscus*), and hoary bats (*L. cinereus*) although there were a small number of passes from other myotis species. By January (Fig. 13B) myotis species besides *M. ciliolabrum*, were gone and there was an increase in silver-haired bats (*L. noctivagans*) at the site. During February, there was no recorded activity by *M. cilioabrum*, but it resumed in early March (Fig. 13C-D). In mid-March, no activity was recorded except for hoary bats (*L. cinereus*) (Fig. 13E). From late March through June, activity at Ingersol Quarry peaked



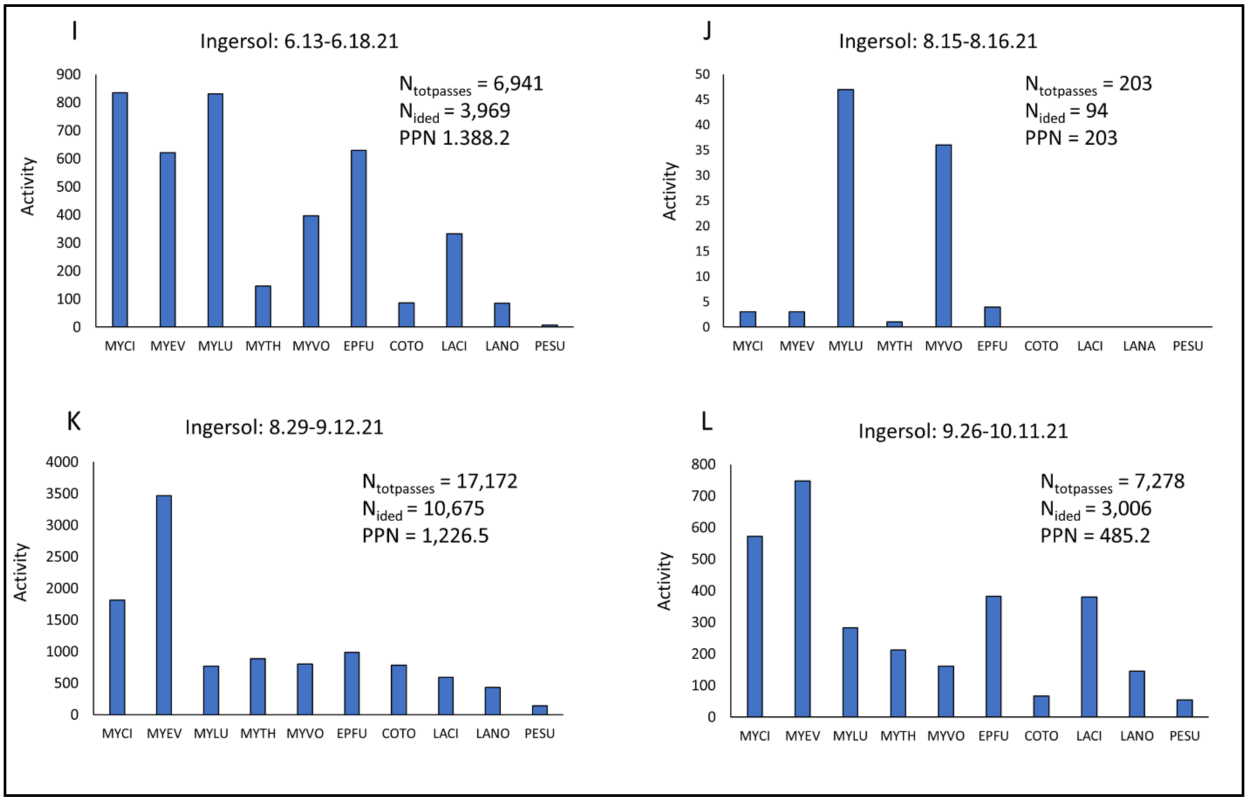


Figure 13(A-L). Species-specific activity at Ingersol Quarry from (A) December 2020 to (L) mid-October 2021. Total passes = total number of sonar captures regardless of identification status, Ided = number of sonar passes identified to species. PPN = passes per night (number of total passes/number of survey nights). MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus*.

(Fig. 13F-I) as myotis species were very active. In late August into early September activity began to decline at the site for many species, with late September passes per night declining to 485.2 from a high of 1,388 PPN in June. Unfortunately, the quarry was inaccessible due to in post-fire recovery mitigation efforts in July.

Conclusions: Ingersol Quarry continues to be a year-round highly important resource for bat at HVR. Activity during the summer is unsurpassed by any other sites in the park as a drinking and foraging area especially for long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), small-footed myotis *(M. ciliolabrum*), and Townsend's big-eared bats (*C. townsendii*). In addition, this site provides drinking opportunities for larger-bodied bats that require a longapproach path to skim the surface (i.e., big-brown bats, *E. fuscus*; hoary bats, *L. cinereus*; and silver-haired bats, *L. noctivagans*). In addition, several species of bats continued to hibernate at Ingersol Quarry in 2021. These species included *M. ciliolabrum*, *E. fuscus*. *L. cinereus*, and *L. noctivagans*.

Recommendations: Continue to monitor seasonal bat activity at Ingersol Quarry. Periodic water quality testing is encouraged.

Elevational Transects

South St. Vrain Elevational Transect: The South St. Vrain (SSV) Canyon transect was run from 6 May – 8 August 2021. The survey was cut short due to closure of the canyon for construction in late August. The 2021 survey differed from the 2019 and 2020 surveys not only in duration but also in the location of the lowest elevational site that was moved from Hall Ranch to Hall II more directly along the SSV stream in 2021 (Fig. 14). Although the Hall Ranch location was originally quite active with bats, in 2019 and 2020 the activity for unknown reasons dropped off precipitously. In addition, moving the detector to a position directly on the SSV stream put it in-line with the upper elevation detectors that are also near the stream.

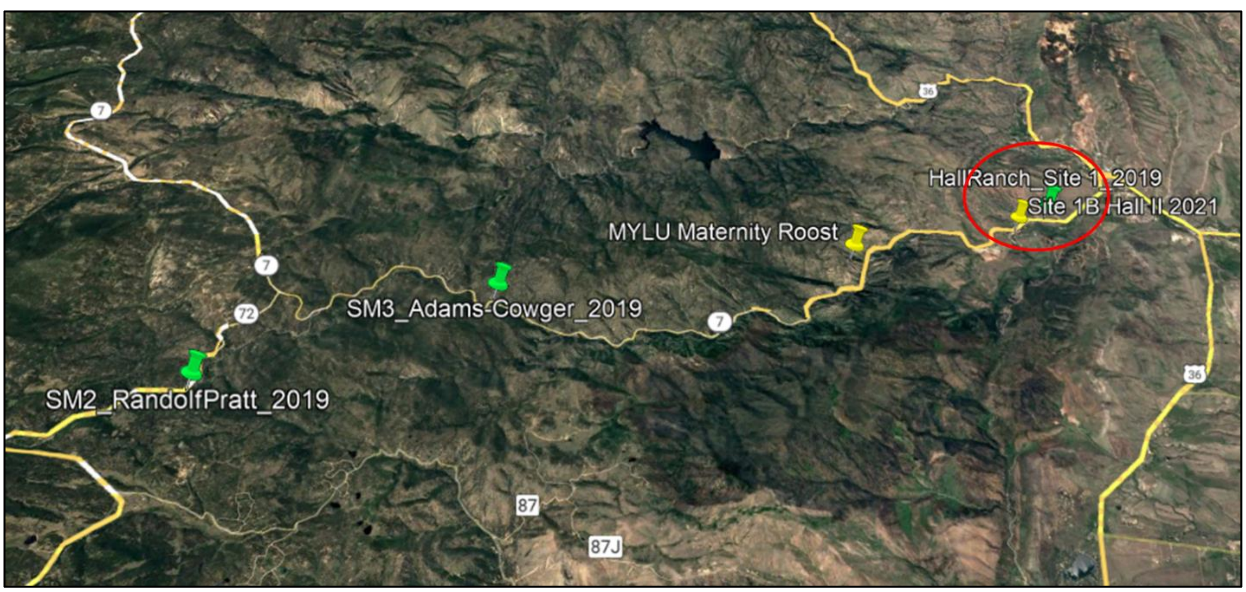


Figure 14. Map showing South St. Vrain Canyon transect for 2021. Lowest elevation site was moved from Hall Ranch to Hall II position directly along the SSV stream (red ellipse indicates relocation).

Activity of Bats: Bat activity at all three sites (Fig. 15A-C) increased from April to July 2021. The detector at Site 1 at Hall II (lowest elevational site) was deployed earlier than the others due to snow at higher elevations in March. This site hit a peak of activity in early-mid July with more than 250 passes per night (PPN) (Fig. 15A) and declined somewhat through late July into early August. Site 2 (Fig. 15B, mid-elevation site near Adams-Cowger property) was very low in activity overall, hitting a peak of 2 PPN in mid-late June. The highest elevation site (Site 3 near Randolf-Pratt property) was very active in 2021, reaching over 200 PPN in mid-July (Fig. 15C) and declining (~100 PPN) in August. Comparisons among sites (Fig. 15D) in PPN showed similar patterns of activity between Site 1 and 3, with Site 2 having very little bat activity in 2021.

