Acoustic Bat Ecology
SURE 2010

Bri Birsa, John Egner, Amy Macemon, Alex Matzinger

Introduction

Habitat use has been examined by bat researchers for several decades but still little is known about habitat associations and influence (Krusic and Neefus, 1995). Only during the summer months does Wisconsin sustain ecosystems that support active bat populations, whereas they hibernate for the remainder of the year in both local and migratory areas (Krusic *et al.* 1995). Thus, to gain a deeper understanding of bats' interaction with their surrounding landscape and ecosystem, several different habitat studies were conducted during the summer months within southeast Wisconsin. Relative activity of the bat species found within Wisconsin was measured through the means of acoustic monitoring. Eight different bat species reside in Wisconsin, and they all echolocate and are potentially detectable, though species determination through echolocation call is not always possible. The species that were possible to detect included *Myotis lucifugus* (Little Brown Myotis), *Myotis septentrionalis* (Northern Long-eared Bat), *Perimyotis subflavus* (Tricolored Bat), *Eptesicus fuscus* (Big Brown Bat), *Lasiurus borealis* (Eastern Red Bat), *Lasiurus cinerus* (Hoary Bat), *Lasionycteris noctivagans* (Silver-haired Bat), *Myotis sodalis* (Indiana Bat). Our primary objective was to monitor bat activity at standing water as compared to moving water sites, with the assumption of more activity at standing sites. Our secondary objective was to monitor bat activity in areas of various levels of building development, with the assumption of more activity in areas with greater developed building structure than in areas of non-developed building structure. This hypothesis was formed from previous studies that have suggested that bats are more active in urban environments than rural environments (Ghert, S. D., Chelsveg, J. E., 2003). Looking at habitat correlations with bat activity allows for a general census to be gathered on approximate bat locations which will aid in building a model for future research questions, management efforts and conservation efforts. Since there have been relatively few research excursions of this nature, this research is meant to provide a basis for others to continue studies. Similarly, the focus on habitat correlation with bat activity in our small study area in southeastern Wisconsin can perhaps be applied to the larger geographical area of the Midwest.

Materials and Methods

Study Area-

To study the relative bat activity around water, we monitored nocturnal activity at six different sites, with replications completed three times per site, within Kenosha County, WI from 12 June through 29 July 2010. Three sites along moving water and three sites along standing water were chosen. All study sites were disjunct from one another with the exception of two study areas, which were part of a river continuum but were 3.5 miles apart. Following Ghert and Chelsveg (2003), we chose our study areas based on size, logistical constraints, safety for equipment and personnel, and shoreline access. Each site displayed similar habitat characteristics, including tall grass, maintained grass, deciduous trees and/or forest, and demonstrated riparian qualities. An influencing factor in choosing standing water sites was the area of the body of water, while moving water sites focused on channel width. Standing water sites in descending order are future

Kenosha County KD Park Pond at 191,440 square meters, Lincoln Park Pond at 15,393 square meters, and Bong Recreation Area dog training pond at 10,210 square meters. Moving water sites in descending order are Pike River on Carthage College campus with an average width of 12 meters, Pike River in Petrifying Springs Park at 11 meters, and Pike creek at Washington Park at 9 meters. The approximate middle latitude and longitude for these sites can be found in Table 1.

