THE MAMMALS OF VICKSBURG NATIONAL MILITARY PARK

by

JENNIFER M. LINEHAN

(Under the Direction of Michael T. Mengak)

ABSTRACT

The National Park Service (NPS) has identified significant gaps in information on the diversity, abundance, and distribution of mammal species in Vicksburg National Military Park (VICK). Given the paucity of information regarding the mammalian communities within this urban park, the objectives of this study were: (1) to document the occurrence of all mammal species, (2) to describe the distribution and relative abundance of each species, and (3) to investigate small mammal habitat affinities within the fragmented landscape. A year-long survey was conducted in 2005. Thirty seven of 46 potential species were found within the park. *Peromyscus* spp. occupancy was best predicted during the summer/fall sampling period on sites with low levels of grassland modification. *Sigmodon hispidus* occupancy was higher on grassland sites during the summer/fall season. Species richness was highest on sites that have larger percentages of vegetative ground cover and that were sampled during the summer/fall season.

INDEX WORDS: habitat associations, inventory, mammals, Mississippi, small mammals, Vicksburg National Military Park

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B.S.F.R., University of Georgia, 2003

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment

of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2007

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ACKNOWLEDGEMENTS

First, I would like to acknowledge the Warnell School of Forestry and Natural Resources at the University of Georgia and the National Park Service for providing funding for this project. Thanks to my committee members, especially Dr. Mike Mengak, Dr. Steven Castleberry, and Dr. Darren Miller. Your support and guidance was invaluable and I enjoyed working with you.

The assistance of Kurt Foote and all the staff at VICK was greatly appreciated. They were a wonderfully helpful group of professionals and welcomed me into their family with open arms. Thanks to Michael Bender who assisted with fieldwork during the summer. His hard work and good attitude made for a pleasant working experience.

Thanks to Alison McCartney and Brent Howze for volunteering their time during the summer to assist with capturing bats.

Finally, a special thanks to my family and friends whose continued love and support have helped to guide me through all my endeavors.

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INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

Inventory and monitoring can provide comprehensive, scientifically based information about the status of floral and faunal populations (Thompson et al. 1998). However many areas lack these baseline data, which prevents assessment of current conditions. There has been a nationwide effort to monitor the biological resources within National Park Service (NPS) units (National Park Service 2004a). The National Park Service has identified significant gaps in information on diversity, abundance, and distribution of mammal species in Vicksburg National Military Park (VICK). Therefore, NPS proposed creation of the first comprehensive inventory of all mammalian species located inside the park, which would be the basis for future monitoring efforts and management actions.

Urban parks face unique challenges regarding management of their natural resources. Overabundant wildlife populations can negatively impact ecosystems due to overbrowsing reduction in plant cover and diversity and may contribute to the transmission of several animal and human diseases (Cote 2004). In addition, species with specific habitat requirements, low reproductive capability, or sensitivity to disturbance, cannot cope with increased human densities and may be out competed by well adaptive species (DeStefan and DeGraaf 2003). Management decisions concerning urban wildlife are vital to maintain acceptable levels of biodiversity. Given the paucity of information regarding mammalian communities within this urban park, my objectives were to: (1) document through existing, verifiable data and targeted field investigations, the occurrence of mammal species, (2) describe distribution and relative abundance of each species, and (3) investigate small mammal habitat associations within the fragmented landscape. These data will be used in management decisions regarding natural resources within VICK and for educational outreach to the public. This research is important for developing future monitoring programs designed to conserve the natural resources of the park.

Thesis Format

This thesis is comprised of four chapters presented in manuscript format. Chapter 1 consists of an introduction to the study and a comprehensive literature review. Chapter 2 reports results of mammalian surveys on VICK and will be submitted to the *Museum of Texas Tech Occasional Papers*. Chapter 3 describes small mammal habitat associations on VICK and will be submitted to the *Southeastern Naturalist*. Lastly, chapter 4 summarizes results and discusses conclusions.

LITERATURE REVIEW

Inventory and Monitoring Programs

Rapid depletion of natural resources and diminishing biodiversity in North America make National Parks a significant haven for a number of ecosystems (National Park Service 2004b). In 1999, Congress created the Natural Resource Challenge aimed at improving management decisions and protection of natural resources in the National Park System. In the past, sound science and research has not always been incorporated into the National Park Service's decision-making process (National Park Service 2004b). Therefore, the Natural Resource Challenge was developed to use science as the foundation for conservation.

The Natural Resource Challenge mandated natural resource inventories for a variety of features in all parks, including presence and distribution of plants and vertebrates and examination of other resources such as water quality, landforms, and climate in all parks. To accomplish this goal, 270 NPS units have been organized into 32 inventory and monitoring networks (National Park Service 2004a). Each network is comprised of park units that share similar geographic and natural resource characteristics and systematic approaches are developed to carry out inventories in its parks (National Park Service 2004a).

Vicksburg National Military Park is included in the Gulf Coast Inventory and Monitoring Network, which is comprised of eight National Parks and encompasses the western third of Florida, the southwestern two-thirds of Alabama, all of Mississippi and Louisiana, the southeastern quarter of Texas, and extends north into the Nashville and Memphis areas of Tennessee. An ecosystem conceptual model will be developed based on geography, habitat, and biodiversity of all NPS units that comprise this network (National Park Service 2005). This model will serve as a tool to make better management decisions at a much larger scale.

Biodiversity in Fragmented and Human Modified Landscapes

Urbanization is a continuing trend that often results in decreased habitat suitability (Kurta and Teramino 1992) for some species, which may eventually lead to local extirpations (Rosenblatt et al. 1999). Small urban parks are frequently assumed to be unsuitable for maintaining high levels of biodiversity due to possible exclusion of species that have large home range requirements, areas that contain small populations, and an abundance of generalist species (Dickman 1987). Mammal species richness was shown to decrease when vegetation structure became more fragmented (Dickman 1987), which may result from increases in predation pressure from raptors, domestic dogs (*Canis lupus*) and cats (*Felis catus*) (Bock et al. 2002). Species that require interior forest habitats and wetland- associated fauna are particularly vulnerable to changing land use patterns and habitat fragmentation (Sharitz et al. 1992, Bellows et al. 2001). However, smaller species may thrive if distances between habitat patches allow for interbreeding and colonization. Rosenblatt et al. (1999) found that most mammalian taxa in areas fragmented by agricultural practices were generalist species that do not appear to have limited distributions.

Slade and Crain (2006) reported that habitat modification such as periodic grassland mowing was potentially disruptive to mammalian communities. Both *Sigmodon hispidus* and *Microtus ochrogaster* showed decreases in abundance in prairie habitats that were mowed; these negative impacts continued for 4-5 months as vegetation recovered. Adams (1984) reported that small mammal density in mowed median strips were one-half the density of unmowed herbaceous median strips. This reduction in small mammal communities may be attributed to a decrease in food availability and loss of cover, which would make individuals more susceptible to predation (Edge et al. 1995, Taitt and Krebs 1983). Not surprising is that other studies have shown that species richness and diversity were lowest in sites containing manicured habitats and within areas surrounded by human altered habitat (Dickman and Doncaster 1987, Sauvajot et al. 1998, Mahan and O'Connell 2005). Bock et al. (2002) reported that proximity to suburban edges had strongly negative effects on abundances of native grassland rodents possibly due to low habitat quality and high predator abundances (i.e. feral cats). Small mammals seem to respond strongly to anthropogenic changes and exhibit species-specific responses depending on their habitat needs (Sauvajot et al. 1998).

Issues Surrounding Urban Wildlife

The alteration of landscapes through urbanization can have profound affects on the distribution and abundance of wildlife populations. Adaptable species can be very successful and have populations that may become overabundant, causing property damage and threatening human health and safety (DeStefano and DeGraaf 2003). Others, particularly species with specific habitat requirements, low reproductive capability, or sensitivity to disturbance, cannot adjust to increased human densities and become rare or locally extinct (DeStefano and DeGraaf 2003).

High density urban wildlife populations may result from increased availability of resources such as food, refugia, or den sites (Riley et al. 1998, Prange et al. 2004). Dense *Procyon lotor* populations are more likely subject to epizootics of contact diseases such as rabies and canine distemper (Riley et al. 1998). Increases in survival rates for *P. lotor* may result from supplemental food and an absence of mortality factors common in rural areas (Riley et al. 1998, Prange et al. 2004). However, vehicle-related mortality factors and disease transmission may be greater in urbanized areas (Prange et al. 2004).

An abundance of free-roaming domestic pets in urban areas have been found to constitute ecological and potential public health problems. *Felis catus* predation can play and important role in bird and small mammal population fluctuations (Woods et al. 2003). Lepczyk et al. (2003) found that on average, a single cat predated between 0.7 and 1.4 birds/ week. In Sweden, cat predation corresponded to 4% of annual production of wild rabbits (*Oryctolagus cuniculus*) and approximately 20% of annual production of field voles (*Microtus agrestis*) and wood mice (*Apodemus silvaticus*) (Liberg 1984). *Canis lupus* is a known reservoir for rabies, canine distemper, and parvovirus (Butler et al. 2003); transmittable to humans and/or wildlife living in close proximity.

Odocoileus virginianus impact on natural ecosystems due to overbrowsing may reduce plant cover and diversity. Deer can degrade forests and persistent browsing can lead to climax species of plants replaced by midlevel and introduced species (Stromayer and Warren 1997, Waller et al. 1997, DeNicola et al. 2000, Cote 2004). Overabundant populations may also contribute to the transmission of several animal and human diseases, such as Lyme disease and bovine tuberculosis (Cote 2004, Schmitt et al. 1997, DeNicola et al. 2000) and significant economic losses associated with crop reduction and vehicle collisions (DeNicola et al. 2000)

Small Mammal Habitat Selection

An understanding of factors responsible for species occurrence is important in order to better comprehend ecosystem components and to predict changes in community composition that might follow habitat alterations. On a macrohabitat scale, environmental factors such as food availability, temperature, ground cover, moisture, and vegetation type affect small mammal distributions (Getz 1961, Snyder and Best 1988, Bellows 2001). Studies comparing species richness and abundance between riparian and upland habitats found the former to have populations with greater diversity and abundance (Doyle 1990, McComb 1993). Factors that contribute to this preference may include greater availability of water and forage such as fruits, herbs, and deciduous shrubs and mast (Doyle 1990). Riparian habitats typically are characterized by a structurally diverse landscape with a greater abundance and diversity of plants species related to a site's size, aspect, soil moisture, amount of woody debris, and time since disturbance (O'Connell et al. 1993, Hannon et al. 2002). However, some studies contradict these findings (Bellows and Mitchell 2000, Osbourne et al. 2005). Similar vegetative structure between the two habitat types may have explained the disparity. Bellows et al. (2001) found a high diversity and community richness in old fields relative to forested habitats. Low diversity and evenness in forested habitats were attributed to high densities of two species.

Numerous studies have investigated the influence of microhabitat characteristics on abundance and distribution of small mammals (Getz 1961, Morris 1979, Geier and Best 1980, Yahner 1986, Dickman 1987, Dueser and Shugart 1978, Snyder and Best 1988, Bellows et al. 2001, Castleberry et al. 2002, Stancampiano and Schnell 2004, Coppeto et al. 2006). Although, microhabitat associations may vary among species, canopy openness, ground cover and plant species richness appear to be the most influential (Wilkins et al. 1980, Carey and Johnson 1995, Bellows et al. 2001, Coppeto et al. 2006). Increases in mammalian species richness were correlated with increasing vegetation density per patch (Geier and Best 1980, Dickman 1987). Coppeto et al. (2006) suggested that the most cost effective approach in conserving small mammals was to gather data at the macrohabitat scale and emphasize coarse-scale assessment of understory structure. Data collected at the macrohabitat scale (e.g. habitat type) may provide suitable areas requiring finer resolution (Orrock et al. 2000).

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CHAPTER 2

INVENTORY OF THE MAMMALIAN SPECIES AT VICKSBURG NATIONAL PARK, VICKSBURG, MISSISSIPPI

[1]Linehan, J.M., M.T. Mengak, S.B. Castleberry, and D.A. Miller. 2007. *To be submitted to the Museum of Texas Tech Occasional Papers.*

Abstract

I conducted a survey of small, meso, and large mammals during 2005 at Vicksburg National Military Park, Vicksburg, Mississippi. I documented mammals using photographs, voucher collections, and sign collection incorporating various capture and monitoring techniques. I detected 1,011 mammals of 37 species from an effort of 9,871 trap nights, 16,392 camera hours, and 352 mist netting hours. I failed to detect nine (*Ochrotomys nuttalli, Oryzomys palustris, Reithrodontomys fulvescens, Ondatra zibethica, Rattus rattus, Rattus norvegicus, Neovison vison, Lontra canadensis, Spilogale putorius*, but because this inventory was inconclusive, these mammals should be regarded as potential occurrences. Overall capture indices were 1.67 per 100 trap nights (TN) for small mammals, 33.45 per 100 TN for meso and large mammals, and 37 per 100 TN for bats. I assessed inventory completeness using species accumulation curves and predicted species richness estimates from program SPECRICH in which trapping effort was found to be sufficient. Species accounts, including remarks concerning habitat associations and relative abundance, are presented for all recorded species.

Key words: bats, capture techniques, inventory, large mammals, meso mammals, mammals, Mississippi, small mammals, species accumulation curve, species richness, Vicksburg National Military Park

Introduction

Urbanization is a continuing trend that often results in a decrease of wildlife habitat and may eventually lead to wildlife extirpations (*Kurta and Teramino 1992*, *Rosenblatt et al. 1999*). Small urban parks are frequently assumed to be unsuitable in maintaining high levels of biodiversity due to possible exclusion of species that have large home range requirements, areas that contain small populations, and an abundance of generalist species (*Dickman 1987*). Rapid depletion of natural resources in North America make National Parks a significant haven for once-widespread species and ecosystems (*National Park Service 2004*).

To date, biological inventories at Vicksburg National Military Park (VICK), Mississippi have focused on birds (*Twedt and Hunt 2001; Somershoe et al. 2004; National Audobon Society 2006*), vascular plants (*Walker 1997*), fishes (*Dibble and Smiley 1999; Dibble 2003*) and herpetofauna (*Keiser 2002*). A paucity of information existed regarding mammalian species at VICK. Therefore, my study was conducted during 2005 to fill informational gaps regarding this urban park's mammalian biodiversity and for use as a basis for management decisions geared to specific resource issues, such as urban encroachment, presence of threatened and/ or endangered species, and prevalence and impacts of exotic species. My primary objectives were to document through existing, verifiable data and targeted field investigations, the presence of all mammal species that occur in VICK, to describe distribution and relative abundance of each species, and to note general habitat associations.

Study Area

Vicksburg National Military Park, located in Warren County, Mississippi and Madison Parish, Louisiana, is included within the Gulf Coast Inventory and Monitoring Network created by the NPS Natural Resource Challenge Initiative. The park was established in 1899 to commemorate the Battle of Vicksburg during the American Civil War and consisted of approximately 728 ha, including four satellite locations in the city of Vicksburg, Mississippi (Louisiana Circle, Navy Circle, South Fort, Pemberton's Headquarters) and one in Delta, Louisiana (Grant's Canal). Each satellite location was less than 0.40 ha. Therefore, I conducted a majority of sampling in the main portion of VICK located in northeastern Vicksburg, adjacent to Clay Street. This portion of VICK was crescent shaped and fragmented by a 26-km tour road

(Figure 2.1). The boundaries encircled a range of steep bluffs with deep valleys lying in between (*Keiser 2002*). The city of Vicksburg completely surrounded the Warren County portion of VICK with residential houses and businesses abundant along park boundaries.

Vicksburg National Military Park was within the East Gulf Coastal Plain. The climate was subtropical *(Stewart 2003*). Mean annual temperatures ranged from 12º C to 25.2º C. Mean annual precipitation was 147.1 cm (*NOAA 2006*). The Warren County portion of the park was located in the Blufflands; a 16 to 40 km wide belt of steep hills bordering the Mississippi alluvial valley (*Walker 1997*). These escarpments were comprised of wind deposited loess sediment that can be highly susceptible to erosion (*Krinitzsky and Turnball 1967*). Vegetation associations on VICK were two-thirds forest and one-third mowed grasslands (*K. Foote, NPS, pers. comm., 31 October 2006*). Forested sections in VICK resulted from plantings by the Civilian Conservation Corp (CCC) during the 1930s to prevent erosion. This mixed mesophytic forest was dominated by southern red oak (*Quercus falcata*) and white oak (*Q. alba*) with southern sugar maple (*Acer barbatum*), basswood (*Tilia americana*), black oak (*Q. velutina*), and northern red oak (*Q. rubra*) comprising a large portion of the overstory. Understory vegetation consisted mainly of American hornbeam (*Carpinus caroliniana*), dogwood (*Cornus florida*), redbud (*Cercis canadensis*), pawpaw (*Asimina triloba*), and sassafrass (*Sassafras albidum*) (*Walker 1997*). Two main streams, Mint Springs and Glass Bayou flowed through VICK and drained into the Yazoo River Diversion Canal, which then emptied into the Mississippi River. The park owned an approximately 0.8 km stretch of land located adjacent to the Yazoo River, which was subject to periodic flooding.

Figure. 2.1. Vicksburg National Military Park,Warren County, Mississippi, USA in 2005.

National Park Service United States Department of the Interior.

Methods

Prior to beginning field inventories, I examined mammalian species accounts for Warren County, Mississippi and Madison Parish, Louisiana. I conducted a search of the museum collection housed at the Mississippi Museum of Natural Science (Jackson, Mississippi) to locate park-specific Warren County voucher specimens and to verify species identification of curated specimens. The Smithsonian National Museum of Natural History and the Louisiana State University Museum of Natural Science provided electronic voucher information for mammals located within Warren County, Mississippi and Madison Parish, Louisiana. All voucher specimens from this survey have been deposited in the Mississippi Museum of Natural Science.

