Report on Continued Research on the Effects on Bats of Forest Structure Changes Caused by Fire and Human Manipulation, Dietary and Heavy Metal Contaminant Analyses and Bats at Hall II Property

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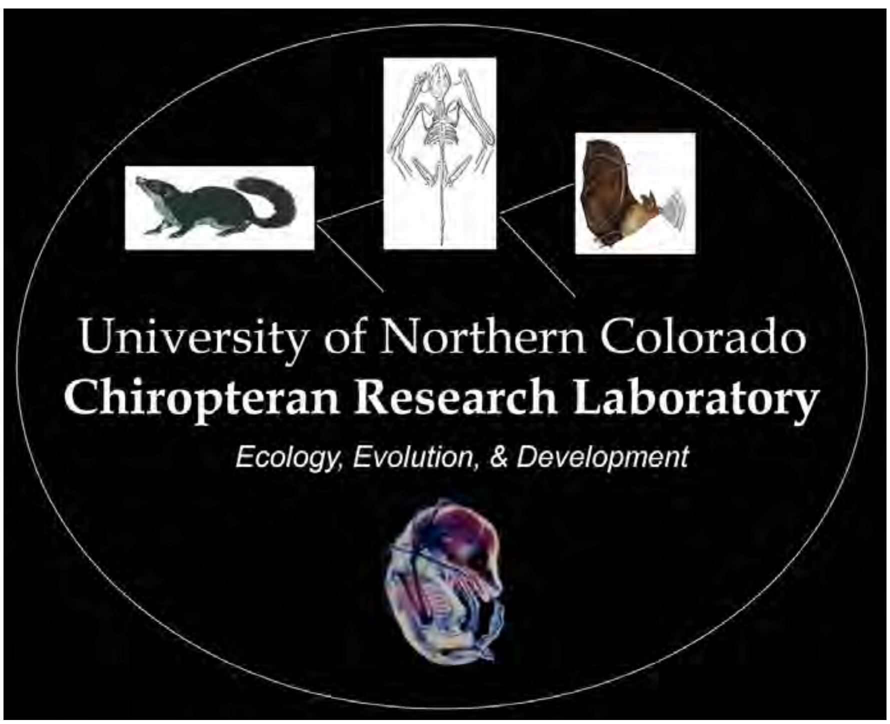

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Abstract: In 2014 we worked at Heil Valley Ranch and Hall II properties owned by Boulder County Parks and Open Space. We mist netted and used SM2BAT+ and EM3 sonar recorders to quantify bat foraging patterns. For the third year were gathered sonar calls from the Overland Burn area, Geer and Plumely canyons, and thinned area near Ingersol Quarry and more than 25 sites at Hall II property. We captured 74 bats of seven species at 14 netting sites distributed across Heil Valley Ranch and Hall II properties and gathered more than 40,000 sonar call sequences. The foraging activity of bats at the Overland Burn sites were similar to that found in 2012 and 2013. The flood of September 2013 had major effects on both Geer and Plumely canyons resulting in a very large number of drinking pools established in each canyon. In Geer Canyon, bat activity increased by 45%, whereas in Plumely Canyon bat activity increased by greater than 75%. For the first time ever since working in Plumely Canyon, we heard and recorded audible communication calls between individuals of the Mexican free-tailed bats indicating that a colony of this species has taken up residence in the area. We also heard and recorded these communication calls at Hall II property. We continue to record definitive sonar calls of tricolor bats (*Perimyotis subflavus*) at Hall II, but have not been able to capture any individuals. The most common species recorded at Hall II property were hoary bats (*Lasiurus cinereus)*, small-footed myotis (*Myotis ciliolabrum)* and little brown myotis (*Myotis lucifugus)*. A large maternity colony of *M. lucifugus* was found along the St. Vrain Canyon from an individual radio-tagged at Hall II property. Although this colony does not roost on Hall II property, this location provides a major drinking site and foraging areas for this species. In fact, the large maternity colony drank from the Pool 1 site in the gravel pit. Three sites tested in the gravel pit showed relatively high levels of dissolved calcium. Although the *M. lucifugus* maternity colony drank from Pool 1 which had the lowest dissolved calcium (although still

higher than other sites tested), Pool 1 also had the least amounts of potentially harmful chemical compound load.

Objectives: **A)** continue to gather data on the Overland Burn site in terms of bat activity across the landscape, **B)** conduct post-flood analysis of canyons hard hit by the September 2013 event, **C)** continue to collect data on before and after forest thinning near Ingersol Quarry in relation to the long-eared myotis (*Myotis evotis*) population, **D)** expand data gathering at Hall II based upon preliminary data gathered in 2013, **E)** conduct radio-telemetry study at Hall II to find significant roost sites, **F)** conduct water quality testing of water sources used by bats for heavy metals and compounds beneficial for bats such as dissolved calcium, **G)** conduct molecular analysis of guano that will allow species level results in terms of dietary preferences among species, **H**) assess guano for heavy metal ingestion.

Methods

Heil Valley Ranch: We continued sonar data collection from the Overland Burn site using the same methods as used in 2012 and 2013. We also monitored Geer and Plumely canyons using SM2s in order to document changes in bat abundance, species richness, species evenness, and assemblage structure after the September flood of 2013. In addition, we mist netted in Plumely Canyon as well as Ingersol Quarry and also placed an SM2 in thinned area next to Ingersol Quarry to track changes in bat foraging patterns in relation to pre-thinning patterns.

Census of Hall II: We used a stratified random sampling technique within a gridded area encompassing Hall II property. The area encompassed by the grid contains about 50% forest stands and 50% montane meadow habitat (Fig. 1). There are 100 squares that we divided into quadrants of 25. To pick set-points ofr SM2s, we randomly chose four numbers using an online random numbers generator (http://www.random.org/integers/?num=25&min=1&max=25&col=10&base=10&format=html&rnd=new). SM2s were placed on the most appropriate tree (i.e. allowing for mostly unobstructed sound detection).

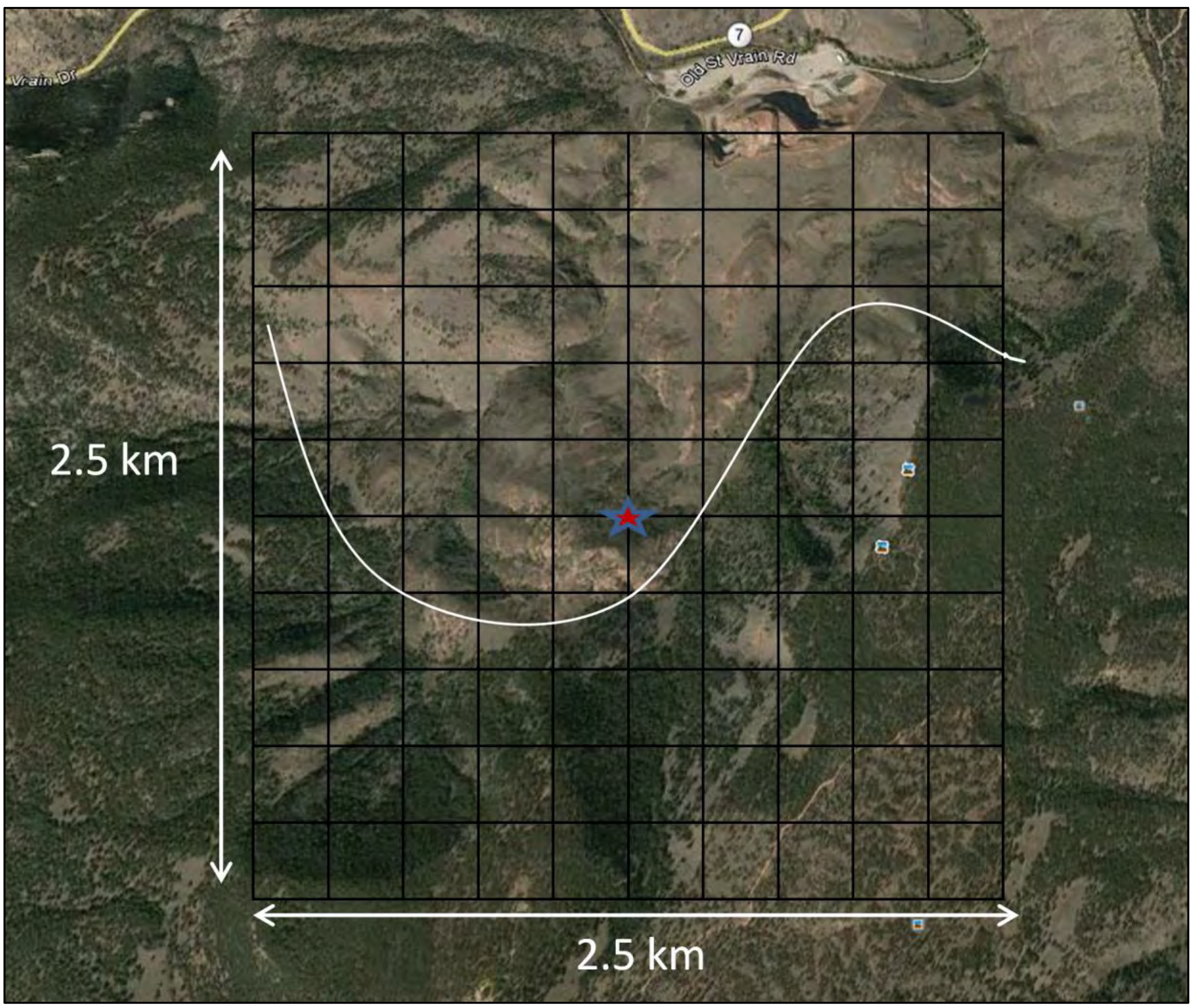


Figure 1. Grid overlay of Hall II property.

SM2s were moved every after 4-6 nights of collecting data depending on if inclement weather on a give night may have reduced bat activity. Sonar calls were downloaded to a laptop computer and analyzed using SonoBat 3.1 species identifying software. Total number of bat sonar calls recorded, regardless of call quality, we tallied as an activity indicator. Assemblage structure was determined using the percentage of calls identified to species by SonoBat.

In addition, we also mist netted at water sources in order to ascertain reproductive and health condition of individuals. We also radio-tagged one female little brown bat (*Myotis lucifugus*) with a 0.26g Holohil radio-transmitter in order to find her maternity roost and define her foraging range.

Water Quality Testing: We tested water quality at three sites at Hall II and three sites a Heil Valley Ranch. We used the dip-methods to collect samples and stored them on ice, delivering the samples to the Boulder County Water Treatment Plant for analysis on the same day

Guano Dietary Analyses: We collected guano samples from bats for molecular analysis of diet. Each bat was placed in an unused small paper bag to avoid cross contamination with other bats for 30 minutes or less and each guano sample from a particular individual was then stored at -17C.

RESULTS

Capture Data from Heil Valley Ranch and Hall II Properties.--We captured 74 bats of seven species at 14 netting sites distributed across Heil Valley Ranch and Hall II properties (Table 1).

Table 1. Capture data from Heil Valley Ranch and Hall II properties in 2014.

