Effects of Weather and Elevation on Relative Summer Abundance and Activity of Bats in the Frank Church River of No Return Wilderness

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Abstract: Bats are considered to be strong indicators of overall environmental conditions because of their size, mobility, and comparatively long lifespan (Fenton, 1997). Seasonal changes in activity are important to understand for conservation and management purposes. However, few studies address this issue in wilderness areas. In the summer of 2005, I examined patterns of bat activity in relation to elevation and weather conditions in a total of four caves and abandoned mines plus eight foraging sites in the Frank Church River of No Return Wilderness in Central Idaho. To estimate relative seasonal activity and abundance, I conducted emergence surveys at cave and mine entrances, and performed acoustic surveys at feeding sites every 14 to 18 days for a total of 2 months during the warm season. I measured weather conditions using a hand-held weather station every 30 minutes throughout the survey. I identified species using the Anabat II echolocation device and its corresponding software, and I mist-netted at 2 caves to check for maternity colonies. Bat activity, estimated roost sizes, and species composition significantly differed between high and low elevation sites. There were also significant positive correlations with barometric pressure, which may influence some of these altitudinal differences. Because there is very little data collected on bats in wilderness areas, any new data is useful for better

understanding their relationship with this type of ecosystem, and will contribute to bat conservation.

Bats are a critical part of the natural ecosystem. They help to maintain balance and increase diversity. For instance, the bats that inhabit The Frank Church River of No Return Wilderness area are insectivorous and greatly influence insect populations. One little brown bat (*Myotis lucifugus*) can consume over 1,200 mosquito-sized insects in one hour (Tuttle, 1998). Guano is also a natural fertilizer for a diversity of plant species, and supports numerous microorganisms, which in turn also benefit fish and crustaceans (Steele, 1989). Because bats play such a critical role in the ecosystem, it is important to learn more about the thermal aspects of bat ecology since it is so vital to their existence. More data collection can help managers to better understand bat ecology and behavior and to then to stem the population declines occurring for many bat species.

Of the many factors that influence bat activity, local weather conditions, such as temperature, humidity, wind speed, and barometric pressure are all important factors that influence bat activity during summer the months. Bats are small mammals and have a large surface to volume ratio, which makes it easy for environmental conditions to effect thermoregulation. If temperature is too cold or hot, bats are forced to use extra energy, which is already limited, to maintain internal body conditions (Fenton, 1997). The presence of high winds greatly limits a bat's ability to fly and makes capturing prey more energy expensive. Humidity also impacts evaporative water loss. When the air is dry, larger quantities of water evaporate from the skin, which can create dehydration. When humidity is high, evaporative water loss is minimal. Barometric pressure tracking in bats contributes to levels of oxygen intake and helps conserve energy. Bats are believed to use barometric pressure to predict insect abundance without ever leaving the roost (Paige, 1995). These thermal properties are still not completely understood and need more research and data collection.

There have been two different studies performed along the Big Creek Drainage since the year 2002. Katie Gillies was an undergraduate student from the University of Idaho, and was the first to do a study of bats in the Taylor Ranch vicinity. Her study consisted of locating 8 mines and caves that were occupied by bats in burned and non burned habitats, comparing the frequency of use, and identifying the species that roost within (Gillies, 2002). In September of 2003 Richard Sherwin from the University of New Mexico examined bat presence/ absence prior to mine closures (Sherwin, 2003). Both of these studies were important in identifying new roosting sites.

Learning more about the relative seasonal activity of bats is helpful in creating better strategies for the conservation of bats. Bats often change roosts seasonally; however this varies among species. Some bats such as Antrozous pallidus have low roost fidelity while others such as *Corynorhinus townsendii* are generally faithful to one site. These patterns are important to know to protect maternity and hibernacula sites, for determining mine closures, and to learn more about bat activity in the wilderness. Mines and caves are crucial for bat habitat for many reasons but the two most important are for raising their young and hibernating. Bats are very sensitive and can be easily disturbed (Tuttle, 1998). When they are disturbed, they are forced to use energy, which is already limited for a bat that is hibernating or producing milk for its young. If one maternity colony or hibernacula site is lost due to a mine closure, it could have devastating effects on population numbers. Knowing which caves are occupied and when they are in use can help managers to reduce the disturbance of important colonies.

If researchers conduct surveys for mine closures at a time when the site is not being used by bats, it could easily be mistaken as unoccupied. For example, when bats hibernate, they rarely defecate therefore it is difficult to determine how much the sites are being used in the winter. Bats also frequently form maternity colonies during summer months to care for their young. Because of the variability of day roosts, a site could be occupied at the time of closure even though it was not so when it was first surveyed (Sherwin, 2003). Not all caves and mines are safe to conduct internal surveys therefore the only way to determine occupancy is to conduct emergence surveys. Knowing when bats use the mines will help researchers to know what kind of enclosure should be used so that important bat habitat can be maintained.

In general, there is very little information about bats in wilderness areas (C. Hescock, Pers. Comm.). Because the surveyed sites were all in a wilderness area, means of transportation was limited to hiking or pack stock. This made it difficult to get to each destination. On the other hand, there was great opportunity to learn about bat activity in a pristine environment with minimal human disturbance. There were seven objectives associated this research:

Objective 1: To survey four caves or mines occupied by bats.

Objective 2: To locate 8 foraging sites for bats and measure feeding activity.

Objective 3: To determine the species composition at each roost and feeding site using the Anabat II echolocation device.

Objective4: To determine relative seasonal abundance and activity at both roosting and foraging sites.

Objective 5: To determine if there are any correlations between bat activity and weather variables.

Objective 6: To select sites that are located at 2 different elevations (2 caves or mines and 4 foraging sites per elevation) but in similar habitats and compare the types of species that are present, and frequency of use in relation to elevation, the time of year, and weather conditions.

Objective 7: To determine if any of the caves or mines includes maternity colonies.

STUDY AREA

Taylor Ranch is located within the Frank Church River of No Return wilderness area in central Idaho. This is the largest wilderness area in the lower US, encompassing 2.3 million acres of land. It is a nearly pristine environment with very little human disturbance and an ecosystem that is fully intact. The habitat types range from bunchgrass and sagebrush slopes, riparian areas, rocky outcrops, and Douglas Fir forests in lower elevations to high elevation Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), and whitebark pine (*Pinus albicaulis*) forests, meadows, and alpine lakes. There is an elevational span of 1,097 – 3,048 meters(m) and Taylor Ranch sits at 1,189 m (TRWFS, 2006) This project encompassed foraging and roosting sites at high and low altitudes within the Big Creek Drainage and Crooked Creek, an associated tributary (Figure 1).

METHODS

The methods used for conducting the external mine and cave surveys was guided by the "Protocol for external Mine Surveys for Bats" (Brown, 1998), which is a standardized procedure. First, potential caves and mines were located on a map of the Frank Church River of No Return Wilderness. I also used the knowledge of Jim and Holly Akenson and other individuals familiar with the area to pinpoint caves and mines not illustrated on the map. I selected 4 sites in total, 2 at a low elevation (average = 1,250 m) and another 2 at high elevation (average = 1,686 m). The difference in elevation was small due to restrictions caused by weather and travel.

