

SUMMER BAT ACTIVITY AT WOODLAND SEASONAL POOLS IN THE NORTHERN GREAT LAKES REGION

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Abstract: Woodland seasonal pools in the northern Great Lakes region, limited in this study to northern Wisconsin and Michigan's Upper Peninsula, are potentially important sites for bat feeding and drinking. In order to determine the influence of pool size, hydroperiod, and structural complexity on relative bat activity, I surveyed pools (17 in 2004, eight in 2005 and 2006) at approximately two-week intervals throughout the summer, documenting bat species use with mist nets and AnaBat II echolocation recording systems. In 189 mist net-nights over three summers, I captured 114 individuals and identified 21,591 AnaBat call sequences. Little brown bats (*Myotis lucifugus*) dominated the captures (75.4%) and AnaBat call sequences (83.3%). Northern myotis (*M. septentrionalis*) were less common (19.3% of captures, 6.4% of identified call sequences) but ubiquitous across pools. Four additional species (*Lasiurus borealis*, *L. cinereus*, *Eptesicus fuscus*, and *Lasiorycteris noctivagans*) were more commonly documented at larger pools. Across all years, relative bat activity (as estimated by call sequences per night) was significantly influenced by pool size (more activity at small and large pools than medium pools) and covaried with the proportion of water remaining in the pool. My study emphasizes the utility of pools of all sizes to bats, as larger-bodied bats preferentially use larger pools, while smaller-bodied *Myotis* spp. are capable of foraging at pools of all sizes. Relative activity of all species was secondarily driven by pool hydroperiod, as the number of bat call sequences per night decreased as the amount of open water declined.

Key Words: AnaBat, bat, hydroperiod, mist net, northern hardwood deciduous forest, seasonal forest pool, vernal pools

INTRODUCTION

Recent studies have examined bat activity across habitat types in forests of the eastern United States (e.g., Krusic et al. 1996, Menzel et al. 2002, Owen et al. 2003, Ford et al. 2005, Menzel et al. 2005b, Broders et al. 2006, Loeb and O'Keefe 2006). Although specific site selection is strongly influenced by bat morphology (e.g., wing loading, aspect ratio; Aldridge and Rautenbauch 1987, Brigham et al. 1997), researchers have generally noted that multiple bat species roosting in forests rely on aquatic systems, using these sites for feeding and drinking. This pattern holds true across the spectrum of lacustrine and riverine habitats in the eastern United States (e.g., Zimmerman and Glanz 2000, Owen et al. 2004, Ford et al. 2005) as well as other parts of North America (von Frecknell and Barclay 1987, Grindal et al. 1999, Seidman and Zabel 2001) and Europe (Vaughan et al. 1997, Russo and Jones 2003). Bat use of several palustrine habitats—bogs, fens, and

beaver ponds—also has been addressed (Ellis et al. 2002, Francl et al. 2004, Menzel et al. 2005a).

The role of woodland seasonal pools—dynamic, palustrine systems with hydrologic cycles that fluctuate seasonally and yearly, and sometimes called vernal pools (Colburn 2004)—is less understood for bats. Recent studies have emphasized the importance of woodland seasonal pools to herpetofauna (Preisser et al. 2000, Zedler 2003), invertebrates (Brooks 2000), and small terrestrial mammals (Brooks and Doyle 2001). Given the importance of open water (von Frecknell and Barclay 1987, Francl et al. 2004) and forest canopy gaps to bats (Chrome and Richards 1988, Grindal and Brigham 1995, 1999, Ford et al. 2005), it is plausible that woodland seasonal pools play an important role in bat foraging activities during spring and summer (Brooks and Ford 2005, Paton 2005).

