HABITAT ASSOCIATIONS AMONG BATS ON

REDSTONE ARSENAL, ALABAMA

Except where reference is made to the work of others, the work described in this thesis is my own or was done in collaboration with my advisory committee. This thesis does not include proprietary or classified information.

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HABITAT ASSOCIATIONS AMONG BATS ON REDSTONE ARSENAL, ALABAMA

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HABITAT ASSOCIATIONS AMONG BATS ON

REDSTONE ARSENAL, ALABAMA

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VITA

Sara Elizabeth Gardner, daughter of Gary Thomas and Ruth Ann Gardner, was born 6 July 1981 in Atlanta, Georgia. In 1999, she graduated *magna cum laude* from Cleveland High School in Cleveland, Tennessee. In 2003, she graduated from Middle Tennessee State University in Murfreesboro, Tennessee, with a Bachelor of Science degree in Biology with a concentration in plant biology. After working as a Research Science Technician for the Missouri Department of Conservation for 2 years, she decided to further her academic education. She entered graduate school at Auburn University in August 2005, where she worked as a Graduate Teaching Assistant and Graduate Research Assistant in the Department of Biological Sciences during her graduate program.

THESIS ABSTRACT

HABITAT ASSOCIATIONS AMONG BATS ON

REDSTONE ARSENAL, ALABAMA

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As forests become more fragmented, more research about use of forests by bats at the landscape level is needed. I employed 2 methods to investigate use of forest by foraging bats; mist-net surveys and ultrasonic-detection surveys. I sampled at a total of 341 sites (248 mist-net sites and 93 ultrasonic-detection sites). I captured 185 bats in mist nets at 82 sites representing 7 species, and I ultrasonically detected bats at 45 sites representing 6 species. This study documented use of Redstone Arsenal as foraging habitat for one endangered species (*Myotis grisescens*) and two species of highest conservation concern (*M. austroriparius* and *M. septentrionalis*). I also compared number of species detected per night using the 2 methods. The ultrasonic-detection method detected more species per night. Unlike other studies, I detected more species overall using mist-net surveys (7 species) than ultrasonic detection (6 species). All species that I recorded using ultrasonic-detection were captured in mist nets.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

HABITAT ASSOCIATIONS OF BATS ON REDSTONE ARSENAL, MADISON CO., ALABAMA, AS DETERMINED BY MIST-NET SURVEYS

ABSTRACT

Little is known about the ecology of forest-dwelling bats, particularly their foraging ecology. I assessed associations of foraging habitats and bats in northern Alabama by capturing bats in mist nets and comparing species of bats captured to types of habitats. Multivariate analysis of variance indicated that the eastern red bat (*Lasiurus borealis*) was associated with evergreen forest, southeastern myotis (*Myotis austroriparius*) was associated with open water and wetlands, evening bat (*Nycticeius humeralis*) was associated with wetlands, and perimyotis (*Perimyotis subflavus*) was associated with open water. This study provided data for use in creating management plans for foraging habitat among southeastern species of bats.

INTRODUCTION

Previous studies of the ecology of bats focused on species that use caves or man-made structures. Recently, interest in learning more about ecology of bats has focused on forest-dwelling species and answering questions related to management of forested habitats to promote continued use by bats (Brigham 2007; Miller et al. 2003). Generally, use of landscape in forested habitats by bats for foraging is not known (Kalcounis-Rüppell et al. 2005; Miller et al. 2003), but we do know that biodiversity in forests is being lost due to habitat fragmentation (Fahrig 2003; Gorresen and Willig 2004) and that patches of remnant forest are becoming increasingly important for bats (Evelyn and Stiles 2007). There is not sufficient information to supply land managers with advice about managing forests to assure presence of appropriate foraging habitats for bats (Miller et al. 2003). Miles et al. (2006) contended that more landscape-level investigations of use of habitats by bats are needed. Composition of landscape (Gorresen and Willig 2004) and type of forest (Kalcounis et al. 1999; Patriquin and Barclay 2003) can be used to determine abundance of species. Gorresen et al. (2005) suggested that it is necessary to use a range of scales at which bats function to determine use of landscape because the landscape is used for both roosting and foraging. This information is crucial in developing management plans for species listed as threatened or endangered by federal and state wildlife-management agencies.

The bat fauna of Alabama includes 15 species; southeastern myotis (*Myotis austroriparius*), gray myotis (*M. grisescens*), little brown myotis (*M. lucifugus*), northern myotis (*M. septentrionalis*), Indiana myotis (*M. sodalis*), perimyotis (*Perimyotis subflavus*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), northern yellow bat (*L. intermedius*), Seminole bat (*L. seminolus*), evening bat (*Nycticeius humeralis*), Rafinesque's big eared bat (*Corynorhinus rafinesquii*), and Brazilian free-tailed bat (*Tadarida brasiliensis*--modified from Best 2004*b*; Hall 1981; Harvey et al. 1999). Two of these species are listed as endangered by the United States Fish and Wildlife Service (*M. grisescens* and *M. sodalis*), one is a state-listed species of highest conservation concern (*C. rafinesquii*), five are of high conservation concern (*L. intermedius*, *M.*

austroriparius, *M. lucifugus*, *M. septentrionalis*, and *T. brasiliensis*), and two are poorly known (*L. noctivagans*, *L. cinereus*; Best 2004*a*).

Relatively little is known about the ecology of bats in Alabama, but considerable research has been conducted within the past 2 decades (e.g., Best and Hudson 1996; Best et al. 1993; Goebel 1996; Henry 1998; Kiser 1996, 2000; Milam 1996; Thomas and Best 2000). Bats occurring on Redstone Arsenal, Madison Co., Alabama, are of special interest because two endangered species are known from the area, *M. grisescens* and *M. sodalis*. In preparing management plans, it is desirable to know if either of these species is present and what habitats they may occupy. Goals of this study were to 1) determine species of bats present on Redstone Arsenal, 2) determine habitat associations at 3 spatial scales, 3) elucidate any differences between capture and random sites, 4) and recommend management practices for Redstone Arsenal, especially for endangered species.

MATERIALS AND METHODS

The study area, Redstone Arsenal, Alabama, includes 15,305 ha in southwestern Madison County. It has been an active military installation since 1941, and it was first used for construction and disposal of chemical-warfare agents. Currently, Redstone Arsenal is headquarters for rocket and missile design and testing by the National Aeronautics and Space Administration (NASA) and the United States Army. Redstone Arsenal is part of the Tennessee Valley physiographic region and is bordered to the south by the Tennessee River. Habitat communities on Redstone Arsenal are upland forest, wet-mesic river floodplain forest, forested palustrine wetlands, springs, and caves (J. C. Godwin and J. L. Hilton, in litt.). I used mist nets to capture bats at 248 sites on Redstone Arsenal in July 2005 (13 sites), May-July 2006 (111 sites), and May–July 2007 (124 sites). I attempted to mist net bats in as many areas as possible and selected netting sites in areas where I believed a bat could be captured (Fig. 1.1). Mist nets were placed on or near forest roads, fire breaks, ponds, and creeks. Mist nets ranged in size from 2.6 to 18 m in length, each being 2.6-m high, and size of net used depended upon size of the feature that was netted. I used a double-stacked configuration at most sites where 1 net was stacked on top of another to increase sampling area. For features that were not large enough to contain a double-stacked net, I used a single-high mist net. Where possible, nets were placed so that vegetation surrounded the sides and top of the net to prevent bats from flying around the net. Each net remained open for a total of 6 hours/night (2000-0200 h). Data on collecting sites, species captured, date and time of capture, sex, age (adult or young-of-year), and reproductive condition, were recorded. Age-group was determined by inspecting the degree of ossification of the epiphyseal plates in joints of the phalanges (Anthony 1988).

I collected coordinates for each sampling site using a Global Positioning System (GPSmap76, Garmin International, Inc., Olathe, Kansas). A landscape-level dataset was obtained from the National Land Cover Database (NLCD) 2001 (Limpert et al. 2007); this database describes 21 classes of land-cover types throughout the United States and was created using high-resolution imagery (J. E. Vogelmann et al., http://seamless.usgs.gov/). I merged 13 classes of landcover that occurred on Redstone Arsenal as described by Aebischer et al. (1993) and investigated 8 types of land cover including open water (rivers, streams, lakes, and ponds), developed land (included buildings and roads), deciduous forest, evergreen forest, mixed forest, scrub (present at edge of forest), open pasture, and wetland (marshes and wooded wetlands). I also used an existing ArcMap data layer obtained from the Natural Resources Division at Redstone Arsenal. The UTM coordinates for each sampling site were imported into ArcMap (Environmental Systems Research Institute 2005). I created 250, 500, and 1,000-m buffers i.e., a specified radius around a given point, used to calculate habitat, around each site (Kennedy 2006). These buffers related to average foraging distances of bats captured (Limpert et al. 2007). Buffers were intersected with a layer of land-cover data for the area covered by Redstone Arsenal plus an area 3 km outside the perimeter for buffers that extended beyond the Arsenal. Next, amount of each habitat (in m^2) within each buffer was calculated using the calculate-area tool in ArcMap. I also created 250 random points to compare with points where nets were placed; the same procedure for creating buffers and calculating amount of habitat was followed. Area of each habitat in the three buffers was calculated for sites where bats were captured, where bats were not captured, and random points. A species was indicated as present (was captured) or absent (was not captured) at sites where nets were placed.

To adequately describe habitats occupied by each species, I performed analyses when ≥10 individuals of that species were captured (Aebischer et al. 1993). Habitat associations were tested using multivariate analysis of variance (MANOVA; McCune and Grace 2002). MANOVA was used to detect differences between habitat variables at sites where bats were captured versus where bats were not captured, at sites where bats were captured versus random points, and at sites where an attempt to capture bats was made (includes capture sites and no-capture sites) versus random points. I also performed GLM (General Linear Models) to see which variables were influencing dependent variables. These tests were performed at each spatial scale for each species; alpha-level was $P < 0.05$.

RESULTS

During July 2005, May–July 2006, and May–July 2007, 248 sites were sampled and 185 bats were captured, representing 7 species (Table 1.1). Because samples for 6 species were large enough, ecological associations of these species were analyzed statistically. Bats were captured at 82 sites. Although positively identified to species, age, sex, and reproductive condition of 13 individuals were not determined due to their escape from the net.

Capture sites versus no-capture sites.--At the 250-m spatial scale, when all capture sites (7 species included) were combined and compared to all no-capture sites, there was a statistically significant difference (Wilk's $\Lambda = 0.934$ $P = 0.036$); developed habitat ($F = 7.02$, $P = 0.009$) was more abundant at no-capture sites and wetland habitat ($F = 8.91$, $P = 0.003$) was more abundant at capture sites. I also wanted to see if there was any difference between groups, i.e., capture sites and no-capture sites, at the species level, so I performed a MANOVA for each species. I tested for differences between capture and no-capture sites for all sites where a species was captured versus all sites where that species was not captured. All habitat variables differed between capture and no-capture sites for *M. austroriparius* (Wilk's $\Lambda = 0.926$, $P = 0.018$). Univariate (general linear model; GLM) analysis indicated that the most important differences between capture and no-capture sites were scrub ($F = 4.47$, $P = 0.035$) and wetland habitats ($F = 11.21$, $P = 0.001$) for *M. austroriparius* (Table 1.2). When I plotted average area of each habitat type for sites where *M. austroriparius* was captured and sites where the species was not captured (Fig. 1.3), there was a greater amount of scrub habitat where *M. austroriparius* was not captured and a greater amount of wetland habitat where the species was captured. When I plotted average areas of each habitat type for all species, I ascertained that, for *N. humeralis,* there was significantly less developed land ($F = 4.42$, $P = 0.036$) and more wetland habitat ($F = 6.34$, $P = 0.013$) at sites where *N. humeralis* was captured resulting in a habitat association with wetland and not with developed land. No significant habitat variable was associated with captures of *E. fuscus*, *L. borealis*, *M. grisescens*, or *P. subflavus*.

At the 500-m spatial scale, when all captures were combined and compared to no-capture sites, there was no statistically significant difference, but developed land ($F = 7.02$, $P = 0.009$) was more abundant at no-capture sites. Wilk's Λ was not significant for any species. I plotted average area of each habitat type as done for the 250-m buffer and determined there was a greater amount of evergreen habitat ($F = 4.76$, $P = 0.030$) present at sites where *L. borealis* was captured, indicating a habitat association (Fig. 1.4). Wetland ($F = 12.53$, $P = 0.001$) habitat was a significant habitat association for *M. austroriparius*. Developed land ($F = 4.71$, $P = 0.031$) was greater at sites where *N. humeralis* was not captured, indicating that *N. humeralis* is not associated with developed land. Open water ($F = 4.44$, $P = 0.036$) was associated with capture of *P. subflavus* and mixed forest ($F = 5.06$, $P = 0.025$) habitat was associated with not capturing *P. subflavus*. There was no significant variable associated with captures of *E. fuscus* or *M. grisescens*.

At the 1,000-m spatial scale, when all captures were combined and compared to no-capture sites, there was no statistically significant difference, but more open water habitat ($F = 5.81$, $P = 0.017$) occurred at capture sites. Habitat variables differed between capture and no-capture sites for one species, *M. austroriparius* (Wilk's $\Lambda = 0.907$, $P = 0.003$). The univariate portion of this analysis indicated that more open water ($F = 4.14$, $P = 0.043$) and wetland ($F = 11.67$, $P = 0.001$), and less deciduous forest ($F = 4.99$, $P = 0.026$) and mixed forest ($F = 5.52$, $P = 0.020$) were statistically significant habitat associations for *M. austroriparius* (Fig. 1.5). Mixed forest ($F = 4.16$, $P = 0.043$) habitat occurred significantly more at sites where *P. subflavus* was captured, resulting in a habitat association. There was no statistically significant habitat association for *E. fuscus*, *L. borealis*, *M. grisescens*, or *N. humeralis*.

Capture sites versus random sites.--At the 250-m spatial scale, when all captures were combined and compared to random sites, there was a statistically significant difference (Wilk's $\Lambda = 0.891$, $P < 0.001$); deciduous forest ($F = 6.73$, $P = 0.010$) was more prevalent at capture sites, while open pasture ($F = 4.99$, $P < 0.001$) was more prevalent at random sites. Habitat variables differed between capture and random sites for *E. fuscus* (Wilk's $\Lambda = 0.935$, $P = 0.018$), *L. borealis* (Wilk's $\Lambda = 0.932$, $P = 0.011$), and *M. austroriparius* (Wilk's $\Lambda = 0.935$, $P = 0.028$). The univariate portion of the analysis indicated that presence of more evergreen forest ($F = 4.27$, $P = 0.040$), mixed forest ($F = 6.16$, $P = 0.014$), and scrub ($F = 4.75$, $P = 0.030$) habitats were associated with capture of *L. borealis* (Fig. 1.6). There was no habitat association for *E. fuscus*, *M. grisescens*, *P. subflavus*, *N. humeralis*, or *M. austroriparius*.

At the 500-m spatial scale, when all captures were combined and compared to random sites, there was an overall difference (Wilk's $\Lambda = 0.901$, $P = 0.037$), and developed ($F = 22.70$, $P < 0.001$), deciduous forest ($F = 6.45$, $P = 0.012$), and wetland ($F = 17.15$, $P < 0.001$) habitats were significantly different between capture sites and random sites. Overall, there was a greater amount of developed habitat at random sites and a greater amount of deciduous forest and wetland habitats at capture sites. Habitat variables differed between capture and random sites for *E. fuscus* (Wilk's $\Lambda = 0.943$, $P = 0.041$), *L. borealis* (Wilk's $\Lambda = 0.933$, $P = 0.035$), *P. subflavus* (Wilk's $\Lambda = 0.938$, $P = 0.034$), and M. *austroriparius* (Wilk's $\Lambda = 0.907$, $P = 0.01$). The univariate portion of analyses indicated that developed land occurred more at random sites for *E. fuscus* ($F = 8.35$, $P < 0.001$), *L. borealis* ($F = 10.28$, $P = 0.041$), *P. subflavus* ($F = 6.34$, $P = 0.012$), *N. humeralis* ($F = 8.36$, $P = 0.004$), and *M. austroriparius* ($F = 5.68$, $P = 0.018$). Wetland habitat was associated with capture of *E. fuscus* ($F = 6.91$, $P = 0.009$), *P. subflavus* ($F = 7.22$, $P = 0.008$), *N. humeralis* ($F = 8.73$, $P = 0.003$), and *M. austroriparius* ($F = 23.27$, $P < 0.001$). Deciduous forest ($F = 5.13$, $P = 0.024$) was significantly associated with captures of *L. borealis*. There was no habitat association related to captures of *M. grisescens*.

At the 1,000-m spatial scale, when all captures were combined and compared to random sites, there was an overall difference (Wilk's $\Lambda = 0.9116$, $P < 0.001$), and open water ($F = 4.37$, $P = 0.037$), deciduous forest ($F = 4.92$, $P = 0.027$), and wetland ($F = 15.54$, $P < 0.001$) were more prevalent at capture sites rather than random sites. Developed ($F = 14.31$, $P < 0.001$) and open pasture ($F = 5.48$, $P = 0.020$) habitats were more abundant at random sites. Habitat variables differed between capture and random sites for *E. fuscus* (Wilk's $\Lambda = 0.889$, $P < 0.001$), *L. borealis* (Wilk's $\Lambda = 0.939$, $P = 0.024$), *P. subflavus* (Wilk's $\Lambda = 0.932$, $P = 0.020$), *N. humeralis* (Wilk's $\Lambda = 0.939$, $P = 0.036$), and *M. austroriparius* (Wilk's $\Lambda = 0.889$, $P < 0.001$). Univariate analyses indicated that area open water was greater at sites where *E. fuscus* ($F = 4.10$, $P = 0.044$)

and *M. austroriparius* ($F = 4.10$, $P = 0.044$) were captured versus random sites, indicating that these species are associated with open water. Developed land was significantly greater at random sites for *E. fuscus* ($F = 4.41$, $P = 0.037$), *L. borealis* ($F = 6.57$, $P = 0.011$), *P. subflavus* ($F = 4.27$, $P = 0.040$), *N. humeralis* ($F = 6.57$, $P = 0.011$), and *M. austroriparius* ($F = 4.41$, $P = 0.034$), resulting in no habitat association between these species and developed land. Wetland habitat was associated with *E. fuscus* ($F = 24.44$, $P < 0.001$), *M. grisescens* ($F = 4.09$, $P = 0.044$), *P. subflavus* ($F = 10.72$, $P = 0.001$), *N. humeralis* ($F = 8.02$, $P = 0.005$), and *M. austroriparius* ($F = 24.44$, $P < 0.001$). Deciduous forest was significantly associated with captures of *L. borealis* ($F = 4.58$, $P = 0.033$).

Capture and no-capture sites versus random sites.--Habitat variables differed between capture plus no-capture sites and random sites at the 250-m (Wilk's $\Lambda = 0.880$, $P < 0.001$), 500-m (Wilk's $\Lambda = 0.896$, $P < 0.001$), and 1,000-m (Wilk's $\Lambda = 0.921$, $P < 0.001$) spatial scales. Univariate analyses indicated that deciduous forest ($F = 17.38$, $P < 0.001$), mixed forest ($F = 7.94$, $P = 0.005$), and scrub ($F = 8.38$, $P = 0.004$) occurred more often at net sites and open pasture ($F = 9.30$, $P = 0.002$) occurred more often at random sites at the 250-m scale. Area of deciduous forest ($F = 12.84$, $P < 0.001$) and wetland ($F = 15.06$, $P < 0.001$) occurred in greater amounts at net sites versus random sites while area of developed ($F = 31.81$, $P < 0.001$) and open pasture ($F = 4.41$, $P = 0.036$) occurred in greater amount at random sites at the 500-m scale. Presence of deciduous forest ($F = 12.46$, $P < 0.001$), scrub ($F = 4.00$, $P = 0.046$), and wetland ($F = 12.33$, $P < 0.001$) habitat were significantly greater at net sites, and developed ($F = 20.09$,

$P < 0.001$) and open pasture ($F = 5.64$, $P = 0.018$) habitats were significantly greater at random sites at the 1,000-m-scale.

DISCUSSION

Comparison of capture versus no-capture sites demonstrated that I caught more bats in areas where open water and wetland habitats occurred more frequently and significantly fewer at sites primarily containing developed land. A study by Sparks et al. (2005) determined that bats avoided developed land while foraging. This could be because there are fewer insects and less diversity of insects in developed areas as opposed to rural areas (Geggie and Fenton 1985; Sparks et al. 2005). Duchamp et al. (2004) also reported that bats (*E. fuscus* and *N. humeralis*) selected more wooded habitats than developed habitats as foraging areas. Contrary to my study, they reported that these species avoided open water when foraging, but Duchamp et al. (2004) did not define creeks and streams as open water while I did.

