

# **Effect of Vegetation Clutter on the Feeding Success of Six Bat Species at UNDERC**

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BIOS 35502: Practicum in Environmental Field Biology  
July 24<sup>th</sup>, 2007

**Abstract:** My study examined the foraging success of six species of bats in palustrine habitats in northern Wisconsin and the Upper Peninsula of Michigan. I estimated foraging success as the number of feeding buzzes divided by the total number of search phase calls. Foraging success and the total number of calls were examined against a spectrum of structural clutter measurements using linear regressions. Feeding success was not significant against any of the vegetation measurements ( $p > 0.05$ ). The total calls were all significant versus vegetation measurements ( $p < 0.05$ ). My results support the theories that bats change call dynamics in differing habitats and add to the practical array of bat capabilities.

### **Introduction**

The study of habitat use is valuable in the conservation of animals. The scope of this study was to examine foraging success across six bat species: the little brown bat (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) the big brown bat (*Eptesicus fuscus*), the hoary bat (*Lasiurus cinereus*), the silver-haired bat (*Lasionycteris noctivagans*), and the red bat (*Lasiurus borealis*).

The six species forage in a large array of habitats, choosing these sites because of food availability and ease of flight. The two most common species at UNDERC (University of Notre Dame Environmental Research Center), the little brown bat and northern myotis, are widespread throughout the continental United States and the Americas (Fenton and Barclay, 1980; Caceres and Barclay, 2000). Northern myotis will forage along the edges of forest over open water (Barbour and Davis, 1969). The northern myotis has a generalized prey base (Caceres and Barclay, 200) and has been documented near vernal ponds (Francl, 2005). A large component of little brown bat diet

is aquatic insects, which makes the open water a beneficial habitat (Fenton and Barclay, 1980). The little brown bat feeds along the forest edge and above the open water (Fenton and Barclay, 1980). The silver-haired bat is known to forage in deciduous, coniferous and mixed forest near edges of water (Kunz, 1982). The big brown bat is a generalist and shows very little preference for foraging habitat (Kurta and Baker, 1990). The hoary bat and the red bat both favor foraging above the canopy and their main prey is moths (Shump and Shump, 1982). Additionally, red bats forage in areas with a reliable source of water and open canopy (Miller et al. 2004).

Many bats in the United States are known to choose roosts near water (Brooks and Ford, 2006). Although many bats feed over large bodies of water, some species forage near palustrine habitats such as bogs, vernal ponds or beaver ponds. Many palustrine habitats that include “open” areas in the canopy are favorable for bat use. Open areas can also provide sufficient space to navigate through sites (Francel, 2005).

Many bat species use echolocation to find and capture prey. The bat emits an ultrasonic signal which strikes a target and is reflected off the target. The returning signal is heard and then interpreted by the bat. However, the vegetation in the area can obstruct foraging by interfering with emitted or returning signals. The ability to navigate in and out of cluttered areas is beneficial to echolocating bats that either attack insects in flight or glean them from the surfaces of vegetation (Vaughan, 2000).

Echolocation signals can vary with species, presence of conspecifics and foraging site (Vaughan, 2000). Call length and frequency will vary to optimize feeding success. The search phase calls are usually narrow frequency and indicate if there is prey in the area (positions 0-3 in Figure 1). The attack phase calls, also known as feeding buzzes,

are shorter, broad-band calls that precisely define the prey's position (Vaughan, 2000 positions 5-10 in Figure 1). Kalko and Schnitzler (1993) found that the individuals' plasticity in echolocation calls allows them to forage in differing habitats. Bats may change calls to approach a signal that is most effective for them. Knowing this, I am not aware of how well this compensates for the challenges of structural clutter.

To examine the bat signals, Anabat technology will be used. Anabat consists of a sensor and software that analyzes and plots the call on a computer screen. Using the calls recorded by Anabat, I identified the number of bats emitting call sequences, which species were present, and the relative rate of feeding buzzes across the sites.

With this information, I examined feeding success (as estimated by a proportion of feeding buzzes among all bat calls) of bats across a spectrum of structural clutter in palustrine habitats. Even though minute amounts of feeding buzzes are unsuccessful (Acharya and Fenton, 1992) the capture rate after entering a feeding buzz should not change significantly between sites.