Brooks and Ford (2005) used echolocation surveys to show that bats selectively use woodland

seasonal ponds in a forest-dominated landscape in Massachusetts. Although they found no difference in species composition (five species) among habitat types, the little brown bat (*Myotis lucifugus* LeConte) calls dominated at seasonal pools and northern myotis (*M. septentrionalis* Trouessart) were more commonly recorded at closed-canopy sites (including seasonal pools) over open-canopy wetland sites (Brooks and Ford 2005). Huie's (2002) study of constructed woodland ponds (permanent waterbodies) in Kentucky demonstrated the multi-season use of the sites by multiple bat species, as well. However, bat use of woodland seasonal ponds in the northern Great Lakes region, restricted in this study to northern Wisconsin and Michigan's Upper Peninsula, has not been addressed. Given the variability in woodland seasonal pool size, hydroperiod, canopy cover, and degree of structural complexity (Palik et al. 2001, Colburn 2004), I examined how bat activity differed across the spectrum of these features.

No known study has addressed differences in bat use of woodland seasonal pools across summer months as related to 1) maximum pool size, 2) relative hydroperiod fluctuations, and 3) microhabitat differences across sites. Given the presence of woodland seasonal pools in northern Wisconsin and Michigan's Upper Peninsula (Colburn 2004), this northern Great Lakes region was a suitable locale at which to study the use and relative activity of bats at these dynamic palustrine habitats.

Six species (big brown bat [*Eptesicus fuscus* Beauvois], hoary bat [*Lasiurus cinereus* Beauvois], little brown bat, northern myotis, red bat [*Lasiurus borealis* Müller], and silver-haired bat [*Lasionycteris noctivagans* LeConte]) that inhabit the northern Great Lakes region (Kurta 1995) are known to use seasonal pools or woodland ponds in other regions of the United States (Huie 2002, Brooks and Ford 2005); a seventh, the eastern pipstrelle [*Perimyotis subflavus* F. Cuvier], is likely restricted to areas of Michigan's Upper Peninsula with mines or caves [Kurta 1995]. Given findings from Huie (2002) and Brooks and Ford (2005), I expected to detect all six species at one or more woodland seasonal pools in this three-year study. I predicted that relative activity (as estimated by number of call sequences per survey) at large (> 500 m²), less structurally complex seasonal pools would be dominated by little brown bats, which preferentially feed over open water (Fenton and Barclay 1980). Larger-bodied bats (hoary bat, big brown bat, and silver-haired bat) that are less maneuverable (Aldridge and Rautenbach 1987, Brooks and Ford 2005) also would be relatively more active at larger, open

pools. In contrast, northern myotis should be more active at smaller, more structurally complex sites (Owen et al. 2004, Brooks and Ford 2005). Furthermore, because Brooks (2000) found that insect abundance was directly proportional to pool water volume, I expected that the foraging activity of insectivorous bats would indirectly respond to changes in water levels. Therefore, I predicted that bat activity would decrease as the area of open water decreased.

METHODS

Site Selection

In 2004, I selected 17 woodland seasonal pools for study, based on accessibility, the ability to locate open water in early May, and pool characteristics, including pool size, canopy cover, and structural complexity. Although site selection was nonrandom, at least 12 sites had been part of long-term invertebrate (G. Craig, University of Notre Dame, 1970s–1994, Blackmore et al. 1993) and herpetological (S. Boyd, University of Notre Dame, 1999–present; Boyd and Hollis 2001) studies, and were considered representative of woodland seasonal pools throughout the region. All sites were situated within stands of northern hardwood deciduous forest, dominated by sugar maple (*Acer saccharum* Marsh.), quaking aspen (*Populus tremuloides* Michx.), black ash (*Fraxinus nigra* Marsh.), or birch (*Betula papyrifera* Marsh., *B. alleghaniensis* Britt.). Eleven pools were located at the University of Notre Dame Environmental Research Center (UNDERC; Vilas Co., Wisconsin and Gogebic Co., Michigan), which contains > 50 recognized woodland seasonal pools and 550 ha of aquatic habitats on its 3,035-ha area (ca. UTM NAD27, Zone 16N, 5122300 N, 303900 E). The remaining six pools were located on the adjacent Ottawa National Forest, which covers > 400,000 ha (USDA Forest Service, <http://www.fs.fed.us/r9/ottawa>) in Michigan's Upper Peninsula. Pools were grouped *a posteriori* into three maximum pool size categories: small (N = 5; maximum area of open water < 250 m²), medium (N = 7; 250–500 m²), and large (N = 5; > 500 m²). I continued this study in 2005 and 2006 at a subset of eight pools to examine year-to-year differences in bat activity versus pools' dynamic physical measures. These eight were selected (after the 2004 survey season) to represent the full spectrum of pool physical diversity (canopy closure, maximum pool size [three small, three medium, two large], and structural complexity) and hydroperiod (2004 dry date range: July 5–August 12). Bat activity (number