To examine the relative bat activity around development, nocturnal activity was monitored at twelve different survey sites. Six sites within developed areas and six sites within non-developed areas were chosen. For both the developed building structure and the non-developed building structure categories, four of the six sites were sampled by us and were located throughout Kenosha County, WI. While the remaining two were surveys provided to us from the Wisconsin Department of Natural Recourses (DNR) and were located throughout the larger geographical area of Wisconsin. The categories of developed and non-developed were determined by whether an area had over 50% building structure (urban) or under 50% (non-urban). Urban sites consisted of neighborhoods, campus, and metropolitan areas. Nonurban sites consisted of preserved recreational areas and northern Wisconsin woods. Urban sites (starting from the highest percent of building structure) were neighborhood between 75th and 72nd Street, and 7th and 3rd Avenue, Pike Bike Trail, DNR Milwaukee River route, neighborhood on 7th Avenue between 33rd Street and 15th Street, DNR route in Columbia County, and Carthage College Campus. Our non-urban sites (starting from least percent of building structure) were Future Kenosha County KD Park, DNR route in Lincoln County, DNR route in Sauk County, Bong Recreation Area route, Petrifying Springs Park, and Chiwaukee Prairie Kenosha Dunes route. The approximate middle latitude and longitude for these sites can also be found in Table 1.

Table 1: Approximate Middle Latitudes and Longitudes of the Water and Development Studies

Site:	Latitude:	Longitude:
Water- Future Kenosha County KD Park Pond	42°33'18.45"N	88°14'21.53"W
Lincoln Park Pond	42°34'17.68"N	87°49'56.75"W
Bong Recreation Area Dog Training Area Pond	42°37'59.39"N	88°10'51.17"W
Pike River on Carthage College Campus	42°37'29.57"N	87°49'22.05"W
Pike River in Petrifying Springs Park	42°38'42.52"N	87°52'5.70"W
Pike creek at Washington Park	42°35'58.00"N	87°49'59.13"W
Development- Neighborhood between 75th and 72nd Street, and 7th and 3rd Avenue	42°33'50.09"N	87°49'6.12"W
Pike Bike Trail	42°31'56.21"N	87°50'41.64"W
DNR Milwaukee River route	43° 2'14.80"N	87°54'8.77"W
Neighborhood on 7th Avenue between 33rd Street and 15th Street	42°36'55.56"N	87°49'24.47"W

DNR route in Columbia County	43°32'28.00"N	89°28'38.31"W
Carthage College Campus	42°37'20.59"N	87°49'15.73"W
Future Kenosha County KD Park	42°33'15.29"N	88°14'20.12"W
DNR route in Lincoln County	45°10'59.59"N	89°44'39.89"W
DNR route in Sauk County	43°25'1.28"N	89°43'54.91"W
Bong Recreation Area	42°37'57.40"N	88° 7'31.77"W
Petrifying Springs Park	42°38'34.48"N	87°52'9.30"W
Chiwaukee Prairie Kenosha Dunes	42°33'17.79"N	87°48'53.30"W

To categorize the development study we estimated habitat type for 9 km square areas that included the acoustic route in Google Earth. If an area had greater than 50% building structure it was deemed urban and if the area had under 50% building structure it was deemed not urban. Building structure was defined as anything man made. While looking at the 9 km square areas we also compared the building structure against the vegetation.

Acoustic Sampling, Ecological Measurements and Sampling Procedure-
Each site was monitored using one Anabat SD1 CF bat detector connected to an HP iPaq X11-21204 (PDA) which ran Anapocket, a handheld version of Analook, to survey the relative activity of foraging and commuting bats within each site each night, weather permitting. (We did not conduct surveys in the rain.) The Anabat SD1 CF's sensitivity was set within the range of 3-6 depending on the amount of background noise during the sampling period. The audio division ratio was set to 16 and the data division ratio was set to 8 every night to ensure attainment of similar bat call files. The HP iPaq acted to store all bat echolocation call files recorded each night, which were then uploaded onto a computer with a Windows operation system to be analyzed the following day.
.
The HP iPaq X11-21204 ran the Anapocket program, which provided GPS availability. Upon starting the Anabat SD1 CF in conjunction with the HP iPaq, Anapocket recorded the starting point of our designated sampling route, tracked the route, and then recorded the ending point of the sampling route. It also had the capability to record the latitude and longitude of the bat calls as waypoints. This GPS file, including both the route and waypoints, was stored within the HP iPaq, and was then uploaded onto the computer, which provided visual recognition of the routes within each sampling site.

