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Characteristics Of Rest Sites Used By Raccoons (procyon Lotor) In Richmond, Kentucky

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CHARACTERISTICS OF REST SITES USED BY RACCOONS (*PROCYON LOTOR*)
IN RICHMOND, KENTUCKY

By

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DEDICATION

This thesis is dedicated to my parents, Robert Lee Ridenour Jr. and Leigh Churchman Ridenour. My dad taught me that accomplishing small goals on a daily basis can lead to the achievement of dreams. My mom taught me that hard work and faith in God will generate pride in all that you do.

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ABSTRACT

The raccoon (*Procyon lotor*) is one of many species that have adapted to living in urban/suburban environments. In this study, radio-tagged raccoons within the city limits of Richmond, KY, were monitored to locate rest sites. A rest site is defined as any site occupied by a raccoon during the non-motile periods of its daily activity cycle. Thirty-three different rest sites were located throughout the spring and summer seasons of 2009-10. With some rest sites being used multiple times for a total of 50.

Of the individual rest sites located, 9, 16, and 8 were located in trees, in shrubs or in the ground, and in buildings, respectively, with no use of tree cavities. The most commonly used tree was black cherry (*Prunus serotina*). Raccoons significantly chose the largest trees available (mean DBH 44.1 cm, $t = 3.44$, $P < 0.05$). Most ground rest sites were associated with abandoned groundhog (*Marmota monax*) burrows and located in vegetated edges and nearby fields. The demands of maintaining a proper thermal neutral zone during the heat of the summer probably accounts for the frequent use of abandoned groundhog burrows as rest sites in this study. Anthropogenic sources were capitalized on by raccoons for use as rest sites in this study, e.g., chimneys, rafters of a warehouse, under a house and in a makeshift tent. Although specific features characterizing the attractiveness of these structures as rest sites were not evident, but it was theorized that predator avoidance and cover played a significant role.

As a non-consumptive approach to raccoon population control in an urban area, I recommend a raccoon management plan implementing one or more of the following: removal of large DBH trees, trapping of groundhogs to eliminate ground rest site options, eliminating points of access into buildings, and increased maintenance (mowing) of overgrown areas.

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CHAPTER 1

INTRODUCTION

The raccoon (*Procyon lotor*) is found throughout most of North America except in parts of the Rocky Mountains (Sanderson 1987) and are highly adaptable ecological generalists (Henner et al. 2004). Its range extends from Alaska and Canada to Panama in the south (Lotze and Anderson 1979). Raccoons thrive in habitats that include mature bottomland forests, hardwood swamps, seashores, and wetlands, and are most abundant near sources of water (Ragland 2005, Sanderson 1987).

The raccoon is an excellent climber and it uses this ability to exploit a diverse set of den and rest sites (Hamilton 1963). A rest site is defined as any site occupied by a raccoon during the non-motile periods of its daily activity cycle (Norment 1991). Two of the raccoons primary rest sites are a tree limb or hollow cavity (Hamilton 1963). They also use fissures in cliffs, ground burrows and thick brush piles on the ground (Hamilton 1963, Lotze and Anderson 1979). Numerous urban structures such as storm sewers and houses are also recognized as suitable rest sites for raccoons (Bolen and Robinson 2003). As evidence of the raccoon's resourcefulness, they have been found to use ventilation ducts of high rise buildings, discarded sofas, chimneys, and attics in houses as urban rest sites (Bolen and Robinson 2003).

In a study involving two different types of forest stands, Gysel (1961) reported raccoons mainly used tree cavities as den sites, but were not opposed to also using ground burrows. Raccoons appeared to prefer tree cavities occurring in Sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and American basswood (*Tilia americana*) with a DBH >51 cm (Gysel 1961). In Iowa and central Mississippi, raccoons preferred American elm (*Ulmus americana*; Cobalka 1952) and mature hardwood forests

(Chamberlain et al. 2003), respectively, as rest/den sites. Mature hardwood forests typically present raccoons with superior resting sites and adequate food and typically have accessible free water (Chamberlain et al. 2003).