of call sequences per evening) of the eight did not differ markedly from the original 17 sites ($t = -0.498$, $df = 125$, $p = 0.620$), so that activity patterns could be compared across years.

Pool Physical Characteristics

I measured maximum length (m) and width (m) of open water at each woodland seasonal pool at 10- to 14-d intervals from ca. May 20 to August 15 of each year to estimate pool area (length x width). I recorded the estimated date(s) of drying (pools were visited ca. every 3 d to monitor drying), when no visible surface water existed. To examine rates of desiccation among pools of different initial sizes, I examined area as a proportion, dividing current pool area by maximum pool area (measured in late May of each year).

I measured forest attributes associated with each woodland seasonal pool to examine the influence of microhabitat features on bat use. To estimate structural complexity in the canopy region, percent tree canopy cover was measured from the middle of the pool with a concave spherical densiometer (average of four readings facing in each of the cardinal directions; Forestry Suppliers, Inc., Jackson, Mississippi, USA). To account for structural complexity at the water's surface, I counted the number of vertical snags, mature trees, and saplings ($dbh \geq 5$ cm) located in or having branches extending into the area encompassing the maximum extent of open water. Therefore, I calculated tree density as the number of trees per m^2 of maximum open water.

Bat Surveys

Bats were surveyed from May 20 to August 15 of each year, depending on suitable weather conditions: temperature $\geq 10^\circ\text{C}$ for entirety of mist-netting effort, and no rain events or strong winds. In 2004, I mist netted each of the 19 sites five times, at 10- to 14-d intervals. With fewer sites in 2005 and 2006, I preferentially selected nights with forecasted temperatures well above the 10°C minimum, and I completed seven rounds in 2005 and six rounds in 2006.

At each site, I set two 2.6-m high (38 mm nylon mesh, reduced-bag; Avinet, Inc., Dryden, New York, USA) mist nets (6 m, 9 m, or 12 m) 60° – 90° from one another, maximizing the greatest span across open water. If two sites were surveyed in one night (as was typically the case), I counted this night as two mist-net-nights. Nets were open from sunset until 4 h after sunset when the first bout of bat

activity typically declines (Milne et al. 2004). All captured bats were identified, weighed, measured (forearm length), sexed, and aged (juvenile versus adult, by examining degree of epiphyseal-diaphyseal fusion; Anthony 1988). I shaved a 1-cm^2 section of fur on the dorsal surface of the bat to be able to document recaptures over each summer. Upon release (closest open area within 30 m of capture point—typically a gravel road), I recorded the individual bat with an AnaBat II detector and AnaBat V ZCAIM unit (Titley Electronics, Ballina, Australia) for as long as it was within range. Although capture data were not statistically analyzed (sample sizes were too small across pools and dates), they were used to reinforce correct call identification from the Anabat II detection surveys.