Fieldwork was conducted following a protocol developed by the Wisconsin DNR as part of their Citizen Bat Monitoring program. General regulations followed included monitoring was started a half hour after sunset, survey duration time lasted at least a half hour and no longer than three hours, monitoring was done at a continuous pace to deter activity bias, and surrounding ecological measurements were taken. Ecological measurements for the water study consisted of (if applicable) water width, water depth, flow rate of water, distance to surrounding vegetation, and percent ground cover. These measurements were taken at every site. Water width, and distance to surrounding vegetation were taken in meters, using a measuring tape. The distance from the water's edge to grass and small shrubs as well as the distance to large shrubs and trees was recorded. Flow rate was taken by recording the time it took a lemon to move the distance of 10 meters downstream. Water depth was then taken by recording the deepest depth within the 10 meters used for the flow rate calculation. Percent ground cover was also assessed by analyzing a circular quadrat that was placed seven meters from the midpoint of the channel. The percent ground cover was recorded using four different categories: bare ground, grass, herbaceous, and tree. Each set of ecological measurements was taken three times per route, once at the start, middle, and end. The middle of the route was determined through analysis of the GPS. Using a Kestrel 3500 Wind Meter weather measurements of temperature, relative humidity, and wind speed were recorded at both the start and the end of sampling routes at each site every night.

Both land and water routes were utilized for acoustic sampling. All bat activity monitoring for the water study was taken either directly by the means of canoes, waders, or other floatation devices on the water, or by walking within <5 meters from the bank. Activity monitoring for the development study was conducted by following pre-established land paths. These sites were sampled using a circuitous route or loop.

Species Identification-
AnalookW displays bats echolocation calls so that they may be viewed and distinguished. In order for a group of pulses, otherwise known as a pass, to be considered for analysis, there must be ≥ 4 pulses with ≤ 1 second separation between each pulse in the pass (Chelsvig, J.E., Gehrt S.D., 2004). Based on a reference call library provided to us by Dr. Kim Livengood, amateur classifications were made as to the species of each bat call file. The passes were judged based on the characteristic frequency, the maximum frequency, the frequency down, the average frequency sweep, and time between calls (Krusic, R.A., Neefus, C.D., 1995). Although our classifications were assigned to the species associated with the bat call file, they hold relatively low value as highly experienced individuals within this field, including members of the DNR, do not claim to be able to distinguish between many bat species due to behavioral similarities in call characteristics. Therefore, bat call files were classified into high (≥35 kHz) and low frequencies (≤35 kHz) based upon where the characteristic call was located. Wisconsin bats that were included in the low frequency species are *Eptesicus fuscus* (Big Brown Bat), *Lasiurus borealis* (Eastern Red Bat), and *Lasiurus cinerus* (Hoary Bat). Wisconsin bats included in the high frequency species are *Myotis lucifugus* (Little Brown Myotis), *Myotis septentrionalis* (Northern Long-eared Bat), *Perimyotis subflavus* (Tricolored Bat), *Lasionycteris noctivagans* (Silver-haired Bat), and *Myotis sodalis* (Indiana Bat). One bat species, *Lasiurus cinereus,* however, was able to be confidently classified since it is the only bat species in Wisconsin to occasionally drop below 20 kHz. Although capturing bat species to ensure accurate classification of call files would have been ideal, classification into high and low categories allowed for general assumptions to be made about bat activity within given habitat types.