DATE	SITE	SPP	AGE	REPRO	MASS	UTM North	UTM West
28-May	Plumely-lower site 2	MYCI	A	NS	4.4	40 09.417	105 18.090
13-Jun	Ingersol Quarry	EPFU	A	NS	14.3	40 11.488	105 18.446
13-Jun	Ingersol Quarry	MYEV	A	NS	5.8	40 11.488	105 18.446
13-Jun	Ingersol Quarry	MYEV	A	P	5.4	40 11.488	105 18.446
13-Jun	Ingersol Quarry	MYLU	A	NS	6.6	40 11.488	105 18.446
13-Jun	Ingersol Quarry	MYLU	A	P	9.5	40 11.488	105 18.446
30-Jun	Hall II retention pond	LACI	A	L	NW	40 12.071	105 17.834
6-Jul	Plumely-upper site 2	MYCI	A	L	5.6	40 09.525	105 18.155
6-Jul	Plumely-upper site 2	MYTH	A	NS	7	40 09.525	105 18.155
10-Jul	Hall II, pool 2	EPFU	A	NS	15	40 12.004	105 17.938
10-Jul	Hall II, pool 2	EPFU	A	NS	NW	40 12.004	105 17.938
10-Jul	Hall II, pool 2	EPFU	A	NS	15.3	40 12.004	105 17.938
10-Jul	Hall II, pool 2	EPFU	A	NS	18.9	40 12.004	105 17.938
10-Jul	Hall II, pool 2	LACI	A	L	26.5	40 12.004	105 17.938
10-Jul	Hall II, pool 2	MYCI	A	NS	4.7	40 12.004	105 17.938
10-Jul	Hall II, pool 2	MYLU	A	NS	8.7	40 12.004	105 17.938
22-Jul	Hall II, W canyon, mid 1	MYEV	A	NS	6.8		
28-Jul	Ingersol Quarry	COTO	A	L	RT	40 11.488	105 18.446
28-Jul	Ingersol Quarry	COTO	A	L	10.8	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYCI	A	NS	4.1	40 11.488	105 18.446
28-Jul	Hall II, west canyon-middle site 1	MYEV	A	NS	6.8	40 11.588	105 18.292
28-Jul	Ingersol Quarry	MYEV	A	NS	6.1	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYEV	A	L	7.2	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYEV	A	L	6.6	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYEV	A	NS	6.4	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYEV	A	NLNP	6.6	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYEV	A	NS	NW	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	NS	5.8	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	L	NW	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	L	NW	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	NS	7.7	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	NLNP	8	40 11.488	105 18.446
28-Jul	Ingersol Quarry	MYTH	A	NLNP	6.7	40 11.488	105 18.446

3-Aug	Hall II, pool 1	MYCI	SA	NLNP	4	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	4.9	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU		NLNP	5.2	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	A	PL	5.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NS	6	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	6.6	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	5.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	5.9	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.7	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	5	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NS	4.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.7	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	NW	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	A	NS	6.1	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	6.7	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	6	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	6.1	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	6.2	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	6	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.8	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	6.1	40 12.086	105 17.982
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.6	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.7	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	SA	NS	5.7	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.1	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	6.3	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.3	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	5.7	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	SA	NLNP	6	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.7	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	J	NLNP	5.3	40 12.085	105 17.950
3-Aug	Hall II, pool 1	MYLU	SA	NS	6.1	40 12.085	105 17.950
11-Aug	Hall II, pool 1	MYLU	A	S	6.2	40 12.085	105 17.950
11-Aug	Hall II, pool 1	MYLU	A	L	RT	40 12.085	105 17.950
11-Aug	Hall II, pool 1	MYLU	SA	NLNP	5.6	40 12.085	105 17.950

17-Aug	Hall II, west canyon-lower	EPFU	A	NS	NW	40 11.824	105 18.287
17-Aug	Hall II, west canyon-lower	EPFU	A	S	14.5	40 11.824	105 18.287
17-Aug	Hall II, west canyon-lower	MYCI	SA	NLNP	5.1	40 11.824	105 18.287
17-Aug	Hall II, west canyon-lower	MYEV	SA	NLNP	NW	40 11.824	105 18.287

Of note, we captured 36 *M. lucifugus* at Pool 1 on Hall II property, all but one of which were juveniles and subadults, and all of which were females with the exception of three individuals. We also captured a lactating female *L. cinereus* at Pool 2 on Hall II property which is rare in that almost all captures over the years of this species have been males or nonreproductive females. Sonar calls of this species were also higher than expected across the Front Range which may indicate that due to the cooler. wetted summer, some females may not have migrated north to give birth, but instead stayed in the Boulder area.

Heil Valley Ranch.--We netted at four sites in the reconfigured drainage of Plumely Canyon (Fig. 2). We captured two *M. ciliolabrum* and one *M. thysanodes* (see Table 1).

Figure 2. Netting locations in Plumely Canyon.

We tested four hypotheses concerning how bat activity will change relative to the 2013 floods that restructured Geer and Plumely canyons. **H1:** *Scouring of drainages in Geer and Plumely canyons will provide new and more frequent drinking opportunities for bats*. **H2:** *Bat activity will increase significantly.* **H3:** *Evenness of species abundances will change*. **H4:** *Bat assemblage dynamics will shift*

Study Site. We studies before and after effects of the 2013 flood event in two canyons (Fig. 3). We placed detectors at two spots in each canyon separated by about 0.25 km from 2011-2014 (Fig. 4).

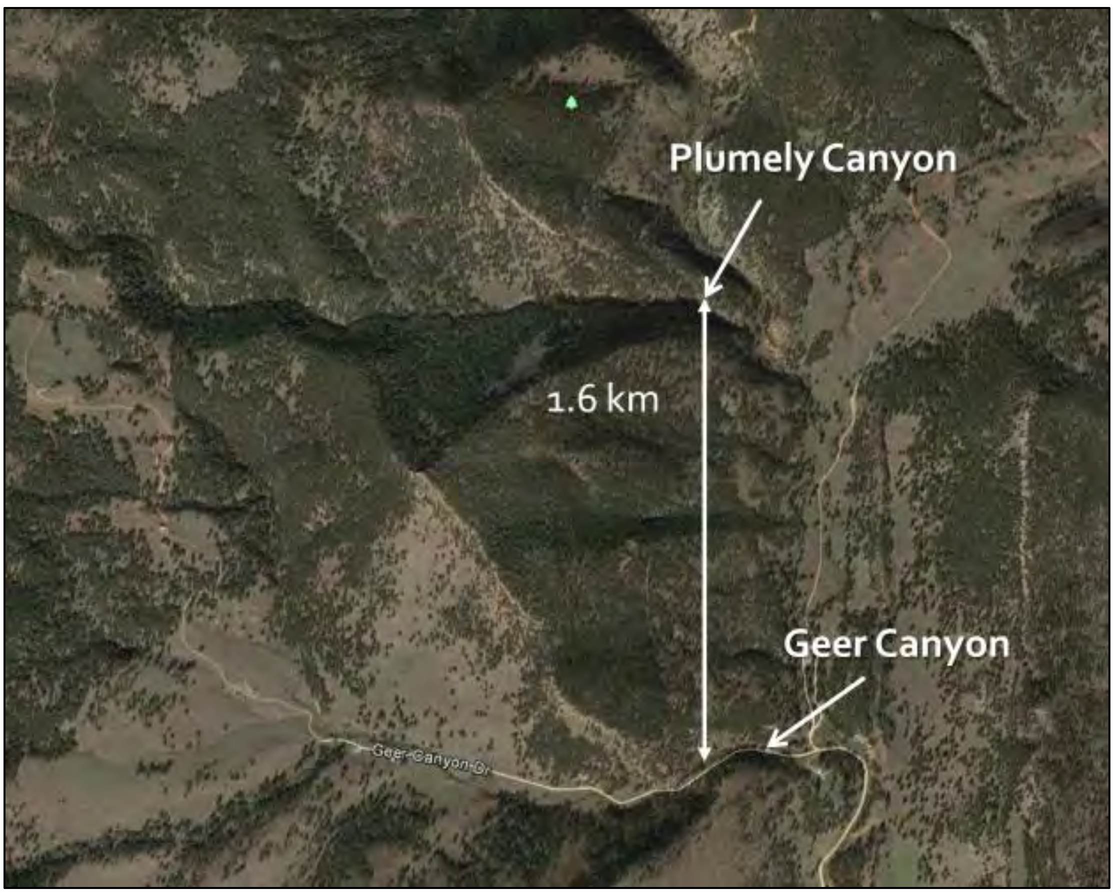


Figure 3. Map showing spatial relationship between Plumely and Geer canyons.

Figure 4. Point locations of sonar detectors in each canyon.

Availability of water was greatly increased in 2014 than in any of the previous years with many drinking pools (>20) available for bats (Fig. 5). The 2013 flood scoured all vegetation from the creek bed and the power of the flood produced many deeper pools capable of retaining water throughout the summer months. Insect biomass was much lower in 2014 than in previous years, perhaps due to scouring of drainages. Biomass in 2012 in Geer Canyon was 470.8mg whereas in 2014 was 2.1mg) and in Plumely Canyon, 2012 was 35.8mg and in 2014 was 2.4mg). It should be noted that we changes insect trap types in 2014, thus it is not clear if all of this decrease was real or due to different trap success.

A

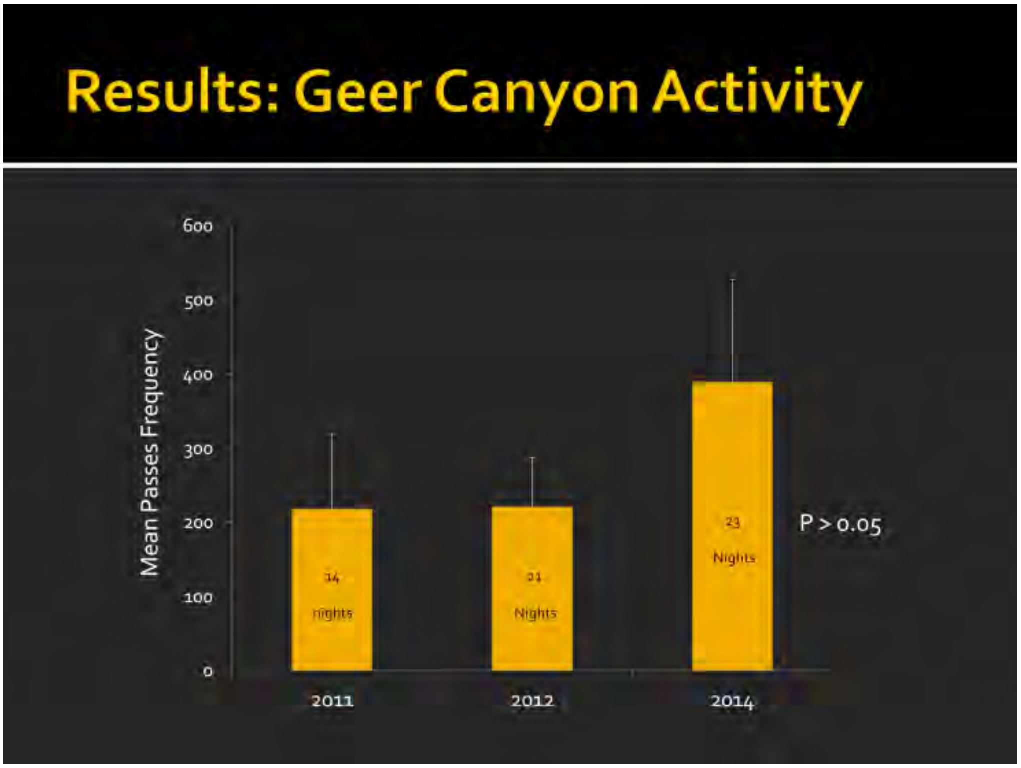
B

C

D

Figure 5.Top photos (A & B) of Geer Canyon before and after flood. Bottom photos (C & D) Plumely canyons before and after flood. Red arrows depict before and after availability of bat drinking sites.

A total of 58 detector nights were gathered for Geer Canyon and 41 detector nights for Plumely Canyon. Both canyons showed an upsurge in bats activity with Geer Canyon increasing by 45% and Plumely Canyon increasing 77% (Fig. 6).