After the initial site selection from maps, I hiked to each site and conducted external pre-surveys during the first week in June. This involved checking the entrances and recording debris, temperature, measuring the size of the opening and approximating the depth, seeing if I could detect airflow or flooding, and looking for visual signs of bat activity such as guano (Navo, 1995). I also recorded a GPS location at this time and looked for nearby water sources that were good foraging sites for bats. To determine site occupancy, I stayed the night to see if any bats emerged from the entrance and conducted preliminary emergence surveys at all potential roosting sites.

In total, I selected 4 roosting sites (2 at high altitude and two at low altitude) and 8 foraging sites (3 at high altitude with an average elevation 1,640 m, and 5 at low altitude with an average elevation of 1,242 m). All surveys were conducted from early June through the first week of August. I arrived at each site and set up one hour before dark. If there was enough moonlight, I situated myself in a way that I could best utilize the natural lights to observe the bats. Other wise, used red light to illuminate the entrance. I counted the number of bats that entered and exited the cave or mine using the Anabat II echolocation device and visual observations. I ended the survey when the bat activity stopped but always stayed at least 2 hours after dark. Temperature, wind speed, humidity, and barometric pressure were also measured every 30 minutes throughout the survey at the entrance of the cave using a Kestrel hand-held weather station. I remained quiet during all surveys to reduce disturbance.

At foraging sites, I sat by water sources to collect foraging data. I performed acoustic surveys by counting the number of fly-bys using the Anabat II echolocation device. Weather conditions were also measured every 30 minutes throughout the survey at the waters edge. I set up one hour before sunset and started the survey when I heard the first bat call. I surveyed each site for two hours after the first bat call. I repeated these procedures at both the cave or mines entrances and feeding sites 2 more times at 12 to 18 day intervals to make a total of 3 surveys at each site.

To determine the species, I recorded the calls from the Anabat II echolocation device and analyzed them later using The Anabat 6 mini-ZCA Interface Module and software system. This created a sonogram which enabled me to identify the call using the Wyoming Anabat call key written by D. Keinath. I also used the data Katie Gillies collected from her research in 2002 to help identify species. I identified and counted the number of each species.

Finally, after all the surveys were completed, I mist-netted Cave Creek cave and Dunce Creek cave to determine if either of the sites included maternity colonies. Because the entrance to cave creek cave was so big, we also set up two other nets along Big Creek and Cave Creek. Katie Gillies and Jason Beck assisted in the capture of bats and helped me to sex, age, weigh, check reproductive status, and take some standard measurements such as the length of the forearm and ear. We surveyed for a total of 3 nights during the first week of August.

After all the data was collected and compiled, I used the statistical package MINITAB 14 to calculate Pearson correlation coefficients to see if there was significant relationship between abundance and activity of bats, weather variables, and species richness. I also used the student’s t-test to see if there was a significant difference between abundance, activity, species richness, and species composition at high and low elevations.

RESULTS

Over the summer of 2005 I monitored 4 roosting and 8 foraging sites (Appendix 1). Thirteen different species were identified with acoustic and mist-net surveys (Appendix 2). The species identified with acoustic surveys include *Myotis yumanensis, Myotis californicus, Myotis ciliolabrum, Myotis lucifugus, Myotis thysanodes, Lasionycteris noctivagans, Eptesicus fuscus, Myotis volans*, *Antrozous pallidus*, *Myotis evotis*, and *Lasiurus cinereus. Euderma maculatum* was also acoustically identified but not recorded. The species identified with mist-net surveys include *Myotis ciliolabrum, Myotis lucifugus, Myotis californicus, Myotis evotis, Myotis volans,* and *Corynorhinus townsendii.* The percentage of species at each site is summarized in Figure 2. On average, the species detected most frequently with the Anabat II echolocation device was *Eptesicus fuscus* (X=43.19). The second most abundant species was *Myotis californicus* (X=26.33) (Figure 3).

Weather conditions and relative activity

On average, there was a positive association with bat activity and temperature but there was not a significant positive correlation between temperature and 1) bat activity or 2) roost size (Appendix 3). There was also a negative association with the greatest change in wind speed and 1) roost estimates and 2)activity, but the only significant correlations found were with overall roost activity ($P=0.05$), and high altitude roosting and foraging activity ($P=0.05$) (Appendix 4). In general, bat roost estimates and activity decreased as relative humidity increased; however there were no significant correlations (Appendix 3). As barometric pressure increased, so did bat roost estimates and activity. There was a significant positive correlation found with all activity ($P=.01$), all roost estimates ($P=0.02$), and all foraging activity ($P=0.03$) at both high and low elevations (Appendix 3).

Weather conditions and species composition

There were no general trends or significant correlations associated with species richness and wind speed or relative humidity (Appendix 4). As temperature increased, on average species richness also increased but there were no significant correlations found (Appendix 4). Species richness increased with barometric pressure. There were significant correlations found with 1) overall activity ($P<.01$) and 2) foraging activity ($P<.01$) at both high and low altitudes (Appendix 4).

Elevation and weather conditions

There were no significant differences in the weather at high and low altitude using a 95% confidence interval with the exception of barometric pressure ($P<.01$) (Figure 4, Appendix 5).

Elevation, bat activity, and species richness

There was significantly less activity at high altitude sites than low altitude sites ($P=0.05$) (Figure 5). The roost estimates were also significantly smaller at high elevation sites than at low elevation sites ($P=0.04$) (Figure 6). There were significantly more species present at low elevation foraging sites than high elevation ($P=0.01$) (Figure 7), but there was no altitudinal difference in species richness at roosting sites. T-test results also showed that there was significantly more Myotis yumanensis ($P=0.01$), Myotis californicus ($P=0.03$), Myotis ciliolabrum ($P<0.01$), and Myotis lucifugus ($P<.01$) activity at low elevation sites verses high elevation sites. The average proportion of species at high and low altitude sites are summarized in Appendix 4.

Weather patterns and time of year

On average the wind speed did not significantly change throughout the summer and there was no regular pattern. Over the course of the summer the average wind speed ranged from 0.73

to 0.87 mph (Figure 8). The average temperature gradually increased throughout the summer from 57^0F to 66^0F (Figure 9). The relative humidity gradually decreased from 68% at the beginning of the summer to 53% at the end (Figure 10). The average barometric pressure increased from 856 hPa to 859 hPa (Figure 11).

Relative seasonal activity and time of year

The average bat activity gradually increased from 211 passes recorded by the Anabat II echolocation device to 242 passes (Figure 12). The average roost estimates also increased from 8 bats per roost at the beginning of the summer to 27 bats per roost at the end (Figure 13).

DISCUSSION

In total, 13 species of bats were identified using acoustic and mist-net surveys along the Big Creek drainage. This is six more species that were previously identified in the study by Gillies (2002) who found a total of seven different species. The species that were not identified in this study include Myotis californicus, Myotis ciliolabrum, Myotis lucifugus, Myotis volans, Corynorhinus townsendii, and Antrozous pallidus. Because Corynorhinus townsendii is species of special concern in the state of Idaho, it would be beneficial to conduct some more surveys in the future to get a better estimate of abundance, and locate important maternity and hibernacula roosts to be protected.