Mammal sampling techniques

Small mammals

I surveyed small mammals, such as murid rodents and shrews, using line transects consisting of Sherman live traps (Forestry Suppliers, Jackson, MS), Victor® snap traps (Victor, Lititz, PA), and pitfall traps in a stratified design for four different habitat types including riparian, grassland, upland, and edge (within 50 m grassland/upland ecotone). Transects consisted of at least 30 trap stations placed 10 m apart in an approximate linear manner and traps were set for four consecutive nights. For most transects, each station consisted of a Sherman live trap and a Victor® snap trap baited with peanut butter and oats set approximately 0.3 m apart. Five pitfall traps were placed at every fifth station using deli cups (8 cm in depth and upper diameter). In addition, one pitfall trap array with drift fence arranged in a "T" configuration was placed in each representative habitat. Drift fences consisted of silt fencing 61 cm high, 100 m long and supported by wooden stakes. I installed 14 pitfall traps per drift fence using 2 # 10 coffee cans taped together. I assessed gender, mass (g), total length (mm), tail length (mm), hind foot length (mm), ear length (mm), and reproductive condition (pregnant, lactating, scrotal) and I identified most individuals to species. To assess *Glaucomys volans* occurrence, I used Sherman live traps mounted 2 m high and positioned vertically along tree boles (*S. Loeb, Clemson University, pers. comm., 15 May 2005*) in bottomland hardwood forest, upland hardwood forest, and upland hardwood edge habitats. I used Tomahawk traps (# 102, 40.6 x 12.7 x 12.7 cm, Tomahawk, WI) to opportunistically target *Tamias striatus*, *Neotoma floridana*, and *Sciurus niger*.

Polymerase Chain Reaction (PCR) analysis was conducted to distinguish between *Peromyscus leucopus and Peromyscus gossypinus*. The morphology of these two sympatric species is extremely similar. Therefore, genetic analysis was implemented to confirm identification. Qiagen DNeasy® Tissue kits (Qiagen, Valencia, CA) were used to extract DNA from 24 tail tissue samples. The tissue was then submerged into a solution that lyses the nuclear membrane, along with a proteinase that denatures proteins. Proteins were separated from the nucleic acids using organic compounds. Finally, DNA was purified from the reagents in the extraction buffer by dialysis (Parker et al. 1998). DNA concentrations were quantified using a spectrophotometer (NanoDrop, Wilmington, DE) which measures light absorbency. DNA solution was diluted to create a 50 µl DNA template with an absorption rate of 12.5ng/µl. A thermal cycler (Bio-Rad Laboratories, Hercules, CA) was used to execute the PCR which consisted of three major phases: 1) the denaturation phase used heat to stop all enzymatic reactions and denature DNA from double to single strands; 2) the annealing phase allowed the oligonucleotide primers to bind to appropriate sites in the template DNA (Hillis et al. 1996); and 3) the extension phase where DNA polymerase copied the DNA strands. Restriction fragment length polymorphism (RFLP) was used to cleave DNA into fragments using suitable restriction enzymes, which only cut the DNA molecule at specific nucleotide sequence recognition sites (Parker et al. 1998). Restriction enzymes, BsgI and SnaBI were used for this digestion because BsgI cuts DNA molecule at *P. leucopus* recognition sites and SnaBI cleaves DNA molecules at *P. gossypinus* recognition sites. Agarose gel electrophoresis was used to separate strands by length and known *Peromyscus* spp. samples were compared to the unknown samples for species identification.

Meso and large mammals

I non-randomly selected survey sites so that most trapping effort was focused in riparian and edge habitats to maximize capture success. Meso mammals, such as *Procyon lotor* and *Didelphis virginiana,* were sampled using Tomahawk traps (#108, 81.3 x 25.4 x 30.5 cm). I used coil spring foothold traps (#3) to target *Canis latrans* and *Lynx rufus*. This capture method was only employed for 18 nights due to conflict with park visitors. I used bait stations with remote cameras (Leaf River, Taylorsville, Mississippi) and targeted nocturnal spotlight surveys to document both meso mammals and large mammals, such as *Urocyon cinereoargenteus, Vulpes vulpes*, and *Odocoileus virginianus (M. Mengak, University of Georgia, pers. comm., 9 November 2004).* For small, meso and large mammals, I estimated capture indices using number captured divided by 100 trap nights corrected for sprung Sherman live traps, Victor ® snap traps, and Tomahawk traps (*Nelson and Clark 1973*).

Bats

I used 6 - 18 m wide, 2.4 m high mist nets placed over streams, small ponds, and flight corridors to sample bats. I recorded mass (g), forearm length (mm), gender, age (Anthony 1988), and reproductive condition (Racey 1988). I attached 0.5g radiotransmitters (Advanced Telemetry Systems, Isanti, Minnesota) to the inter-scapular region of *Nycticeius humeralis* (n=7) using Skin Bond® (Pfizer Hospital Products Group Inc., Largo, FL). I used a R-2000 (Advanced Telemetry Systmes, Isanti, MN) receiver and a 4-element yagi antenna to track bats to day roosting structures for approximately 10 days throughout the life of the transmitter. I surveyed bridges, monuments, and old buildings for possible bat roosting locations. Data collected at two ponds located < 100 m outside park boundaries were included in this study. Bats captured at these locations could potentially forage and roost inside the park. I calculated mist net hours using the number of hours mist nets were in operation multiplied by the number of nets open. I estimated capture indices for bats using the number of bats captured divided by the number of net hours.

I recorded calls of free-flying bats after capture with an ANABAT II bat detector system (Titley Electronics, Ballina, Australia) during mist net sampling. This allowed for the development of a call library that was used to confirm identification of recorded bats. Throughout the bat sampling period, I placed several ANABAT II units in areas thought to have high concentrations of bats to survey for additional species of bats and to locate possible productive mist netting locations. Calls were downloaded and analyzed using ANALOOK Software (version 4.8p). A call library was used for comparison to qualitatively identify recorded calls.

Mammals not easily captured through conventional trapping methods were documented opportunistically. Stream and river surveys were necessary to document semi-aquatic species, such as *Castor canadensis* and *Myocastor coypus*. Other species were recorded only by visual observations, such as *Sylvilagus floridanus*. I recorded road-killed animals as encountered but only collected them if the specimen was in suitable condition to obtain voucher material.

I documented all captured species using photographs and opportunistically identified and photographed relevant sign (e.g., tracks, scat, burrows). I prepared voucher specimens if field identification was uncertain or if there was a first incidence of capture for VICK. Abundance category estimates relative to my sampling protocol were based on the following scale: rare = 1-5, uncommon = 6-10, fairly common = 11-20, common = 21-50, abundant = 51+. I generated species accumulation curves only for small mammals, meso and large mammals, and bats captured and used them in comparison with the projected species richness estimates derived from the program SPECRICH (*Hines 1996*) to quantitatively estimate inventory completeness. SPECRICH uses a jackknife estimator to predict species richness when capture probabilities vary among animals (*Burnham and Overton 1979*).

Results

I sampled 253 locations within VICK (Table 2.1) and documented 1,011 mammals through capture or observation, which comprised eight orders, 17 families, and 37 mammal species (Table 2.2). Thirteen small mammal species were captured with *Peromyscus* spp. (*n* = 45, 3.1%), *Sigmodon hispidus* (*n* = 27, 1.9%), *Sciurus niger* (*n* = 11, 0.76%), and *P. gossypinus* (*n* = 11, 0.76%) captured most frequently [65% of small mammals and 5% of overall mammals captured (Figure 2.2)]. Trapping effort to sample this group included pitfalls (1,320 nights), Sherman live traps (4,800 nights), Victor snap traps (3,216 nights), small-sized Tomahawk traps (348 nights), and remote cameras (16,392 hours) (Table 2.3). I documented 10 meso and large mammal species with *Procyon lotor* (*n* = 82, 26.5%), *Didelphis virginiana* (*n* = 81, 26.1%), and *Odocoileus virginianus* (*n* = 52, 16.8%) captured most often [> 69% of meso and large mammals and 11% of overall mammals captured (Figure 2.3)]. Trapping effort used to sample this group included large-sized Tomahawk traps (169 nights), foothold traps (18 nights), and remote cameras (16,392 hours) (Table 2.4). I captured seven bat species using 352 mist net hours in riparian habitats (181 hours), forest corridors (68 hours) and over roads (103 hours). *Nycticeius humeralis (n* = 40, 42.1%)*, Eptesicus fuscus (n* = 27, 28.4%)*,* and *Lasiurus borealis (n* = 18, 19%) were captured most often [> 89% of bats and 5% of overall mammals captured (Figure 2.4)]. *Tadarida brasilensis* was documented using acoustic survey methods only.

Overall capture success for small mammals was 1.91%; greatest in riparian habitats (2.34%), followed by edge habitats (1.71%), upland habitats (1.18%), and grassland habitats (0.67%) (Table 2.5). The apparent absence of some small mammal species was probably an artifact of low capture rates for pitfall traps (0.5%), Victor snap traps (2.1%), Sherman live traps set on the ground (2.3%), and in trees (0.3%), remote cameras (1.9%), and small sized Tomahawk traps (3.9%) (Table 2.6). Capture rates for some traps may be low due to the high level of trap disturbance for Sherman live traps set on the ground (24%), in trees (8%), Victor snap traps (56%), and small-sized Tomahawk traps (44%) (Table 2.7). Meso and large mammal overall capture success was high (30%) in comparison to small mammals, where riparian habitats (42.4%), roads (30.8%), and urban areas (25.6%) had the highest capture success (Table 2.5). Remote cameras (38.9%), foothold traps (38.9%), and large sized Tomahawk traps (16.0%) had the greatest capture success (Table 2.6). Overall bat capture success was also relatively high (26.4%), with most species captured over streams or ponds (32.6%), followed by forest corridors (22.1%), and roadways (20.4%) (Table 2.8). Riparian areas were the most productive for capturing the highest number of individuals for most species; a notable exception was *Eptesicus fuscus*. This species was captured most frequently over roads (15.5%) and forest corridors (14.7%) (Table 2.8).

A species accumulation curve reflecting the predicted species richness for small mammals displayed an asymptote at 15 species (*SE* = 2, *CI* = 13 - 17) (Figure 2.5). Thirteen small mammal species were documented, which falls within the confidence interval of the interpolated estimate. A meso and large mammal species accumulation curve showed an asymptote at 12 species (*SE* = 2, *CI* = 10 - 14) for estimated species richness (Figure 2.6). Ten meso and large mammal species were recorded, which falls within the confidence interval for the predicted estimate. Predicted species richness for bats was estimated at 9 species (*SE* = 2, *CI* = 7 - 11) (Figure 2.7). Seven bat species were documented during this inventory falling within the estimated prediction.

The following species accounts include information regarding relative abundance and general habitat associations for 37 mammalian species recorded. Accounts are arranged according to *Baker et al. (2003)*. Standardized nomenclature and taxonomic classification follows *Wilson and Reeder (2005)*. An asterisk identifies non-native species. Specimens examined include individuals collected as vouchers and photographs obtained from remote cameras and capture observations. I used *Hall (1981)* for subspecific designations.

ORDER DIDELPHIMORPHIA

Family Didelphidae

Didelphis virginiana virginiana (Kerr, 1792)

Virginia Oppossum

Didelphis virginiana was among the most abundant meso-mammal species located within park boundaries. I recorded 81 captures using Tomahawk traps and 11 were observed through spotlight surveys and opportunistic visual sightings (Table 2.9). This species had an even distribution throughout the park and was found to occupy most sampled habitats, including grassland, edge, and riparian sites. Numerous tracks were observed along streambanks.

This nocturnal mammal requires hollow trees or ground burrows for protective cover during the day and for nesting sites (*Golley 1962*). Its ability to flourish in habitats that are in close proximity to urbanization was evident at VICK in part to its omnivorous diet, consisting of insects, fruits and seeds (Whitaker and Hamilton 1988), which were readily available.

Specimens examined (59).-USA: Mississippi; Warren County, 200 meters N Pemberton Ave., UTM 15-703115N-3581925E, 1 (VICK Cam1-1); Mint Springs, UTM 15-700722N-3583781E, 1 (VICK Cam1-60); Needmorbottom, UTM 15-701560N-3584139E, 1 (VICK Cam2-23); Boy Scout Trail S Louisiana Monument, UTM 15-702661N-3581514E, 3 (VICK Cam2-27); Mint Springs, UTM 15-700812N-3583804E, 16 (VICK Cam2-37, VICK Cam2-42, VICK Cam2-43, VICK Cam2-44, VICK Cam2-45, VICK Cam2-48, VICK Cam2-49, VICK Cam2-50, VICK Cam2-51, VICK Cam2-52, VICK Cam2-53, VICK Cam2-54, VICK Cam2-55, VICK Cam2-56, VICK Cam2-57, VICK Cam2-60); Boy Scout Area, UTM 15-702635N-3584467E, 1 (VICK Cam3-12); Boy Scout Trail N Graveyard Rd., UTM 15-702504N-3583608E, 1 (VICK Cam3-32); Glass Bayou off Modern Jackson Rd., UTM 15-703126N-3582694E, 1 (VICK Cam3-54); Boy Scout Trail at Grant Ave. and Union Ave. intersection, UTM 15-703311N-3583971E, 12 (VICK Cam4-60, VICK Cam4-61, VICK Cam4-62, VICK Cam4-63, VICK Cam4-74, VICK Cam4-75, VICK Cam4-76, VICK Cam4-77, VICK Cam4-78, VICK Cam4-79, VICK Cam4-80, VICK Cam4-81); National Cemetery, UTM 15-700343N-3583952E 2 (VICK Cam4-87, VICK Cam4-88); Yazoo River Watershed, UTM 15-700075N-3583600E, 1 (VICK Cam12a-6); Glass Bayou at Modern Jackson Rd., UTM 15-702785N-3582580E 4 (VICK Cam12a-30, VICK Cam12a-31, VICK Cam12a-32, VICK Cam12a-34); Boy Scout Trail S

Louisiana Monument, UTM 15-702556N-3581377E, 1 (VICK Cam27-9); Sherman Circle, UTM 15-703428N-3584300E, 11 (VICK Cam34-2, VICK Cam34-4, VICK Cam34-5, VICK Cam34-6, VICK Cam34-8, VICK Cam34-9, VICK Cam34-10, VICK Cam34-12, VICK Cam34-13, VICK Cam34-15, VICK Cam34-20); E Graveyard Rd., UTM 15-702952N-3583768E, 1 (VICK 178,179); Union Ave. 400 m W Grant Ave., UTM 15-701366N-3584374E, 1 (VICK 186-189); Ranger Station, UTM 15-702743N-3582008E, 1 (VICK 5271).

ORDER SORICOMORPHA

Family Soricidae

Sorex longirostris longirostris (Bachman, 1837)

Southeastern Shrew

Sorex longirostris was once considered rare in the lower one-third of Mississippi (*Wolfe 1971*). Further research has suggested that this shrew is not particularly uncommon nor habitat specific in Mississippi. The apparent scarcity may have been the result of secretive habits and inappropriate collection methods (*Wolfe and Esher 1981*). The only specimen captured in this study was collected with pit fall traps (Table 2.9). Logistic constraints prevented installation of multiple pitfall trap arrays in replicated habitat types, which may explain the low capture success for this species. The single individual was captured adjacent to downed woody debris in an upland forested site dominated by water oak (*Quercus nigra*), pecan *(Carya illinoensis*), and eastern redbud.

Specimens examined (1).-USA: Mississippi; Warren County, Boy Scout Area, UTM 15-702339N-3584380E, 1 (VICK 5274).

Blarina carolinensis minima (Bachman, 1837)

Southern Short-tailed Shrew

Blarina carolinensis is typically more abundant than other sympatric shrew species, including *Cryptotis parva* and *Sorex longirostris* (*Mengak et al. 1987; Gerard and Feldhammer 1990*). I captured eight specimens using Victor snap traps and observed six road-killed individuals, making this species fairly common (Table 2.9). However, I recorded most individuals in the southern portion of the park. This species was found in all four habitat types sampled. Dominant vegetation consisted of box elder (*Acer negundo)*, sweetgum (*Liquidambar styraciflua),* Chinese privet (*Ligustrum sinense*), tulip poplar (*Liriodendron tulipifera*), water oak, swamp chestnut oak (*Q. michauxii)*, bamboo (*Arundaria gigantea)*, and Johnson grass (*Sorghum halepense)*.

Specimens examined (10).-USA: Mississippi; Warren County, South Loop, UTM 15-701633N-3579679E, 1 (VICK 5277); South Loop, UTM 15-701139N-3579400E, 1 (VICK 5278); Fort Garrott, UTM 15-701281N-3579838E, 2 (VICK 5279, VICK 5281); South Loop, UTM 15-701728N-3579943E, 1 (VICK 5282); Boy Scout Trail between Tour Stop 4 and 5, UTM 15-703141N-3583414E, 1 (VICK 5302); 200 m N of Pemberton Ave., UTM 15-703099N-3581913E (VICK 5304); SE Boy Scout Meeting Area, UTM 15-702776N-3584324E, 1 (VICK 5307); Old Hwy 27 100 m S Park Entrance, UTM 15-702307N-3580356E, 1 (VICK 5325); South Fort, UTM 15-697789N-3577411E, 1 (VICK 5333).

Cryptotis parva parva (Say, 1823)

North American Least Shrew

I collected a single *Cryptotis parva* during this survey and one was reported as road kill during a herpetological survey in April 2001 (*E. Kaiser, personal communication, 2005 May*).

Although this shrew species is considered rare for VICK (Table 2.9), it is reportedly found in all parts of the state and is categorized as fairly common (*Wolfe 1971*). *Cryptotis parva* generally occurs in upland grasslands, fields, roadsides, and meadows (*Choate et al. 1994*). The only captured individual was notably collected in the Yazoo River Watershed Area with black willow (*Salix nigra*) dominating the capture location. As with *Sorex longirostris*, logistic constraints prevented installation of multiple pitfall arrays in replicated habitat types which may have attributed to low capture success.

Specimens examined (1).-USA: Mississippi; Warren County, Yazoo River Watershed, UTM 15-700153N-3583624E, 1 (VICK 5332).

Family Talpidae

Scalopus aquaticus howelli, (Jackson, 1914)

Eastern Mole

Although I only documented seven *Scalopus aquaticus* specimens (Table 2.9), numerous mole tunnels were observed near residential housing and administrative buildings. Therefore, I considered this species as common. Distribution was concentrated in the northwestern section of the park, where individuals were recorded at the National Cemetery, Ranger's Quarters, and along forested roads. These results were consistent with previous literature that suggests that grassy meadows, gardens, cemeteries, lawns, and wooded areas are all preferred habitat (*Lowery 1974*).

Specimens examined (4).-USA: Mississippi; Warren County, Ranger's Quarters, UTM 15-700593N-3583989E, 1 (VICK 5280); Trail to Waterfall S National Cemetery, UTM 15-700400N-3583701E, 1 (VICK 5283); National Cemetery, UTM-15-700407N-3583998E, 1

(VICK 31); 30 m N Jackson Rd. Bridge on Union Ave., UTM-15-703174N-3582810E, 1 (VICK 480-486).