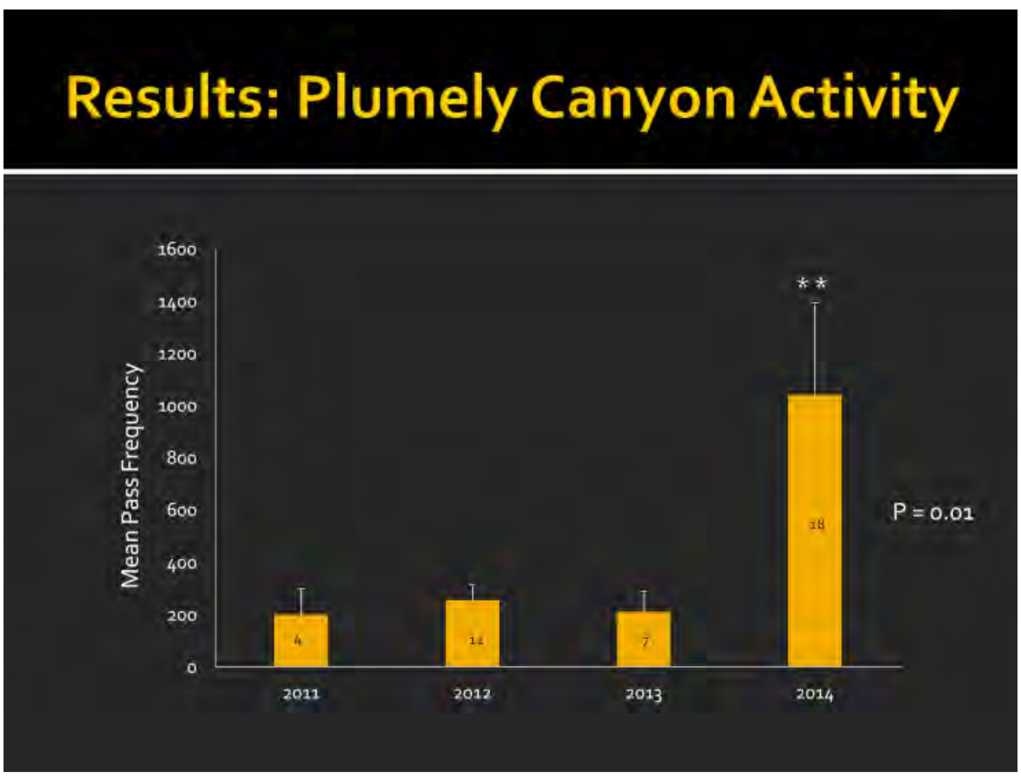


Figure 6. Results of activity in Geer (top) and Plumely (bottom) canyons before and after 2013 floods as measured in 2014.

We also found changes in species evenness, especially in Geer Canyon in which evenness increased substantially (Fig. 7). Species richness in Plumely Canyon ranged from 5-7 species present during any recording series, whereas in Geer Canyon there were always 9 and 10 bat species present during all recording sessions.

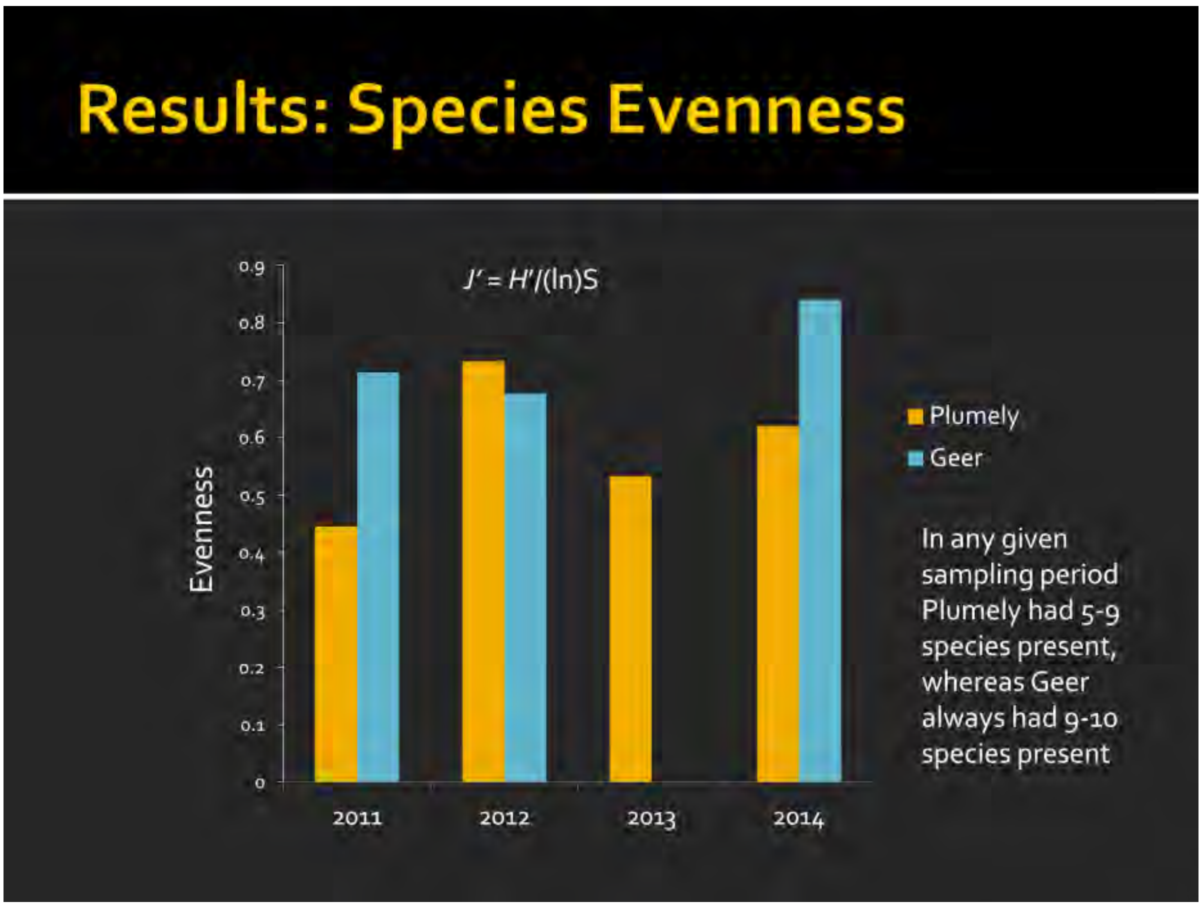
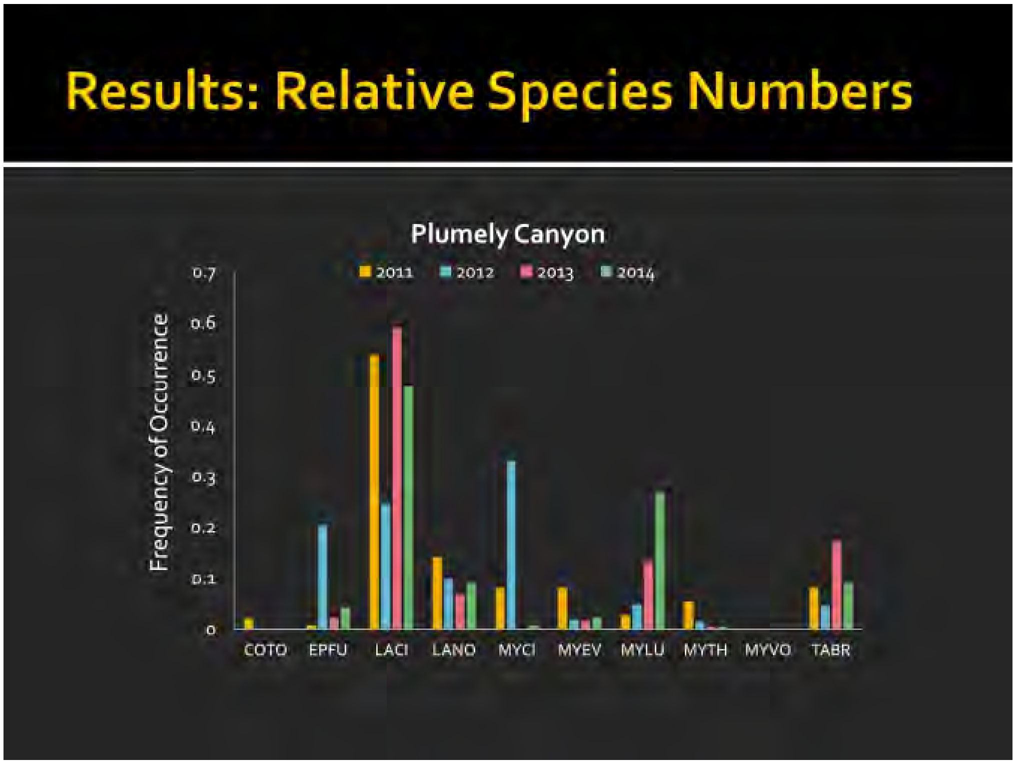


Fig. 7. Relationship of species evenness in Geer and Plumely canyons before and after the 2013 flood event.

In addition, in both cases, the species that reacted most positively from increased water availability were the little brown myotis, *Myotis lucifugus* (MYLU) and the small-footed myotis, *M. ciliolabrum* (Fig. 8).



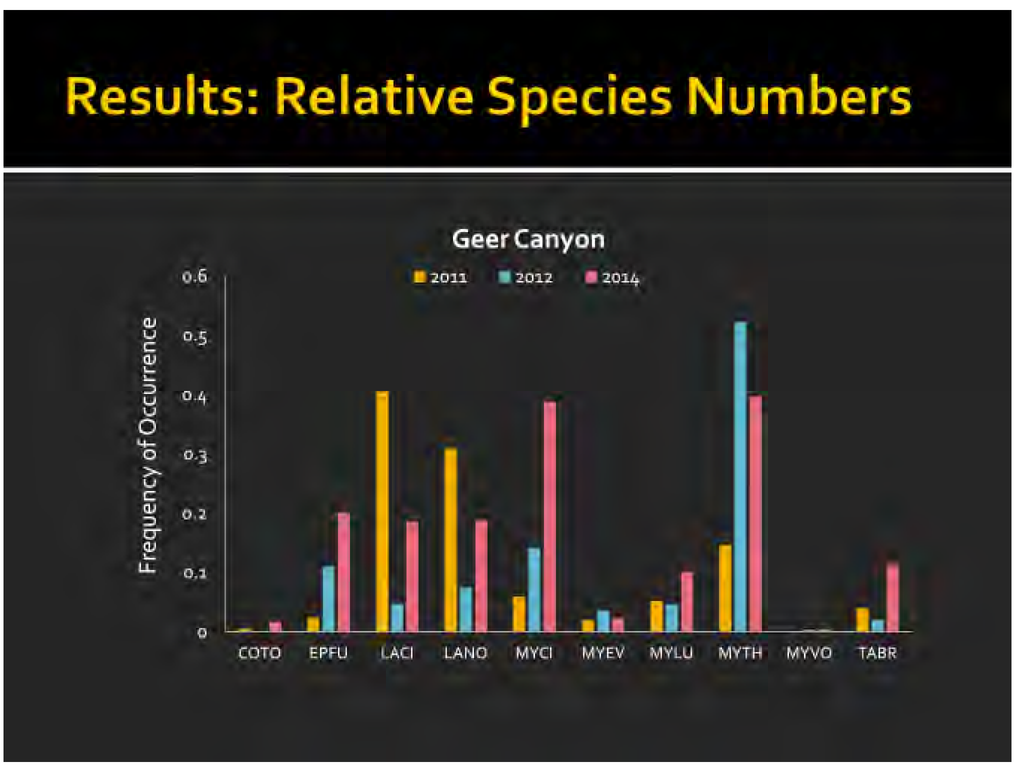


Figure 8. Relative changes in species numbers across years in Plumely (top) and Geer (bottom) canyons.

Hall II: We mist netted at eight water source sites in 2014 (Fig. 9) and captured 48 bats (Table 2). Water availability was high in 2014 resulting in a wider distribution of drinking sources and likely a lower capture rate at water sources netted.

Figure 9. Locations of the eight water source locations trapped in 2014. Please see Table 1 for complete data.

