THE IMPACTS OF THREE COMMON MESOPREDATORS ON THE REINTRODUCED POPULATION OF EASTERN WILD TURKEYS IN TEXAS

A Dissertation

by

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ABSTRACT

Early in the 20^{th} century wild turkeys (*Meleagis gallopavo*) in North America were on the brink of extinction. Conservation and reintroduction efforts ensured that this species recovered throughout most of its historic range. Efforts to reintroduce eastern wild turkeys (*Meleagris gallopavo sylvestris*) to the Pineywoods of east Texas have achieved limited success. Previous research suggested that predation may have confounded this reintroduction. My aim was to quantify the influence of mesopredators on the wild turkey population in the Pineywoods. Raccoons (*Procyon lotor*), bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) occur sympatrically in east Texas and are thought to prey on wild turkeys, their nests and poults. I fitted bobcats, coyotes and raccoons with both GPS and VHF collars. I used location data and GIS applications to estimate home ranges, home range overlap and habitat selection for the mesopredators. I used scat analysis to determine the diet of mesopredators and to establish whether they preyed on wild turkeys. I used capture mark recapture (CMR) techniques to investigate small mammal population dynamics. I analyzed the CMR data on an annual and seasonal basis. I used spotlight counts and track plates to assess the seasonal relative abundance of eastern cottontail rabbits (*Sylvilagus floridana*). I used artificial nests to identify likely nest predators of wild turkey nests. I found that mesopredators in the Pineywoods had larger home ranges than elsewhere in the southeast. Bobcat and coyote home ranges varied seasonally, being largest in summer and fall respectively. Raccoon home ranges did not vary seasonally. Bobcats and coyotes shared space more than did raccoons with bobcats or coyotes. There was differential habitat selection between species, but mature pine and young pine were important to the mesopredators and as nesting habitat for eastern wild turkeys. I found no wild turkey remains in scat samples. White tailed deer (*Odocoileus virginianus*), lagomorphs and small mammals occurred in the diets of all three mesopredators. Small mammal numbers varied seasonally, declining from spring to summer, in synchrony with mesopredator diet diversification, and wild turkey nesting and brood rearing. Lagomorph abundance did not vary seasonally. Bobcats were predominantly carnivorous while coyotes and raccoons were omnivorous, consuming seasonal fruit and insects. American crows (*Corvus brachyrhynchos*) and raccoons were the primary artificial nest predators. Crows depredated most artificial nests, except in summer, when raccoons depredated the most nests. I concluded that the impact of mesopredators on wild turkeys was not as severe as suggested by previous research. I suggested a combination of video monitoring live wild turkey nests to identify nest predators, improvement of nesting habitat to reduce mesopredator / wild turkey nest encounters, and a program of conditioned taste aversion to reduce any nest predation by mesopredators.

DEDICATION

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1 - INTRODUCTION

The wild turkey (*Meleagris gallopavo*) is the largest gallinaceous game bird native to north America, and has close links to the American culture (Kennamer et al. 1992). Subsequent to the colonization of North America by Europeans, the wild turkey declined across its range by the late 1800's, and were probably at their lowest numbers by the late 1930s (Mosby 1975) when they were on the brink of extinction (Kennamer et al. 1992). Active restoration programs, throughout their historic range, have led to the broad spectrum revival of the five wild turkey sub-species (eastern wild turkey; *M. g. silvestris*, Florida wild turkey; *M. g. osceola*, Merriam's wild turkey; *M. g. merriami*, Rio Grande wild turkey; *M. g. intermedia*, and, Gould's wild turkey; *M. g. mexicana*) (Kennamer et al. 1992). In general, attempts to reestablish wild turkeys have been successful and the wild turkey is now extant throughout most of the US states that were considered its natural range and have been introduced into 10 States not included in their historic range (Kennamer et al. 1992).

Historically, eastern wild turkeys occupied approximately 12000 ha in east Texas (Campo 1989), overharvesting of both turkeys and timber led to a precipitous decline of the eastern sub-species in this region (Newman 1945, Campo 1989, Isabelle 2010). Early attempts to reintroduce wild turkeys to east Texas (prior to 1979) were unsuccessful (Newman 1945, Mosby 1975). Subsequently, >7000 wild caught eastern wild turkeys, from several states, have been released in east Texas (Texas Parks and

Wildlife (TPWD), Unpublished data) (Isabelle, 2010). Despite these attempts to restore the eastern wild turkey to east Texas, recent estimates indicate that the extant population is approximately 15000 individuals, distributed across east Texas in fragmented sub-populations that are susceptible to local extinction (Tapley et al. 2006, Seidel 2010). Several factors are important to the success of reintroduction programs, the founder population should be relatively large (>100 individuals), the habitat should be suitable for the species in question, species that breed early and have large clutches reintroduce better than others, herbivores can be more easily reintroduced than carnivores and with respect to birds, morphologically similar species have a greater depressing effect on the success of a reintroduction than do congenerics (Griffith et al. 1989, Fischer and Lindenmayer 2000). Additionally, in many reintroductions, success hinges on the removal of the perturbation that caused the local extinction of the species in question (Fischer and Lindenmayer 2000).

Reasons for the failure of wild turkey reintroductions could include: habitat fragmentation, habitat modification, weather conditions, poor reproductive performance, stressful capture and handling methods and predation (Wakeling et al. 2001). Many reasons have been advanced to explain the failure of the east Texas wild turkey reintroduction programs. There is substantial evidence that predation is the primary cause of mortality for all wild turkeys apart from adult gobblers (Speake 1980, Hamilton and Vangilder 1992, Miller and Leopold 1992, Hughes et al. 2005 , Kennamer 2005).

One of the reasons for the failure of the reintroduction program may therefore be predation by mammalian mesopredators.

Several authors have commented that mesopredators prey upon wild turkeys (Lovell et al. 1995, Nguyen et al. 2003, Spohr et al. 2004, Holdstock et al. 2006). Depredations may have a limiting effect on the recruitment potential of low-density populations (Messier and Crête 1985, Newsome et al. 1989, Trout and Tittensor 1989, Hanski et al.1993, Terborgh et al. 2001), such as the reestablished population of eastern wild turkeys in East Texas. Little is known about the mesopredator guild and its dynamics in East Texas as attested by the lack of available literature relating to the ecology of the mesopredators in East Texas.

Predators regulate their prey in two ways, by numerically reducing the populations of prey species and by altering the behavior of prey (Schmitz 1998, Brown 1999, Berger et al. 2001, Miller et al. 2001). The effect of a reduction in the numbers of a prey species allows other prey species, which under conditions of competition might be out competed by the prey species, to persist. In absence of the predator the weaker of the competing prey species might be out competed (Henke and Bryant 1999, Miller et al. 2001).
The effect of predators extends beyond their direct effect on their prey to the structure of the community (Ripple and Beschta 2004). The effect is transmitted through the impact on their prey (generally herbivores) by reducing or modifying the impact that the prey have on the vegetation, this in turn affects the distribution, abundance and interactions

within both the invertebrate and avian community (Miller et al. 2001). Therefore predators can be seen to influence the functioning of the entire ecosystem. The reduction or absence of carnivores can lead to the simplification or degradation of entire ecosystems (Ripple and Beschta 2004). In addition to consuming herbivorous prey, keystone predators have an influence on the sympatric populations of mesopredators through intraguild predation (intraguild predation is the killing of one species of predator by another) where the two predatory species are competing for a shared prey resource (Polis and Holt 1992).

Mesopredators are often defined as species of the order carnivora weighing 1 - 15kg (Buskirk 1999), but in most areas mesopredators are recognized as all those carnivorous or omnivorous vertebrates that are not top predators (Risk 2005, Roemer et al. 2009). Under this definition, approximately 90% of all carnivora fall into the category of mesopredators (Gittleman and Gomper 2005). The importance of mesopredators can be assessed in relation to two scenarios; first where within an ecosystem they are promoted to top carnivore status by virtue of the absence, displacement or extinction of large apex predators, secondly within communities that contain apex predators (Crooks and Soulé 1999, Gittleman and Gomper 2005).

Recent theoretical and empirical studies indicate that the importance of mammalian mesopredators is far greater than previously thought (Roemer et al. 2009). It seems that mesopredators may be essential to the functioning of ecosystems. In certain circumstances mesopredators can reduce nutrient subsidies, they can facilitate nutrient flow, and they can drive certain prey species to extinction and alter the distribution of prey. Mesopredators can fulfill unique roles that larger carnivores cannot fill – where they act as seed dispersers or where they prey on seed dispersers. Mesopredators may influence the population of larger carnivores by playing host to pathogens that limit larger carnivores. It is clear, therefore, that the influence of the mammalian mesopredator is greater than simply their effect on their prey resources. The role of the mesopredator is complex and results from their interactions with both biotic and abiotic components of the environment in which they are found.

Where large top carnivores have been excluded or eliminated, as is the case in east Texas, (Bailey 1905, Truett and Lay 1994, Schmidly and Davis 2004), mesopredators fulfill the role of the apex predator and may control the numbers and dynamics of other mesopredators through intraguild predation and interference competition (Polis and Holt 1992, Sih et al. 1998, Roemer et al. 2009). In multi-predator systems behavioral interactions between competing predators may tend to reduce the predation rates by one or all of the predators (Sih et al. 1998). For much of the United States, and particularly for the Pineywoods of east Texas, there is little information with regard to the sympatric relationships between mesopredators, and their interactions with prey resources. Bobcats (*Lynx rufus*), coyotes (*Canis latrans*) and raccoons (*Procyon lotor*) are mesopredators that are known to prey on wild turkeys in all phases of their life history (egg, poult and adult) (Miller and Leopold 1992, Schmidly and Davis 2004).

Consequently these species are most likely to have the greatest influence of eastern wild turkeys in east Texas. To determine what the influence of these mesopredators was on the eastern wild turkeys, in the Pineywoods of east Texas, it was necessary to pursue three lines of investigation;

1. The spatial ecology of the mesopredators, including home range use and overlap, and habitat selection: Space use is one of the key ecological factors that determine the interactions between predators and between predators and their prey (Sih 2005). Patterns of spatial use and habitat selection influence encounter rates, predation rates and consequently predator prey population and community dynamics (Sih 2005). Inter-specific competition between carnivores greatly influences the structure and function of biological communities (Berger and Gese 2007). The consequence of shared space use by predators result is intra-guild interactions. These interactions include intra-guild predation (Palomares et al. 1995), an extreme form of interference competition (Polis et al. 1989, Fedriani et al. 2000), active avoidance behavior, and differential space and habitat use (Sih et al. 1998). The presence of a diverse predator community is less likely to detrimentally influence prey populations than a depauperated predator guild (Palomares et al. 1995, Barnowe-Meyer et al. 2010).
2. Prey selection by mesopredators: A number of mechanisms affect mesopredator prey selection. The seasonal availability and population dynamics of prey (other than eastern wild turkeys) of the mesopredators. The feeding habits of predators reflect the availability of suitable prey and the adaptations that enable individual

predators to subdue and consume prey (Krebs 1978, Sunquist and Sunquist 1989). Investigation of the feeding habits of mesopredators can shed light on inter-specific competition and niche separation. The extent of niche differentiation and resource partitioning determines whether species can co-exist or competitively exclude each other (Pianka 1973, Carvalho and Gomes 2004, Merwe et al. 2009). An important mode of resource partitioning is the degree of dietary overlap between sympatric species (Hayward and Kerley 2008, Merwe et al. 2009). The overlap is constrained not only by the species' physical ability to obtain food, but also by the spatial and temporal availability of food (Azevedo et al. 2006, Merwe et al. 2009). Predators respond behaviorally to variations in prey populations. The changes in food availability as a result of a decline in the prey populations often cause predators to alter their diets from selective to opportunistic ones (Dunn 1977, Jędrzejewska and Jędrzejewski 1998, Schmidt and Ostfeld 2003;2008).

3. Mesopredator predation on wild turkey nests: Poor nest survival is one of the primary limitations to the successful recruitment of bird species (Dreibelbis et al. 2008). The main cause of nest mortality in avian species is predation (Ricklefs 1969, Rotenberry 1989, Martin 1993, Mezquida 2001;2003). This factor is influential with regard to ground nesting birds (Ricklefs 1969, Dreibelbis et al. 2008) which are particularly vulnerable to mammalian and avian predation (Marcstrom et al. 1988, Newton 1993, Fletcher et al. 2010). Being a ground nesting species, this is relevant to wild turkeys (*Meleagris gallopavo*) because

nesting hens, nests and young poults are consequently especially vulnerable to predation (Glidden 1975, Speake 1980, Miller and Leopold 1992).