Throughout the mist netting effort, I recorded bat echolocation calls with an AnaBat II detector (sensitivity set to 6, previously found to record most bat calls but no insect interference; Brooks and Ford 2005) and AnaBat V ZCAIM unit (calls stored on a compact flash card to maximize quality). I used the same location for each repeated pool visit. I positioned the recorder so that structural complexity was minimized and hence, bat detection was maximized (Johnson et al. 2002, Francel et al. 2004, Brooks and Ford 2005). Although active recording was occasionally utilized, the detector remained pointed above and across the water to maximize bat recognition over the pool. Additionally, initial comparisons of active vs. passive recording techniques revealed no significant differences in the number of recorded call sequences. A single call sequence was defined as the 15-sec recording saved as a unique file by the AnaBat system. I filtered call sequence records prior to analysis (AnaBat default filters 6–9 or “newfilt” by Britzke and Murray 2000), and identified call sequences to species using call variables displayed in Analook 4.7j (C. Corben, <http://users.lmi.net/corben/AnaBat.htm>) and Analyze 2.3 software (S. Jolly, Titley Electronics, Ballina, Australia). Only sequences with ≥ 3 individual pulses were analyzed (Johnson et al. 2002, Francel et al. 2004).

I identified bat call sequences to species using a dichotomous key based on call frequency, slope, and curvature values for the seven species potentially inhabiting the northern Great Lakes region (Johnson et al. 2002, Owen et al. 2004, M. A. Menzel unpublished data). This key has been utilized in numerous studies in the mid-Atlantic and northeastern United States (e.g., Francel et al. 2004, Brooks and Ford 2005, Ford et al. 2005) with similar bat communities. The call attribute thresholds coincide with results from Britzke's (2003)

linear discriminant function analyses. To acknowledge within- and between-species variation in call characteristics, I supplemented this key with call characteristics of hand-released bats from the current study and call sequences shared among researchers working in Michigan (unpublished data from L. Kruger, Michigan Technological University, A. Kurta, Eastern Michigan University, and M. Wund, University of Michigan), as well as calls provided with the Analook software (C. Corben, <http://users.lmi.net/corben>). To further acknowledge within-species call plasticity of *Myotis* spp. across habitat types and degrees of spatial complexity, I supplemented this modified key with Wund's (2006) little brown bat call characteristic ranges according to habitat structure. However, if the identity of the *Myotis* call sequence remained questionable, the identification defaulted to "*Myotis* spp." Although feeding buzzes frequently occurred throughout surveys, they were not quantified in this study.

Because bat activity has shown to be affected by temperature (Vaughan et al. 1997), I documented temperature on-site 4 h after sunset (as an indicator of coolest temperature during recordings) using a Kestrel 3000 (Nielsen-Kellerman, Boothwyn, Pennsylvania, USA). Although moon phase and cloud cover also were recorded, initial analyses showed no discernible relationship to bat activity and these factors were not included in subsequent analyses.

Statistical Analyses

Statistical analyses were performed using either Systat 10.0 (SPSS, Inc., Chicago, Illinois, USA) or SAS 9.1 (SAS Institute, Inc., Cary, North Carolina, USA). For all analyses, call sequences per survey (number per 4 h) and proportion of water remaining both were square-root-transformed to ensure normality ([skewness/standard error of skewness] < 2.0). In SAS, I ran a mixed linear model to examine bat activity (call sequences per survey) across pool size categories with repeated measures (year with round embedded accounted for substantial variation within and between years, but was not examined as a treatment). Additionally, proportional water remaining was a covariate, as larger pools in this study held water later into the summer. A post-hoc least-square means comparison further determined which pool sizes differed from one another.

To determine if individual species were more active in particular pool-size categories, I used separate analyses of variance to examine species activity (average number of call sequences per round per year) across pool sizes and years. Additional analyses of variance examined trends in habitat

variables (tree density, canopy coverage) across pool size categories.