Table 2. Netting sites and captured at Hall II property

Site	Species (Number Captured)
Pool 1	MYLU (36), MYCI (1)
Pool 2	MYCI (1), MYLU (1), EPFU (3), LACI (1)
Retention Pond	LACI (1)

Site	Species (Number Captured)
West Canyon-Lower Pool	MYCI (1), MYEV (1), EPFU (2)
West Canyon-Middle-Site 1	MYEV (1)
West Canyon-Middle-Site 2	No captures

EM3 recording in the west canyon near netting sites gave rise to 100 sonar call recordings of which 51 were discernable to six species. Of these 16 were *M. ciliolabrum*, 15 were *L. cinereus*, 13 were *M. lucifugus*, five were *E. fuscus*, one was *L. noctivagans*, and one was *Tadarida brasiliensis* (Fig. 10).

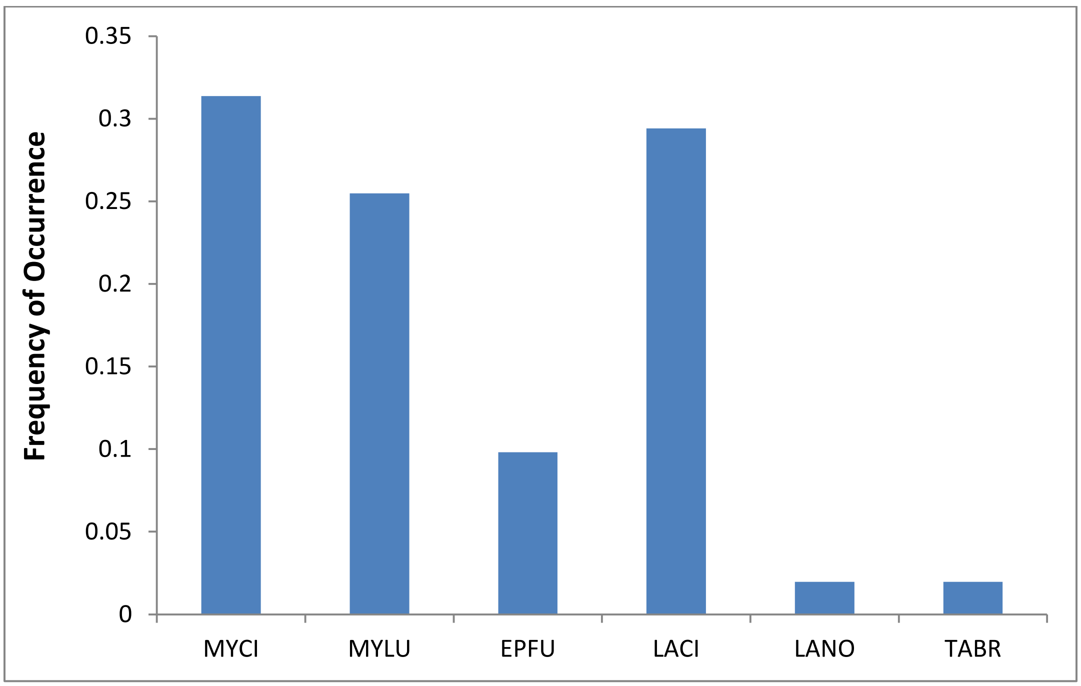


Figure 10. Frequency of occurrence in west canyon at Hall II by species.

EM3 recordings at the Pool 2 site at the base of the main gravel pit cliff area on 9 and 10 July resulted in 198 call sequences of which 104 were analyzable to species. Of these 64 calls were *L.*

cinereus, 34 were *M. lucifugus*, three were *E. fuscus*, two were *M. ciliolabrum*, and 1 was *T. brasiliensis* (Fig. 11).

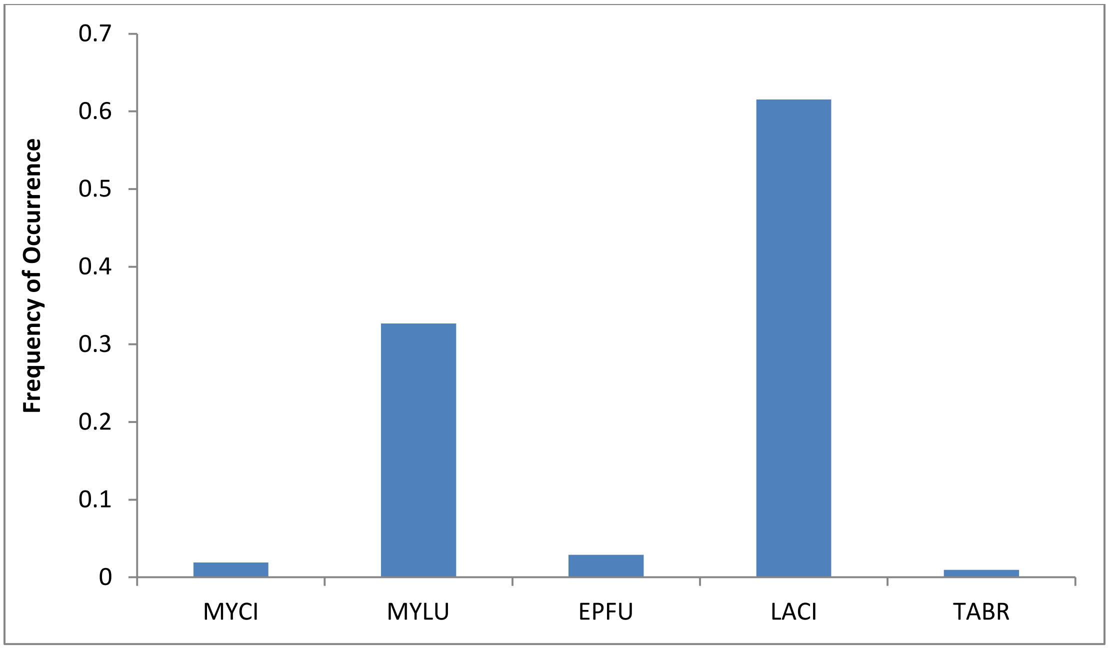


Figure 11. Frequency of occurrence of five species detected at Pool 2 (see Fig. 8) on 9 and 10 July.

We also sampled outside a mine adit located along the western border of Hall II (see Fig. 12 below) that was suspected to house a colony of Townsend's big-eared bats *(Corynorhinus townsendii*) on the night of July 31, 2014 and recorded seven passes from *E. fuscus*, seven from *L. cinereus*, one from *M. cilolabrum*, one from *M. thysanodes*, and one from *T. brasiliensis*. No bats exited the adit on this night.

We sampled 22 sites with SM2 sonar recorders. Seven sites were in cottonwood riparian habitat, six were in open montane meadow, and eight were in forested habitat. GPS reading were gathered to record exact placement of SM2s within each sampling square (Table 2). Figure 11 shows a map of SM2 placements across the landscape.

Table 3. SM2+BAT sonar detector information for placement of 22 sites at Hall II property

Detector	UTM N	UTM W	Elevation	Accuracy	Habitat
3	40.11.828	105.17.458	5747	19.7	Montane Meadow
3.1	40.11.725	105.17.329	6119	21	Ponderosa Pine Forest
3.2	40.11.692	105.17.328	6171	18.3	Ponderosa Pine Forest
3.3	40.11.454	105.18.004	5963	21	Montane Meadow
3.4	40.11.360	105.18.194	6053	19.1	Ponderosa Pine Forest/Juniper drainage
3.5	40.11.504	105.18.451	5859	16	Montane Meadow
4	40.11.792	105.17.887	5821	16.6	Montane Meadow (SM2 failed)
4	40.11.792	105.17.887	5821	16.6	Montane Meadow
4.1	40.11.653	105.17.979	5877	16.5	Montane Meadow
4.2	40.11.475	105.17.931	5929	27	Cottonwood Riparian
4.3	40.11.462	105.18.349	5964	19.9	Cottonwood Riparian
4.4	40.11.497	105.18.595	6040	20.6	Ponderosa Pine Forest
5	40.12.228	105.17.632	5487	16.1	Cottonwood Riparian
5.1	40.12.092	105.17.714	5536	20	Cottonwood Riparian
5.2	40.12.033	105.18.112	5328	16.6	Cottonwood Riparian
5.3	40.11.893	105.18.274	5583	18.6	Cottonwood Riparian
5.4	40.11.724	105.18.333	5737	14.9	Montane Meadow
6	40.12.002	105.17.415	5606	17	Cottonwood Riparian
6.1	40.11.692	105.17.513	5991	28	Ponderosa Pine Forest
6.2	40.11.713	105.17.543	5831	17.1	Ponderosa Pine Forest with Aspen Stand
6.3	40.11.390	105.17.954	5978	21	Ponderosa Pine Forest
6.4	40.11.371	105.18.308	6053	15.9	Montane Meadow
6.5	40.11.701	105.18.602	6133	23.8	Ponderosa Pine Forest

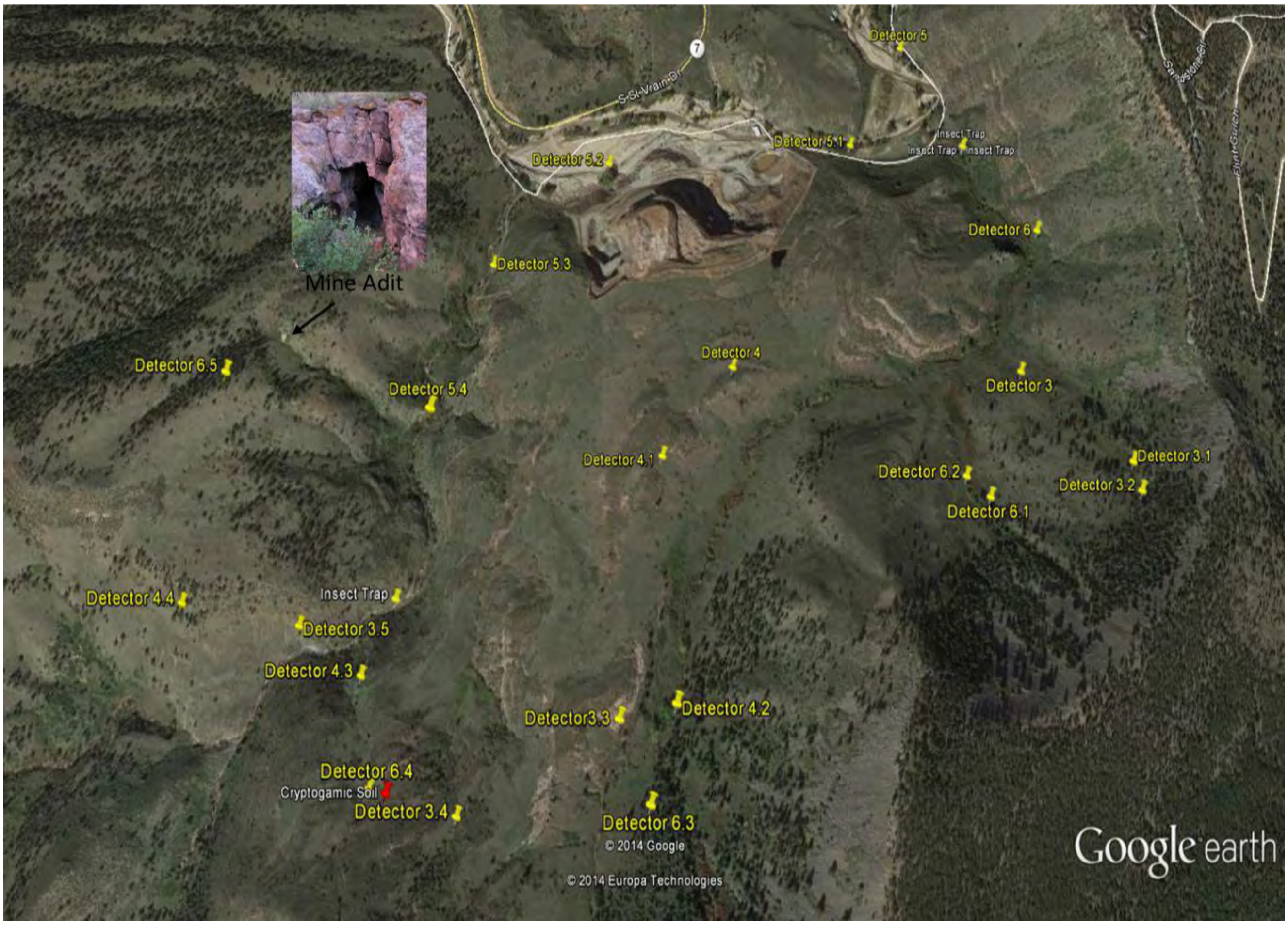


Figure 12. Hall II property landscape illustrating placement of SM2+BAT sonar detector in 2014.