2 - COMPLEX SPATIAL INTERACTIONS BETWEEEN MESOPREDATORS RESULT IN A REDUCED THREAT TO THE SURVIVAL OF WILD TURKEY NESTS IN EAST TEXAS

Summary

Coyotes (*Canis latrans*), bobcats (*Lynx rufus*) and raccoons (*Procyon lotor*) occur sympatrically in east Texas. Spatial interactions between predators are central to an understanding of their behavioral ecology. I investigated the nature of the interactions among these mesopredators in the Pineywoods by estimating home ranges and core areas for all three species on an annual and seasonal basis using kernel (95%, 50%) analysis and the minimum convex polygon (MCP) method. I estimated home range overlap within species and among species using both Utilization Distribution Overlap Index (UDOI) and percentage of overlap. I estimated habitat selection by mesopredators using compositional analysis on the level of second (home range relative to the study sites) and third order (locations within the home range) habitat selection. Finally, I used compositional analysis to investigate possible relationships in habitat selection between mesopredators during spring and nesting eastern wild turkeys (*Meleagris gallopavo silvestris*). Home ranges of bobcats and coyotes were similar in extent whereas raccoons had smaller home ranges than either bobcats or coyotes. There was no apparent difference in home range size for any of the species on a seasonal basis. Male bobcats had larger home ranges than female bobcats, but there was no sex based differentiation in home range size for either of the other species. Home range percentage overlap within species varied greatly from the results using UDOI, it appeared that the percentage of overlap exaggerated the extent to which individuals of the same species shared space. Bobcats and coyotes shared space to a greater extent than did raccoons with either bobcats or coyotes. There was differential habitat selection between species, but it was clear that both mature pine and young pine were important habitat components for all three species of mesopredator. Wild turkeys selected young pine and mature pine for nest sites, and it seemed that coyotes, bobcats and raccoons selected these habitat types during the nesting season. This indicated that there might have been increased predation pressure on nesting wild turkeys due to a combined impact from the mesopredators. My results show that there are complex spatial relationships within and among mesopredators. Mesopredators show differential home range and habitat selection characteristics. There was a combined effect of the mesopredators on one another and that probably damped the effect on the population of eastern wild turkeys during the nesting season.

Key Words: Bobcat (*Lynx rufus*), Coyote (*Canis latrans*), Raccoon (*Procyon lotor*), mesopredator, home range, utilization distribution overlap index (UDOI), compositional analysis, eastern wild turkey (*Meleagris gallopavo silvestris*)

Introduction

Space use is one of the key ecological factors that determine the interactions between predators and between predators and their prey (Sih 2005). Patterns of spatial use and habitat selection influence encounter rates, predation rates and consequently predator prey population and community dynamics (Sih 2005). Inter-specific competition between carnivores greatly influences the structure and function of biological communities (Berger and Gese 2007). The consequence of shared space use by predators result is intra-guild interactions. These interactions include intra-guild predation (Palomares et al. 1995), an extreme form of interference competition (Polis et al. 1989, Fedriani et al. 2000), active avoidance behavior, and differential space and habitat use (Sih et al. 1998). The presence of a diverse predator community is less likely to detrimentally influence prey populations than a depauperated predator guild (Palomares et al. 1995, Barnowe-Meyer et al. 2010).

The predator guild in the Pineywoods of East Texas is much altered from its historic composition as a result of habitat alteration and extirpation (Truett and Lay 1994, Palomares et al. 1995). Before being extirpated, East Texas was home to several large carnivores including jaguars (*Panthera onca*), pumas (*Felis concolor*), Louisiana black bears (*Ursus americanus luteolus*) and red wolves (*Canis lupus rufus*) (Truett and Lay 1994). The present situation is that the predator guild is comprised of mesopredators; this guild is dominated by the *de facto* top carnivore, the coyote (*Canis latrans*). Throughout North America the wild turkey (*Meleagris gallopavo*) is an important game species. Its decline and subsequent reestablishment throughout most of its range is a classic example of a successful reintroduction program (Kennamer et al. 1992 , Vance et al. 2005, Tapley et al. 2006). In some areas the reintroduction of wild turkeys has not been successful, despite those regions being included in its historical geographical range. The Pineywoods is such an area, in relation to the eastern wild turkey (*Meleagris gallopavo silvestris*). Despite decades of reintroduction and translocations, regional populations of eastern wild turkey remain isolated and susceptible to local extirpation (Isabelle 2010, Seidel 2010). Since the 1970's >7500 eastern wild turkeys have been translocated to the region, but successful reestablishment has been limited, due to a combination of poor survival, low reproductive success, and differential success of a variety of translocation techniques (Lopez et al. 2000). Beyond these, predation is also thought to be a significant factor in the failure of the wild turkey nests and successful recruitment (Vander Haegen et al. 1988, Kelly 1992b, Vangilder and Kurzejeski 1995), and is therefore likely to be a serious hurdle to the re-colonization of the Pineywoods by wild turkeys.

Wild turkeys are large, ground nesting birds and feature in the diets of predators (Speake et al. 1985, Miller and Leopold 1992, Roberts et al. 1995). During the nesting and brood rearing period wild turkeys suffer increased vulnerability to predation, due to their ground nesting habit (Miller and Leopold 1992, Vangilder and Kurzejeski 1995). In this period not only are the nesting females subjected to an increased threat of predation, but the eggs and poults are known to be subjected to high levels of predation from a variety of nest predators including the entire spectrum of mammalian mesopredators, armadillo's (*Dasypus novemcinctus*), and feral hogs (*Sus scrofa*), avian nest predators and snakes (Miller and Leopold 1992).

Reliable estimates of home range and core area size are the starting point for any analysis of the behavioral ecology of mesopredators (Bekoff and Wells 1980, Chamberlain et al. 2000). There are no such figures for coyotes, bobcats or raccoons for the timber areas of the east Texas Pineywoods. Home ranges comprise areas of general use (the home range) and areas of concentrated use (the core area). In practice, an animal's home range is that area that an animal uses whilst conducting its normal day to day activities (Burt 1943). The theoretical definition of a home range is the probability distribution defining an animal's use of space (Van Winkle 1975, Fieberg and Kochanny 2005) and is known as a utilization distribution (UD). The modern definition of the home range is the smallest area that is associated with a 95% probability of finding the specific animal. The area encompassed by home ranges of animals are used disproportionately, some areas are used more frequently or with greater intensity than other areas. The areas of high intensity use are core areas (Leuthold 1977) and are thought to be local epicenters of important resources for the individual in question (Clarke 1998).

Home range sizes are thought to scale with body size (Lindstedt et al. 1986, Makarieva et al. 2005). Bobcats (*Lynx rufus*) and raccoons (*Procyon lotor*) are similar in body size while coyotes are considerably larger (Schmidly 1994). Based on this, it seems that bobcats and raccoons should have similar sized home ranges, with coyotes having larger home ranges.

The degree to which home ranges overlap relates to the extent to which individuals share space (Seidel 1992, Fieberg and Kochanny 2005, Wronski 2005). Home range overlap has both a spatial and temporal component – in other words, home range overlap is a measure of the degree to which individuals within the same species overlap in their use of an area in both space and time. In addition, overlap between species can suggest the level to which different species tolerate or avoid one another.

Habitat selection is the process by which an animal chooses which habitat components to use (Morrison 2009). Animals select habitats based on their requirement of specific resources to satisfy their basic needs of survival and reproduction. Differentiation in habitat selection between sexes and within and among species is an indicator of differential resource use and differential adaptation (Pianka 2000). Where there is overlap in habitat use, there may be competition. Competition is an interaction between two or more individuals or populations, in respect to a resource that is limiting, that has a negative effect on one or more of the competitors (Pianka 2000). Where competition exists, there are likely to be stronger and weaker competitors. Species that have identical resource requirements cannot coexist in the same area (Pianka 2000). The corollary of this is that if species coexist there must be some level of differentiation in their resource requirements (Pianka 2000, Begon et al. 2006).

Competition is recognized to take two forms, exploitation competition and interference competition. Where two species use a resource, which is in short supply, and the result is a reduction of that resource, exploitation competition is said to occur. A more direct form of competition (interference competition) occurs when two species interact such that one species prevents the other from gaining access to a resource (Pianka 2000). Another component of habitat selection pertains to habitat selected by prey species. In this case the habitats selected by eastern wild turkeys as nest sites vary in many respects, but all of them have well developed vegetation approximately 1m above ground (Porter 1992) with a dense understory (Holbrook et al. 1985, Lazarus and Porter 1985, Holbrook et al. 1987, Schmutz et al. 1989, Isabelle 2010). There are two mechanisms by which prey species reduce the likelihood of being preyed upon, by avoiding the habitats used by predators and by reducing the likelihood of predation when predators and prey coexist (Brodie Jr et al. 1991). Wild turkeys are unlikely to be able to defend themselves from a direct attack by one of these mesopredators. Therefore, wild turkeys are thought to adopt predator avoidance strategies that include nest concealment and the selection of habitats that minimize the likelihood of predator encounters (Picman 1988).

My focus in this study was to determine the nature of the spatial interactions between three mesopredators that are known to prey on wild turkeys; coyotes, bobcats, and raccoons, in the Pineywoods of East Texas. Additionally, I investigated the spatial relationship between the interactions of these mesopredators, during the wild turkey nesting season (spring), and the habitat selected by wild turkeys for nest sites.
In this investigation I expected the following:

1. Home range sizes of mesopredators should scale according to body size,

2. Because the three species of mesopredator occurred on both study sites, there should be some degree of spatial partitioning between species.
3. There should have been a high degree of overlap between the ranges of individuals of the same species due to similar resource requirements.
4. The overlap of the home ranges of bobcats and coyotes, bobcats and raccoons and coyotes and raccoons should have differed because of differential resource requirements.
5. There should have been differentiation in the habitat use displayed by the three species of mesopredators.
6. The habitat selected by wild turkeys for nesting should have differed from that selected by mesopredators.

Study area

I conducted this study in the Pineywoods of east Texas. The Pineywoods stretch across east Texas, northwestern Louisiana and southwestern Arkansas. It is the western extent of the Southeastern coastal plain and the vegetation communities bear close resemblance to the southeastern mixed forest and southeastern conifer forest vegetation types. Little of the original longleaf pine (*Pinus palustris*) forests remain, and have been largely replaced by even-aged loblolly pine (*Pinus taeda*) plantations. Much of the natural vegetation of the Pineywoods has been compromised due to the planting of pine plantations and the exclusion of fire (Omernik et al. 2008).

The Pineywoods are a continuation of the forests from adjacent states (Murphy 1976). The eastern most region of Texas is characterized by a mixture of extensive pine and mixed pine and hardwood forests. The topography is that of gently rolling hills with swampy low-lying areas. Historically these pine forests were successional to hardwood forests (Landers Jr. 1987).

Commercial forestry in the region has increased since the 1992 forest surveys were completed (Kelly 1992a;b). In 1992, the USFS estimated that 67.5 % of the land in this part of East Texas was comprised of two dominant forest types: - loblolly pine (*Pinus taeda*)/ shortleaf pine (*Pinus echinata*) and longleaf pine / slash pine (*Pinus elliottii*). Estimates in 2003 indicate that there had been a marginal increase in the area under commercial forestry, from 4.78 million hectares in 1992, to 4.82 million hectares in 2003 (Rudis and Station 2008). Significantly, the amount of land under pine (*Pinus*) had increased by 30% to 2.27 million hectares between 1992 and 2002 (U.S. Department of Agriculture 2002, Rudis and Station 2008). It is likely that the percentage of land dedicated to softwood timber production will continue to increase (Haynes 2002). The remaining landscape supported a combination of woodland types including; oak (*Quercus* spp.)/ hickory (*Carya* spp.), oak/ gum (*Nyssa* spp.)/ cypress (*Taxodium* spp.), and oak/ pine mix (Murphy 1976, Kelly 1992a;b, Sivanpillai et al. 2005).

The nature of ownership is such that private land owners account for 63% of the ownership, with large portions of this land being in relatively small parcels of 0.4 to 3.6

ha. The consequence of the small parcel sizes is an increased degree of forest fragmentation (U.S. Department of Agriculture 2002). The habitat available for wild turkeys is substantially modified from that in which they used to occur. With the increase in timber plantations, continued habitat modification and increasing urbanization and turkey habitat is increasingly more fragmented now than in the past.