Results

Over the course of our study, we recorded and analyzed approximately 1920 minutes of bat call data in 2187 total files from all sites. Figure 1 displays the relative bat activity (in pass per minute) by the date surveyed. There was much variability in activity with no apparent increase or decrease over the course of our study. The standing versus moving water study is addressed in

Figures 2 and 3. There was greater bat activity at the standing water sites when compared to the moving water sites (Figure 2). There was also a greater amount of low frequency bat activity at both the standing and moving water sites (Figure 2). Figure 3 breaks down the water study by each site surveyed. The highest amount of activity was seen at Future Kenosha County KD Park pond, while the least activity was seen at Petrifying Springs Park (Figure 3). Figure 4 shows the relative bat activity in the development study. As a whole, there was more bat activity detected in urban areas than non urban areas. Interestingly, the relation between low frequency bats and high frequency bats was inverted in the urban and non urban areas (Figure 4). Figure 5 compares the bat activity between the general habitat types of standing water, moving water, urban and non urban areas. The standing water areas had the highest amount of bat activity, while the urban areas had the lowest amount of activity.

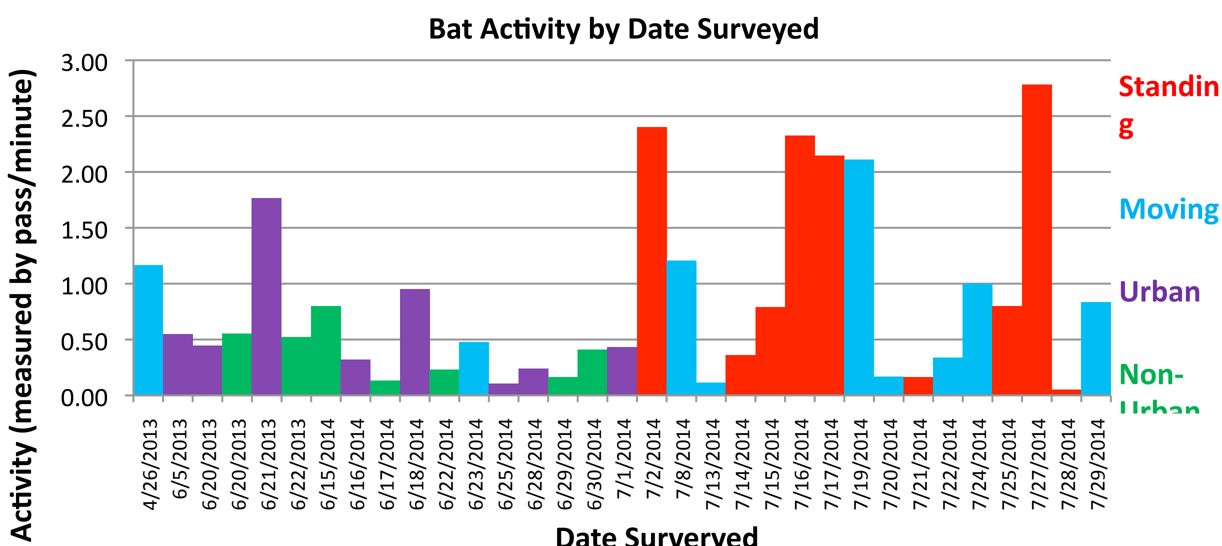

Figure 1: All the survey dates gathered during the summer of 2010, with an exception to all the 2009 dates (given to us from the WI-DNR) showing the bat activity in passes per minute. The color coding represents the type of environment the survey was conducted (Standing, Moving, Urban, Nonurban).