ORDER CHIROPTERA

It is difficult to investigate roosting habitat for bats without incorporating radiotelemetry or intensive acoustic sampling due to the volant nature of bats. With the exception of *Eptesicus fuscus* and *Nycticeius humeralis*, roosting habitat presented here is solely based on previous literature.

Family Vespertilionidae

Lasiurus borealis borealis (Müeller, 1776)

Eastern Red Bat

Lasiurus borealis was fairly common inside the park (Table 2.9). I captured 18 at nine mist netting locations. Two unidentified *Lasiurus* sp. escaped from mist nets before proper identification could be made. It is probable that these two individuals were *L. borealis*, given the relative scarcity of *Lasiurus seminolus* occurrence. *L. borealis* predominately roosts solitarily in tree foliage, often found hanging from a leaf petiole or a small twig (*Barbour and Davis 1969*). In the Coastal Plain of South Carolina and Georgia, this bat was found commonly roosting in sweetgum, black gum (*Nyssa sylvatica*), white oak, laurel oak *(Q. laurifolia*), and water oak (*Menzel et al. 1998*). In mixed mesophytic forests in Kentucky, with similar forest composition to VICK, tulip poplar, American beech (*Fagus grandifolia*), and water oak comprised most of the roost trees selected (*Hutchinson and Lacki 2000*). Studied conducted in Mississippi, found *L. borealis*

Specimens examined (4).-USA: Mississippi; Warren County, Illinois Monument, UTM-15-703098N-3582356E, 1 (VICK 319, 320); Confluence of Mint Springs and Mint Springs Tributary, UTM 15-701468N-3584139E, 2 (VICK 5291, 383); Mud Stuck Pond, UTM 15-702826N-3581021E, 1 (VICK 516, 517).

Lasiurus cinereus cinereus (Beauvois, 1796)

Hoary Bat

Lasiurus cinereus is migratory and exhibits changing seasonal distributions (*Schmidly 1991*). *Barbour and Davis (1969)* described this bat as uncommon throughout most of the eastern United States. Because only one individual was captured during the summer, I considered this species as rare in VICK (Table 2.9). This forest bat typically roosts solitarily in tree foliage 3.0 - 4.6 m above the ground (*Schmidly 1991*). It has been found roosting in tree species such as elm (*Ulmus* spp.), black cherry (*Prunus serotina*), plum (*Prunus* sp.), box elder, and Osage orange (*Maclura pomifera*) (*Shump and Shump 1982*).

Specimens examined (1).-USA: Mississippi; Warren County, Confluence of Mint Springs and Mint Springs Tributary, UTM 15-701468 E-3584139 N, 1 (VICK 5292).

Lasiurus seminolus (Rhoads, 1895)

Seminole Bat

I captured a single *Lasiurus seminolus* in a forest corridor (Table 2.9). This species is rare in VICK possibly due to the lack of preferred habitat. Previous literature has shown that this bat has a close association with Spanish moss (*Tillandsia usneoides*) (*Constantine 1958; Jennings 1958*) and with pine communities (*Menzel et al. 1998, Miller 2003*). However, this species was captured in Tennessee (*Kennedy et al. 1984*) in habitat similar to VICK, where the dominant tree species included oak (*Quercus* sp.), hickory (*Carya* sp.), beech (Betulaceae), dogwood (*Cornus* sp.), buckeye (*Aesculus* sp.), birch (*Betula* sp.) and maple (*Acer* sp.).

Specimens examined (0).

Pipistrellus subflavus subflavus (F. Cuvier, 1832)

Eastern Pipistrelle

Pipistrellus subflavus is fairly common throughout its geographic range (*Choate et al. 1994*). I captured six at three mist netting locations, therefore this bat is considered uncommon in VICK (Table 2.9). This species is known to occupy caves, mines, rock crevices, man-made structures, and tree foliage (*Schmidly 1991*).

Specimens examined (5).-USA: Mississippi; Warren County, SE Missouri Monument, UTM 15-702844N-3583140E, 1 (VICK 353-359); Mint Springs, UTM 15-700698N-3583780E, 2 (VICK 422-427, VICK 776-786); Mint Springs, UTM 15-700493N-3583721E, 2 (VICK 5293, VICK 796-805, VICK 808, 809).

*Eptesicus fuscus fuscus (*Beauvois*, 1796)*

Big Brown Bat

Eptesicus fuscus was the most abundant bat species documented at VICK. I captured 27 at six mist netting sites (Table 2.9). This species typically roosts in man-made structures but may occupy hollow trees, crevices, or behind loose bark (*Choate et al. 1994*). A maternity colony with approximately 62 occupants was observed under the Clay Street Bridge on 17 May 2005. The same bridge had approximately 94 bats roosting underneath it on 31 May 2005. Another maternity colony with approximately 15 individuals was found occupying the Illinois monument on 8 May 2005. One pup was collected from the floor of this monument. I found three *E. fuscus* roosting under the shutters of the old Superintendent's quarters, located across from the Surrender Interview Site on Pemberton Avenue.

Specimens examined (5).-USA: Mississippi; Warren County, Illinois Monument, UTM 15-703098N-3582356E, 3 (VICK 5294, VICK 316, VICK 318, VICK 321, VICK 322); 30 m N Jackson Rd. Bridge on Union Ave., UTM 15-703174N-3582810E, 1 (VICK 457-471); Old Superintendent's Quarters, UTM 15-702812N-3582051E, 2 (VICK 1020, 1020a).

Nycticeius humeralis humeralis (Rafinesque, 1818)

Evening Bat

Nycticeius humeralis was a common species found to occur at VICK. I captured 40 individuals at nine mist netting locations (Table 2.9). *Barbour and Davis (1969)* described this species as common throughout the southern coastal states. This species typically will roost in tree cavities and behind exfoliating bark (*Jennings 1958; Chapman and Chapman 1990; Menzel et al. 1999; Miles 2005*) and will also occupy buildings (*Barbour and Davis 1969; Chapman and Chapman 1990*). My observational radiotelemetry study found this bat located in man made structures, such as telephone poles, and trees including white oak, sycamore (*Platanus occidentalis*), sugarberry (*Celtis laevigata*), and box elder.

Specimens examined (6).-USA: Mississippi; Warren County, 30 m N Jackson Rd. Bridge on Union Ave., UTM 15-702844N-3583140E, 2 (VICK 5289, VICK 350-352); Confluence of Mint Springs and Mint Springs Tributary, UTM 15-701468N-3584139E, 1 (VICK 375-380); Mint Springs, UTM 15-700698N-3583780E, 3 (VICK 768-773, VICK 787-795, VICK 774, VICK 775, VICK 910, 911).

Family Molossidae

Tadarida brasiliensis cynocephala (Le Conte, 1831)

Brazilian Free-tailed Bat

Tadarida brasiliensis may be locally abundant if suitable roosting locations are found, but may have spotty distribution throughout the central part of its range (*Barbour and Davis 1969*). These bats predominately occupy buildings in the eastern part of the United States (*Schmidly 1991*). They can also be found to use rock fissures (*Schmidly 1991*) and crevices under bridges (*Buchanan 1958*). I considered this species rare in VICK (Table 2.9). No individuals were captured using mist nets. This bat was documented through acoustic surveys.

Specimens examined (0).

Bat species of unverified occurrence.

Myotis austroriparius

Southeastern Myotis

The Louisiana State University Museum of Natural Science reported one record for this species documented from Madison Parish, Louisiana. However, it is unlikely that this bat would occupy the VICK Madison Parish satellite location as that the site is less than 0.4 ha and does not have habitat suitable for *Myotis austroriparius* to occur, which is assumed to be swampy bottomland hardwood forests (*Gooding and Langford 2004*). It would be unlikely for this species to occupy VICK due to assumed lack of suitable habitat and rarity of occurrence.

Lasiurus intermedius

Northern Yellow Bat

The Mississippi Museum of Natural Science reported one Warren County, Mississippi record for this species documented from Palmyra Island, located approximately 40 km west of

VICK. *Lasiurus intermedius* is known to occur within the southern quarter of the state (*Jones and Carter 1989*), although it does not appear to be common in this part of its range (Wolfe 1971). The distribution of this bat is closely associated with its preferred roosting substrate, Spanish moss (*Jennings 1958; Barbour and Davis 1969; Schmidly 1991; Menzel et al. 1998*). Lack of Spanish moss in VICK may limit its occurrence.

Corynorhinus rafinesquii

Rafinesque's Big-eared Bat

The Smithsonian Institution (United States National Museum) reported two Madison Parish, Louisiana records for this species documented from Tallulah, Louisiana. The Louisiana State University Museum of Natural Science also reported a record from Madison Parish, Louisiana. Although this species has a wide distribution in the southeast, it is considered rare throughout most of its range (*Lance et al. 2001*). It is unlikely that this bat would occupy the VICK- Madison Parish satellite location as this site does not have suitable habitat. In Louisiana and Mississippi, this species is known to occupy bridges (*Lance et al. 2001; Trousdale and Beckett 2005*), but a bridge survey of VICK did not result in finding this species. Bottomland hardwood forests that consist of large diameter *Nyssa* tree species appear to be the preferred habitat in Louisiana and Mississippi (*Lance et al. 2001; Gooding and Langford 2004; Trousdale and Beckett 2005*). It is unlikely that this bat would occupy VICK due to lack of suitable habitat and rarity of occurrence.

ORDER CINGULATA

Family Dasypodidae

Dasypus novemcinctus mexicanus (Peters, 1864)

Nine-banded Armadillo

Dasypus novemcinctus was a fairly common species inside the park. I documented four with remote cameras and 10 during roadside surveys (Table 2.9). They were evenly distributed in the northern and central portions of the park. This species can be found in a multitude of habitats, such as brushy or disturbed areas, moist woodlands, pastures, and scrub. They will occur where soil permits easy digging and enough food is available to support their needs (*Whitaker and Hamilton 1998*). Observations of *D. novemcinctus* damage were obvious in many grassy areas of the park. These animals are known to dig and root for adult and larval insects and other invertebrates (*Choate et al. 1994*).

Specimens examined (8).-USA: Mississippi; Warren County, Boy Scout Trail S Louisiana Monument, UTM 15-702600N-3581239E, 4 (VICK Cam12a-8, VICK Cam12a-9, VICK Cam12a-10, VICK Cam12a-12); Fort Hill, UTM 15-700343N-3583311E, 1 (VICK 301, 302); 200 m N Illinois Monument on Union Ave., UTM 15-703377N-3582360E, 1 (VICK 915, 916); Boy Scout Area entrance, UTM 15-702157N-3584008E, 1 (VICK 5317); Maintenance Area, UTM 15-702191N-3580797E, 1 (VICK 1025).

ORDER LAGOMORPHA

Family Leporidae

Sylvilagus aquaticus aquaticus (Bachman, 1837)

Swamp Rabbit

Although only one *Sylvilagus aquaticus* individual was documented with a remote camera, scat was periodically observed near stream bottoms (Table 2.9). Therefore, I classified this species as uncommon. This rabbit is generally found close to water; its distribution is limited to floodplains, bottomlands, and areas adjacent to tributaries of rivers and streams (*Lowe 1958; Terrel 1972; Chapman and Feldhammer 1981; McCollum and Holler 1994*). Suitable habitats include thickets of switchcane (*Arundinaria gigantea*), privet (*Ligustrum* spp.), blackberry (*Rubus* spp.), honeysuckle (*Lonicera* spp.), or greenbriar (*Smiliax* spp.), which is used as escape cover (*Bearden et al. 2002*). This species tends to have morphological traits similar to *Sylvilagus floridanus*, although *S. aquaticus* tends to be the larger of the two species. The photographed rabbit was identified as *S. aquaticus* based on the location (a stream bottom with an abundance of switchcane in the northwestern portion of the park).

Specimens examined (1).-USA: Mississipi; Warren County, Mint Springs, UTM 15-700812N-3583804E, 1 (VICK 5318).

Sylvilagus floridanus alacer (Bangs, 1896)

Eastern Cottontail

I observed *Sylvilagus floridanus* was seven times during road surveys (Table 2.9). Scat was observed frequently. It was a fairly common inhabitant of the park. Many diverse locations meet the habitat requirements for this species. It is commonly found in disturbed, early successional and transitional habitats often with an abundance of well distributed escape sites that were dense, thorny, low-growing, woody perennials (*Chapman et al. 1982*). This rabbit was often observed near hedgerows and in open grassy areas along the tour road at VICK. There was no photographic or capture record for this species. Documentation was entirely based on observations.

Specimens examined (0).

ORDER RODENTIA

Family Sciuridae

Tamias striatus pipilans (Lowery, 1943)

Eastern Chipmunk

Tamias striatus is a common species in VICK. I captured four in Tomahawk traps and with remote cameras. I visually confirmed 22 individuals (Table 2.9). This species inhabits primarily deciduous forested areas and can be found in open bushy habitats and mature forests (*Snyder 1982*). In VICK**,** this species was found predominantly in fragmented habitats along the tour road. It was also regularly recorded in forested riparian areas.

Specimens examined (5).-USA: Mississippi; Warren County, 200 m N Pemberton Ave., UTM 15-703143N-3581960E, 2 (VICK Cam1-22, VICK Cam1-31); Boy Scout Trail at Grant Ave. and Union Ave. intersection, UTM 15-703311N-3583971E, 1 (VICK Cam4-73); Service Rd. between Maintenance Area and Visitor Center, UTM 15-702377N-3580682E, 1 (VICK 923, 925); Glass Bayou, UTM 15-703001N-3582711E, 1 (VICK 5327).

Sciurus niger subauratus (Bachman, 1838)

Eastern Fox Squirrel

Sciurus niger was one of the most abundant species observed inside the park. I captured 11 using Tomahawk traps and with remote cameras. There were many visual encounters with this species but only 29 were recorded (Table 2.9). *S. niger* prefer open oak hickory forests and park-like habitats (*Whitaker and Hamilton 1998*). In VICK, they were found in most habitat types, including upland, riparian and edge. They were most abundant in manicured areas, such as the National Cemetery and the Visitor Center. Observed individuals exhibited two types of color morphs, which included the melanistic (i.e. black phase) and the grizzled rusty phase.

Specimens examined (15).-USA: Mississippi; Warren County, Service Road Between Maintenance Area and Visitor Center, UTM 15-702377N-3580682E, 1 (VICK 5276); 200 m N Pemberton Ave., UTM 15-703143N-3581960E, 2 (VICK Cam1-25, 1-28); Mint Springs, UTM 15-700722N-3583781E, 1 (VICK Cam1-57); Boy Scout Trail Sherman Circle, UTM 15-703260N-3584309E, 1 (VICK Cam2-19); Mint Springs, UTM 15-700812N-3583804E, 1 (VICK Cam2-40); Turtle Pond, UTM 15-700861N-3584486E, 1 (VICK Cam4-29); Trail behind Restoration Shop, UTM 15-700803N-3584376E, 1 (VICK Cam12a-38); Sherman Circle, UTM 15-703428N-3584300E, 3 (VICK Cam34-3, VICK Cam34-16, VICK Cam 34-21); 400 N Main Entrance, UTM 15-702322N-3580537E, 1 (VICK 142); E Graveyard Rd., UTM 15-702956N-3583720E, 1 (VICK 180-185); Intersection of Visitor Center and South Loop, UTM 15-702054N-3580559E, 1 (VICK 405); 50 m N Shirley House, UTM 15-703296N-3582497E, 1 (VICK 844-846).

Glaucomys volans saturatus (Howell, 1915)

Southern Flying Squirrel

Although I captured only five *Glaucomys volans* specimens were captured in Sherman live traps and one road-killed specimen was observed, this nocturnal species is probably common within VICK (Table 2.9). This squirrel is known to occupy deciduous forests (*Dolan and Carter 1977*) and is not restricted to a particular forest type or any mast-producing tree species (*Muul*

1974). In VICK, *Glaucomys volans* was captured at three locations, mostly in bottomland hardwood habitats.

Specimens examined (5).-USA: Mississippi; Warren County, 200 m N Pemberton Ave., UTM 15-703099N-3581913E, 4 (VICK 5305, VICK 518-525, VICK 526-531,VICK 602-605); South Loop between bridges 1 and 3, UTM 15-701633N-3579679E, 1 (VICK 712-714).

Family Castoridae

Castor canadensis carolinensis (Rhoads, 1898)

American Beaver

I considered *Castor canadensis* as rare in VICK, but this species could be fairly common along the Yazoo River. This species occurs in rivers, streams, impoundments**,** and lakes with relatively constant water levels (*Hill 1982*). I had three visual encounters in Mint Springs Tributary, west of Connecting Avenue, which flows into the Yazoo River (Table 2.9). Since all observations were made in the same location, it is possible that the same individual was encountered. No lodges or dams were located but numerous beaver chews and slides were observed in the Yazoo River Watershed among black willow stands.

Specimens examined (2).-USA: Mississippi; Warren County, Mint Springs, UTM 15-700400N-3583701E, 2 (VICK 5343, VICK 1021).

Family Muridae

Reithrodontomys humulis humilis (Audubon and Bachman, 1841)

Eastern Harvest Mouse

Reithrodontomys humulis occupies the entire state of Mississippi (*Jones and Carter 1989*). I captured this species only three times; therefore, I considered this species as rare (Table 2.9). This rodent is known to occupy abandoned fields, briar thickets, and honeysuckle patches

(*Lowery 1974*). It has also been observed in open, uncultivated fields, especially those with stands of relatively dense grass (*Cothran et al. 1991*). Most open grasslands on VICK were mowed regularly, which may limit this species distribution. However, I did document *R. humulis* in forest-grassland edge habitat.

Specimens examined (1).-USA: Mississippi; Warren County, E Graveyard Rd., UTM 15-703053N-3583674E, 1 (VICK 5270).

Peromyscus gossypinus gossypinus (LeConte, 1853)

Cotton Deer Mouse

Peromyscus gossypinus was a fairly common inhabitant of VICK. I positively identified 11 individuals using PCR analysis (Table 2.9). In VICK, this rodent was most abundant in bottomland hardwoods habitats but also was found in upland areas. Forty-five observed individuals could not be identified to the species level. These individuals were believed to be either *P. gossypinus* or *P. leucopus*.