RESULTS

Pool Physical Characteristics

Maximum pool area ranged from 0–2,133 m² across sites and years. Maximum areas of open water were smaller (\bar{x} = 51.1%; range 0.4%–100% decrease in maximum area) in 2005 compared to 2004, but fairly comparable (\bar{x} = 2.2% decrease in maximum area; range 50.4% increase in maximum area — 24.9% decrease in maximum area) in 2006. The initial and final dates of pool drying varied among years, with one small pool remaining dry throughout the 2005 season. Multiple dry dates for some pools were recorded in 2005 and 2006, due to heavy late-July rain events in both years (specific dates available from the author). The lowest temperature recorded for the surveyed evenings (4 h after sunset) in 2004 (\bar{x} = 15.0°C) was significantly lower (ANOVA, F = 8.293, p < 0.001) than that in 2005 (\bar{x} = 18.0°C; Tukey's p = 0.001) and 2006 (\bar{x} = 17.5°C; Tukey's p = 0.008) but the latter two years did not differ (Tukey's p = 0.869).

In examining habitat variables across pool size categories, I found canopy cover was significantly less in large pools (\bar{x} = 73%, range 24%–98%) as compared to both medium (\bar{x} = 96%, range 91%–99%) and small ones (\bar{x} = 98%, range 96%–100%; ANOVA, F = 19.219, p < 0.001; Tukey's p < 0.001), but that tree density (range 0.0–0.20 per m²) did not differ across pool sizes (large \bar{x} = 0.066 per m², medium \bar{x} = 0.027 per m², small \bar{x} = 0.010 per m²; F = 1.069, p = 0.356).

Bats Surveys

One hundred fourteen adult individual bats were captured and 21,591 AnaBat call sequences recorded and identified over three summers (189 mist net nights). Relative bat activity was highest within the first 60 min after sunset, in which 46.6% of all calls were recorded across all years. Richness, based on captures and AnaBat identifications, ranged from one bat species (at one small pool) to six (at one large pool and one medium pool) per site within a single year. Little brown bats, documented at 16 of 17 pools, dominated the captures (75.4%) and AnaBat call sequences (83.3% of call sequences) across years. I recorded northern myotis at all 17 sites, but they accounted for just 19.3% of captures and 6.4% of all AnaBat call sequences across all years. Four additional species (red bat [eight pools],

Table 1. Average number of bat species echolocation call sequences per 4-h AnaBat survey (\pm 95% CI) for three sizes (small, medium, large) of northern Great Lakes region woodland seasonal pools in 2004 (N = 17 pools; five dates), 2005 (N = 8 pools; seven dates), and 2006 (N = 8 pools; six dates).

Species	Small		Medium		Large	
	Average	CI	Average	CI	Average	CI
<i>Eptesicus fuscus</i>						
2004	0.04	0.08	0	0	3.88	5.33
2005	0.10	0.19	0.48	0.44	16.14	17.67
2006	0.06	0.13	0.39	0.80	5.42	6.12
<i>Lasiurus borealis</i>						
2004	0.42	0.46	0.14	0.28	1.00	1.53
2005	0.14	0.28	0.29	0.47	0.21	0.42
2006	2.78	2.26	0.11	0.18	9.75	6.02
<i>Lasiurus cinereus</i>						
2004	0	0	0	0	0	0
2005	0	0	0	0	1.36	2.13
2006	0	0	0.06	0.13	28.50	39.76
<i>Lasionycteris noctivagans</i>						
2004	0	0	0	0	0	0
2005	0.05	0.09	0	0	7.14	9.79
2006	0.06	0.13	0.11	0.27	9.17	11.89
<i>Myotis lucifugus</i>						
2004	88.29	28.19	77.89	21.72	75.92	23.28
2005	132.67	39.74	67.86	32.08	189.57	51.89
2006	92.39	24.82	70.22	37.78	127.25	40.06
<i>Myotis septentrionalis</i>						
2004	9.04	4.60	8.69	3.14	3.79	2.16
2005	3.00	1.41	6.29	2.76	0.86	0.65
2006	3.44	1.39	2.78	3.92	38.42	42.55
Unidentified <i>Myotis</i> spp.						
2004	5.67	2.38	6.86	2.52	5.63	2.74
2005	5.14	2.67	4.81	2.30	5.36	3.18
2006	4.94	2.16	3.61	2.55	5.25	2.06

hoary bat [three pools], big brown bat [five pools], and silver-haired bat [four pools]) were captured and/or recorded less frequently at these sites (Table 1). Calls identified only to *Myotis* spp. accounted for 4.7% of calls across all years.