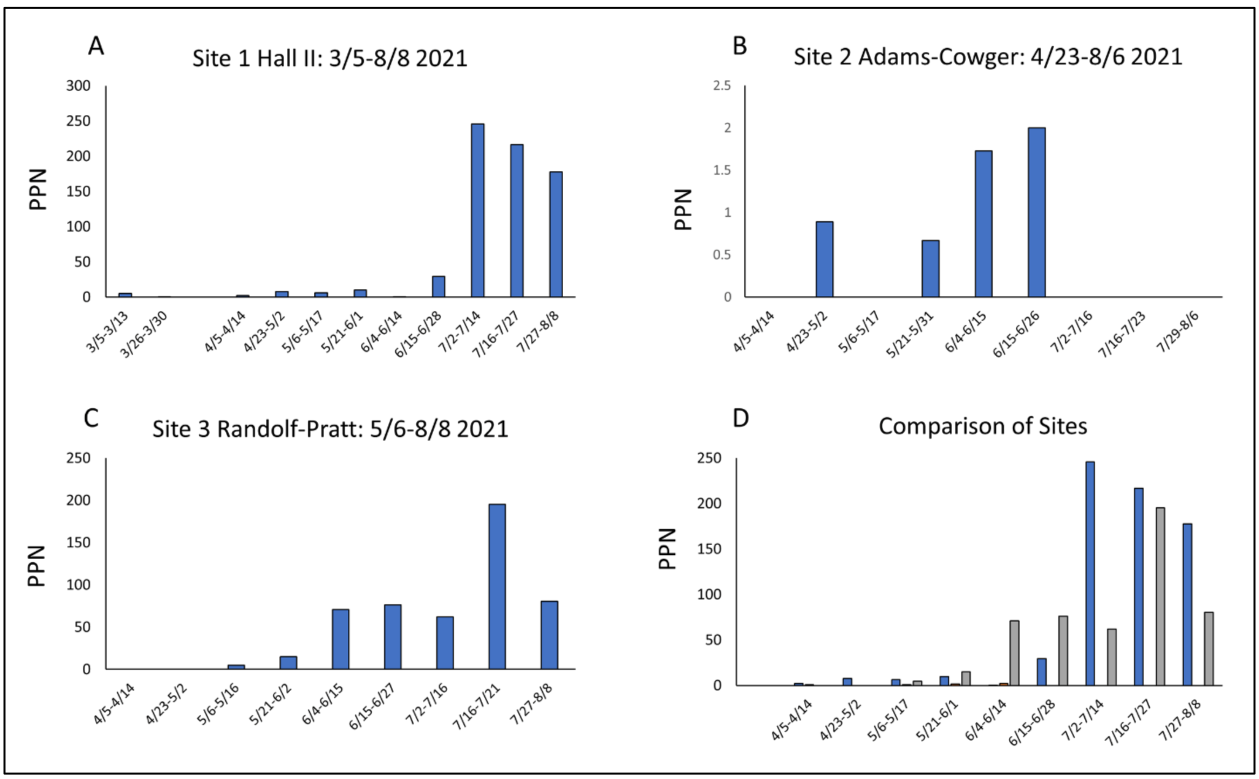
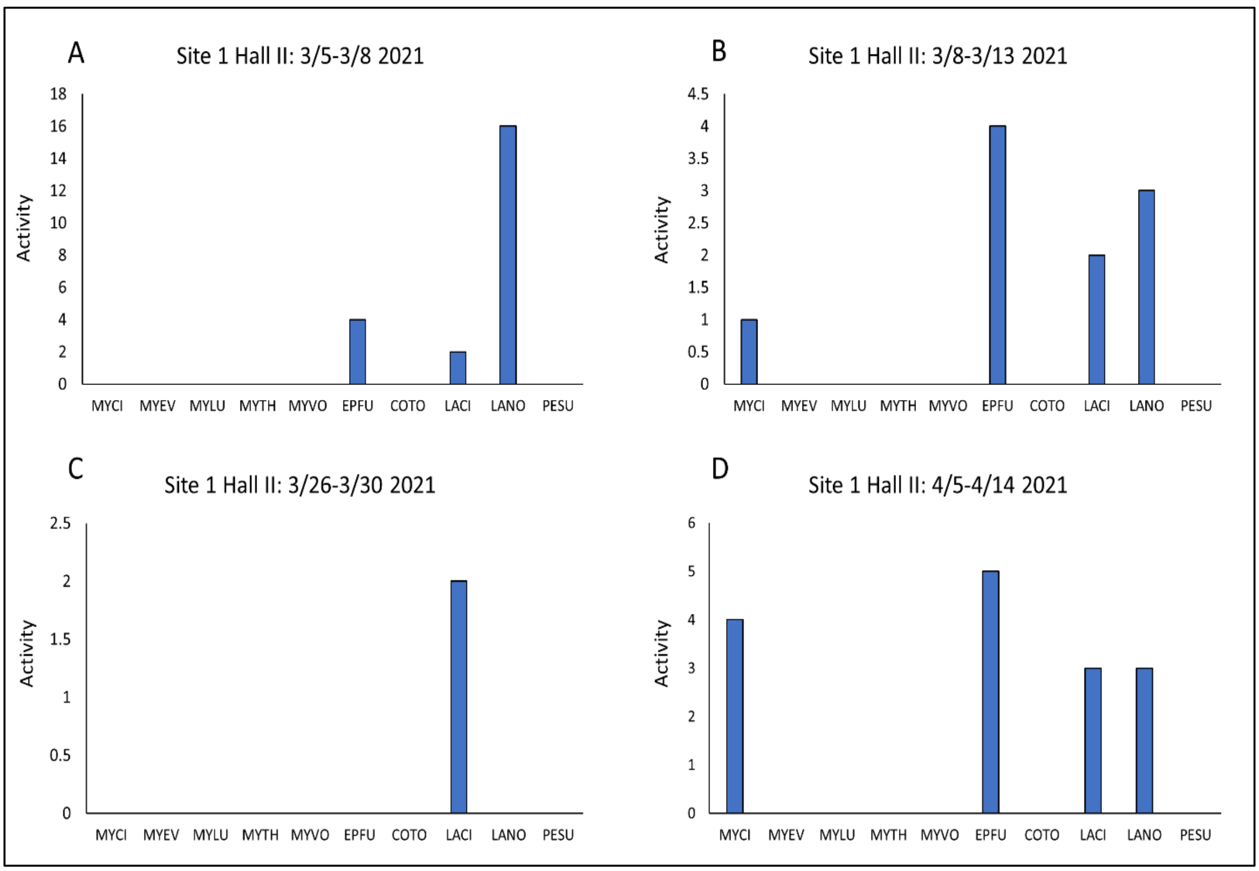
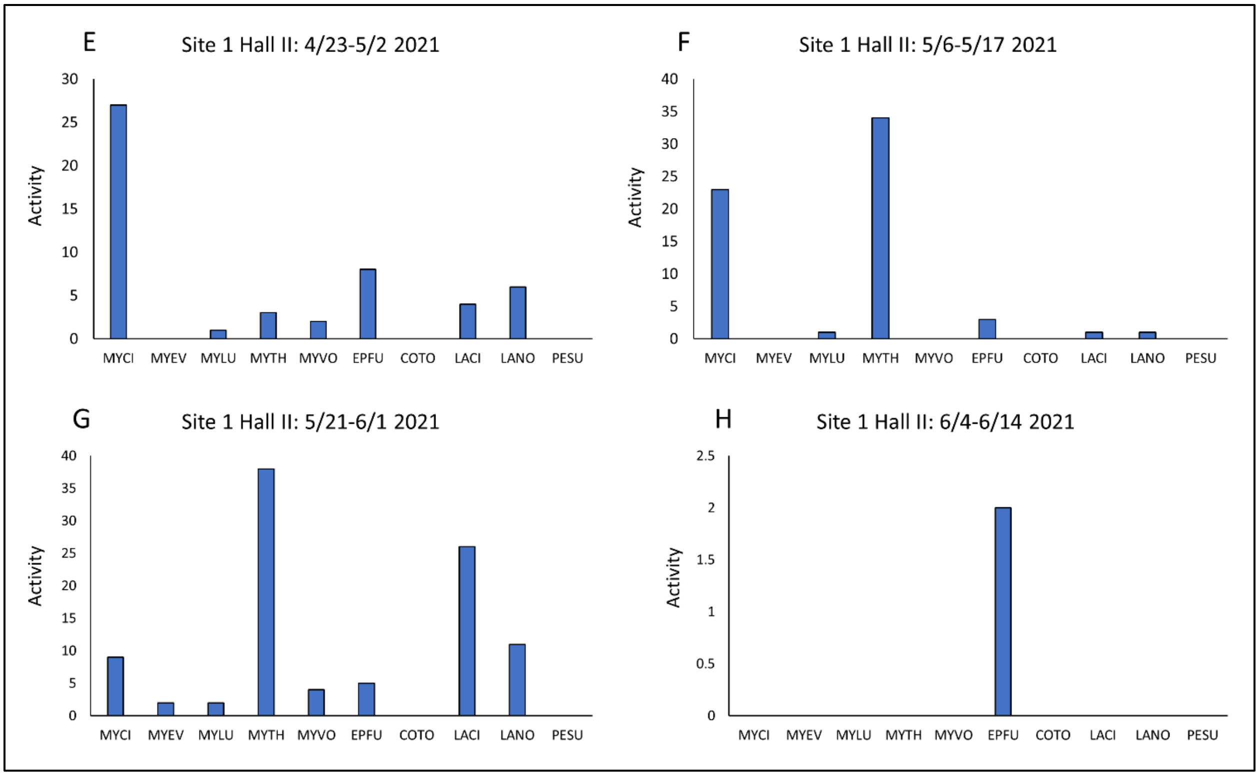
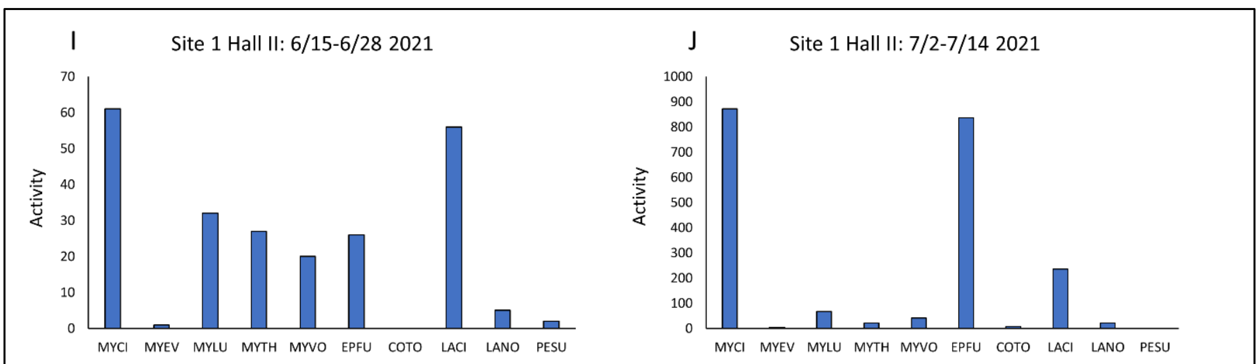


Figure 15. (A-C) Bat activity at each site along South St. Vrain Canyon in 2021. D) Comparison of bat activity among sites in 2021. PPN = passes per night. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus.*

Bat Species Activity: Species-specific activity: For Site 1 (Hall II, 40^o 12.380N, 105^o 17.642W, 1699m), lowest elevational location, recordings from early March (Fig. 16A, B) indicated the presence of only three species: big brown bats (*E. fuscus*), hoary bats (*L. cinereus*), and silver-haired bats (*L. noctivagans*). These species are all open aerial foragers with two of these, *L. cinereus* and *L. noctivagans*, considered primarily long-distance migratory species. In mid-March, these species are joined by small-footed myotis (*M. ciliolabrum*). However, in late March (Fig. 16C), there is a lull in activity among all species except *L. cinereus*. In early April (Fig. 16D), activity returns to mid-March levels, but by the end of April into early May (Fig. 16E, F), other myotis species are present and this pattern continued except in early June (Fig. 16H) which showed only big brown bats (*E. fuscus*) using the site. In mid-June (Fig. 16I), nine of 10 species were present (the exception being Townsend's big-eared bat, *C. townsendii*). In July, all 10 species were present (Fig. 16J, K).







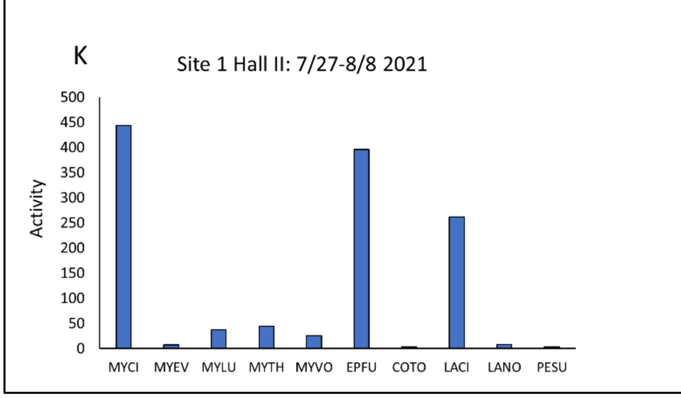


Figure 16. (A-K) Species-specific distribution of bats at Hall II (lowest elevational site from SSV transect) from 5 March - 8 August 2021. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus.*

At Site 2 (proximate to Adams-Cowger, Hall II, 40^{o} 10.275N, 105^{o} 24.799W, 2236m) bat activity relatively low (see Fig. 15) with only 29 identifiable passes between 23 April and 26 June

(Fig. 17). Of these, 14 (48.2%) were from open-aerial foragers (*E. fuscus*, *L. cinereus*, and *L. noctivagans*). Of these, eight of the passes were from *L. noctivagans*, four were from *E. fuscus*, and two were from *L. cinereus*. Among myotis species, only three were detected and of these, 13 were from *M. ciliolabrum* with one pass each from *M. lucifugus* and *M. thysanodes*. No bat sonar calls were recorded after 26 June in 2021 (see Fig. 15). Not recorded at this site in 2021 compared to 2020 were *M. ciliolabrum, M. evotis, M. volans, C. townsendii*, and *P. subflavus*.

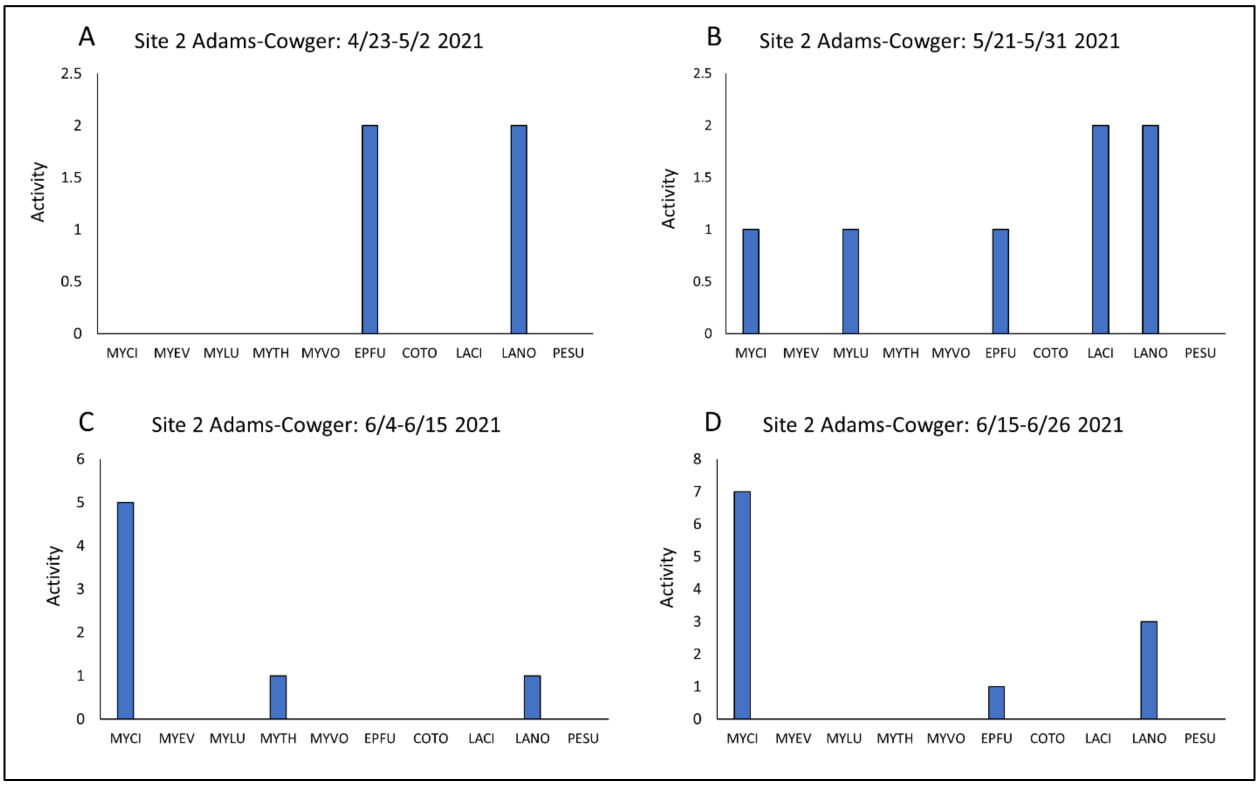
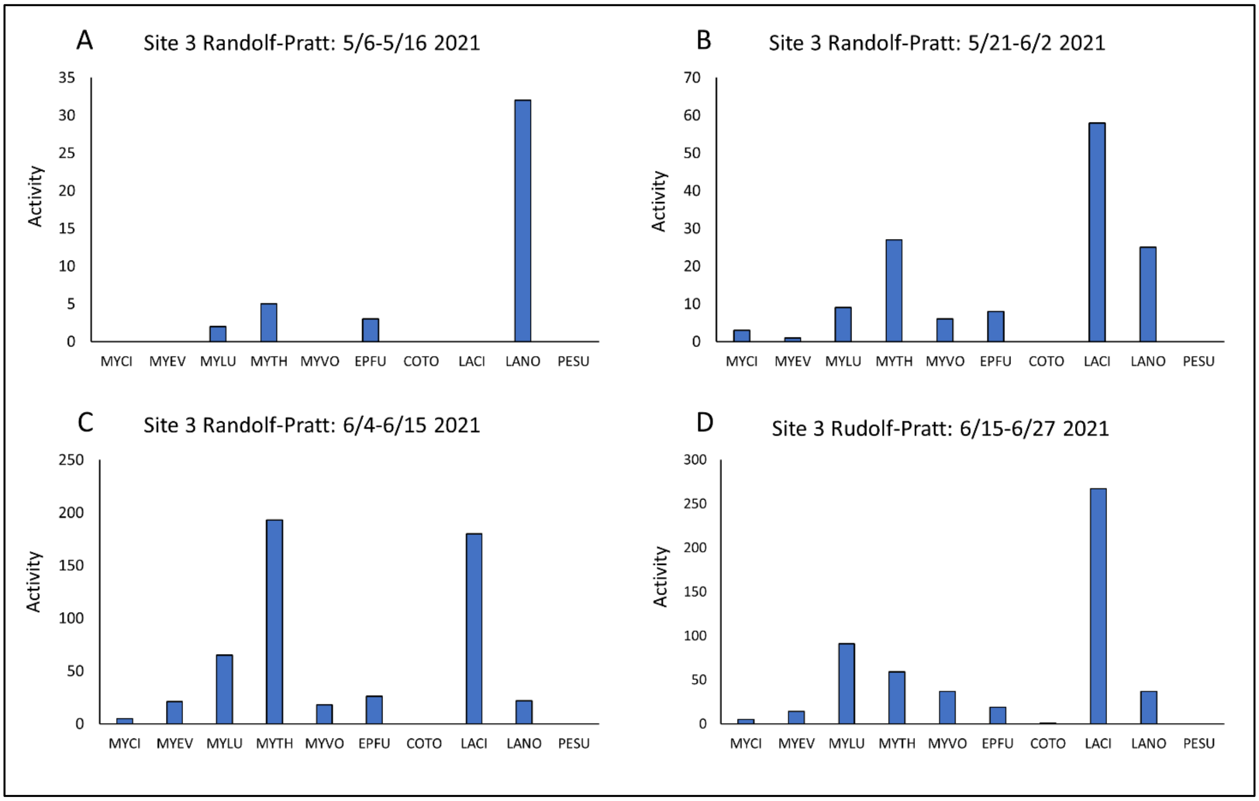


Figure 17. (A-K) Species-specific distribution of bats at Site 2 proximate to Adams-Cowger property (mid-elevational site from SSV transect) from 23 April – 26 June 2021. No bat sonar calls were detected at this site after 16 June. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus.*

Site 3 (proximate to Randolf-Pratt property) was moved to the north-side of the street from the south side for better equipment security (40° 08.748N, 105° 28.274W, 2445m). I determined that this fundamentally would not change the survey properties for bat sonar relative to the site used in 2019 and 2020. No bat species were recorded at this site in late April and the first night of May. From 6 – 16 May four species were recorded (Fig. 18A-G) including

Myotis lucifugus and *M. thysanodes* as well as *E. fuscus* and *L. noctivagans*. Eight species were recorded at this site from the nights 21 May through the night of 1-2 June. These included calls from all five myotis species and *E. fuscus*, *L. cinereus*, and *L. noctivagans*. Although *M. lucifugus* showed relatively high activity at the site from mid-April to early August, high activity from *M. thysanodes* in late May through mid-June is notable. Townsend's big-eared bat (*C. townsendii* and tricolored bats (*P. subflavus*) were not recorded from this site in 2021.