Based on comparison of capture versus random sites, significantly more bats were captured in areas that had a greater amount of deciduous forest and wetland habitat and a lesser amount of developed land and open pasture. Bats frequently use deciduous forest (Barbour and Davis 1969; Davis and Mumford 1962; Fujita and Kunz 1984; LaVal et al. 1977) for foraging and less frequently use wetland habitat (Barbour and Davis 1969) for foraging. *L. borealis* (Shump and Shump 1982), *E. fuscus*, and *N. humeralis* (Duchamp et al. 2004) often forage in open fields.

Comparison of capture and no-capture sites versus random sites verified that I did not sample randomly and that I chose to set nets at sites that had more deciduous forest, mixed forest, scrub, and wetland habitats, while random sites had more developed land

and open pasture. It is possible that habitat associations I detected were influenced by placement of nets. A way to remedy this in future studies would be to randomly place nets; however, when surveying for bats, success of capture decreases with random placement of nets, because it is difficult to catch bats in nets that are not conducive to capture, i.e., nets placed in a pasture or in the middle of a cluttered forest lack the structural component of canopy that funnels bats into the net. Bats are more easily captured in nets placed across flyways or over water (Kunz and Kurta 1988). Sites that are conducive to capturing bats include those that are at a water source or across paths used as flyways (Kunz and Kurta 1988). Because I did not randomly place nets, I have more confidence in habitat associations I ascertained using comparison of capture versus no-capture sites as compared to comparison of capture versus random sites.

Absence of bats at a site may be influenced by factors other than habitat surrounding the site. For example, fog reduces foraging activity by bats (Pye 1971). Phase of the moon may (Fenton et al. 1977) or may not (Hayes 1997) influence activity of bats. Also, as light intensity of the moon increases, bats forage higher in the canopy (Fenton et al. 1977; Hecker and Brigham 1999). This does not directly affect whether or not bats forage but where they forage. During my study, it was possible that on moonlit nights bats may have moved higher in the canopy above my mist nets. A more probable cause for absence of bats at a site is a decrease in abundance of insects. Activity of bats decreases as biomass of insects decreases; therefore, if insects are not available, activity of bats will be limited to drinking and commuting (Hayes 1997).

Redstone Arsenal was used as foraging habitat by 1 of the 2 endangered species of bats that occur in Alabama. No *M. sodalis* was captured, but 11 *M. grisescens* of both sexes were captured on the Arsenal. One female was post-lactating (Table 1.1), which indicated *M. grisescens* was reproducing on or near Redstone Arsenal. *M. grisescens* born in summer 2006 also were captured in 2006. It is likely that *M. grisescens* roosts outside of Redstone Arsenal near the Tennessee River (Tuttle 1976), although it is possible that *M. grisescens* roosts on Redstone Arsenal. Clearly, Redstone Arsenal is within the foraging range of this endangered species.

Most *M. grisescens* captured were at sites where mist nets were over water, but 4 were captured over roadways surrounded by deciduous forest that acted as flyways to riparian areas. *M. grisescens* forages over rivers and lakes, and probably uses small creeks and streams as foraging areas or as flyways to get to larger bodies of water to forage (Best and Hudson 1996; Harvey et al. 1999). My study was unable to detect a specific habitat association for *M. grisescens*, but this species forages in riparian areas (LaVal et al. 1977) and uses forest canopy as protection against predation (Tuttle 1976).

Number of captures increased toward the end of summer (Fig. 1.2). This probably is related to the time that young become volant. Young bats are able to fly 3-4 weeks after they are born (Decher and Choate 1995; Best 2004*a*), and as inexperienced flyers, they are relatively easy to catch in mist nets.

My study did not detect a significant habitat association for *E. fuscus*, but previous studies have shown *E. fuscus* to be a habitat generalist (Agosta 2002; Kurta and Baker 1990). *L. borealis* is associated with evergreen forest and is known to fly above tree canopy and over open pastures (LaVal et al. 1977; Shump and Shump 1982). I suspect that *L. borealis* is also a habitat generalist when foraging because I captured the species in many habitats. *M. austroriparius* foraged in open water and wetland habitats, similar to habitats described by Barbour and Davis (1969). *M. austroriparius* was associated with areas that had less scrub, deciduous forest, and mixed forest. *N. humeralis* was associated with wetland habitats, and away from developed land. The species forages in woodlands and roosts in buildings (Watkins 1972), but has not been documented to forage in wetlands. I frequently captured *N. humeralis* foraging over ponds. *P. subflavus* foraged over open water and it was associated with areas containing less mixed forest. This species uses streams and forest edges as foraging habitat (Davis and Mumford 1962; Fujita and Kunz 1984; LaVal et al. 1977).

Species of bats that were not captured on Redstone Arsenal, but whose geographic ranges include the Arsenal are listed in Table 1.4. More sampling sites or different sampling techniques, such as ultrasonic-detection systems, could be employed to increase chances of detecting these species. There are 4 species of bats that my study did not detect that were recorded outside of my study area in Jackson County, a county adjacent to Madison County. I observed *Corynorhinus rafinesquii* roosting in a cave, and *Lasionycteris noctivagans*, *Lasiurus cinereus*, and *Myotis sodalis* were captured in mist nets in autumn 2008 (pers. observ.). If sampling at Redstone Arsenal extended into autumn, it is possible that these species would be detected. There is no recent record of *M. lucifugus* from Alabama, and more research on this species is needed (Best 2004*c*). Overall, this study provided data for use by land managers. This study may also provide a time-effective and cost-effective method for collecting and analyzing habitat data by using GIS techniques rather than collecting vegetation data in the field. MANOVA tests indicated that sites where I placed nets were statistically different from random sites at 3 spatial scales. Sites I chose had greater amounts of open water, deciduous forest, and wetland habitats, which probably are more desirable habitats for bats.

Management Implications.--One endangered species, *M. grisescens*, was captured on Redstone Arsenal during this study. It also was captured on the Arsenal in the past (J. C. Godwin and J. L. Hilton, in litt.). Because *M. grisescens* is associated with wetlands, and because other studies have ascertained that the species is associated with rivers and lakes (Best and Hudson 1996) and riparian areas in general (LaVal et al. 1977), I suggest that these areas be preserved for foraging habitat for *M. grisescens*. I recommend that riparian areas on Redstone Arsenal be preserved as foraging habitat for all bats and that amount of lands to be developed be kept to a minimum. Future studies are needed to investigate microhabitat variables important to bats on Redstone Arsenal. It also is necessary to have information about habitats bats are using year-round as opposed to just one season of monitoring (Ball 2002).

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Table 1.1. Species, sample size (*n*), gender, age-class, and reproductive status of bats captured at Redstone Arsenal, Madison Co., Alabama: YOY, young-of-the-year; NN, not pregnant and not lactating; L, lactating; PL, post-lactating; PR, pregnant; I, immature; S, scrotal; NS, non-scrotal; U, undetermined.

Species	*n*	Gender		Age		Reproductive status							
		Male	Female	Adult	YOY	NN	L	PL	PR	I	S	NS	U
Eptesicus fuscus	53	13	39	42	8	11	16	6	1	4	8	5	1
Lasiurus borealis	54	16	28	23	21	1	5	9	1	12	12	4	10
Myotis austroriparius	15	6	9	9	6	-	5	2	-	2	1	5	-
Myotis grisescens	11	9	2	7	4	-	-	1	-	1	2	7	-
Myotis septentrionalis	2	2	-	1	1	-	-	-	-	-	-	2	-
Nycticeius humeralis	33	17	15	28	4	4	4	7	-	1	15	2	1
Perimyotis subflavus	16	11	5	12	3	1	2	1	-	1	2	9	-
Unidentified *Myotis*	1	-	-	-	-	-	-	-	-	-	-	-	1
Total	185												

Table 1.2. Significant habitat associations of bats on Redstone Arsenal, Madison Co., Alabama, 2005-2007, as determined by GLM comparing mean area of each habitat type where a species was captured versus sites where it was not captured. A positive sign indicates habitats where bats were captured and a negative sign indicates habitat where bats were not captured. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

Variable and Size of Buffer	Species
	Lasiurus borealis
Evergreen 500-m	(+)*
	Myotis austroriparius
Shrub/Scrub 250-m	(-)*
Wetland 250-m	(+)**
Wetland 500-m	(+)**
Open Water 1,000-m	(+)*
Deciduous 1,000-m	(-)*
Mixed Forest 1,000-m	(-)*
Wetland 1,000-m	(+)**
	Nycticeius humeralis
Developed 250-m	(-)*
Wetland 250-m	(+)*
Developed 500-m	(-)*
	Perimyotis subflavus
Open Water 500-m	(+)*
Mixed Forest 500-m	(-)*
Mixed 1,000-m	(-)*

Table 1.3. Significant habitat associations for bats on Redstone Arsenal, Madison Co., Alabama, 2005-2007, as determined by GLM comparing mean area of each habitat type at sites where a species was captured against random sites. A positive sign indicates habitats where bats were detected and a negative sign indicates habitats where bats were not detected. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

Variable and Size of Buffer	Species
	Eptesicus fuscus
Developed 500-m	(-)**
Wetland 500-m	(+)*
Open Water 1,000-m	(+)*
Developed 1,000-m	(-)*
Wetland 1,000-m	(+)**
	Lasiurus borealis
Evergreen Forest 250-m	(+)*
Mixed Forest 250-m	(+)*
Shrub/Scrub 250-m	(+)*
Developed 500-m	(-)**
Deciduous Forest 500-m	(+)*
Developed 1,000-m	(-)**
Deciduous Forest 1,000-m	(+)*
	Myotis austroriparius
Developed 500-m	(-)*
Wetland 500-m	(+)**
Open Water 1,000-m	(+)*
Developed 1,000-m	(-)*
Wetland 1,000-m	(+)**
	Nycticeius humeralis
Developed 500-m	(-)**
Wetland 500-m	(+)**
Developed 1,000-m	(-)*
Wetland 1,000-m	(+)*
	Perimyotis subflavus
Developed 500-m	(-)*
Wetland 500-m	(+)*
Developed 1,000-m	(-)*
Wetland 1,000-m	(+)**

Table 1.4. Species of bats that were not captured at Redstone Arsenal, Madison Co., Alabama, but potentially occur there.

Corynorhinus rafinesquii
Lasionycteris noctivagans
Lasiurus cinereus
Lasiurus seminolus
Myotis lucifugus
Myotis sodalis
Tadarida brasiliensis

Fig. 1.1 Sites where mist nets were placed to capture bats on Redstone Arsenal, Madison, Co., Alabama, summers 2005-2007.

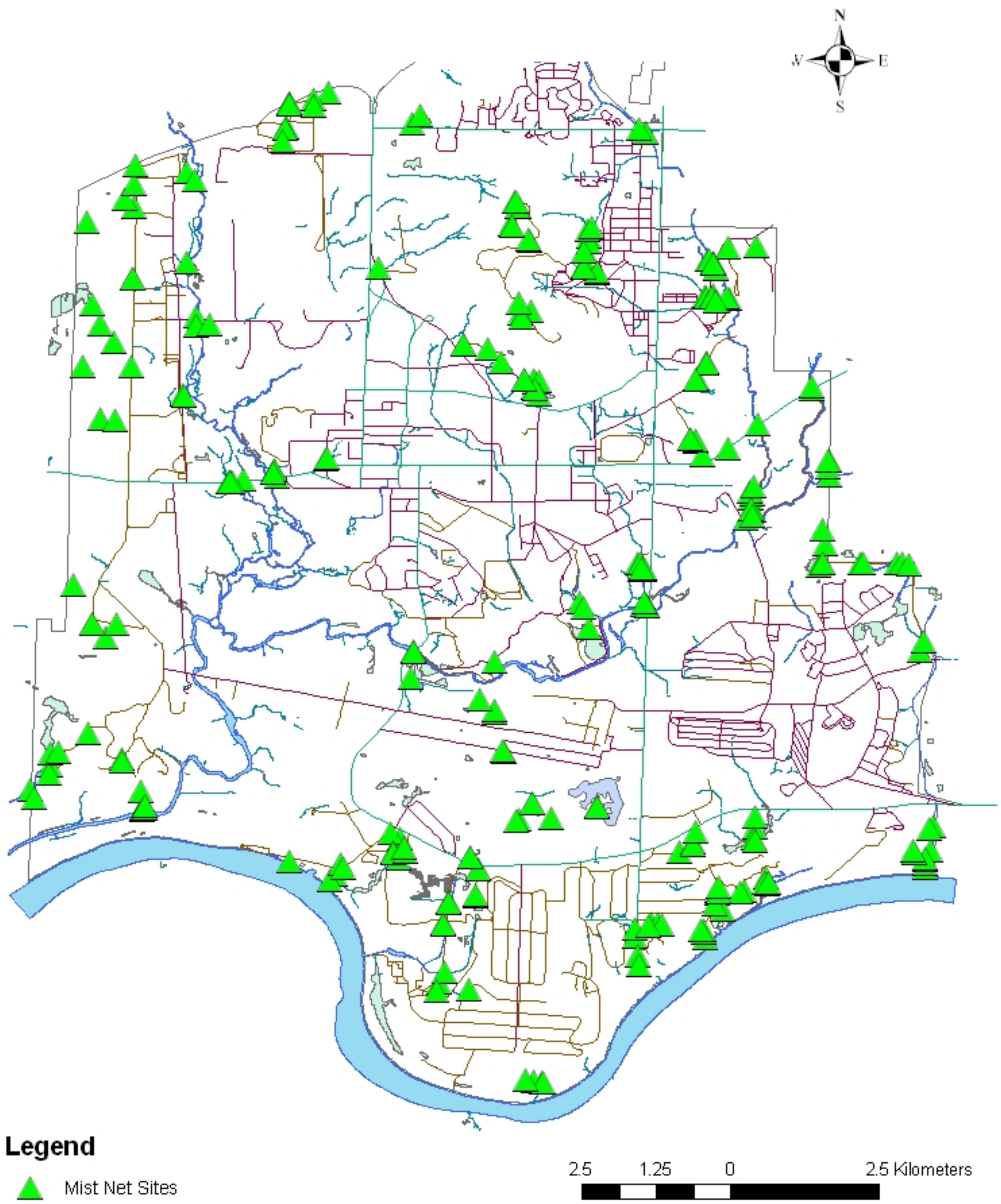


Fig. 1.2 Dates bats were captured at Redstone Arsenal, Madison Co., Alabama. These data indicate that number of bats captured increased as summers progressed during 2005-2007.

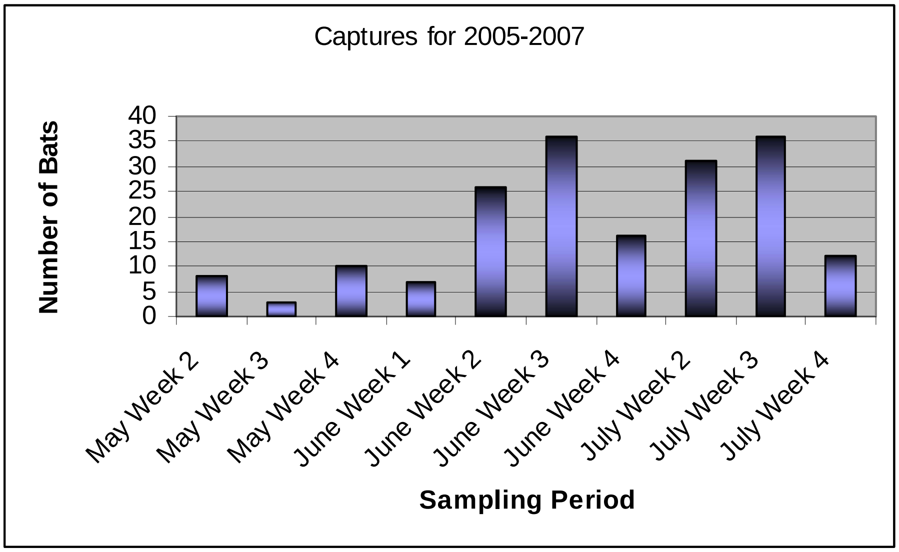


Fig. 1.3 Average area (m^2) of habitat types at the 250-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates no-capture sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

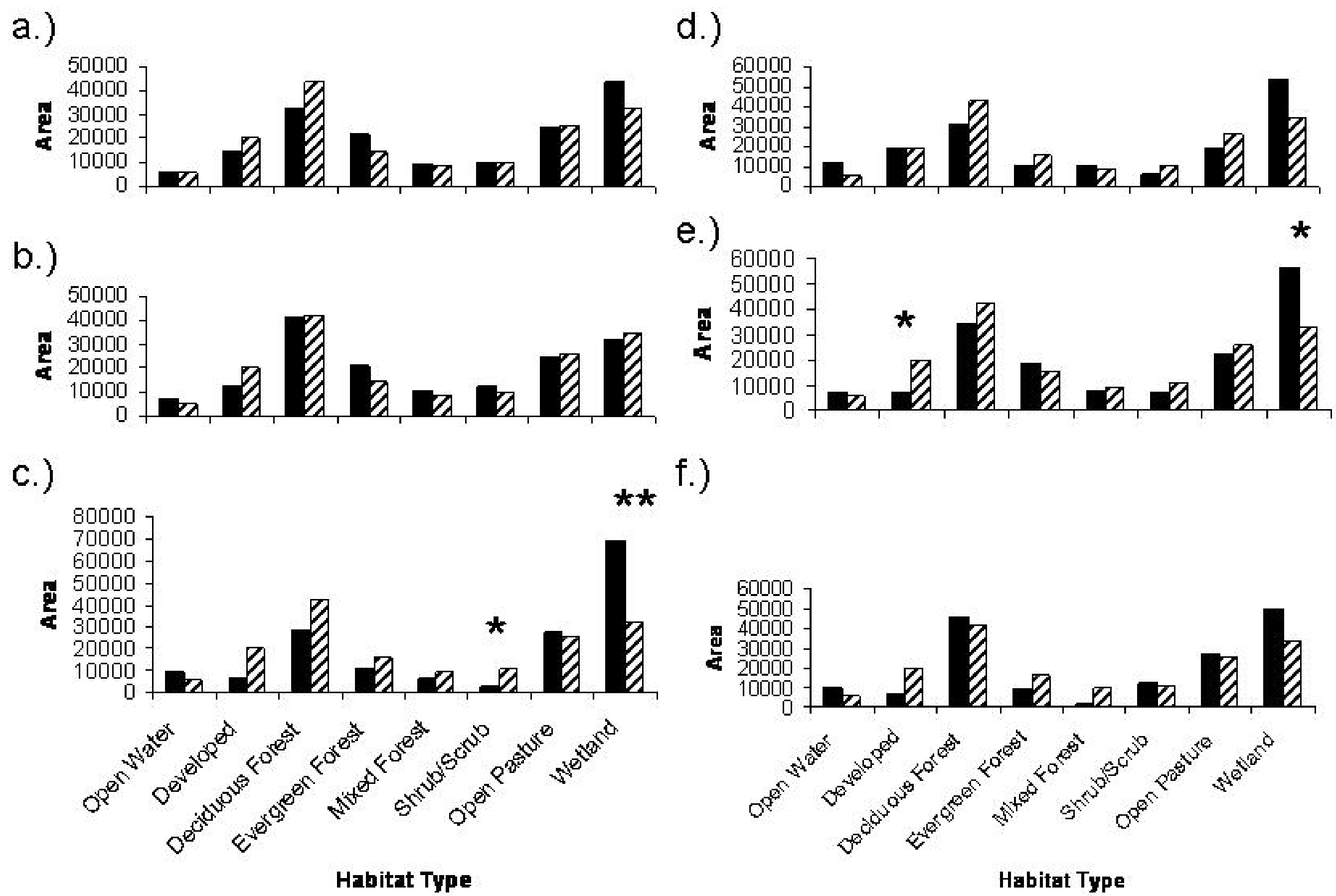


Fig. 1.4 Average area (m^2) of habitat types at the 500-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates no-capture sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