The mean annual rainfall in the Pineywoods is 1,192 millimeters (mm), with a monthly mean that varies between a low of 55 mm in July and 116.4 mm in May. The mean annual minimum temperature is 12.8° Celsius (C) and the mean annual maximum temperature is 25.5° C. The mean maximum temperature in the summer is 35° C (Sivanpillai et al. 2005). During my study, the mean annual temperature was 19.4° C, the minimum temperature recorded was – 5.3° C, and the maximum temperature was 38° C (NOAA 2012). The mean annual rainfall during my study was 1015 mm, with the highest rainfall occurring in 2009 (1243 mm) and the lowest in 2011 (832 mm) (NOAA 2012).

I conducted this study in the Nacogdoches and Angelina counties in east Texas, from January 2009 to September 2011. The two properties that formed the core of the study site are the Winston 8 Ranch (33 77 10 N, 348 64 10 W) (1360 ha, owned by Mr. Simon Winston) and the Cottingham Hunting Club Property (37 23 02 N, 347 83 15 W) (5000 ha, owned by Hancock Forest Management). I selected these properties because they were the only properties known to harbor populations of radio tagged eastern wild turkeys. Additionally, several wild turkey reintroductions have been attempted in these counties (Isabelle 2010).

Wild turkeys were released on the Winston 8 ranch in 2002 (1 male, 11 females) and 2003 (2 males, 7 females). From February 2007 to February 2008, a further 83 wild turkeys (66 female, 17 male) were released on the Winston 8 Ranch as part of a 'super-stocking' (Lopez et al. 2000) program (Isabelle 2010). The Cottingham Hunting club was not used as a 'super-stocking' site. In 1990, 15 wild turkeys were released about 3 km from the site and it seems that they continue to exist and nest on this property (Isabelle 2010).

Methods

To compare the biology of three species of mesopredator and the wild turkey it was necessary to select a data collection schedule that is relevant to all species. Therefore, I used the natural (solstices and equinoctial) seasons (winter: 21 December to 20 March, spring: 21 March to 20 June, summer: 21 June to 20 September, fall: 21 September to 20 December). Not only is this schedule relevant to all the mesopredators, but it also accommodates wild turkey biology well because the onset of the period of increased vulnerability in turkeys (nesting season) coincides with the onset of spring (Lehman et al. 2003) – early in April. Nearly all turkeys are nesting by mid-April regionally (Isabelle 2010).

I used padded leghold traps will used to capture 18 bobcats (8 females and 10 males) (Chamberlain et al. 2003b, Preuss 2005, Cochrane et al. 2006, Tucker et al. 2008), 16 coyotes (7 females and 9 males) (Person and Hirth 1991, Grinder and Krausman 2001, Arjo and Peltscher 2004), and I used cage traps to capture 20 raccoons (9 females and 11 males) (Gehrt et al. 2004, Prange et al. 2004, Rosatte et al. 2007) over the entire study. My trapping effort was continuous throughout the trapping seasons in each year of my study. I immobilized the captured animals using a mass and species appropriate dose of TELAZOL (http://www.fortdodge.eu), delivered via an intra-muscular injection. I fitted 10 bobcats and 10 coyotes with Televilt Tellus GPS collars (Followit Lindesberg AB, Bandygatan 2, SE-71134 Lindesberg Sweden), in addition, I fitted a further 8 bobcats and 6 coyotes with VHF collars (Advanced Telemetry Systems, Inc. 470 First Avenue North, Isanti, Minneapolis 55040). I fitted 20 raccoons with ATS VHF radio collars (Advanced Telemetry Systems, Inc. 470 First Avenue North, Isanti, Minneapolis 55040). I attempted to achieve a sample size of 20 study animals per species, throughout my study, to determine resource selection (Alldredge and Ratti 1986, Leban et al. 2001). The use of GPS collars was appropriate in the case of bobcats and coyotes, as it allowed for fine-scale home range and habitat use pattern analysis (Rodgers et al. 1994, Girard et al. 2002, Mills et al. 2006). I programmed the GPS collars to record an hourly location for the study animals throughout their nocturnal activity period (Anderson 2003, Bekoff 2003, Schmidly and Davis 2004), and they recorded the position of the animal at midday. The GPS collars were fitted with UHF download devices which allowed for regular monitoring of the movements of the collared animals and to verify that the GPS units were functioning properly. I attempted to download data from each GPS collar every month. The GPS collars were fitted with automatic drop-off devices that allowed for recovery and refurbishment of the collars (Mills et al. 2006). The drop-off devices were programmed to drop off after 365 days; alternatively I could trigger the drop-off if the collar started transmitting a mortality or low battery signal.

Because of the relatively small body size of raccoons, it was not cost effective to fit them with GPS collars; I therefore decided to use VHF collars on these animals. I attempted to locate raccoons, and VHF collared bobcats and coyotes, on each site at least three times each week, using standard radio telemetry protocols (Amlaner Jr and Macdonald 1980). I collected location data for VHF collared animals at both during the day and at night to ensure that the estimates were true reflections of the space and habitat use displayed by these species.

I estimated each animal location by taking at least three azimuths towards the strongest radio signal, within 10 minutes of each other. I entered all azimuths into Program Locate III for windows mobile (Nams 2006) whilst in the field. I censored any locations for which the estimated error ellipse was greater than 10000 m^2.

I used location data to investigate the habitat selection of the bobcats, coyotes (GPS locations and VHF locations) and raccoons (VHF locations). There are four basic designs to determine habitat selection by any given species (Thomas and Taylor 1990, Millspaugh and Marzluff 2001, Thomas and Taylor 2006). I determined habitat use based on three of these designs for the species under investigation. I used design 2 to determine the vegetation type used within home ranges of individual animals to that which was available within the study area, and design 3 to compare that to the proportional use of various vegetation types by an individual to the habitat available within its home range. Because I used nest locations as a proxy for wild turkey nest vegetation selection, I used design 1 to compare the extent to which wild turkeys used specific vegetation types for nesting to the vegetation types that mesopredators selected within the study sites.

I used compositional analysis to estimate habitat selection by the mesopredators (Aebischer et al. 1993). I compared the habitat composition of the study sites to the habitat composition within the home ranges (second order selection) of individuals of each species on an annual and seasonal basis. I then determined the habitat associated with each location for each animal and converted these, animal-wise, to percentage use values for each animal for each habitat type (third order selection), on an annual and seasonal basis.

I compared the vegetation types that wild turkeys used for their nest sites to the vegetation types selected by bobcats, coyotes and raccoons during the spring. To assess the vegetation type used by eastern wild turkeys for nesting I first located the nests by using a combination of radio telemetry and fine scale triangulation. Throughout the nesting season in 2009 and 2010 I located radio-tagged female wild turkeys on a daily basis. When I found that a female had remained in the same location for three consecutive days, I assumed that she had initiated incubation of her eggs (Paisley et al. 1998). Once I had determined that nesting had been initiated I established the precise location of the nest, making sure not to disturb the hen while she was incubating her eggs (Swanson 1996, Miller 1998, Isabelle 2010), by taking azimuths from four positions around the likely location of the nest site and determining the location of the nest site using Program Locate (Nams 2006). Once I was certain that the hen had left the nest, I searched around the projected location for evidence of the nest such as egg shells or a distinctive nest depression (Isabelle 2010). Having located the nest, I recorded the specific location using a handheld GPS device.

I compared the degree to which the mesopredators selected vegetation types to that displayed by wild turkeys for locating their nests. I compared the percentage vegetation type composition for locations of each animal to the vegetation composition of the study sites. With regard to the wild turkeys, I determined the vegetation type relative to each nest location and then converted this to a percentage composition. I compared this nest site vegetation composition to the vegetation composition of the study sites using compositional analysis (Aebischer et al. 1993).

I based the vegetation classification within the study sites and within the home ranges of various species on the habitat classification according to the Texas Ecological Systems

Classification Project (Phase 2) (Comer and NatureServe 2003). I collapsed the original 49 narrowly defined vegetation types to 7 broad vegetation classes according to the land cover types of the Texas Eocological Systems Classification Project (Phase 2) (Comer and NatureServe 2003) (Table 2.1). I used the following descriptors to designate the different vegetation types – mixed forest (A), deciduous forest (B), mature pine (C), riparian zone (D), grassland (E), agri/urban (F) and pine plantation (G).

Analyses

I uploaded the GPS collar data and the telemetry data, for each individual, into Hawth's Tools extension for Arc/Info (Beyer 2004). Two analysis protocols are commonly used to estimate the home range of animals, the minimum convex polygon method (MCP) (Nielsen and Woolf 2001, Laver and Kelly 2008) and the kernel analysis (Worton 1989, Nielsen and Woolf 2001, Laver and Kelly 2008) method. I estimated the home ranges for bobcats, coyotes and raccoons using both the MCP and kernel methods.

The MCP method is the only method that is directly comparable between studies because it is derived in the same manner no matter what analysis package is used (Lawson and Rodgers 1997). Current thinking suggests that the use of the MCP method should be limited to identifying forays outside the home range (Laver and Kelly 2008) – perhaps in search of wild turkey nests in the case of the mesopredators in this study. The MCP home ranges reported here are reported at the 100% level, they are, however, not used in the analysis of habitat selection or home range overlap.

Table 2.1: *The vegetation types used in the analysis of vegetation used by mesopredators and wild turkeys in the Pineywoods of east Texas from January 2009 to August 2011*

Value	**Ecological**	**Common name**	**Landcover**	**Percent Contribution**
Mixed Forest (Type A)				
14	West Gulf Coastal Plain Mesic Hardwood Forest	Pineywoods: Southern Mesic Pine / Hardwood Forest	Mesic Mixed Forest	2.59
17	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Pine / Hardwood Forest or Plantation	Mixed Forest	5.00
20	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Dry Pine / Hardwood Forest or Plantation	Mixed Forest	2.13
23	West Gulf Coastal Plain Sandhill Oak and Pine Forest and Woodland	Pineywoods: Sandhill Oak / Pine Woodland	Mixed Forest	0.93
76	West Gulf Coastal Plain Pine-Hardwood Flatwoods	Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation	Flatwoods Mixed Forest	1.39
Total				**12.05**
Deciduous Forest (Type B)				
15	West Gulf Coastal Plain Mesic Hardwood Forest	Pineywoods: Southern Mesic Hardwood Forest	Mesic Deciduous Forest	3.06
18	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Upland Hardwood Forest	Deciduous Forest	4.54
21	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Dry Upland Hardwood Forest	Deciduous Forest	2.59
24	West Gulf Coastal Plain Sandhill Oak and Pine Forest and Woodland	Pineywoods: Sandhill Oak Woodland	Deciduous Forest	1.39
77	West Gulf Coastal Plain Pine-Hardwood Flatwoods	Pineywoods: Hardwood Flatwoods	Flatwoods CD Forest	1.76
100	Mainly Natural Azonal Subsystems	Native Invasive: Deciduous Woodland	Deciduous Forest	1.76
102	Mainly Natural Azonal Subsystems	Native Invasive: Juniper Shrubland	Evergreen Shrubland	1.39
107	Mainly Natural Azonal Subsystems	Native Invasive: Deciduous Shrubland	Deciduous Shrubland	2.78
Total				**19.28**
Mature Pine (Type C)				
16	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Pine Forest or Plantation	Pine Forest	5.10
19	West Gulf Coastal Plain Pine-Hardwood Forest	Pineywoods: Dry Pine Forest or Plantation	Pine Forest	3.43
22	West Gulf Coastal Plain Sandhill Oak and Pine Forest and Woodland	Pineywoods: Sandhill Pine Woodland	Pine Forest	1.95
75	West Gulf Coastal Plain Pine-Hardwood Flatwoods	Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation	Flatwoods Pine Forest	1.48
Total				**11.96**

Table 2.1: (Continued)