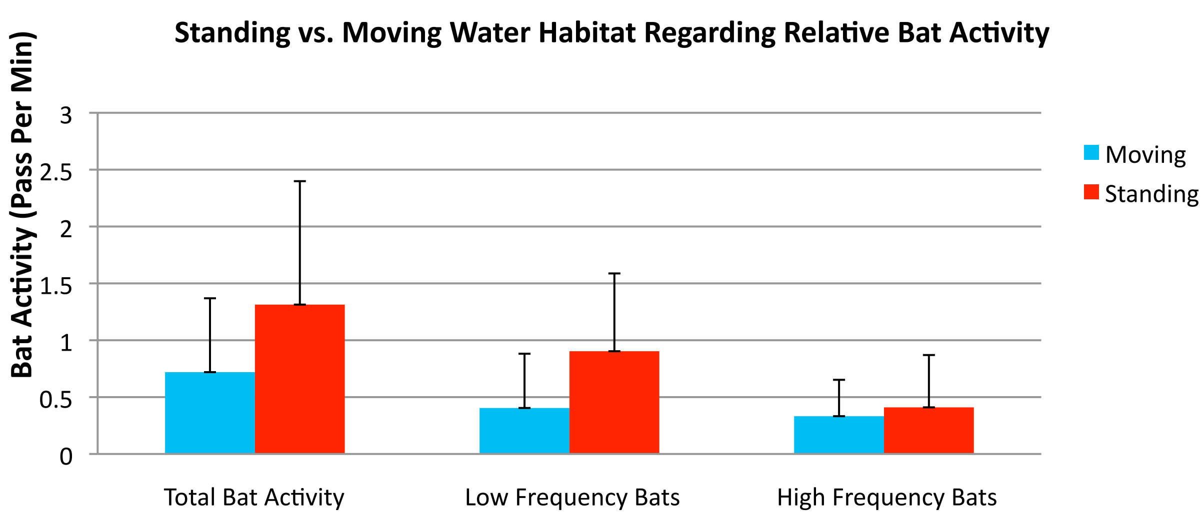

Figure 2: Relative bat activity of standing water versus moving water with the sub-catergories of low and high frequency bats. The bars represent one standard deviation.

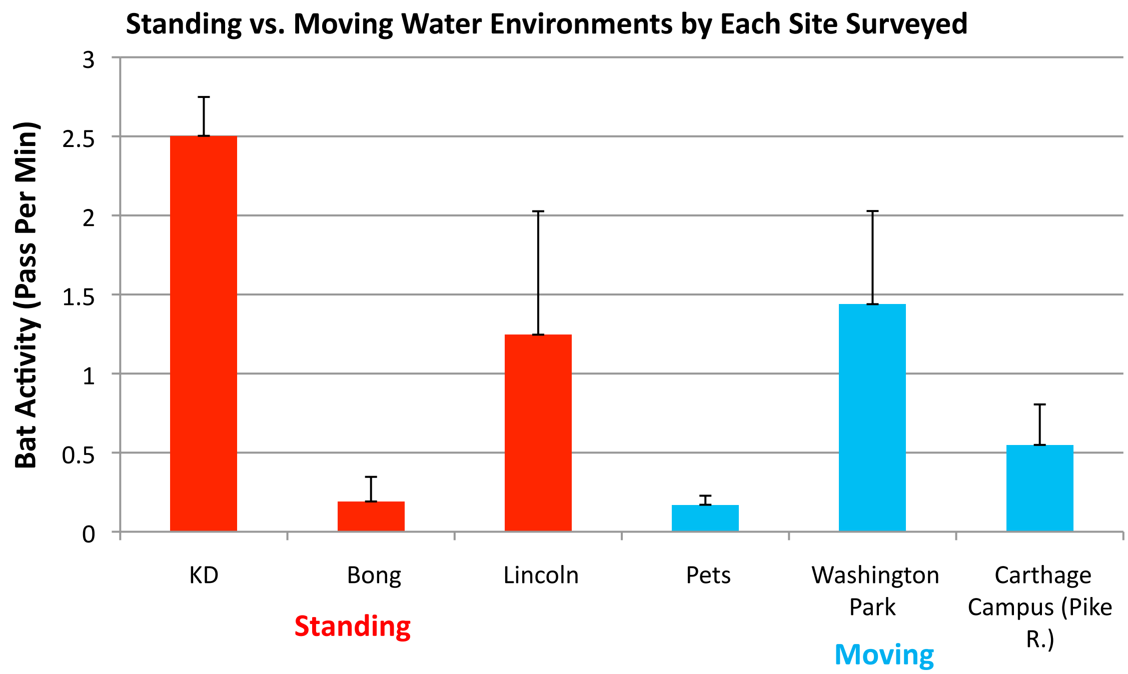

Figure 3: Each site surveyed for standing and moving water are shown above showing more of a comparison of bat activity within the standing versus moving water habitat type. The bars represent one standard deviation.