Specimens examined (10).-USA: Mississippi; Warren County, 200 m N Pemberton Ave., UTM 15-703099N-3581913E, 2 (VICK 5295, VICK 5297); Boy Scout Trail between Tour Stops 4 and 5, UTM 15-703141N-3583414E, 2 (VICK 5300, VICK 5301); Between Tour Stops 4 and 5, UTM 15-703387N-3583143E, 1 (VICK 5311); Mint Springs, UTM 15-700644N-3583757E, 1 (VICK 5321); Yazoo River Watershed, UTM 15-700153N-3583624E, 5 (VICK 5330,VICK 5331,VICK 5335, VICK 5339, VICK 5340);

Peromyscus leucopus leucopus (Rafinesque, 1818)

White-footed Deer Mouse

Although PCR analysis confirmed the identification of only seven individuals, *Peromyscus leucopus* was probably a fairly common inhabitant of VICK (Table 2.9). Forty-five

Peromyscus spp. could not be identified to the species level and it is possible that some of these individuals could be classified as *P. leucopus*. This species was documented mostly in riparian and grassland habitat. *P. leucopus* and *Peromyscus gossypinus* were sympatric at two trapping locations, grassland-hardwood edge and bottomland hardwood.

Specimens examined (7).-USA: Mississippi; Warren County, Boy Scout Area, UTM 15-702631N-3584423E, 1 (VICK 5273); NE Union Ave. and Jackson Rd., UTM 15-703377N-3582360E, 1 (VICK 5275); Union Ave. 200 m N Pemberton Ave., UTM 15-703099N-3581913E, 3 (VICK 5296, VICK 5298, VICK 5299); Mint Springs, UTM 15-700644N-358757E, 2 (VICK 5322, VICK 5323).

Sigmodon hispidus hispidus (Say and Ord, 1825)

Hispid Cotton Rat

Sigmodon hispidus was a common species found in VICK. I captured 27 using Sherman live traps and Victor snap traps (Table 2.9). One individual was observed near a pitfall array in a grassland habitat. I captured *S. hispidus* mostly in unmowed grassland and prairie habitats with vegetation consisting of broomsedge (*Andropogon virginicus*), blackberry, and Johnson grass.

Specimens examined (9).-USA: Mississippi; Warren County, Fort Hill, UTM 15-700343N-3583311E, 3 (VICK 5306, VICK 5308, VICK 5309); 200 m N Pemberton Ave. and Union intersection, UTM 15-702888N-3581915E, 3 (VICK 5310, VICK 5312, VICK 650-653); Old Hwy. 27 100 m S Park Entrance, UTM 15-702307N-3580356E, 2 (VICK 5324, VICK 5326); Fort Garrett, UTM-15-700343N-3583311E, 1 (VICK 624-626).

Neotoma floridana rubida (Bangs, 1898)

Eastern Woodrat

Neotoma floridana was an uncommon species located inside the park. I captured eight using Sherman live traps and Tomahawk traps (Table 2.9). This woodland species can be found in a variety of habitats. They were documented in most park habitat types including riparian, grassland, and edge.

Specimens examined (3).-USA: Mississippi, Warren County, Union Ave. 400 m W Grant Ave, UTM 15-701365N-3584339E, 1 (VICK 190-192); Mississippi Monument, UTM 15-702302N-3581527E, 1 (VICK 5303); Mint Springs, UTM 15-700644N-3583757E, 1 (VICK 937).

*Mus musculus brevirostris** (Waterhouse, 1837)

House Mouse

Mus musculus was fairly common in VICK. I captured 10 using Sherman live traps and Victor snap traps and one individual was observed (Table 2.9). This species is distributed throughout the United States (*Lowery 1974*). Although this rodent is highly correlated with human populations, it frequently is found in old fields, agricultural areas, marshes, and forests (*Wolfe 1971*). In VICK, *Mus musculus* was found in bottomland forested areas dominated by black willow and edge habitat comprised mostly of sweetgum, water oak, and Chinese privet.

Specimens examined (8).-USA: Mississippi; Warren County, E Mississippi Monument, UTM 15-702302N-3581527E, 1 (VICK 5284); Yazoo River Watershed, UTM 15-700153N-3583624E, 1 (VICK 5329); Yazoo River Watershed, UTM 15-700197N-3583750E, 5 (VICK 5336, VICK 5337, VICK 5338, VICK 5341, VICK 5342); Yazoo River Watershed, UTM 15-702888N-3581915E, 1 (VICK 995-999).

Microtus pinetorum auricularis (Bailey, 1898)

Woodland Vole

Microtus pinetorum was considered rare but may be fairly common in its preferred habitat. I captured three using pitfall traps and one road-killed individual was observed (Table 2.9). This species is reported to occur in low densities and significant sampling effort is required for detection (*McCann et al. 2002*). This vole occupies a variety of habitats, including leaf litter in forests, and grasslands comprised of brush and brambles. It also has been found underneath mats of honeysuckle, in roadways and along fencerows (*Choate et al. 1994*). In VICK, it was found in upland habitat dominated by pecan, redbud, water oak, Chinese privet, and winged elm (*Ulmus alata*).

Specimens examined (3).-USA: Mississippi; Warren County, Boy Scout Area, UTM 15-702339N-3584380E, 3 (VICK 5285, VICK 5286, VICK 5287).

Family Myocastoridae

*Myocastor coypus bonariensis** (Geoffory St.-Hilaire)

Coypu

This species is considered rare in VICK. I did not capture any *Myocastor coypus* individuals. However, a set of tracks was photographed on a stream bank in the southern portion of VICK. This species was introduced to clean up over vegetated lakes and for use as a furbearer (*Davis and Schmidly 1994*). It occupies freshwater or brackish marshes and may compete for habitat with muskrats (*Whitaker and Hamilton 1998*). *Choate et al. (1994)* reported that this species is common to abundant in coastal marshes and along major waterways. This may be supported by anecdotal observations along the Yazoo River from a River Boat Captain.

Specimens examined (0).

Sciurus carolinensis

Eastern Gray Squirrel

Sciurus carolinensis ranges throughout the state of Mississippi (*Jones and Carter 1989*). The Louisiana State University Museum of Natural Science provided six records of *S. carolinensis* in Madison Parish, Louisiana. It is possible that this species could be found on the small VICK satellite, although available habitat is limited. Their absence could be explained by the following three possibilities: (1) *Sciurus niger – S. carolinensis* competition. These two species are sympatric over a large portion of their range (*Flyger and Gates 1982*). Although both species have similar ecological requirements, minor differences exist in habitat selection preference (*Flyger and Gates 1982, Edwards et al. 2003*). *S. carolinensis* prefer extensive, contiguous mature forests, often with dense undergrowth (*Flyer and Gates 1982*). In contrast, *S. niger* inhabit open, mature, upland forests with sparse understory (*Nixon and Hansen 1987*). Therefore, interspecific competition between these two species is not likely the best explanation for the lack of *S. carolinensis* occurrence at VICK. The last two possible explanations, (2) insufficient sampling methods and (3) lack of suitable habitat to meet life requirement needs were addressed using GIS to model life requisites of the gray squirrel habitat suitability index (HSI) (*Allen 1987*), including winter food availability and cover/reproduction requirements. The habitat at VICK was found unsuitable to support the life requisites of eastern gray squirrels. Percent tree canopy was the limiting factor for the winter food and cover/reproduction requirements. Forested sections in the park were planted by the Civilian Conservation Corp (CCC) during the 1930s to prevent erosion. These forests are not old enough to create a closed canopy environment conducive for the presence of *S. carolinensis*. Support for this model comes from *Ross (1996)*; the author found that *S. carolinensis* abundance in Mississippi, was positively correlated with stand age, hard mast abundance, presence of woody plants, and understory debris.

Reithrodontomys fulvescens

Fulvous Harvest Mouse

The Louisiana State University Museum of Natural Science provided one record for *Reithrodontomys fulvescens* in Madison Parish, Louisiana. It could possibly occur on the VICK satellite location, although the lack of available habitat is a limiting factor. This species occurs in the southwestern half of Mississippi (*Choate et al. 1994*) and is often found in old fields and brushy areas (*Wolfe 1971*). It is possible that this rodent could be a future addition to the main potion of VICK. However, unmowed old fields were not numerous.

Ochrotomys nuttalli

Golden Mouse

The Mississippi Museum of Natural Science reported three Warren County, Mississippi records and the Louisiana State University Museum of Natural Science reported five Warren County, Mississippi records for *Ochrotomys nuttalli*. This species has a statewide distribution in Mississippi (*Jones and Carter 1989*). Forested areas, hedgerows, brushy thickets, and dense field edges are its primary habitats (*Cothran et al. 1991*). It is probable that this species could be a future addition to the park's faunal list.

Oryzomys palustris

Marsh Oryzomys

The Louisiana State University Museum of Natural Science provided one record for *Oryzomys palustris* in Madison Parish, Louisiana. The Louisiana satellite contains a small ephemeral pond whose edges may provide suitable habitat, although the occasional presence of water may not be sufficient for the occurrence of this species. In Mississippi, this rodent ranges throughout the state (*Jones and Carter 1989*). Habitat preferences include wet, marshy areas, such as grassy ditches, the edges of lakes and streams, and fields with damp soil. It is rarely ever found in dry fields or in well-drained forests (*Lowery 1974*). It could be possible for this species to reside in the park; however, there is a lack of suitable habitat.

Ondatra zibethicus

Common Muskrat

There were no museum records for this species. *Ondatra zibethicus* occurs throughout the state of Mississippi where suitable aquatic habitat is present (*Jones and Carter 1989*). This rodent can be found in coastal and inland marshes, lakes, ponds, sloughs, streams, and rivers. However, they are adaptable, and can reside in a wide range of marginal habitats, including ditches, canals, pits, and strip-mined ponds. In general, they require water and some form of emergent, submergent, floating, or shoreline vegetation (*Erb and Perry 2003*). It is possible that this species could be a future addition to the park's faunal list. Suitable habitat is available in the Yazoo River Watershed or along the streams and creeks that flow throughout the park.

*Rattus rattus**

Roof Rat

The Mississippi Museum of Natural Science reported two Warren County, Mississippi records for *Rattus rattus*. This introduced species occurs in urban regions of the eastern and southern United States (*Lowery 1974*) and is closely associated with human populations, especially in coastal areas (*Wolfe 1971*). It is likely that the roof rat will be added to the mammalian faunal list due to the proximity of VICK to urban areas.

*Rattus norvegicus**

Brown Rat

The Mississippi Museum of Natural Science reported seven Warren County records for *Rattus norvegicus.* This introduced species is found throughout the United States (*Lowery 1974*) and is also closely associated with humans (*Wolfe 1971*). It is likely that in the future this species will be added to the park's faunal list.

ORDER CARNIVORA

Family Canidae

Canis lupus

Domestic Dog

Canis lupus was an abundant species found inside the park's boundaries. I documented 50 with remote cameras and foot hold traps and 13 individuals were observed traveling along roadways (Table 2.9). This species was found in all habitat types and was most abundant in riparian and edge habitats. It was evident that there were feral dogs inhabiting the park, as well as pets that probably resided at one or more of the many residences surrounding the park.

Specimens examined (49).-USA: Mississippi; Warren County, South Loop culvert, UTM 15-701723N-3579927E, 1 (VICK Cam1-78); Bridge crossing NE weather station, UTM 15-702407N-3584492E, 2 (VICK Cam2-3); Boy Scout Trail S Louisiana Monument, UTM 15-702661N-3581514E, 3 (VICK Cam2-24, VICK Cam2-34, VICK Cam2-35); Mint Springs, UTM 15-700812N-3583804E, 26 (VICK 5319, VICK Cam3-35, VICK Cam3-36, VICK Cam3-39, VICK Cam3-40, VICK Cam3-46, VICK Cam3-48, VICK Cam3-49, VICK Cam3-51); Boy Scout Trail at Sherman Circle, UTM 15-701363N-3584368E, 2 (VICK Cam3-3, VICK Cam3-4); Boy Scout Area, UTM 15-702635N-3584467E, 3 (VICK Cam3-8); Turtle Pond, UTM 15-

700861N-3584486E, 9 (VICK Cam4-45, VICK Cam4-46); Boy Scout Trail S Louisiana Monument, UTM 15-702600N-3581239E, 1 (VICK Cam12a-11); Boy Scout Trail S Louisiana Monument, UTM 15-702556N-3581377E, 2 (VICK Cam 27-1).

Canis latrans frustror (Woodhouse, 1851)

Coyote

Canis latrans is highly adaptable and is maintaining or increasing its population in many parts of its range (*Whitaker and Hamilton 1998*). They were observed traveling along the tour road on three occasions (Table 2.9). I documented scat along the tour road as well. This species is probably a periodic transient. *Canis latrans* can occupy a large range of habitats, ranging from open areas to forests. They are well suited in areas with a diversity of habitats, including thickets, brushy areas, and small woodlots. Their dens are often found in banks, mounds, or under overhangs (*Whitaker and Hamilton 1998*).

Specimens examined (0).

Vulpes vulpes fulva (Desmarest, 1820)

Red Fox

Vulpes vulpes was a fairly common species inside the park. I photographed 12 using remote cameras and observed eight individuals along the tour road (Table 2.9). *Vulpes vulpes* is an adaptable species that thrives within the limits of urban cities, including Vicksburg. Species Distribution was concentrated in the northern and southern portions of the park and it was found to be most abundant along forest edges, open areas and along streams and ponds.

Specimens examined (12).-USA: Mississippi; Warren County, National Cemetery, UTM 15-700675N-3583783E, 4 (VICK Cam1-89, VICK Cam1-90, VICK Cam1-91, VICK Cam1-95); Bridge crossing NE weather station, UTM 15-702407N-3584492E, 1 (VICK Cam2-10);

Connecting Ave. Bridge, UTM 15-700646N-3583759E, 2 (VICK 5288, VICK Cam4-8); Sherman Circle, UTM 15-703428N-3584300E, 5 (VICK Cam34-11, VICK Cam34-14, VICK Cam34-17, VICK Cam34-19, VICK Cam34-22).

Urocyon cinereoargenteus floridanus (Rhoads, 1895)

Gray Fox

Urocyon cinereoargenteus was considered a fairly common inhabitant of VICK. I recorded 20 using remote cameras and foothold traps and observed one individual while conducting a spotlight survey (Table 2.9). This species is typically associated with deciduous forests (*Whitaker and Hamilton 1998*). Den sites include hollow trees and logs, underground burrows, rock outcrops, and brush piles (*Fritzell and Haroldson 1982*). In VICK, *U. cinereoargenteus* distribution was concentrated in the northwestern portion of the park and was documented frequently along streams, ponds, and in the National Cemetery. *Urocyon cinereoargenteus* and *Vulpes vulpes* were sympatric at two locations, the National Cemetery and Connecting Ave. Bridge.

Specimens examined (20).-USA: Mississippi; Warren County, Connecting Ave. Bridge, UTM 15-700619N-3583819E, 1 (VICK Cam1-44); Mint Springs, UTM 15-700898N-3583874E, 1 (VICK Cam3-31); National Cemetery, UTM 15-700439N-3583852E, 3 (VICK Cam3-60, VICK Cam3-81, VICK Cam3-82); Connecting Ave. Bridge, UTM 15-700646N-3583759E, 6 (VICK Cam4-6, VICK Cam4-9, VICK Cam4-10, VICK Cam4-11, VICK Cam4-14, VICK Cam4-15); Turtle Pond, UTM 15-700861N-3584486E, 7 (VICK Cam4-22, VICK Cam4-23, VICK Cam4-27, VICK Cam4-28, VICK Cam4-32, VICK Cam4-38, VICK Cam4-51); Boy Scout Trail from Confederate Ave. to Cairo Museum, UTM 15-701673N-3583702E, 1 (VICK

Cam21-1); Intersection of Union Ave. and Boy Scout Area entrance, UTM 15-702157N-3584008, 1 (VICK 5316).

Family Procyonidae

Procyon lotor varius (Nelson and Goldman, 1930)

Raccoon

Procyon lotor was one of the most abundant species found at VICK. I documented 82 using Tomahawk traps and remote cameras. I observed nine individuals through spotlight surveys or opportunistic sightings (Table 2.9). This carnivore had a fairly even distribution throughout the park and was documented in most habitat types, including upland, edge, and riparian; however, habitats associated with water were preferred. This generalist species has an opportunistic and omnivorous diet, which allows it to thrive in VICK, where fruit, nuts, seeds, and crayfish (*Cambarus* spp., *Astacus* spp.) were fairly abundant. Also, garbage from the residential areas surrounding the park's boundaries is probably used as another food base.

Specimens examined (71).-USA: Mississippi; Warren County, 200 m N Pemberton Ave., UTM 15-703115N-3581924E, 1 (VICK 5272); Mint Springs, UTM 15-700722N-3583781E, 2 (VICK Cam1-59, VICK Cam1-63); South Loop Culvert, UTM 15-701723N-3579927E, 5 (VICK Cam1-68, VICK Cam1-77, VICK Cam1-79); Boy Scout Trail S Louisiana Monument, UTM 15-702661N-3581514E, 2 (VICK Cam2-25, VICK Cam2-33); Mint Springs, UTM 15-700812N-3583804E, 1 (VICK Cam2-47); Boy Scout Trail between Mile Posts 4 and 5, UTM 15-700898N-3583874E, 4 (VICK Cam3-22, VICK Cam3-23, VICK Cam3-24, VICK Cam3-28); Glass Bayou culvert off Modern Jackson Rd., UTM 15-703126N-3582694E, 2 (VICK Cam3-55, VICK Cam3-66); Turtle Pond, UTM 15-700861N-3584486E, 8 (VICK Cam4-21, VICK Cam4-24, VICK Cam4-33, VICK Cam4-55, VICK Cam4-57, VICK Cam4-58, VICK Cam4-59); Boy

Scout Trail S Louisiana Monument, UTM 15-702753N-3581938E, 1 (VICK Cam8-1); Old Superintendent's Quarters, UTM 15-702753N-3581938E, 1 (VICK Cam12a-1); 30 m SW Boy Scout Meeting Area, UTM 15-702535N-3584199E, 4 (VICK Cam12a-2, VICK Cam12a-3, VICK Cam12a-4, VICK Cam12a-5); Boy Scout Trail S Louisiana Monument, UTM 15-702600N-3581239E, 1 (VICK Cam12a-7); Glass Bayou at Modern Jackson Rd., UTM 15-702785N-3582580E, 8 (VICK Cam12a-21, VICK Cam12a-22, VICK Cam12a-23, VICK Cam12a-29, VICK Cam12a-33, VICK Cam12a-35, VICK Cam12a-36, Boy Scout Trail S Louisiana Monument, UTM 15-702556N-3581377E, 7 (VICK Cam27-2, VICK Cam27-3, VICK Cam27-4, VICK Cam27-5, VICK Cam27-6, VICK Cam27-7, VICK Cam27-8); Boy Scout Area 100 m W weather station, UTM 15-702282N-3584353E, 15 (VICK Cam27-10, VICK Cam29-1, VICK Cam29-2, VICK Cam29-3, VICK Cam29-4, VICK Cam29-5, VICK Cam29-6, VICK Cam29-7, VICK Cam29-8, VICK Cam29-9, VICK Cam29-10, VICK Cam29-11, VICK Cam29-12); Thayer's Approach, UTM 15-701938N-3583752E, 2 (VICK Cam29-14, VICK Cam29-15); Sherman Circle, UTM 15-703428N-3584300E, 1 (VICK Cam34-18); Fort Garrett, UTM 15-701281N-3579838E, 1 (VICK 283); Boy Scout Meeting Area, UTM 15-702581N-3584413E, 1 (VICK 637-640); SE Boy Scout Meeting Area, UTM 15-702859N-3584371E, 1 (VICK 641-643); South Loop, UTM 15-701612N-3579782E, 1 (VICK 690, 691); W Tributary Stout's Bayou, UTM 15-701894N-3580314E, 1 (VICK 902); E Tributary Stout's Bayou, UTM 15-702576N-3580881E, 1 (VICK 909).