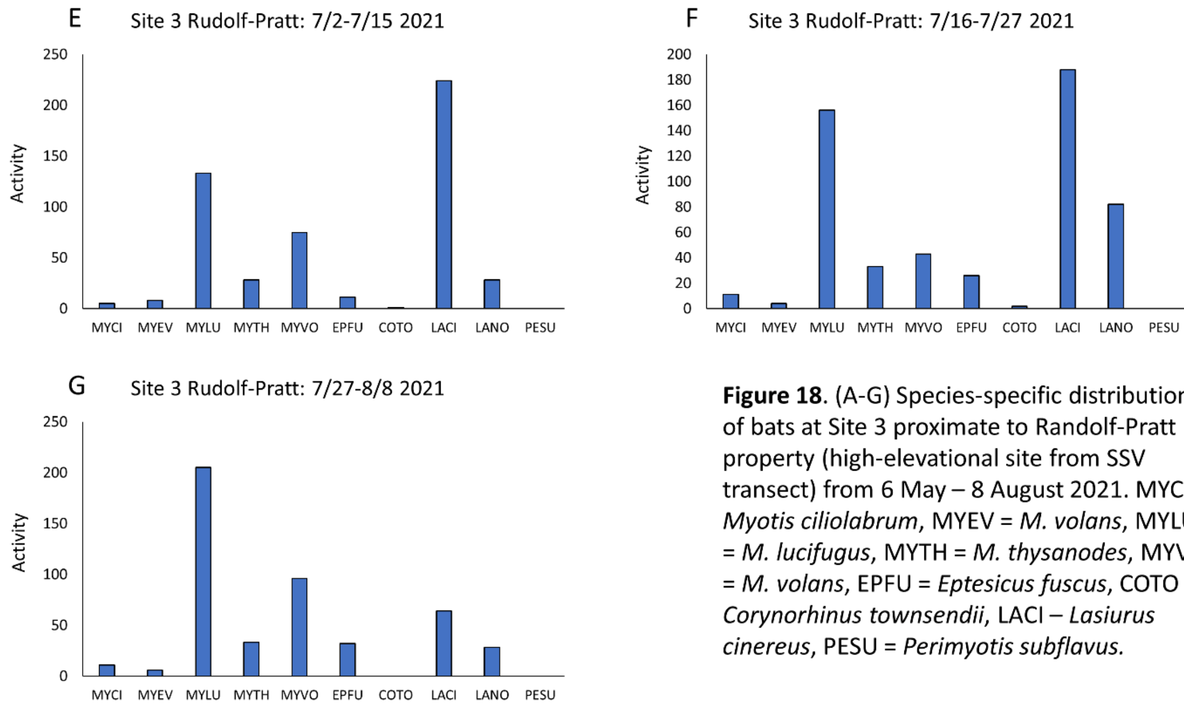


Figure 18. (A-G) Species-specific distribution of bats at Site 3 proximate to Randolf-Pratt property (high-elevational site from SSV transect) from 6 May – 8 August 2021. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus.*

Conclusions: The patterns observed in South St. Vrain Canyon in 2021 were quite different from what was observed in 2020 or 2019. The differences observed were mostly at Site 2, the mid-elevation site, which showed very little activity in 2021 compared to previous years, with activity beginning in June 2019 and July 2021. The highest species-richness was five in May and declined to three species in June, with no sonar calls recorded at this site thereafter. In addition, Site 3, the highest elevation site did not become active until July in 2019 and 2020, but in 2021 became active in May, although with low activity, and this activity peaked in July. In addition, at times nine of 10 Boulder County species were recorded at this site and this site remained similarly active through the nights of 7-8 August 2021.

Lefthand Canyon Elevational Transect: This transect was established on 10 September and ran till 5 November 2021. Lowest elevational site (LHT-Site 1, 40^o 7.937N, 105^o 17.905W) was located at Heil Valley Ranch near the old schoolhouse. Two intermediate sites were surveyed to determine levels of activity. LHT-Site 2A (40^o 4.103N, 105^o 26.334W, ele 2472m) was located within ½ mile (1 km) of Reynolds/Gail property in proximity to Lefthand Creek. The detector was then moved to Site 2B (40° 4.088N, 105° 26.550W, ele 2447m) at a beaver pond located less than ¼ mile (0.5 km) west of Site 2A. LHT-Site 3 (40° 4.714N, 105° 30.687W, ele 2915m) was located off of Brainard Road about ¼ mi (0.5 km) south of Duck Lake (Fig. 19).

Figure 19. Map showing locations of sonar detector placement along an elevation gradient in Lefthand Canyon in September, October, and early November 2021. Site 1 is located at HVR, Site 2A and B were located in proximity of Reynolds/Gail Property and Site 3 was off Brainard Lake Road south of Duck Lake.

Activity of Bats: Bat activity at each of the three elevational sites was documented using SMU Mini Bat Detectors once the survey of burn sites at HVR ended. Therefore, this survey did not begin until September, but gives some insight into bat activity along Lefthand Canyon from early September till early November. Overall bat activity data were translated into passes per night to accommodate slight differences in detection nights among sites (Fig. 20). Activity at the lowest elevational site (Site 1) was highest in early September and declined somewhat in mid-late September and declined precipitously from Mid -October to early-November (Fig 20A). The mid-elevational sites (Site 2A, B) showed the opposite patterns of Site one, with increasing activity from early September to mid-October (Fig. 20B). However, it should be noted that the detector was moved from a streamside location to a series of beaver ponds during this time. Unfortunately, during the first survey period after this move (9/19-10/30) the detector malfunctioned and did not record any data. Therefore, the area of the beaver ponds (Site 2B) may have been more active all along relative to Site 2A. Site 3 (highest elevational site) showed highest activity in September, and this declined transitionally into late October (Fig. 20C). Comparison among sites available is depicted in Fig. 20D.

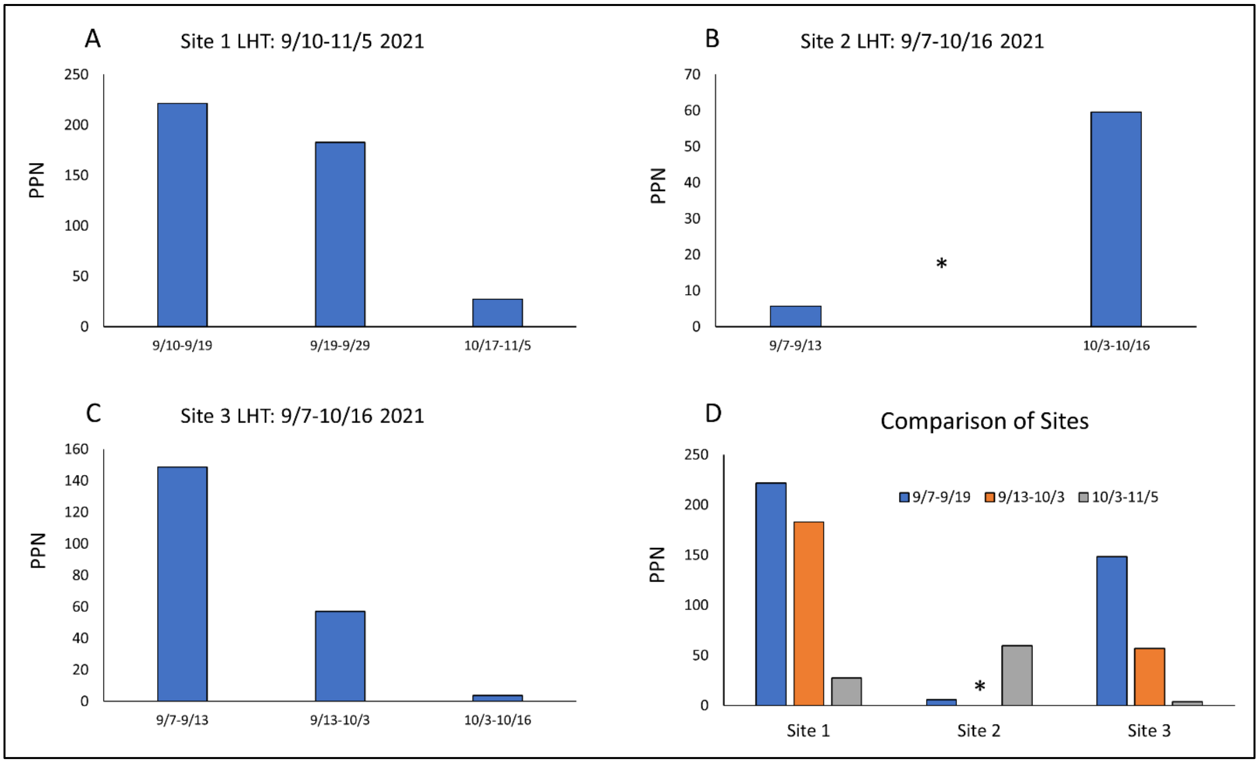
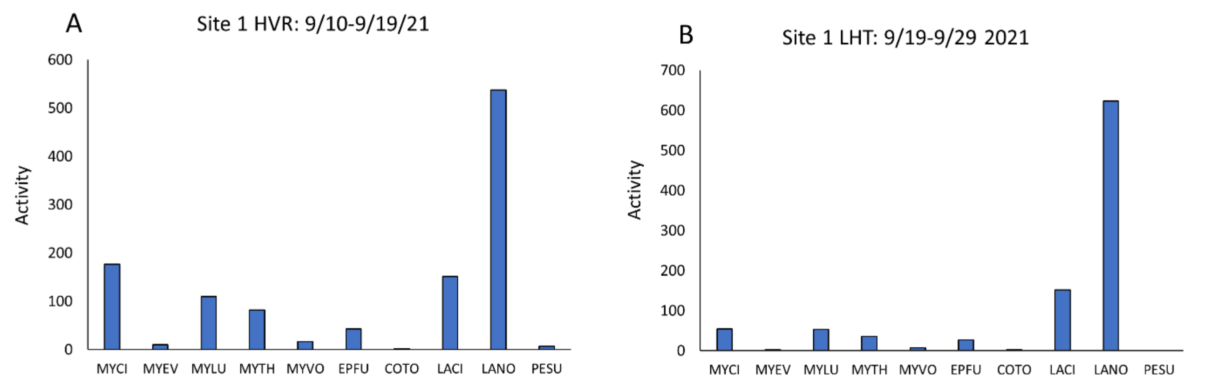


Figure 20 (A-D). Lefthand Canyon Transect sonar data translated into passes per night (PPN) plotted against sonar survey dates at three sites along an elevational gradient. Site 1 (A) lowest elevational site (LHT-Site 1, 40° 7.937N, 105° 17.905W). Plot for Site 2 is pooled data from two sites (Site 2A and B) which were less than ½ mile apart. (B) Site 2A (40° 4.103N, 105° 26.334W, ele 2472m) was located within ½ mile (1 km) of Reynolds/Gail property in proximity to Lefthand Creek. The detector was then moved to Site 2B (40° 4.088N, 105° 26.550W, ele 2447m) at a beaver pond located less than ¼ mile (0.5 km) west of Site 2A. (C) Site 3 (40° 4.714N, 105° 30.687W, ele 2915m) was located off of Brainard Road about ¼ mi (0.5 km) south of Duck Lake (see Fig. 19). (D) Comparison plot of all sites. Asterisks indicate no data collected at Site 2 due to detector malfunction.

Bat Species Activity: At Site 1 of the LHT, much of the activity from early-September to early-November was from silver-haired bats (*L. noctivagans*). As for myotis species, in early-September (Fig. 21A) the number of passes were in the hundreds and this attenuated in October and November (Fig. 21B, C), indicating bats were leaving the area, likely moving to higher elevation over-wintering sites.



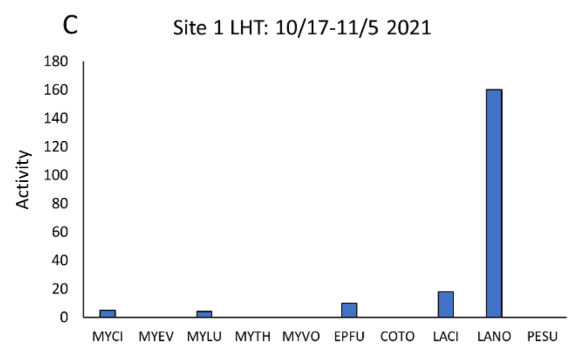


Figure 21. (A-C) Species-specific distribution of bats at Site 1 of LHT from 10 September to 5 November 2021. MYCI = *Myotis ciliolabrum*, MYEV = *M. volans*, MYLU = *M. lucifugus*, MYTH = *M. thysanodes*, MYVO = *M. volans*, EPFU = *Eptesicus fuscus*, COTO = *Corynorhinus townsendii*, LACI – *Lasiurus cinereus*, PESU = *Perimyotis subflavus.*

Mid-elevation sites 2A and B showed highest relative activity (Fig. 22A, B) for silver-haired bats (*L. noctivagans*). Site 2B at the beaver ponds was much more active than Site A, as mentioned, having seven species present. Of the myotis, the long-eared myotis (*M. evotis*) was the most active. Big brown bats (*E. fuscus*) and hoary bats (*L. cinereus*) were also relatively high in activity.