Henner et al. (2004) reported that in an agricultural/prairie region of Mississippi raccoons chose rest sites closer to water and crop fields, indicating that raccoons may select rest sites based on the configuration of certain resources. Males chose ground dens most often while females predominantly chose trees, indicating that trees are more important for females, especially females with young (Henner et al. 2004).

Berner and Gysel (1967) postulated raccoons prefer to use ground burrows in the summer and winter because of their thermal properties, i.e., cooler temperature in the summer and warmer temperature in the winter. Raccoons did not use tree cavities as much in the summer, instead preferring to lie on top of tree squirrel leaf nests, sites presumably cooler than a tree cavity (Berner and Gysel 1967).

McComb (1980) indicated that along with quality and/or quantity of food, parasites, and disease, one possible limitation to urban raccoon populations is the availability of adequate den sites. Raccoons from suburban, urban, and industrial areas were less productive than ones from surrounding agricultural and forested areas (McComb 1980). McComb (1980) concluded that urban populations of raccoons were maintained by immigration rather than successful production of litters and removing den and mast trees to decrease productivity could be a successful management strategy.

In suburban Washington D.C. Hadidian et al. (1991) reported that, although trees were the main structure used by raccoons as rest sites, houses and man-made ground sites, e.g., storm sewers, were also readily used. Hadidian et al. (1991) noted that raccoons in their urban study area often reused rest sites. Fritzell (1978) found that raccoons used wetland habitat and building sites 44% and 28% of the time, respectively, as rest sites. Fritzell (1978) also noted that, with the exception of females with litters, raccoons in his study rarely returned to rest sites used the previous night.

In a study completed in the city of Glendale, Ohio, Hoffman (1979) recorded a density of 1 raccoon/1.5 ha, and observed large groupings of raccoons at favored resting and feeding areas. Ten different raccoons were captured in the top of a garage and eight different raccoons were found in the roof of a church, indicating that suburban raccoons may often congregate together (Hoffman 1979).

In Cincinnati, Ohio, Schinner and Cauley (1974) reported peak raccoon densities of 3.5 animals/ha; further illustrating the ability of urban raccoons to reach exceptionally high population densities [see also Prange et al. (2003)]. In addition to high densities, raccoons at urban and suburban sites have been reported to exhibit survival rates higher than those reported for raccoons in rural habitat (Prange et al. 2003). High density populations of raccoons in an urban environment can lead to nuisance problems and present a public health threat (Prange et al. 2003). Diseases, especially rabies, are a concern in urban populations of wildlife (Rosatte et al. 1987). Rosatte et al. (1991) reported that for an urban population of raccoons, disease may be a density dependent factor influencing population size since den sites and food were readily available.

The objective of this study was to determine the sites/structures used as diurnal rest sites by raccoons within the city of Richmond, Kentucky. Chamberlain et al. (2001) noted animals select habitats to satisfy energetic requirements, obtain resources necessary for reproduction and survival and/or to meet thermoregulatory requirements. To understand a species' ecology, it is imperative to understand how the species interacts with these habitats (Chamberlain et al. 2001). By understanding the rest site preferences for raccoons in an urban environment such as Richmond, wildlife managers can better understand how to manage these animals to decrease the nuisance and lessen the possibility of disease outbreaks such as rabies.

CHAPTER 2

METHODS

This study took place within the limits of the City of Richmond, Madison County, Kentucky. Richmond is a city of approximately 31,000 inhabitants and encompasses 58 km^2. Over 58% of the land located within the city limits is undeveloped (not in urban use), while 28.5%, 11.7%, and 9.4% of the area is zoned as residential, public/semipublic, and commercial/industrial, respectively (City of Richmond 2006). Of the public land, over 261 ha occur in city parks (City of Richmond 2006). Three streams radiate outward from the city, Silver Creek, Otter Creek, and Tates Creek. Of the undeveloped land within the city, agriculture areas are dominated by graminoids associated with livestock grazing and hay production, while the majority of the remaining areas are mainly dominated by forbs and graminoids associated with secondary succession and deciduous trees (pers. observ.).