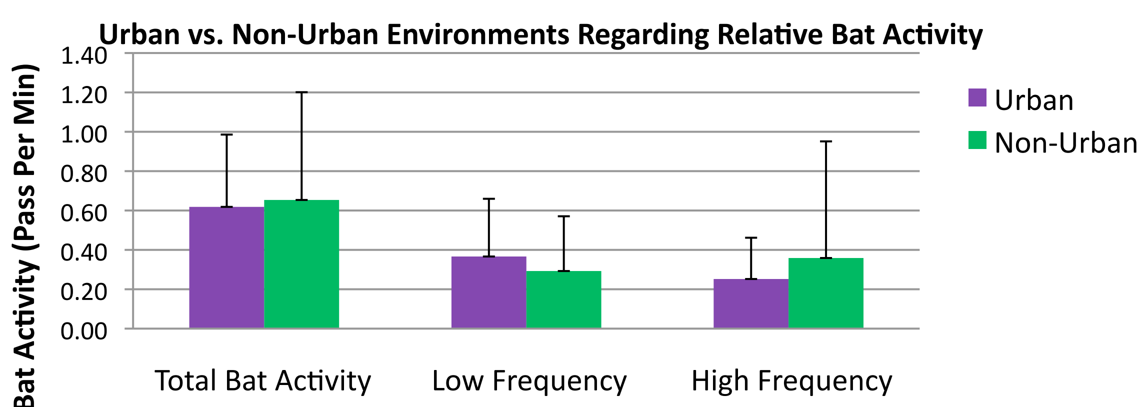

Figure 4: Relative bat activity comparing urban to nonurban enivronments. Also, included are the sub-catergories of low frequency bats and high frequency bats. The bars represent one standard deviation.