Family Mustelidae

Mustela frenata arthuri (Hall, 1927)

Long-tailed Weasel

Mustela frenata occurs in forest-edge habitats, brushlands, forests, fencerows, and occasionally agricultural and urban areas (*Choate et al. 1994*). Park habitat would seem to favor the presence of this small carnivore; however, the occurrence of this species was rare with only one road-killed individual observed after the completion of the field study (Table 2.9).

Specimens examined (1).-USA: Mississippi; Warren County, 1st bridge after Main Entrance, UTM 15-702563N-3580726E, 1 (VICK 5344).

Family Mephitidae

Mephitis mephitis nigra (Peale and Palisot de Beauvois, 1796)

Striped Skunk

This species is most abundant in grassy fields, brushy areas, culverts, and hedgerows and were often found near buildings (*Whitaker and Hamilton 1998*). Although park habitat would be conducive for the presence of this species, the occurrence of *Mephitis mephitis* was rare (Table 2.9). Two individuals were documented on the lawn of the Visitor Center and one additional observation was made in the National Cemetery prior to field investigations. According to park employees, *Mephitis mephitis* observations have steadily declined over the last few years.

Specimens examined (1).-USA-Mississippi; Warren County, Visitor Center, UTM 15-702252N-3580588E, 1 (VICK 5313).

Family Felidae

*Felis catus** (Schreber, 1775)

Domestic Cat

This species commonly occurs within VICK. I recorded one animal using a remote camera and 31 were observed inside the park (Table 2.9). The majority of *Felis catus* were found living in association with houses, barns, and buildings. They are thought to prefer grasslands or disturbed areas. Burrows, thickets, rock piles, or hollow logs make ideal places to raise young (*Whitaker and Hamilton 1998*). In VICK, this species was evenly distributed throughout most of the park with the exception of the northeastern portion of the park; it was observed in most habitat types, including grassland, edge, and riparian. It was evident that there were feral cats inhabiting the park, as well as pets, which probably resided in one of the many residences surrounding the park.

Specimens examined (2).- USA: Mississippi; Warren County, National Cemetery, UTM 15-700675N-3583783E, 1 (VICK Cam1-87); National Cemetery, UTM 15-700343N-3583952E, 1 (VICK 5334).

Lynx rufus floridanus (Rafinesque, 1817)

Bobcat

Lynx rufus was considered uncommon inside the park. I photographed seven with remote cameras and three were observed by park employees (Table 2.9). The cryptic nature of this species could have made detection difficult given that numerous tracks were common along streams throughout the park. This species uses a wide variety of habitats, including hardwood, coniferous, or mixed forests. It is successful at adapting to a constantly changing environment

(*Whitaker and Hamilton 1998*), therefore the fragmented landscape comprising VICK might be considered suitable habitat.

Specimens examined (7).-USA-Mississippi; Warren County, Glass Bayou culvert at Modern Jackson Rd., UTM 15-703126N-3582694E, 1 (VICK 5328); Glass Bayou at Modern Jackson Rd., UTM 15-702785N-3582580E, 5 (VICK Cam12a-24, VICK Cam12a-25, VICK Cam12a-26, VICK Cam12a-27, VICK Cam12a-28); Boy Scout Trail S Louisiana Monument UTM 15-702556N-3581377E, 1 (VICK Cam27-10).

Carnivore species of unverified occurrence.

Ursus americanus

American Black Bear

The Smithsonian Institute (United States National Museum) reported 13 Madison Parish, Louisiana records for *Ursus americanus*. The Louisiana State University Museum of Natural Science reported one record for Madison Parish, Louisiana. The Mississippi Museum of Natural Science reported three Warren County, Mississippi records for this species. Current research has documented six individuals in Warren County in 2005 (*B. Young, pers. comm., February 2005*). The Yazoo River could provide a travel corridor for transient bears that may temporarily occupy the major portion of the park. It is possible that a bear could on occasion occupy the Louisiana satellite; however, the size of this area is not large enough to support a resident.

Neovison vison

Mink

The Mississippi Museum of Natural Science reported two Warren County, Mississippi records for this species. It ranges across the entire state of Mississippi (*Jones and Carter 1989*). *Neovison vison* inhabit a variety of habitats including tropical swamps, prairies, temperate and boreal forests, freshwater and saltwater coastal areas, and tundra. The presence of this species is affected mostly by the availability of water and food throughout its geographic range (*Lariviére 2003*). It is possible that *N. vison* could be a future addition to the park's faunal list. Suitable habitat is available in the Yazoo River Watershed or along the streams and creeks that travel throughout the park.

Spilogale putorius

Spotted Skunk

There were no museum records for *Spilogale putorius* in Warren County. It occurs in the southern and eastern parts of Mississippi but is absent from the northwest portion adjacent to Arkansas (*Jones and Carter 1989*). This species inhabits weedy fields and woodlots but seems to avoid heavily forested areas and wetlands (*Whitaker and Hamilton 1998*). There is suitable park habitat available; therefore, it is possible that this species could be a future addition to the park's faunal list.

Lontra canadensis

North American River otter

Lontra canadensis has been reported throughout Mississippi where suitable aquatic habitat occurs (*Jones and Carter 1989*). The Smithsonian Institute (United States National Museum) reported two Madison Parish, Louisiana records for this species. It is unlikely that this species occurs in the Madison Parish satellite location due to a lack of permanent water sources. However, it is possible that this species could occur in the major portion of the park given that there is suitable habitat in the Yazoo River Watershed or along the streams and creeks that travel throughout the park.

ORDER ARTIODACTYLA

Family Cervidae

Odocoileus virginianus virginianus (Zimmermann, 1780)

White-tailed Deer

Odocoileus virginianus were one of the most abundant species known to occur in VICK. I recorded 52 using remote cameras and 110 were visually encountered (Table 2.9).

Optimal habitats include the bushy stage of deciduous forest development, where juvenile trees and shrubs provide food and cover (*Cothran et al. 1991*). In VICK, white-tailed deer were found in every habitat type and were distributed evenly throughout the park.

Specimens examined (53).-USA: Mississippi; Warren County, South Loop culvert, UTM-15-701723N-3579927E, 8 (VICK Cam1-66, VICK Cam1-71, VICK Cam1-72, VICK Cam1-73, VICK Cam1-74, VICK Cam1-75, VICK Cam1-80, VICK Cam1-81); Boy Scout Trail at Sherman Circle, UTM 15-701363N-3584368N, 4 (VICK Cam3-1, VICK Cam3-2, VICK Cam3-7); Mint Springs, UTM 15-700812N-3584226E, 2 (VICK Cam3-37, VICK Cam3-38); Turtle Pond, UTM 15-700861N-3584486E, 19 (VICK 5320, VICK Cam4-25, VICK Cam4-26, VICK Cam4-39, VICK Cam4-40, VICK Cam4-41, VICK Cam4-42, VICK Cam4-43, VICK Cam4-48, VICK Cam4-49, VICK Cam4-50, VICK Cam4-52, VICK Cam4-53, VICK Cam4-56); Boy Scout Trail N Graveyard Rd., UTM 15-702539N-3583708E, 4 (VICK Cam8-2, VICK Cam8-3, VICK Cam8-4); Boy Scout Trail N Graveyard Rd., UTM 15-702795N-3583650E, 7 (VICK Cam12a-13, VICK Cam12a-14, VICK Cam12a-15, VICK Cam12a-16, VICK Cam12a-17); Trail behind Restoration Shop, UTM 15-700803N-3584376E, 3 (VICK Cam12a-20, VICK Cam12a-37); Boy Scout Trail from Confederate Ave. to Cairo Museum, UTM 15-701673N-3583702E, 1 (VICK Cam21-2); Boy Scout Area, UTM 15-702282N-3584353E, 2 (VICK Cam29-13); Edge of

Kudzu Management Area, UTM 15-701339N-3579952E, 1 (VICK Cam29-16); Boy Scout Trail N Graveyard Rd., UTM 15-702662N-3583717E, 1 (VICK Cam34-1); South Loop, UTM 15-701281N-3579838E, 1 (VICK 675-681).

Discussion

My study documented 37 of 46 potential mammal species, or 80% of expected occurrences. This includes 14 small mammal species with *Peromyscus* spp., (most likely *P. leucopus or P. gossypinus*), and *Sigmodon hispidus* most frequently captured while *Sciurus niger* and *Tamias striatus* were the most commonly observed. Trapping effort for small mammals appears to be sufficient based upon the predicted species richness estimates. Therefore, low capture success may have resulted from a high level of trap disturbance presumably from meso carnivores, such as *Procyon lotor* and *Didelphis virginiana*. These opportunistic feeders were frequently observed near sampling locations and were often trapped and moved to mediate trap disturbance. Capture indices for small mammals were greatest in riparian areas and lowest in grassland habitats. The lack of capture success in the grassland habitats may have resulted from regular grass mowing maintenance that prevented the establishment of populations.

Vicksburg National Military Park's urban setting influences the species that may occur. Sixteen meso and large mammal species were documented with sufficient trapping effort based upon species richness estimates. *Procyon lotor* and *Didelphis virginiana* were captured most frequently and *Odocoileus virginianus* and *Felis catus* were most commonly observed. Capture indices were especially high in riparian habitats, on roads, and in urban areas. Human dominated areas tend to support tolerant species, which share certain common characteristics. In general, species that live in disturbed ecosystems are those that have the capability to reproduce quickly and disperse widely. They tend to be generalists - able to tolerate a broad range of habitat conditions and food sources; they also tend to be cosmopolitan species-found over a wide range of habitat locations (*Wilson 1992*).

Six bat species were captured using mist net trapping and one additional species was recorded through acoustic sampling. In comparison to small mammals, capture success was high for bats in all sampled habitats including riparian areas, forest corridors, and roads. Projected species richness estimates revealed that this group was satisfactorily sampled. All bat species expected to occur were documented. *Eptesicus fuscus* and *Nycticeius humeralis* were trapped most frequently, which might reflect the ability of these two species to adapt to an increasingly developed landscape. *Eptesicus fuscus* were regularly observed roosting under bridges, inside the Illinois Monument, and in an administration building. Radiotelemetry revealed that almost half (*n*=4) of roosting structures used by radio tagged *Nycticeius humeralis* were located in utility poles. This might suggest that tree roosts were limiting for this species but further research is necessary for confirmation.

Myotis austroriparius, Lasiurus intermedius, Corynorhinus rafinesquii, Sciurus carolinensis, and *Ursus americanus* were undetected and presumed absent due to limited habitat availability. For most of the remaining undetected species, *Ochrotomys nuttalli*, *Oryzomys palustris*, *Reithrodontomys fulvescens*, *Ondatra zibethica*, *Rattus rattus*, *Rattus norvegicus*, *Neovison vison*, *Lontra canadensis*, *Spilogale putorius*, this inventory was inconclusive and therefore these mammals should be regarded as potential occurrences. Low numbers of *Mus musculus* detections and the absence of two other commensal species, *Rattus rattus* and *Rattus norvegicus* were surprising considering the close proximity to urban settlements.

Although the mammalian communities of VICK were found to be somewhat diverse, it is vital to understand the effect that urbanization has on wildlife communities. Protecting islands of habitat like VICK may become crucial in preventing losses in species diversity.

Management Implications

The alteration of landscapes through urbanization can have profound affects on the distribution and abundance of wildlife populations. Adaptable species can be very successful and have populations that may become overabundant, causing property damage and threatening human health and safety (*DeStefano and DeGraaf 2003*).

High density urban wildlife populations may result from increased availability of resources such as food, refugia, or den sites (*Riley et al. 1998, Prange et al. 2004*). Dense *Procyon lotor* populations are more likely subject to epizootics of contact diseases such as rabies and canine distemper (*Riley et al. 1998*). Increases in survival rates for *P. lotor* may result from supplemental food and an absence of mortality factors common in rural areas (*Riley et al. 1998, Prange et al. 2004*). However, vehicle-related mortality factors and disease transmission may be greater in urbanized areas (*Prange et al. 2004*). Direct urban management of *P. lotor* numbers likely will require continuous control measures, because populations are capable of quickly repopulating an area after the resident population has been reduced. The reduction of anthropogenic food sources may be the most effective control measure (*Prange et al. 2003*).

An abundance of free-roaming domestic pets in urban areas have been found to constitute ecological and potential public health problems. (*Liberg 1984, Butler 2003, Lepczyk et al. 2003, Woods et al. 2003*) *Felis catus* populations can potentially have a negative ecological impact on wildlife communities in VICK. Predation can play and important role in bird and small mammal population fluctuations (Woods et al. 2003). *Lepczyk et al. (2003)* found that on average, a single cat predated between 0.7 and 1.4 birds/ week. The Mississippi fly way passes through VICK and over 185 species have been documented (*Cooper et al. 2004*). Species of high conservation priority, such as the white-eyed vireo, worm-eating warbler, hooded warbler, Swainson's warbler, and Kentucky warbler may be at risk if cat populations continue to grow unchecked. In Sweden, cat predation corresponded to 4% of annual production of wild rabbits (*Oryctolagus cuniculus*) and approximately 20% of annual production of field voles (*Microtus agrestis*) and wood mice (*Apodemus silvaticus*) (*Liberg 1984*). The abundant *Canis lupus* population at VICK may require some type of management control due to the possible threat to humans and surrounding wildlife. This species are known reservoirs for rabies, canine distemper, and parvovirus (*Butler et al. 2003*); transmittable to humans and/or wildlife living in close proximity. Lethal control measures for domestic cat and dog populations may not be understood and tolerated by the general public (*Ash and Adams 2003*). Alternate population control methods such as trap-test-vaccinate-alter-return (TTVAR) may be more acceptable to stakeholders (*Ash and Adams 2003*). Public education and leash law enforcement may help to keep domestic pet populations in check (*Feldman 1974*).

Odocoileus virginianus has adapted quite well to VICK's semi-urban environment. Expanding urban sprawl have created excellent deer habitat with an abundance of food and protection from hunters and nonhuman predators (*DeNicola et al. 2000*). *O. virginianus* impact on natural ecosystems due to overbrowsing reduces plant cover and diversity and deer can degrade forests where persistent browsing can lead to climax species of plants replaced by midlevel and introduced species (*Stromayer and Warren 1997, Waller et al. 1997*, *DeNicola et al. 2000, Cote 2004*). Overabundant populations may also contribute to the transmission of several animal and human diseases, such as Lyme disease and bovine tuberculosis (*Cote 2004,* *Schmitt et al. 1997, DeNicola et al. 2000*) and significant economic losses associated with crop reduction and vehicle collisions (*DeNicola et al. 2000*). Browse lines were evident in some forested habitats and evaluation of current densities may be needed to develop appropriate management strategies if populations continue to increase to the point of requiring nuisance control.

Human-wildlife problems are socially defined and vary among different groups (*Decker and Gavin 1987*). An animal is considered a nuisance when its population grows beyond cultural carrying capacity (*Carpenter 2000*). The merging of human ecology and wildlife ecology with the conservation of natural resources is critical to conservation success in human-dominated landscapes. Understanding public attitudes and perceptions, promoting wildlife education, and initiating sensible methods of control when necessary is key (*DeStefano and DeGraaf 2003*).