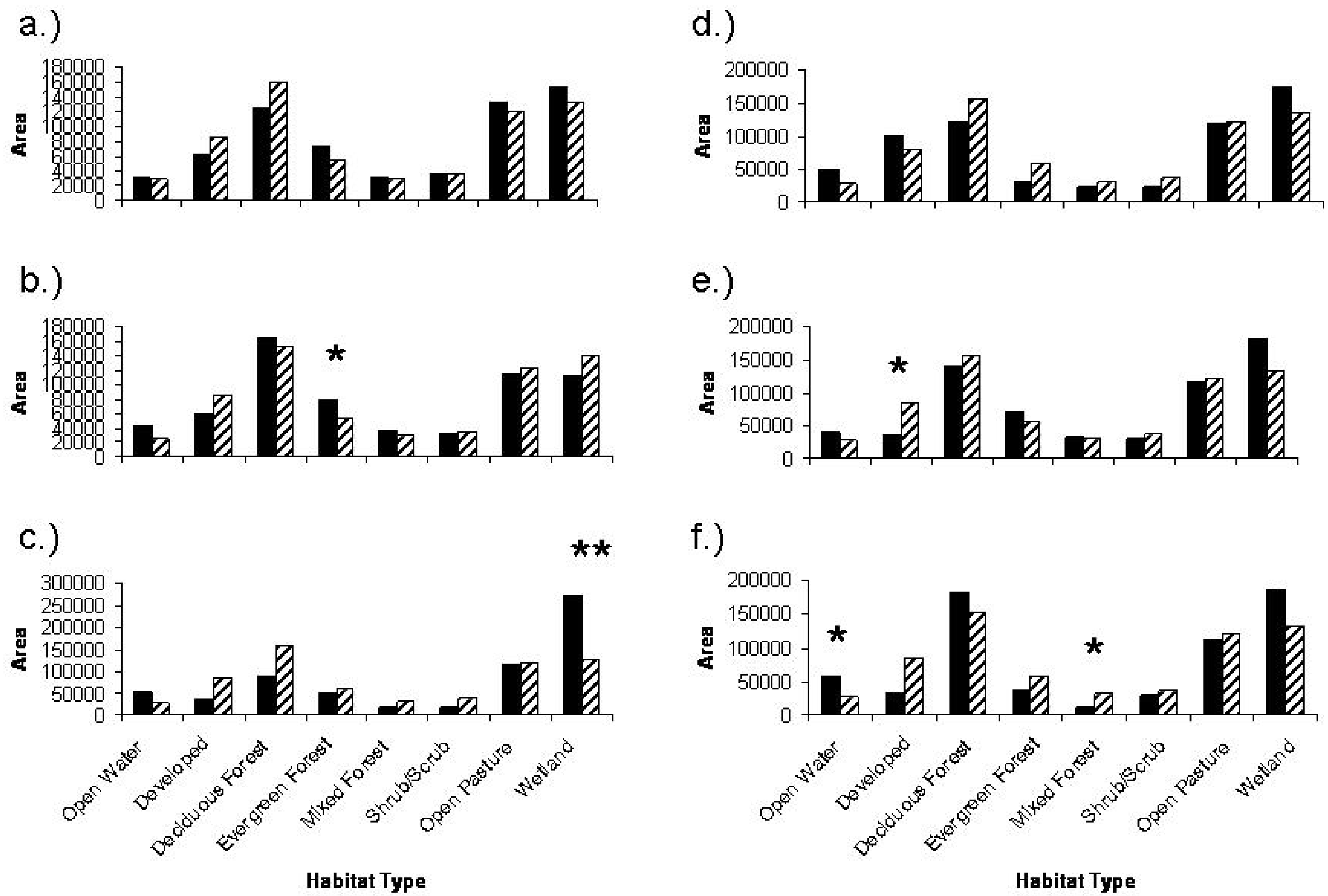


Fig. 1.5 Average area (m^2) of habitat types at the 1,000-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates no-capture sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

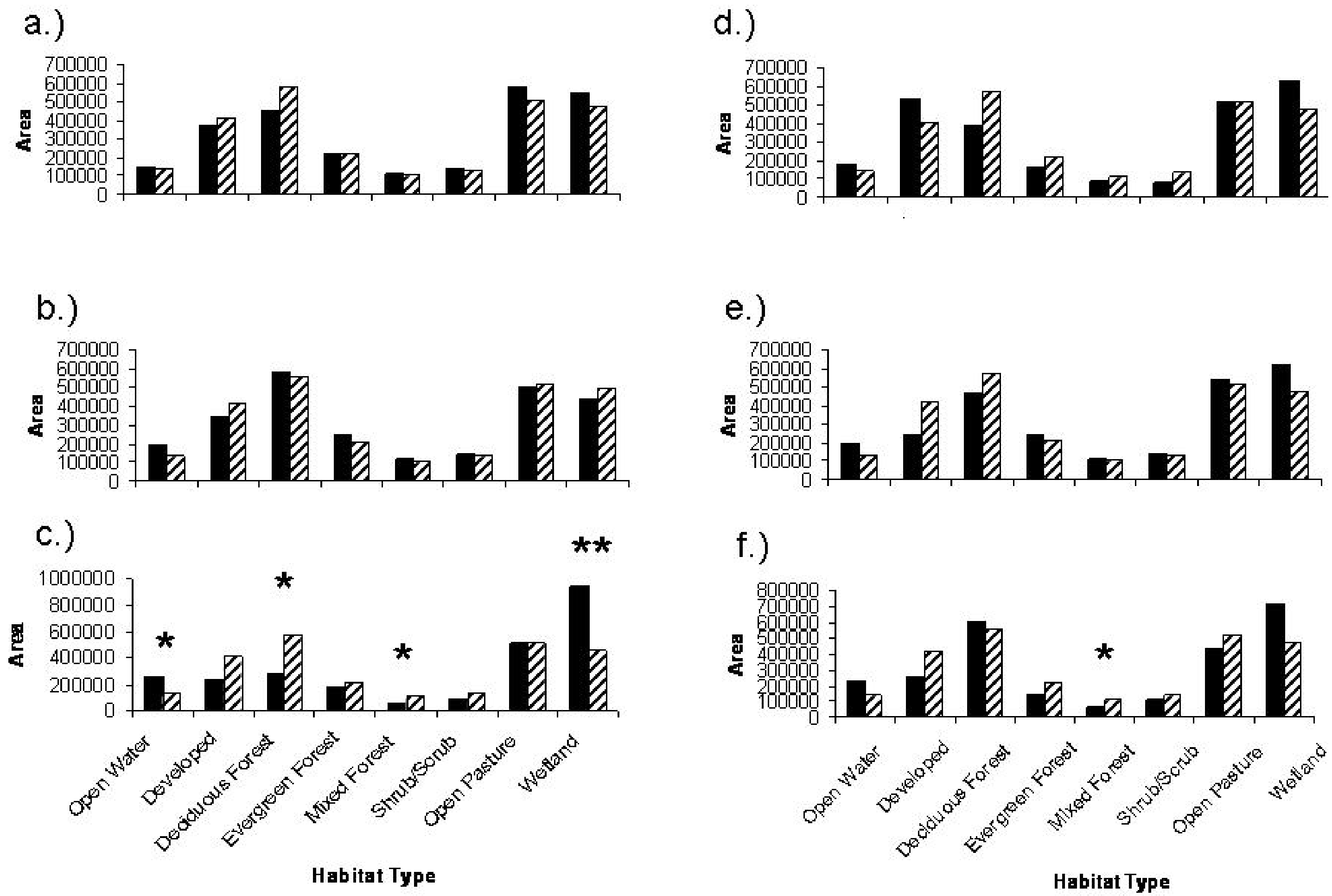


Fig. 1.6 Average area (m^2) of habitat types at the 250-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

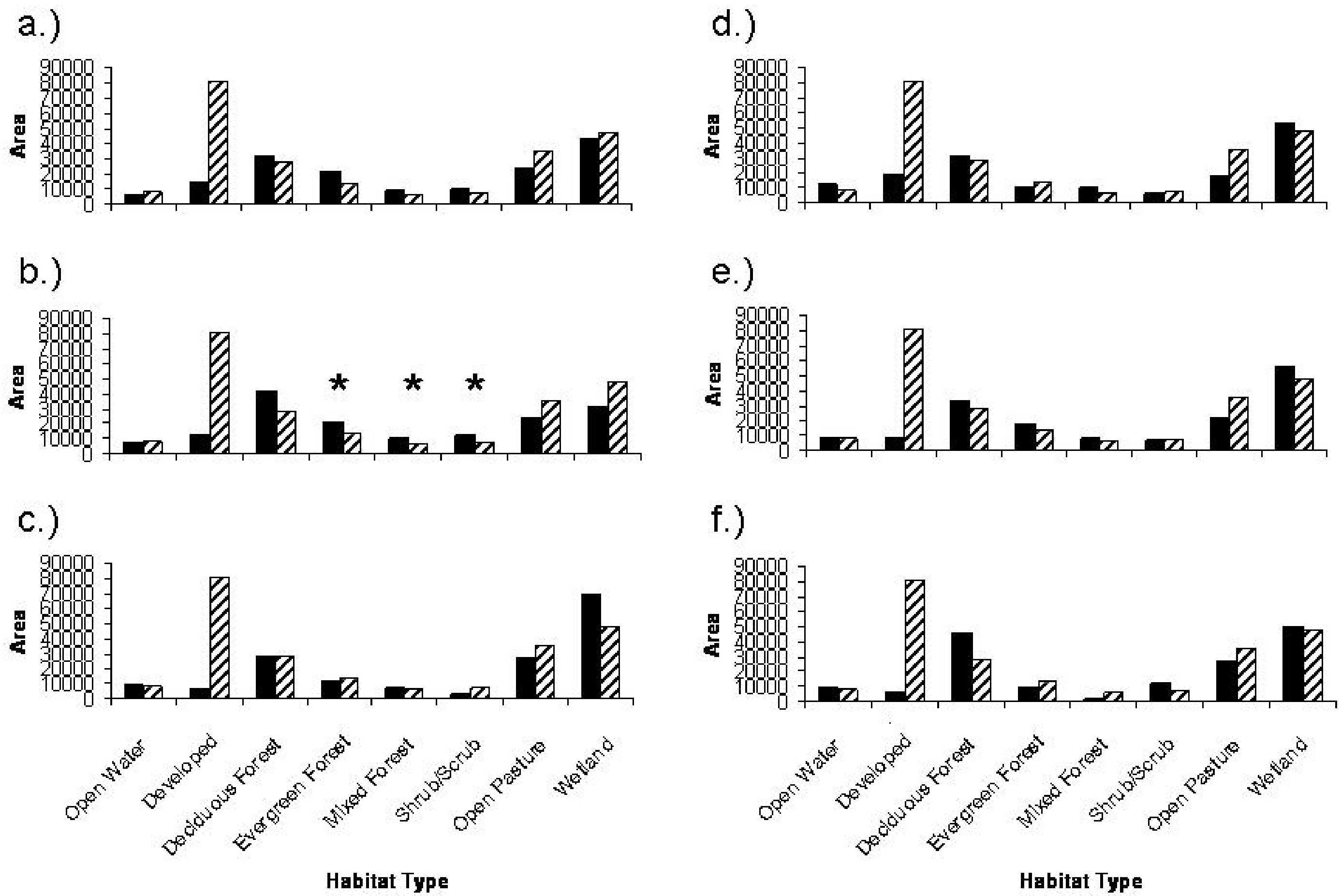


Fig. 1.7 Average area (m^2) of habitat types at the 500-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

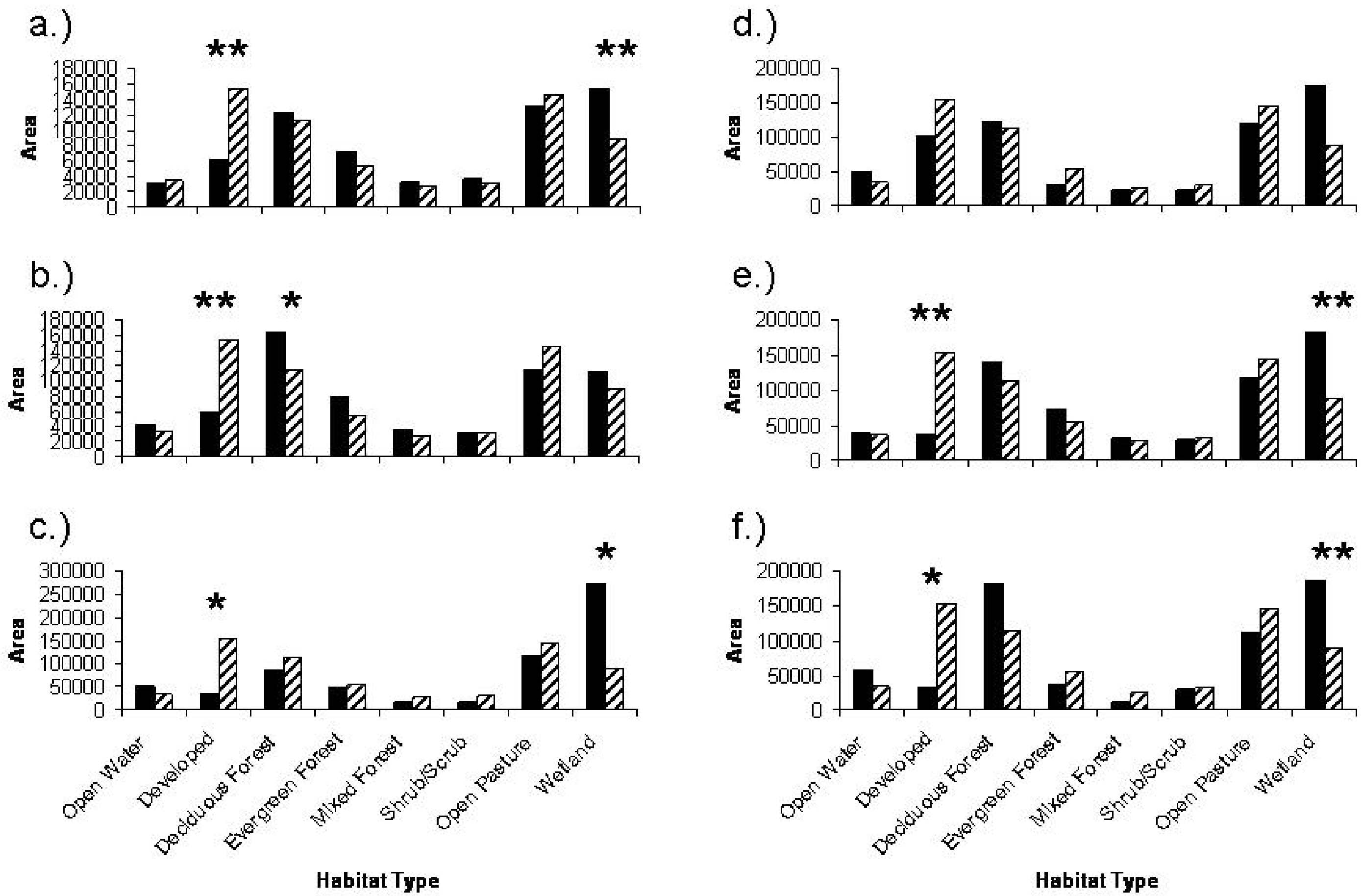


Fig. 1.8 Average area (m^2) of habitat types at the 1,000-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates capture sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis austroriparius*, d) *M. grisescens*, e) *Nycticeius humeralis*, and f) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

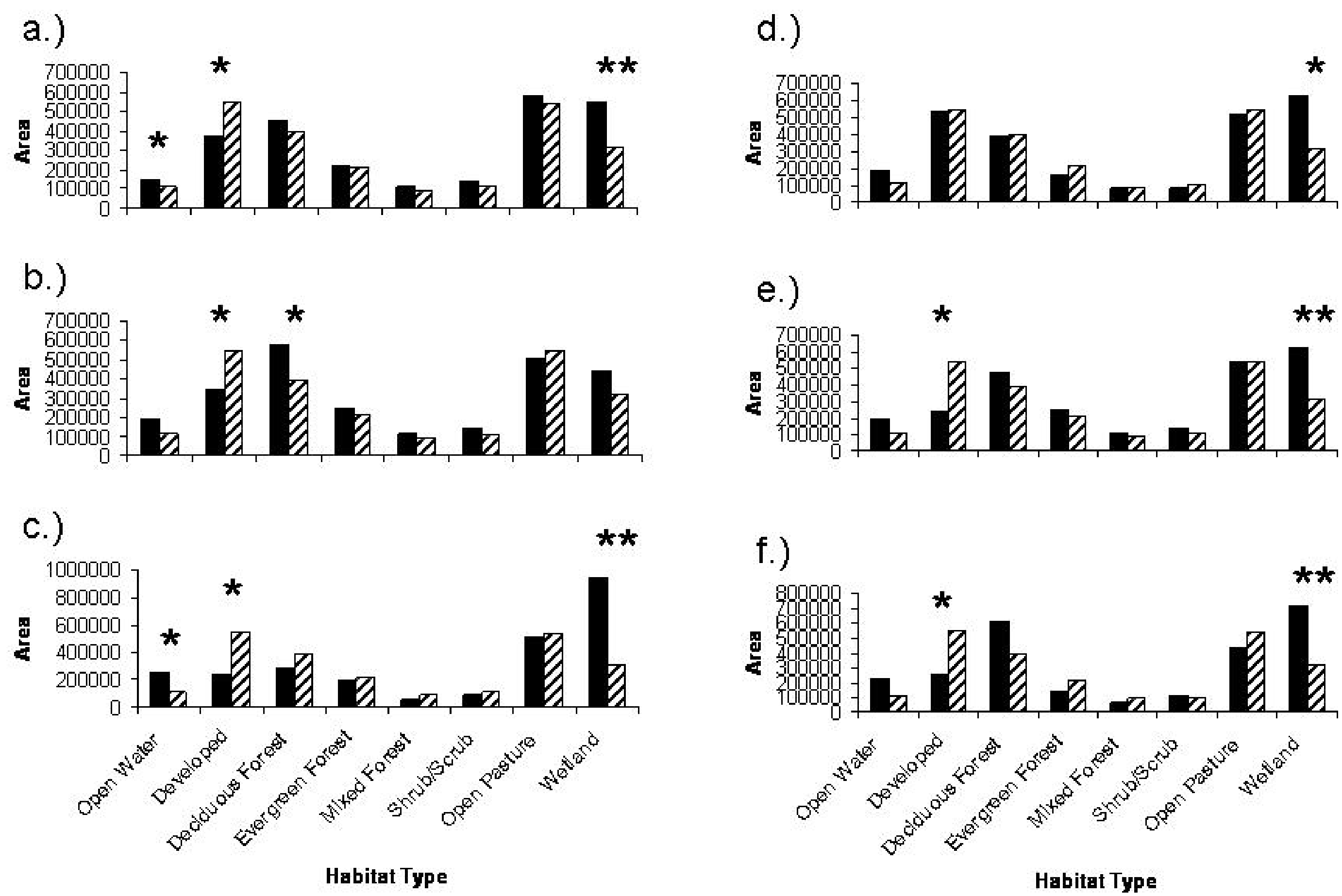
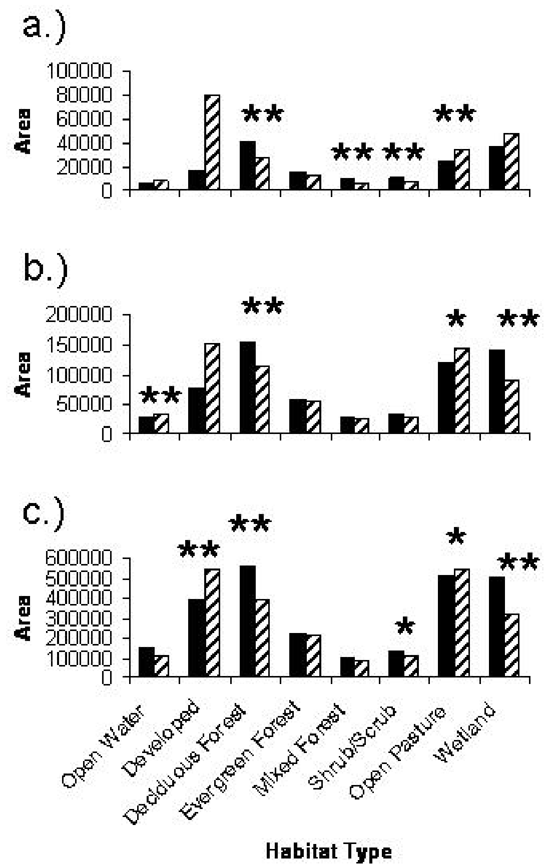


Fig. 1.9 Average area (m^2) of habitat types at the a) 250-m, b) 500-m, and c) 1,000-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates sites where nets were placed (captures and no-captures) and a striped bar indicates random sites. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.



CHAPTER 2: HABITAT ASSOCIATIONS AMONG BATS ON REDSTONE ARSENAL, MADISON CO., ALABAMA, AS DETERMINED BY ULTRASONIC-DETECTION SURVEYS

ABSTRACT

Ultrasonic detection of bats may allow the observer to detect species that are less frequently captured in mist nets. In this study, I used AnaBat SD1 detectors to obtain species identification at locations in northern Alabama. I used multivariate analysis to evaluate associations between habitat types and species using those habitats at 3 spatial scales. Results obtained from this study suggested the following associations: the eastern red bat (*Lasiurus borealis*) with open water, gray myotis (*Myotis grisescens*) with open water and deciduous forest, evening bat (*Nycticeius humeralis*) with open water, and perimyotis (*Perimyotis subflavus*) with open water and wetlands.