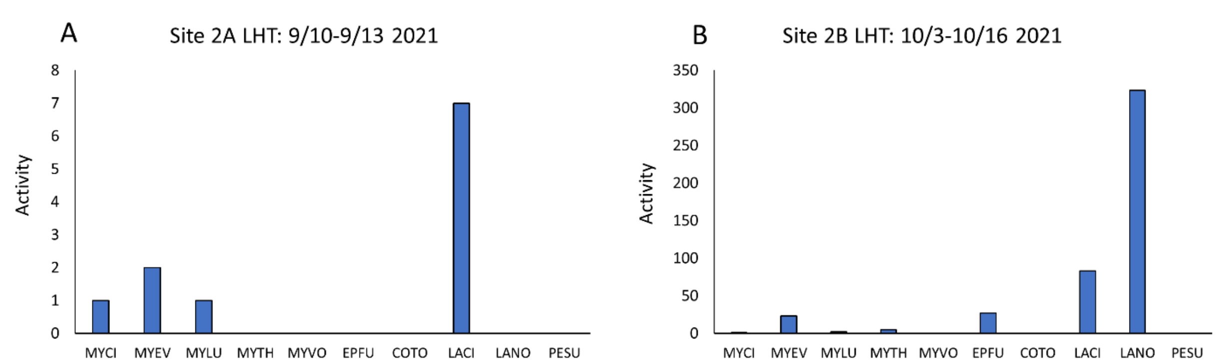


Figure 22. Species activity at (A) Site 2A and (B) Site 2B, both mid-elevational sites in Lefthand Canyon. Species acronyms as in Fig. 21.

Conclusions: Continue to track the elevational gradient in South St. Vrain Canyon to establish how bats are using this elevational gradient as climate warming continues. The late-season deployment of detectors in Lefthand Canyon gave insight into finding low-mid-high-elevation sites for continued monitoring. Lefthand Canyon has a much steeper and higher gradient than South St. Vrain Canyon and thus may show different patterns of use.

Recommendations: Continue to track bat activity in Boulder County canyons over elevational gradients. Long-term data can be compared to shifts in annual temperatures and precipitation in relation to climate warming.

Eastern Properties

Walden Ponds: I surveyed Site 1 and 3 (the most productive of the four sites established in 2019) at Walden Ponds. Site 1 is among cottonwood trees near South Boulder Creek and Site 3 is at the eastern-most pond (Fig. 22).

Figure 22. Map showing sites 1 and 3 surveyed at Walden Ponds in 2021.

At Site 1 there was a total of 2,028 bat call sequences recorded over two survey sessions (6/29-7/3 and 7/20-7/23 2021). Activity increased between late June and Late July (Fig. 23). Species-specific activity showed 6-7 species present (Fig. 24).

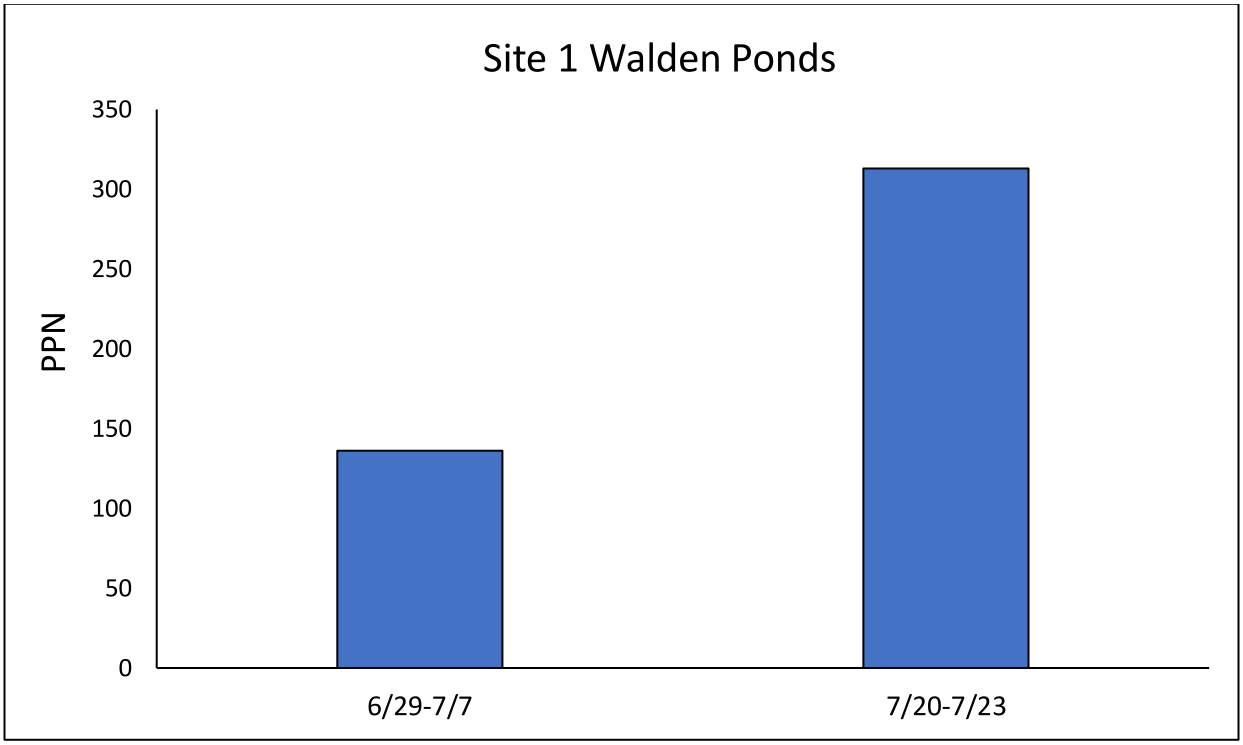


Figure 23. Passes per Night (PPN) at Site 1 of Walden Ponds in June and July. Number of passes per night more than doubled from late June to late July.

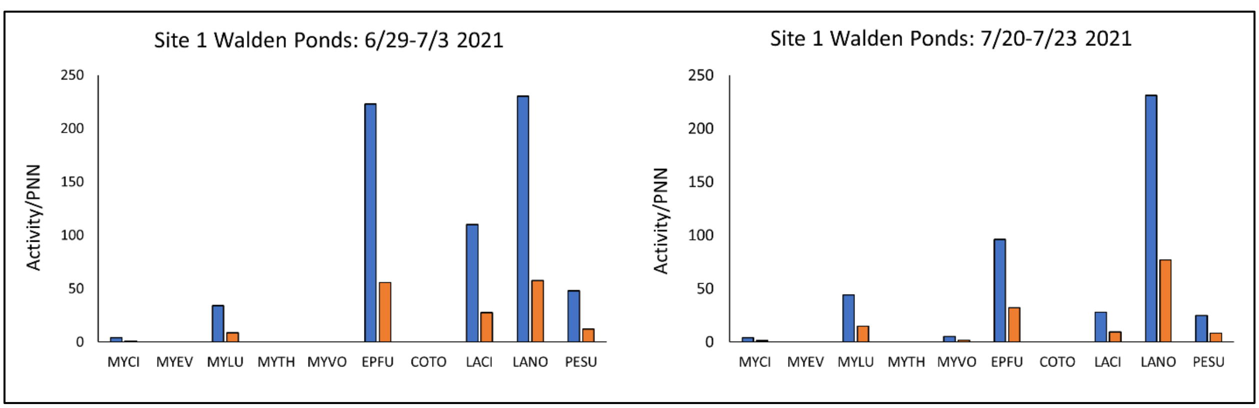


Figure 24. Species specific Activity (blue bars) and Passes per Night (orange bars) adjusted for survey nights at Site 1 at Walden Ponds in late June and late July 2021.

Most active were by open aerial species, the silver-haired bat (*L. noctivagans*) and big brown bat (*E. fuscus*). Of the myotis species, the most active were little brown bats (*M.*

lucifugus). Tricolored bats (*P. subflavus*) composed 5.8% of identified calls during survey 1 and 7.4% of identified calls during the second survey period.

At Site 3 there was a total of 3,311 bat call sequences recorded over two survey sessions (6/21-6/24 and 7/26-7/30 2021). Activity decreased between late June and Late July with Passes per Night dropping from 616.6 PPN to 365.2 PPN (Fig. 25). Species-specific activity

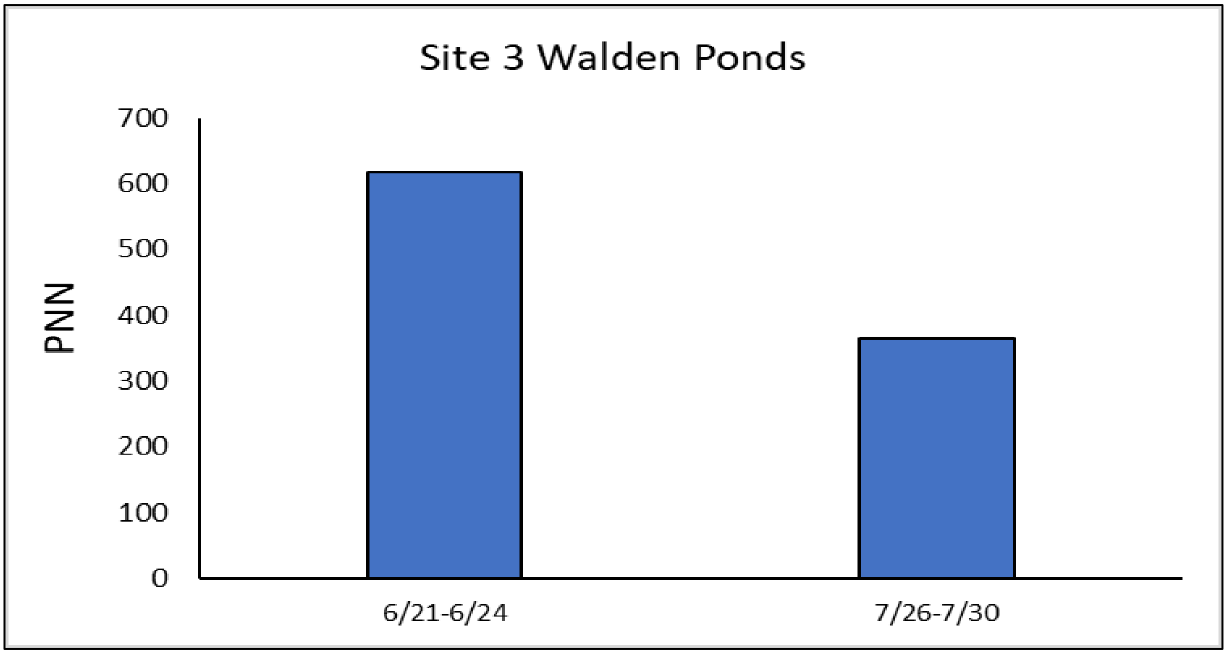


Figure 25. Passes per Night (PPN) at Site 3 of Walden Ponds in June and July. Number of passes per night more decreased from late June to late July.

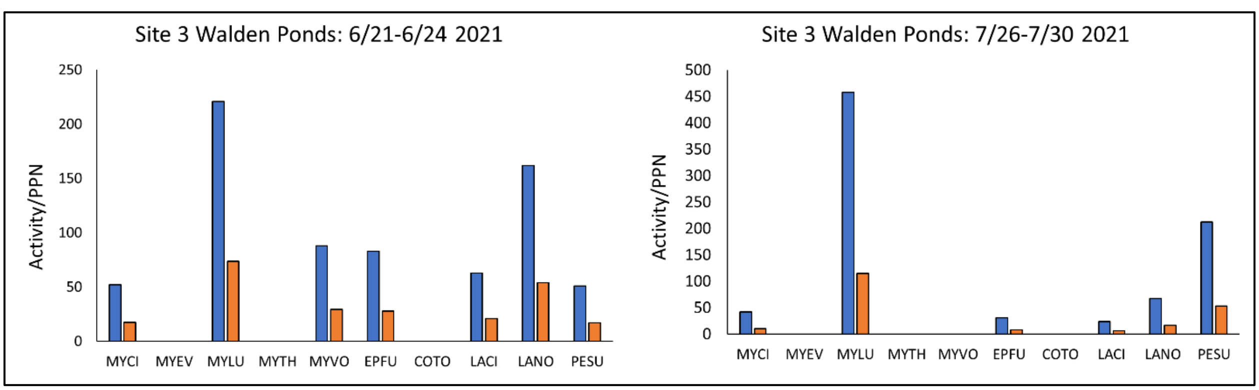


Figure 26A. Species specific Activity and Passes per Night adjusted for survey nights at Site 3 at Walden Ponds in late June and late July 2021.

showed decreases in PPN for myotis species as well as *E. fuscus* and *L. noctivagans* (Fig. 26A). However, tricolored bats (*P. subflavus*) made up 7.1% of identified calls at the end of June and in July this increased to 25.4% as well as increased from 17 PPN to 53 PPN respectively. Average PPN was 37.6 in 2021 which was a decline from 120.8 PPN in 2020 but was still higher than in 2018 and 2019 (Fig. 26B).