Based on the data collected, barometric pressure seemed to have an impact on bat activity. As barometric pressure increased, bat activity, roost estimates, and species composition also significantly increased. Generally speaking, when the barometric pressure is high, the air is sinking, usually resulting in fair weather. When the barometric pressure is low or falling, air is rising, usually resulting in cloudy skies and precipitation (GW, 2006). So when the weather is stormy, bat activity decreases and vice versa. This result is not consistent with a study by

K.N.Paige (1995) who found a negative correlation with bat activity at roost sites and barometric pressure.

Altitude also had a significant impact on bat activity, roost estimates, and species richness. At high elevations, there was significantly less bat activity, smaller roost estimates, and less diversity in the number of species. This is consistent with various studies that have documented greater bat activity at lower elevations (Thomas 1988; Barclay 1991; Grindal et al. 1999). In general, bat activity also increased throughout the summer as temperature and barometric pressure increased.

The data did not show any significant differences in weather variables at high and low elevations with the exception of barometric pressure. This could be a result of an inadequate difference in altitude. Due to the primitive modes of travel, the lack of manpower, time constraints, and problems associated with weather, I had to select high elevation sites that were much lower than planned and had to keep my sample size small. This could explain the lack of significant correlations and altitudinal differences.

These findings include some biases that could also influence the results. First, weather conditions such as temperature and barometric pressure have also been found to have significant correlations with insect activity (Paige, 2005), which could also influence bat activity. However due to the complexity of bat predator-prey relationships and time constraints, insect sampling was not feasible for this study. Second, it was difficult to find survey sites that were located in the same habitat types, so there could be some differences related to the vegetation types at each site. Third, all of the high elevation roosting sites were mines and the low sites were natural caves. Therefore, the differences found in roost estimates could be associated with potential differences in structure not necessarily barometric pressure. Finally, all the high elevation foraging sites were located at ponds and the low sites were located on creeks. I tried to survey pooled areas located along the low elevation creeks to reduce biases but the difference in water types could also influence bat activity. In the future I would suggest conducting similar surveys that eliminate some of these biases.

ACKNOWLEDGEMENTS

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Figure 1: Site map

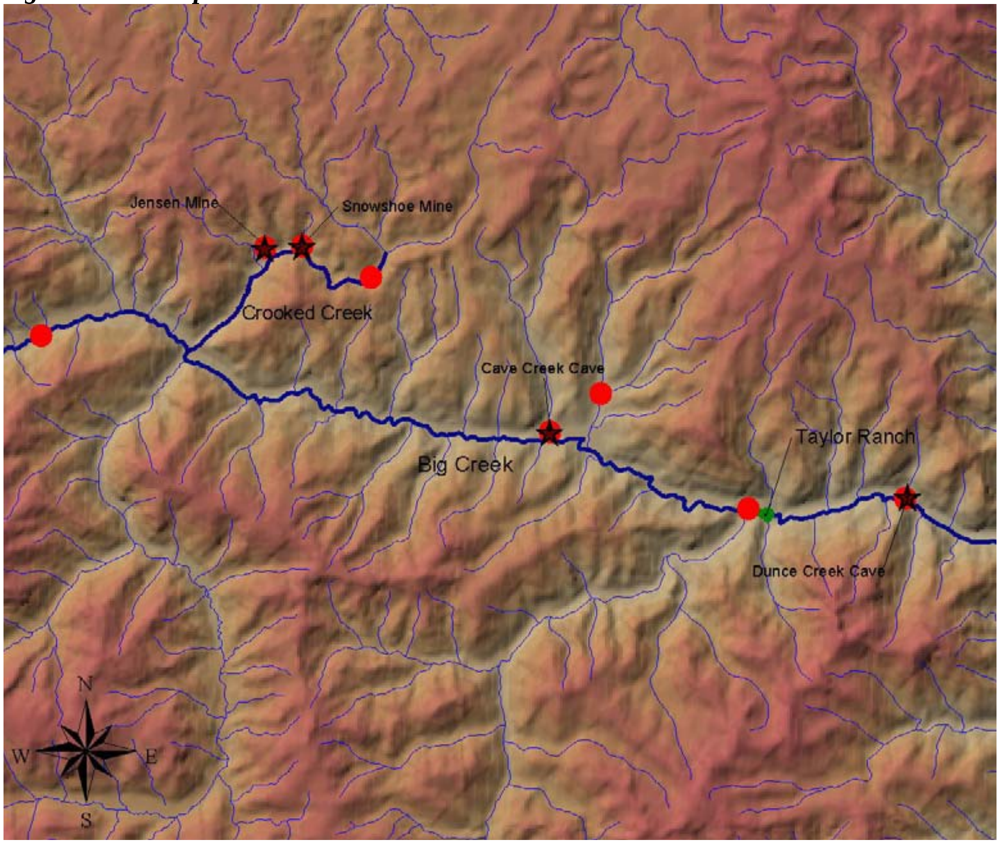


Figure 2: Species composition at each study site

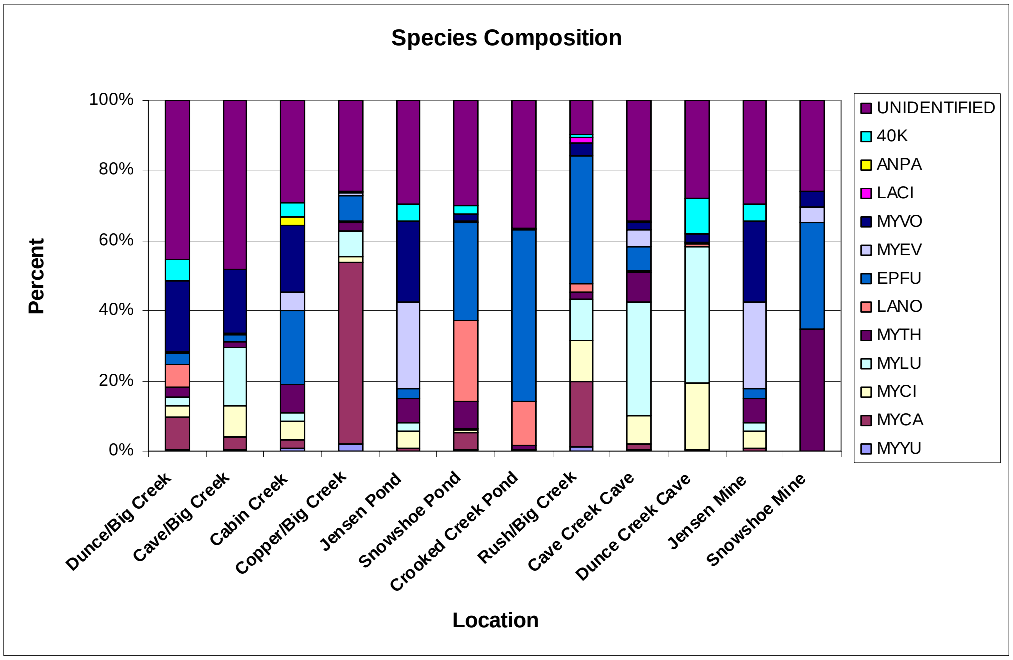


Figure 3: Average proportion of species at high and low elevations.