INTRODUCTION

Acoustic-monitoring devices may be more reliable in identifying bats in an area of interest because there is a potential bias in using mist nets for studies of foraging ecology. Some species are more easily captured by mist nets, while fast-flying, high-altitude species may not be captured in mist nets (Lacki et al. 2007). For example, the Brazilian free-tailed bat (*Tadarida brasiliensis*) is a high-flying species that occurs in Alabama (Wilkins 1989). This species, as well as others, are detectable ultrasonically and have been monitored using acoustic-monitoring devices in the southeastern United States (Britzke 2003).

AnaBat (Titley Electronics, Ballina, New South Wales, Australia) detectors use frequency-division to make echolocation calls by bats audible to humans. The Zero-Crossing Analysis Interface Module (ZCAIM: Titley Electronics, Ballina, New South Wales, Australia) of AnaBat records the call and allows the observer to graphically observe calls (Fenton et al. 2001). Call files are downloaded to a computer from a compact flash (CF) card and can be analyzed using the DOS-operated program Analook (Version 4.9 j: Titley Electronics, Ballina, New South Wales, Australia). It is possible to analyze variables such as frequency, wavelength, duration, and slope. Measures of these parameters are unique for each species of bat, so that comparisons can be made among calls that were collected in the field and calls of known species of bats (Britzke 2003).

There are 2 methods of monitoring echolocation calls of bats; actively and passively. Active monitoring is done when the observer uses an acoustic-monitoring device to collect calls by directing the device toward a bat that is flying overhead. Active monitoring allows the observer to collect long, high-quality calls and identify bats on the wing but requires an observer to be present with the acoustic-monitoring device at all times. For passive monitoring, acoustic-monitoring devices are left overnight or for multiple nights, usually in a weather-proof container, and parameters of calls are stored for later analysis (Murray et al. 1999). Passive monitoring is used more often for studies of use of habitats because multiple acoustic-monitoring devices can collect data over a longer period than with active monitoring. Several studies have used AnaBat, an ultrasonic-detection system, as a means of investigating habitat use by bats (Erickson and

West 2003; Glendell and Vaughan 2002; Kalcounis et al. 1999; Loeb and O'Keefe 2006; Vaughan et al. 1997; Yates and Muzika 2006). In this study, I used AnaBat to assess habitat relationships among a community of bats in northern Alabama.

MATERIALS AND METHODS

The study area was Redstone Arsenal, Madison Co., Alabama, which was described in Chapter 1. I used 3 AnaBat SD1 ultrasonic detectors (Titley Electronics, Ballina, New South Wales, Australia) to detect bats at 93 sites during May-July 2007. All detectors were deployed 3nights/week at different sites, and each was moved to a new location the following night. I attempted to place detectors in as many areas of Redstone Arsenal as possible and selected sites in areas where I believed a bat could be detected (Fig. 2.1). Features where detectors were placed included fly-ways along roads and creeks, open fields, and ponds. Detectors were contained in a weatherproof housing and directed toward a Lexan reflector placed at a 45° angle to limit interference of rain with the detector's microphone (Fig. 2.2; modified from Yates and Muzika 2006). Detectors were placed ca. 1.5 m from the ground on a tree, fence-post, or utility pole. Each detector was set at a sensitivity of 7.5 and programmed to record from 1800 to 0600 h CDT.

Files were analyzed using discriminant-function analysis as described by Britzke (2003). Data from detectors were downloaded to a personal computer and viewed using Analook version 4.9j. I used a filter created by E. Britzke (pers. comm.) to remove ultrasonic calls that had <5 pulses in a sequence. This filter also removed files created by noise of wind and insects. Parameters of calls were imported into MINITAB 14, and I performed discriminant-function analysis. For a species to be considered present at a site, there had to be ≥2 sequences from a species (because pulses from one species of bat can resemble the call of another species), where ≥50% of pulses in the sequence were identified as that species (modified from Samoray 2002). I defined a valid call as one that had ≥5 pulses in a sequence, where there were ≥2 sequences from a species at each site with ≥50% of pulses in the sequence identified as that species (modified from Samoray 2002).

The same procedure for importing data, creating buffers, and calculating habitat was performed as outlined in Chapter 1. I also used 250 random points generated as described in Chapter 1 to make comparisons with points where bats were detected and for creating habitat analyses. Area of each habitat in the 3 buffers was calculated for sites where bats were detected, where bats were not detected, and at random points. A species was indicated as either present (was detected) or absent (was not detected).

I performed analyses for species only when calls of that species were detected at ≥10 sites (Aebischer et al. 1993). Habitat associations were tested using multivariate analysis of variance (MANOVA; McCune and Grace 2002). MANOVA was used to determine if there was a difference between habitat variables at sites where bats were detected versus where bats were not detected, at sites where bats were detected versus random points, and at sites where an attempt to detect bats was made (includes detection sites and no-detection sites) versus random points. These tests were performed at each spatial scale for each species; alpha-level was $P < 0.05$.

RESULTS

During May–July 2007, I recorded calls at 93 sites. Over the sampling season, 104 valid identifications of bats were ascertained at 45 of the sites; these identified calls represented 6 species. Species identified were the big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), gray myotis (*Myotis grisescens*), northern myotis (*M. septentrionalis*), evening bat (*Nycticeius humeralis*), and perimyotis (*Perimyotis subflavus*). Five of the species had a sample size ≥10 and were used in statistical analyses (*M. septentrionalis* was excluded).

Detection sites versus no-detection sites.--At the 250-m spatial scale, when detections of all species were combined and compared to no-detection sites, there was an overall difference (Wilk's $\Lambda = 0.811$, $P = 0.020$). Open water ($F = 8.52$, $P = 0.004$) and deciduous forest ($F = 5.14$, $P = 0.026$) occurred in greater amounts where bats were detected, and developed land ($F = 4.37$, $P = 0.039$) occurred more at sites where bats were not detected. Habitat variables differed between detection and no-detection sites for two species, *M. grisescens* (Wilk's $\Lambda = 0.605$, $P < 0.001$) and *P. subflavus* (Wilk's $\Lambda = 0.633$, $P < 0.001$). This indicates that overall, habitat at detection sites was statistically different from habitat at no-detection sites for these two species. The univariate (general linear model; GLM) portion of the analysis indicated that area of open water ($F = 8.42$, $P = 0.005$) was significantly different between sites where *L. borealis* was detected versus sites where *L. borealis* was not detected. When I plotted average area of open water at detection sites and at no-detection sites, I determined that a greater area open water occurred at sites where *L. borealis* was captured. I plotted average area for all types of habitat at detection versus no-detection sites to make habitat associations for each species. Open water ($F = 17.48$, $P < 0.001$) and deciduous forest ($F = 13.75$, $P < 0.001$) were associated with detection of *M. grisescens* (Table 2.2). Developed land ($F = 5.25$, $P = 0.024$) and open pasture ($F = 12.76$, $P < 0.001$) were associated with sites where *M. grisescens* was not detected. For *N. humeralis,* open water ($F = 7.90$, $P = 0.006$) was a habitat association. Open water ($F = 21.38$, $P < 0.001$) and wetland ($F = 11.46$, $P = 0.001$) were associated with detection of *P. subflavus*. Developed ($F = 10.14$, $P = 0.002$), mixed forest ($F = 4.79$, $P = 0.031$), and open pasture ($F = 7.01$, $P = 0.010$) habitats were associated with sites where *P. subflavus* was not detected. There was no significant habitat association for *E. fuscus*.

At the 500-m-spatial scale, when habitat variables from all sites where bats were detected were combined and compared to no-detection sites, there was no overall difference, but open water ($F = 5.83$, $P = 0.018$) and deciduous forest ($F = 4.68$, $P = 0.033$) occurred more at detection sites while developed habitat ($F = 4.90$, $P = 0.029$) occurred more at no-detection sites. Habitat variables differed between detection and no-detection sites for two species, *M. grisescens* (Wilk's $\Lambda = 0.679$, $P < 0.001$) and *P. subflavus* (Wilk's $\Lambda = 0.768$, $P = 0.003$). The univariate portion of this analysis indicated that open water ($F = 9.96$, $P = 0.002$) was significantly greater for sites where *L. borealis* was detected. Open water ($F = 11.80$, $P = 0.001$), developed ($F = 6.57$, $P = 0.012$), deciduous forest ($F = 19.08$, $P < 0.001$), and open pasture ($F = 10.19$, $P = 0.001$) were significantly different between detection and no-detection sites for *M. grisescens*. Open water and deciduous forest occurred more where *M. grisescens* was,detected, and developed land and open pasture occured more where *M. grisescens* was not detected. Significant habitat associations for *P. subflavus* were open water ($F = 9.59$, $P = 0.003$) and wetland ($F = 8.98$, $P = 0.004$). Developed lands ($F = 11.40$, $P = 0.001$) and mixed forest ($F = 4.44$, $P = 0.038$) were less abundant where the species was detected. There was no significant habitat association for *E. fuscus* or *N. humeralis*.

At the 1,000-m spatial scale, when all detections were combined and compared to no-detection sites, there was no statistically significant difference, and no habitat variable was significant. Habitat variables differed between detection and no-detection sites for *M. grisescens* (Wilk's $\Lambda = 0.703$, $P < 0.001$) and *P. subflavus* (Wilk's $\Lambda = 0.788$, $P = 0.008$). The univariate portion of this analysis and plots of average amounts of type of habitat for detection sites and no-detection sites indicated that deciduous forest ($F = 23.38$, $P < 0.001$) was associated with detection of *M. grisescens*. Developed land ($F = 4.83$, $P = 0.031$) and open pasture ($F = 8.96$, $P = 0.004$) habitats occurred more where *M. grisescens* was not detected and were not habitat associations for *M. grisescens*. Open water ($F = 6.99$, $P = 0.010$) and wetland ($F = 6.97$, $P = 0.010$) were habitat associations for *P. subflavus*. Developed lands ($F = 10.41$, $P = 0.002$) and mixed forest ($F = 4.34$, $P = 0.040$) occurred more in no-detection sites and were not associated with capture of this species. There was no significant habitat association for *E. fuscus*, *L. borealis*, or *N. humeralis*.

Detection sites versus random sites.--When all detections were combined and compared to random sites at the 250-m spatial scale, there was no overall statistical difference and no single habitat variable was significant. Habitat variables differed overall between detection and random sites for *M. grisescens* (Wilk's $\Lambda = 0.935$, $P = 0.021$) and *P. subflavus* (Wilk's $\Lambda = 0.937$, $P = 0.022$). The univariate portion of the analysis and plots of average amounts of habitat types indicated that presence of open water was associated with detections of *M. grisescens* ($F = 7.70$, $P = 0.006$), *N. humeralis* ($F = 4.61$, $P = 0.033$), and *P. subflavus* ($F = 8.11$, $P = 0.005$). Deciduous forest was associated with detection of *M. grisescens* ($F = 8.20$, $P = 0.005$), while amount of open pasture ($F = 6.12$, $P = 0.014$) was greater at random sites and was not a habitat association. There was no statistically significant habitat variable for *E. fuscus* or *L. borealis*.

At the 500-m spatial scale, when all detections were combined and compared to random sites, there was no overall difference, but developed land ($F = 4.98$, $P = 0.026$) was greater at random sites. Habitat variables differed between detection and random sites for *M. grisescens* (Wilk's $\Lambda = 0.931$, $P = 0.015$) and *P. subflavus* (Wilk's $\Lambda = 0.941$, $P = 0.033$). The univariate portion of the analysis and comparison of plots of average area of habitat types indicates that open water ($F = 4.34$, $P = 0.038$) and deciduous forest ($F = 12.72$, $P < 0.001$) are habitat associations for *M. grisescens*. Developed land was significantly greater at random sites for *M. grisescens* ($F = 6.14$, $P = 0.038$) and *P. subflavus* ($F = 8.91$, $P = 0.003$), which indicates that these species more often occur outside of these habitats. Wetland ($F = 8.78$, $P = 0.003$) was a good predictor of detection of *P. subflavus*. There was no significant habitat association for *E. fuscus*, *L. borealis,* or *N. humeralis*.

At the 1,000-m spatial scale, when all detections were combined and compared to random sites, there was no statistically significant difference and no habitat variable was statistically significant. Habitat variables differed between detection and random sites for *M. grisescens* (Wilk's $\Lambda = 0.909$, $P = 0.001$) and *P. subflavus* (Wilk's $\Lambda = 0.943$, $P = 0.044$). Univariate analysis of area for each habitat type indicate that deciduous forest ($F = 20.22$, $P < 0.001$) is associated with capture of *M. grisescens*, and developed land ($F = 4.65$, $P = 0.032$) and open pasture ($F = 7.14$, $P = 0.008$) were significantly greater at random sites; therefore, *M. grisescens* occurs less often than expected in these habitats.

Developed land ($F = 7.86$, $P = 0.005$) also was not a positive habitat association for *P. subflavus*, but wetland ($F = 8.54$, $P = 0.004$) was a habitat association. There was no statistically significant variable for *E. fuscus*, *L. borealis*, or *N. humeralis*.

Detection and no-detection sites versus random sites.--There was no statistically significant difference between habitat variables at sites where detectors were placed and random sites for the 250-m buffers. At the 500-m spatial scale, GLM detected a difference between sites where detectors were placed and random sites. Deciduous forest ($F = 5.93$, $P = 0.016$) occurred more in sites where detectors were placed. At the 1,000-m spatial scale, there was a difference in amount of developed land between sites where detectors were placed and random sites and developed land ($F = 4.98$, $P = 0.026$) occurred more in random sites. Thus, all species of bats occurred less frequently than expected in developed land.

DISCUSSION

Analyses of data comparing sites where bats were detected with sites with no-detection revealed that detectors that were placed in areas with open water and deciduous forest were significantly more likely to detect bats than detectors that were placed in areas with developed lands. Data from capture versus random sites also indicated that bats were significantly less likely to occur on developed land. As area of developed land increased, bats were less likely to use the landscape for foraging habitat. When data from detection and no-detection sites were compared to random sites, there was no statistically significant difference in composition of habitat types at the 250-m spatial scale. I did not sample randomly at the 500 and 1,000-m scales and chose to place detectors in sites that had more deciduous forest while random sites had more developed land.

As expected, I detected no significant habitat association for *E. fuscus*, which agrees with previous studies that have shown this species is a habitat generalist (Agosta 2002; Kurta and Baker 1990; Chapter 1). An examination of types of habitat where *E. fuscus* was detected indicated that it occurred at sites with open water, deciduous forest, evergreen forest, mixed forest, open pasture, and wetland. It is clear that *E. fuscus* is a habitat generalist at Redstone Arsenal.

My study demonstrated that *L. borealis* was associated with open water. This species flies above the tree-canopy and over open pastures (LaVal et al. 1977; Shump and Shump 1982), but had not been reported previously to spend significant time foraging over open water.

I determined that *M. grisescens* foraged over open water and in deciduous forest and avoided developed land and open pasture. *M. grisescens* forages over open water and in riparian areas using the forest for cover (Best and Hudson 1996; Goebel 1996; Henry 1998; Tuttle 1976), which explains why the species was negatively associated with open areas such as developed lands and open pasture. Although *M. grisescens* will commute through non-riparian areas on its way to forage in open-water habitat, it is not known to forage in non-riparian areas (Best and Hudson 1996; Tuttle 1979).

My study has shown that *N. humeralis* was associated with open water. *N. humeralis* forages in woodlands and roosts in buildings (Watkins 1972), but has not been documented to forage over open water.

Perimyotis subflavus foraged in open water and wetland habitats and avoided developed land and mixed forest. This species uses streams and forest edges as foraging habitats (Davis and Mumford 1962; Fujita and Kunz 1984; LaVal et al. 1977), but has not been documented to use wetland habitats.

Other species of bats that were not detected on Redstone Arsenal, but whose ranges cover the Arsenal are listed in Table 2.3. One of the motives for using ultrasonic detection, as noted in Chapter 1, was that it may be possible to detect species on Redstone Arsenal that were not captured in mist nets. I was particularly interested in detecting *Tadarida brasiliensis*, a species that flies at high altitudes and is not easily captured in mist nets (Wilkins 1989). I did not detect this species on the Arsenal, and it is difficult to tell whether the species does not occur on Redstone Arsenal or, perhaps, it may occur in the study area but was overlooked by my methods of detection. Further investigation is needed to ascertain the presence of the species here and elsewhere in northern Alabama.

Management Implications.--Because I determined that *M. grisescens* foraged in sites with open water and deciduous forest and because most captures occurred at sites with open water and deciduous forest, I recommend that these areas be preserved for use by bats on Redstone Arsenal. *M. grisescens* avoids areas with developed land and open pasture, so I encourage facility managers to keep these types of habitats to a minimum when managing for bats. While some studies use results from acoustic detection to determine management plans, other researchers suggest that acoustic detection should be used only for generating a priori hypotheses about use of habitats (Miller et al. 2003). I believe it is necessary to use mist nets to capture bats and have these species in hand for positive identification before finalizing management plans.

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Table 2.1. Significant habitat associations for bats that occur on Redstone Arsenal, Madison Co., Alabama, 2005-2007, as determined by GLM comparing mean area of each habitat type at sites where a species was detected to sites where that species was not detected. A positive sign indicates habitats where bats were detected and a negative sign indicates habitat where bats were not detected. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

Variable and size of buffer	Species
	Lasiurus borealis
Open Water 250-m	(+)*
Open Water 1,000-m	(+)**
	Myotis grisescens
Open Water 250-m	(+)**
Developed 250-m	(-)*
Deciduous Forest 250-m	(+)**
Open Pasture 250-m	(-)**
Open Water 500-m	(+)**
Developed 500-m	(-)*
Deciduous Forest 500-m	(+)**
Open Pasture 500-m	(-)**
Deciduous Forest 1,000-m	(+)**
Open Pasture 500-m	(-)**
	Nycticeius humeralis
Open Water 250-m	(+)*
	Perimyotis subflavus
Open Water 250-m	(+)**
Developed 250-m	(-)**
Mixed Forest 250-m	(-)*
Open Pasture 250-m	(-)*
Wetland 250-m	(+)**
Open Water 500-m	(+)**
Developed 500-m	(-)**
Mixed Forest 500-m	(-)*
Wetland 500-m	(+)**
Open Water 1,000-m	(+)*
Developed 1,000-m	(-)**
Mixed Forest 1,000-m	(-)*
Wetland 1,000-m	(+)*

Table 2.2. Significant habitat associations for bats that occur on Redstone Arsenal, Madison Co., Alabama, 2005-2007, as determined by GLM comparing mean area of each habitat type at sites where a species was detected against random sites. A positive sign indicates habitats where bats were detected and a negative sign indicates habitats where bats were not detected. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

Variable and size of buffer	Species
	Myotis grisescens
Open Water 250-m	(+)*
Deciduous Forest 250-m	(+)*
Open Pasture 250-m	(-)*
Open Water 500-m	(+)*
Developed 500-m	(-)*
Deciduous Forest 500-m	(+)**
Open Pasture 500-m	(-)*
Developed 1,000-m	(-)*
Deciduous Forest 1,000-m	(+)**
Open Pasture 500-m	(-)*
	Nycticeius humeralis
Open Water 250-m	(+)*
	Perimyotis subflavus
Open Water 250-m	(+)*
Developed 500-m	(-)**
Wetland 500-m	(+)**
Developed 1,000-m	(-)*
Wetland 1,000-m	(+)*

Table 2.3. Species of bats that occur in the geographic range of Redstone Arsenal, Madison Co., Alabama, that were not detected during this study.

Corynorhinus rafinesquii
Lasiurus cinereus
Lasionycteris noctivagans
Lasiurus seminolus
Myotis austroriparius
Myotis leibii
Myotis lucifugus
Myotis sodalis
Myotis lucifugus
Tadarida brasiliensis

Fig. 2.1. Sites were AnaBat detectors were placed on Redstone Arsenal, Madison, Co., Alabama, summer 2007.