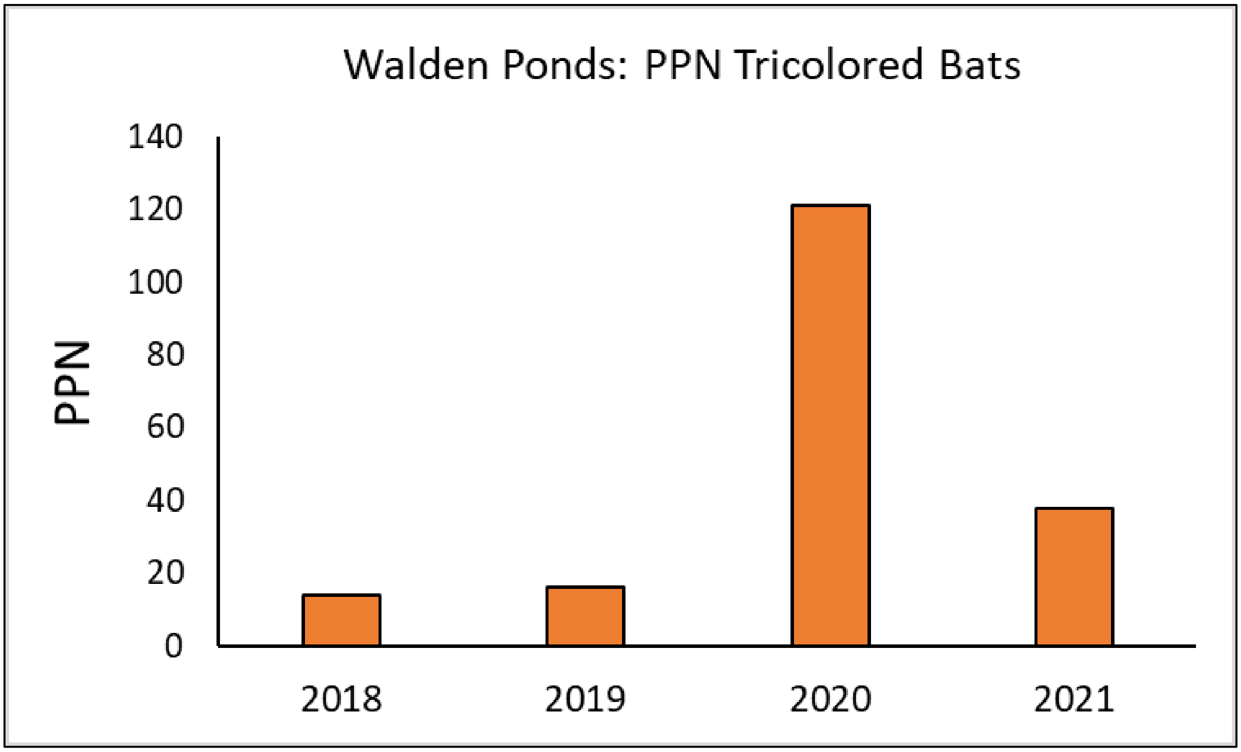


Figure 26B. Passes per night of PESU at Site 3 Walden Ponds 2018-2021.

Twin Lakes: Two sites were monitored in 2021 and these were the same sites monitored in 2019 and 2020 (Fig. 27). Site 1 was monitored four times with SMU Mini Bat detectors from 12 June to 21 September, whereas Site 2 was monitored from 12 July till 10 September 2021.

Figure 27. Map of sites sampled at Twin Lakes in 2021 which were the same as in 2020.

Over three survey periods, 2,234 bat call sequences were recorded at Site 1. Comparison of the three survey periods showed an increase in activity from June into July with waning activity in early September (Fig. 28).

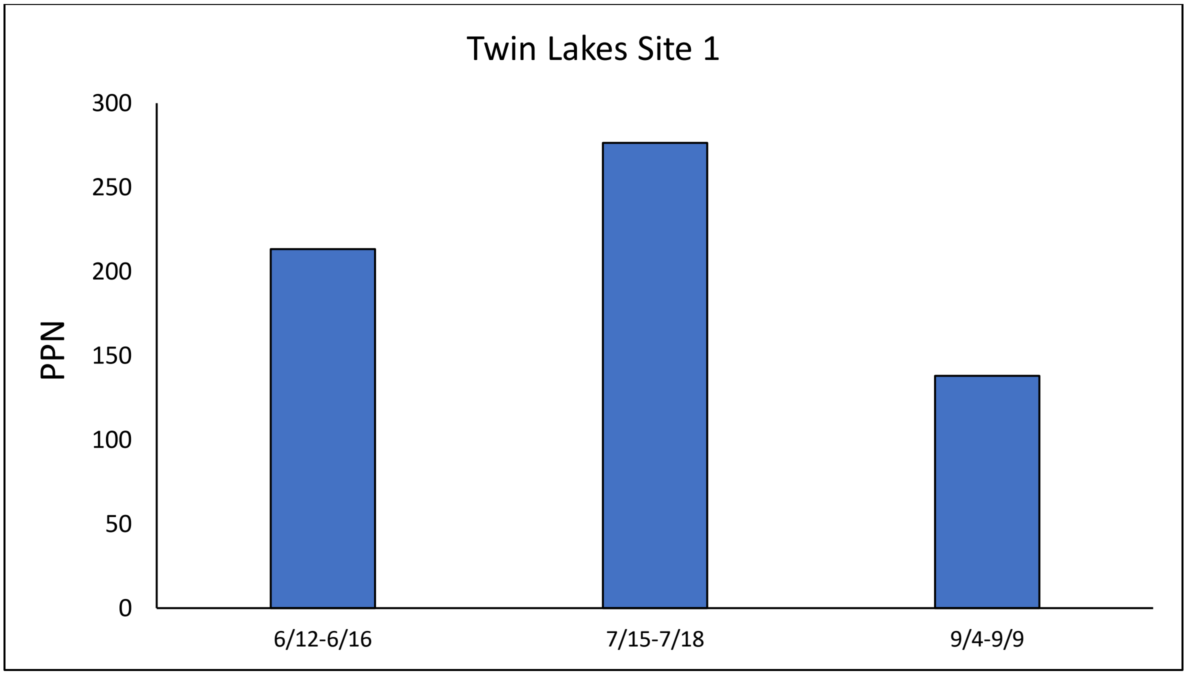


Figure 28. Activity of bats expressed at Passes per Night (PPN) to accommodate different nights in each survey period. Overall bat activity increased from June to July and decreased in September 2021.

Of the eight species recorded at Site 1, species-specific activity showed that the silver-haired bat (*L. noctivagans*) was the most consistently active species (Fig. 29). Big brown bats (*E. fuscus*) were most active in July, whereas little brown myotis (*M. lucifugus*) was by far the most overall active myotis species, with activity peaking in July as well. Tricolored bats (*P. subflavus*) composed 15.8% of PPN in June, 13.3% of PPN in July, and 12.3% of PPN in September. Therefore, this species continues to be active at Site 1.

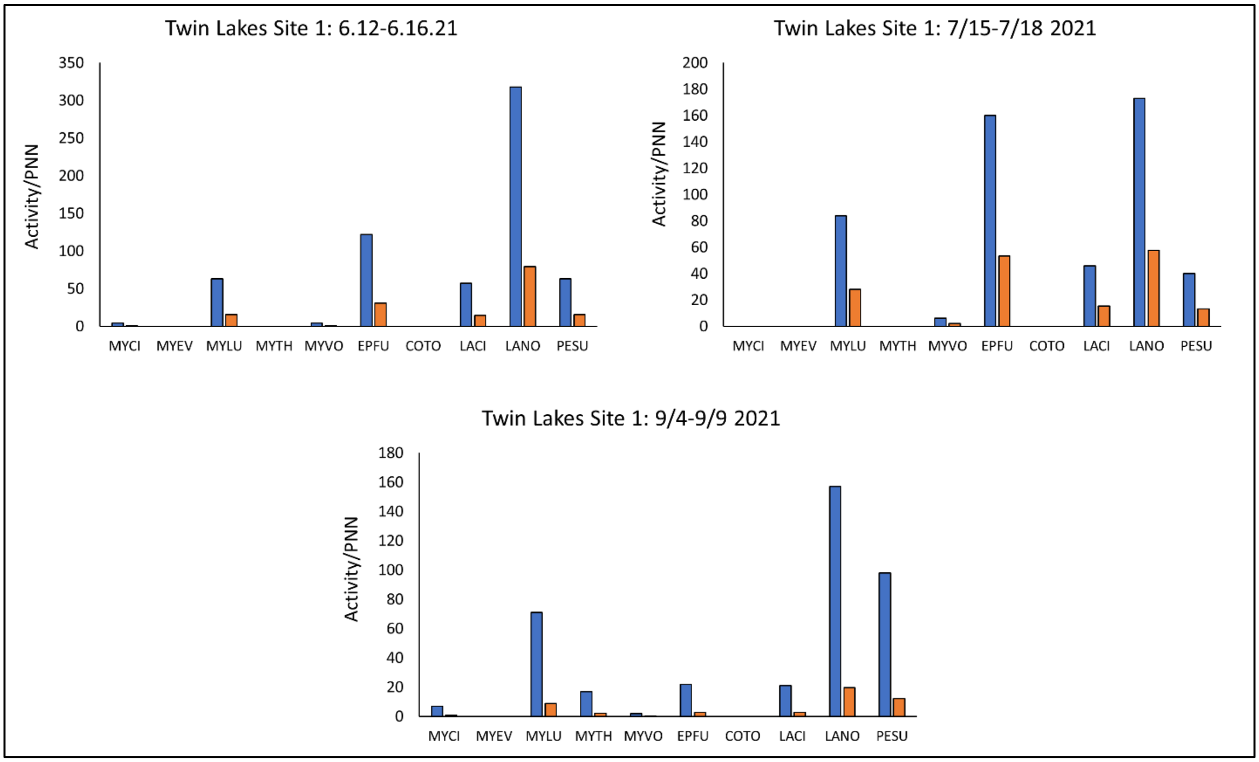


Figure 29. Species-specific activity (blue bars) and Passes per Night (orange bars) at Site 1 at Twin Lakes in June, July and September 2021.

Site 2: At Site 2 2,754 call sequences were recorded over three survey periods. However, the last survey period consisted only of a single night due to detector malfunction (Fig. 30). Comparing survey periods, highest activity was in July which then tapered off in September.

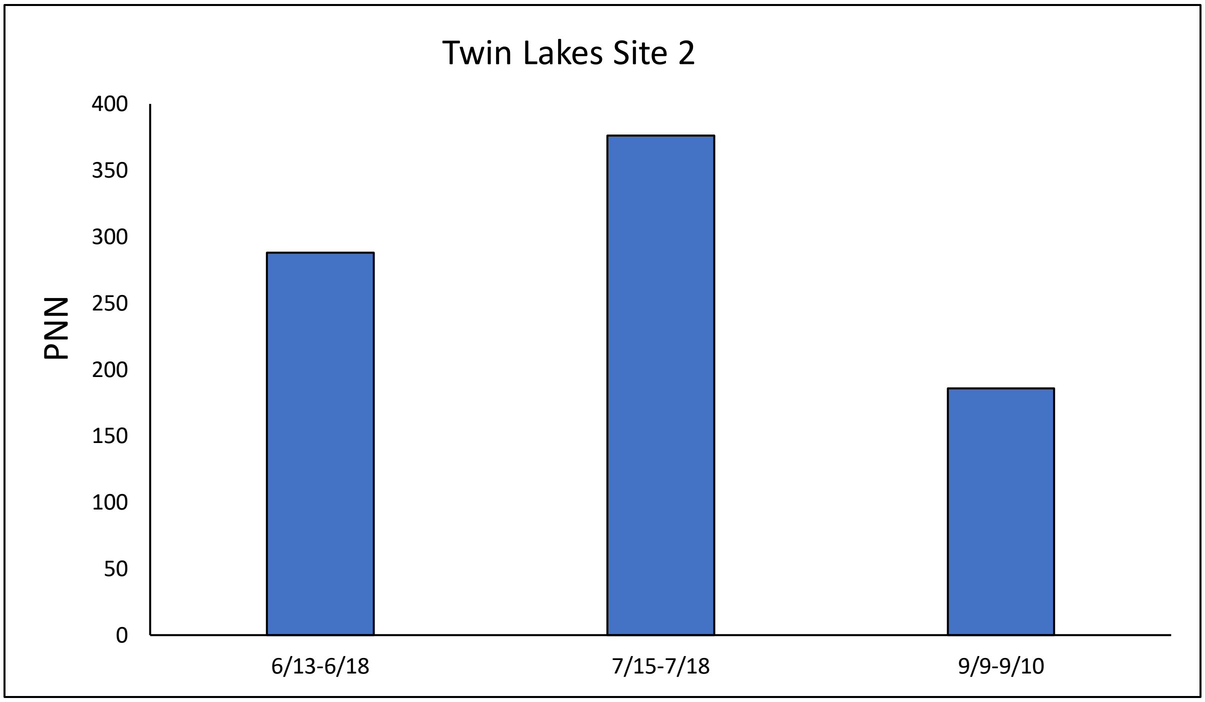


Figure 30. Activity of bats expressed at Passes per Night (PPN) to accommodate different nights in each survey period. Overall bat activity increased from June to July and decreased in September 2021.

Species-specific activity showed that seven species were active in July. For myotis species, this included small-footed myotis (*M. ciliolabrum*), little brown myotis (*M. lucifugus*), and long-legged myotis (*M. volans*). Big brown bats (*E. fuscus*) were very active in July but had much lower presence in June and September. Of particular note at this site was the high activity of tricolored bats (*P. subflavus*). In June, tricolored bats composed 36.9% of all identified calls, whereas in July, they composed 49.9%. In September, tricolored bat calls were 71.7% of identified calls, however, this survey was only a single night. This corridor along Lefthand Ditch with many cottonwoods present composes prime habitat for this species (Fig. 31A). In fact, passes per night continue to increase rather exponentially with 2021 exceeding 65 PPN, whereas in 2020 PPN was about 16 and in previous years, just a few passes (Fig. 31B).