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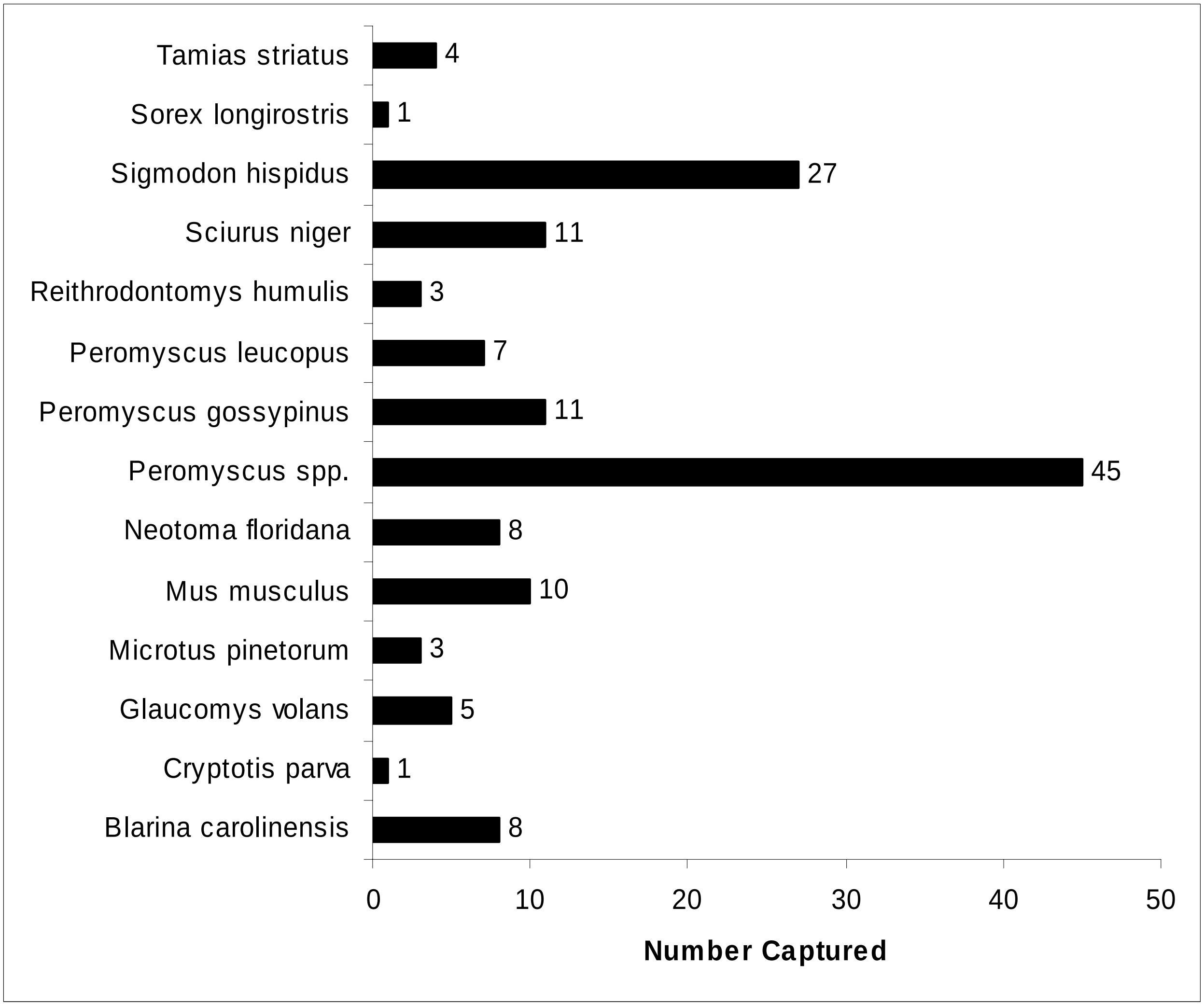

Figure 2.2. Number of small mammals captured at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

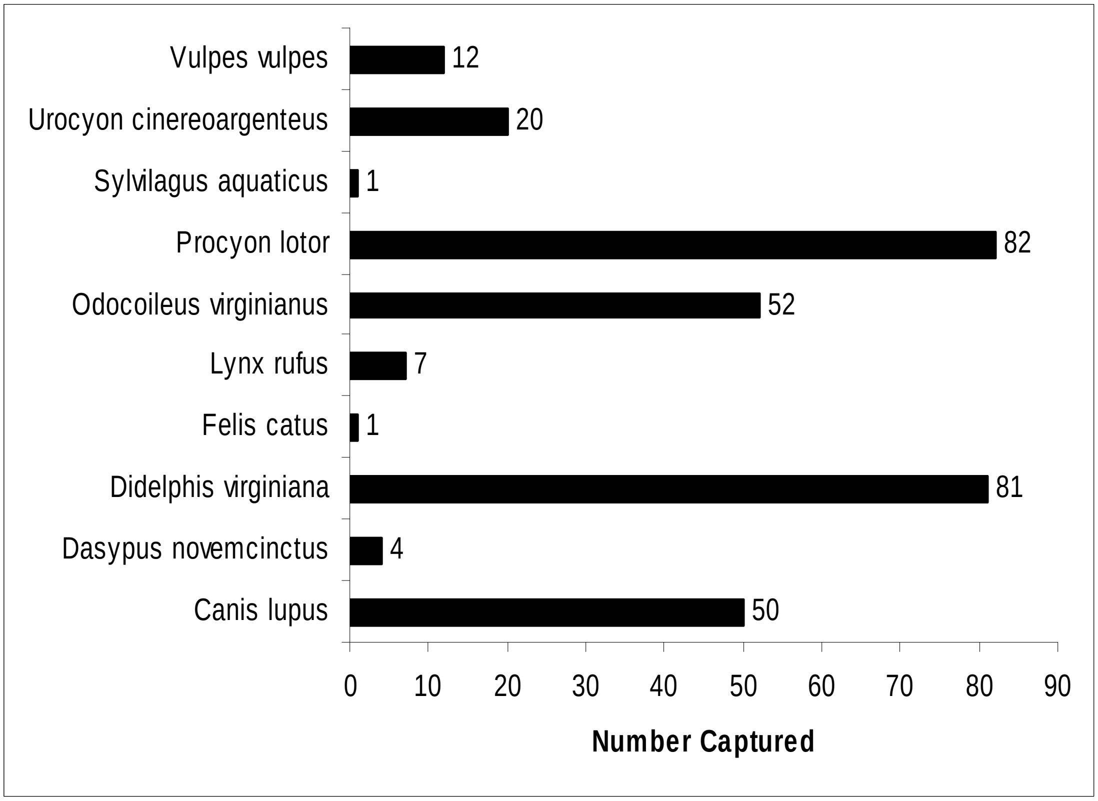

Figure 2.3. Number of meso and large mammals captured at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

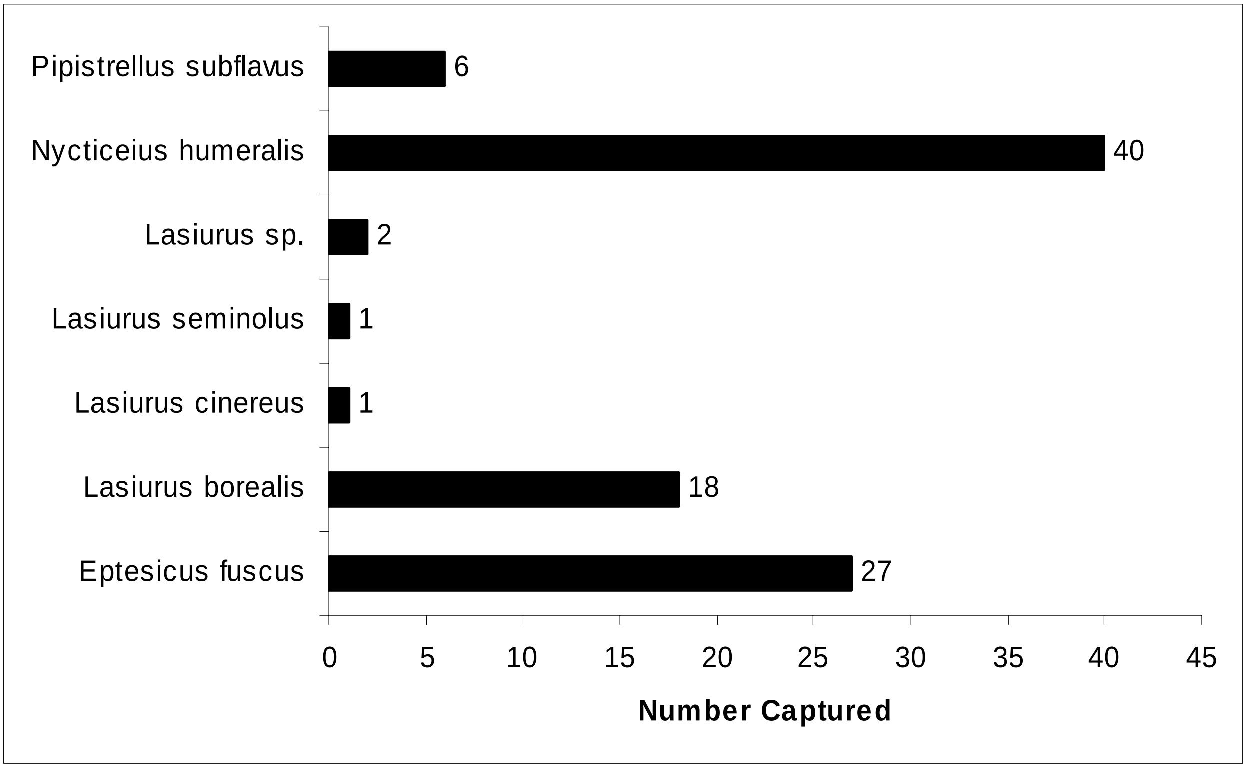

Figure 2.4. Number of bats captured at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

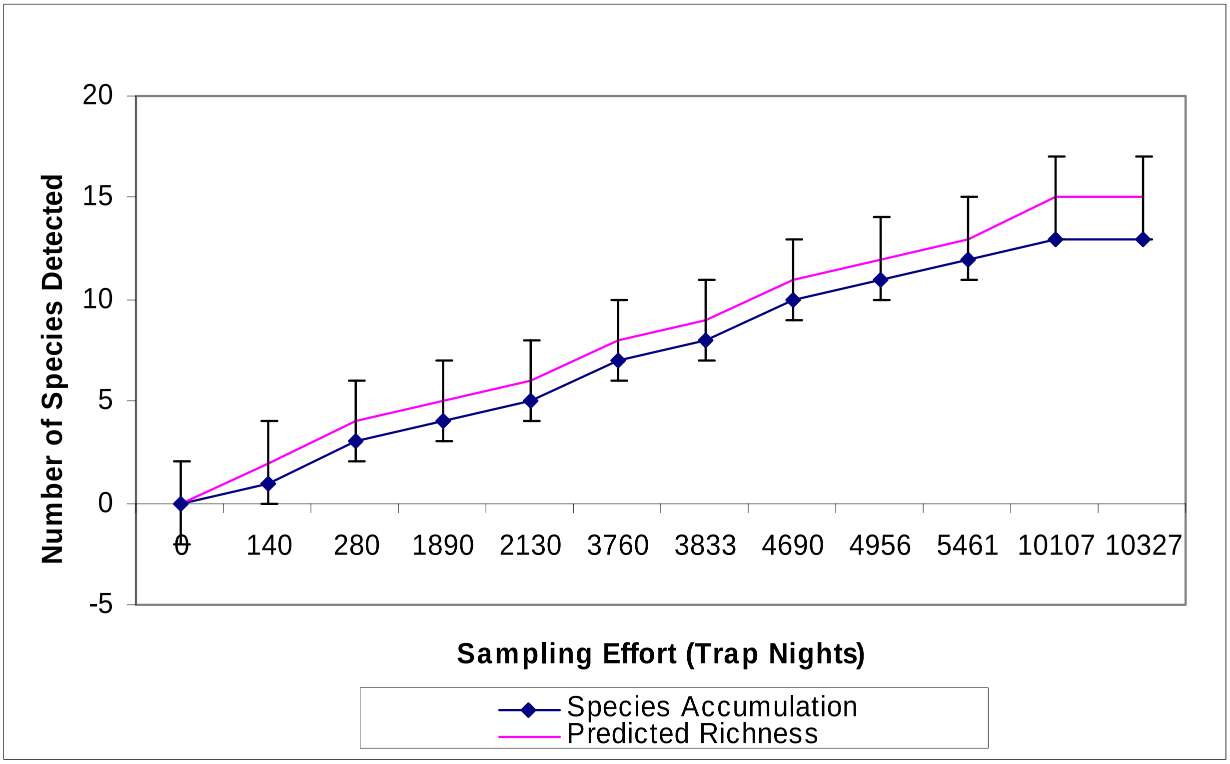

Figure 2.5. Cumulative species richness for small mammals at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

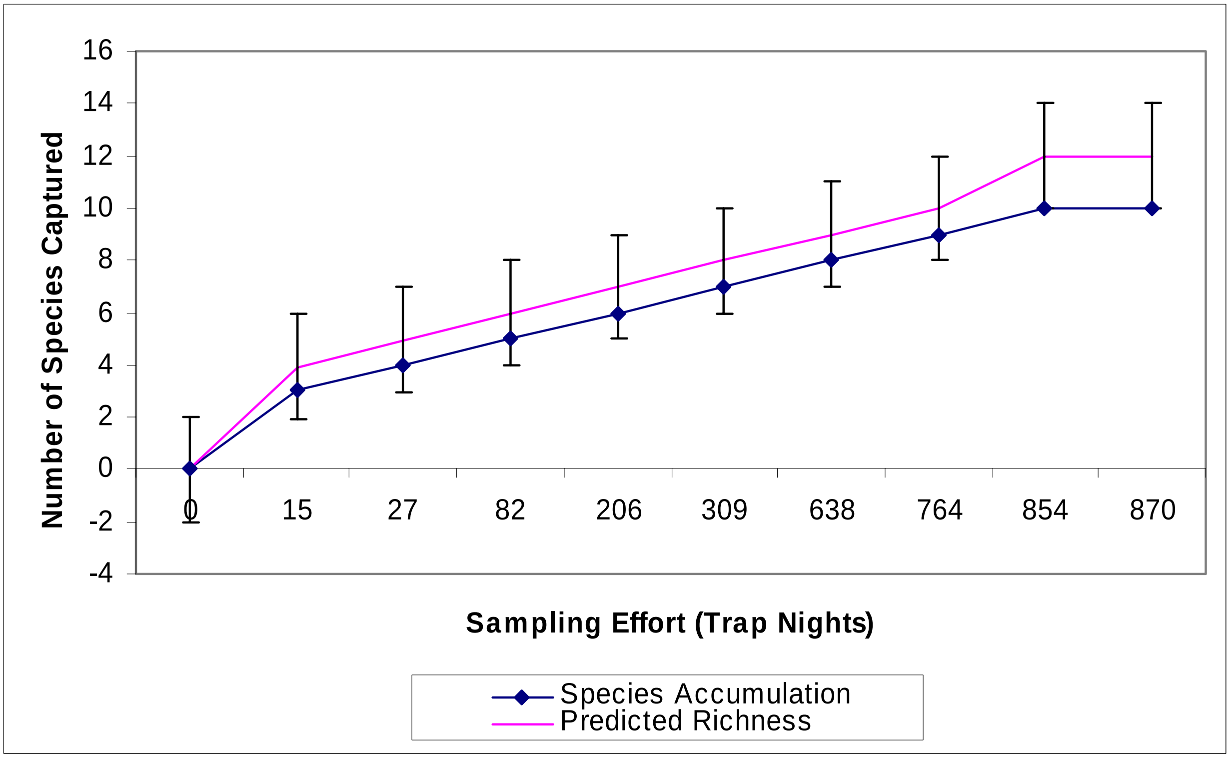

Figure 2.6. Cumulative species richness for meso and large mammals at Vicksburg National Military Park, Vicksburg, MS in 2005.

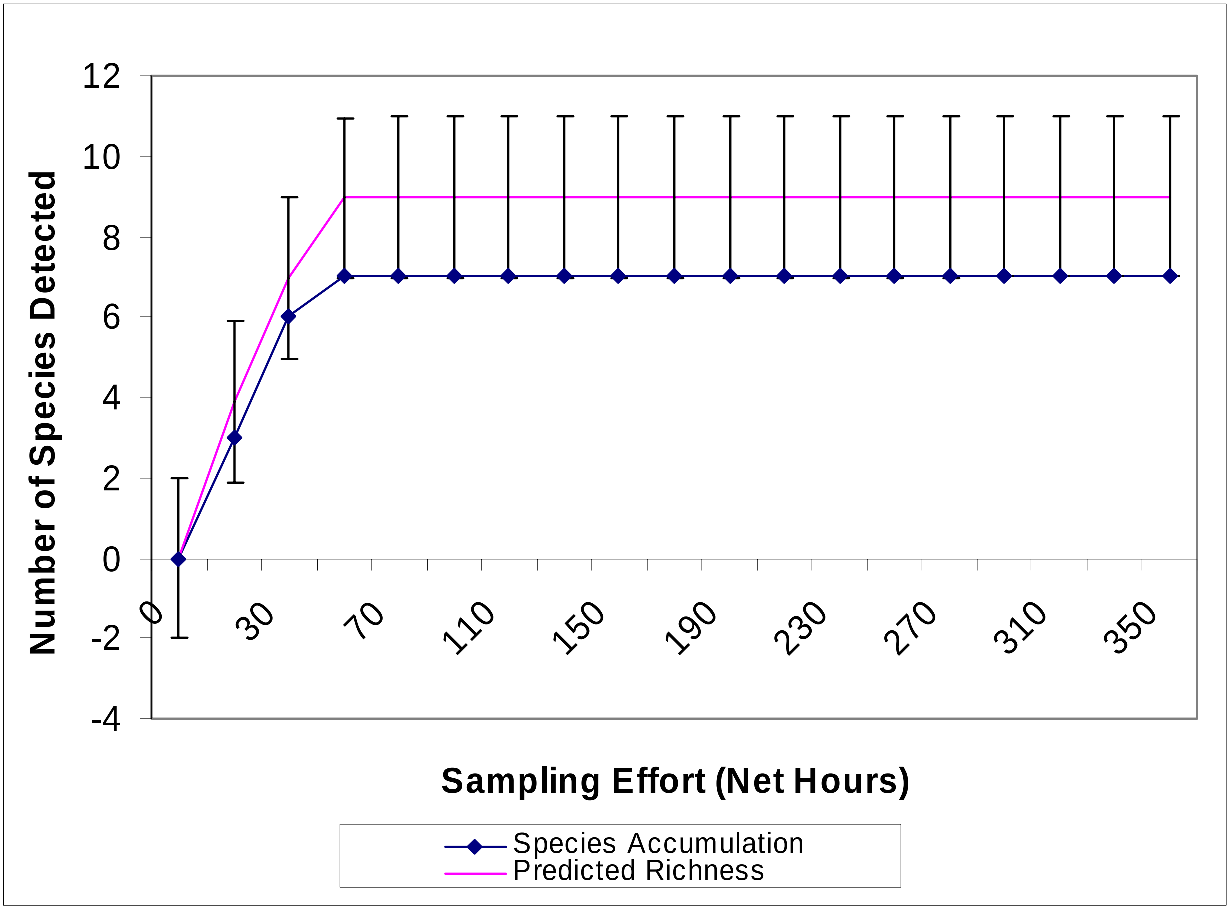

Figure 2.7. Cumulative species richness for bats at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Table 2.1. Number of locations sampled for each trapping method used to capture small mammals, meso and large mammals, and bats in Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Trapping Method	Number of locations
Small mammal transect	23
Tomahawk trap (Small)	85
Tomahawk trap (Large)	39
Remote Camera	75
Foothold trap	14
Mist net	17
Total	253

Table 2.2. Taxonomic checklist of mammal species documented in Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

ORDER DIDELPHIMORPIA

Family Didelphidae

Didelphis virginiana, Virginia Opossum

ORDER SORICOMORPHA

Family Soricidae

Sorex longirostris, Southeastern Shrew

Blarina carolinensis, Southern Short-tailed Shrew

Cryptotis parva, North American Least Shrew

Family Talpidae

Scalopus aquaticus, Eastern Mole

ORDER CHIROPTERA

Family Vespertilionidae

Lasiurus borealis, Eastern Red Bat

Lasiurus cinereus, Hoary Bat

Lasiurus seminolus, Seminole Bat

Pipistrellus subflavus, Eastern Pipistrelle

Eptesicus fuscus, Big Brown Bat

Nycticeius humeralis, Evening Bat

Family Molossidae

Tadarida brasiliensis, Brazilian Free-tailed Bat

Table 2.2. Continued.