Value	**Ecological**	**Common name**	**Landcover**	**Percent Contribution**
Riparian (Type D)				
53	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Temporarily Flooded Mixed Pine / Hardwood Forest	Floodplain Mixed Forest	0.74
54	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Temporarily Flooded Hardwood Forest	Floodplain CD Forest	1.48
56	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Deciduous Successional Shrubland	Floodplain Deciduous Shrubland	0.56
57	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Herbaceous Wetland	Floodplain Marsh	0.83
58	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Seasonally Flooded Hardwood Forest	Floodplain Bottomland Forest	0.93
59	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Wet Prairie	Floodplain Herbaceous	0.93
60	West Gulf Coastal Plain Large River Floodplain Forest	Pineywoods: Bottomland Baldcypress Swamp	Floodplain Swamp	1.76
62	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest	Riparian Mixed Forest	4.08
63	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest	Riparian CD Forest	3.34
65	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Deciduous Successional Shrubland	Riparian Deciduous Shrubland	1.02
66	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Herbaceous Wetland	Riparian Marsh	1.48
67	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Seasonally Flooded Hardwood Forest	Riparian Bottomland Forest	2.87
68	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Wet Prairie	Riparian Herbaceous	2.87
69	West Gulf Coastal Plain Small Stream and River Forest	Pineywoods: Small Stream and Riparian Baldcypress Swamp	Riparian Swamp	0.83
70	West Gulf Coastal Plain Wet Hardwood Flatwoods	Pineywoods: Wet Hardwood Flatwoods	Flatwoods CD Forest	0.56
71	West Gulf Coastal Plain Flatwoods Pond	Pineywoods: Herbaceous Flatwoods Pond	Flatwoods Marsh	1.11
74	West Gulf Coastal Plain Seepage Swamp and Baygall	Pineywoods: Seepage Swamp and Baygall	Marsh	1.85
Total				**27.25**
Grassland (Type E)				
25	West Gulf Coastal Plain Sandhill Oak and Pine Forest and Woodland	Pineywoods: Sandhill Grassland or Shrubland	Grassland	0.93
81	West Gulf Coastal Plain Weches Glade	Pineywoods: Weches Herbaceous Glade	Grassland	1.11
82	West Gulf Coastal Plain Southern Calcareous Prairie	Pineywoods: Southern Calcareous Mixedgrass Prairie	Grassland	1.85
99	Mainly Natural Azonal Subsystems	Pineywoods: Disturbance or Tame Grassland	Grassland	4.73
Total				**8.62**
Agri / Urban (Type F)				
110	Mainly Natural Azonal Subsystems	Barren	Barren	2.04
112	Mainly Natural Azonal Subsystems	Open Water	Open Water	2.59
113	Agriculture and other Human-related, Azonal Subsystems	Row Crops	Agriculture	2.22
114	Agriculture and other Human-related, Azonal Subsystems	Grass Farm	Grass Farm	1.11
118	Agriculture and other Human-related, Azonal Subsystems	Urban High Intensity	Urban High	1.39
119	Agriculture and other Human-related, Azonal Subsystems	Urban Low Intensity	Urban Low	1.67
Total				**11.03**

Table 2.1: (Continued)

Value	Ecological	Common name	Landcover	Percent Contribution
Pine Plantation (Type G)				
115	Agriculture and other Human-related, Azonal Subsystems	Pine Plantation > 3 meters tall	Pine Forest	5.10
116	Agriculture and other Human-related, Azonal Subsystems	Pine Plantation 1 to 3 meters tall	Pine Forest	4.73
Total				**9.82**

Fixed kernel analysis using least squares cross validation (LSCV) to determine the smoothing factor (*h*) is the favored method of estimating and expressing home ranges (Worton 1995, Seaman and Powell 1996, Hemson et al. 2005). Although the Kernel home range estimation method is the most statistically robust home range estimator in use today and gives a predictive home range size and intensity of use estimation (Seaman and Powell 1996, Börger et al. 2006, Mills et al. 2006), in some cases it can produce results that over-smooth or under-smooth the data (Hemson et al. 2005). During preliminary analysis of the data I discovered that in some cases, using LSCV, my data suffered from both over-smoothing and under-smoothing. To overcome this problem, and to make the home range and core estimates comparable between species, I used the fixed kernel estimator and 0.85 *href* as the smoothing factor. I used all the locations for both VHF and GPS collars to estimate the home range for each individual. I used the 95% utilization distribution (UD) to estimate the home ranges and the 50% UD to estimate the core areas of use for all species, both on a seasonal and annual basis.

I used two-way analysis of variance (ANOVA) blocked by year to examine the differences in home range and core areas of use among species. Similarly, I used two-way ANOVA blocked by year to examine the differences in home ranges and core areas of use between sexes and across seasons. I blocked by year in the case of all species because some individuals from all species were monitored for more than one year and sample sizes were lower in the early portion of the study. Where I found significant differences ($P < 0.05$), I used a multiple comparison test (Tukey HSD test) within ANOVA to identify the specific component of that variable that led to the difference and the extent of that difference. All home ranges were estimated based on a minimum of 25 locations per season, with those locations distributed throughout the season. Because the raw data did not conform to a normal distribution, I used a log transformation to normalize the data. All analyses were performed on these transformed data. Unless otherwise stated, all analyses were performed using Program R (R Development Core Team 2008).

Home Range Overlap

Using the utilization distributions resulting from my home range estimates, I estimated the degree of home range overlap between individuals of the same species (where and if overlap occurred), and between species. I used two methods to do this, the Utilization Distribution Overlap Index (UDOI) (Fieberg and Kochanny 2005), and the percentage overlap method (Mizutani and Jewell 1998, Millspaugh and Marzluff 2001). The utilization distribution overlap index is based on Hurlburt's $E/E_{uniform}$ statistic (Fieberg and Kochanny 2005). The UDOI rates the extent of overlap between a pair of home ranges, based on the projected utilization distribution of the two individuals. Two home ranges that do not overlap score an index value of 0, whereas home ranges that overlap completely and are uniformly distributed score 1. However, an index score can exceed 1 for pairs that have a high degree of overlap, but are non-uniformly distributed (Fieberg and Kochanny 2005, Berger and Gese 2007). The percentage overlap method uses the area of overlap between two home ranges as a metric of the overlap. The area of overlap is used as the numerator and each of the home range areas are used as denominators –

this results in a pair of fractions that can then be converted to percentage values (White and Garrott 1990, Mizutani and Jewell 1998, Millspaugh and Marzluff 2001). This is an intuitive representation of the overlap between home ranges and I have included it here, to facilitate comparison with other studies, despite criticisms that it might result in large estimates of overlap even though the likelihood of finding the two animals in the same area is negligible (Fieberg and Kochanny 2005).

Habitat Selection

I used a dedicated compositional analysis program, Compos Analysis 6.3+ (Smith et al. 2010), to estimate the species, seasonal and gender specific habitat selection displayed by the study animals. This program used automated log-ratio analysis of compositional data to stratify habitat preference based on radio-tracking data (Smith 2004). The program followed the methods outlined for compositional analysis (Aebischer et al. 1993). I examined differences of log-ratios between habitat use and habitat availability percentages using a multivariate analysis of variance (MANOVA). If I detected significant differences between habitat use and availability, I constructed a ranking matrix of t-tests to examine habitat preferences (Aebischer et al. 1993). To overcome problems associated with the variability in the number of locations recorded for each individual animal, I used a weighting function that uses the square route of the number of locations for each individual and attributes a weighting to this set of locations accordingly (Smith et al. 2010).

The absolute minimum number of individuals that compositional analysis is valid for is 6 (Aebischer et al. 1993). These analyses were further constrained by the fact that there need to be at least as many sample units (animals) as there are habitat types, the upshot of this is that for all my analyses I required a minimum of 7 individuals for all compositional analyses.

Results

I monitored 18 bobcats (eight females and 10 males), 16 coyotes (seven females and nine males), and 20 raccoons (nine females and 11 males), for varying lengths of time (minimum = 3 months, maximum = 27 months), between January 2009 and August 2011.

Bobcats

For bobcats I estimated 23 annual (11 female and 12 male), 13 winter (six female and seven male), 20 spring (eight female and 12 male), 16 summer (six female and 10 male), and eight fall (three female and five male) home ranges and core areas (Table 2.2) (Appendix 1). Bobcat home ranges did not vary between years ($F = 1.45$, df = 2, $P = 0.243$). Home range size varied between sexes, with female home ranges being approximately 35% of the size of male home ranges for the entire year ($F = 20.47$, df = 1, $P < 0.001$). On a seasonal basis bobcat home ranges differed between sexes, with male home ranges consistently being larger than those of females' (Table 2.2). In spring

Table 2.2: *Mean home range sizes for bobcats in the Pineywoods of east Texas determined using kernel analysis* (href *0.85*) *and 95 % and 50 % isopleths to represent the extent of the home range and the core area*

Species	**Sex**	**Season**	***n***	**Core SE**	**Mean Core (ha)**	**Range SE**	**Mean Range (ha)**
Bobcat	Both	Fall	8	268	826	1223	3689
Bobcat	Female	Fall	3	94	356	480	1510
Bobcat	Male	Fall	5	382	1109	1725	4996
Bobcat	Both	Spring	20	119	553	448	2319
Bobcat	Female	Spring	8	64	274	231	1259
Bobcat	Male	Spring	12	177	739	664	3026
Bobcat	Both	Summer	16	83	516	451	2622
Bobcat	Female	Summer	6	63	295	302	1419
Bobcat	Male	Summer	10	109	649	599	3343
Bobcat	Both	Winter	13	65	308	234	1314
Bobcat	Female	Winter	6	126	310	410	1127
Bobcat	Male	Winter	7	68	306	273	1475
Bobcat	Both	Annual	23	108	598	484	2766
Bobcat	Female	Annual	11	52	282	226	1403
Bobcat	Male	Annual	12	162	889	748	4015

and summer female home ranges were 42% of the size of male home ranges, in fall female home ranges were 30% of the size of male home ranges and in winter the female home ranges were 76% of the size of male home ranges (Table 2.2). Despite this variation in relative home range sizes between male and female bobcats, the interaction of season and sex was not significant (F = 0.68, df = 3, P = 0.568). Bobcat home ranges varied according to season (F = 3.078, df = 3, P = 0.036). The seasons where differences were evident were the comparisons between bobcat home ranges in winter and fall (Tukey HSD difference = -0.877, P = 0.051) where the mean home range in winter was 36% of that in fall (Table 2.2). In addition to this there was a difference between the home mean home ranges when comparing winter and summer (Tukey HSD difference = -0.698, P = 0.067), the winter home range was 50% of that in summer (Table 2.2).

Bobcat core areas did not vary between years (F= 2.001, df = 2, P = 0.145). Core area size varied between sexes, with female core areas being approximately 32% of the size of male core areas for the entire year (F = 17.631, df = 1, P < 0.001) (Table 2.2). Bobcat core areas did vary on a seasonal basis with the core areas of female bobcats consistently being smaller than those of male bobcats. In spring, female bobcat core areas were 37% of the size of male core areas, in summer female core areas were 45% of the size of male core areas, in fall, female core areas were 32% of the size of male core areas, and in winter, female and male core areas were similar in size (Table 2). At $\alpha = 0.05$, there was no seasonal difference between the sizes of bobcat core areas (F = 2.71, df = 3, P =

0.055). This nearly significant relationship was likely caused by the difference between the core areas between winter and fall (Tukey HSD difference = -0.92, *P* = 0.048), where the mean core area size in winter was 37% of that of fall core areas (Table 2.2).

There were also; site-wise variances in home ranges (*F* = 4.74, df = 1, *P* = 0.033) and core areas (F = 5.59, df= 1, *P* = 0.02). The home ranges from the Cottingham site were approximately 70% of the size of those estimated on the Winston site (Tukey HSD difference = 0.42, *P* = 0.03), with the core areas on Cottingham being 62% of the size of those for the Winston site (Tukey HSD difference = 0.47, *P* = 0.02). There was no difference between home range (*F* = 0.283, df= 1, *P* = 0.597) and core area (*F* = 0.189, df = 1, *P* = 0.665) estimates between GPS and VHF collars.