I studied this at UNDERC in northern Wisconsin (Vilas County) and the Upper Peninsula of Michigan (Gogebic County). UNDERC contains a large variety of palustrine habitats, including bogs, ponds, streams, vernal ponds and beaver ponds. Using these sites is beneficial because there is little human intrusion and previous research in this geographic area is limited.

My hypothesis was that the feeding buzz success would diminish over the increasing structural clutter for all six species, even though some of the species are smaller and more maneuverable, like little brown bats and northern myotis. I used

Anabat technology to analyze bat echolocation sequences and calculate the relative number of feeding buzzes across all the sites.

## **Methods**

### **Site Selection**

My partner (Jessica Lee) and I ventured into the field during the day time and selected 33 palustrine locations that fulfill the site requirements. Site requirements include open water with varying degrees of vegetation clutter. We pinpointed the locations using GPS technology (Figure 2).

### **Bat Surveys**

At each site we set up Anabat equipment to monitor bat signals. We recorded signals from sunset until roughly four hours after sunset on evenings where the temperature remained above 50°F (10°C).

The signals were analyzed and tabulated using Anabook, a graphics program which helps assigning calls to species. This revealed the number of call sequences, the number of bat species and the proportional number of feeding buzzes compared to total number of call sequences.

Additionally, I set up mist nets, up to 10 m high, to capture bats in flight. I recorded the species of bat and other physical measurements, including gender, age, weight and forearm length. The mist nets helped me verify the Anabat call sequences I identified.

### **Habitat Measures**

To estimate the relative amount of structural clutter at each site, the next set of measurement were that of vegetation cover, vegetation density and vertical density. We

will be using a concave spherical densitometer (Forestry Suppliers, Jackson, MS) to measure the canopy cover in the sites we choose. I used a range pole to measure the Levins vertical density index (Levins, 1968) and the vegetation volume (Mills et al., 1991) in the sites. I calculated values for each site, based on 20 random points selected within the site.

### **Statistical Analysis**

I used a regression (feeding buzz proportion versus canopy percent and vegetation volume) to determine if the amount of structural clutter has a significant effect on the foraging success of bats. I ran a regression to see if vegetation density and canopy cover affect the total amount of calls in an area. I ran all the regressions separately after this. I used SYSTAT 12.0 (Systat Software Inc, San Jose, California) to run these regressions.

Before running statistical analyses, I  $\text{Log}_{10}$  -transformed the number of calls, average canopy cover, and vertical density to normalize those sets of data. An interaction variable was introduced between vegetation volume and canopy cover to determine if these two variables acting together skewed the data. The interaction variable was found to be non-significant ( $p > 0.05$  in all cases), so I continued with the analyses as planned. The transformed percent canopy data and total vegetation volume data were standardized so that their range encompassed the same interval.

### **Results**

I recorded 5137 calls and 660 feeding buzzes across 33 sites. I detected all six bat species across all sites through Anabat recordings (Table 1). Little brown bats (84% of all calls) were by far the most abundant species at UNDERC, but, hoary bats (9% of all calls), and red bats (4% of all calls) were also well-represented. Foraging success varied

from 0% - 26% across sites. Furthermore, I captured 11 little brown bats, two northern myotis, and two silver-haired bats across all sites.

Canopy cover varied from 0.00% – 97.48% across sites, while total vegetation volume varied from 0.00071 – 0.02214. The vertical density, as measured by the Levins index varied from 1.00 – 5.68.

The first regression tested the relationship between the proportion of feeding buzzes to total calls (foraging success) against the combined effects of canopy cover and vegetation volume. There was no statistical significance between the proportion of feeding buzzes versus canopy cover ( $p=0.406$ ) and vegetation volume ( $p=0.627$ , Table 2). The data set was widely scattered as is shown by the  $R^2$  value of 0.057 (Table 3).

The second regression examined the relationship between total number of calls against canopy cover and vegetation volume as independent variables. There was no statistical significance found between total calls and canopy cover ( $p = 0.176$ ), and a marginally significant trend between total calls and vegetation volume ( $p = 0.114$ , Table 3).