A total of 33,191 sonar call sequences were recorded among the 22 SM2BAT+ placements (110 detector nights) on Hall II with 3,853 of these of a quality to be analyzed to species. The distribution of bat species across the landscape varied by habitat with the highest species richness during foraging was found in the central meadow areas (Fig. 13). Samplings from insect traps are still underway at this point.

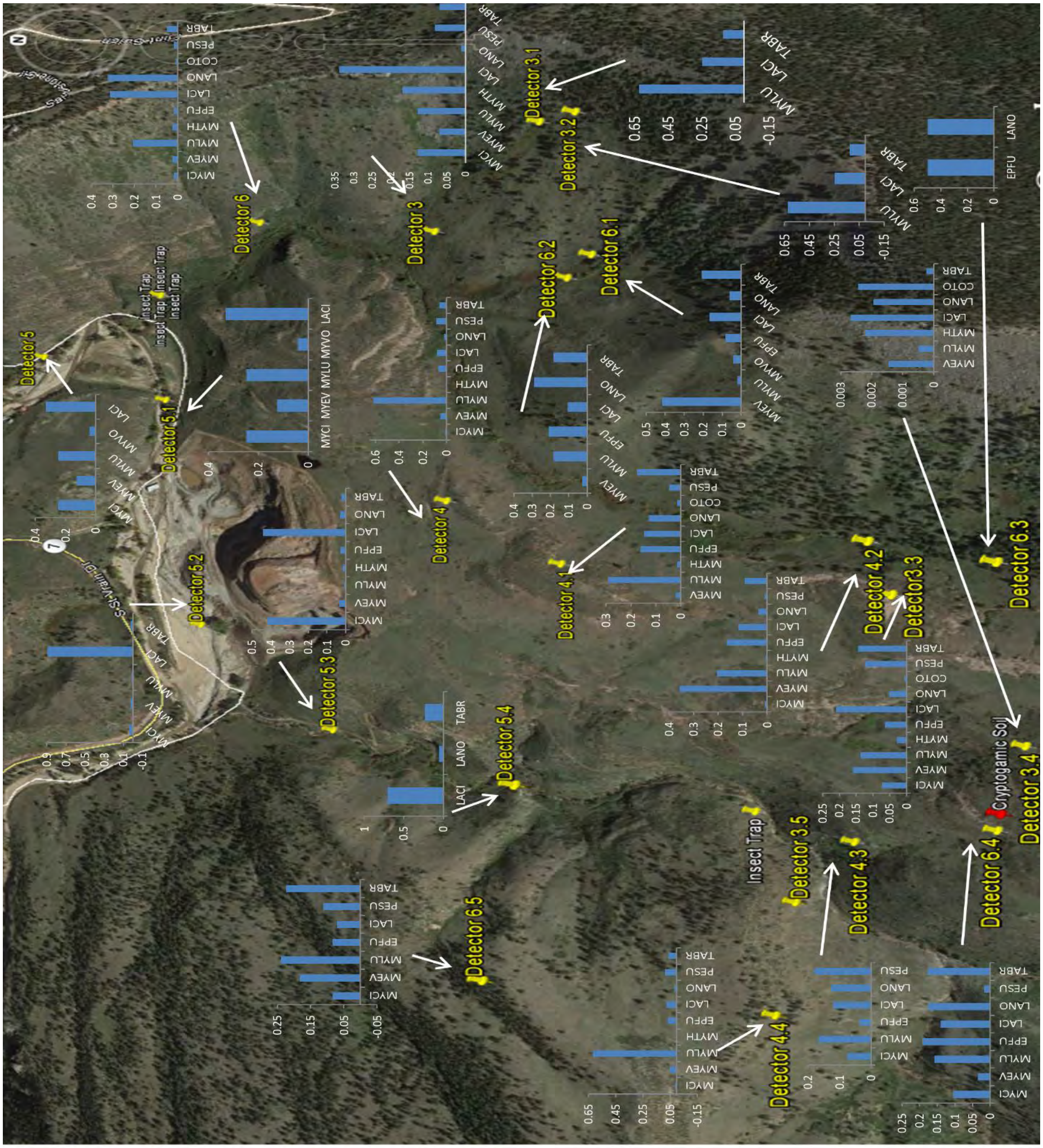


Figure 13. Distribution of bat species abundance based upon sonar recordings from 22 plots at Hall II.

Radio-Telemetry: We radio-tagged two lactating females in 2014. One was a Townsend's big-eared bat (*Corynorhinus townsendii*) for which a radio signal was never reacquired during an exhaustive search. We also tagged a female little brown bat (*Myotis lucifugus*) at Hall II property at the Pool 2 site. We did find the maternity colony of this individual located in a roadside rock face on St. Vrain Road west of Hall II (Fig. 14). The colony appeared to house a few hundred individuals. Radio tracking and sonar recording from detectors indicate the pathway by which this colony arrives on Hall II property and arrives at the Pool 2 drinking site. In addition, the main foraging area for this colony is in open meadow just south of the gravel pit area where we captured the female (Fig. 11). Together the three detectors placed in the demarcated foraging area recorded 541 little brown bat sonar calls. No other detectors recorded more than 22 calls from *M. lucifugus*.

Figure 14. Locations of little brown bat (*M. lucifugus*) maternity roost (pinpoint circled in red), the pathway by which the little brown bat colony moves from its roost onto Hall 2 property (yellow line) drinking and foraging heavily around Pool 1, and two main areas of the colony (thatched area). Yellow line indicates known path throughout radio-telemetry taken at the roost site and from Pool 1, blue overlay indicates suspected route, but bat was out of range of telemetry receiver.

New Species Presence

Mexican free-tailed bats (*Tadarida brasiliensis*): For the first time ever we recorded distinctive audible communication calls of Mexican free-tailed bats (TABR) in Boulder County (Fig. 15). These calls were recorded at Hall II property in the west canyon and in Plumely Canyon on Heil Valley Ranch. Although TABR calls have been recorded over the years in the Boulder area, verification of their accuracy was unclear because *L. noctivagans* calls are commonly misconstrued as TABR calls by SonoBat. However, the recording of communication calls give high-probability that this species occurs in some numbers in the area. The nearest known colony of this species is located in the San Luis Valley in south-central Colorado.

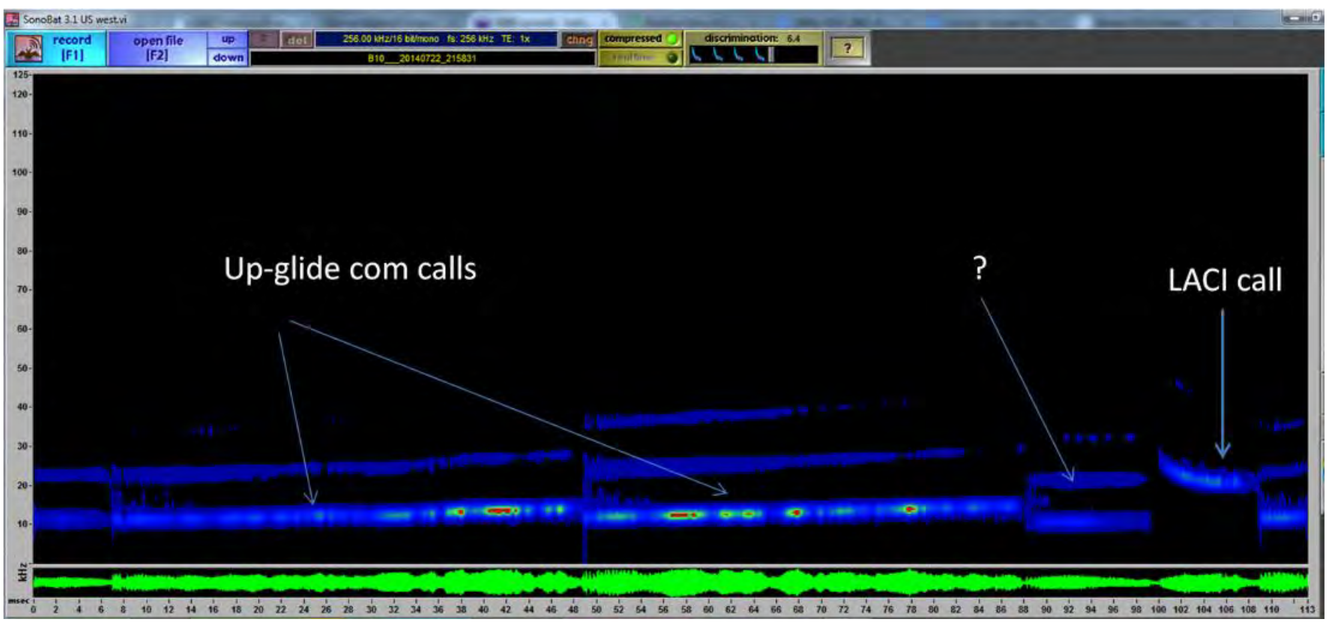


Figure 15. Suspected long-duration communication calls of the Mexican free-tailed bat recorded in West Canyon, Hall II property 2014. LACI refers to call from a hoary bat (*Lasiurus cinereus*). ? refers to unknown sonar calls, but probably from a Mexican free-tailed bat.

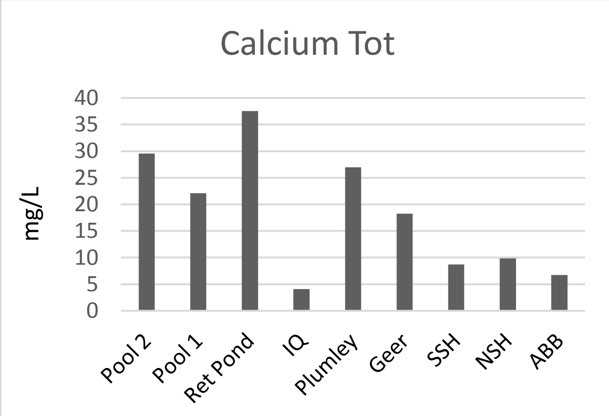
We continue to record sonar call sequences that contain multiple calls with associated high-probability (95%-100%) of emission from tricolor bats (*Perimyotis subflavus*) (previously known as the eastern pipistrelle, *Pipistrellus subflavus*). We continue to try and capture some individuals and find their roost site(s).

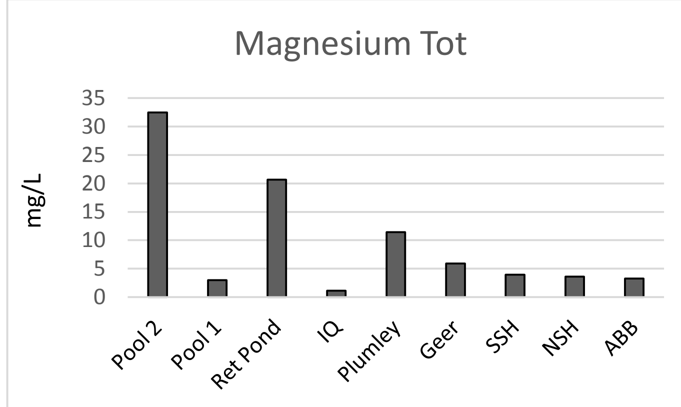
Water Quality Testing

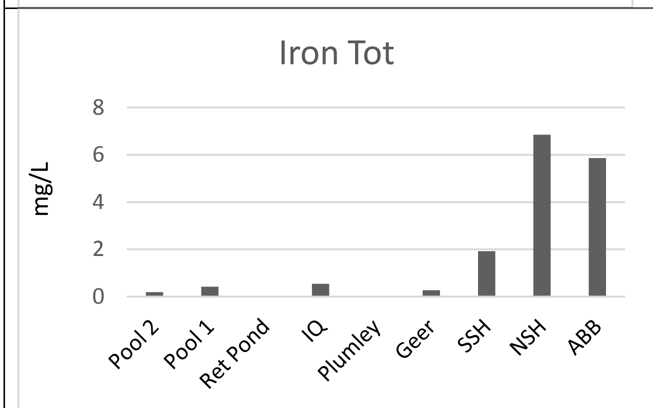
We sampled nine sites for 18 water quality variables in Boulder County. Three sites were located at Hall II, three sites at Heil Valley Ranch and three sites on Shanahan Ridge located on City of Boulder OSMP property for comparison (Table 4). Figure 16 shows distributions of elements across each water source.