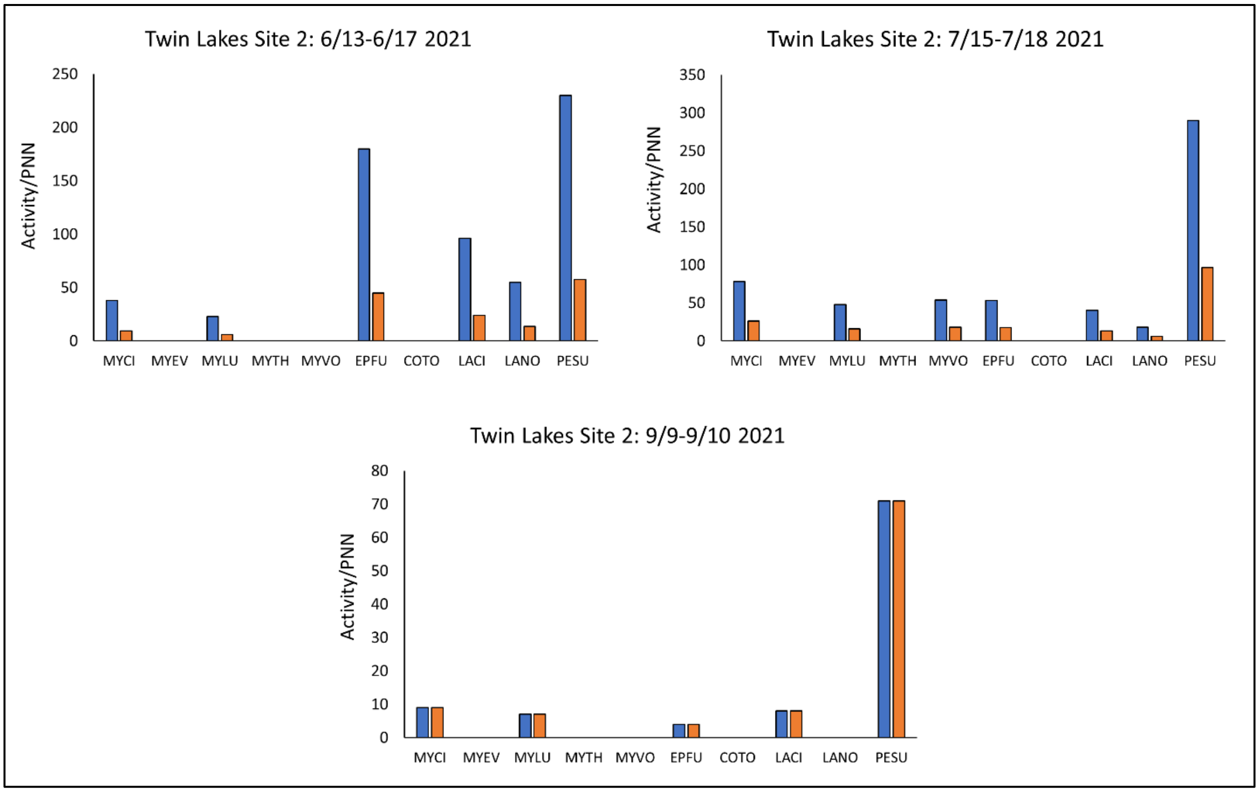


Figure 31A. Species-specific Activity (blue bars) and Passes per Night (PPN, orange bars) at Site 2 at Twin Lakes in June, July and September 2021. Please note that survey 3 only involved a single night due to detector malfunction. Therefore, PPN is quantitatively the same as activity.

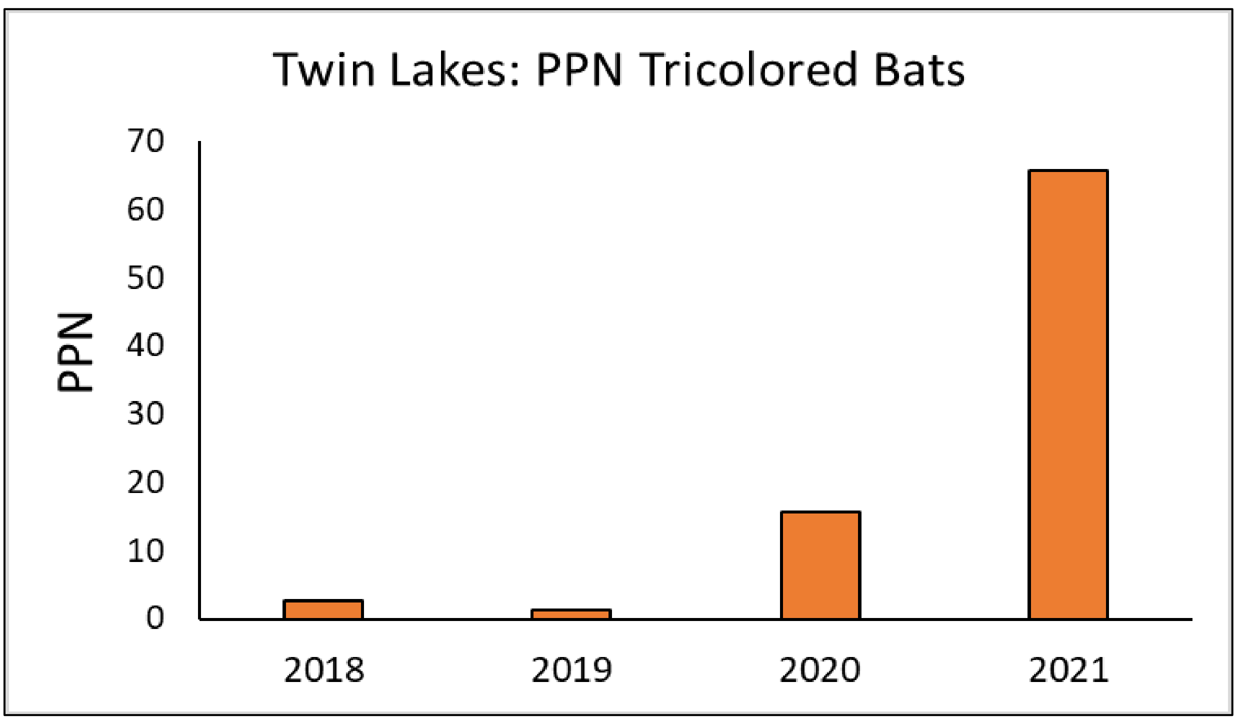


Fig. 31B. Passes per night of PESU along Site 2 Lefthand Ditch at Twin Lakes from 2018-2021.

Conclusions: Twin Lakes and Walden ponds are prime tricolored bat (*P. subflavus*) habitats. In addition, many other species also take advantage of these protected areas including some long-legged myotis (*M. volans*) as well as fringed myotis (*M. thysanodes*). These species typically are foothills distributed and even though it appears to be just a few individuals, these areas support seven of 10 Boulder County species on one level or another.

Recommendations: Continue to protect these areas, especially along streams, ponds and ditches in terms of water availability, water quality, and deciduous trees that allow for roosting sites for many bat species, and in the case of tricolored bats, nursery sites for females and young.

High-Elevation Human-Structure Maternity Colonies

Three high-elevational sites that contain human-made structures that bats are using as maternity roosts were monitored in 2021. These included Blue Jay Mine, Cardinal Mill, and Rocky Mountain Mammoth (Fig. 32).

Figure 32. Map showing locations of three high-elevational sites having human-made structures housing bats.

Blue Jay Mine: This site is located southeast of the township of Jamestown (40^{o} 6.511, 105^{o} 22.027, ele. 2161m) and consist of a grated vertical mine shaft with an outbuilding (Fig. 33). Extensive guano inside the outbuilding suggest maternity colonies are present (Fig. 34).

Figure 33. Map of Jamestown and location of Blue Jay Mine.

Figure 34. Guano pile inside Blue Jay Mine outbuilding indicating the presence of one or more maternity colonies using the structure.

Sonar data collected at the site from 26 August to 6 September 2021 resulted in 1,927 bat sonar sequences were recorded resulting an average of 175.2 Passes per Night (PPN) of which 1,171 were identified to species. Species -specific sonar analysis indicated that of the eight species identified, the two most prevalent species at the site during this time frame were little-brown bats (*M. lucifugus*) and long-legged myotis (*M. volans*). Small-footed myotis (*M. ciliolabrum*) were also quite active (Fig. 35A). Adjusted for passes per night (PPN, Fig. 35B), this patterns holds, but also indicated that these three myotis species may be using the outbuilding as a maternity site. However, this much activity in mid-September at this elevation may also indicate that the grated shaft of the mine itself may be a hibernaculum for one or more of these species and the building site itself may be a swarming/mating area. It should also be noted that because Townsend's big-eared bats were recorded at the site, all on the night/morning of 8/28-8/29, the possibility that this species is using the site for reproduction and/or hibernation, remains open.

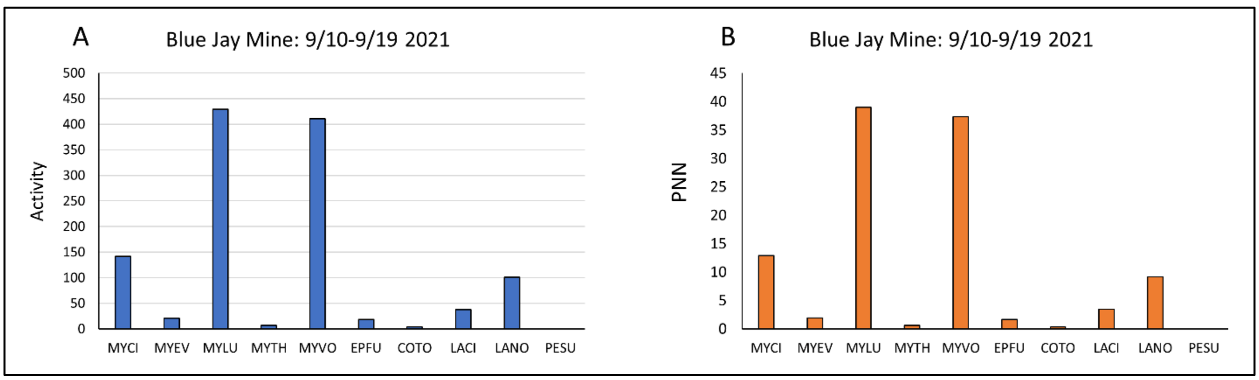


Figure 35. Species-specific sonar analysis of Blue Jay Mine in September. (A) Raw number of passes per species (i.e., Activity), (B) Activity data translated into Passes per Night (PPN) for relative comparisons.

Conclusions: In 2020, an SM2 was placed at this site in October and found zero activity. However, in 2021, a SMU Mini sonar detector was placed at the same spot and recorded nearly 2,000 passes over 11 nights. The discrepancy between these two samples may be due to either the bats leaving the area, going into hibernation by October, or malfunction of the SM2 in 2020. The first two possibilities are unlikely as even if either of these were true some bat passes would likely have been recorded from one or more of the eight species found present in 2021.

This leaves the likelihood that the detector malfunctioned in 2020. Exactly how this site is being used by bats remains to be determined with more data.

Recommendation: Further and more intensive monitoring of this site is in order to determine seasonal patterns of use including which species may be using the outbuilding as a maternity/mating site and which species may be using the mine itself as a hibernaculum.

Rocky Mountain Mammoth: This site consists of an outbuilding (Fig. 36) and is located off of Magnolia Rd (39° 58.904, 105° 23.843, ele. 2516m). Sonar data collected at the site from 18-21 June resulted in 650 bat sonar sequences recorded of which 236 were identified to species and an average of 216.6 passes per night (PPN). Unfortunately, an SM2 placed at the site in September appears to have malfunctioned and did not record any bat sonar, or even noise files.

Figure 36. Photograph of Rocky Mountain Mammoth outbuilding in 2021.

Species-specific analysis indicated that the long-legged myotis (*M. volans*) continues to be the most prominent species at this site as it has been over the last three years. The site is a likely a maternity roost for this species and thus is an important site for protection. Also present in relatively high numbers was little brown myotis (*M. lucifugus*) and small-footed myotis (*M. ciliolabrum*) which also may be roosting as maternity colonies (Fig. 37). In addition, in June 2021, we collected guano from the site that the Colorado Parks and Wildlife tested for the fungus that causes white-nosed syndrome (*Pseudogymnoascus destructans*) and found no evidence of its presence.

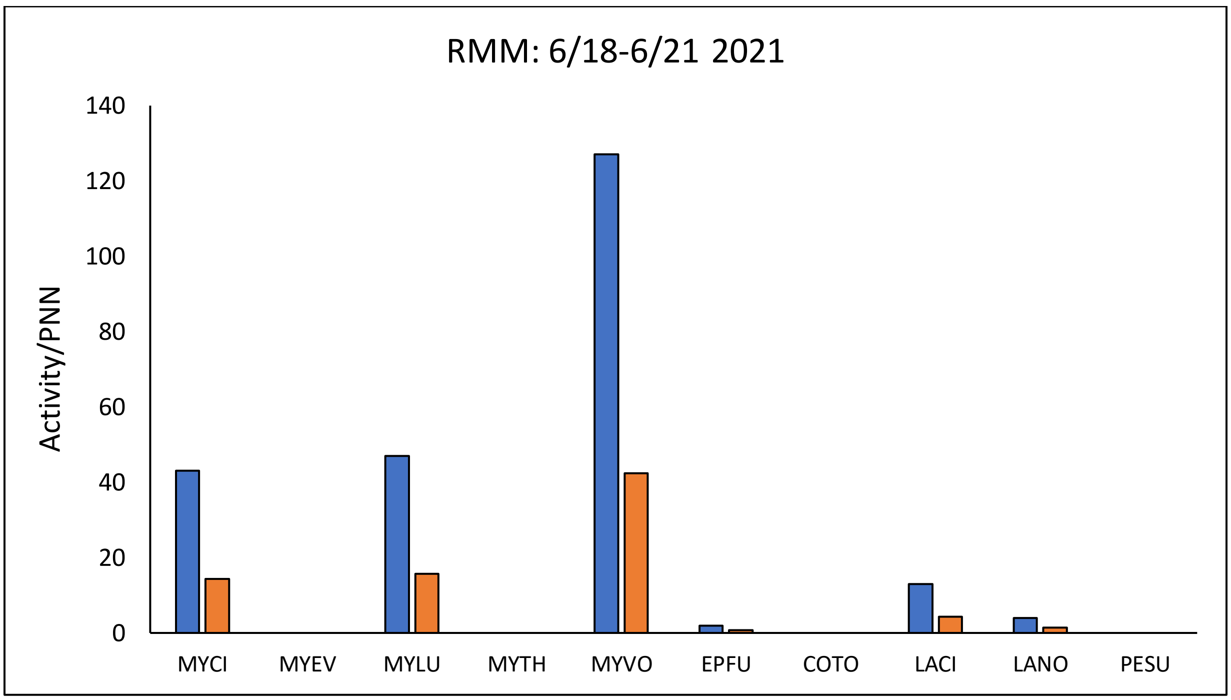


Figure 37. Species-specific sonar analysis of Rocky Mountain Mammoth (RMM) in June 2021. Blue bars indicate number of passes per species (i.e., Activity), whereas orange bars indicate Passes per Night (PPN) for relative comparisons.

Conclusions: Rocky Mountain Mammoth appears to be stable relative to previous years' data and remains an important high-elevation site for several myotis species likely using the structure as a maternity roost.

Recommendations: Continue to monitor, limit human-disturbance, and protect this site.

Cardinal Mill: This site is located west of Nederland off of Caribou Rd. (39^{o} 57.946, 105^{o} 32.993, ele. 2689m) and consists of a large processing building. An SM4 detector was placed on a fencepost just west of the mill (Fig. 38). Survey periods were 6/18-6/24, 8/1-8/15, and 8/30-9/16 2021.