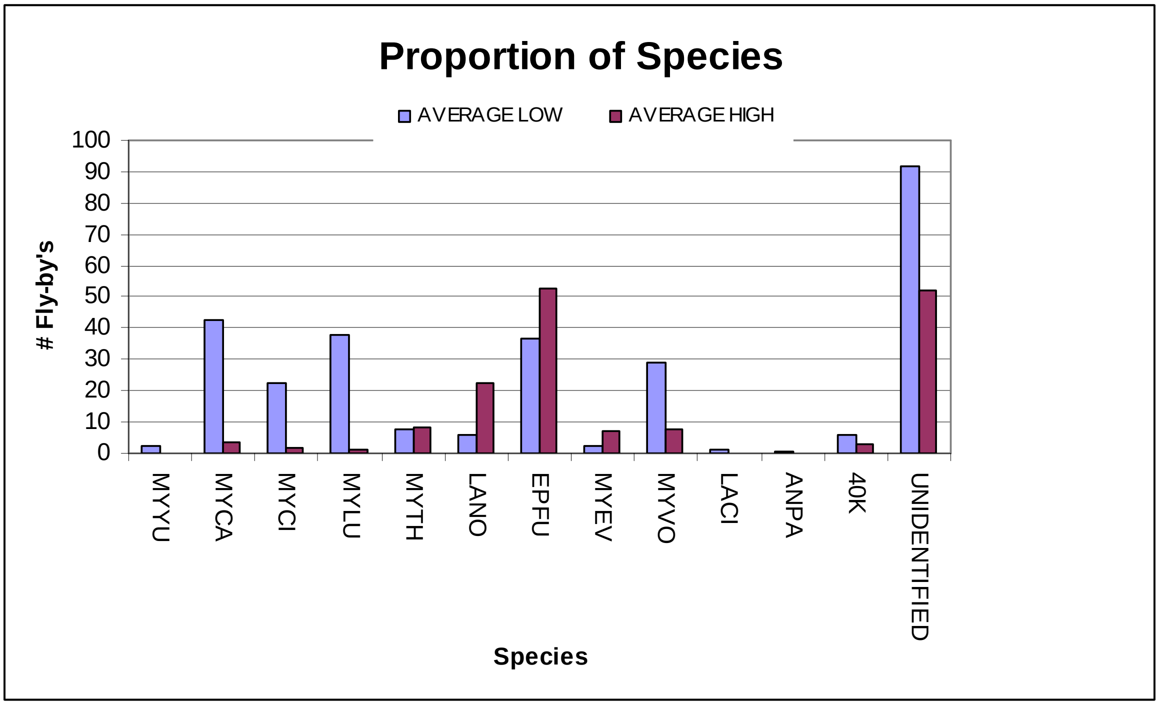


Figure 4: Students t-test results showing the difference in barometric pressure at high vs. low altitude with a 95% CI.

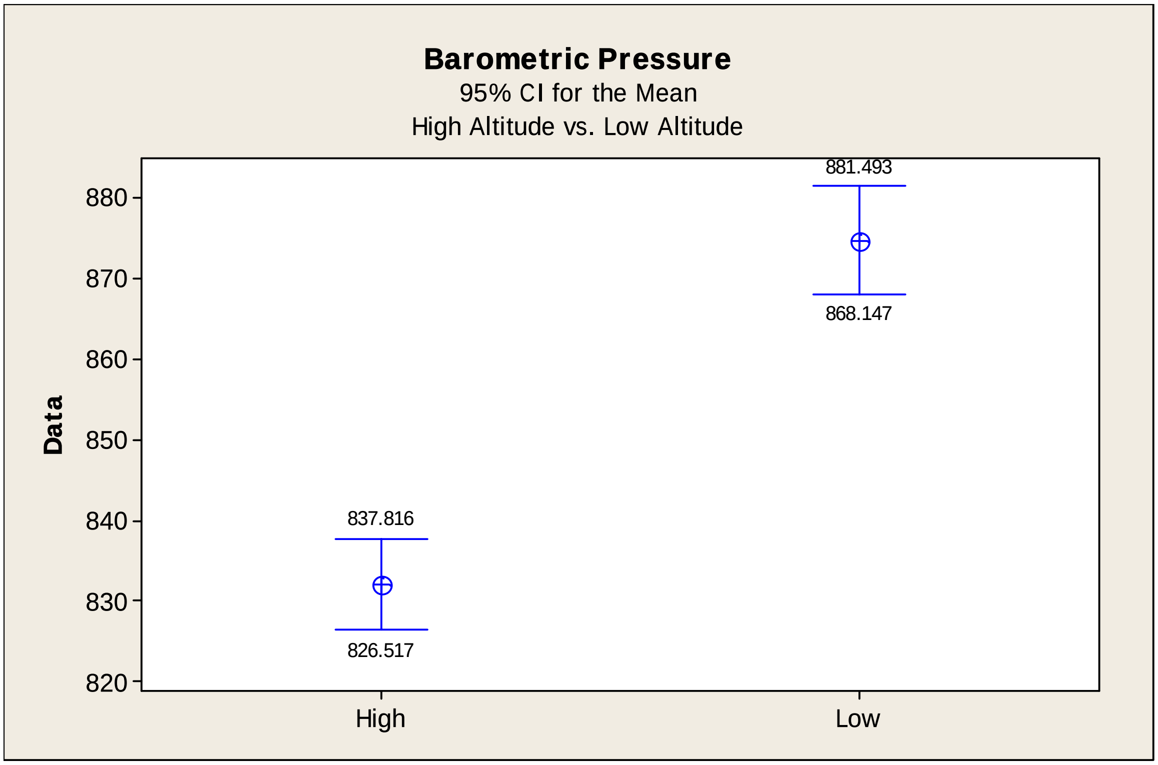


Figure 5: Students t-test results showing the difference in activity at high vs. low altitude sites with a 95% CI.

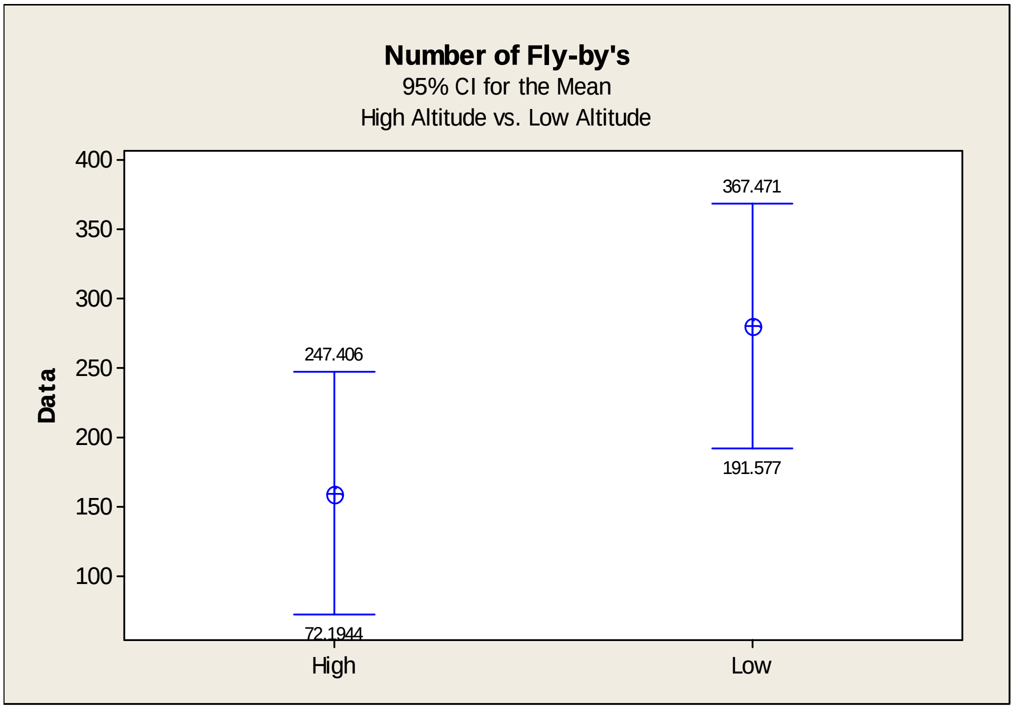


Figure 6: Students t-test results showing the difference in roost estimates at high vs. low altitude sites with a 95% CI.