Raccoons in this study were captured during the spring, summer, and fall seasons of 2009 and in the summer season of 2010 within the City of Richmond (KY) by using Tomahawk Live Traps (Tomahawk Live Trap Co., Tomahawk, WI). Canned cat food was used as bait (Ragland 2005). Traps were set near areas that were anticipated to be frequented by raccoons, e.g., local golf courses, parks, and other areas with water and accessible food. Eyewitness accounts of raccoons in the area also aided in locations for trap placement. Trap locations were documented by using a Global Positioning System (GPS). Traps were checked each morning and closed during the day to prevent non-target animals (e.g., dogs, cats) from being captured. Traps were reopened and the bait reset to allow for capture at night when raccoons typically forage. Any animal captured other than a raccoon was immediately released.

Once captured, raccoons were transferred from the Tomahawk trap to a ‘squeeze cage’ (Tomahawk Live Trap Model 306SQ) in which one side could be pressed inward in order to pin the animal to the side of the cage. The animal was then transported to a local veterinarian’s office (Dr. Keith Long, DVM, Richmond Veterinary Clinic); where it was sedated and radio collar attached. Distilled water was applied to the eyes of the sedated animals to prevent drying and eyes were shielded from light to prevent retinal damage. The sedated animal was monitored until it regained full motor function in order to limit the chances of the animal being harmed following release. Procedures related to raccoon capture and handling were reviewed by Eastern Kentucky University’s Institutional Animal Care and Use Committee and approved as Protocol #009-2008.

The study was restricted to adult raccoons. Raccoon age was determined based upon mass (Voight and Lotimer 1981) and sexual characteristics such as teat size and color in females and penis visibility and descended testes in males (Gysel 1961). Unless sexual characteristics indicated that it was an adult, any animal caught weighing <4 kg was considered a juvenile and released (Voight and Lotimer 1981). Basic museum measurements (total body length, tail length, hind foot length, and ear length), weight, sex, and age class (juvenile or adult) was determined for each adult raccoon captured. Plans for more detailed aging raccoons were abandoned due to the inaccuracy of using tooth wear to assign age to adult raccoons (Grau et al. 1970).

Radio collars were fitted to adult raccoons if the total weight of the collar was <4% of the animal’s total body weight. Animals were fitted with lithium powered radio collars (Wildlife Materials Inc., Carbondale, IL) and tracked by using a Model TRX-24 receiver (Wildlife Materials Inc., Carbondale, IL) and a hand-held three element yagi antenna. Transmitter frequencies ranged from 150.017 to 150.954.

The majority of animal tracking occurred during the hours when raccoons are least active (1300 to 1700 hrs; Berner and Gysel 1967). Animals were tracked starting in the spring season of 2009, but the majority of tracking occurred in the spring and summer seasons of 2010. Daytime rest sites were located by triangulation followed by homing the radio-collared animals and visually confirming the animal's specific location (White and Garrett 1990).

Rest sites were classified as tree, building, or ground (Hadidian et al. 1991). If the rest site was a tree cavity or tree limb, the tree species, diameter at breast height (DBH), and tree height and cavity height were determined.