Figure 38. Photograph of Cardinal Mill in 2021 showing placement of SM4 bat sonar detector attached to fencing.

Overall bat activity based on total number of bat passes recorded at the mill peaked in the September survey period (Fig. 39, blue bars). However, when adjusted to Passes per Night (PNN) due to differing survey period lengths, data show relative activity was highest in August with over 1,000 passes per night (Fig. 39, orange bars).

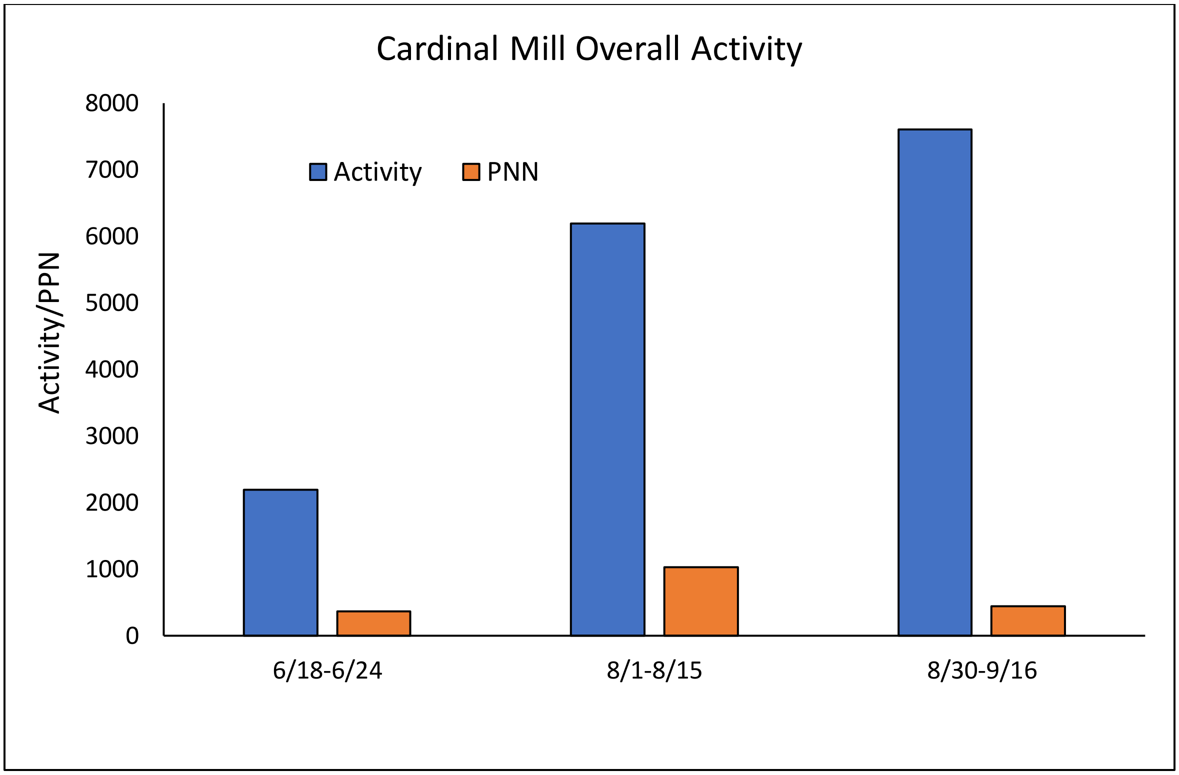


Figure 39. Overall number of passes recorded (blue bats) and adjustment to Passes per Night (PPN, orange bars), indicates that although the longer survey period in September resulted in more passes recorded, adjust for survey length indicates that August had the highest bat activity with more than 1,000 PPN.

Species-specific activity indicated that whereas seven of 10 species were recorded in June, this increased to 10 of 10 species in August and September. In all three survey periods, little brown myotis (*M. lucifugus*) and long-legged myotis (*M. volans*) were by far the most active. In June, *M. lucifugus* composed 42.3% of all passes, whereas *M. volans* composed 42.7%. In early-mid-August, *M. lucifugus* composed 35.2%, whereas *M. volans* composed 52.4% and in September, *M. lucifugus* composed 28.5%, whereas *M. volans* contributed 35.0%. Together, these two species by far made up the majority of call passes recorded, especially in June and August. This percentage declined somewhat in September, likely due to dispersal of individuals from the maternity colonies, as well as more individuals of other species moving up from lower elevations to nearby hibernation sites (Fig. 40).

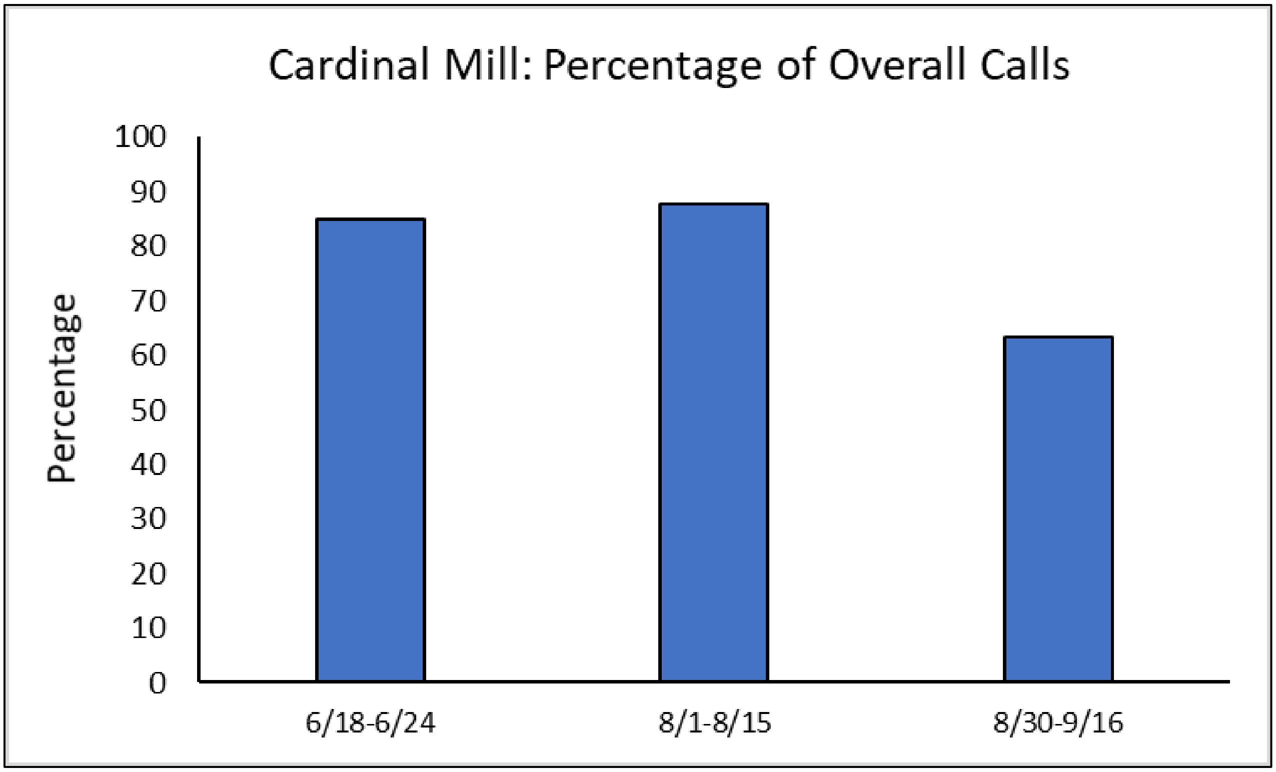


Figure 40. Percentages of calls identified as little brown myotis (*M. lucifugus*) and long-legged myotis (*M. volans*) combined in relation to all calls recorded during each survey period.

Other myotis species active at the site were small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), and fringed myotis (*M. thysanodes*) may also have smaller maternity colonies in the mill (Fig. 41). As is, we only have verified data on *M. volans* using this site as a nursery roost as several dead young of the year have been found. The large numbers of *M. lucifugus* indicate a likely maternity roost, but this species can also form large bachelor colonies. Therefore, it remains unclear which type of colony is present for *M. lucifugus*.

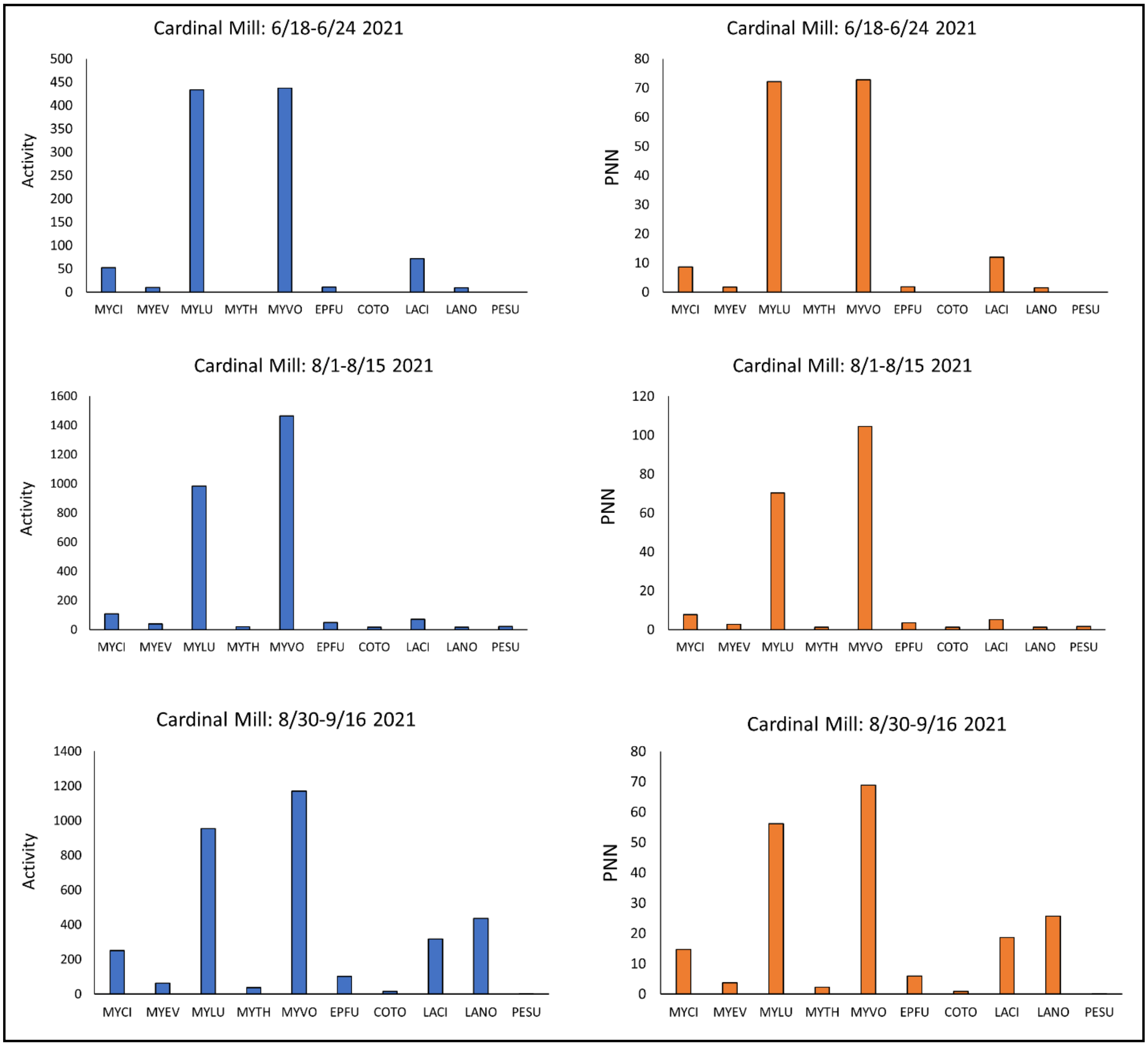


Figure 41. Species-specific activity patterns at Cardinal Mill in June, August, and September 2021.

Conclusions: Cardinal Mill continues to be an important high-elevation maternity site for long-legged myotis (*M. volans*) and a large colony, likely maternity, for little brown myotis (*M. lucifugus*). These two species composed greater than 85% of all sonar calls recorded in June and August. This site is unique as it possesses a thermal environment conducive to the inhabitance of bat nursery colonies of females and their young which is likely rare at this elevation and area.

Recommendations: Continue to protect this site and minimize human disturbances during the reproductive season (April-October). Although *M. lucifugus* is generally considered to be tolerant of human disturbance, *M. volans* is much less accepting and is rarely found residing in human-occupied, or disturbed, buildings.

Synthesis

Generally speaking, overall bat activity in Boulder County was high in 2021. Record precipitation in May (5.76) was 180% of average (BoulderCast.com). This ended abnormally dry and moderate drought conditions in Boulder County (Fig. 42). Such levels of precipitation likely

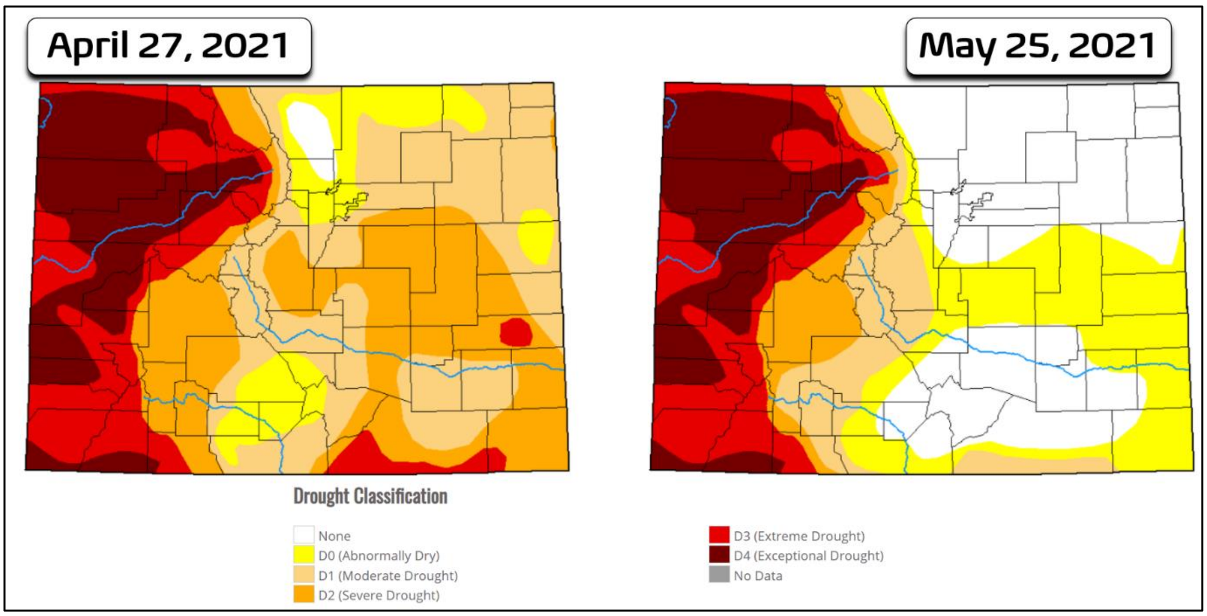


Figure 42. Maps of drought severity for Colorado, including Boulder County, in April and May 2021.

increased significantly vegetative growth and insect population growth. Although bats appeared to come out of hibernation later due to significant late season snow in April and May, the abundance of food and water likely provided a resource base in Boulder County conducive to high levels reproduction and survival for bats, and other wildlife (Fig. 43). These conditions likely influenced recovery of Heil Valley Ranch after the Cal-Wood fire and provided opportunities for wildlife to return to the area even after such a devastatingly destructive event.