ORDER CINGULATA

Family Dasypodidae

Dasypus novemcinctus, Nine-banded Armadillo

ORDER LAGOMOROPHA

Family Leporidae

Sylvilagus aquaticus, Swamp Rabbit

Sylvilagus floridanus, Eastern Cottontail

ORDER RODENTIA

Family Sciuridae

Tamias striatus, Eastern Chipmunk

Sciurus niger, Eastern Fox Squirrel

Glaucomys volans, Southern Flying Squirrel

Family Castoridae

Castor canadensis, American Beaver

Family Muridae

Reithrodontomys humulis, Eastern Harvest Mouse

Peromyscus gossypinus, Cotton Deer Mouse

Peromyscus leucopus, White-footed Deer Mouse

Sigmodon hispidus, Hispid Cotton Rat

Neotoma floridana, Eastern Woodrat

Mus musculus, House Mouse*

Microtus pinetorum, Woodland Vole

Table 2.2. Continued.

Family Myocastoridae
Myocastor coypus, Coypu*
ORDER CARNIVORA
Family Canidae
Canis lupus, Domestic Dog*
Canis latrans, Coyote
Vulpes vulpes, Red Fox
Urocyon cinereoargenteus, Gray Fox
Family Procyonidae
Procyon lotor, Raccoon
Family Mustelidae
Mustela frenata, Long-tailed Weasel
Family Mephitidae
Mephitis mephitis, Striped Skunk
Family Felidae
Felis catus, Domestic Cat*
Lynx rufus, Bobcat
ORDER ARTIODACTYLA
Family Cervidae
Odocoileus virginianus, White-tailed Deer

* non-native species

Table 2.3. Trapping effort (Trap Nights) used to sample small mammals at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

	Habitat					
Capture method	Grassland	Upland	Edge	Riparian	Urban	Total
Pitfall trap	398	258	438	226	0	1,320
Sherman live trap (Ground)	520	656	920	1100	0	3,196
Sherman live trap (Tree)	0	540	540	524	0	1,604
Victor snap trap (Rat)	40	20	20	0	0	80
Victor snap trap (Mouse)	400	656	980	1100	0	3,136
Tomahawk trap (Small)	38	43	38	229	0	348
Remote camera*	600	936	5,208	8,304	1,344	16,392

* Reported as camera hours

Table 2.4. Trapping effort (Trap Nights) used to sample meso and large mammals at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

	Habitat						
Capture method	Grassland	Upland	Edge	Riparian	Road	Urban	Total
Tomahawk trap (Small)	38	43	38	229	0	0	348
Tomahawk trap (Ground)	3	5	18	103	14	26	169
Foothold trap	0	0	0	6	12	0	18
Remote camera*	600	936	5,208	8,304	0	1,344	16,392

* Reported as camera hours

Table 2.5. Capture success (# captured/100 trap nights) by habitat type for small mammals, meso and large mammals, and bats captured at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

	Habitat							
Faunal Group	Riparian	Grassland	Upland	Edge	Urban	Road	Forest Corridor	Total
Small Mammals*	2.34	0.67	1.18	1.71	-	-	-	1.91
Meso and Large Mammals*	42.4	4.55	24.14	16.85	25.61	30.77	-	30.04
Bats*	32.6	-	-	-	-	20.39	22.06	26.99

* Dashes indicate that sampling did not occur for habitat listed

Table 2.6. Capture success (# captured/100 trap nights) for trap types used to sample small mammals and meso and large mammals at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

	Trap Types							
Faunal Group	Pitfall	Victor Snap	Sherman (Ground)	Sherman (Tree)	Camera	Tomahawk (Small)	Tomahawk (Large)	Foothold
Small Mammals*	0.46	2.12	2.31	0.32	1.9	3.9	-	-
Meso and Large Mammals*	-	-	-	-	38.9	7.8	16	38.9

* Dashes indicate that sampling did not occur for trap type listed

Table 2.7. Trap disturbance (# tripped traps/total traps) for small mammal trap types at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

	Trap Type			
Habitat	Sherman live trap (Ground)	Sherman live trap (Tree)	Victor snap trap	Tomahawk trap (Small)
Riparian	0.28	0.08	0.67	0.52
Edge	0.23	0.09	0.54	0.5
Upland	0.32	0.06	0.62	0.66
Grassland*	0.06	-	0.26	0.03
Total	0.24	0.08	0.56	0.44

* Dashes indicate that sampling did not occur for trap type listed

Table 2.8. Capture success (# captured/100 trap nights) by habitat type for bats using mist nets at Vicksburg National Military Park, Vicksburg, MS, USA in 2005. Number of captured individuals in parentheses.

	Habitat Type			
Species	Riparian	Forest Corridor	Road	Total
Eptesicus fuscus	0.6 (1)	14.7 (10)	15.5 (16)	7.7 (27)
Lasiurus borealis	8.3 (15)	1.5 (1)	1.9 (2)	5.1 (18)
Lasiurus cinereus	0.6 (1)	0	0	0.3 (1)
Lasiurus seminolus	0	1.5 (1)	0	0.3 (1)
Lasiurus sp.	1.1 (2)	0	0	0.6 (2)
Nycticeius humeralis	19.3 (35)	2.9 (2)	2.9 (3)	11.4 (40)
Pipistrellus subflavus	2.8 (5)	1.5 (1)	0	1.7 (6)
Number Captured	59	15	21	95
Trap Nights	181	68	103	352
Capture Success	32.6	22.1	20.4	26.4

Table 2.9. Summary of mammals documented at Vicksburg National Military Park, Vicksburg, MS, USA in 2005. Abundance category estimates were based on the following scale: rare = 1-5, uncommon = 6-10, fairly common = 11-20, common = 21-50, abundant = 51+.

Scientific Name	# Captured	# Observed	Abundance Category
Didelphis virginiana	81	11	Abundant
Sorex longirostris	1	0	Rare
Blarina carolinensis	8	6	Fairly Common
Cryptotis parva	1	0	Rare
*Scalopus aquaticus**	0	7	Common
Lasiurus borealis	18	0	Fairly Common
Lasiurus cinereus	1	0	Rare
Lasiurus seminolus	1	0	Rare
Pipistrellus subflavus	6	0	Uncommon
Eptesicus fuscus	27	176	Abundant
Nycticeius humeralis	40	0	Common
Tadarida brasiliensis	0	3	Rare
Dasypus novemcinctus	4	10	Fairly Common
*Sylvilagus aquaticus**	0	0	Uncommon
*Sylvilagus floridanus**	0	7	Fairly Common
Tamias striatus	5	21	Common
*Sciurus niger**	11	29	Abundant
*Glaucomys volans**	5	1	Common
Castor canadensis	0	3	Rare

Table 2.9. Continued.

Reithrodontomys humilis	3	0	Rare
Peromyscus gossypinus	11	0	Fairly Common
*Peromyscus leucopus**	7	0	Fairly Common
Sigmodon hispidus	27	1	Common
Neotoma floridana	8	0	Uncommon
Mus musculus	10	1	Fairly Common
Microtus pinetorum	3	1	Rare
Myocastor coypus	0	1	Rare
Canis lupus	50	13	Abundant
Canis latrans	0	3	Rare
Vulpes vulpes	12	8	Fairly Common
Urocyon cinereoargenteus	20	1	Common
Procyon lotor	82	9	Abundant
Mustela frenata	0	1	Rare
Mephitis mephitis	0	2	Rare
Felis catus	1	31	Common
Lynx rufus	7	3	Uncommon
Odocoileus virginianus	52	110	Abundant

*****Additional visual and sign observations indicate that abundance estimates may be higher than what the number of captures and recorded observations would indicate.

CHAPTER 3

HABITAT ASSOCIATIONS FOR SMALL MAMMAL COMMUNITIES IN A FRAGMENTED LANDSCAPE IN WESTERN MISSISSIPPI

[1]Linehan, J.M. and M.T. Mengak. 2007. *Submitted to the Southeastern Naturalist*

Abstract: Urban parks face unique challenges regarding preservation of their natural resources. Vicksburg National Military Park (VICK) in Vicksburg, Mississippi is no exception. Management decisions concerning urban wildlife are vital in order to maintain natural levels of biodiversity. To that end, a clear understanding of small mammal community dynamics and habitat selection criteria are necessary. I investigated the effects of both habitat and seasonal covariates on detection probabilities, site occupancy and species richness of small mammal species in western Mississippi. I sampled small mammals at 23 sites in riparian, grassland, upland hardwood, and edge habitats during two sampling seasons. Seasonal variation and the level of habitat modification best predicted *Peromyscus* spp. occupancy. *Sigmodon hispidus* occupancy estimates were best explained by seasonal variation and habitat type. Species richness was highest on sites that have a large percentage of vegetative ground cover and sampled during the summer/fall season. Conservation of important macrohabitats within VICK and promotion of microhabitat characteristics important to small mammals, such as ground cover vegetation would provide suitable habitat for a diverse group of small mammals.

Key words: detection, fragmentation, macrohabitat, microhabitat, Mississippi, occupancy, *Peromyscus* spp., *Sigmodon hispidus,* species richness, small mammals, urban park

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INTRODUCTION

Fragmentation and urbanization continue to threaten biodiversity. Small urban parks are frequently assumed to be unsuitable for maintaining high levels of biodiversity due to possible exclusion of species that have large home range requirements, areas that contain small populations, and an abundance of generalist species (Dickman 1987). Dickman (1987) found that mammal species richness decreased when vegetation structure became more fragmented. Species that require interior forest habitats and wetland-associated fauna are particularly vulnerable to changing land use patterns and habitat fragmentation (Sharitz et al. 1992, Bellows et al. 2001). However, smaller species may thrive if distances between habitat patches allow for interbreeding and colonization. As encroachment and habitat loss continue, management decisions that concern urban/suburban mammal species will become increasingly important in maintaining natural levels of biodiversity at acceptable population densities.

Small mammal species are an important component of functional ecosystems. They serve as prey for reptilian, avian and mammalian predators and can influence the distribution and abundance of such predators (Carey and Johnson 1995). They are vital seed and fungal disseminators and may consume large amounts of invertebrates, including insects that may be detrimental to forests (Carey and Johnson 1995, Coppeto et al. 2006). Slade and Crain (2006) found that regular disturbances, such as mowing were potentially disruptive to mammalian communities. Both *Sigmodon hispidus* and *Microtus ochrogaster* showed decreases in abundance in prairie habitats that were mowed; these negative impacts continued for 4-5 months as vegetation recovered. Adams (1984) reported that small mammal density in mowed median strips was one-half the density of unmowed herbaceous median strips. This reduction in small mammal density may be attributed to a decrease in food availability and loss of cover, which could make animals more susceptible to predation (Edge et al. 1995, Taitt and Krebs 1983).

Small mammals seem to respond strongly to anthropogenic changes and exhibit species-specific responses depending on their habitat needs (Sauvajot et al. 1998). Therefore, information regarding how small mammal species select habitats is important to predict changes in community composition that may follow habitat alterations. By understanding small mammal community dynamics, managers can have some insight into overall ecosystem function. Therefore, my objectives were to describe habitat associations for small mammal species in regards to dominant habitat types within a fragmented, urban park landscape and to examine impacts of habitat modification and season on occupancy and distribution of small mammal species and community richness. I tested the hypothesis that small mammal species occupancy and diversity differed among a variety of macrohabitat types. I also examined microhabitat covariates to evaluate their relative importance to occurrence and detectability of small mammal species.

STUDY AREA

Vicksburg National Military Park, located in Warren County, Mississippi and Madison Parish, Louisiana, was established in 1899 to commemorate the Battle of Vicksburg during the American Civil War and consists of approximately 728 ha, including four satellite locations in the city of Vicksburg, Mississippi (Louisiana Circle, Navy Circle, South Fort, Pemberton's Headquarters) and one in Delta, Louisiana (Grant's Canal). Each satellite location was fewer than 0.40 ha. Therefore, I conducted a majority of sampling in the main portion of VICK located in northeastern Vicksburg, adjacent to Clay Street.

Vicksburg National Military Park was within the East Gulf Coastal Plain. The climate was described as subtropical (Stewart 2003). Mean annual temperatures ranged from 12º C to 25.2º C. Mean annual precipitation was 147.1 cm (NOAA 2006). The Warren County portion of the park was located in the Blufflands; a 16 to 40 km wide belt of steep hills bordering the Mississippi alluvial valley (Walker 1997). These escarpments were comprised of wind deposited loess sediment that can be highly susceptible to erosion (Krinitzsky and Turnball 1967). Forested sections in VICK resulted from plantings by the Civilian Conservation Corp (CCC) during the 1930s to prevent erosion. This mixed mesophytic forest was dominated by southern red oak (*Quercus falcata*) and white oak (*Q. alba*) with southern sugar maple (*Acer barbatum*), basswood (*Tilia americana*), black oak (*Q. velutina*), and northern red oak (*Q. rubra*) comprising a large portion of the overstory. Understory vegetation consisted mainly of American hornbeam (*Carpinus caroliniana*), dogwood (*Cornus florida*), redbud (*Cercis canadensis*), pawpaw (*Asimina triloba*), and sassafrass (*Sassafras albidum*) (Walker 1997). Two main streams, Mint Springs and Glass Bayou, flowed through VICK and drained into the Yazoo River Diversion Canal, which then emptied into the Mississippi River. The park owned an approximately 0.8 km stretch of land located adjacent to the Yazoo River, which was subject to periodic flooding.

The main section of VICK was crescent shaped, fragmented by a 26-km tour road (Figure 1) and completely surrounded by the city of Vicksburg with residential houses and businesses abundant along park boundaries. Habitat alteration was widespread throughout the study area. Human-altered habitat patches occurred across open areas, and roads and trails fragmented most of the landscape. Vicksburg National Military Park's 324 ha of grasslands required a regular mowing regime to preserve this urban park's battlefield conditions.

METHODS

Small mammal sampling

I conducted trapping during two separate periods in 2005, (January – April and July – November) at 23 sites (9,684 trap nights). I sampled 13 of the 23 sites during both trapping periods. At each site, I surveyed small mammals using line transects consisting of Sherman live traps (Forestry Suppliers, Jackson, MS), Victor® snap traps (Victor, Lilitz, PA), and pitfall traps in a stratified design for four habitat types (riparian, upland, and edge). Transects consisted of at least 30 trap stations placed 10m apart in an approximate linear manner. Traps were set for four consecutive nights and baited with a mixture of peanut butter and oats. For most, transects, each station consisted of a Sherman live trap and a Victor® snap set approximately 0.3m apart. Five pitfall traps were placed at every fifth station using deli cups (8 cm in depth and upper diameter). In addition, one pitfall trap array with drift fence arranged in a "T" configuration was placed in each representative habitat. Drift fences consisted of silt fencing 61 cm high, 100 m long and supported by wooden stakes. I installed 14 pitfall traps per drift fence using 2 # 10 coffee cans taped together. Logistic constraints prevented replication of arrays. I assessed gender, weight (g), total length (mm), tail length (mm), hind foot length (mm), ear length (mm), and reproductive condition (pregnant, lactating, scrotal). *Peromyscus* spp. were grouped together because positive identification could not be made for all individuals captured. To assess *Glaucomys volans* occurrence, I used Sherman live traps mounted 2m high and position vertically on trees (S. loeb, Clemson University, pers comm., 15 May 2005) in bottomland hardwood forest, upland hardwood forest, and upland or bottomland hardwood edge habitats. I used Tomahawk traps (# 102, 40.6 x 12.7 x 12.7 cm, Tomahawk, WI) to opportunistically target *Tamias striatus*, *Neotoma floridana*, and *Sciurus niger*.

Habitat Associations

I conducted macrohabitat sampling for bottomland, upland, and edge habitats during July-August 2005. I quantified overstory and understory vegetation using the point-centered quarter method at every other station along trapping transects where the starting point station was randomly selected (Cottam and Curtis 1956). Each sample point represented the center of four compass directions (N, S, E, W) and divided the sampling area into four quadrants (NE, NW, SE, SW) (Cottam and Curtis 1956). Data I recorded for both overstory and understory trees included diameter breast height (DBH;cm) of the closest tree, species identification, and distance to closest tree for all four quadrants (Table 3.1). I used these data to calculate density (trees/ha), basal area (m^2/ha) and species richness for overstory and understory trees (Table 3.1). I sampled microhabitat components during September 2005 for bottomland, upland, edge, and grassland habitats. I estimated tree canopy cover at every sample site for all four quadrants using a densitometer (Forestry Suppliers, Jackson, Mississippi) and visually estimated ground cover percentages for total ground cover, vegetation cover, litter cover, and down woody debris (Table 3.1). I recorded measurements within a 1 m- radius circular plot centered on each trapping station. I examined habitat modification for grassland habitats and gave each sampled grassland site a ranking of 0, 1, 2, or 3, which represented the level of disturbance that occurred as a result of park landscaping and maintenance (Table 3.2).

Data Analysis

I calculated a Pearson's Product Moment Correlation Coefficient matrix to test whether relationships existed between explanatory habitat variables (PROC CORR; SAS Institute). I assumed that pairs of variables with $r > |0.7|$ were highly correlated and inclusion would result in an unacceptable level of multicollinearity (Pavlacky and Anderson 2007). Significant correlations ($p \leq 0.05$) between variables resulted in the exclusion of parameters from further analysis.

Using the method described by Mackenzie et al. (2002), I estimated detection probability (p) and occupancy (Ψ) at the species and community levels. This method is a likelihood-based approach for describing the proportion of sites occupied when species detection probabilities are <1 and allows for missing observations. This approach has the following possible outcomes regarding whether a species is detected: 1) site was occupied and the species was detected, 2) site was occupied and the species was not detected, or 3) site was unoccupied. The following assumptions are required: 1) occupancy state at each site is constant within survey seasons, 2) probability of occupancy does not change across sites, or covariates are included to account for differences, and 3) probabilities of species detection between sites are independent (Mackenzie et al. 2006). This method allows for the inclusion of habitat data allowing the probability of detecting species to be modeled as a function of site-specific covariates (Mackenzie et al. 2002).