Coyotes

For coyotes I estimated 18 annual (nine male and nine female), 11 winter (five male and six female), 17 spring (nine female and eight male), 13 summer (six male and seven female) and six fall (four male and two female) home ranges and core areas (Table 2.3) (Appendix 1). There was no difference in the size of the home ranges based on sex (*F* = 2.520, df = 1, *P* = 0.092), collar type (GPS or VHF) (*F* = 0.164, df = 1, *P* = 0.688), or season (*F* = 1.237, df = 3, *P* = 0.308), or site (*F* = 0.017, df = 1, *P* = 0.897). Despite there being no statistical difference in seasonal coyote home ranges, there was substantial seasonal variation in coyote home range sizes. There was no difference in the size of the core areas based on sex (*F* = 2.828, df = 1, *P* = 0.070), collar type (*F* =

Table 2.3: *Mean home range sizes for coyotes in the Pineywoods of east Texas determined using kernel analysis* (href *0.85*) *and 95 % and 50 % isopleths to represent the extent of the home range and the core area.*

Species	**Sex**	**Season**	***n***	**Core SE**	**Core Mean (ha)**	**Range SE**	**Range Mean (ha)**
Coyote	Both	Fall	6	319	1166	1959	6520
Coyote	Female	Fall	2	684	1086	3451	4845
Coyote	Male	Fall	4	418	1207	2627	7358
Coyote	Both	Spring	17	142	608	889	3566
Coyote	Female	Spring	9	188	571	1020	3149
Coyote	Male	Spring	8	230	650	1562	4035
Coyote	Both	Summer	13	367	926	1494	3957
Coyote	Female	Summer	7	435	815	1558	3471
Coyote	Male	Summer	6	607	935	2977	4605
Coyote	Both	Winter	11	178	465	1101	2821
Coyote	Female	Winter	6	216	419	1135	2425
Coyote	Male	Winter	5	358	596	2151	3296
Coyote	Both	Annual	18	212	852	1128	4844
Coyote	Female	Annual	9	293	831	1428	4677
Coyote	Male	Annual	9	325	873	1833	5011

0.005, df = 1, $P = 0.941$), season ($F = 1.494$, df = 3, $P = 0.230$), or site ($F = 0.417$, df = 1, $P = 0.522$). It seemed that there were differences in home range ($F = 10.222$, df= 2, $P = 0.003$) and core areas ($F = 11.49$, df = 2, $P = 0.001$) based on different years. The home ranges of coyotes in 2010 were 49% of the size of those in 2009 (Tukey HSD difference = -1.25, $P = 0.01$), and 2011 home ranges were 26% of the size of those in 2009 (Tukey HSD difference = -1.87, $P < 0.001$). The difference in home range size between 2010 and 2011 was not significant (Tukey HSD difference = -0.62, $P = 0.17$). The same relationship prevailed relative to coyote core areas. The 2010 core areas were 61% of the size of those in 2009 (Tukey HSD difference = -1.24, $P = 0.008$), while the core areas in 2011 were 21% of the size of those in 2009 (Tukey HSD difference = -1.86, $P < 0.001$). There was no significant difference between the core areas in 2010 and 2011 (Tukey HSD difference = -0.62, $P = 0.14$).

Raccoons

For Raccoons, I estimated 29 annual (16 male and 13female) (Table 2.4), 25 winter (15 male and 10 female), 30 spring (17 male and 13 female), 26 summer (16 male and 10 female), and 17 fall (nine male and eight female) home ranges and core areas (Appendix 1). There was no difference in estimates of home range based on sex ($F = 1.465$, df = 1, $P = 0.229$), season ($F = 0.25$, df = 3, $P = 0.858$), or site ($F = 2.157$, df = 1, $P = 0.145$). Similarly there was no difference in estimates of core areas based on sex ($F = 2.140$, df = 1, $P = 0.147$), season ($F = 0.567$, df = 3, $P = 0.638$), or site ($F = 1.533$, df = 1, $P =$

Table 2.4: *Mean home range sizes for raccoons in the Pineywoods of east Texas determined using kernel analysis (*href *0.85) and 95 % and 50 % isopleths to represent the extent of the home range and the core area.*

Species	**Sex**	**Season**	***n***	**Core SE**	**Core Mean (ha)**	**Range SE**	**Range Mean (ha)**
Raccoon	Both	Fall	17	22	83	90	374
Raccoon	Female	Fall	8	14	52	83	278
Raccoon	Male	Fall	9	39	110	153	459
Raccoon	Both	Spring	30	9	68	37	315
Raccoon	Female	Spring	13	12	58	55	279
Raccoon	Male	Spring	17	13	75	51	342
Raccoon	Both	Summer	26	20	78	86	418
Raccoon	Female	Summer	10	12	55	80	359
Raccoon	Male	Summer	16	31	93	132	455
Raccoon	Both	Winter	25	18	93	65	416
Raccoon	Female	Winter	10	28	86	102	388
Raccoon	Male	Winter	15	22	96	87	434
Raccoon	Both	Annual	29	9	68	44	407
Raccoon	Female	Annual	13	9	54	51	336
Raccoon	Male	Annual	16	14	80	67	465

0.219). There was a difference in home range sizes ($F = 4.19$, df = 2, $P = 0.019$) and core area sizes ($F = 4.28$, df = 2, $P = 0.017$) between years. The home range size in 2011 was approximately 70% of the home range size in 2009 (Tukey HSD difference = -0.62, $P = 0.04$) and 2010 (Tukey HSD difference = -0.74, $P = 0.017$), while there was no difference in the range size estimates between 2009 and 2010 (Tukey HSD difference = 0.12, $P = 0.81$). In the core areas only differed between 2010 and 2011 (Tukey HSD difference = -0.84, $P = 0.01$) core areas in 2011 being 67% of the size of those in 2010. There was no difference between the core areas comparing 2009 and 2010 (Tukey HSD difference = 0.27, $P = 0.44$), and 2009 and 2011 (Tukey HSD difference = -0.58, $P = 0.09$).

Between Species

I compared home range and core areas between species. There was a difference between the estimates of home range ($F = 115.24$, df = 2, $P < 0.001$) and the estimates of core areas ($F = 114.44$, df = 2, $P < 0.001$) among all species. In addition there was a effect of year on this relationship. Both home ranges ($F = 9.14$, df = 2, $P < 0.001$), and the core areas ($F = 9.04$, df = 2, $P < 0.001$) altered based on year. There was a difference between the home range sizes of raccoons and bobcats (Tukey HSD difference = -1.89, $P < 0.001$), and raccoons and coyotes (Tukey HSD difference = -2.02, $P < 0.001$). However there was no difference between the home range sizes of bobcats and coyotes (Tukey HSD difference = 0.13, $P = 0.75$). The mean home range size of raccoons was 15% of that of bobcats and 8 % of that of coyotes. It should be noted that although there was no statistical difference between the home range sizes of bobcats and coyotes, bobcat mean home range size was 57% of that of coyotes. The same relationship was evident when comparing core areas. There was a difference between the size of core areas between raccoons and bobcats (Tukey HSD difference = -2.00, $P < 0.001$), and between raccoons and coyotes (Tukey HSD difference = -2.01, $P < 0.001$). However, there was no difference between the core area size of bobcats and coyotes (Tukey HSD difference = 0.01, $P = 0.99$). The mean core area size of raccoons was 11% of that of bobcats and 8% of that of coyotes. Despite there being no difference in the sizes of the core areas, bobcat core areas were 70% of the size of those of coyotes. There was no effect of year on the species-wise relationship of home ranges ($F = 2.65$, df = 2, $P = 0.07$) or core areas ($F = 1.353$, df = 2, $P = 0.266$).

Home range overlap

There was no difference in the UDOI values for the relationships between home range overlap between male bobcats with male bobcats, male bobcats with female bobcats and female bobcats with female bobcats ($F = 2.600$, df = 2, $P = 0.084$) (Table 2.5). There was no influence of season on these relationships for bobcats ($F = 0.769$, df = 3, $P = 0.517$), and the interaction of season with the sex-wise pairings was not significant ($F = 0.371$, df = 5, $P = 0.866$).

There were no differences in the UDOI values for coyotes relative to the home range overlap between male coyotes with male coyotes, male coyotes with female coyotes and

Table 2.5: *Utilization Distribution Overlap Index values for bobcats comparing the degree of home range overlap between different sex-wise groupings, for the Pineywoods of east Texas, between January 2009 and September 2011.*

Species	**Interaction**	**Year**	**Season**	**Site**	***n***	**SE**	**Mean UDOI**
Bobcat	FF	2010	Annual	Cottingham	6	0.030	0.04
Bobcat	FF	2010	fall	Cottingham	1	na	0.07
Bobcat	FF	2010	Spring	Cottingham	1	na	0.09
Bobcat	FF	2010	Annual	Winston	1	na	0.00
Bobcat	FF	2010	Spring	Winston	1	na	0.00
Bobcat	FF	2010	Summer	Winston	1	na	0.00
Bobcat	FF	2010	Winter	Winston	1	na	0.03
Bobcat	FF	2011	Annual	Cottingham	6	0.017	0.02
Bobcat	FF	2011	Spring	Cottingham	3	0.000	0.00
Bobcat	FF	2011	Winter	Cottingham	6	0.014	0.02
Bobcat	FM	2010	Annual	Cottingham	4	0.126	0.15
Bobcat	FM	2010	Spring	Cottingham	2	0.011	0.01
Bobcat	FM	2010	Summer	Cottingham	1	na	0.03
Bobcat	FM	2010	Annual	Winston	4	0.123	0.19
Bobcat	FM	2010	Spring	Winston	4	0.051	0.14
Bobcat	FM	2010	Summer	Winston	4	0.097	0.14
Bobcat	FM	2010	Winter	Winston	4	0.200	0.24
Bobcat	FM	2011	Annual	Cottingham	8	0.007	0.01
Bobcat	FM	2011	Spring	Cottingham	6	0.006	0.01
Bobcat	FM	2011	Winter	Cottingham	4	0.062	0.08
Bobcat	FM	2011	Annual	Winston	3	0.309	0.43
Bobcat	FM	2011	Spring	Winston	3	0.314	0.35
Bobcat	FM	2011	Summer	Winston	1	na	0.15
Bobcat	MM	2009	Annual	Cottingham	6	0.016	0.02
Bobcat	MM	2009	fall	Cottingham	3	0.006	0.01
Bobcat	MM	2009	Spring	Cottingham	6	0.006	0.01
Bobcat	MM	2009	Summer	Cottingham	6	0.018	0.03
Bobcat	MM	2010	Annual	Winston	1	na	0.14
Bobcat	MM	2010	Spring	Winston	1	na	0.11
Bobcat	MM	2010	Summer	Winston	1	na	0.05
Bobcat	MM	2010	Winter	Winston	1	na	0.14
Bobcat	MM	2011	Annual	Winston	3	0.039	0.10
Bobcat	MM	2011	Spring	Winston	3	0.028	0.03
Bobcat	MM	2011	Winter	Winston	1	na	0.03

FF : overlap of female with female
FM : overlap of female with male
MM : overlap of male with male

Table 2.6: *Utilization Distribution Overlap Index values for coyotes comparing the degree of home range overlap between different sex-wise groupings, for the Pineywoods of east Texas, between January 2009 and September 2011.*

Species	**Interaction**	**Year**	**Season**	**Site**	***n***	**SE**	**Mean UDOI**
Coyote	FF	2010	Annual	Winston	6	0.142	0.189
Coyote	FF	2011	Annual	Winston	1	na	0.034
Coyote	FF	2010	Fall	Winston	1	na	0.018
Coyote	FF	2010	Spring	Winston	6	0.145	0.212
Coyote	FF	2010	Summer	Winston	6	0.107	0.125
Coyote	FF	2010	Winter	Winston	1	na	0.032
Coyote	FF	2011	Winter	Winston	1	na	0.009
Coyote	FM	2009	Annual	Cottingham	2	0.719	0.976
Coyote	FM	2010	Annual	Cottingham	3	0.000	0.000
Coyote	FM	2010	Annual	Winston	4	0.158	0.281
Coyote	FM	2011	Annual	Winston	2	0.002	0.015
Coyote	FM	2009	Fall	Cottingham	1	na	1.125
Coyote	FM	2009	Spring	Cottingham	2	0.215	0.607
Coyote	FM	2010	Spring	Winston	4	0.025	0.062
Coyote	FM	2009	Summer	Cottingham	2	0.019	0.341
Coyote	FM	2010	Summer	Winston	4	0.172	0.223
Coyote	FM	2010	Winter	Winston	2	0.190	0.234
Coyote	FM	2011	Winter	Winston	2	0.008	0.008
Coyote	MM	2009	Annual	Cottingham	1	na	0.437
Coyote	MM	2010	Annual	Cottingham	3	0.001	0.001
Coyote	MM	2009	Spring	Cottingham	1	na	0.530
Coyote	MM	2010	Spring	Cottingham	1	na	0.002
Coyote	MM	2009	Summer	Cottingham	1	na	0.072
Coyote	MM	2010	Summer	Cottingham	1	na	0.001

FF : overlap of female with female
FM : overlap of female with male
MM : overlap of male with male

female coyotes with female coyotes ($F = 0.280$, df= 2, $P = 0.758$) (Table 2.6). There was no influence of season on these relationships ($F = 1.755$, df = 3, $P = 0.175$) and the interaction of season with the sex-wise pairings was not significant ($F = 2.222$, df= 5, $P = 0.089$). Similarly, there were no differences in the UDOI values for raccoons relative to the home range overlap between male raccoons with male raccoons, male raccoons with female raccoons and female raccoons with female raccoons ($F = 1.819$, df = 2, $P = 0.165$) (Table 2.7). There was no influence of season on these relationships ($F = 0.731$, df = 3, $P = 0.535$), and the interaction of the seasons with the sex-wise pairings of interactions was not significant ($F = 0.284$, df = 5, $P = 0.944$).