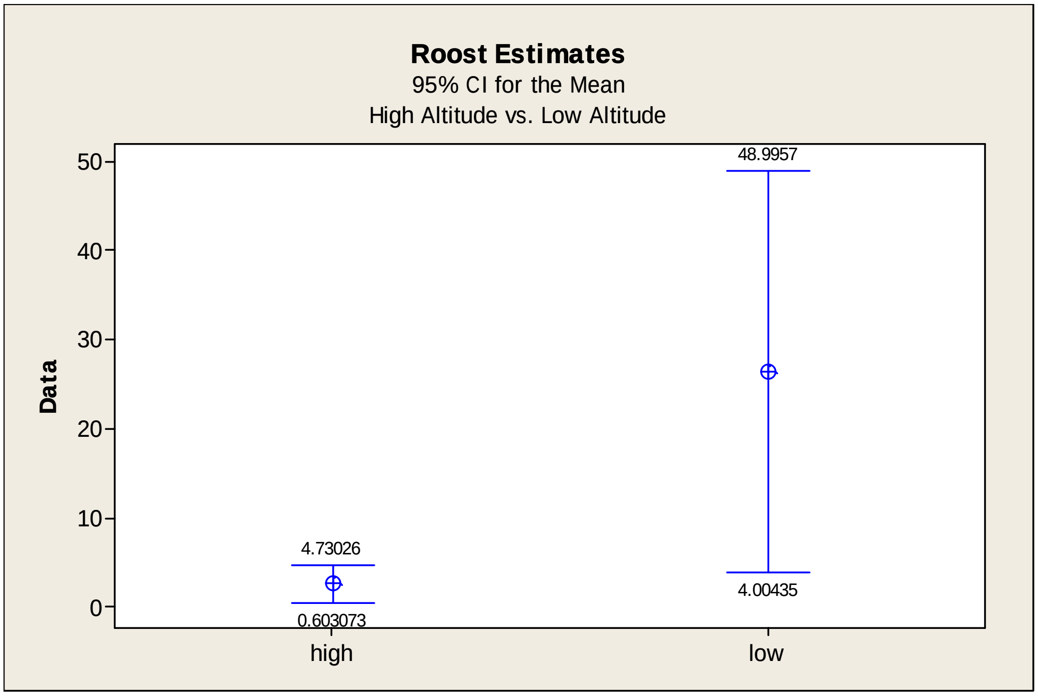


Figure 7: Students t-test results showing the difference in species richness at high vs. low altitude sites with a 95% CI.

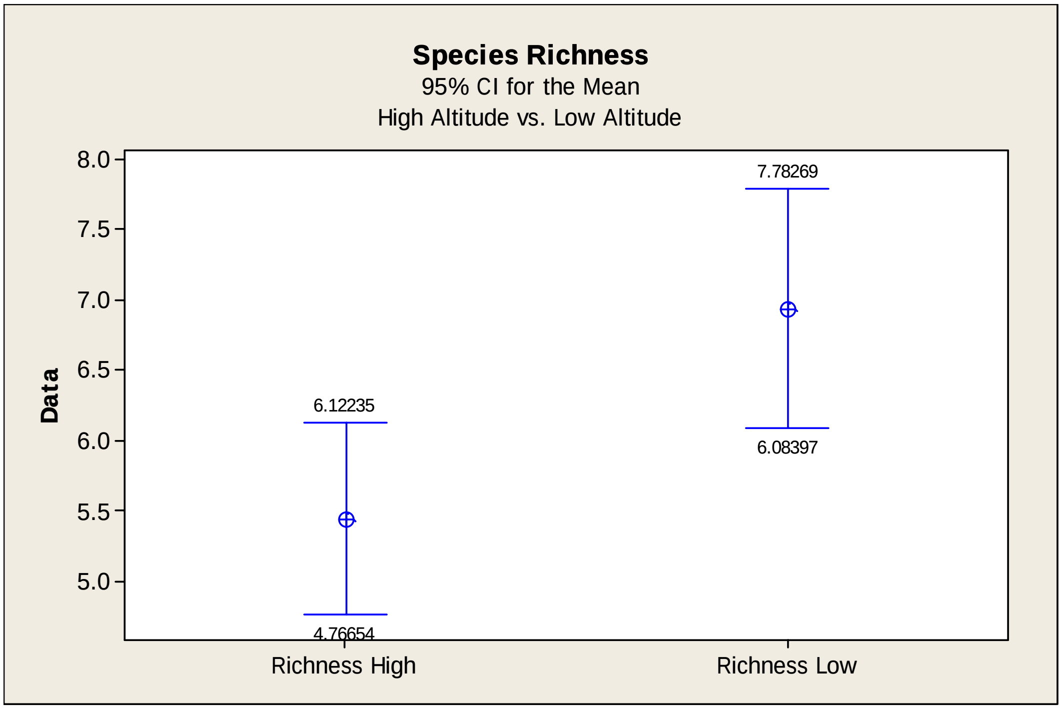


Figure 8: Average wind speed throughout the summer.