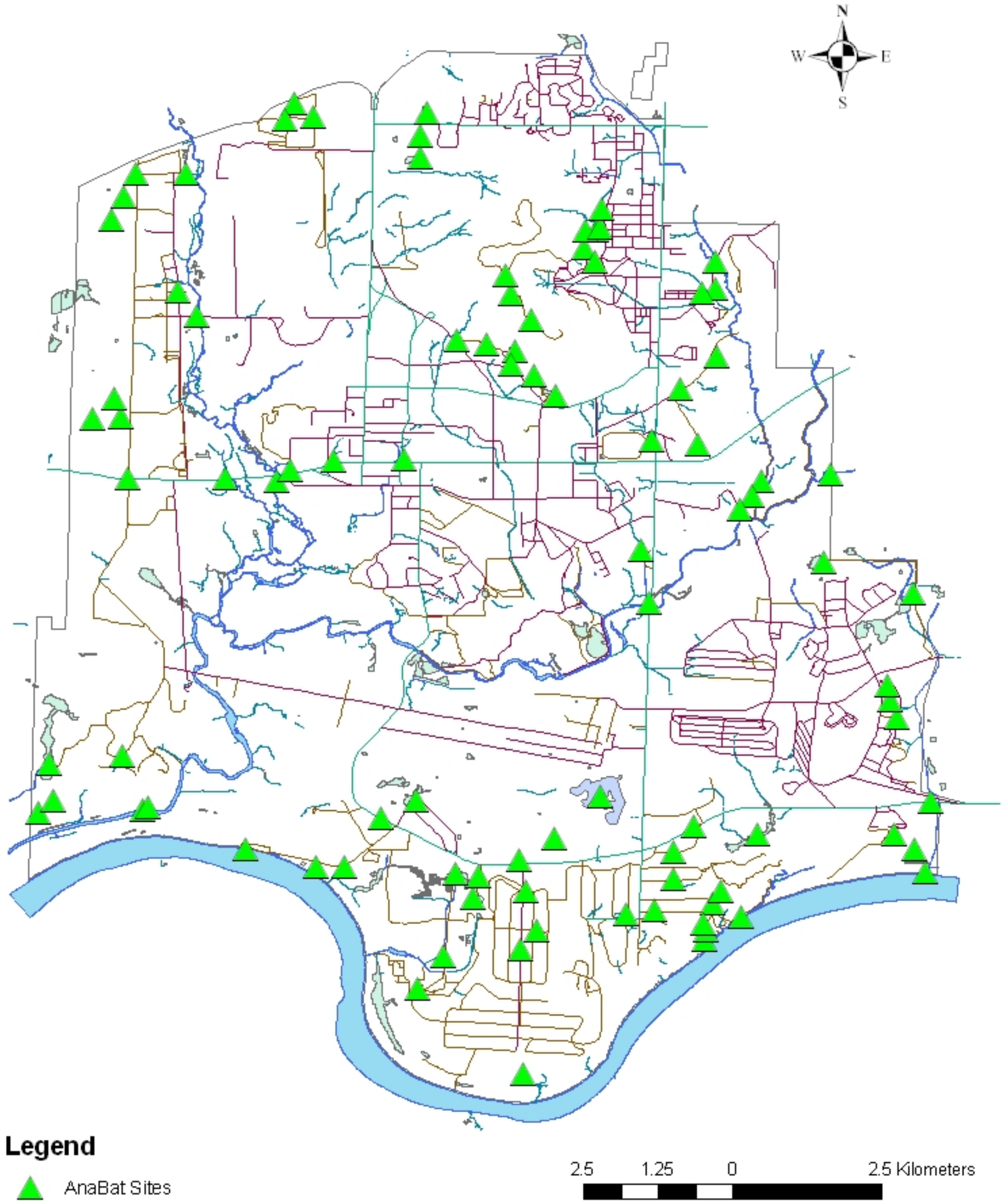


Fig. 2.2. Photo of the weather-proof housing in which AnaBat detectors were placed during the study of foraging habitats of bats at Redstone Arsenal, Madison Co., Alabama, 2007.

Figure 2.3 Representative echolocation calls for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus* as detected by an acoustic-monitoring device at Redstone Arsenal, Madison, Co., Alabama.

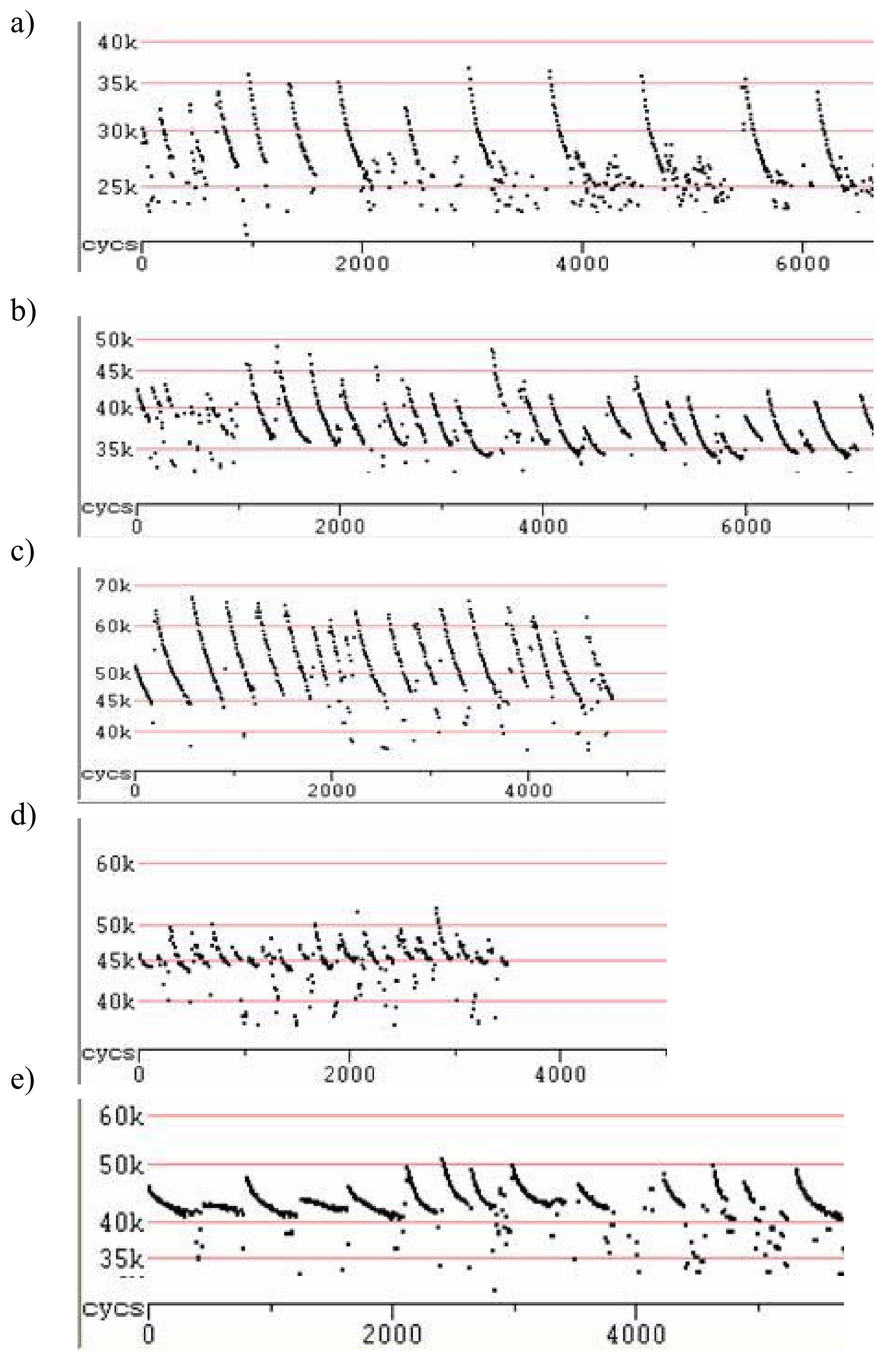


Fig. 2.4 Average area (m^2) of habitat types at the 250-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates no-detection sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

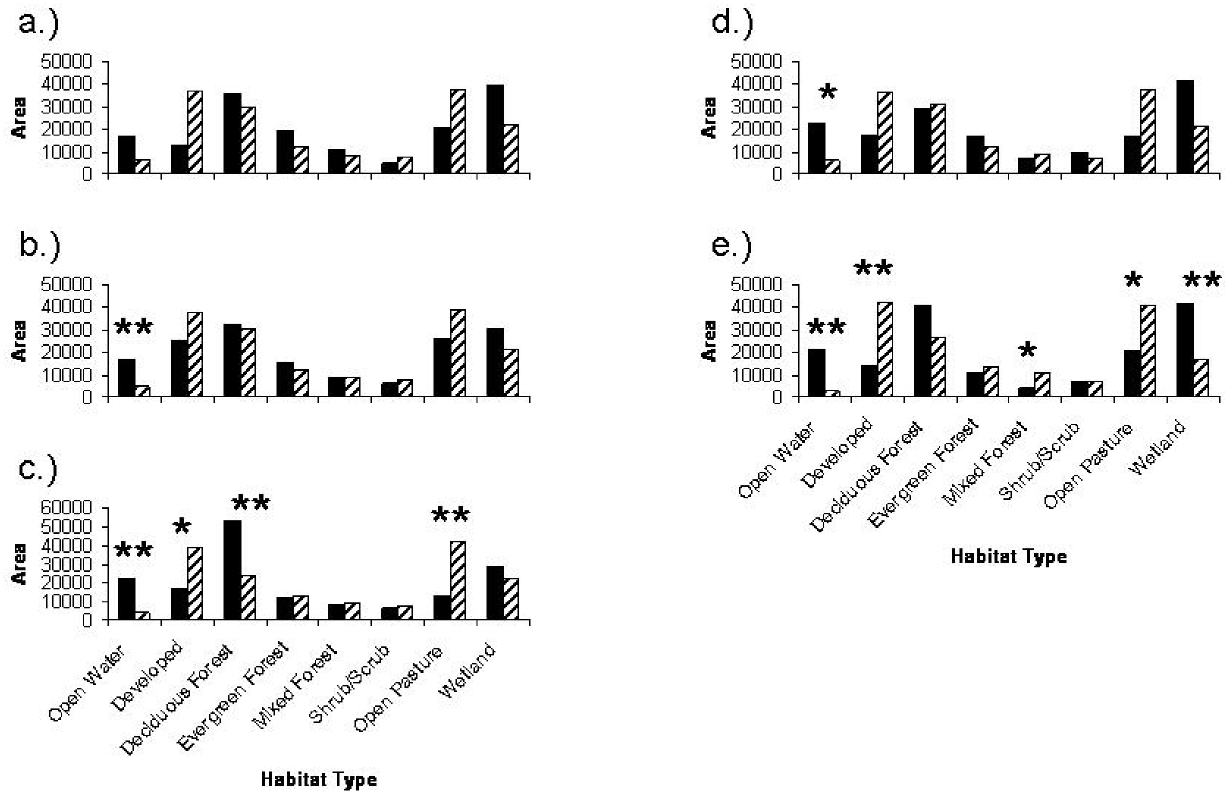


Fig. 2.5 Average area (m^2) of habitat types at the 500-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates no-detection sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

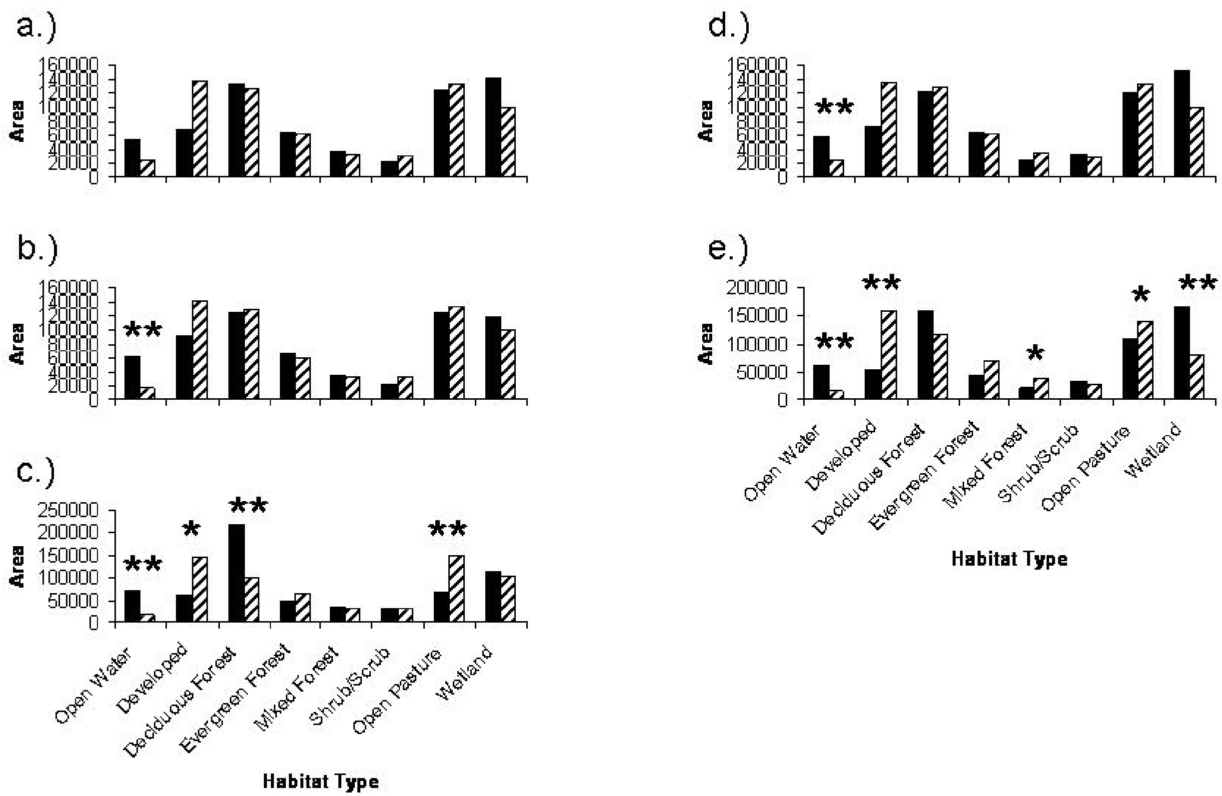


Fig. 2.6 Average area (m^2) of habitat types at the 1,000-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates no-detection sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

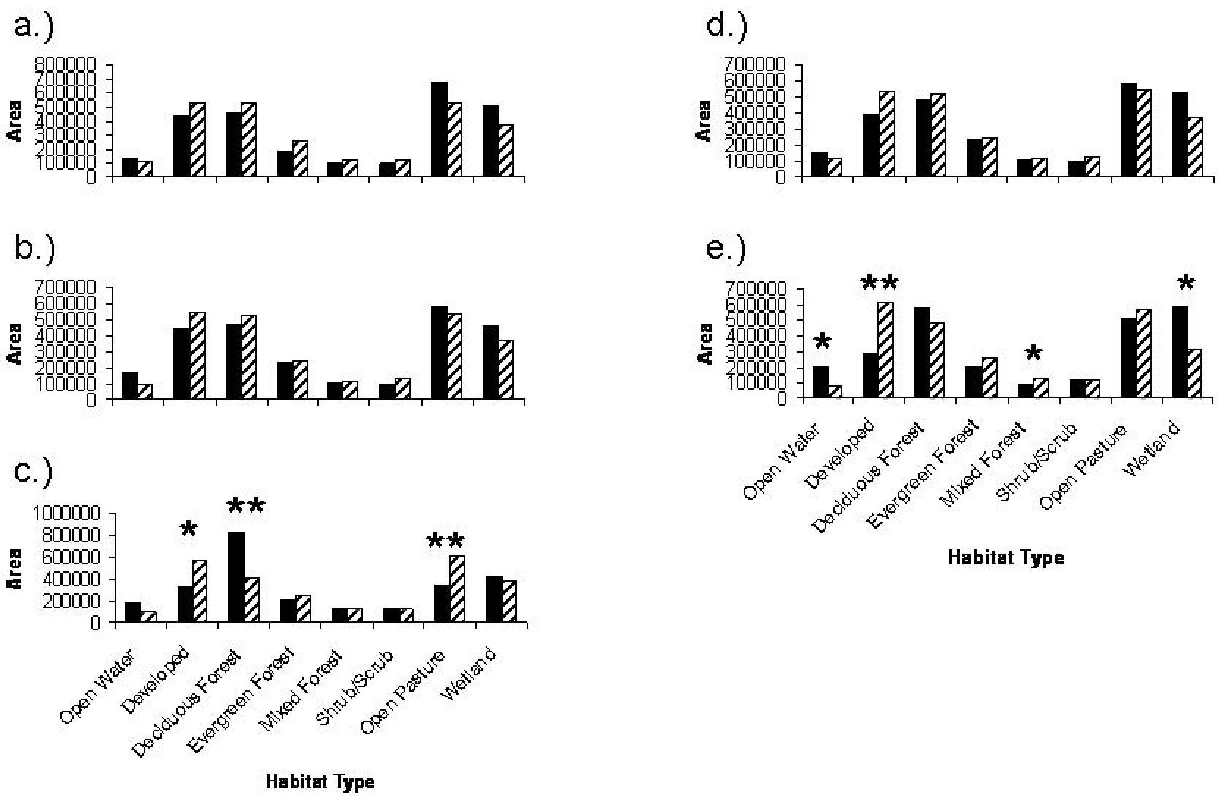


Fig. 2.7 Average area (m^2) of habitat types at the 250-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

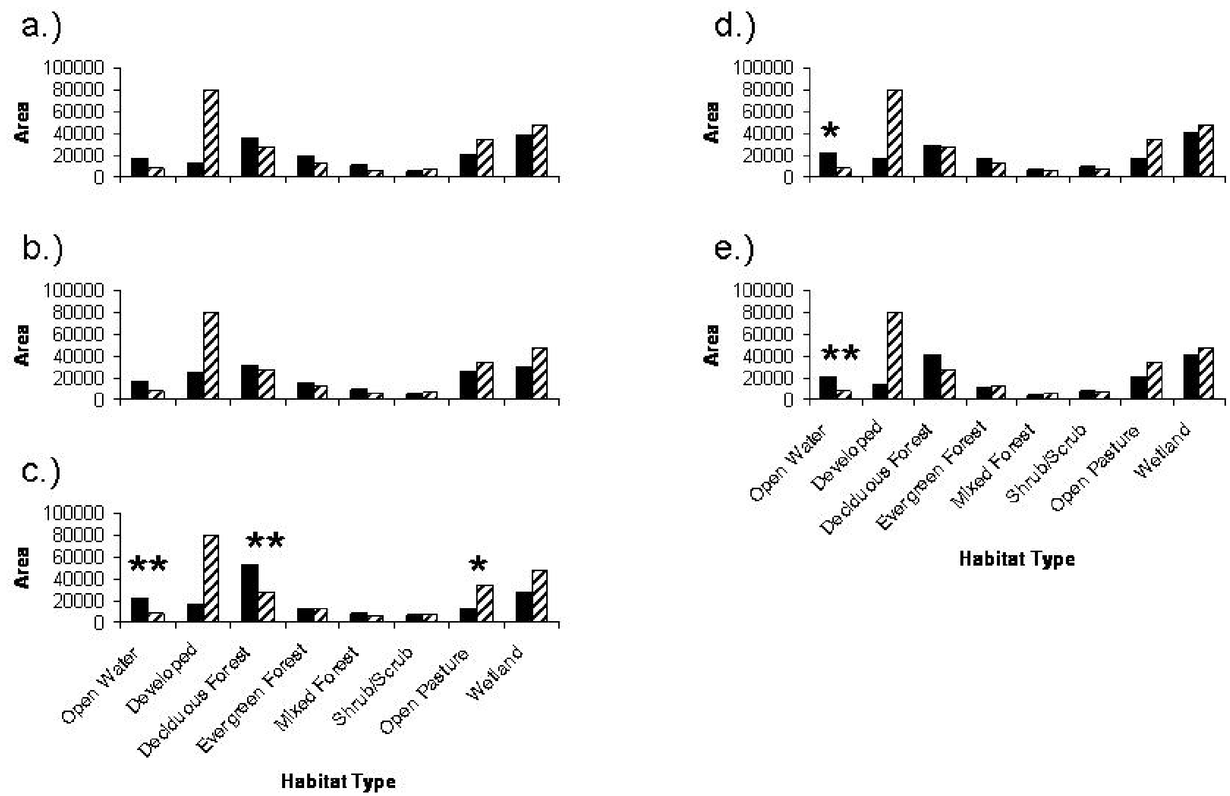


Fig. 2.8 Average area (m^2) of habitat types at the 500-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

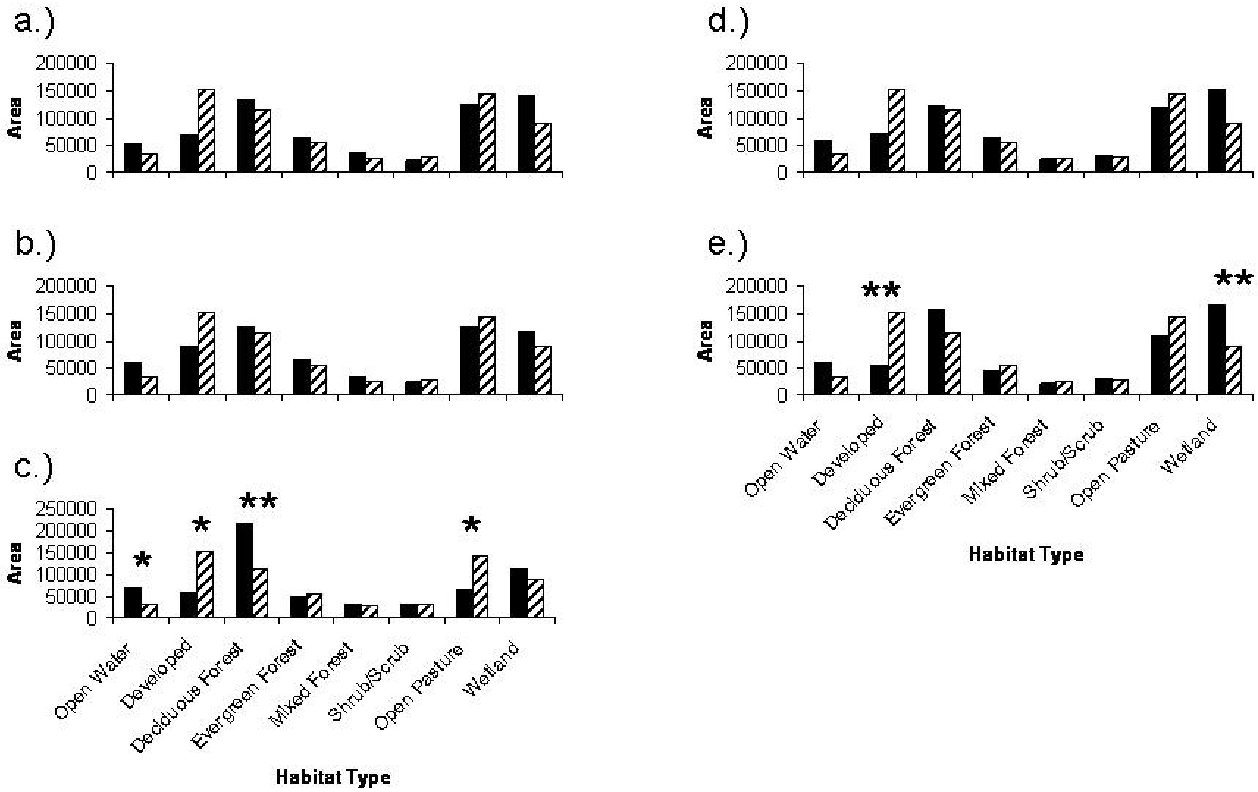


Fig. 2.9 Average area (m^2) of habitat types at the 1,000-m spatial scale at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates detection sites and a striped bar indicates random sites for a) *Eptesicus fuscus*, b) *Lasiurus borealis*, c) *Myotis grisescens*, d) *Nycticeius humeralis*, and e) *Perimyotis subflavus*. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.