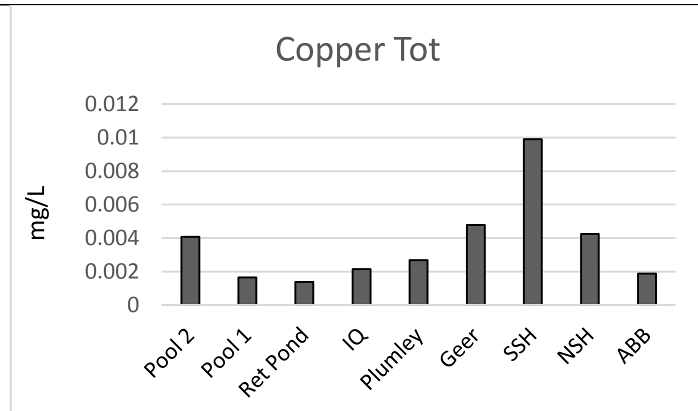
Table 4. Quantity in milligrams per liter for nine water sources that bats use for drinking in Boulder County. From left to right, the first six of the sites are on property managed by Boulder County Parks and Open Space, whereas the last three sites are managed by the City of Boulder Open Space and Mountain Parks.

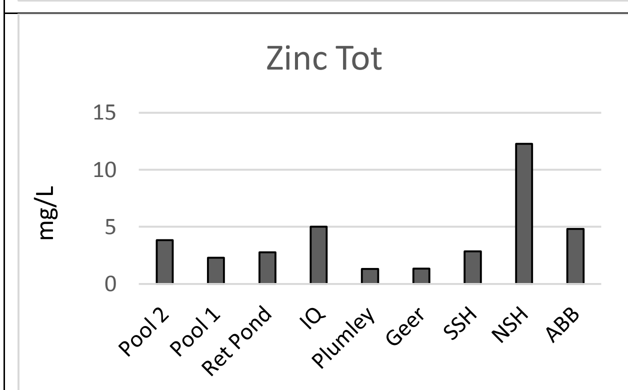
	Pool 2	Pool 1	Ret Pond	IQ	Plumley	Geer	SSH	NSH	ABB
Alkalinity, Total as Ca	187.50000	68.00000	167.50000	13.50000	137.00000	86.50000	54.00000	48.50000	42.50000
Aluminum Tot	0.06700	0.01459	0.03716	0.06293	0.00390	0.00456	0.21870	5.15700	2.74800
Arsenic Tot	0.00030	0.00012	0.00020	0.00012	0.00053	0.00079	0.00518	0.00462	0.00465
Cadmium	0.00006	0.00002	0.00001	0.00011	0.00014	0.00005	0.00026	0.00005	0.00005
Calcium Tot	29.53000	22.08000	37.53000	4.08800	26.97000	18.25000	8.71000	9.87000	6.70900
Carbon Dis Organic	11.69100	3.19250	5.07890	21.91010	7.01610	4.06890	27.79480	15.17270	17.57550
Carbon Total Organic	12.03400	3.28750	5.42700	23.51550	6.92910	4.13340	28.59690	17.17710	18.25670
Chloride Dis IC	12.17400	0.82270	0.00240	0.58940	2.43620	1.38010	3.55430	2.46720	1.79650
Copper Tot	0.00407	0.00165	0.00138	0.00214	0.00269	0.00478	0.00990	0.00424	0.00189
Fluoride Dis IC	0.60780	0.27520	0.51010	0.16090	0.05860	0.44370	0.35990	0.46920	0.27710
Iron Tot	0.18560	0.41510	0.00176	0.53780	0.00199	0.26650	1.91600	6.85600	5.86700
Lead Tot	0.00192	0.00038	0.00030	0.00011	0.00020	0.00014	0.00074	0.00955	0.00351
Magnesium Tot	32.47000	2.98700	20.68000	1.13200	11.42000	5.94200	3.97400	3.60600	3.28100
Manganese Tot	0.19670	0.49770	0.05856	0.00119	0.00228	0.00358	0.00267	0.16910	0.00175
Nitrogen Nitrate Dis IC	0.02350	0.00550	0.03110	0.01540	0.01270	0.00890	0.00770	0.04500	0.03580
Selenium Tot	0.00442	0.00026	0.00367	0.00026	0.00026	0.00026	0.00026	0.00030	0.00026
Sulfate Dis IC	26.02760	3.35540	27.29570	1.15400	4.95320	8.45110	8.42500	10.47250	7.22880
Zinc Tot	0.00384	0.00229	0.00278	0.00501	0.00132	0.00133	0.00284	0.00123	0.00482

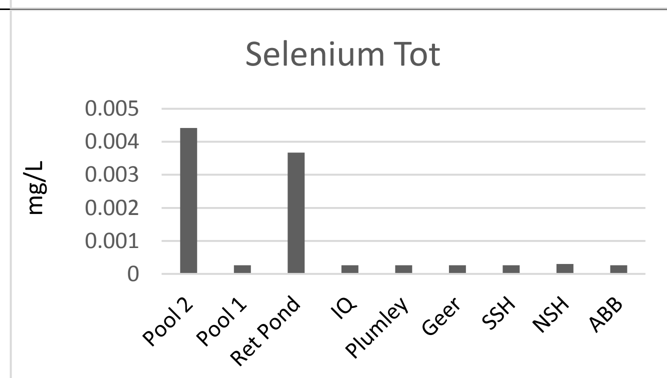

Calcium Tot
mg/L
0
5
10
15
20
25
30
35
40
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB


Magnesium Tot
mg/L
0
5
10
15
20
25
30
35
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB


Iron Tot
mg/L
0
2
4
6
8
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB


Copper Tot
mg/L
0
0.002
0.004
0.006
0.008
0.01
0.012
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB


Zinc Tot
mg/L
0
5
10
15
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB


Selenium Tot
mg/L
0
0.001
0.002
0.003
0.004
0.005
Pool 2
Pool 1
Ret Pond
IQ
Plumley
Geer
SSH
NSH
ABB

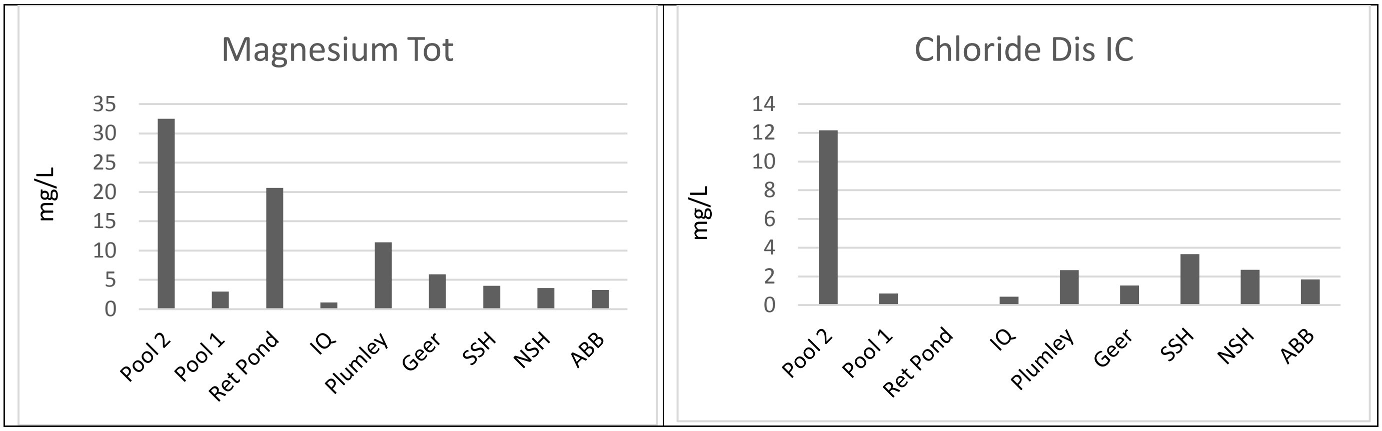
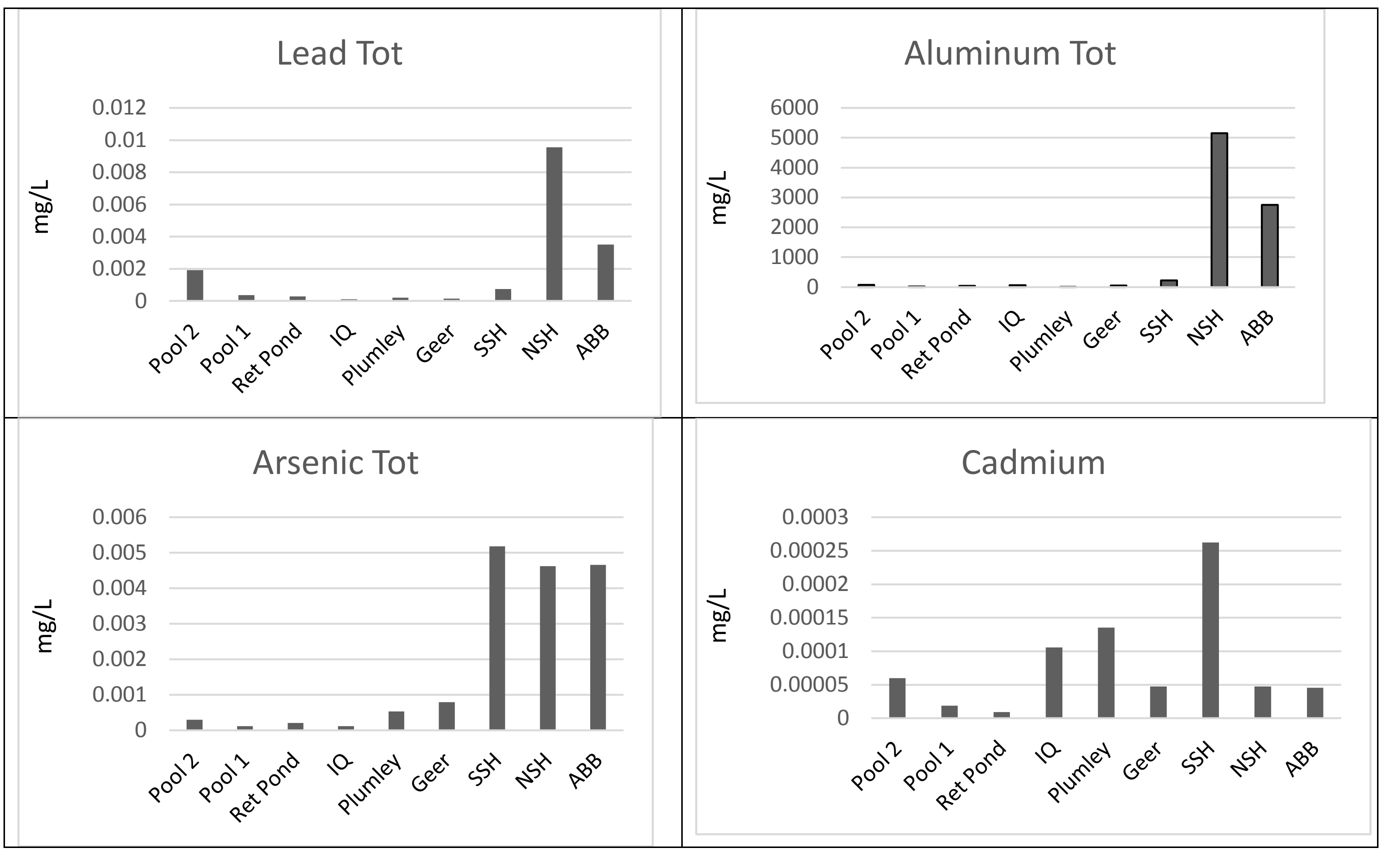


Figure 16. Elements required for proper metabolic function in mammals and their availability in drinking sites used by bats. Pool 1, Pool 2, and Retention Pond are sites at Hall II, Plumely and Geer canyons at Heil Valley Ranch and SSH, NSH and ABB are on Shanahan Ridge on OSMP property.