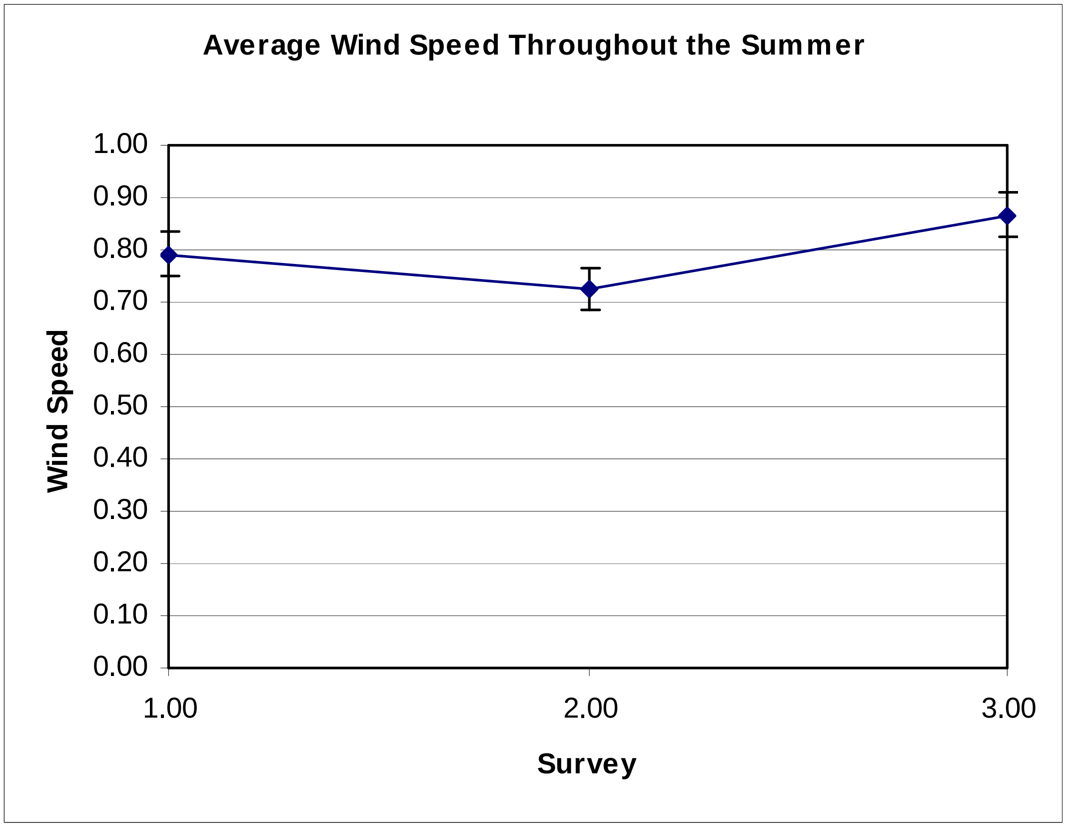


Figure 9: Average temperature throughout the summer.

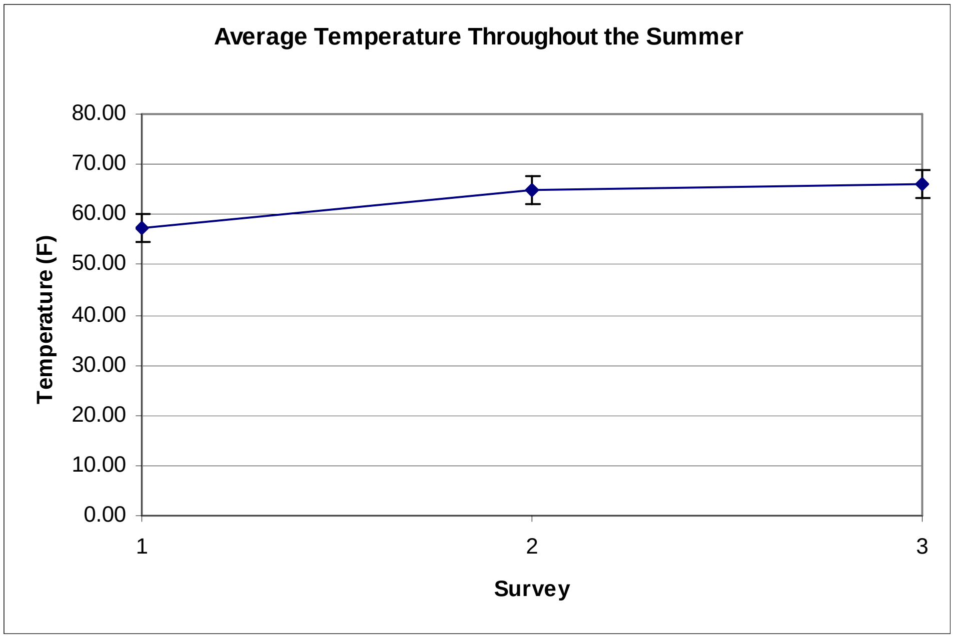


Figure 10: Average relative humidity throughout the summer.

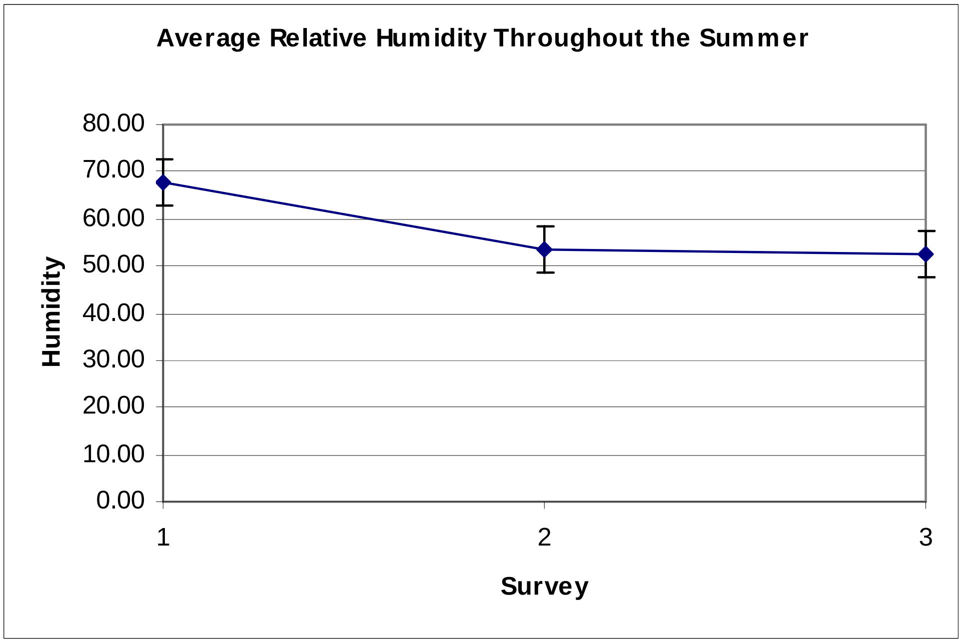


Figure 11: Average barometric pressure

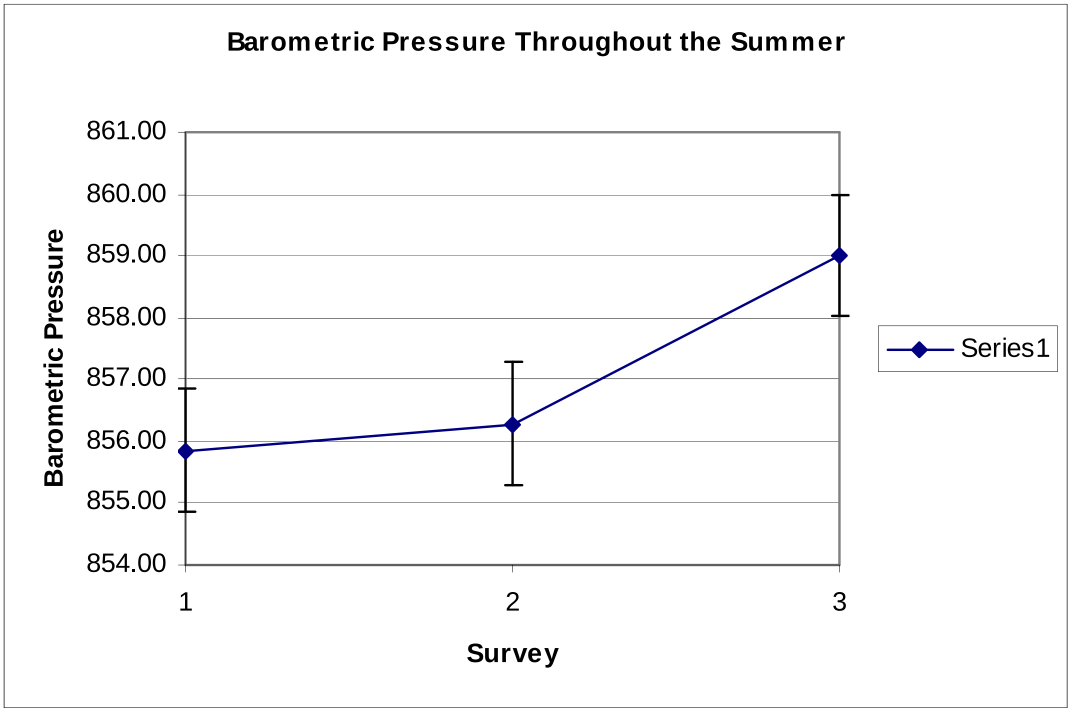


Figure 12: Average bat activity throughout the summer.