Vegetation sampling followed the procedures of Ragland (2005). By uing the rest site tree as the center of an 11.3 m^2 (0.04 ha) radius circular plot, vegetation around raccoon rest sites was quantified. Trees were defined as woody vegetation with a DBH >4 cm. All trees within the plot were identified, and height and DBH determined. Tree height was determined by using a clinometer (Forestry Suppliers, Inc., Jackson, MS). Transects 11.3 m in length, and originating from the rest site tree, were established in the four cardinal directions (north, south, east, and west). Point intercept sampling was conducted every 1 m along each transect to determine percent canopy cover, shrub cover, ground cover (forb, grass, litter, bare ground), horizontal cover, and average shrub height. Percent canopy, shrub, and ground cover was obtained by using a densitometer (Geographic Resource Solutions, Arcata, CA) at every meter along the transect (while the operator was facing in each of the four cardinal directions). Percent canopy cover, shrub cover, and ground cover were determined by adding the point samples covered by canopy, shrubs, or ground, dividing by the total number of points sampled, and multiplying by 100. A horizontal cover board containing 60 squares (6 rows of 10 squares, each square 56.25cm^2) was used to determine the percent horizontal cover. The cover board was placed at every meter along each of the four transects. Squares, obstructed by vegetation 50% or more, were counted from a seated position at the origination point of the transect. A seated position was used to simulate the point of view of a predator. Percent horizontal coverage was determined by adding the number of squares $\geq$50% covered at each sample point, dividing by the total number of points sampled, and multiplying by 100. Mean shrub height was determined by averaging the shrub height values for all four transects. Due to shrubs not appearing at every point, the height of the nearest shrub within 1m was measured and incorporated into the average.

In order to create a control site, I identified the nearest tree $\geq$ 25 m from the rest site using a GPS. The distance of 25 m was used in order to place the control site outside of the rest site's vegetation sampling plot. The tree was assumed to not have been used as a rest site and served as the center of an 11.3 m^2 plot which was subjected to the same sampling procedure as described for rest site trees.

If a raccoon was found in a ground cavity, the entrance dimensions (maximum width x height) were determined. If the animal was found in brush, thick shrubs, or a ground cavity, the surrounding vegetation was subjected to the same vegetation sampling as described for tree rest sites. When dealing with building rest sites, I attempted to acquire permission to either enter the building or walk around the property and determine the raccoon's possible location, e.g., in the basement, inside the wall, in the attic/under the roof, or in the chimney. For each building rest site, the following were determined: (a) the distance from the building to the nearest tree, (b) the nearest tree's identity, DBH, height, height of the lowest limb, and maximum width and height of any cavities, (c) distance to the nearest source of water, and (d) distance to the nearest vegetated edge.

Canopy, ground, and horizontal cover values were determined to violate the assumption of normality in tree and ground rest sites by using the Shapiro-Wilk test, so the Wilcoxon Rank Sum test was used to determine if there was a significant difference ($P<0.05$) between rest sites and control sites for mean canopy, ground and horizontal cover. Shrub cover, tree height, tree DBH, and shrub height data did not violate the assumption of normality; so a two-sample t-test was used to determine if there was a significant difference between rest sites and control sites for average shrub cover, tree height, DBH, and shrub height. To determine if raccoons used each type of rest site (trees, ground, buildings) equally, a Chi-square analysis was employed.

CHAPTER 3

RESULTS

Fourteen raccoons, nine opossums (*Didelphis virginianus*), and ten domestic cats were captured during the trapping seasons. Trapping success was 9.8% (14 raccoons in 143 trap nights). Attempts were made to capture equal numbers of male and females but seven females and four males were collared. Three animals were not collared; one animal was euthanized due to disease, one animal was released because it was a juvenile and did not meet the weight criteria, and a lactating female with a badly cut front leg was released after being treated by the veterinarian. During the study (subsequent to being collared and released), one animal was found dead on the highway and the radio signals of two raccoons were never detected following release.

Thirty-three different rest sites were located from Spring 2009 through Summer 2010, with the majority found in Summer 2010. Raccoons were tracked to rest sites a total of 50 times with some rest sites being used multiple times. Of the 33 individual rest sites located, 9, 16, and 8 were located in trees, in shrubs or in the ground, and in buildings, respectively. No raccoons were located in tree cavities. Raccoons did not select a specific type of rest site, whether tree, building, or ground ($\chi^2 = 3.455$, $P = 0.177$).