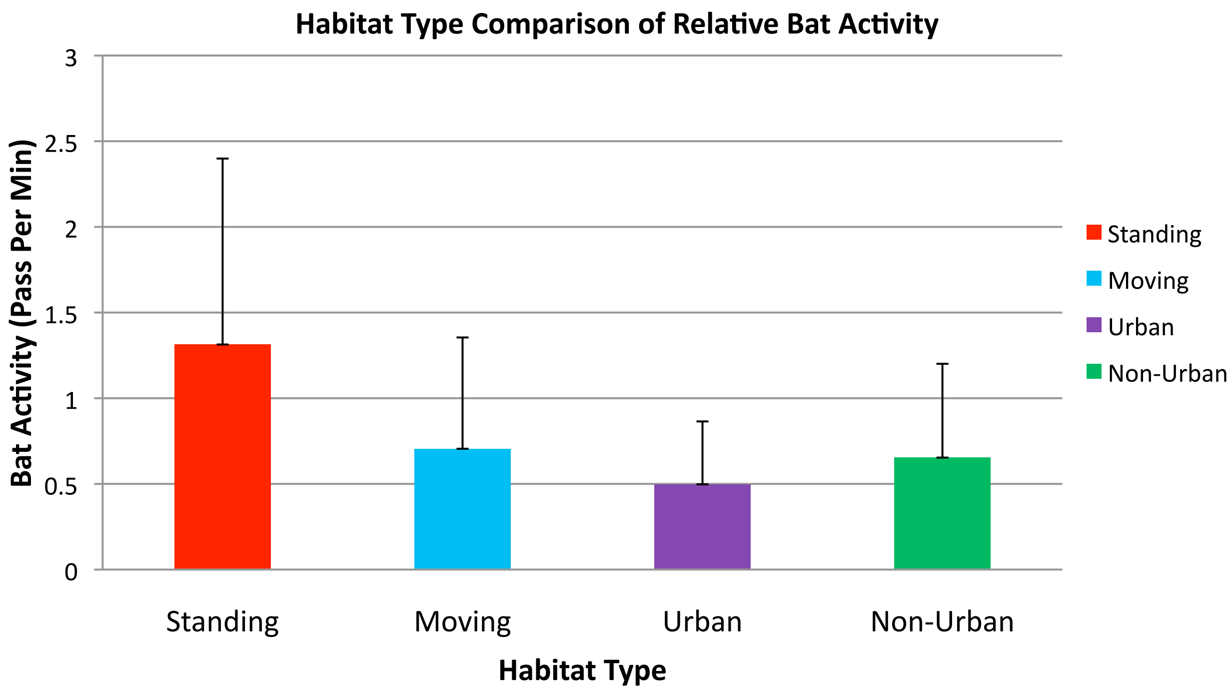

Figure 5: All four habitat classifications (Standing water, moving water, urban environment, and nonurban environment) showing the relative bat activity in passes per minute. The bars represent one standard deviation.

Discussion

Factors that potentially influence the presence, activity, and abundance of a bat species in a habitat include the physical structure of the habitat, abundance of prey, availability of water, microclimate, competition, proximity to roost sites, and exposure to predators (Anthony et al., 1985; Avery, 1985; Bell, 1980; Fenton, 1970; Kunz, 1973). Similarly, the ability of a bat species to use a structural habitat type may depend on its mechanical and perceptual adaptations such as echolocation characteristics, aspect ratios, and wing loading (Fenton, 1990; Norberg and Rayner, 1987). The previously listed variables suggest much opportunity for variability when trying to establish habitat correlations to bat activity.

The results of the water study suggest that bat activity is more concentrated over standing water than moving water. Statistically, however, there is a weak correlation. Figure 2 illustrates total bat activity for the three standing water sites combined and the three moving water sites combined. Figure 2 also shows total bat activity for the high and low frequency bats for the water study. Although bat activity remains higher in at the standing sites for total, as well as high and low frequency bat activity categories, the difference is minimal, with no greater than 0.6 pulses per minute difference in any one category. This supports our initial hypothesis that relative bat activity will be higher over standing water. However, since there is such a minimal difference between the two sites, the effect could be due to chance. One explanation of the higher bat activity over standing water may be due to the varying abundance of insects. We assume bats are general insectivorous predators, and are able to capture prey in proportion to what is available in the area (Von Frenkell and Barclay 1987). The smoother, more predictable surface of pools may make feeding close to the water's surface easier. Further, a calm surface reflects echolocation calls primarily away from the bat. The main echoes the bat receives are therefore potential prey in front of it. Over moving water the acoustic situation is much more cluttered and the bat has to process more echoes, making insect detection potentially more difficult (Von Frenkell, and Barclay, 1987).

However, there are still many variables that influence rates of bat activity. There is an obvious disjunct in the rate of bat activity in KD County Park as compared to other water sites, as it displays the highest rate of activity (Figure 2). Lincoln Park and Washington Park display similar rates of bat activity which may suggest some similar rate of bat activity at standing habitat type as both areas were relatively maintained parks surrounded by a relatively high amount of building structure. Bong Recreational Area and Petrified Springs Park show similar low rates of bat activity which is interesting considering both areas were as secluded as KD County Park, which displayed significantly higher rates of bat activity. Carthage Campus Pike River displayed higher rates of activity than Bong and Petrified Springs, which was not a result that was expected to surface as the Carthage Campus Pike River and Petrified Springs River follow the same river continuum. This suggests that there may be minimal correlation of bat activity to the habitat types of the moving stires or that the percentage of surrounding building structure influences bat activity, as Carthage Campus Pike River was more heavily surrounded by building structure. The reasons for these correlations, however, are unclear.