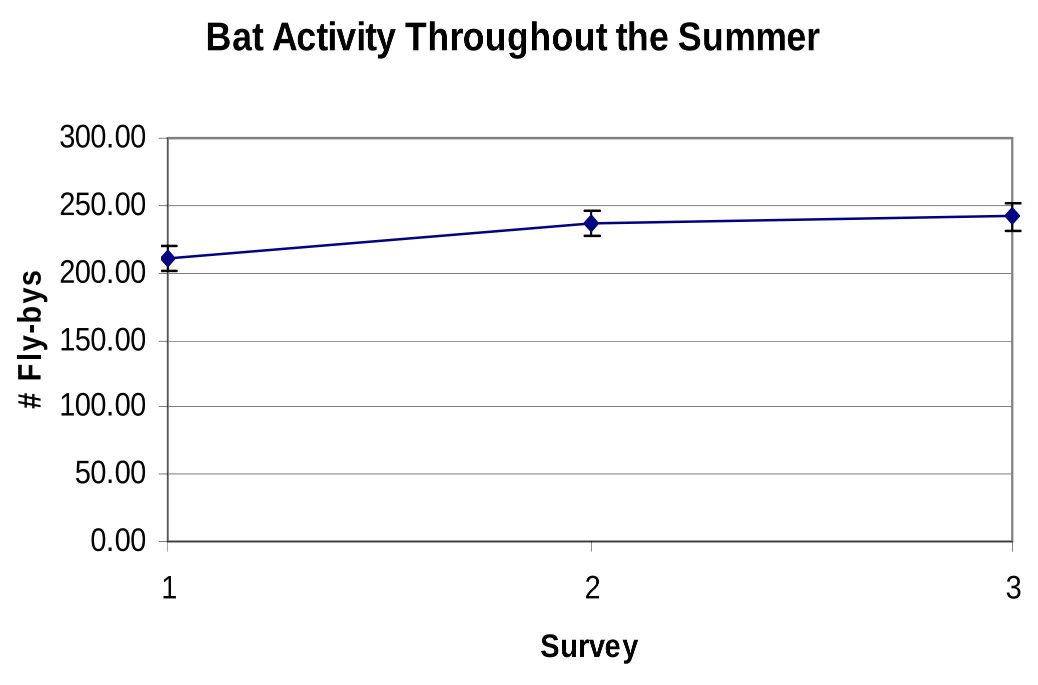
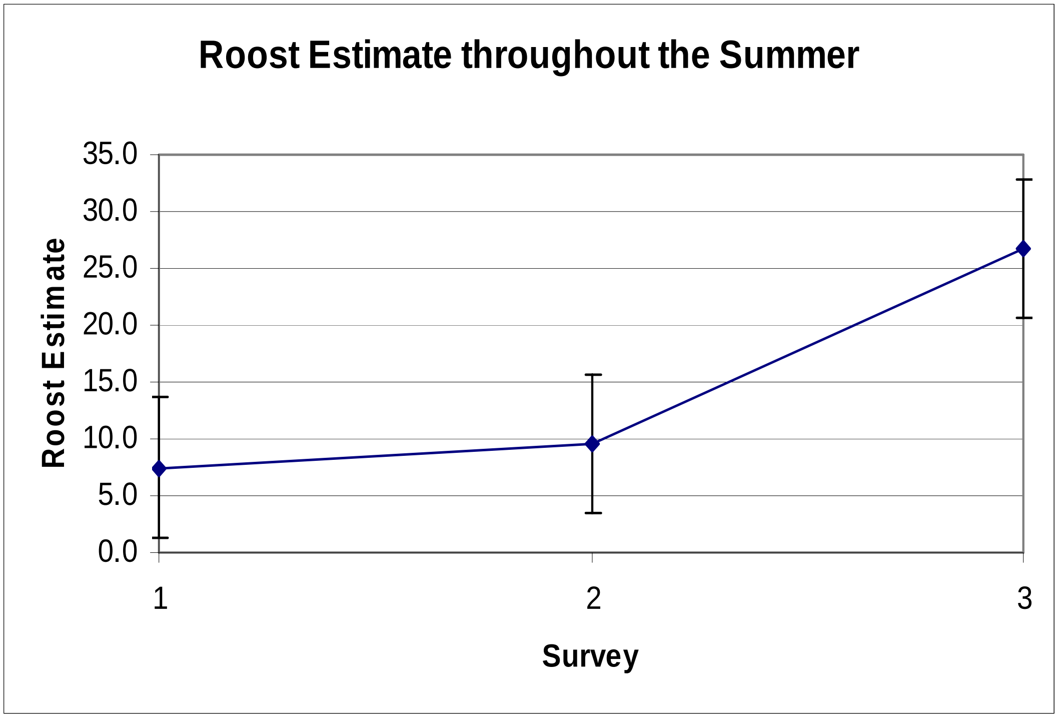


Figure10: Average roost estimates throughout the summer.



Appendix 1: Survey site information.

Type	Elevation	Location	UTM Coordiantes
Forage	1,692 m	Crooked Creek pond	11T 0654104 UTM 5005329
Roost	1,625 m	Snowshoe Mine	11T 0651567 UTM 5006588
Forage	1,542 m	Snowshoe Mine lower pond	11T 0651496 UTM 5006346
Roost	1,685 m	Jensen Mine	11T 0650084 UTM 5006473
Forage	1,685 m	Jensen Mine pond	11T 0650084 UTM 5006473
Forage	1,293 m	Cabin Creek marsh	11T 0662832 UTM 5000960
Roost	1,217 m	Dunce Creek Cave	11T 0674493 UTM 4997062
Forage	1,134 m	Dunce Creek/ Big Creek	11T 0674379 UTM 4996997
Forage	1,109 m	Rush Creek/ Big Creek	11T 0668444 UTM 4996613
Roost	1,284 m	Cave Creek Cave	11T 0660895 UTM 4999523
Forage	1,239 m	Cave Creek/ Big Creek	11T 0660612 UTM 4999456
Forage	1,437 m	Copper Camp/ Big Creek	11T 0641584 UTM 5003139

Appendix 2: Species recorded and captured at each location.