Raccoon tree rest sites in this study were located most frequently in black cherry (n = 3, *Prunus serotina*), in addition raccoons used silver maple (n=2, *Acer saccharinum*), and black walnut (*Juglans nigra*), black locust (*Robinia pseudoacacia*), slippery elm (*Ulmus rubra*), and red mulberry (*Morus rubra*) trees once. Tree height was similar for used trees compared to trees at control sites (13.93 $\pm$ 5.76m vs 10.68 $\pm$ 4.57m, t =1.66, $P = 0.131$). However, tree DBH was significantly larger for used trees compared to control site trees (44.1 $\pm$ 19.1cm vs 21.2 $\pm$ 14.1cm, $t = 3.44$, $P < 0.05$).

The average height above the ground for tree limbs used as rest sites by raccoons in this study (n = 8) was 11.07 ± 5.1 m. I was unable to discern the location of one raccoon using a tree as a rest site due to the thick layer of ivy covering the tree. The mean maximum entrance height and width of ground burrows used as rest sites (n=11) were 35.17 ± 7.10 cm and 30.92 ± 10.53 cm, respectively.

Of the 9 rest sites located in buildings or other man-made structures; 3 were located in chimneys, 3 in the rafters of a warehouse, 1 under a house, 1 in a makeshift tent, and 1 on a telephone pole (due to a thick covering of ivy I was unable to detect the exact location). The average distance from building rest sites to the nearest vegetated edge was 32.32 ± 43.83 m. One building rest site was within 1m of water. There was no water in the vicinity of the other building rest sites. Trees located closest to building rest sites were black cherry, black walnut (*Juglans nigra*), tulip poplar (*Liriodendron tulipifera*), gingko (*Gingko biloba*), silver maple (*Acer saccharinum*), box elder (*Acer negundo*), and red cedar (*Juniper virginiana*), and each tree was located only once. Trees associated with building rest sites were located 8.38 ± 7.84 m from the rest site structure, and were characterized by a mean DBH, height, and height of the lowest limb of 24.04 ± 15.03 cm, 7.10 ± 1.44 m, 2.57 ± 1.56 m, respectively. I did not find any tree cavities in trees associated with building rest sites. Trees used as rest sites were significantly larger than trees associated with building rest sites with respect to DBH and tree height (t = 2.31, P = > 0.05; t = 3.42, P > 0.05).

There was no significant difference between tree rest sites and control sites within 0.04 ha sampling plots for mean tree density (8.25 ± 5.37, 6.71 ± 3.99, t = .634, P = 0.537), ground cover (62.8 ± 34.4%, 75.6 ± 26.0%, W = 23, P = 0.609), canopy cover (85.2 ± 14.4%, 65.9 ± 26.3%, W =41, P = 0.147), horizontal cover (26.7 ± 15.1%, 16.04 ± 12.02%, W =29, P = 0.955), shrub cover (64.2 ± 19.3%, 60.1 ± 20.1%, t = 0.404, P = 0.693), and shrub height (102.2 ± 38.4 cm, 89.8 ± 39.5 cm, t = 0.663, P = 0.559).

There was no significant difference between ground rest site and control sites, respectively, within 0.04ha sampling plots for mean tree density (3.79 ± 3.75, 6.27 ± 3.93, t = -1.60, P = 0.123), ground cover (69.4 ± 18.8%, 71.6 ± 21.7%, W = 67.5, P = 0.622), canopy cover (60.8 ± 32.3%, 62.3 ± 34.2%, W = 72.5, P = 0.827), horizontal cover (22.2 ± 11.1%, 23.2 ± 11.7%, W =69, P = 0.687), shrub cover (57.5 ± 21.0%, 60.4± 18.7%, t = -0.373, P = 0.712), and shrub height (102.3 ± 31.7 cm, 89.5 ± 38.8 cm, t = .887, P = 0.386).