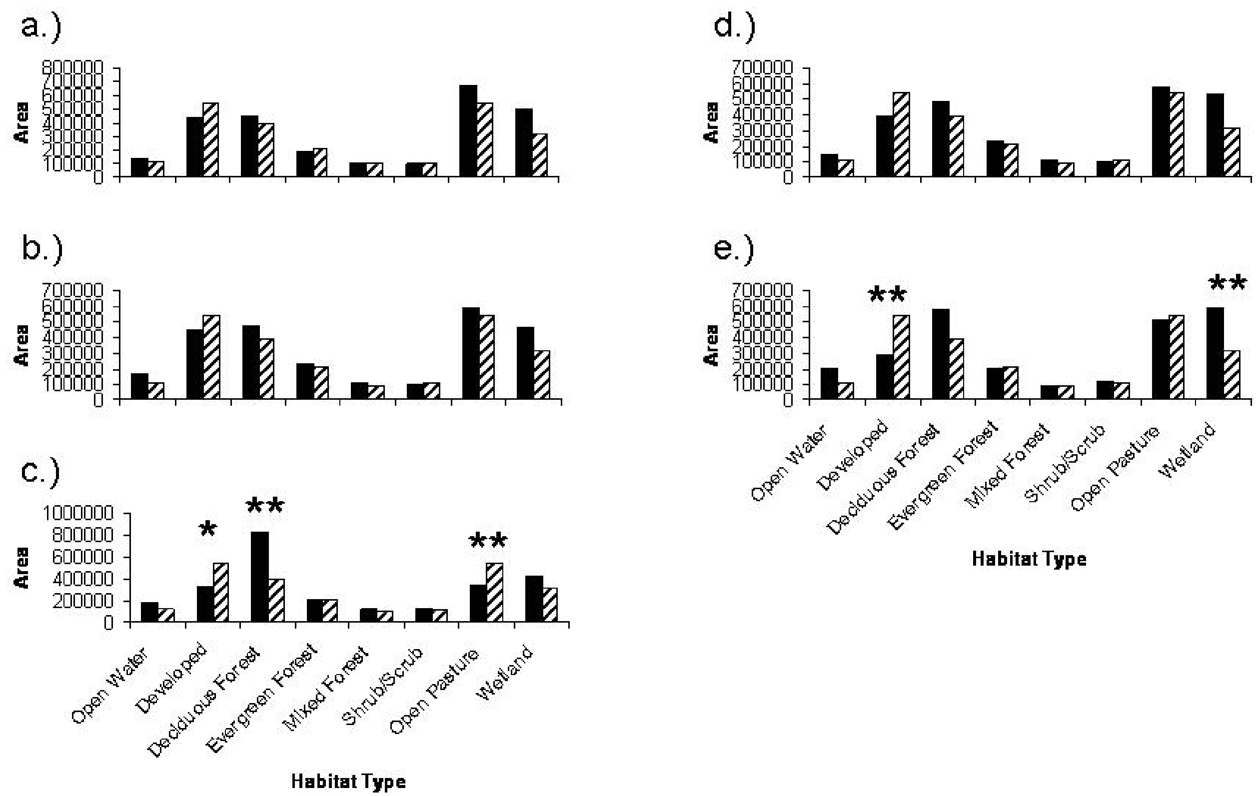
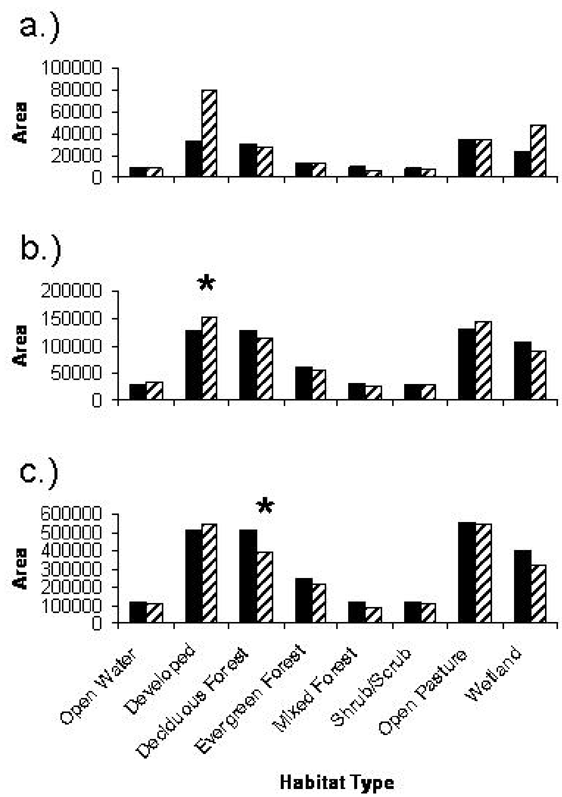


Fig. 2.10 Average area (m^2) of habitat types at the a) 250-m, b) 500-m, and c) 1,000-m spatial scales at Redstone Arsenal, Madison Co., Alabama, where a solid black bar indicates sites where detectors were placed and a striped bar indicates random sites. One asterisk indicates $P < 0.05$ and two asterisks indicate $P < 0.01$.



CHAPTER 3: COMPARING SURVEY METHODS TO ELUCIDATE HABITAT ASSOCIATIONS OF BATS ON REDSTONE ARSENAL, ALABAMA

ABSTRACT

This study compared number of species per night observed using 2 methods of sampling commonly employed to survey for bats; mist nets and ultrasonic detection. A Student *t*-test was used to compare data obtained using mist nets and ultrasonic-detection devices to assess habitat associations of bats in northern Alabama. Overall, 7 species were captured in mist nets and 6 species were detected ultrasonically. However, more species of bats per night were detected using ultrasonic methods. Unlike other studies, this study revealed that more species were observed using mist nets than ultrasonic-detection devices. This conclusion may be influenced by amount of clutter in habitats that were sampled.

INTRODUCTION

Two methods of surveying populations of bats include mist nets and ultrasonic detection. Mist nets are a common sampling technique used for capturing bats that allows the observer to examine the animal in-hand to identify species (Kunz and Kurta 1988). Having the bat in hand allows collection of data about population demographics, such as sex, age, and reproductive status, which may be useful in developing management plans (Murray et al. 1999). In the past 2 decades, researchers have used ultrasonic-detection devices for identifying bats (Bell 1980; Britzke 2003; Fenton and

Bell 1981; Livengood 2003; Loeb and O'Keefe 2006; O'Farrell 1997; Yates and Muzika 2006).

Data collected with mist nets may be biased because they only capture species that fly low and do not capture species that primarily fly over open fields, open water, or above the canopy (Kunz and Brock 1975); ultrasonic-detection devices allow the observer to sample a larger area (O'Farrell and Gannon 1999). Acoustical monitoring also has its biases, namely the under-representation of certain species whose calls are not detected easily or species that fly above the range of the ultrasonic-detection device (Murray et al. 1999). It also is difficult to identify calls of species that were recorded in areas of clutter such as in forested habitats (Jones et al. 2000; Patriquin et al. 2003). The purpose of my study was to compare average number of species detected each night using mist-net surveys and acoustical monitoring. Previous studies have used both sampling techniques at a site to make comparisons between methods (Kuenzi and Morrison 1998; Murray et al. 1999; O'Farrell and Gannon 1999). Because my study focused on sampling as much area of Redstone Arsenal as possible, only one method was used at each site.

MATERIALS AND METHODS

Data were collected as in Chapters 1 and 2; the study area was described in Chapter 1. I calculated number of species per night determined by mist netting and by ultrasonic detection. A Student *t*-test was used to determine if there was a significant difference between number of species detected by each method.

RESULTS

There were 0-5 species captured in mist nets/night and the average was 1.8 species/night ($SD = 1.5$, $n = 59$; Table 3.1). There were 0-5 species detected using

AnaBat SD1 and the average was 2.6 (*SD* = 1.6, *n* = 30). All species captured in mist nets were detected ultrasonically except for the southeastern myotis (*Myotis austroriparius*). No additional species was identified using ultrasonic detection. There was a statistically significant difference in number of species per night recorded by the 2 methods. Results from the *t*-test indicate that average number of species per night was greater using ultrasonic detection ($P = 0.013$, $t = 2.55$, $df = 87$).

DISCUSSION

My results were at variance with findings by others. More individuals were detected using acoustic monitoring than by mist nets; thus, biodiversity was greater when ultrasonic detection was used (Murray et al. 1999; O'Farrell and Gannon 1999). My study documented verification of presence of more species by using mist nets than by using AnaBat detectors, because *M. austroriparius* was not recorded using ultrasonic detection. Other studies have detected *M. austroriparius* using AnaBat and reported that it was associated with riparian areas (Britzke 2003; Ford et al. 2006). The reason that I did not detect *M. austroriparius* using AnaBat detectors is that habitats in which this species occurs are forested and ultrasonic detectors have difficulty detecting calls of species in habitats that have clutter (forested areas; Patriquin et al. 2003). Although I attempted to deploy detectors in areas without clutter, identifications of calls were limited due to clutter. Representation of species on Redstone Arsenal possibly was limited by the effect of clutter (Patriquin et al. 2003).

My observations were concordant with those reported by Murray et al. (1999); that is, the endangered gray myotis (*M. grisescens*) was detected at more sites with AnaBat detectors than with mist nets. This possibly could be because I placed detectors over open water, over which *M. grisescens* was known to forage, while I could not place nets over large areas of open water.

The northern myotis (*Myotis septentrionalis*) is considered difficult to detect by some researchers (Hickey and Neilson 1995), but has been detected successfully by others (Murray et al. 1999). My study recorded *M. septentrionalis* for both techniques of monitoring.

Mist net surveys provide collection of sex, age, and reproductive condition data that is lost when acoustical detection alone is used (Kuenzi and Morrison 1998). For example, in 1 mist net over a pond, I captured 6 female evening bats (*Nycticeius humeralis*), of which 5 were either lactating or post-lactating. The site where I placed my mist net was probably near a maternity roost since several female individuals were captured in one net.

Use of ultrasonic detection is the least intrusive method and can be used repeatedly at a site while bats will learn to avoid mist nets with repeated encounters at a site (Kunz and Brock 1975). Using both methods together provides a more complete inventory of species than using either method alone because each method has its benefits (Kuenzi and Morrison 1998; O'Farrell and Gannon 1999; Murray et al. 1999).

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Table 3.1. Values used in a *t*-test to compare number of species per night that were captured in mist nets and by AnaBat on Redstone Arsenal, Madison Co., Alabama.

Number of Species per Night		
	Mist Net	AnaBat
Range	0 - 5	0 - 7
n	104	94
Mean	1.76	3.13
SD	1.466	2.081

APPENDIX 1.

Date, time, general location, GPS coordinates, species, sex, age, and reproductive status of bats captured at Redstone Arsenal, Madison Co., Alabama, 2005-2007.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
20 July 2005							
	2048	Creek Road	34˚38.528'N, 86˚36.819'W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
	2117	Creek Road	34˚38.415'N, 86˚36.805'W	*Myotis septentrionalis*	Male	Young-of-Year	Immature
	2154	Creek Road	34˚38.528'N, 86˚36.819'W	*Myotis grisescens*	Male	Young-of-Year	Immature
	2154	Creek Road	34˚38.565'N, 86˚36.809'W	*Eptesicus fuscus*	Female	Adult	Postlactating
	2201	Creek Road	34˚38.528'N, 86˚36.819'W	*Eptesicus fuscus*	Male	Young-of-Year	Immature
	2326	Creek Road	34˚38.528'N, 86˚36.819'W	*Myotis septentrionalis*	Male	Adult	Testes nonscrotal
	2331	Creek Road	34˚38.528'N, 86˚36.819'W	*Lasiurus borealis*	Female	Young-of-Year	Immature
	2340	Creek Road	34˚38.528'N, 86˚36.819'W	*Perimyotis subflavus*	Male Adult		Testes nonscrotal
21 July 2005							
	0045	Creek Road	34˚38.528'N, 86˚36.819'W	*Lasiurus borealis*	Female	Adult	Postlactating
	0121	Creek Road	34˚38.528'N, 86˚36.819'W	*Perimyotis subflavus*	Female	Young-of-Year	Immature
	0146	Creek Road	34˚38.339'N, 86˚36.869'W	*Lasiurus borealis*	Male	Adult	Testes nonscrotal
	2115	1.25 mile N Gate 3	34˚37.937'N, 86˚35.495'W	*Eptesicus fuscus*	Female	Young-of-Year	Immature
	2138	1.25 mile N Gate 3	34˚37.945'N, 86˚35.808'W	*Lasiurus borealis*	Female	Adult	Postlactating
	2316	1.25 mile N Gate 3	34˚37.945'N, 86˚35.808'W	*Perimyotis subflavus*	Male	Young-of-Year	Immature

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
22 July 2005							
	0055	1.25 mile N Gate 3	34˚37.939'N, 86˚35.827'W	*Perimyotis subflavus*	Male	Young-of-Year	Immature
	2053	Recreation Area 2	34˚35.010'N, 86˚36.674'W	*Eptesicus fuscus*	Male	Young-of-Year	Immature
25 May 2006							
	2120	S of Shields Road	34˚35.045'N 86˚40.669'W	*Lasiurus borealis*	Male	Adult	Testes nonscrotal
31 May 2006							
	2110	S of Patton Road	34˚34.532'N 86˚37.882'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
01 June 2006							
	2220	Indian Creek	34˚38.763'N 86˚41.180'W	*Myotis austroriparius*	Female	Adult	Lactating
02 June 2006							
	0120	Indian Creek	34˚38.763'N 86˚41.180'W	*Myotis austroriparius*	Male	Adult	Testes nonscrotal
	2107	Nature Center	34˚34.775'N 86˚37.082'W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
	2330	Nature Center	34˚34.826'N 86˚37.149'W	*Myotis grisescens*	Male	Adult	Testes nonscrotal
10 June 2006							
	2410	Gate 8	34˚41.859'N 86˚37.782'W	*Myotis grisescens*	Male	Adult	Testes nonscrotal
14 June 2006							
	2110	Quarry Pond	34˚39.616'N 86˚38.806'W	*Lasiurus borealis*	Male	Adult	Testes nonscrotal
15 June 2006							
	2240	Tupelo Swamp on Martin Road	34˚39.070'N 86˚37.378'W	*Myotis austroriparius*	Male	Young-of-Year	Immature
16 June 2006							
	0015	Tupelo Swamp on Martin Road	34˚39.044'N 86˚37.329'W	*Nycticeus humeralis*	Female	Adult	Lactating
	2322	McAlpine Road	34˚33.210'N 86˚38.803'W	*Eptesicus fuscus*	Female	Adult	Lactating
17 June 2006							
	2122	Anderson Road	34˚41.185'N	*Eptesicus*	Female	Adult	Lactating

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
			86˚42.448'W	*fuscus*			
	2149	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Postlactating
	2149	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Lactating
	2149	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Lactating
	2311	Anderson Road	34˚41.851'N 86˚42.448'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2315	Anderson Road	34˚40.540'N 86˚42.464'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2328	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Not pregnant Not lactating
	2340	Anderson Road	34˚40.121'N 86˚42.634'W	*Myotis austroriparius*	Male	Adult	Testes nonscrotal
	2354	Anderson Road	34˚41.185'N 86˚42.448'W	*Lasiurus borealis*	Female	Adult	Postlactating
18 June 2006							
	0051	Anderson Road	34˚41.185'N 86˚42.448'W	*Lasiurus borealis*	Female	Adult	Postlactating
	0051	Anderson Road	34˚41.185'N 86˚42.448'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
	0104	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Postlactating
	0122	Anderson Road	34˚40.540'N 86˚42.464'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
	0245	Anderson Road	34˚39.951'N 86˚42.634'W	*Nycticeus humeralis*	Female	Adult	Postlactating
21 June 2006							
	2011	East Perimeter	34˚38.105'N 86˚36.142'W	*Lasiurus borealis*	Female	Adult	Postlactating
	2013	East Perimeter	34˚38.105'N 86˚36.142'W	*Lasiurus borealis*	Female	Adult	Postlactating
	2042	East Perimeter	34˚38.105'N 86˚36.142'W	*Nycticeus humeralis*	Male	Adult	Testes nonscrotal
	2042	East Perimeter	34˚38.105'N 86˚36.142'W	*Perimyotis subflavus*	Female	Adult	Lactating
	2042	East Perimeter	34˚38.105'N 86˚36.142'W	*Lasiurus* sp.	Undetermined sex, age, and reproductive status		

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	2150	East Perimeter	34˚38.743'N 86˚36.113'W	*Myotis austroriparius*	Female	Young-of-Year	Immature
22 June 2006							
	0132	East Perimeter	34˚38.105'N 86˚36.142'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2020	East Perimeter	34˚35.158'N 86˚35.234'W	*Lasiurus borealis*	Female	Adult	Postlactating
	2020	East Perimeter	34˚35.158'N 86˚35.234'W	*Lasiurus borealis*	Female	Adult	Postlactating
	2151	East Perimeter	34˚35.197'N 86˚35.240'W	*Myotis austroriparius*	Male	Young-of-Year	Immature
	2158	East Perimeter	34˚35.316'N 86˚35.186'W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
	2210	East Perimeter	34˚35.158'N 86˚35.234'W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
	2210	East Perimeter	34˚35.158'N 86˚35.234'W	*Nycticeus humeralis*	Male	Adult	Testes nonscrotal
	2210	East Perimeter	34˚35.158'N 86˚35.234'W	*Myotis austroriparius*	Female	Adult	Lactating
	2324	East Perimeter	34˚35.316'N 86˚35.186'W	*Myotis austroriparius*	Male	Young-of-Year	Immature
23 June 2006							
	0120	East Perimeter	34˚35.158'N 86˚35.234'W	*Myotis grisescens*	Female	Adult	Postlactating
	2226	East Perimeter	34˚37.883'N 86˚37.828'W	*Myotis austroriparius*	Female	Adult	Lactating
12 July 2006							
	2107	Bradford Sinks	34˚36.392'N 86˚42.868'W	*Eptesicus fuscus*	Female	Adult	Postlactating
	2119	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Eptesicus fuscus*	Male	Adult	Testes nonscrotal
	2127	Bradford Sinks	34˚36.016'N 86˚42.232'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2240	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Eptesicus fuscus*	Male	Adult	Testes nonscrotal
	2307	Bradford Sinks	34˚36.392'N 86˚42.868'W	*Eptesicus fuscus*	Female	Adult	Postlactating