Using percentage overlap values, the degree to which overlap between home ranges and core areas differed between species (Table 2.8, 2.9, 2.10). The extent to which home ranges overlapped differed between species ($F = 7.850$, df = 2, $P < 0.001$), in addition to this there was a significant effect of the extent to which different sex-wise pairs overlapped ($F = 3.162$, df = 3, $P = 0.024$). There was no effect of season on the extent to which home ranges overlapped ($F = 0.562$, df = 3, $P = 0.690$). The extent to which core areas of use differed between species was not significant ($F = 3.021$, df = 2, $P = 0.052$) and there was no difference is the extent to which different sex-wise pairs overlapped ($F = 1.602$, df = 3, $P = 0.191$). Despite the marginal nature of the non-significant result for the overlap values between species, when subjected to the Tukey HSD procedure, there were no differences between species, bobcat and coyote (Tukey HSD difference = 12.40,

Table 2.7: *Utilization Distribution Overlap Index values for raccoons comparing the degrees of home range overlap between different sex-wise groupings, in the Pineywoods of east Texas, between January 2009 and September 2011*

Species	**Interaction**	**Year**	**Season**	**Site**	***n***	**SE**	**Mean UDOI**
Raccoon	FF	2009	Annual	Cottingham	10	0.074	0.102
Raccoon	FF	2010	Annual	Cottingham	2	0.000	0.000
Raccoon	FF	2009	Fall	Cottingham	6	0.045	0.047
Raccoon	FF	2009	Spring	Cottingham	6	0.000	0.000
Raccoon	FF	2010	Spring	Cottingham	3	0.001	0.001
Raccoon	FF	2009	Summer	Cottingham	6	0.006	0.006
Raccoon	FF	2010	Summer	Cottingham	3	0.035	0.035
Raccoon	FF	2009	Winter	Cottingham	6	0.071	0.108
Raccoon	FM	2009	Annual	Cottingham	15	0.071	0.084
Raccoon	FM	2009	Annual	Winston	3	0.086	0.114
Raccoon	FM	2010	Annual	Cottingham	6	0.271	0.400
Raccoon	FM	2010	Annual	Winston	4	0.020	0.021
Raccoon	FM	2011	Annual	Cottingham	2	0.466	0.466
Raccoon	FM	2009	Fall	Cottingham	4	0.156	0.156
Raccoon	FM	2009	Fall	Winston	3	0.050	0.070
Raccoon	FM	2009	Spring	Cottingham	24	0.041	0.057
Raccoon	FM	2009	Spring	Winston	4	0.103	0.152
Raccoon	FM	2009	Spring	Winston	4	0.035	0.050
Raccoon	FM	2010	Spring	Cottingham	6	0.172	0.287
Raccoon	FM	2010	Spring	Winston	8	0.147	0.194
Raccoon	FM	2011	Spring	Cottingham	2	0.329	0.329
Raccoon	FM	2009	Summer	Cottingham	20	0.041	0.046
Raccoon	FM	2010	Summer	Cottingham	6	0.125	0.202
Raccoon	FM	2009	Winter	Cottingham	16	0.063	0.126
Raccoon	FM	2010	Winter	Winston	8	0.088	0.179
Raccoon	FM	2011	Winter	Cottingham	3	0.249	0.249
Raccoon	MM	2009	Annual	Cottingham	3	0.003	0.003
Raccoon	MM	2009	Annual	Winston	3	0.284	0.427
Raccoon	MM	2010	Annual	Cottingham	1	na	0.676
Raccoon	MM	2010	Annual	Winston	6	0.039	0.098
Raccoon	MM	2009	Fall	Winston	3	0.220	0.220
Raccoon	MM	2010	Fall	Winston	3	0.016	0.151
Raccoon	MM	2009	Spring	Cottingham	15	0.001	0.001
Raccoon	MM	2009	Spring	Winston	6	0.084	0.143
Raccoon	MM	2009	Spring	Winston	6	0.130	0.201
Raccoon	MM	2010	Spring	Cottingham	1	na	0.936
Raccoon	MM	2010	Spring	Winston	6	0.027	0.091
Raccoon	MM	2009	Summer	Cottingham	10	0.001	0.002
Raccoon	MM	2010	Summer	Cottingham	1	na	0.330
Raccoon	MM	2010	Summer	Winston	6	0.030	0.059
Raccoon	MM	2009	Winter	Cottingham	6	0.016	0.022
Raccoon	MM	2010	Winter	Winston	6	0.115	0.265
Raccoon	MM	2011	Winter	Cottingham	3	0.004	0.004
Raccoon	MM	2011	Winter	Winston	1	na	0.060

FF : overlap of female with female
FM : overlap of female with male
MM : overlap of male with male

Table 2.8: *The percentage overlap between home ranges and core areas of bobcats in the Pineywoods of east Texas from January 2009 to September 2011*

Species	**Interaction**	**Season**	**Core / range**	***n***	**SE**	**mean %**
Bobcat	F * M	Annual	Core	3	17	57
Bobcat	F*F	Annual	Core	2	0	0
Bobcat	M*F	Annual	Core	3	8	21
Bobcat	M*M	Annual	Core	8	8	14
Bobcat	F * M	Annual	Range	14	9	44
Bobcat	F*F	Annual	Range	16	4	14
Bobcat	M*F	Annual	Range	14	4	19
Bobcat	M*M	Annual	Range	20	6	35
Bobcat	F * M	Fall	Core	*	*	*
Bobcat	F*F	Fall	Core	*	*	*
Bobcat	M*F	Fall	Core	*	*	*
Bobcat	M*M	Fall	Core	2	6	12
Bobcat	F * M	Fall	Range	*	*	*
Bobcat	F*F	Fall	Range	2	6	26
Bobcat	M*F	Fall	Range	*	*	*
Bobcat	M*M	Fall	Range	6	13	29
Bobcat	F * M	Spring	Core	2	28	28
Bobcat	F*F	Spring	Core	*	*	*
Bobcat	M*F	Spring	Core	2	7	7
Bobcat	M*M	Spring	Core	4	14	30
Bobcat	F * M	Spring	Range	10	10	43
Bobcat	F*F	Spring	Range	4	8	19
Bobcat	M*F	Spring	Range	10	4	14
Bobcat	M*M	Spring	Range	26	5	24
Bobcat	F * M	Summer	Core	3	19	26
Bobcat	F*F	Summer	Core	*	*	*
Bobcat	M*F	Summer	Core	3	8	15
Bobcat	M*M	Summer	Core	2	5	48
Bobcat	F * M	Summer	Range	8	13	41
Bobcat	F*F	Summer	Range	4	1	1
Bobcat	M*F	Summer	Range	8	3	11
Bobcat	M*M	Summer	Range	6	10	42
Bobcat	F * M	Winter	Core	5	11	20
Bobcat	F*F	Winter	Core	2	1	1
Bobcat	M*F	Winter	Core	5	12	17
Bobcat	M*M	Winter	Core	2	5	9
Bobcat	F * M	Winter	Range	7	8	34
Bobcat	F*F	Winter	Range	2	15	23
Bobcat	M*F	Winter	Range	7	10	27
Bobcat	M*M	Winter	Range	4	11	30

F*M : Overlap of female home range by male
F*F: Overlap of female home range with female
M*F: Overlap of male home range by female
M*M: Overlap of male home range by male

Table 2.9: *The percentage overlap between home ranges and core areas of coyotes in the Pineywoods of east Texas from January 2009 to September 2011*

Species	**Interaction**	**Season**	**Core / range**	***n***	**SE**	**mean %**
Coyote	F * M	Annual	Core	4	20	42
Coyote	F*F	Annual	Core	2	0	0
Coyote	M*F	Annual	Core	4	16	25
Coyote	M*M	Annual	Core	2	8	13
Coyote	F * M	Annual	Range	9	12	53
Coyote	F*F	Annual	Range	14	10	45
Coyote	M*F	Annual	Range	9	8	36
Coyote	M*M	Annual	Range	8	10	21
Coyote	F * M	Fall	Core	1	*	40
Coyote	F*F	Fall	Core	*	*	*
Coyote	M*F	Fall	Core	1	*	43
Coyote	M*M	Fall	Core	*	*	*
Coyote	F * M	Fall	Range	1	*	77
Coyote	F*F	Fall	Range	6	15	40
Coyote	M*F	Fall	Range	1	*	89
Coyote	M*M	Fall	Range	*	*	*
Coyote	F * M	Spring	Core	1	*	77
Coyote	F*F	Spring	Core	4	17	36
Coyote	M*F	Spring	Core	1	*	36
Coyote	M*M	Spring	Core	2	4	18
Coyote	F * M	Spring	Range	8	9	46
Coyote	F*F	Spring	Range	12	11	45
Coyote	M*F	Spring	Range	8	9	32
Coyote	M*M	Spring	Range	6	11	22
Coyote	F * M	Summer	Core	4	11	29
Coyote	F*F	Summer	Core	2	22	40
Coyote	M*F	Summer	Core	4	11	45
Coyote	M*M	Summer	Core	2	29	34
Coyote	F * M	Summer	Range	5	15	31
Coyote	F*F	Summer	Range	10	12	44
Coyote	M*F	Summer	Range	5	15	46
Coyote	M*M	Summer	Range	4	24	28
Coyote	F * M	Winter	Core	1	*	31
Coyote	F*F	Winter	Core	*	*	*
Coyote	M*F	Winter	Core	1	*	43
Coyote	M*M	Winter	Core	*	*	*
Coyote	F * M	Winter	Range	3	8	28
Coyote	F*F	Winter	Range	2	3	11
Coyote	M*F	Winter	Range	3	10	32
Coyote	M*M	Winter	Range	*	*	*

F*M : Overlap of female home range by male
F*F: Overlap of female home range with female
M*F: Overlap of male home range by female
M*M: Overlap of male home range by male

Table 2.10: *The percentage overlap between home ranges and core areas of raccoons in the Pineywoods of east Texas from January 2009 to September 2011*

Species	**Interaction**	**Season**	**Core / range**	***n***	**SE**	**mean %**
Raccoon	F * M	Annual	Core	4	12	26
Raccoon	F*F	Annual	Core	0	0	0
Raccoon	M*F	Annual	Core	4	12	25
Raccoon	M*M	Annual	Core	8	6	14
Raccoon	F * M	Annual	Range	21	5	25
Raccoon	F*F	Annual	Range	8	5	17
Raccoon	M*F	Annual	Range	21	4	20
Raccoon	M*M	Annual	Range	34	4	26
Raccoon	F * M	Fall	Core	3	19	37
Raccoon	F*F	Fall	Core	2	7	22
Raccoon	M*F	Fall	Core	3	5	13
Raccoon	M*M	Fall	Core	10	10	25
Raccoon	F * M	Fall	Range	10	11	25
Raccoon	F*F	Fall	Range	4	13	32
Raccoon	M*F	Fall	Range	10	5	17
Raccoon	M*M	Fall	Range	14	8	45
Raccoon	F * M	Spring	Core	4	21	43
Raccoon	F*F	Spring	Core	*	*	*
Raccoon	M*F	Spring	Core	4	18	38
Raccoon	M*M	Spring	Core	4	13	59
Raccoon	F * M	Spring	Range	11	8	27
Raccoon	F*F	Spring	Range	6	3	11
Raccoon	M*F	Spring	Range	11	8	27
Raccoon	M*M	Spring	Range	24	5	33
Raccoon	F * M	Summer	Core	3	14	29
Raccoon	F*F	Summer	Core	*	*	*
Raccoon	M*F	Summer	Core	3	13	15
Raccoon	M*M	Summer	Core	10	7	28
Raccoon	F * M	Summer	Range	15	9	37
Raccoon	F*F	Summer	Range	6	9	19
Raccoon	M*F	Summer	Range	15	17	36
Raccoon	M*M	Summer	Range	38	4	25
Raccoon	F * M	Winter	Core	4	11	33
Raccoon	F*F	Winter	Core	2	11	24
Raccoon	M*F	Winter	Core	4	9	34
Raccoon	M*M	Winter	Core	8	12	50
Raccoon	F * M	Winter	Range	13	6	26
Raccoon	F*F	Winter	Range	12	8	25
Raccoon	M*F	Winter	Range	13	8	35
Raccoon	M*M	Winter	Range	26	6	28

F*M : Overlap of female home range by male
F*F: Overlap of female home range with female
M*F: Overlap of male home range by female
M*M: Overlap of male home range by male

$P = 0.08$), bobcat and raccoon (Tukey HSD difference = 10.07, $P = 0.09$), and coyote and raccoon (Tukey HSD difference = -2.32, $P = 0.90$). I estimated the percentage of overlap in home ranges and core areas within each species. Bobcat male home ranges overlapped 35% on an annual basis, 29% in fall, 24% in spring, 42% in summer and 30% in winter. Female home ranges overlapped 14% on an annual basis, 26% in fall, 19% in spring, 1% in summer and 23% in winter. The extent to which female home ranges were overlapped by male home ranges was 44% annually, no overlap in fall, 43% in spring, 41% in summer and 34% in winter. The extent to which male home ranges were overlapped by female home ranges was 19% annually; no overlap was seen in fall, 14% in spring, 11% in summer and 27% in winter (Table 2.8). Core areas overlapped substantially less (Table 2.8).