CHAPTER 4

DISCUSSION

Raccoons are a species of wildlife that thrive in an urban setting because they are ecological generalists that adjust well to the surrounding environment (Henner et al. 2004). Trees are the predominant form of rest sites used in a range of rural habitats (Gysel 1961, Chamberlain et al. 2003, Cobalka 1952, Berner and Gysel 1967). However, research results regarding rest site use in an urban/suburban environment vary. Hadidian et al. (1991), in Washington D.C., noted that while trees were predominantly used by raccoons, man-made structures were acceptable forms of rest sites. Fritzell (1978) found raccoons in buildings 28% of the time. Raccoons in an urban environment tend to reuse rest sites (Hadidian et al. 1991), but not on consecutive nights (Fritzell 1978); and multiple raccoons will use the same rest site in areas of favored foraging (Hoffman 1979). McComb (1980) concluded that rest sites could be a limiting factor for raccoons in urban environments; while Rosatte et al. (1991) claimed that food and rest sites were readily available and disease was a density dependent factor affecting the population.

Determining tree species used as rest sites by raccoons has received considerable attention. In Michigan, raccoons preferred sugar maple, American beech, and American basswood as diurnal rest sites (Gysel 1961). In Iowa, raccoons preferred American elm (Cobalka 1952), and in central Mississippi, mature hardwood forests (Chamberlain et al. 2003). Norment (1991) found raccoons using predominantly oaks (76.9%), with no use of black cherry on the Central Kentucky Wildlife Management Area near Richmond, Kentucky. In a study done on the Blue Grass Army Depot, also near Richmond, Kentucky, Ragland (2005) found the highest percentage of tree species used as rest sites by female~~s~~ raccoons to be red cedar while males used black cherry most often, with red cedar being the most used tree species overall. Based on the results of this study, and observations by Ragland (2005) and Gysel (1961), maple and black cherry trees appear to have characteristics that make them appealing to raccoons as tree rest sites. Raccoons typically choose rest sites that put them closer to energetic requirements for survival, i.e., food and water (Chamberlain et al. 2003). The soft mast provided by black cherry trees could be one reason raccoons frequent the trees as rest sites.

Like any urbanized area, the City of Richmond has cleared the majority of its forested areas. As a result of this tree removal, there are typically few old (large DBH) trees left in an urban area. When given a choice of trees to use as rest sites, raccoons in this study typically used the largest trees available (mean DBH 44 cm); a trend also noted by Gysel (1961; mean rest site tree DBH > 51 cm DBH) and Ragland (2005; 41 cm).

In a forested area of Illinois, Wilson and Nielson (2007) found raccoons using ground burrows only 1% of the time, with low use speculated to be due to an abundance of predators, i.e., coyotes (*Canis latrans*) and bobcats (*Lynx rufus*). Ragland (2005) noted raccoons in ground rest sites 52% of the time, with increased use in the summer, fall, and winter. In Washington D.C., raccoons were found to use ground rest sites 12% of the time, but groundhogs (*Marmota monax*) were absent from the study area and all ground rest sites were associated with anthropogenic sources (Hadidian et al. 1991). Most ground rest sites in my study were associated with groundhog dens and located in vegetated edges and nearby field, especially in areas of fruiting pokeweed (*Phytolacca spp.*) and blueberry (*Vaccinium spp.*).

Berner and Gysel (1967) have suggested it is the thermal properties associated with ground dens that make them attractive as raccoon rest sites, i.e., cooler in the summer and warmer in the winter. The demands of maintaining a proper thermal neutral zone during the heat of the summer probably accounts for the frequent use [as oppose to tree limbs and tree cavities (Hamilton 1963)] of abandoned groundhog burrows as rest sites in this study.