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	2313	Bradford Sinks	34˚36.392'N 86˚42.868'W	*Eptesicus fuscus*	Female	Adult	Postlactating
	2327	Bradford Sinks	34˚36.392'N 86˚42.868'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	2338	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
13 July 2006							
	0040	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	0040	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Eptesicus fuscus*	Female	Adult	Postlactating
	0152	Bradford Sinks	34˚36.094'N 86˚43.217'W	*Eptesicus fuscus*	Female	Adult	Lactating
	0218	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Nycticeus humeralis*	Male	Young-of-Year	Testes scrotal
	0218	Bradford Sinks	34˚37.747'N 86˚43.004'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2300	Test Area 1	34˚36.885'N 86˚39.932'W	*Eptesicus fuscus*	Female	Young-of-Year	Immature
14 July 2006							
	0234	Test Area 1	34˚36.885'N 86˚39.932'W	*Lasiurus borealis*	Female	Young-of-Year	Immature
19 July 2006							
	2050	S Anderson Road	34˚37.263'N 86˚42.708'W	*Lasiurus borealis*	Female	Young-of-Year	Immature
	2222	S Anderson Road	34˚37.263'N 86˚42.708'W	*Myotis austroriparius*	Female	Adult	Postlactating
	2223	S Anderson Road	34˚37.263'N 86˚42.708'W	*Nycticeus humeralis*	Male	Young-of-Year	Testes scrotal
20 July 2006							
	0153	S Anderson Road	34˚37.263'N 86˚42.708'W	*Myotis austroriparius*	Female	Adult	Postlactating
	0204	S Anderson Road	34˚37.244'N 86˚42.937'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	0204	S Anderson Road	34˚37.244'N 86˚42.937'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	0204	S Anderson Road	34˚37.244'N 86˚42.937'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Lasiurus borealis*	Female	Adult	Postlactaqting
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Male	Young of Year	Testes scrotal
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Female	Adult	Postlactating
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Female	Adult	Postlactating
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Female	Young-of-Year	Immature
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Female	Adult	Postlactating
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Perimyotis subflavus*	Male	Young-of-Year	Testes scrotal
	2136	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
	2140	Lady Anne Lake	34˚40.109'N 86˚41.886'W	*Nycticeus humeralis*	Female	Adult	Not pregnant Not lactating
	2140	Lady Anne Lake	34˚40.109'N 86˚41.886'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2140	Lady Anne Lake	34˚40.109'N 86˚41.886'W	*Eptesicus fuscus*	Female	Adult	Postlactating
	2140	Lady Anne Lake	34˚40.109'N 86˚41.886'W	*Myotis grisescens*	Female	Young-of-Year	Immature
	2303	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Lasiurus borealis*	Female	Young-of-Year	Immature
21 July 2006							
	0110	Lady Anne Lake	34˚40.190'N 86˚41.879'W	*Eptesicus fuscus*	Female	Adult	Lactating
	0228	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Lasiurus borealis*	Female	Young-of-Year	Immature
	0228	Lady Anne Lake	34˚40.304'N 86˚42.826'W	*Nycticeus humeralis*	Female	Adult	Not pregnant Not lactating
	2115	Anderson Road	34˚37.344'N 86˚38.306'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
26 July 2006							
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis grisescens*	Male	Young-of-Year	Testes nonscrotal
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis* sp.	Undetermined sex, age, and reproductive status		
	2350	Field Training Center	34˚40.834’N 86˚36.780’W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
27 July 2006							
	0004	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis grisescens*	Male	Young-of-Year	Testes nonscrotal
	2110	McKinley Demolition Range	34˚35.254’N 86˚39.389’W	*Lasiurus borealis*	Female	Young-of-Year	Immature
	2140	Lady Anne Lake	34˚40.109’N 86˚41.886’W	*Nycticeus humeralis*	Female	Adult	Not pregnant Not lactating
	2140	Lady Anne Lake	34˚40.109’N 86˚41.886’W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2140	Lady Anne Lake	34˚40.109’N 86˚41.886’W	*Eptesicus fuscus*	Female	Adult	Postlactating
	2140	Lady Anne Lake	34˚40.109’N 86˚41.886’W	*Myotis grisescens*	Female	Young-of-Year	Immature
	2303	Lady Anne Lake	34˚40.304’N 86˚42.826’W	*Lasiurus borealis*	Female	Young-of-Year	Immature
26 July 2006							
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis grisescens*	Male	Young-of-Year	Testes nonscrotal
	2040	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis* sp.	Undetermined sex, age, and reproductive status		
	2350	Field Training Center	34˚40.834’N 86˚36.780’W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
27 July 2006							
	0004	Field Training Center	34˚40.352’N 86˚37.023’W	*Myotis grisescens*	Male	Young-of-Year	Testes nonscrotal
	2110	McKinley Demolition Range	34˚35.254’N 86˚39.389’W	*Lasiurus borealis*	Female	Young-of-Year	Immature

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	2203	McKinley Demolition Range	34˚35.612’N 86˚38.647’W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
28 July 2006							
	0156	McKinley Demolition Range	34˚35.612’N 86˚38.647’W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
09 May 2007							
	2042	Recreation Area 2	34˚35.028’N, 86˚36.700’W	*Lasiurus borealis*	Male	Adult	Testes nonscrotal
	2046	Recreation Area 2	34˚35.020’N, 86˚36.665’W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2120	Path to Nature	34˚34.932’N, 86˚37.124’W	*Lasiurus borealis*	Female	Adult	Not pregnant Not lactating
	2129	Recreation Area 2	34˚35.020’N, 86˚36.665’W	*Eptesicus fuscus*	Female	Adult	Pregnant Not lactating
	2129	Recreation Area 2	34˚35.020’N, 86˚36.665’W	*Nycticeus humeralis*	Female	Adult	Not pregnant Not lactating
	0142	Recreation Area 2	34˚35.020’N, 86˚36.665’W	*Lasiurus borealis*	Male	Adult	Testes nonscrotal
10 May 2007							
	0042	McAlpine Road	34˚33.203’N, 86˚38.724’W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
11 May 2007							
	0135	Fitness Trail	34˚40.650’N, 86˚38.327’W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
	0135	Fitness Trail	34˚40.650’N, 86˚38.327’W	*Eptesicus fuscus*	Female	Adult	Lactating
16 May 2007							
	0135	Indian Creek and Martin Road	34˚38.674’N, 86˚41.558’W	*Perimyotis subflavus*	Male	Adult	Testes scrotal
18 May 2007							
	2100	Weeden Mountain	34˚41.187’N, 86˚38.960’W	*Perimyotis subflavus*	Female	Adult	Not pregnant Not lactating
23 May 2007							
	2137	Huntsville Spring Branch, Patton Road	34˚37.945’N, 86˚37.841’W	*Perimyotis subflavus*	Male	Adult	Testes nonscrotal
24 May 2007							
	2100	Hansen Road	34˚40.623’N,	*Eptesicus* 86˚37.150’W	Female *fuscus*	Undetermined age and reproductive status	

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	0030	Hansen Road	34˚40.623'N, 86˚37.150'W	*Eptesicus fuscus*	Female	Adult	Lactating
	0045	Hansen Road	34˚40.623'N, 86˚37.150'W	*Eptesicus fuscus*	Female	Adult	Lactating
25 May 2007							
	0130	N Anderson Road	34˚39.735'N, 86˚42.480'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
30 May 2007							
	2100	Test Area 6	34˚41.508'N, 86˚41.973'W	*Lasiurus borealis*	Female	Adult	Pregnant
	2100	Test Area 6	34˚40.679'N, 86˚41.974'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2100	Test Area 6	34˚40.679'N, 86˚41.974'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	0137	Test Area 6	34˚41.508'N, 86˚41.973'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
31 May 2007							
	2225	Bradford Sinks	34˚35.871'N, 86˚43.400'W	*Nycticeus humeralis*	Undetermined sex, age, and reproductive status		
1 June 2007							
	0110	Rock Quarry	34˚39.595'N, 86˚38.753'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive stataus		
6 June 2007							
	2010	Test Area 1	34˚36.594'N, 86˚39.162'W	*Lasiurus borealis*	Male	Adult	Testes scrotal
7 June 2007							
	2000	McKinley Range	34˚35.589'N, 86˚38.962'W	*Lasiurus borealis*	Female	Adult	Lactating
	2338	McKinley Range	34˚35.589'N, 86˚38.962'W	*Perimyotis subflavus*	Female	Adult	Lactating
	0145	McKinley Range	34˚35.589'N, 86˚38.962'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
8 June 2007							
	2100	Adams Cave	34˚34.277'N, 86˚37.852'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	2211	Adams Cave	34˚34.357'N, 86˚37.864'W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
	2211	Adams Cave	34˚34.645'N, 86˚37.637'W	*Myotis grisescens*	Male	Adult	Testes scrotal

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	0035	Adams Cave	34˚34.645'N, 86˚37.637'W	*Myotis grisescens*	Male	Adult	Testes nonscrotal
13 June 2007							
	2305	Buxton Rd Chemical Contamination Site	34˚34.214'N, 86˚39.619'W	*Lasiurus borealis*	Female	Adult	Lactating
	0136	Buxton Rd Chemical Contamination Site	34˚34.214'N, 86˚39.619'W	*Lasiurus borealis*	Male	Adult	Testes scrotal
14 June 2007							
	2050	Water Facility	34˚39.936'N, 86˚39.445'W	*Lasiurus borealis*	Female	Adult	Lactating
20 June 2007							
	2117	Creek Road	34˚38.597'N, 86˚36.833'W	*Nycticeus humeralis*	Female	Adult	Lactating
	2117	Creek Road	34˚38.597'N, 86˚36.833'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2344	Creek Road	34˚38.436'N, 86˚36.823'W	*Myotis austroriparius*	Male	Young-of-Year	Testes scrotal
	0110	Creek Road	34˚38.597'N, 86˚36.833'W	*Myotis grisescens*	Male	Adult	Testes scrotal
21 June 2007							
	2100	East Perimeter	34˚38.244'N, 86˚36.177'W	*Myotis austroriparius*	Female	Adult	Lactating
	2100	East Perimeter	34˚38.244'N, 86˚36.177'W	*Myotis austroriparius*	Female	Young-of-Year	Not pregnant Not lactating
22 June 2007							
	2106	Timmons Cemetery Road	34˚35.425'N, 86˚36.795'W	*Lasiurus borealis*	Male	Adult	Testes scrotal
	2230	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
	2230	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2230	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2359	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2359	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Eptesicus fuscus*	Female	Adult	Lactating
	0030	Timmons Cemetery Road	34˚35.373'N, 86˚37.356'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
	0128	Timmons Cemetery Road	34˚35.491'N, 86˚37.330'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
27 June 2007							
	2016	Shield Road	34˚35.220N, 86˚41.039'W	*Lasiurus borealis*	Female	Adult	Lactating
	2025	Shield Road	34˚35.220N, 86˚41.039'W	*Lasiurus borealis*	Female	Adult	Lactating
12 July 2007							
	2145	East Perimeter Near Gate 3	34˚37.933N, 86˚35.390'W	*Myotis austroriparius*	Female	Adult	Lactating
	2145	East Perimeter Near Gate 3	34˚37.934N, 86˚35.450'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
	2240	East Perimeter Near Gate 3	34˚37.933N, 86˚35.390'W	*Eptesicus fuscus*	Female	Adult	Lactating
	2340	East Perimeter Near Gate 3	34˚37.934N, 86˚35.450'W	*Eptesicus fuscus*	Female	Young-of-Year	Not pregnant Not lactating
	0040	East Perimeter Near Gate 3	34˚37.934N, 86˚35.450'W	*Eptesicus fuscus*	Female	Young-of-Year	Not pregnant Not lactating
	0040	East Perimeter Near Gate 3	34˚37.934N, 86˚35.450'W	*Eptesicus fuscus*	Male	Young-of-Year	Testes scrotal
13 July 2007							
	2100	Frisbee Golf Course on Vincent	34˚40.914N, 86˚38.306'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2100	Frisbee Golf Course on Vincent	34˚40.914N, 86˚38.306'W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
	2100	Frisbee Golf Course on Vincent	34˚40.914N, 86˚38.306'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2200	Frisbee Golf Course on Vincent	34˚41.009N, 86˚38.280'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	2200	Frisbee Golf Course on Vincent	34˚40.976N, 86˚38.319'W	*Myotis grisescens*	Male	Adult	Testes scrotal
	2300	Frisbee Golf Course on Vincent	34˚40.863N, 86˚38.305'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	2300	Frisbee Golf Course on Vincent	34˚41.009N, 86˚38.280'W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
	2400	Frisbee Golf Course on Vincent	34˚40.863N, 86˚38.305'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	0130	Frisbee Golf Course on Vincent	34˚40.914N, 86˚38.306'W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
	0130	Frisbee Golf Course on Vincent	34˚40.914N, 86˚38.306'W	*Eptesicus fuscus*	Male	Young-of-Year	Testes scrotal

APPENDIX 1. Continued.

Date	Time (CDT)	Locality	GPS coordinates	Species	Sex	Age	Reproductive status
18 July 2007							
	0015	Madkin Mountain	34˚40.212N, 86˚38.936'W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
	0057	Madkin Mountain	34˚40.212N, 86˚38.936'W	*Lasiurus borealis*	Undetermined sex, age, and reproductive status		
	0110	Madkin Mountain	34˚40.236N, 86˚38.830'W	*Eptesicus fuscus*	Male	Adult	Testes scrotal
19 July 2007	2115	Bradford Mountain Rock Shelter	34˚35.693N, 86˚42.372'W	*Perimyotis subflavis*	Female	Adult	Postlac.tating
	2130	Bradford Mountain Rock Shelter	34˚36.136N, 86˚42.562'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	2335	Bradford Mountain Rock Shelter	34˚36.136N, 86˚42.562'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2335	Bradford Mountain Rock Shelter	34˚36.136N, 86˚42.562'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	0040	Bradford Mountain Rock Shelter	34˚36.136N, 86˚42.562'W	*Lasiurus borealis*	Male	Young-of-Year	Testes scrotal
	0100	Bradford Mountain Rock Shelter	34˚36.136N, 86˚42.562'W	*Nycticeus humeralis*	Male	Adult	Testes scrotal
	0145	Bradford Mtn. Rock Shelter	34˚36.136N, 86˚42.562'W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
26 July 2007	2215	Pasture Near Gate 1	34˚35.243N, 86˚35.232'W	*Lasiurus borealis*	Female	Young-of-Year	Not pregnant Not lactating
	2335	Pasture Near Gate 1	34˚35.243N, 86˚35.232'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating
	2358	Pasture Near Gate 1	34˚35.243N, 86˚35.232'W	*Eptesicus fuscus*	Female	Adult	Not pregnant Not lactating

APPENDIX 2.

Localities where mist nets were placed and no bat was captured at Redstone Arsenal, Madison Co., Alabama, 2005-2007.

Date	Locality	GPS coordinates
21 July 2005	1.25 mile N Gate 3	34˚37.943'N, 86˚35.525'W
22 July 2005	Recreation Area 2	34˚35.076'N, 86˚36.693'W
22 July 2005	Recreation Area 2	34˚34.926'N, 87˚37.134'W
22 July 2005	Recreation Area 2	34˚34.949'N, 87˚37.130'W
24 May 2006		34˚42.234'N, 86˚40.680'W
24 May 2006	Mathew's Cave	34˚42.133'N, 86˚41.038'W
24 May 2006		34˚42.167'N, 86˚40.813'W
24 May 2006		34˚41.913'N, 86˚41.065'W
25 May 2006		34˚35.427'N, 86˚40.026'W
25 May 2006		34˚35.473'N, 86˚40.115'W
25 May 2006		34˚35.093'N, 86˚40.622'W
26 May 2006	Road to Ponds 48N and 48S	34˚35.530'N, 86˚36.783'W
26 May 2006	Road to Ponds 48N and 48S	34˚35.620'N, 86˚36.784'W
26 May 2006	Timmon's Cemetery Road	34˚35.308'N, 86˚37.483'W
26 May 2006	Timmon's Cemetery Road	34˚35.389'N, 86˚37.353'W
31 May 2006	Adam's Cave	34˚34.652'N, 86˚37.735'W
31 May 2006	near Adam's Cave	34˚34.655'N, 86˚37.682'W
31 May 2006	South end of Patton Road	34˚34.599'N, 86˚37.885'W
01 June 2006	Madison Road	34˚38.681'N, 86˚41.584'W
01 June 2006	Madison Road	34˚38.681'N, 86˚41.561'W
01 June 2006	Tributary to Indian Creek	34˚38.789'N, 86˚41.172'W
02 June 2006	Nature Center	34˚34.945'N, 86˚36.881'W
02 June 2006	Nature Center	34˚34.934'N, 86˚36.921'W
07 June 2006	Weeden Mountain Road	34˚41.035'N, 86˚39.016'W
07 June 2006	Weeden Mountain Road	34˚41.240'N, 86˚38.974'W
07 June 2006	Weeden Mountain Road	34˚41.191'N, 86˚38.945'W
07 June 2006	Weeden Mountain Road	34˚40.886'N, 86˚38.851'W
08 June 2006		34˚40.592'N, 86˚38.225'W
08 June 2006		34˚40.643'N, 86˚38.349'W

APPENDIX 2. Continued.

Date	Locality	GPS coordinates
08 June 2006		34˚40.648'N, 86˚38.332'W
08 June 2006		34˚40.782'N, 86˚38.337'W
09 June 2006	Redstone Links	34˚41.954'N, 86˚39.909'W
09 June 2006	Redstone Links	34˚42.023'N, 86˚39.837'W
09 June 2006	Stream near Gate 8	34˚41.868'N, 86˚37.788'W
14 June 2006	Quarry Pond	34˚39.619'N, 86˚38.893'W
14 June 2006	Quarry Pond	34˚39.534'N, 86˚38.801'W
14 June 2006	Quarry Pond	34˚39.591'N, 86˚38.792'W
15 June 2006	Tupelo Swamp	34˚39.768'N, 86˚37.236'W
15 June 2006	Tupelo Swamp	34˚39.627'N, 86˚37.318'W
15 June 2006	Tupelo Swamp	34˚38.921'N, 86˚37.272'W
16 June 2006	McAlpine Road	34˚33.204'N, 86˚38.727'W
16 June 2006	Iceberg Lake	34˚35.148'N, 86˚39.314'W
16 June 2006	Iceberg Lake	34˚34.904'N, 86˚39.336'W
21 June 2006	East Perimeter	34˚37.916'N, 86˚36.211'W
21 June 2006	East Perimeter	34˚37.945'N, 86˚36.176'W
22 June 2006	East Perimeter Creek	34˚35.234'N, 86˚35.235'W
23 June 2006	East Perimeter	34˚37.541'N, 86˚37.767'W
23 June 2006	East Perimeter	34˚37.560'N, 86˚37.804'W
23 June 2006	East Perimeter	34˚37.886'N, 86˚37.793'W
23 June 2006	East Perimeter	34˚37.936'N, 86˚37.851'W
28 June 2006	Hansen Road	34˚40.676'N, 86˚37.177'W
28 June 2006	Hansen Road	34˚40.625'N, 86˚37.145'W
28 June 2006	Hansen Road	34˚40.711'N, 86˚37.218'W
28 June 2006	Hansen Road	34˚40.329'N, 86˚37.148'W
28 June 2006	Hansen Road	34˚40.393'N, 86˚37.167'W
29 June 2006	Igloo Pond	34˚34.047'N, 86˚39.396'W
29 June 2006	Igloo Pond	34˚34.115'N, 86˚39.663'W
29 June 2006	Igloo Pond	34˚34.652'N, 86˚39.630'W
29 June 2006	Igloo Pond	34˚34.847'N, 86˚39.580'W
13 July 2006	Test Area 1	34˚37.133'N, 86˚39.900'W
13 July 2006	Test Area 1	34˚36.578'N, 86˚39.168'W

APPENDIX 2. Continued.