Location	**Cave Creek Cave**	**Dunce Creek Cave**	**Snowshoe Mine**	**Jensen Mine**	**Dunce/Big Creek**	**Rush/Big Creek**	**Copper/Big creek**	**Cave/Big Creek**	**Cabin Creek**	**Jensen Pond**	**Snowshoe Pond**	**Crooked Creek Pond**
Species Present	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYEV MYVO	MYCA MYCI MYLU LANO EPFU MYVO COTO	MYTH EPFU MYEV MYVO	MYCA MYCI MYLU MYTH EPFU MYEV MYVO	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYEV MYVO	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYVO ANPA LACI	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYEV MYVO	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYEV MYVO	MYYU MYCA MYCI MYLU MYTH EPFU MYEV MYVO ANPA	MYCA MYCI MYLU MYTH EPFU MYEV MYVO	MYYU MYCA MYCI MYLU MYTH LANO EPFU MYEV MYVO	MYCI MYLU MYTH LANO EPFU MYEV MYVO
# Species	9	7	4	7	9	10	9	9	9	7	9	7

Appendix 3: All Pearson Correlations performed for roost estimates and foraging activity.

Weather Variable	**All Fly-bys**	**All roost Act.**	**All roosts est.**	**All Forage Act.**	**All High Act.**	**High Roost Act.**	**High Roost est.**	**High Forage Act**	**All Low Act.**	**Low Roost Act.**	**Low Roost Est.**	**Low Forage Act.**
Avg. Wind Sp.	0.151	-0.465	-0.583	0.157	-0.463	0.972	0.651	-0.59	0.449	-0.639	-0.46	0.38
(Coeff./P-Value)	0.378	0.128	0.046	0.464	0.082	0.001	0.162	0.094	0.041	0.172	0.358	0.162
Avg Temp.	-0.074	0.427	0.417	-0.059	-0.258	0.236	0.447	-0.358	-0.073	0.429	0.422	0.011
(Coeff./P-Value)	0.667	0.166	0.178	0.783	0.354	0.653	0.375	0.343	0.753	0.396	0.404	0.97
Avg. Humid.	0.138	-0.488	-0.417	0.04	0.428	-0.59	-0.4	0.569	-0.002	-0.456	-0.464	-0.227
(Coeff./P-Value)	0.423	0.108	0.178	0.854	0.111	0.218	0.432	0.11	0.992	0.363	0.354	0.417
Avg. BP	0.423	0.55	0.647	0.439	0.451	-0.575	0.042	0.602	0.324	0.128	0.093	0.458
(Coeff./P-Value)	0.01	0.064	0.023	0.032	0.091	0.233	0.937	0.086	0.152	0.809	0.861	0.086
Start Temp.	-0.05	0.445	0.421	-0.054	-0.221	0.355	0.623	-0.281	-0.001	0.549	0.568	0.011
(Coeff./P-Value)	0.771	0.147	0.172	0.803	0.428	0.49	0.186	0.464	0.998	0.26	0.239	0.969
End Temp.	-0.044	0.419	0.388	-0.04	-0.195	0.354	0.54	-0.323	-0.07	0.32	0.301	0.023
(Coeff./P-Value)	0.801	0.176	0.212	0.852	0.487	0.491	0.268	0.397	0.763	0.537	0.562	0.936
Change in Temp.	-0.003	-0.129	-0.1	-0.02	-0.025	-0.163	0.069	0.134	0.141	0.44	0.542	-0.021
(Coeff./P-Value)	0.986	0.69	0.756	0.927	0.929	0.757	0.897	0.731	0.542	0.383	0.266	0.942
Avg. Change in WS	0.045	-0.518	-0.435	0.005	-0.256	0.002	-0.098	-0.187	0.101	-0.447	-0.263	-0.028
(Coeff./P-Value)	0.796	0.085	0.158	0.985	0.358	0.997	0.853	0.631	0.662	0.374	0.615	0.92
Gr. Change in WS	0.046	-0.585	-0.441	0.116	-0.522	-0.538	-0.491	-0.469	0.123	-0.582	-0.42	0.137
(Coeff./P-Value)	0.788	0.046	0.151	0.59	0.046	0.271	0.323	0.203	0.595	0.226	0.407	0.627
Sm. Change in WS	-0.004	-0.062	-0.174	-0.227	0.012	0.398	0.332	-0.138	-0.07	***********	***********	-0.354
(Coeff./P-Value)	0.981	0.848	0.588	0.285	0.966	0.434	0.52	0.723	0.762	************	***********	0.196

Appendix 4: All Pearson correlations performed for species richness.

Weather Variable	**All sites**	**All roosts**	**All Forage**	**All High**	**High Roost**	**High Forage**	**All Low**	**Low Roosts**	**Low Forage**
Avg. Wind Sp.	0.205	-0.104	0.3	0.114	0.782	-0.414	0.386	-0.153	0.409
(Coeff./P-Value)	0.231	0.749	0.155	0.988	0.066	0.268	0.084	0.773	0.13
Avg Temp.	0.007	0.201	0.041	0.082	0.541	-0.445	-0.215	-0.412	0.086
(Coeff./P-Value)	0.969	0.531	0.849	0.771	0.268	0.231	0.35	0.417	0.76
Avg. Humid.	0.086	-0.155	-0.039	-0.017	-0.74	0.603	0.149	0.471	-0.316
(Coeff./P-Value)	0.619	0.63	0.855	0.952	0.092	0.086	0.519	0.346	0.252
Avg. BP	0.506	0.38	0.661	-0.016	-0.712	0.485	0.309	-0.32	0.592
(Coeff./P-Value)	0.002	0.222	0	0.954	0.113	0.186	0.172	0.536	0.02
Start Temp.	0.038	0.197	0.079	0.094	0.613	-0.443	-0.06	-0.27	0.198
(Coeff./P-Value)	0.828	0.54	0.714	0.739	0.195	0.233	0.797	0.605	0.478
End Temp.	0.042	0.222	0.057	0.232	0.685	-0.244	-0.255	-0.463	0.048
(Coeff./P-Value)	0.809	0.487	0.79	0.405	0.133	0.528	0.264	0.356	0.866
Change in Temp.	-0.017	-0.162	0.032	-0.406	-0.603	-0.378	0.409	0.663	0.246
(Coeff./P-Value)	0.92	0.614	0.882	0.133	0.205	0.316	0.066	0.151	0.377
Avg. Change in WS	0.104	-0.209	0.152	-0.324	0.042	-0.688	0.231	-0.037	0.19
(Coeff./P-Value)	0.545	0.514	0.478	0.239	0.937	0.04	0.315	0.945	0.498
Gr. Change in WS	0.131	-0.249	0.35	-0.401	-0.245	-0.284	0.231	-0.156	0.339
(Coeff./P-Value)	0.448	0.434	0.094	0.139	0.64	0.459	0.313	0.768	0.216
Sm. Change in WS	0.07	-0.042	-0.115	-0.047	0.176	-0.641	0.056	*****	-0.149
(Coeff./P-Value)	0.687	0.897	0.594	0.876	0.738	0.063	0.811	*****	0.595

Appendix 5: Students t-test results of differences in weather at high and low elevations.

Test	T-Value	P-Value
Average WS	-1.1	0.286
Average Temp.	-0.38	0.706
Average Humid.	-0.38	0.706
Average BP	**-10.77**	**0.00**
Start Temp.	-0.39	0.705
End Temp.	-0.75	0.466
Change in Temp.	0.75	0.461
Average Change in WS	-1.37	0.185
Gr. Change in WS	-1.4	0.178
Sm. Change in WS	-1.02	0.322