Bolen and Robinson (2003) noted the broad use of anthropogenic sources as raccoon rest sites in an urbanized environment, e.g., ventilation ducts, discarded sofas, chimneys, and attics in houses. I found a similar use of anthropogenic structures as rest sites. Exactly what feature(s) made man-made structures so attractive to raccoons as rest sites in this study is not clear. Given that trees located near man-made structures used as rest sites were much smaller (in terms of DBH and height) than trees used as rest sites in other areas of the city, I hypothesize cover and predator avoidance, i.e., height off the ground, were features that made anthropogenic structures attractive to raccoons in Richmond, Kentucky.

Knowing what items are used by raccoons as rest sites in an urban environment can be used as an indirect, non-lethal population reduction technique. Based on the information obtained in this study, I believe eliminating rest sites may encourage raccoons within an area to emigrate (out of a neighborhood, out of a park, out of an industrial complex, etc.) to sites that offer more rest sites. Accomplishing such localized or regional control might be achieved by: (1) encouraging the public to eliminate raccoon access to chimneys and warehouses by covering them with a layer of mesh instead of solely attempting to remove the problem raccoon while not fixing the issue, i.e., removing the point of access into the building (Vantassel 1999); (2) regular trapping programs to eliminate groundhogs from within the city limits; therefore eliminating ground rest site availability for raccoons; (3) based upon previous research of reused tree rest sites (Ragland 2005, Fritzell 1978, Hadidian et al. 1991) and tendency for raccoons in this study to use large trees, removal of trees with DBH > 40 cm may help disperse an urban raccoon population; and (4) burning or mowing. Prescribed burning has been speculated as a management tool for raccoons in rural situations (Chamberlain et al. 2003). Prescribed burning is typically not feasible in an urban situation, however, elimination of overgrown areas, like abandoned lots and right-of-ways [removing brush piles that can serve as raccoon rest sites (Lotze and Anderson 1979)], through regular mowing or spraying could have the same impact on a raccoon's environment as prescribed burning.

Humans continue to impact forests throughout the United States. In turn, animals accustomed to living in rural areas are thrust into urban environments. Many individuals enjoy viewing wildlife in their own backyard until those animals become a nuisance or a health threat to the public. The information gathered in this study can be integrated into an urban habitat management plan for raccoons which would give wildlife managers a baseline for controlling raccoon populations should the need arise.

CHAPTER 5

LITERATURE CITED

Berner, A., and L. W. Gysel. 1967. Raccoon use of large tree cavities and ground burrows. Journal of Wildlife Management 31: 706-714.

Bolen, E. G., and W. L. Robinson. 2003. Wildlife Ecology and Management. Pearson Education, Inc., Saddle River, NJ.

Chamberlain, M.J., L.M. Conner, and B.D. Leopold. 2001. Seasonal habitat selection by raccoons (*Procyon lotor*) in intensively managed pine forests of Central Mississippi. American Midland Naturalist 147: 102-108.

Chamberlain, M. J., L. M. Conner, B.D. Leopold, and K.M. Hodges. 2003. Space use and multi-scale habitat selection of adult raccoons in Central Mississippi. Journal of Wildlife Management 67: 334-340.

City of Richmond. 2006. Comprehensive Plan 2006. City of Richmond, Planning and Zoning Department, Richmond, KY.

Cobalka, J. L. 1952. Resting Habits of the Raccoon (*Procyon lotor*) in Central Iowa. M.S. Thesis, Iowa State University, Ames, IA.

Fritzell, E. K. 1978. Habitat use by prairie raccoons during the waterfowl breeding season. Journal of Wildlife Management 42.1: 118-127.

Grau, G. A., G. C. Sanderson, and J. P. Rogers. 1970. Age determination of raccoons. Journal of Wildlife Management 34:364–372.

Gysel, L. W. 1961. An ecological study of tree cavities and ground burrows in forest stands. Journal of Wildlife Management. 25.1: 12-20.