Coyote male home ranges overlapped 21% on an annual basis, I detected no overlaps in fall, 22% in spring, 28% in summer and I found no overlaps in winter. Female ranges overlapped by 45% on an annual basis, 40% during the fall, 45% in the spring, 44% in the summer and 11% in the fall. The extent to which female home ranges were overlapped by male home ranges was 53% on an annual basis, 77% in fall (Caution – only one animal), 46% in spring, 31% in summer and 28% in winter. The extent to which male home ranges were overlapped by female home ranges was 36% on an annual basis, 89% in fall, 32% in spring, 46% in summer, and 32% in winter (Table 2.9). In many instances I found that core areas overlapped (Table 2.9).

Raccoon male home ranges overlapped by 26% on an annual basis, 45% in fall, 59% in spring, 25% in summer and 28% in winter. Female home ranges overlapped 17% on an annual basis, 32% in fall, 11% in spring, 19% in summer and 25% in winter. The extent to which female home ranges were overlapped by male home ranges was 25% on an annual basis, 25% in the fall, 27% in the spring, 37% in the summer and 26% in the winter. The extent to which male home ranges were overlapped by female home ranges was 20% on an annual basis, 17% in the fall, 27% in the spring, 36% in the summer and 35% in the winter. The core areas overlapped less than the home ranges (Table 2.10). Using UDOI values for each species, I calculated the likely differential space use patterns between species pairs. There was a significant difference between the species-wise interactions (F = 15.17, df = 2, $P < 0.001$), and the seasonal overlap index values ($F = 8.21$, df = 3, $P < 0.001$), the interaction between these variables also proved significant ($F = 2.60$, df = 6, $P = 0.017$). The Tukey HSD procedure revealed that the cause of this differentiation is the difference in space use comparing the overlap between bobcats and coyotes (UDOI = 0.13) and bobcats and raccoons (UDOI = 0.07) (Tukey Difference value = 0.06, $P < 0.001$), coyotes and bobcats (UDOI = 0.13) and coyotes and raccoons (UDOI = 0.04) (Tukey Difference value = -0.090, $P < 0.001$). This showed that there was little difference in the overlap between coyotes and raccoons and bobcats and raccoons (Tukey Difference value = -0.027, $P = 0.125$). The seasons that contributed to this difference was the difference between winter and spring (Tukey Difference value <0.001, $P < 0.001$) and the difference between winter and summer (Tukey Difference value < 0.001, $P < 0.001$).

Habitat selection

There was no difference in the habitat composition between sites ($W = 33$, $P = 0.318$), and the sites were comprised of seven habitat types according to the following percentage composition, mixed forest (Type A, 1.20%), deciduous forest (Type B, 6.90%), mature pine (Type C, 76.30%), riparian zone (Type D, 1.4%), grassland (Type E, 3.7%), agri/urban (Type F, 0.06%), and young pine plantation (Type G, 10.44%). If the mesopredators were to use the vegetation in accordance to its availability, I would have expected the sequences of habitats within my habitat selection tables to reflect the proportional contribution of each habitat type (C,G,B,E,D,A,F).

Bobcats

Bobcats displayed habitat selection on both the second and third order level (Table 2.11, 2.12 and 2.13) (Appendix 2, 3, 4, 5, 6, 7) on an annual and seasonal basis. Female bobcats did not display significant levels of selection on either the second or third order on an annual basis, although at a third order level their selection was marginally non-significant ($P = 0.052$) suggesting that there may be some biological significance to their selection of habitat types. At the second order level bobcats in general and male bobcats included a high proportion of agri/urban, Riparian, and mixed forest habitat within their home ranges. In general, bobcats included more grassland than expected in their home ranges. Mixed forest and young pine habitats contributed relatively little within the home ranges of bobcats. At the third order level, bobcats in general and male bobcats

Table 2.11: *Second and third order habitat selection, as determined for bobcats in the Pineywoods of East Texas, from January 2009 to September 2011*

Second order selection (home range relative to site)

Species	**Sex**	**Season**	λ	χ^2	**df**	***P***	**Ranked habitat sequence most to least used**
Bobcat	Both	Annual	0.303	26.272	6	0.000	F>D>>>A>E>>>G>B>C
Bobcat	Female	Annual	0.378	9.731	6	0.137	D>A>E>G>F>C>B
Bobcat	Male	Annual	0.156	22.302	6	0.001	F>>>D>>>A>E>B>>>G>>>C
Bobcat	Both	Fall	0.191	13.231	6	0.040	F>D>>>E>B>G>C>A
Bobcat	Female	Fall	*	*	*	*	*
Bobcat	Male	Fall	*	*	*	*	*
Bobcat	Both	Spring	0.282	25.301	6	0.000	F>D>A>E>B>G>>>C
Bobcat	Female	Spring	0.270	10.464	6	0.106	E>A>F>G>D>C>B
Bobcat	Male	Spring	0.203	19.131	6	0.004	F>D>A>E>B>G>>>C
Bobcat	Both	Summer	0.155	29.812	6	0.000	F>D>>>A>E>B>G>>>C
Bobcat	Female	Summer	*	*	*	*	*
Bobcat	Male	Summer	0.010	46.511	6	0.000	F>D>A>E>B>>>G>C
Bobcat	Both	Winter	0.245	18.305	6	0.006	F>D>E>A>B>G>>>C
Bobcat	Female	Winter	*	*	*	*	*
Bobcat	Male	Winter	0.019	27.872	6	0.000	F>>>D>E>B>A>G>C

Third order selection (locations relative to home range)

Species	**Sex**	**Season**	λ	χ^2	**df**	***P***	**Ranked habitat sequence - most to least used**
Bobcat	Both	Annual	0.379	20.393	6	0.002	A>G>C>B>E>D>>>F
Bobcat	Female	Annual	0.249	12.503	6	0.052	G>C>B>A>D>E>F
Bobcat	Male	Annual	0.330	13.320	6	0.038	A>C>G>B>E>D>F
Bobcat	Both	Fall	0.177	12.124	6	0.059	C>G>B>A>D>E>F
Bobcat	Female	Fall	*	*	*	*	*
Bobcat	Male	Fall	*	*	*	*	*
Bobcat	Both	Spring	0.353	20.820	6	0.002	A>G>C>B>D>E>>>F
Bobcat	Female	Spring	0.017	32.830	6	0.000	G>C>D>B>A>E>F
Bobcat	Male	Spring	0.436	9.959	6	0.126	A>B>G>C>E>D>F
Bobcat	Both	Summer	0.149	24.742	6	0.000	A>B>C>G>E>D>>>F
Bobcat	Female	Summer	*	*	*	*	*
Bobcat	Male	Summer	0.021	34.857	6	0.000	A>B>C>E>G>D>>>F
Bobcat	Both	Winter	0.309	15.270	6	0.018	G>C>E>B>D>A>F
Bobcat	Female	Winter	*	*	*	*	*
Bobcat	Male	Winter	0.263	9.349	6	0.155	E>G>B>C>D>A>F

A = Mixed forest, B = Deciduous forest, C = Mature pine, D = Riparian zone, E = Grassland
F = Agri / urban habitat, G = Young pine
Sequence = Ranking sequence according to t - tests
Symbols separated by >, those to the left are more highly ranked than those to the right
Symbols separated by >>>, the habitat type to the left is selected significantly more than the one to its' immediate right at $\alpha = 0.05$.
Symbols separated by =, both habitat type are of equal rank
* No data available or sample size too small

included mixed forest as the most selected habitat type, young pine was selected by all bobcats, and agri/urban habitat was the least selected habitat type.

In fall, bobcats included a high proportion of agri/urban and riparian areas within their home ranges, grassland and deciduous forests contributed approximately as they were represented, young pine, mature pine and mixed forest contributed less than would be expected to the home ranges. Within bobcat home ranges, in fall, bobcats selected habitats in the same order to that in which they occurred, apart from the grassland and mixed forest categories being reversed within the order of selection (Table 2.11, 2.12 and 13).

In spring, at the second order level, bobcats in general and male bobcats included a high proportion of agri/urban habitat and riparian habitat within their home ranges, mixed forest was also included more than expected, while deciduous forest, young pine and mature pine contributed less than expected. Female bobcats displayed no significant second order habitat selection during spring. On the third order level, bobcats in general and female bobcats selected relatively high proportions of mixed forest and young pine habitats. Female bobcats, in particular selected a high proportion of young pine and riparian vegetation during this period. Grassland areas were selected less in the spring by bobcats in general and female bobcats. Agri/urban habitat was selected the least.

Table 2.12: *Percentage habitat contribution to home ranges of mesopredators relative to that available within study sites (Second order habitat selection) for mesopredators in the East Texas Pineywoods between January 2009 and August 2011*

Species	**Sex**	**Season**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Sig**
Site %	NA	All	1.20	6.92	76.28	1.42	3.67	0.06	10.44	
Bobcat	Female	Annual	3.24	8.34	61.54	7.67	6.86	0.63	11.72	
Bobcat	Male	Annual	3.07	12.45	50.34	14.64	7.95	2.71	8.84	**
Bobcat	Both	Annual	3.15	10.58	55.43	11.47	7.45	1.76	10.15	**
Bobcat	Female	Spring	2.88	9.41	59.63	8.67	6.89	0.78	11.73	
Bobcat	Male	Spring	3.26	12.60	51.49	12.33	8.20	2.46	9.66	**
Bobcat	Both	Spring	3.11	11.33	54.75	10.86	7.67	1.79	10.49	**
Bobcat	Female	Summer	2.42	10.24	53.21	13.64	8.43	1.10	10.96	
Bobcat	Male	Summer	3.38	12.15	54.92	11.75	7.53	1.21	9.06	**
Bobcat	Both	Summer	3.02	11.44	54.28	12.46	7.87	1.17	9.77	**
Bobcat	Female	Fall	1.05	6.76	71.65	4.31	5.60	1.26	9.37	
Bobcat	Male	Fall	3.52	13.40	52.71	11.43	7.63	2.95	8.37	
Bobcat	Both	Fall	2.59	10.91	59.81	8.76	6.86	2.32	8.74	**
Bobcat	Female	Winter	3.45	8.28	61.21	6.59	6.79	0.35	13.33	
Bobcat	Male	Winter	2.19	14.13	53.23	10.76	9.35	2.20	8.15	**
Bobcat	Both	Winter	2.77	11.43	56.91	8.83	8.17	1.35	10.54	**
Coyote	Female	Annual	4.37	15.47	46.93	11.58	10.83	1.26	9.56	**
Coyote	Male	Annual	3.73	10.75	63.06	4.12	6.03	2.15	10.16	**
Coyote	Both	Annual	4.07	13.25	54.52	8.07	8.57	1.68	9.85	**
Coyote	Female	Spring	4.42	15.18	47.75	12.15	9.97	1.38	9.16	**
Coyote	Male	Spring	2.60	9.52	65.84	3.75	6.63	0.64	11.02	
Coyote	Both	Spring	3.56	12.52	56.26	8.20	8.40	1.03	10.04	**
Coyote	Female	Summer	3.34	13.55	52.74	8.83	10.55	0.86	10.14	*
Coyote	Male	Summer	3.19	11.49	62.43	3.78	8.78	0.26	10.06	
Coyote	Both	Summer	3.27	12.67	56.90	6.66	9.79	0.60	10.10	**
Coyote	Female	Fall	4.08	13.83	52.30	7.44	12.76	1.91	7.68	
Coyote	Male	Fall	1.98	5.67	76.35	2.44	2.45	0.10	11.01	
Coyote	Both	Fall	3.38	11.11	60.32	5.77	9.32	1.31	8.79	
Coyote	Female	Winter	3.94	12.63	48.62	12.90	11.27	1.06	9.58	
Coyote	Male	Winter	4.66	11.45	64.07	2.34	3.97	3.36	10.16	
Coyote	Both	Winter	4.26	12.10	55.64	8.10	7.95	2.11	9.84	**
Raccoon	Female	Annual	0.85	4.72	69.37	5.54	6.56	0.23	12.72	
Raccoon	Male	Annual	0.72	6.67	74.66	2.96	5.23	0.70	9.06	*
Raccoon	Both	Annual	0.78	5.83	72.40	4.07	5.80	0.50	10.63	**
Raccoon	Female	Spring	0.70	7.75	66.72	7.08	5.75	0.24	11.76	**
Raccoon	Male	Spring	0.73	5.13	76.95	2.47	5.72	0.23	8.77	**
Raccoon	Both	Spring	0.72	6.26	72.52	4.47	5.73	0.23	10.06	**
Raccoon	Female	Summer	1.50	6.27	70.04	3.19	7.69	0.18	12.14	*
Raccoon	Male	Summer	0.91	4.89	78.51	2.78	4.76	0.16	8.01	**
Raccoon	Both	Summer	1.15	5.46	74.98	2.95	5.98	0.17	9.73	**
Raccoon	Female	Fall	0.35	4.72	73.13	3.93	3.58	0.15	14.13	**
Raccoon	Male	Fall	0.70	7.64	75.42	3.38	3.80	0.39	8.67	
Raccoon	Both	Fall	0.54	6.27	74.34	3.64	3.69	0.28	11.24	**
Raccoon	Female	Winter	1.04	6.01	67.56	7.84	4.41	0.31	12.83	*
Raccoon	Male	Winter	0.60	7.25	68.99	6.19	5.04	0.95	10.98	**
Raccoon	Both	Winter	0.77	6.78	68.45	6.81	4.81	0.71	11.67	**