Six regressions compared the vegetation measures versus total calls and feeding success separately against total vegetation volume, vertical density and percent canopy cover. All three vegetation measures yielded significant negative relationships ( $p = 0.019$ ,  $p = 0.013$ ,  $p = 0.048$  respectively) when compared to total bat calls (Table 2). There was a negative relationship with the three variables, with total calls going down while vegetation measures increased. When the vegetation measures were compared to the proportion of feeding buzzes, none resulted in statistical significance ( $p = 0.300$ ,  $p = 0.219$ ,  $p = 0.641$ ; Table 2). Two regressions were run with vertical density (Levins

index) as the independent factor versus feeding success and total calls as dependent factors. The first regression between the Levins index and proportion was not significant ( $p > 0.05$ ). The second regression with Levins index versus total calls was significant ( $p=0.048$ ), with a negative relationship ( $r = -0.283$ , Table 2).

### **Discussion**

The results reveal information about bat foraging and the capabilities they have developed through time. My hypothesis, that feeding success would diminish due to large amounts of clutter was not supported by the data. The bats in the study did not show clear patterns in foraging capability in differing habitats. It does seem however, that bats prefer to forage in more open areas, as supported by the negative relationship between total activity and vegetation clutter measures.

An estimate of the range bats can successfully echolocate extends as far as 7 - 10 meters (Kalko and Schnitzler, 2001). In a forest, however, vegetation clutter would decrease that distance. Faced with this problem, many species of bats have developed intraspecific differences in frequency and duration. Bats that move into dense vegetation to hunt and forage have call plasticity and adjust to the surroundings (Kalko and Schnitzler, 2001).

The majority (84%) of bat calls analyzed were that of the little brown bat. Wund (2006) found that little brown bats change their calls between habitats by raising frequency, decreasing call duration and switching to a higher frequency modulation. It has also been found that along with little brown bats, northern myotis will alter calls depending on habitat (Broders, 2004). In addition to this plasticity, it seems that some bats can tolerate residual echolocation reflecting off of clutter (Siemers, 2000; Kalko and



Schnitzler, 2001). Siemers (2000) found that the bats were able to differentiate between prey and vegetation that were only several centimeters away.

The results in this study contradict my hypothesis but support others' findings. The results in my study validate the work of Broders (2004), Siemers (2000) and Wund (2006). Because the bats in the study foraged with the same efficiency over a variety of habitats, they may have changed call and behavior to account for changes in vegetation and canopy. My work also showed that bats more often foraged in more open areas, supporting the work of Brigham et al.'s (1997) findings that little brown bats habitat choice is affected by vegetation clutter.

This project was not without limitations. The timeframe for using the Anabat technology and trapping bats was limited. The vegetation measures we used do maintain an error in that they may not be a perfect estimate of vegetation in the study sites. In terms of trends, grouping all the species of bats together may have skewed data; however, because the strong majority (84%) of calls were little brown bats, trends evident in the other five species may not have been adequately represented. In the future, studies and statistical analysis could focus on a single species if sufficient time was available.

The exhibited variation in behavior manifests itself to such an extent that foraging success does not diminish through forest and increased clutter. By accomplishing this, the bats are able to maintain vast amounts of suitable area for foraging. The only limitation presented to the bats then would be the presence of water for drinking. The bats are able to move from water source to water source while foraging. This alone can extend the bats' territory and remove stress if a single water source dries up. The implications of this study not only add to the array of practical systems bats have

developed, but also serve as a reminder that animals have developed solutions to problems which anthropocentric minds consider wholly infeasible.

### Acknowledgements

Thanks are extended to Jessica Lee (University of Notre Dame) for the countless hours spent in the field and in the lab. I would like to thank Karen Francl (Radford University) for guidance and support in numerous areas. I appreciate the help of Luke DeGroot (Ohio State University) with statistical analysis. I would like to thank the Hank family for providing the endowment to research at the field station.

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Table 1: Locality (UTM NAD27, Zone 16N) information and physical measures (average percent canopy, Levins index of diversity, and total vegetation volume [TVV]) for 33 sites surveyed for bats in summer 2007 at UNDERC.