Only two little brown bats were recaptured during the study; both recaptures occurred within the same evening's survey at the same pools in which they were originally captured. I did not recapture any other marked individuals across dates or sites.

Although not significant, average bat activity marginally differed across all dates ($F = 2.03$, $p = 0.135$) in 2005 ($\bar{x} = 138.0 \pm 29.0$ call sequences per survey) as compared to 2004 ($\bar{x} = 92.6 \pm 72.7$ call sequences per survey); 2006 ($\bar{x} = 123.9 \pm 28.6$ call sequences per survey) did not differ from the previous years.

Bat activity (call sequences per survey; as repeated measures across years) differed across pool sizes ($F = 9.71$, $df = 2$, $p < 0.001$) and according to the proportion of water remaining (as a covariate;

$F = 6.60$, $df = 1$, $p = 0.011$). Bat activity was greater at large (Estimate = 3.304, SE = 0.760, $df = 185$, $t = 4.35$, $p < 0.001$) and small (Estimate = 1.842, SE = 0.721, $df = 185$, $t = 2.56$, $p = 0.040$) pools when compared to medium-sized pools (Scheffe test). However, large and small pools did not differ (Estimate = 1.462, SE = 0.784, $df = 185$, $t = 1.87$, $p = 0.178$).

Both *Myotis* species exhibited similar activities among pool sizes across all years (Table 2). However, when all *Myotis* calls (including unidentified *Myotis* spp.) were considered, I found marginally higher ($p = 0.081$) activity at large and small pools as compared to medium-sized pools. Just one species, the big brown bat, was consistently more active at larger pools over small and medium pools across all survey years (Table 2). Three species (red bat, silver-haired bat, and hoary bat) showed high activity levels at larger pools than both small and medium ones, but trends were inconsistent across years (Table 2).

Table 2. Analyses of variance for individual bat species activity (average number of call sequences per survey by year) across woodland seasonal pool size ($df = 2$), year ($df = 2$), and size-year interaction ($df = 4$; F-statistic, p-value listed for each). Activity trend indicates which woodland seasonal pool size(s) significantly differed and if trend was consistent across three survey years (Y; accounting for interaction).

Species	Pool size		Year		Size*year		Activity trend
	F	p	F	p	F	p	
<i>Eptesicus fuscus</i>	10.04	0.001	2.48	0.105	1.07	0.394	Large > medium, small
<i>Lasiurus borealis</i>	7.86	0.003	14.67	< 0.001	5.66	0.002	Large > medium, small (Y3 only)
<i>Lasiurus cinereus</i>	6.17	0.007	4.48	0.022	3.61	0.019	Large > medium, small (Y3 only)
<i>Lasionycteris noctivagans</i>	8.61	0.002	4.40	0.024	2.89	0.044	Large > medium, small (Y2, Y3)
<i>Myotis lucifugus</i>	2.39	0.113	2.03	0.154	1.07	0.395	None
<i>Myotis septentrionalis</i>	0.10	0.903	1.04	0.37	1.67	0.191	None
All <i>Myotis</i>	2.80	0.081	1.64	0.214	1.25	0.318	Large, small > medium

DISCUSSION

In this three-year study, I detected six bat species across a set of 17 woodland seasonal pools. Overall bat activity was higher at the larger and smaller pool sizes, trends driven by larger-bodied bat activity being concentrated at large pools and *Myotis* activity being marginally higher at both large and small pools (Table 1, 2). Canopy cover was related to pool size (lower over the larger pools). However, tree density (one measure of structural complexity) did not show clear trends.