Date	Locality	GPS coordinates
13 July 2006	Test Area 1	34˚36.221'N, 86˚39.078'W
14 July 2006	Bradford Mountain	34˚35.698'N, 86˚42.375W
14 July 2006	Bradford Mountain	34˚35.696'N, 86˚42.351'W
14 July 2006	Bradford Mountain	34˚35.727'N, 86˚42.348'W
14 July 2006	Bradford Mountain	34˚35.857'N, 86˚42.388'W
14 July 2006	Bradford Mountain	34˚36.148'N, 86˚42.566'W
19 July 2006	South Anderson Road	34˚37.378'N, 86˚42.832'W
19 July 2006	South Anderson Road	34˚37.377'N, 86˚42.608'W
20 July 2006	Lady Anne Lake	34˚39.475'N, 86˚42.008'W
20 July 2006	Lady Anne Lake	34˚39.470'N, 86˚41.994'W
21 July 2006	Anderson Road	34˚37.040'N, 86˚39.169'W
21 July 2006	Anderson Road	34˚37.579'N, 86˚38.395'W
21 July 2006	Anderson Road	34˚37.536'N, 86˚38.359'W
26 July 2006	Field Training Center	34˚40.818'N, 86˚37.029'W
26 July 2006	Field Training Center	34˚40.363'N, 86˚37.045'W
27 July 2006	McKinley Technical and Tactical Demolition Range	34˚35.715'N, 86˚38.229'W
27 July 2006	McKinley Technical and Tactical Demolition Range	34˚35.747'N, 86˚38.820'W
27 July 2006	McKinley Technical and Tactical Demolition Range	34˚35.596'N, 86˚38.938'W
09 May 2007	Path to Nature	34˚34.980'N, 86˚37.126'W
10 May 2007	McAlpine Road	34˚33.229'N, 86˚38.876'W
10 May 2007	Igloo Pond	34˚34.906'N, 86˚39.333'W
10 May 2007	Igloo Pond	34˚35.145'N, 86˚39.314'W
11 May 2007	Fitness Trail	34˚40.593'N, 86˚38.231'W
11 May 2007	Fitness Trail	34˚40.640'N, 86˚38.352'W
11 May 2007	Fitness Trail	34˚40.783'N, 86˚38.354'W
16 May 2007	Indian Creek and Martin Road	34˚38.785'N, 86˚41.176'W
16 May 2007	Indian Creek and Martin Road	34˚38.758'N, 86˚41.182'W
16 May 2007	Indian Creek and Martin Road	34˚38.682'N, 86˚41.572'W
17 May 2007	Martin Road Tupelo Swamp	34˚39.764'N, 86˚37.227'W
17 May 2007	Martin Road Tupelo Swamp	34˚39.611'N, 86˚37.336'W

APPENDIX 2. Continued.

Date	Locality	GPS coordinates
17 May 2007	Martin Road Tupelo Swamp	34˚39.058'N, 86˚37.333'W
17 May 2007	Martin Road Tupelo Swamp	34˚39.073'N, 86˚37.377'W
18 May 2007	Weeden Mountain	34˚40.888'N, 86˚38.851'W
18 May 2007	Weeden Mountain	34˚41.022'N, 86˚39.010'W
18 May 2007	Weeden Mountain	34˚41.241'N, 86˚38.969'W
23 May 2007	Huntsville Spring Branch, Patton Road	34˚37.541'N, 86˚37.770'W
23 May 2007	Huntsville Spring Branch, Patton Road	34˚37.579'N, 86˚37.802'W
23 May 2007	Huntsville Spring Branch, Patton Road	34˚37.886'N, 86˚37.792'W
23 May 2007	Huntsville Spring Branch, Patton Road	34˚37.887'N, 86˚37.824'W
24 May 2007	Hansen Road	34˚40.369'N, 86˚37.183'W
24 May 2007	Hansen Road	34˚40.328'N, 86˚37.146'W
24 May 2007	Hansen Road	34˚40.707'N, 86˚37.212'W
24 May 2007	Hansen Road	34˚40.674'N, 86˚37.170'W
25 May 2007	North Anderson Road	34˚39.254'N, 86˚42.755'W
25 May 2007	North Anderson Road	34˚39.242'N, 86˚42.625'W
25 May 2007	North Anderson Road	34˚39.733'N, 86˚42.919'W
30 May 2007	Test Area 6	34˚41.440'N, 86˚41.893'W
30 May 2007	Test Area 6	34˚40.123'N, 86˚41.757'W
31 May 2007	Bradford Sinks	34˚35.804'N, 86˚43.358'W
31 May 2007	Bradford Sinks	34˚36.206'N, 86˚43.210'W
31 May 2007	Bradford Sinks	34˚36.222'N, 86˚43.135'W
1 June 2007	Rock Quarry	34˚39.480'N, 86˚38.753'W
1 June 2007	Rock Quarry	34˚39.527'N, 86˚38.796'W
1 June 2007	Rock Quarry	34˚39.617'N, 86˚38.888'W
6 June 2007	Test Area 1	34˚36.225'N, 86˚39.085'W
6 June 2007	Test Area 1	34˚36.697'N, 86˚39.300'W
6 June 2007	Test Area 1	34˚37.130'N, 86˚39.901'W
7 June 2007	McKinley Range	34˚35.262'N, 86˚39.389'W
7 June 2007	McKinley Range	34˚35.744'N, 86˚38.823'W

APPENDIX 2. Continued.

Date	Locality	GPS coordinates
7 June 2007	McKinley Range	34˚35.716'N, 86˚38.231'W
8 June 2007	Adams Cave	34˚34.631'N, 86˚37.761'W
12 June 2007	NW Anderson Road	34˚41.049'N, 86˚42.880'W
12 June 2007	NW Anderson Road	34˚41.264'N, 86˚42.542'W
12 June 2007	NW Anderson Road	34˚41.397'N, 86˚42.446'W
12 June 2007	NW Anderson Road	34˚41.566'N, 86˚42.440'W
13 June 2007	Buxton Road Chemical Contamination Area	34˚34.838'N, 86˚39.580'W
13 June 2007	Buxton Road Chemical Contamination Area	34˚34.643'N, 86˚39.627'W
13 June 2007	Buxton Road Chemical Contamination Area	34˚34.041'N, 86˚39.692'W
14 June 2007	Water Facility	34˚39.937'N, 86˚39.445'W
14 June 2007	Water Facility	34˚39.900'N, 86˚39.230'W
14 June 2007	Water Facility	34˚39.778'N, 86˚39.100'W
20 June 2007	Creek Road	34˚38.635'N, 86˚36.796'W
20 June 2007	Creek Road	34˚38.366'N, 86˚36.819'W
21 June 2007	East Perimeter	34˚37.937'N, 86˚36.170'W
21 June 2007	East Perimeter	34˚38.812'N, 86˚36.122'W
21 June 2007	East Perimeter	34˚38.872'N, 86˚36.124'W
22 June 2007	Timmon's Cemetery Road	34˚35.406'N, 86˚36.792'W
27 June 2007	Shield Road	34˚35.250'N, 86˚40.039'W
27 June 2007	Shield Road	34˚35.190'N, 86˚40.571'W
27 June 2007	Shield Road	34˚35.152'N, 86˚40.542'W
11 July 2007	Environmental Area Shield Road	34˚35.308'N, 86˚40.088'W
11 July 2007	Environmental Area Shield Road	34˚35.287'N, 86˚40.086'W
11 July 2007	Environmental Area Shield Road	34˚35.303'N, 86˚39.974'W
11 July 2007	Environmental Area Shield Road	34˚35.340'N, 86˚39.986'W
12 July 2007	East Perimeter Near Gate 3	34˚37.145'N, 86˚35.281'W

APPENDIX 2. Continued.

Date	Locality	GPS coordinates
12 July 2007	East Perimeter Near Gate 3	34˚37.227'N, 86˚35.251'W
18 July 2007	Madkin Mountain	34˚40.179'N, 86˚38.917'W
18 July 2007	Madkin Mountain	34˚40.310'N, 86˚38.942'W
19 July 2007	Bradford Mountain Rock Shelter	34˚35.701'N, 86˚42.359'W
19 July 2007	Bradford Mountain Rock Shelter	34˚35.705'N, 86˚42.354'W
19 July 2007	Bradford Mountain Rock Shelter	34˚35.719'N, 86˚42.348'W
20 July 2007	Rustic Lodge	34˚34.518'N, 86˚37.239'W
20 July 2007	Rustic Lodge	34˚34.563'N, 86˚37.262'W
20 July 2007	Rustic Lodge	34˚34.591'N, 86˚37.255'W
20 July 2007	Rustic Lodge	34˚34.587'N, 86˚37.286'W
25 July 2007	Mathew's Cave	34˚42.123'N, 86˚41.036'W
25 July 2007	Mathew's Cave	34˚41.902'N, 86˚41.066'W
25 July 2007	Mathew's Cave	34˚41.904'N, 86˚41.067'W
25 July 2007	Mathew's Cave	34˚41.790'N, 86˚41.097'W
25 July 2007	Mathew's Cave	34˚42.109'N, 86˚40.812'W
26 July 2007	Pasture Near Gate 1	34˚35.298'N, 86˚35.334'W
26 July 2007	Pasture Near Gate 1	34˚35.313'N, 86˚35.354'W
26 July 2007	Pasture Near Gate 1	34˚35.518'N, 86˚35.202'W

APPENDIX 3.

Localities where AnaBat detectors were placed and bats were detected at Redstone Arsenal, Madison Co., Alabama, 2007.

Date	AnaBat ID	Locality	GPS coordinates	Species detected
09 May 2007	AB1	Path to Nature	34˚34.820'N, 86˚37.199'W	None
09 May 2007	AB2	Path to Nature	34˚34.942'N, 86˚37.127'W	None
09 May 2007	AB3	Recreation Area 2	34˚34.706'N, 86˚36.941'W	*Lasiurus borealis* *Myotis grisescens* *Perimyotis subflavus*
10 May 2007	AB4	McAlpine Road	34˚33.278'N, 86˚38.914'W	*Eptesicus fuscus* *Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
10 May 2007	AB5	Igloo Pond	34˚34.875'N, 86˚39.377'W	*Nycticeius humeralis* *Perimyotis subflavus*
10 May 2007	AB6	Igloo Pond	34˚35.077'N, 86˚39.321'W	*Nycticeius humeralis*
11 May 2007	AB7	Fitness Trail	34˚40.780'N, 86˚38.359'W	None
11 May 2007	AB8	Fitness Trail	34˚40.662'N, 86˚38.268'W	None
11 May 2007	AB9	Fitness Trail	34˚40.947'N, 86˚38.255'W	None
16 May 2007	AB10	Indian Creek and Martin Road	34˚38.690'N, 86˚41.625'W	None
16 May 2007	AB11	Indian Creek and Martin Road	34˚38.662'N, 86˚41.157'W	*Perimyotis subflavus*
16 May 2007	AB12	Indian Creek and Martin Road	34˚38.767'N, 86˚41.030'W	None
17 May 2007	AB13	Martin Road Tupelo Swamp	34˚39.793'N, 86˚37.152'W	None
17 May 2007	AB14	Martin Road Tupelo Swamp	34˚39.509'N, 86˚37.486'W	None
17 May 2007	AB15	Martin Road Tupelo Swamp	34˚38.998'N, 86˚37.336'W	*Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
18 May 2007	AB16	Golf Course	34˚42.013'N, 86˚39.788'W	None
18 May 2007	AB17	Golf Course	34˚41.804'N, 86˚39.856'W	None
18 May 2007	AB18	Golf Course	34˚41.609'N, 86˚39.850'W	None
23 May 2007	AB19	Huntsville Spring Branch, Patton Road	34˚37.562'N, 86˚37.779'W	*Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
23 May 2007	AB20	Huntsville Spring Branch, Patton Road	34˚38.034'N, 86˚37.844'W	None

APPENDIX 3. Continued.

Date	AnaBat ID	Locality	GPS coordinates	Species detected
23 May 2007	AB21	Huntsville Spring Branch, Patton Road	34˚39.030'N, 86˚37.749'W	*Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
24 May 2007	AB22	Hansen Road	34˚40.416'N, 86˚37.166'W	*Lasiurus borealis* *Perimyotis subflavus*
24 May 2007	AB23	Hansen Road	34˚40.658'N, 86˚37.174'W	*Eptesicus fuscus* *Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
24 May 2007	AB24	Hansen Road	34˚40.377'N, 86˚37.297'W	None
25 May 2007	AB25	Anderson Road	34˚39.235'N, 86˚42.829'W	*Eptesicus fuscus* *Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
25 May 2007	AB26	Anderson Road	34˚39.241'N, 86˚42.575'W	None
25 May 2007	AB27	Anderson Road	34˚39.417'N, 86˚42.633'W	None
30 May 2007	AB28	Test Area 6	34˚40.165'N, 86˚41.879'W	*Eptesicus fuscus* *Lasiurus borealis* *Nycticeius humeralis* *Perimyotis subflavus*
30 May 2007	AB29	Test Area 6	34˚41.464'N, 86˚41.978'W	None
30 May 2007	AB30	Test Area 6	34˚40.383'N, 86˚42.053'W	None
31 May 2007	AB31	Bradford Sinks	34˚35.656'N, 86˚43.325'W	None
31 May 2007	AB32	Bradford Sinks	34˚35.758'N, 86˚43.183'W	None
31 May 2007	AB33	Bradford Sinks	34˚36.090'N, 86˚43.223'W	*Myotis grisescens* *Perimyotis subflavus*
1 June 2007	AB34	Rock Quarry	34˚39.850'N, 86˚38.987'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Perimyotis subflavus*
1 June 2007	AB35	Rock Quarry	34˚39.447'N, 86˚38.624'W	*Perimyotis subflavus*
1 June 2007	AB36	Rock Quarry	34˚39.632'N, 86˚38.819'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Nycticeius humeralis* *Perimyotis subflavus*

APPENDIX 3. Continued.

Date	AnaBat ID	Locality	GPS coordinates	Species detected
6 June 2007	AB37	Test Area 1	34˚38.860'N, 86˚40.003'W	None
6 June 2007	AB38	Test Area 1	34˚38.849'N, 86˚40.641'W	None
6 June 2007	AB39	Test Area 1	34˚38.685'N, 86˚42.508'W	None
7 June 2007	AB40	McKinley Range	34˚35.800'N, 86˚38.217'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Nycticeius humeralis* *Perimyotis subflavus*
7 June 2007	AB41	McKinley Range	34˚35.422'N, 86˚38.639'W	None
7 June 2007	AB42	McKinley Range	34˚35.216'N, 86˚38.952'W	None
8 June 2007	AB43	Adams Cave	34˚34.726'N, 86˚37.983'W	None
8 June 2007	AB44	Adams Cave	34˚34.759'N, 86˚37.724'W	None
8 June 2007	AB45	Adams Cave	34˚35.042'N, 86˚37.553'W	None
12 June 2007	AB46	NW Anderson Road	34˚41.035'N, 86˚42.662'W	*Lasiurus borealis*
12 June 2007	AB47	NW Anderson Road	34˚41.256'N, 86˚42.554'W	None
12 June 2007	AB48	NW Anderson Road	34˚41.460'N, 86˚42.433'W	None
13 June 2007	AB50	Buxton Road Chemical Contamination	34˚35.092'N, 86˚39.536'W	*Myotis grisescens* *Perimyotis subflavus*
13 June 2007	AB51	Buxton Road Chemical Contamination	34˚34.346'N, 86˚39.640'W	None
13 June 2007	AB52	Buxton Road Chemical Contamination	34˚34.056'N, 86˚39.883'W	None
14 June 2007	AB53	Water Facility	34˚39.940'N, 86˚39.521'W	None
14 June 2007	AB54	Water Facility	34˚39.726'N, 86˚39.032'W	*Lasiurus borealis* *Myotis grisescens* *Perimyotis subflavus*
14 June 2007	AB55	Water Facility	34˚39.903'N, 86˚39.253'W	None
20 June 2007	AB56	Creek Road	34˚38.669'N, 86˚36.754'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Myotis septentrionalis* *Perimyotis subflavus*
20 June 2007	AB57	Creek Road	34˚38.533'N, 86˚36.836'W	None
20 June 2007	AB58	Creek Road	34˚38.411'N, 86˚36.954'W	None
21 June 2007	AB59	East Perimeter	34˚37.639'N, 86˚35.368'W	None

APPENDIX 3. Continued.

Date	AnaBat ID	Locality	GPS coordinates	Species detected
21 June 2007	AB60	East Perimeter	34˚37.925'N, 86˚36.187'W	None
21 June 2007	AB61	East Perimeter	34˚38.727'N, 86˚36.125'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Perimyotis subflavus*
22 June 2007	AB62	Timmon's Cemetery	34˚35.287'N, 86˚37.550'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens*
22 June 2007	AB63	Timmon's Cemetery	34˚35.452'N, 86˚36.789'W	*Myotis grisescens* *Perimyotis subflavus*
22 June 2007	AB64	Timmon's Cemetery	34˚35.525'N, 86˚37.371'W	None
27 June 2007	AB65	Shield Road	34˚35.322'N, 86˚41.439'W	*Lasiurus borealis* *Myotis grisescens* *Nycticeius humeralis* *Perimyotis subflavus*
27 June 2007	AB66	Shield Road	34˚35.157'N, 86˚40.544'W	None
27 June 2007	AB67	Shield Road	34˚35.158'N, 86˚40.798'W	*Lasiurus borealis*
29 June 2007	AB68	Shield Road/Buxton Road	34˚35.598'N, 86˚40.208'W	None
29 June 2007	AB69	Shield Road/Buxton Road	34˚35.759'N, 86˚39.885'W	None
29 June 2007	AB70	Shield Road/Buxton Road	34˚35.459'N, 86˚35.551'W	*Perimyotis subflavus*
11 July 2007	AB71	Environmental Area Shield Road	34˚34.934'N, 86˚38.899'W	None
11 July 2007	AB72	Environmental Area Shield Road	34˚34.578'N, 86˚38.789'W	*Myotis grisescens*
11 July 2007	AB73	Environmental Area Shield Road	34˚34.402'N, 86˚38.943'W	None
12 July 2007	AB74	Environmental Area Shield Road	34˚36.511'N, 86˚35.518'W	None
12 July 2007	AB75	Environmental Area Shield Road	34˚36.668'N, 86˚35.579'W	*Eptesicus fuscus*
12 July 2007	AB76	Environmental Area Shield Road	34˚36.801'N, 86˚35.609'W	*Lasiurus borealis*
13 July 2007	AB77	Frisbee Golf Course Vincent	34˚40.940'N, 86˚38.350'W	*Myotis grisescens*
13 July 2007	AB78	Frisbee Golf Course Vincent	34˚40.970'N, 86˚38.222'W	*Lasiurus borealis*
13 July 2007	AB79	Frisbee Golf Course Vincent	34˚41.135'N, 86˚38.199'W	*Myotis grisescens*
18 July 2007	AB80	Madkin Mountain	34˚40.135'N, 86˚38.849'W	*Myotis grisescens*

APPENDIX 3. Continued.

Date	AnaBat ID	Locality	GPS coordinates	Species detected
18 July 2007	AB81	Madkin Mountain	34˚40.368'N, 86˚39.025'W	*Myotis grisescens*
18 July 2007	AB82	Madkin Mountain	34˚40.535'N, 86˚39.082'W	*Myotis grisescens* *Perimyotis subflavus*
19 July 2007	AB83	Bradford Mountain Rock Shelter	34˚35.679'N, 86˚42.382'W	*Myotis grisescens* *Perimyotis subflavus*
19 July 2007	AB84	Bradford Mountain Rock Shelter	34˚35.699'N, 86˚42.331'W	*Myotis grisescens* *Perimyotis subflavus*
19 July 2007	AB85	Bradford Mountain Rock Shelter	34˚36.165'N, 86˚42.562'W	*Lasiurus borealis* *Myotis grisescens*
20 July 2007	AB86	Rustic Lodge	34˚34.494'N, 86˚37.272'W	None
20 July 2007	AB87	Rustic Lodge	34˚34.584'N, 86˚37.261'W	*Lasiurus borealis*
20 July 2007	AB88	Rustic Lodge	34˚34.643'N, 86˚37.277'W	None
25 July 2007	AB89	Mathew's Cave	34˚42.104'N, 86˚40.998'W	None
25 July 2007	AB90	Mathew's Cave	34˚41.954'N, 86˚41.081'W	*Lasiurus borealis*
25 July 2007	AB91	Mathew's Cave	34˚41.979'N, 86˚40.832'W	*Eptesicus fuscus* *Lasiurus borealis*
26 July 2007	AB92	Pasture Near Gate 1	34˚35.110'N, 86˚35.264'W	*Eptesicus fuscus* *Lasiurus borealis* *Myotis grisescens* *Myotis septentrionalis* *Perimyotis subflavus*
26 July 2007	AB93	Pasture Near Gate 1	34˚35.313'N, 86˚35.364'W	*Perimyotis subflavus*
26 July 2007	AB94	Pasture Near Gate 1	34˚35.746'N, 86˚35.212'W	*Lasiurus borealis*