Site name	UTM E	UTM N	Percent Canopy	Levins Index	TVV
Beaver Bog	305788	5123598	5.57	1.32	0.002
Beaverbat Beaver Pond	307749	5124943	8.68	3.45	0.005
Beavergate Bog	305361	5125879	1.41	2.13	0.010
Boomer Bog	304229	5123629	9.41	2.58	0.012
Buck Marsh	305803	5124498	7.97	2.13	0.009
Caketown Bog	304938	5125698	1.44	2.80	0.017
Castleberry Bog	307930	5125185	5.11	3.02	0.017
Cranberry Grape Marsh	302626	5123490	21.56	3.00	0.016
Cranberry Juice Vernal Pond	303463	5123575	99.59	1.90	0.010
Dead Marshes	307097	5125477	11.16	1.97	0.006
Delicious Beaver Pond	306708	5125800	11.17	2.91	0.014
Donut Beaver Pond	306793	5123355	9.50	1.00	0.001
Donut Bog	306885	5123284	1.21	1.13	0.006
Fern Gully Marsh	306084	5123765	57.88	1.99	0.016
Fitted Briefs Beaver Pond	307530	5125035	63.59	4.70	0.018
Foggy Beaver Pond	308018	5124958	33.07	1.71	0.004
Forest Service Bog	307135	5120573	0.43	1.00	0.002
Hellenthal Bog	307976	5121075	0.00	1.00	0.001
Junior Bog	305777	5122712	6.73	1.81	0.010
North Gate Bog	307509	5125599	0.19	1.00	0.001
NorthWest Beaver Pond	303368	5125334	5.43	2.11	0.007
Peyton Pond	307337	5125769	31.87	4.52	0.022
Pseudonine Vernal Pond	304129	5122696	52.54	2.41	0.011
Reddington Pond	306103	5125749	1.97	1.70	0.009
Snag Marsh	304499	5122437	7.34	3.48	0.019
Tender Bog	305108	5122480	3.57	1.00	0.002
Vernal Pond 6	303976	5122397	25.82	2.46	0.016
Vernal Pond J	306374	5123704	95.52	3.70	0.011
Vernal Pond K	306394	5123746	84.92	5.68	0.016
Vernal Pond Proximity	305466	5122370	97.48	2.98	0.015
Vernal Pond V	305945	5124813	51.03	1.63	0.007
Ward Creek	305827	5125193	48.76	3.59	0.024
Willow Marsh	305088	5125678	15.18	3.85	0.020

Table 2: The coefficients, standard error, replicates, squared R and p-values for regressions with proportion and total calls vs. TVV average, canopy average (transformed), vertical density (transformed) as separate independent factors.

	$\beta$	SE	N	R <sup>2</sup>	p-value
Proportion of feeding buzzes					
Canopy	0.010	0.012	33	0.022	0.406
TVV	-0.006	0.012	33	0.008	0.627
Vertical Density	-0.012	0.025	33	0.007	0.641
Total Calls					
Canopy	-0.158	0.064	33	0.164	0.019
TVV	-0.167	0.064	33	0.183	0.013
Vertical Density	-0.283	0.137	33	0.121	0.048

Table 3: The coefficients, standard error, replicates, squared R and p-values for regressions with proportion and total calls vs. TVV average and canopy average as independent variables.

	$\beta$	SE	N	R <sup>2</sup>	p-value
Proportion of feeding buzzes					
Canopy	0.017	0.014	33	0.057	0.219
TVV	-0.014	0.014	33	0.057	0.300
Total Calls					
Canopy	-0.100	0.072	33	0.232	0.176
TVV	-0.118	0.072	33	0.232	0.114

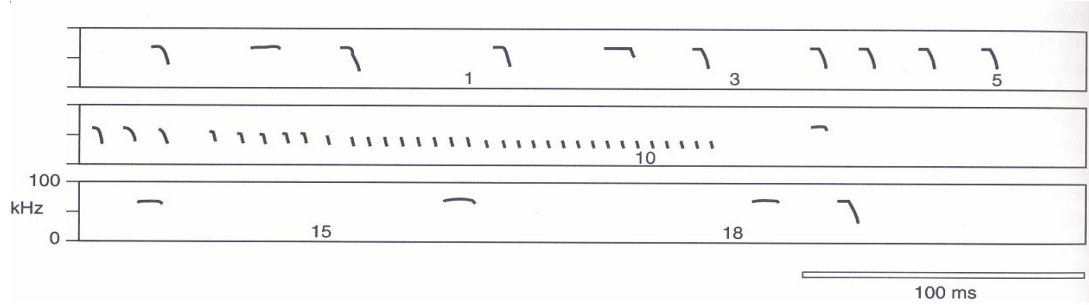


Figure 1: Generic bat search and attack. Feeding buzz occurs between 5 and 10 on the numbered scale. (from Vaughan, 2000).



Figure 2: Map of sites where recordings were taken.