Hadidian, J., D. A. Manski and S. Riley. 1991. Daytime resting site selection in an urban raccoon population. Pp. 39-45 *in* Wildlife Conservation in Metropolitan Environments, L.W. Adams and D.L. Leedy (eds). National Institute for Urban Wildlife, Columbia, MD.

Hamilton, W. J. Jr. 1963. The Mammals of Eastern United States. Hafner Publishing Company, New York, NY.

Henner, Chrissie M., M.J. Chamberlain, B.D. Leopold, and L. W. Burger, Jr. 2004. A multi-resolution assessment of raccoon den selection. Journal of Wildlife Management 68:179-187.

Hoffman, C. O. 1979. Weights of suburban raccoons in southwestern Ohio. Ohio Journal of Science 79: 139-142.

Lotze, J-H., and S. Anderson. 1979. *Procyon lotor*. Mammalian Species 119: 1-8.

McComb, W. C. 1980. Effects of land use upon food habits, productivity, and gastrointestinal parasites of raccoons. Pp. 642-651 *in* J.A. Chapman and D. Pursley (eds.). Worldwide Furbearer Conference Proceedings, Frostburg, MD.

Norment, J. 1991. Home range dynamics, habitat use, and resting and denning habits of raccoons (*Procyon lotor*) in Central Kentucky. M.S. Thesis, Eastern Kentucky University, Richmond.

Prange, S., S. D. Gehrt, and E. P. Wiggers. 2003. Demographic factors contributing to high raccoon densities in urban landscapes. Journal of Wildlife Management 67: 324-333.

Ragland, P. 2005. Characteristics of trees used as rest sites by raccoons (*Procyon lotor*) on the Blue Grass Army Depot, Kentucky. M.S. Thesis, Eastern Kentucky University, Richmond.

Rosatte, R.C., M.J. Power, and C.D. MacInnes. 1987. A Strategy for controlling rabies in urban skunks and raccoons. Pp 161-167 *in* L.W. Adams and D.L. Leedy (eds.). Integrating Man and Nature in the Metropolitan Environment. Proceedings of a National Symposium on Urban Wildlife, National Institute for Urban Wildlife, Columbia, MD.

Rosatte, R.C., M.J. Power, and C.D. MacInnes. 1991. Ecology of urban skunks, raccoons, and foxes in Metropolitan Toronto. Pp. 31-38 *in* L.W. Adams and D.L. Leedy (eds.). Wildlife Conservation in Metropolitan Environments, National Institute for Urban Wildlife, Columbia, MD.

Sanderson, G.C. 1987. Raccoon. Pp. 487-499 *in* Novak M., J. Baker, M. Obbard, and B. Mallach (eds). Wild Furbearer Management and Conservation in North America, Ministry of Natural Resources, Ontario, Canada.

Schinner, J.R., and D.L. Cauley. 1974. The ecology of urban raccoons in Cincinnati, Ohio. Pp. 125-130 *in* J.H. Noyes and D.R. Progulske (eds.). Wildlife in an Urbanizing Environment. Planning and Resource Development Series No. 28, Holdsworth Natural Resources Center, Massachusetts Cooperative Extension Service, Univ. Massachusetts, Amherst.

Vantassel, S. 1999. Wildlife Removal Handbook: a Guide to the Capture and Control of Wild Urban Animals. Wildlife Control Supplies, Simsbury, CT.

Voigt, D. R., and J. S. Lotimer. 1981. Radio Tracking Terrestrial Furbearers System Design, Procedures, and Data Collection. Pp. 151-188 *in* J. A. Chapman and D. Pursley (eds.). Worldwide Furbearer Proceedings, Frostburg, Md.

White, ,G.C., and R.A. Garrott. 1990. Analysis of Wildlife Radio-Tracking Data. Academic Press, Inc., New York, NY.

Wilson, S. E., and C. K. Nielsen. 2007. Habitat characteristics of raccoon daytime resting sites in southern Illinois. American Midland Naturalist
157.1: 175-186.