The results of the development study did not support the initial hypothesis, but instead supported the null hypothesis that there would be no difference in bat activity between urban and non-urban sites. Figure 3 displays the rate of bat activity for all of the urban sites combined and the non-urban sites combined. It also displays that rate of high frequency bat activity and low frequency activity. There is minimal difference in any of the categories. The only difference lays in the inverse relationship of high and low frequency bat activity between urban and nonurban sites. However, this relationship is not statistically significant, and may be due to chance.

This research is critical as the onset of White Nose syndrome becomes an increasingly dominant factor in the vitality of cave roosting bat species populations. Not only did this research highlight habitat areas that bats do and do not utilize, but with continued research there is hope of establishing guidelines of bat habitat preferences and habits so that management and conservation efforts may be formulated around them. This research may be continued using the same sites; however, this research also stands as groundwork for other individuals' personal research questions.

Acknowledgements

First and foremost we thank Dr. Deanna Byrnes for constant patience, reassurance, and leadership – as well as providing us with snacks on our long road trips. Without her positive attitude and humor, we may have given up after the first four ticks.

We also thank the Student Undergraduate Research Experience (SURE) Program at Carthage College and the R.Z.S. Thomas Torhorst Wildlife Conservation Fund through the Racine Zoological Society for support for our project.
Field work was conducted with the help of Kevin Crosby, Bob Hinderholtz and Chuck Gohs with the loan of their canoes, Beth Goeppinger at Richard Bong Recreation Center, Wisconsin Department of Natural Resources volunteers Melissa Keenan and Brian for experience, and Spc. Matt Snorek at Union Grove.

We are grateful to Jonathon Rudie, General Manager of Kenosha County Division of Parks, for allowing us access to Future Kenosha County KD Park, and Petrifying Springs Park to conduct research every week.

Last, but certainly not least, we would like to thank bat specialist Dave Reddell, and conservation ecologist J. Paul White, and the rest of the bat biologists at the Wisconsin Department of Natural Resources for providing us with extra bat sonograms and a layout of protocol for conducting bat monitoring surveys.

Literature Referenced

Anthony, E.L.P., M.H. Stack, and T.H. Kunz., 1981. "Night roosting and the nocturnal time budget of the little brown bat, *Myotis lucifugus:* effects of reproductive status, prey density, and environmental conditions". Oecologia, 51: 151-156.

Avery, M.I., 1985. "Winter activity by pipistrelle bats". The Journal of Animal Ecology, 54: 721-738.

Bell, G.P. 1980. "Habitat use and response to patched of prey by desert insectivorous bats". Canadian Journal of Zoology, 58: 1876-1883.

Fenton, M.B., 1970. "A technique for monitoring bat activity with results obtained from different environments in southern Ontario". Canadian Journal of Zoology, 48: 847-851.

Kunz, T.H., 1973. "Resource utilization: temporal and spatial components of bat activity in central Iowa". Journal of Mammalogy, 54: 14-32.

Gehrt, S. D. and Chelsvig, J. E. 2003. "Bat Activity In An Urban Landscape: Patterns At The Landscape and Microhabitat Scale". Ecological Applications, 13 (4): 939-950.

Gehrt, S. D. and Chelsvig, J. E. 2004. "Species-Specific Patterns of Bat Activity In An Urban Landscape". Ecological Applications, 14 (2): 625-635.

Krusic, Rachel and Neefus, Christopher. 1995. "Habitat Associations of Bat Species in the White Mountain National Forest". The Journal of Wildlife Management, 60 (3): 185-198.

Kunz, T.H., 1973. "Resource utilization: temporal and spatial components of bat activity in central Iowa". Journal of Mammalogy, 54: 14-32.

Norberg, U.M. and J.M.V. Rayner. 1987. "Ecological morphology and flight in bats: wing adaptations, flight performance, foraging strategy and echolocation". Phil. Trans. R. Soc. London B. Biol. Sci. 316:335-427.