My prediction that bat activity would decrease in direct relation to the area of open water was supported, suggesting that bats visit these pool habitats, partly because of the water they may provide, and partly because the seasonal pools provide an opening in the canopy gap for less obstructed flight and foraging (Chrome and Richards 1988, Grindal and Brigham 1995, 1999, Ford et al. 2005). My examination of species-specific trends further supports this conclusion. Specifically, larger-bodied big brown, silver-haired, red, and hoary bats generally were more commonly recorded at the larger pools with less canopy cover, although activity trends were inconsistent across years for three of the four species (Table 2). This may simply be an artifact of low detection rate, as two species (hoary bat, silver-haired bat) were undetected in the first survey year and the other two (red bat, big brown bat) averaged less than one call sequence per survey in that year (Table 1). However, in years when overall detection of these species was higher, my data support the idea that bat morphology and habitat structure are factors in bat activity levels across habitats—that is, large-bodied, less maneuverable species more commonly forage in open habitats (Aldridge and Rautenbach 1987, Norberg and Rayner 1987, Brooks and Ford 2005). Little brown bats and northern myotis showed no marked

activity difference across pool size; perhaps the ubiquity of bats in this genus across all sites support their general preference for the presence of open water (of a wide range of sizes; Fenton and Barclay 1980) or simply small canopy gaps in a forested environment (Barbour and Davis 1969). Owen et al. (2003) found that northern myotis in the central Appalachians could successfully use small forest canopy gaps—gaps too small for larger-bodied bats to efficiently forage. Similarly, the seasonal pools in my study might serve the same purpose in this northern Great Lakes region. Furthermore, although Owen et al. (2003) did not specifically examine the influence of forested waterbodies on the landscape, the authors noted that capture success was higher over ephemeral pools as compared to riparian habitats. Future studies comparing these sites to forest gaps and other wetlands lacking permanent open water may elucidate such differences.

Due to the dynamic nature of these woodland seasonal pools, I found marginally significant differences in bat activity between two of the three survey years. Because bats are probably “choosing” these pools based on structural features (canopy cover) in combination with the proportional amount of water remaining, it is not surprising that activity varied to some extent across years.

Although the reliability of species identifications with recordings from the AnaBat II detection system has been questioned (Barclay 1999, Fenton 2001), multiple studies support this system’s value in assessing relative bat habitat use (Ellis et al. 2002, Francl et al. 2004, Owen et al. 2004, Brooks and Ford 2005, Menzel et al. 2005b). Additionally, by using the same call characteristics used to detect inter- and intraspecific differences in other habitats (Wund 2006), confidence that my call identifications were correct is bolstered. Furthermore, the combined use of mist netting and acoustic surveys helped minimize inherent biases; AnaBat can underestimate the relative

abundance of species with low intensity echolocation calls (Murray et al. 1999). Both mist nets and AnaBat call sequence identifications indicated that little brown bats were dominant at my study sites.

While Brooks and Ford (2005) showed that differences existed in bat activity levels among habitat types in a forested landscape of the northeastern United States, my study identified patterns and preferences across a spectrum of microhabitat features associated with woodland seasonal pools. My findings in the northern Great Lakes region emphasize that woodland seasonal pools were used by bats throughout the summer months, with relative activity being influenced by pool size (and related canopy measures) and hydroperiod. These microhabitat differences among sites may permit some partitioning among bat species across a spectrum of structural complexity and water availability.

These results might be useful in improving forestry Best Management Plans (BMP), which recognize water resources and wildlife management as fundamental components of sustainable forest management (Stuart and Edwards 2006). Regional BMPs have proven effective in maintaining water quality and protecting aquatic resources in forested habitats. Because bat species differ in relative activity levels among pool sizes, my research suggests that maintaining woodland seasonal pools of various sizes may have biological value.

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