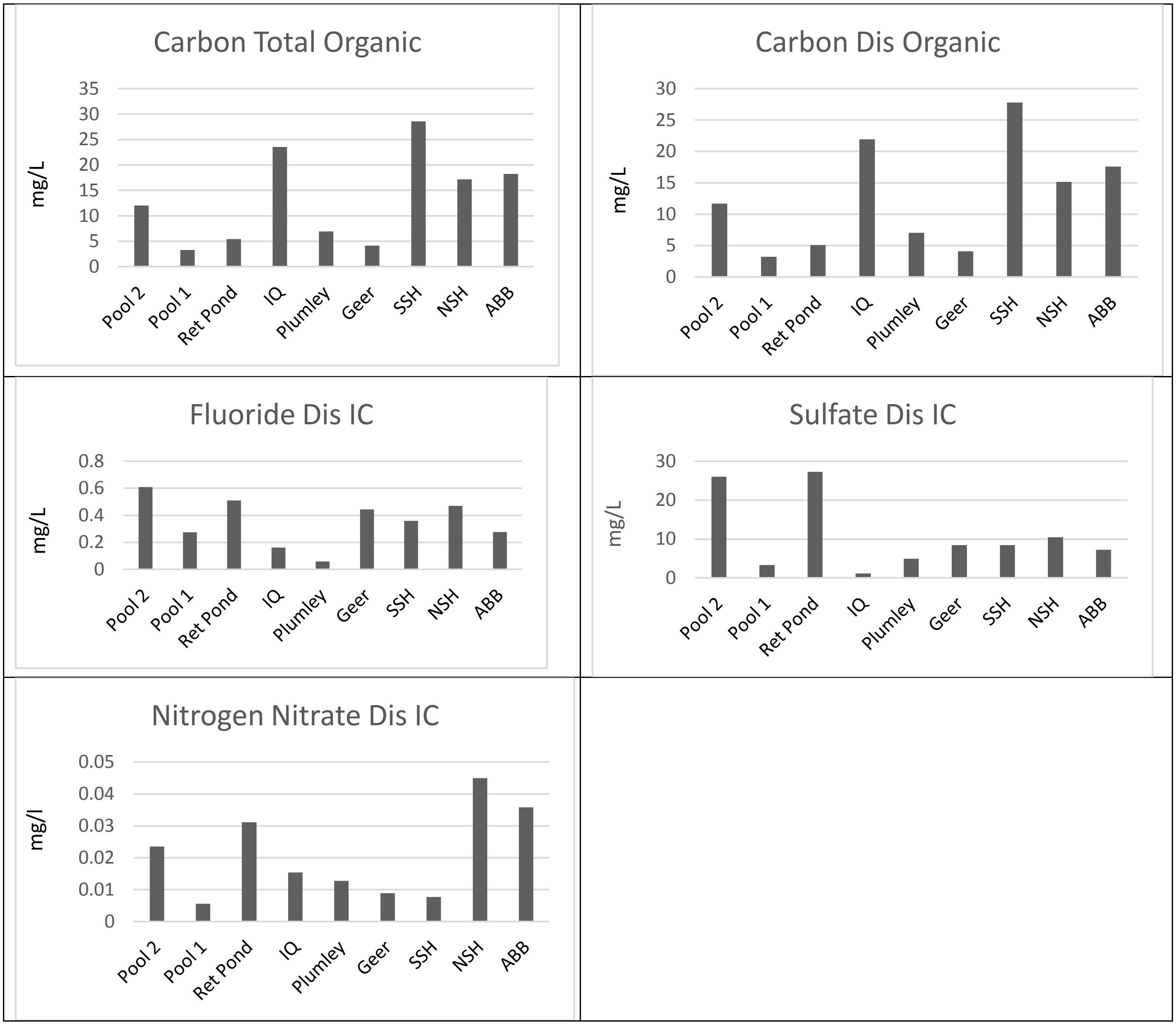


Figure 17. Distribution of elements potentially harmful to bats and other wildlife drinking at surveyed water sites.

Table 5. Drinking water contaminants, levels considered dangerous to humans, and long-term exposure effects (source EPA website). MCLG = maximum contamination level goal, maximum contamination level.

Contaminant	**MCLG mg/L**	**MCL**	**Health effects from long-term exposure above MCL, unless specified at short-term**	**Sources of contamination in drinking water**
Arsenic	0	0.010	Skin damage or problems with circulatory system, increased risk of cancer	Erosion of natural deposits, runoff from orchards and glass and electronic production wastes
Cadmium	0.005	0.005	Kidney damage	Erosion of natural deposits
Copper	1.3	1.3	Short-term exposure: gastrointestinal distress; Long-term exposure: liver or kidney damage	Erosion of natural deposits, household plumbing systems
Fluoride	4.0	4.0	Bone disease	Discharge from steel/metal factories, plastic and fertilizer factories
Lead	0	0.015	Infants and children: delays in physical or mental development, deficits in attention span and leaning abilities. Adults: kidney problems, high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Nitrate measured as nitrogen	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines

Calcium: The distribution of calcium is important to bats because female bats cannot attain enough from their diet to replace losses due to lactation. Calcium levels were highest at the water sources on Hall II property. Highest number of bat activity was at Pool 1 where a maternity colony with juveniles from a nursery roost visited in mass to drink (see Fig. 15). Although Pool 1 which the lowest dissolved calcium from the tree sites tested in the gravel pit, it also had the least amounts of potentially harmful chemical compound loads. Pool 2 had the highest dissolved calcium, but was used predominately by large-bodied bat species, *E. fuscus* and *L. cinereus* likely because it was a much larger pool that allowed for bats of this size to drink on the wing. Curiously, the *L. cinereus* that we captured at this site was a lactating female. Capturing a lactating female of this species is very rare as most female *L. cinereus* migrate farther north giving birth and raising their young in northern areas such as Montana. Other useful elements presented in Table 4 are distributed throughout different water sources that bats may visit to attain different minerals.

Potentially Harmful Elements: Of the harmful elements tested (Table 4), none appear to be at concentrations that would be harmful to bats, based upon human effects if ingested above stated amounts (Table 5). However, insects such as caddisflies, a common food for insectivorous bats in Boulder County, bioaccumulated highly significant levels of elements such as cadmium after being exposed at concentrations of 0.003 mg/L over 28 days and mayflies suffered high mortality under similar exposure (Spehar et al. 1970). Because bats consume high numbers of insects each night, bioaccumulation in insects as well as high mortality in insects may have significant effects on survivorship, especially among juvenile bats.

Overland Burn 2014

Sonar data gathered from the Overland Burn site at Heil Valley Ranch showed that most of the activity was in the Meadow site, followed by Burn 1, Forest and Burn 2. This pattern matches the two previous years, although in 2014, the Forest site had more activity than in previous years. The Meadow and Burn 2 sites had the highest species richness with nine species each, followed by Burn 1 and Forest sites. Highest and Species Richness was in the Meadow habitat (Fig. 18). The pattern of bat activity among test sites across years was similar (Fig. 19).

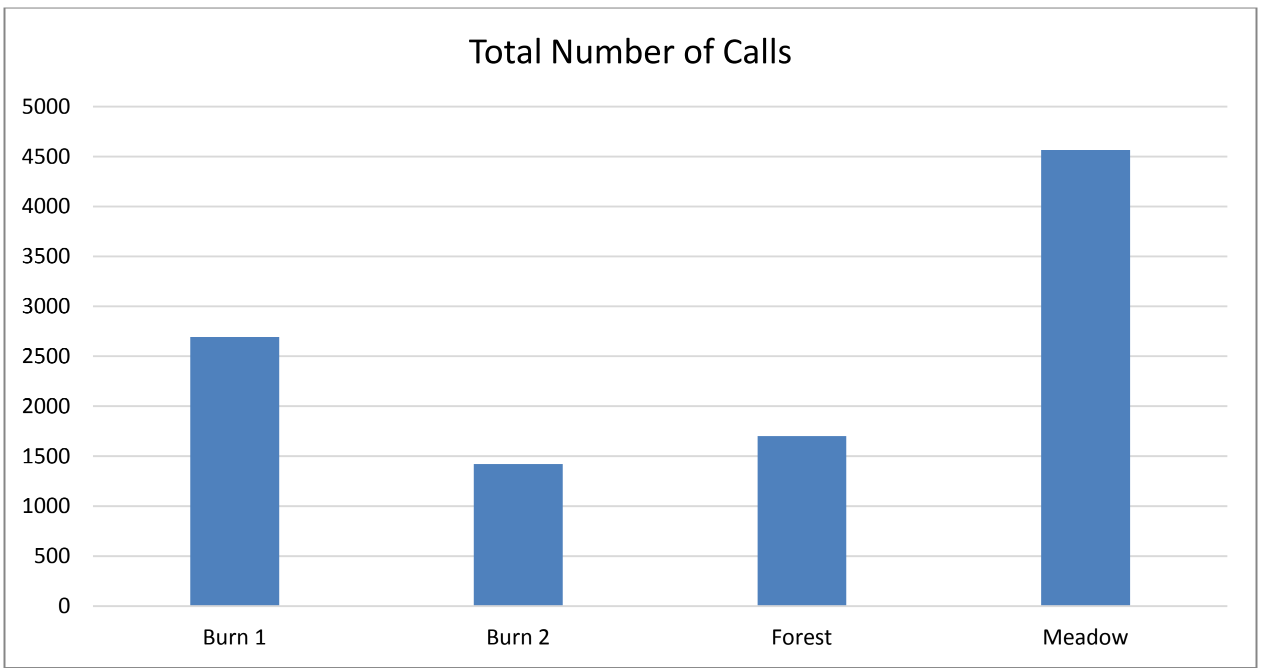


Figure 18. Total numbers of bat sonar calls recorded per site in the Overland Burn area in 2014.