The program PRESENCE (Proteus Research and Consulting Ltd., Dunedin, New Zealand) was used to estimate p and Ψ at all 23 sites. The first set of analyses concerned the two most frequently captured mammals, *Peromyscus* spp. and *Sigmodon hispidus* as low capture rates prevented unbiased modeling for all other species captured. First, I assumed that site occupancy and detection probabilities were constant across time and sites, *Ψ (.) p (.)*. I used this model as a basis of comparison with the naïve estimate of species detection (# species detected/site). However, it is not the best representation of data collected but was necessary to compare relative importance of the four habitat types sampled without incurring biases due to model parameter estimates. Importance of covariates on p and Ψ were modeled using the logit function of season and/or habitat characteristics (habitat type, habitat modification, and ground cover component). I tested importance of each covariate separately with the following combinations: 1) occupancy probability was held constant across all sites, *Ψ(.)* and detection probability varied according to habitat covariates, *p(Habcov)* or season, *p (Season)*, 2) detection probability was held constant across all sites, *p(.)* and occupancy probability varied according to habitat characteristics, *Ψ(Habcov)* or season, *Ψ(Season)*, 3) the interaction between the habitat covariates and season was investigated with occupancy probability and detection probability each held constant, *Ψ(.) p(HabcovxSeason)*, *Ψ(HabcovxSeason) p(.)*. I constructed a set of 21 candidate models for *Peromyscus* spp. and *Sigmodon hispidus* based upon parameters that were most likely to be important. Each model was ranked according to Akaike's Information Criterion (AIC) adjusted for small sample sizes (AICc) (Akaike 1973, Burnham and Anderson 2002). The second set of analyses included all species detected to estimate relative community richness (Mackenzie 2006). The combinations used to test each covariate were the same as in the previous analysis. Thirteen candidate models were constructed based upon the most influential parameters. Each model was ranked using AIC values.

RESULTS

I captured 130 small mammals comprising 11 species at 23 locations. Capture success was estimated at 1.91 captured/100 trap nights corrected for sprung traps (Nelson and Clark 1973). This correction is necessary to improve accuracy of this estimate due to the high level of trap disturbance for Sherman live traps (ground), Sherman live traps (tree), Victor® snap traps, and small size Tomahawk traps (24%, 8%, 56%, 44%, respectively) (Table 3.3).

Significant correlations existed ($p \leq 0.05$) between macrohabitat variables resulting in their exclusion. The covariates included in further analyses included habitat type, ground cover, litter cover, down woody debris and habitat modification.

Single species analysis

When applying the model where site occupancy and detection probabilities were constant, I found that detection probability, $p(.)$ across habitat types were similar (Table 3.4) for *Peromyscus* spp. Site occupancy, $\hat{\psi}(.)$ varied among habitat types with riparian and edge sites having the largest occupancy estimates ($\hat{\psi}(.)$ = 1.0, SE = 0; $\hat{\psi}(.)$ =0.77, SE = 0.22, respectively) (Table 3.4). Detection probability and occupancy estimates could not be compared across habitat types for *Sigmodon hispidus* as this species was detected only in grassland habitats.

Peromyscus spp. occupancy was best explained by a season and habitat modification interaction model (w_i = 0.81), with *Peromyscus* spp. occupancy greater in the summer/fall season and less in grassland habitats that had landscaping maintenance. However, the next model describing a seasonal effect was < 3 Δ AICc units from the best model indicating a reasonable level of support (Burnham and Anderson 2002) (Table 3.5).

The best approximating model regarding *Sigmodon hispidus* occupancy was a season and grassland interaction where this species is more likely to occupy grassland habitats during the summer/fall season (w_i = 0.67). The season and vegetation cover interaction model was < 2 Δ AICc units from the best approximating model indicating substantial empirical support (Burnham and Anderson 2002). Sites with a large percentage of cover during the summer/fall season have a likely chance of *S. hispidus* occupancy (w_i = 0.33) (Table 3.5).

Community-level analysis

Species richness analysis included the following 11 species: *Blarina carolinensis, Cryptotis parva, Sorex longirostris, Peromyscus* spp.*, Reithrodontomys humulis, Mus musculus, Sigmodon hispidus, Microtus pinetorum, Neotoma floridana, Glaucomys volans*, and *Sciurus niger*. The season and vegetation cover interaction model was most likely to produce the greatest community richness estimates where more species were likely to occupy areas with a larger percent of herbaceous and woody vegetation during the summer/fall season (w_i = 0.88) (Table 3.6). The season and riparian interaction model indicates reasonable support (< 4 Δ AICc units) for occupancy in riparian habitats during the summer/fall months (w_i = 0.12).

DISCUSSION

Peromyscus spp. were ubiquitous in all habitat types sampled. However, riparian habitats had the greatest occupancy estimates, which is consistent with other studies (Doyle 1990, McComb 1993). Factors that account for this preference may include greater availability of forage, such as fruits, herbs, and deciduous shrubs and mast. Riparian habitats typically are characterized by a structurally diverse landscape with a greater abundance and diversity of plants species related to a site's size, aspect, soil moisture, amount of woody debris, and time since disturbance (O'Connell et al. 1993, Hannon et al. 2002). However, some studies have shown no differences in species abundances, diversity, or richness estimates between riparian and upland habitats (Bellows and Mitchell 2000, Osbourne et al. 2005). These authors suggested that a lack of difference in vegetative structure between the two habitat types was the reason for similarities. In my study, vegetation cover percentages were an important predictor of community richness. Riparian habitats had greater percentages of vegetative cover and a denser understory in comparison with upland habitats, which may explain riparian habitat preference for *Peromyscus* spp.

Peromyscus spp. occupancy was best predicted by grassland habitat modification with seasonal variation. Previous studies have reported similar results where decreases in small mammal species abundance and diversity were attributed to periodic mowing practices (Wilkins et al. 1980, Adams 1984, VanDruff and Rowse 1986, Slade and Crain 2006). Wilkins et al. (1980) found that rodent densities and richness were directly related to plant diversity and amount of plant cover that comprised each habitat. Slade and Crain (2006) found that *Sigmodon hispidus* abundance was reduced in mowed strips whereas *Peromyscus leucopus* densities did not change significantly. The authors detected *P. leucopus* most often along hedgerows throughout their study. Unmowed strips 2-3 m wide were left adjacent to hedgerows, which may explain the lack of a response. My study area consisted of grassland habitats mowed entirely without retention of unmowed buffers to provide refugia for movement or dispersal.

Peromyscus spp. were captured most often during the summer/fall season. Sampling during breeding season may have resulted in greater capture success. Wolff (1985) found *Peromyscus* spp. reproductive season in Virginia extended from late March or April through late October or early November, with a bimodal peak in activity in April-June and September-October. Seasonal fluctuations of small mammal populations may also be explained by intra- and inter- specific competition, weather and food availability (Smith et al. 1974, Wolf 1985, Merritt et al. 2001).

Sigmodon hispidus occupancy was best explained by grassland habitats with seasonal variation. Grass-dominated fields are the preferred habitat of this species (Odum 1955, Cameron 1977, Adams 1984, Whitaker and Hamilton 1998, Slade and Crain 2006). The summer/fall season was when capture success for this species was at its highest. The summer growing season may provide more vegetative cover at sites that were left unmowed. *Sigmodon hispidus* can be prolific wherever adequate cover, such as hedgerows, fields, overgrown grass, and thickets, is available (Cothran et al. 1991). Previous studies (Odum 1955, Cameron 1977) have shown that maximum densities occurred during fall which may also explain the temporal variation observed.

Community richness and diversity were greatest at sites with large percentages of vegetative cover during the summer/fall season. Dickman (1987) also reported that mammalian species richness increased with increasing density of vegetation per patch. Bellows et al. (2001) did not find significant differences in small mammal abundances among macrohabitat types based on captures/unit effort. He found 27% of the variation in small mammal distributions was attributed to microhabitat characteristics. Not surprising is that other studies have shown that species richness and diversity were lowest in sites containing manicured habitats and surrounded by human altered habitat (Dickman and Doncaster 1987, Sauvajot et al. 1998, Mahan and

O'Connell 2005). Bock et al. (2002) reported that proximity to suburban edges had strongly negative effects on abundances of native grassland rodents possibly due to low habitat quality and high predator abundances.

Understanding the role of small mammals in an ecosystem and conserving the composition and function of that system will benefit many other species. Small mammals serve critical functions by dispersing seeds, controlling insect populations, serving as a prey base, and providing hibernacula for many other mammals, insects, and herpetafauna (Nagorsen 1996). Conservation of important macrohabitats (grassland, riparian) and promoting microhabitat characteristics such as ground cover vegetation would provide suitable habitat for a diverse group of small mammals. Grassland sites maintained by periodic mowing should retain a variety of species of small mammals if narrow strips are mowed early in the growing season (Slade and Crain 2006). A maintenance program that leaves 10- to 20- m wide buffer strips between mowed fields and woods or a program that includes rotational mowing would improve habitat for small mammals, increase their density, and likely provide a greater prey base for predators. Such a program would not only enhance wildlife values but would reduce associated mowing and maintenance costs for VICK. In general, small mammals seem to respond strongly to habitat modification and exhibit species-specific responses, which are dependent upon their habitat preferences (Sauvajot et al. 1998). Decreasing degree of habitat alteration and proper maintenance of current natural areas may promote species diversity and abundance in urban parks, such as VICK.

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Figure 3.1. Vicksburg National Military Park, Warren County, Mississippi, USA. National Park Service. United States Department of the Interior.

Table 3.1. Description of macrohabitat and microhabitat variables measured at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Habitat Variable	Description
Macrohabitat	
Overstory DBH	DBH ≥ 10.16 cm
Overstory Tree Species Richness	Number of species ≥ 10.16 cm DBH
Distance to Closest Overstory Tree	Distance to closest tree ≥ 10.16 cm DBH
Understory DBH	DBH < 10.16 cm and > 2.54 cm
Understory Tree Species Richness	Number of species < 10.16 cm and > 2.54 cm DBH
Distance to Closest Understory Tree	Distance to closest tree < 10.16 cm and > 2.54 cm DBH
Microhabitat	
Canopy Cover	% canopy cover
Ground Cover	% ground cover
Vegetation Cover	% forbs and grasses
Litter Cover	% dead leaves and pine needles
Down Woody Debris	% logs

Table 3.2. Level of landscape disturbance (mowing) rankings for small mammals in grassland habitats at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Disturbance Ranking	Level of Landscaping Disturbance
0	Undisturbed
1	Mowed once > 1+ years
2	Mowed once/year
3	Mowed < 1 year

Table 3.3. Trap disturbance (# tripped/# total traps) for small mammal traps at Vicksburg National Military Park, Vicksburg, Mississippi, USA in 2005.

	Trap Type			
Habitat	Sherman live trap (Ground)	Sherman live trap (Tree)	Victor® snap trap	Tomahawk trap (small)
Riparian	0.28	0.08	0.67	0.52
Edge	0.23	0.09	0.54	0.5
Upland	0.32	0.06	0.62	0.66
Grassland*	0.06	-	0.26	0.03
Total	0.24	0.08	0.56	0.44

* Dashes indicate that sampling did not occur for trap type listed

Table 3.4. Parameter estimates of occupancy *(Ψ)* and detectability *(p)* using model, *Ψ(.) p(Cov)* for *Peromyscus* spp. in grassland, upland, riparian, and edge habitats at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Habitat	*Ψ(min)*	*Ψ (obs)*	$\hat{\psi}$ *(.)*	*SE* $\hat{\psi}$ *(.)*	$\hat{p}$ *(.)*	*SE* $\hat{p}$ *(.)*
Grassland	0.72	0.09	0.35	0.2	0.48	0.19
Upland	0.72	0.17	0.7	0.25	0.35	0.1
Riparian	0.72	0.26	1	0	0.39	0.07
Edge	0.13	0.77	0.22	0.37	0.1	

Table 3.5. AICc values for competing *Ψ(.) p(Cov)* models for *Peromyscus* spp. and *Sigmodon hispidus* from 23 sites at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Model, by Species	ΔAICc	w_i	$\hat{p}$	$\hat{\psi}$	$SE(\hat{\psi})$
Peromyscus spp.					
Ψ(.) p(season x habmod)	0	0.81	0.28	0.85	0.11
Ψ(.) p(season)	2.89	0.19	0.50	0.72	0.11
Ψ(.) p(.)	12.39	0.002	0.37	0.72	0.11
Sigmodon hispidus					
Ψ(.) p(season x grassland)	0	0.67	0.98	0.76	0.22
Ψ(.) p(season x vegcover)	1.45	0.33	0.99	0.75	0.23
Ψ(.) p(.)	13.21	0.001	0.43	0.18	0.08

Table 3.6. AIC values for competing *Ψ(.) p(Cov)* community richness models from 23 sites at Vicksburg National Military Park, Vicksburg, MS, USA in 2005.

Multi Species Model	ΔAIC	w_i	$\hat{p}$	$\hat{\psi}$	$SE(\hat{\psi})$
Ψ(.) p(season x vegcover)	0	0.88	0.20	0.25	0.04
Ψ(.) p(season x riparian)	3.96	0.12	0.63	0.24	0.04
Ψ(.) p(.)	19.46	0.0001	0.24	0.23	0.16

CHAPTER 4

SUMMARY AND CONCLUSIONS

Inventories of federal lands have become increasingly important to establish baseline conditions for investigations aimed at documenting anthropogenic influences and other impacts responsible for environmental change. Prior to this study, the mammalian fauna at Vicksburg National Military Park (VICK) had not been investigated. My research documented 80% of the mammal species that have distributions that overlap VICK. This list includes 14 small mammal species, 16 meso and large mammal species, and seven bat species. *Procyon lotor* and *Didelphis virginiana* were captured most frequently. This is of little surprise because these two species are highly adaptable to VICK's urban landscape. Increases in mesopredator populations are a potential consequence of habitat alteration and fragmentation (Oehler and Litvaitis 1996). High population densities may have cascading effects on prey (e.g. songbirds) and may increase competitive interactions within the guild (Ginger et al. 2003).

For the nine undetected species, *Ochrotomys nuttalli*, *Oryzomys palustris*, *Reithrodontomys fulvescens*, *Ondatra zibethica*, *Rattus rattus*, *Rattus norvegicus*, *Neovison vison*, *Lontra canadensis*, *Spilogale putorius*, this inventory was inconclusive and therefore these mammals should be regarded as potential occurrences. Additional effort should focus on recording these species and providing more detailed documentation of several other species known by few specimens, including *Sorex longirostris, Cryptotis parva*, *Lasiurus cinereus, Lasiurus seminolus*, *Tadarida brasiliensis*, *Sylvilagus aquaticus*, *Reithrodontomys humulis, Castor canadensis, Myocastor coypus, Mustela frenata,* and *Mephitis mephitis.* This type of baseline information is important for managers to make long-term decisions regarding sustainability and biodiversity. These species may be rare at VICK and difficult to detect.

For small mammals to successfully exploit an urban environment, they must be able to disperse to remnant patches of natural and regenerating vegetation and they must exist in these patches long enough to reproduce (Dickman and Loncaster1989). Knowing the preferred habitat types and characteristics of small mammals will enable proper conservation. Therefore, habitat associations of the two most commonly detected small mammal species, *Peromyscus* spp. and *Sigmodon hispidus* at VICK were investigated. Species richness estimates relative to habitat type and habitat characteristics were also addressed. *Peromyscus* spp. were ubiquitous throughout the study site. However, riparian habitats and to a lesser extent edge habitats were preferred. Wilkins et al. (1980) found that rodent densities and richness were directly related to plant diversity and the amount of plant cover that comprised each habitat. Riparian and edge habitats at VICK were characterized by high levels of ground vegetation and structure which help to explain the high occurrence of *Peromyscus* spp.

Grassland habitats that were not subjected to periodic mowing maintenance and sampled during summer/fall best predicted occurrence of *Peromyscus* spp. when incorporating habitat variables. Previous studies have reported similar results where decreases in small mammal species abundance and diversity were attributed to periodic mowing practices (Wilkins et al. 1980, Adams 1984, VanDruff and Rowse 1986, Slade and Crain 2006). The summer/fall season had the highest incidence of capture. Sampling during the breeding season may explain the increase in capture success (Wolff 1985). Small mammal population seasonal fluctuations may also be explained by intra- and inter- specific competition, density, weather and food availability (Smith et al. 1974, Wolf 1985, Merritt et al. 2001).

Sigmodon hispidus occupancy was best explained by grassland habitats with seasonal variation. These results are not surprising because grass-dominated fields are the preferred habitat (Odum 1955, Cameron 1977, Adams 1984, Whitaker and Hamilton 1998, Slade and

Crain 2006). Studies have shown that maximum densities occurred during fall (Odum 1955, Cameron 1977), which may also explain the temporal variation I observed.

Species richness and diversity were greatest in sites with large percentages of vegetative cover during the summer/fall season. Mammalian species richness has been to shown to increase with greater densities of vegetation per patch (Dickman 1987). Protecting islands of habitat like VICK may become crucial in promoting species diversity. Adequate knowledge of species that inhabit an area and their habitat requirements are vital to their conservation. The most effective conservation strategy for the mammalian fauna at VICK is to maintain and restore large, native forest and stream ecosystems with adequate connectivity to surrounding areas to facilitate dispersal and gene flow. Reduced mowing may enhance habitat characteristics for several small mammal species and their predators (mammalian and avian) and grassland birds.

The alteration of landscapes through urbanization can have profound affects on the distribution and abundance of wildlife populations. Adaptable species can be very successful and have populations that may become overabundant, causing property damage and threaten human health and safety (DeStefano and DeGraaf 2003). High density urban wildlife populations may result from increased availability of resources such as food, refugia, or den sites (Riley et al. 1998, Prange et al. 2004). Dense populations are more likely to transmit diseases potentially harmful to humans and wildlife (Riley et al. 1998), may have negative ecological impacts on native flora and fauna (Liberg 1984, Butler 2003, Lepczyk et al. 2003, Woods et al. 2003) and cause significant economic losses associated with crop reduction and vehicle collisions *(*DeNicola et al. 2000). Implementation of management programs aimed at reducing overabundant mammals, such as *Procyon lotor, Felis catus, Canis lupus*, and *Odocoileus virginianus*, may be warranted if problems causing property damage and threats to human and wildlife health and safety become a concern. Understanding public attitudes and perceptions, promoting wildlife education, and initiating sensible methods of control when necessary is key (DeStefano and DeGraaf 2003).

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