Figure 43. Photograph taken in May of an area severely burned by the Cal-Wood fire in October 2020. Two mule deer (*Odocoileus hemionus*) making their way through the site.

Long-term surveys, such as the one for bats at HVR, are critical to our understanding of animal and plant populations in a changing world. The diversity of sites sampled in 2021 for bats, including eastern riparian properties, lower, middle and higher elevation canyon properties, and human-made structures now acting as wildlife habitat, allow for a broad and deep understanding of bat populations in Boulder County. Such data sets are invaluable for current and future management of our precious wildlands.

Comparisons of Long-Term Survey Sites: Pre- and Post-Burn (Three Case Studies)

Three sites at HVR have long-term sonar survey data from 2016-2021 allowing for pre- and post-burn analyses of overall bat activity and species-specific use patterns.

Upper Geer Canyon: Several survey areas have occurred over the years along Geer Canyon between the Caretaker's house and below the maternity roost of fringed myotis (*M. thysanodes*) (Fig. 44). In most years, the survey point was near a heavily used water source across from the caretaker's home (marked with a red x).

Figure 44. Map showing long-term survey area in Upper Geer Canyon.

Bat activity translated into Passes per Night (PPN) to adjust for differing sampling periods (Fig. 45, left) from 2016 to 2019 increased, however, 2020 showed less PPN with 2021 (post-burn data) showing a rebound and slight increase in PPN.

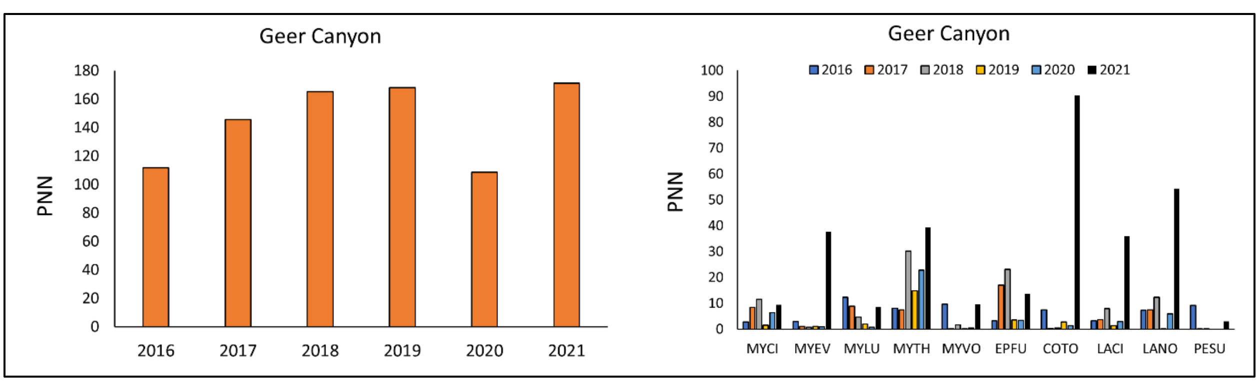


Figure 45. (Left) Passes per Night (PPN) of bats in Geer Canyon from 2016-2021. (Right) Species-specific PPN across years. Black bars indicate post-burn year 2021.

Species-specific patterns of bat activity across years (Fig. 45, right) shows that some species increased PPN in Geer Canyon noticeably in post-burn surveys in 2021 (black bars). This was true for long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), Townsend's long-eared bat (*C. townsendii*), hoary bat (*L. cinereus*) and silver-haired bat (*L. noctivagans*). Of particular note was the large increase in *C. townsendii* in the canyon.

Plumely Canyon: This site is located next to a small water source that typically holds water throughout the summer months (Fig. 46).

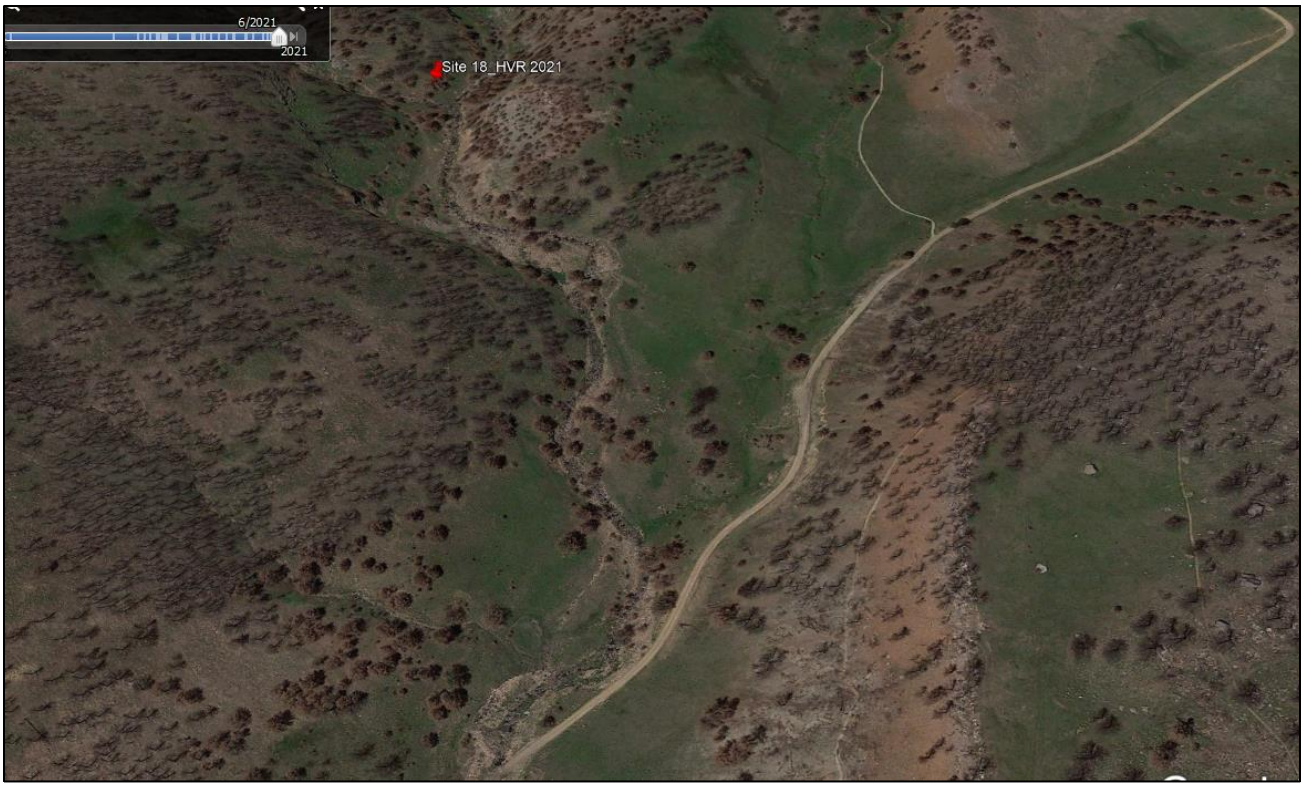


Figure 46. Map showing position of sonar detector in Plumely Canyon near a summer water source.

Bat PPN at this site (Fig. 47, left) fluctuated over the five years (note: unfortunately, the detector malfunctioned in 2019 and therefore no data were gathered). Summer 2020 was the highest activity recorded at the site and in 2021 (post-burn).

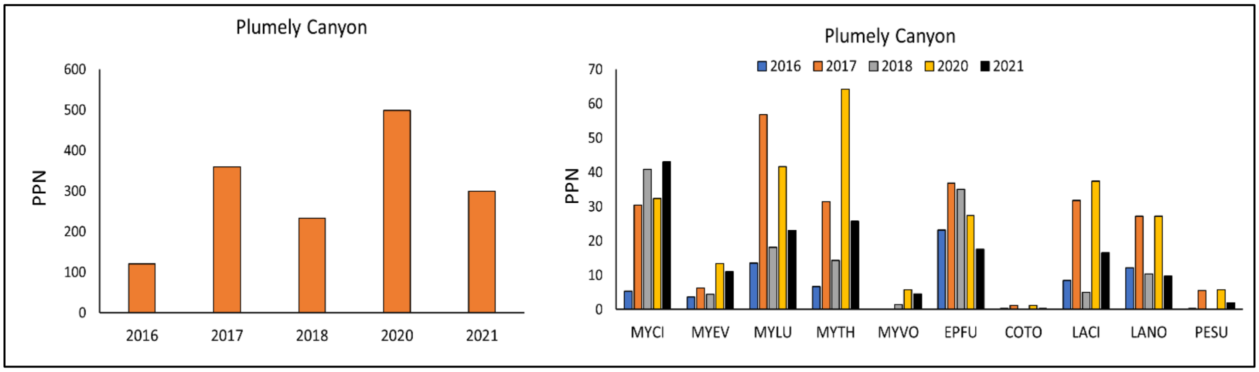


Figure 47. (Left) Passes per Night (PPN) of bats in Plumely Canyon from 2016-2021, with the exception of 2019. (Right) Species-specific PPN across years. Black bars indicate post-burn year 2021.

Species-specific patterns of bat activity across years (Fig. 47, right) shows that most species decreased PPN in Plumely Canyon in post-burn surveys in 2021 (black bars) but mostly in alignment with previous years. The exception was the small-footed myotis (*M. ciliolabrum*) which showed a slight increase in PPN.

MYEV-Thinned Site: This site (Fig. 48, Site 21 for 2021 survey) is located east of Ingersol Quarry and is a site that had very high activity of long-eared myotis (*M. evotis*) before significant thinning of the stand took place in 2012. Post-thinning showed significant increases in overall bat activity, but the incursion of more individuals of nonclutter specialist possibly caused

Site 48. Map of MYEV-Thinned Site (Site 21 during 2021 survey) near Ingersol Quarry.

M. evotis to possibly caused *M. evotis* to abandon the site mostly. It is also possible that just the change in habitat structure and/or preferred food base caused them to forage elsewhere. However, in 2017, this species use of the site rebounded somewhat as other species for unknown reasons reduced their foraging at the site. Overall bat PPN showed significant declined in 2019 and 2020 but showed a large increase in post-burn year 2021 (Fig. 49, left).

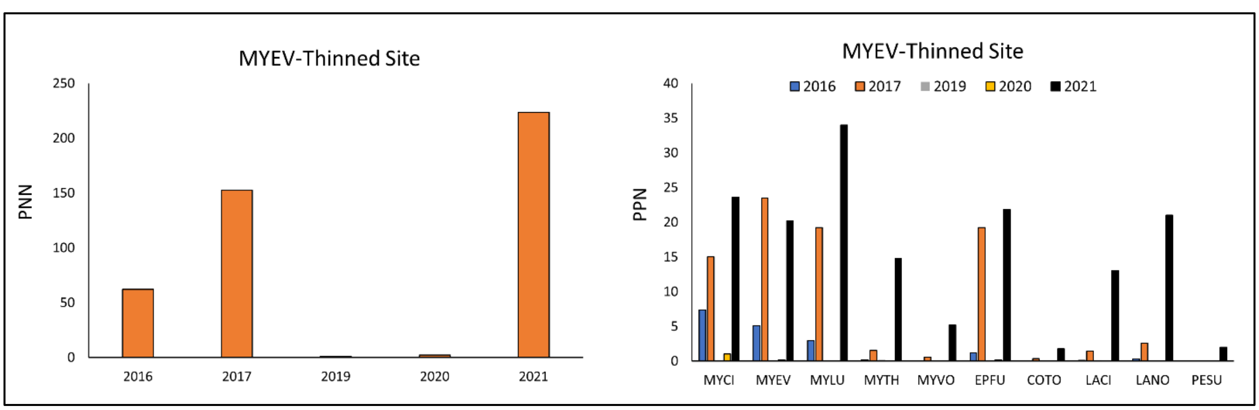


Figure 49. (Left) Passes per Night (PPN) of bats at the MYEV-thinned site from 2016-2021. (Right) Species-specific PPN across years. Black bars indicate post-burn year 2021.

Species-specific patterns of bat activity across years (Fig. 49, right) showed that some species increased PPN in the MYEV-thinned site noticeably in post-burn surveys in 2021 (black bars). In fact, this was true for all species except the long-eared myotis (*M. evotis*). However, the long-eared myotis did increase its PPN during this time compared to the two previous years even though other bat species were present at the site.

Conclusions: The long-term data presented here indicates that bats were generally as active or, in some cases, more active at these sites in 2021, the post-burn year. The sites monitored in Geer Canyon in 2021 ranged from Moderate to Severe Burn w/o needles present. Both the Plumely and MYEV-Thinned sites were classified as severe burn w/needles. Unfortunately, no long-term monitored sites were in untouched or low impact fire areas. However, it does appear that bats readily used burned areas of various severity in which to forage. In the case of the MYEV-thinned site, bat activity increased dramatically in 2021. If these patterns hold long-term is yet to be determined.

Other Wildlife Sightings

Prairie rattlesnake (*Crotalus viridis*) on road near north-end of prairie dog colony, Heil Valley Ranch, 15 August 2021.

Trailcam: Mountain lion (*Felis concolor*) Ingersol Quarry April 2021.

Trailcam: Bull elk (*Cervis canadensis*) Ingersol Quarry

Trailcam: Red fox (*Vulpes vulpes*) at Ingersol Quarry.

Trailcam: Striped skunk (*Mephitis mephitis*) at Ingersol Quarry.

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