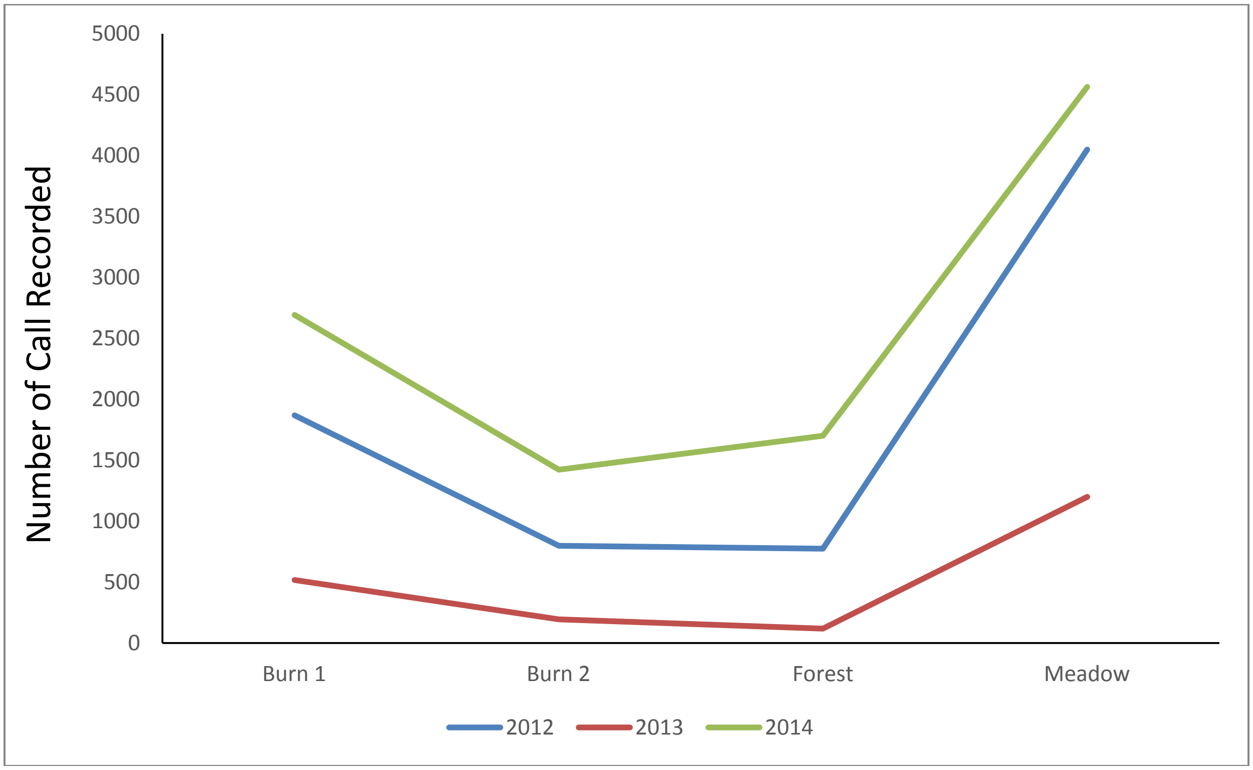


Figure 19. Total number of calls recorded in the Overland Burn sites in 2012, 2013, 2014. All three years show similar distribution patterns of bat activity across sites.

The distribution of species across plots differed. *Myotis ciliolabrum*, *M. lucifugus*, and *M. thysanodes* foraged mostly in Meadow habitat, whereas *M. evotis* preferred the forest. *Eptesicus fuscus*, *L. cinereus*, and *L. noctivagans* foraged mostly in the Burn sites, but were more abundant in Burn 1, whereas *Tadaria brasiliensis* preferred Burn 2 (Fig. 20).

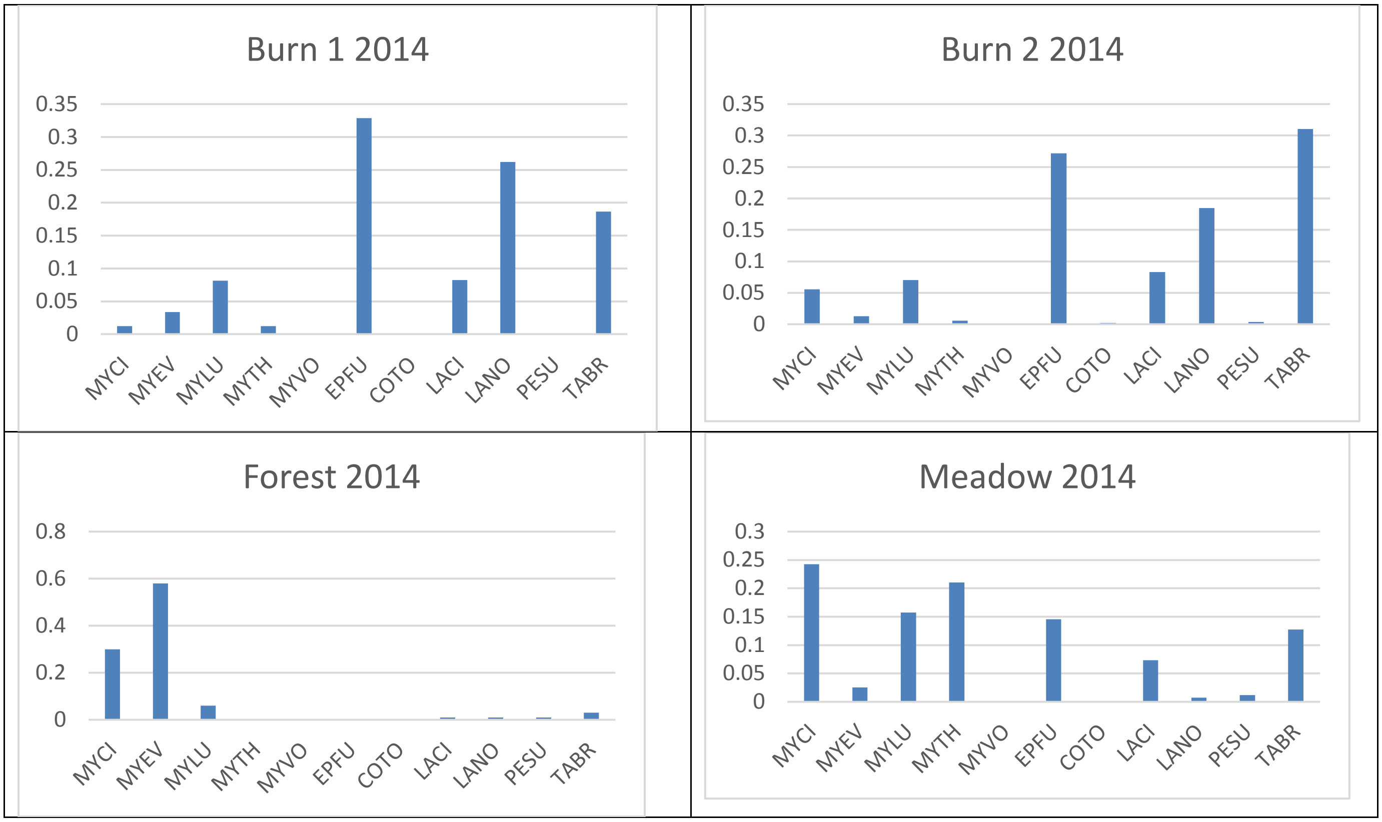


Figure 20. Frequency distribution of bat species across the four plots in the Overland Burn at Heil Valley Ranch in 2014.

Thinned Site near Ingersol Quarry and *Myotis evotis*

In 2013 after the forest stand was thinned, the frequency of occurrence of long-eared myotis (*Myotis evotis*) dropped precipitously. In 2012, *M. evotis* composed about 64% of all sonar calls recorded, whereas after thinning in 2013, *M. evotis* occurrence dropped to 21.9% and in 2014 was 22.6%. This a drop off in use of about 64% (Fig. 20). Before thinning little brown bats (*M. lucifugus*) composed 19.5% of all sonar calls recorded and this increased to 43.9% and 45.1% in 2013 and 2014 respectively.

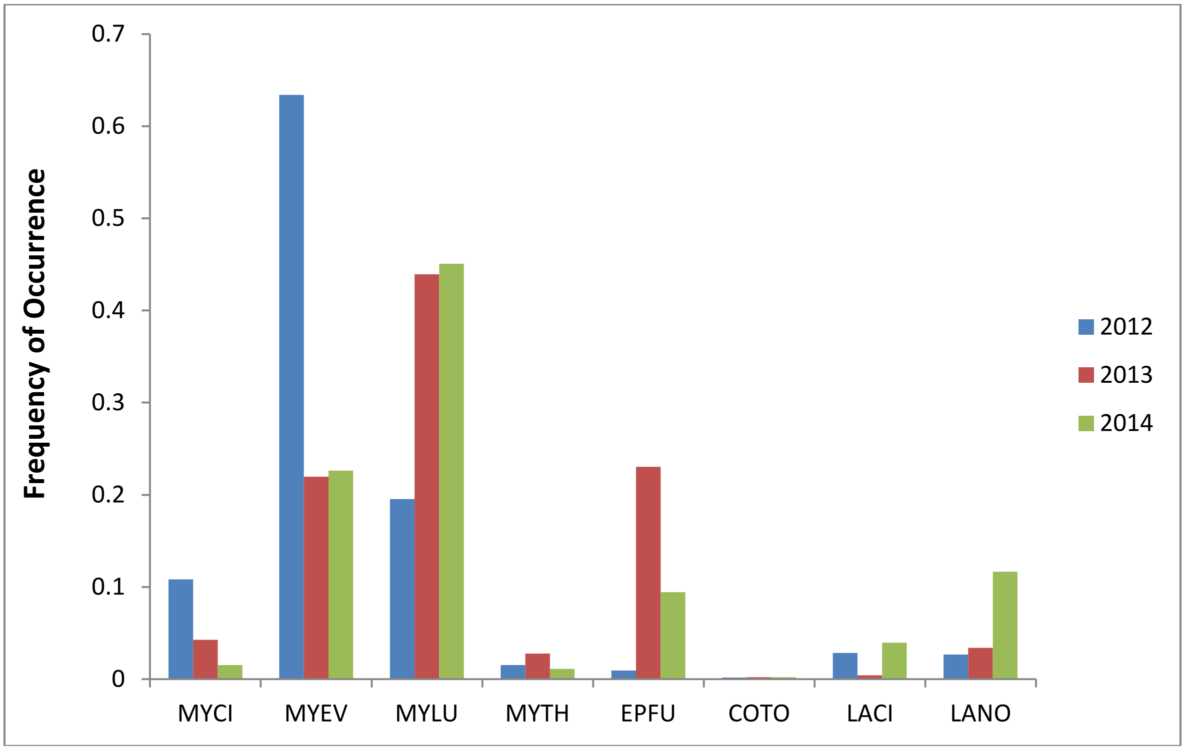


Figure 21. Distribution of bat species using a ponderosa pine stand before thinning (2012) and after thinning 2013 and 2014.

Molecular Analysis of Guano

We are currently designing a new technique that will give unprecedented information on species-specific foraging and diet. MS student Kelsey Gonzales is working with Dr. Seth Frietze (UNC faculty) to develop this technique. The analysis will take several months. I will file an addendum to this report when completed.

Conclusions

All four of my hypotheses were supported. Bats showed a increase in activity based upon sonar call recording in both canyons. Plumely Canyon, a normally dry canyon, showed a significant increase in activity. Geer Canyon also showed a large increase in activity, but the change was not significant due to high variation in nightly activity patterns. In both canyons, activity by MYCI and MYLU doubled or tripled. Species Evenness increased in Geer Canyon in 2014, but was highly variable over the years in Plumely Canyon, including in 2014. Assemblage structure shifted with increases in some species and decreases in others. Thus changes in water availability appear to have significantly positive effects on bat activity. Because the West is cited to become hotter and drier with increases in the frequency of severe droughts, providing water for bats near roost sites may be a way to mitigate some of the effects of climate disruption on local and regional bat populations. Future study will look for further changes and stabilization around a new normal.

Future Research Considerations

- Replicate sonar analysis at Hall II as 2014 was a wetter/cooler years than normal. This may be why so many hoary bats remained in the area rather than migrating further north. Because hoary bats are known to eat other bat species, their presence in high abundance can have a significant effect on other bat species.
- Continue to net in Plumely Canyon and Hall II in attempt to capture a Mexican free-tailed bat (*Tadarida brasiliensis*), radio tag an individuals and find the roost site.
- Continue to net at Hall II in effort to capture and find the roost site of the tricolored bat, *Perimyotis subflavus* (previously known as eastern pipistrelle, *Pipistrellus subflavus*)
- Continue to monitor Plumely and Geer canyons for bat activity in relation to the 2013 flood event to quantify how these two canyons stabilize over the next 5 years.

- Continue to monitor anthropogenic changes to forest structure and associated changes in bat activity and abundance.
- Continue to monitor the mine adit at Hall II for use by Townsend's big-eared bat (*Corynorhinus townsendii*).
- Expand survey efforts into Hall property that provides unique habitats for bats and may give rise to previously undiscovered populations of bat species along the Front Range.
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