** Selection significant at $\alpha = 0.05$

* Selection significant at $\alpha = 0.1$

A: Mixed forest, B: Deciduous forest, C: Mature Pine, D: Riparian, E: Grassland, F: Agri/urban/barren, G: Young Pine

Table 2.13: *Mean percentage of location relative to habitat contribution to home range (third order habitat selection) by bobcats in the Pineywoods of East Texas from January 2009 - August 2011.*

	Sex	Season	Source	A	B	C	D	E	F	G	Sig
Bobcat	Female	Annual	Home range	3.24	8.34	61.54	7.67	6.86	0.63	11.72	
Bobcat	Female	Annual	Locations	3.45	10.57	53.98	8.39	4.51	0.49	18.62	*
Bobcat	Male	Annual	Home range	3.07	12.45	50.34	14.64	7.95	2.71	8.84	
Bobcat	Male	Annual	Locations	4.64	13.81	48.44	13.72	7.50	0.99	10.89	**
Bobcat	Both	Annual	Home range	3.15	10.58	55.43	11.47	7.45	1.76	10.15	
Bobcat	Both	Annual	Locations	4.13	12.42	50.82	11.44	6.22	0.77	14.20	**
Bobcat	Female	Spring	Home range	2.88	9.41	59.63	8.67	6.89	0.78	11.73	
Bobcat	Female	Spring	Locations	2.40	12.94	50.06	11.11	4.39	0.14	18.96	**
Bobcat	Male	Spring	Home range	3.26	12.60	51.49	12.33	8.20	2.46	9.66	
Bobcat	Male	Spring	Locations	6.10	12.73	47.41	15.12	6.08	0.60	11.96	
Bobcat	Both	Spring	Home range	3.11	11.33	54.75	10.86	7.67	1.79	10.49	
Bobcat	Both	Spring	Locations	4.62	12.82	48.47	13.52	5.40	0.41	14.76	**
Bobcat	Female	Summer	Home range	2.42	10.24	53.21	13.64	8.43	1.10	10.96	
Bobcat	Female	Summer	Locations	1.33	18.81	47.07	16.98	7.60	1.07	7.13	
Bobcat	Male	Summer	Home range	3.38	12.15	54.92	11.75	7.53	1.21	9.06	
Bobcat	Male	Summer	Locations	6.06	12.52	51.86	10.15	7.12	1.17	11.12	**
Bobcat	Both	Summer	Home range	3.02	11.44	54.28	12.46	7.87	1.17	9.77	
Bobcat	Both	Summer	Locations	4.61	14.46	50.38	12.25	7.27	1.14	9.89	**
Bobcat	Female	Fall	Home range	1.05	6.76	71.65	4.31	5.60	1.26	9.37	
Bobcat	Female	Fall	Locations	0.54	9.61	64.97	5.39	3.92	1.08	14.49	
Bobcat	Male	Fall	Home range	3.52	13.40	52.71	11.43	7.63	2.95	8.37	
Bobcat	Male	Fall	Locations	3.60	15.33	59.79	6.40	4.68	0.23	9.97	
Bobcat	Both	Fall	Home range	2.59	10.91	59.81	8.76	6.86	2.32	8.74	
Bobcat	Both	Fall	Locations	2.29	12.88	62.01	5.97	4.36	0.59	11.91	*
Bobcat	Female	Winter	Home range	3.45	8.28	61.21	6.59	6.79	0.35	13.33	
Bobcat	Female	Winter	Locations	3.57	7.09	58.75	6.54	4.28	0.69	19.08	**
Bobcat	Male	Winter	Home range	2.19	14.13	53.23	10.76	9.35	2.20	8.15	
Bobcat	Male	Winter	Locations	0.69	15.53	45.58	13.29	11.05	2.19	11.68	
Bobcat	Both	Winter	Home range	2.77	11.43	56.91	8.83	8.17	1.35	10.54	
Bobcat	Both	Winter	Locations	2.02	11.63	51.66	10.17	7.92	1.50	15.10	**

** Selection significant at $\alpha = 0.05$

* Selection significant at $\alpha = 0.1$

A: Mixed forest, B: Deciduous forest, C: Mature Pine, D: Riparian, E: Grassland, F: Agri/urban/barren, G: Young Pine

Male bobcats did not display significant levels of third order selection at this time (Table 2.11, 2.12 and 2.13).

During summer, bobcats in general and male bobcats included more Agri/urban, riparian, and mixed forest habitat than expected within their home ranges, with relatively little deciduous forest, young pine and grassland within their home ranges. At the third order level, in summer, bobcats in general and male bobcats selected a high proportion of mixed forest and deciduous forest habitat and less than expected proportions of mixed forest, other habitat types were selected approximately according to their occurrence (Table 2.11, 2.12 and 2.13).

In winter, on the second order level, bobcats in general and male bobcats included higher than expected proportions of agri/urban, riparian and grassland habitats within their home ranges. Young pine and mature pine contributed less than expected at this level. On the third order level, bobcats in general selected a high proportion of young pine and grassland, other habitat types were selected approximately according to their occurrence. Male bobcats did not display significant levels of third order selection during winter (Table 2.11, 2.12 and 2.13).

Coyotes

Annually, on the second order level, coyotes included higher proportions of Agri/urban, mixed forest and riparian habitat types in their home ranges than expected. At this time, coyotes included lower than expected proportions of deciduous forest, mature pine and young pine than expected. Only male coyotes displayed significant levels of selection on the third order level. At this level, male coyotes selected habitat types in accordance with their occurrence, except grasslands that they selected in a higher proportion to that in which it occurred (Table 2.12, 2.14, and 2.15) (Appendix 2, 3, 4, 5, 6, 7).

During spring coyotes in general and female coyotes showed significant levels of selection. At the second order level, coyotes selected higher than expected proportions of Agri/urban, mixed forest and grassland habitat types. Coyotes included lower than expected proportions of mature pine, young pine and deciduous forest habitats in their home ranges. On the third order level, coyotes in general and male coyotes displayed significant levels of selection. Coyotes in general and male coyotes selected a higher than expected proportion of the grassland habitat during this period (Table 2.12, 2.14, and 2.15).

In summer, coyotes in general displayed significant levels of second order habitat selection. At this time coyotes included higher than expected proportions of Agri/urban, mixed forest, grassland, and riparian habitat types in their home ranges. Coyotes included less deciduous forest, young pine and mature pine habitat, than expected, in their home ranges. Coyotes did not display significant levels of habitat selection of the third order during summer (Table 2.12, 2.14, and 2.15).

Table 2.14: *Second and third order habitat selection, as determined for coyotes in the Pineywoods of East Texas, from January 2009 to September 2011*

Second order selection (home range relative to site)

Species	**Sex**	**Season**	**λ**	**χ^2**	**df**	***P***	**Ranked habitat sequence (most to least used)**
Coyote	Both	Annual	0.130	34.633	6	0.000	F>A>D>B>E>G>>>C
Coyote	Female	Annual	0.001	62.660	6	0.000	F>>>A>D>E>B>>>G>>>C
Coyote	Male	Annual	0.185	13.481	6	0.036	F>A>D>B>G>E>C
Coyote	Both	Fall	*	*	*	*	*
Coyote	Female	Fall	*	*	*	*	*
Coyote	Male	Fall	*	*	*	*	*
Coyote	Both	Spring	0.363	17.233	6	0.008	F>A>E>B>D>G>>>C
Coyote	Female	Spring	0.024	33.546	6	0.000	F>>>A>E>D>B>>>G>C
Coyote	Male	Spring	0.481	5.854	6	0.440	A>F>G>B>C>E>D
Coyote	Both	Summer	0.291	17.276	6	0.008	F>A>E>D>B>>>G>>>C
Coyote	Female	Summer	0.245	11.265	6	0.081	F>A>D>E>B>>>G>>>C
Coyote	Male	Summer	*	*	*	*	*
Coyote	Both	Winter	0.105	24.843	6	0.000	F>A>D>B>E>G>C
Coyote	Female	Winter	*	*	*	*	*
Coyote	Male	Winter	*	*	*	*	*

Third order selection (locations relative to home range)

Species	**Sex**	**Season**	**λ**	**χ^2**	**df**	***P***	**Ranked habitat sequence (most to least used)**
Coyote	Both	Annual	0.499	11.833	6	0.066	C>E>G>D>B>A>F
Coyote	Female	Annual	0.390	8.478	6	0.205	C>E>G>D>B>A>F
Coyote	Male	Annual	0.042	25.386	6	0.000	C>E>G>B>D>A>F
Coyote	Both	Fall	*	*	*	*	*
Coyote	Female	Fall	*	*	*	*	*
Coyote	Male	Fall	*	*	*	*	*
Coyote	Both	Spring	0.350	17.825	6	0.007	E>C>G>B>D>A>>>F
Coyote	Female	Spring	0.514	5.994	6	0.424	E>C>B>G>D>A>F
Coyote	Male	Spring	0.013	34.899	6	0.000	E>G>C>A>D>B>F
Coyote	Both	Summer	0.457	10.174	6	0.118	E>G>C>B>D>A>F
Coyote	Female	Summer	0.267	9.237	6	0.161	E>C>G>B>D>A>F
Coyote	Male	Summer	*	*	*	*	*
Coyote	Both	Winter	0.440	9.026	6	0.172	E>C>B>G>A>D>>>F
Coyote	Female	Winter	*	*	*	*	*
Coyote	Male	Winter	*	*	*	*	*

A = Mixed forest, B = Deciduous forest, C = Mature pine, D = Riparian zone, E = Grassland
F = Agri / urban habitat, G = Young pine
Sequence = Ranking sequence according to t - tests
Symbols separated by >, those to the left are more highly ranked than those to the right
Symbols separated by >>>, the habitat type to the left is selected significantly more than the one to its immediate right at α = 0.05.
Symbols separated by =, both habitat types are of equal rank
* No data available or sample size too small

Table 2.15: *Mean percentage of location relative to habitat contribution to home range (third order habitat selection) by coyotes in the Pineywoods of East Texas from January 2009 - August 2011.*

	Sex	**Season**	**Source**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Sig**
Coyote	Female	Annual	Home range	4.37	15.47	46.93	11.58	10.83	1.26	9.56	
Coyote	Female	Annual	Locations	2.13	14.22	46.52	15.38	12.31	0.66	8.79	
Coyote	Male	Annual	Home range	3.73	10.75	63.06	4.12	6.03	2.15	10.16	
Coyote	Male	Annual	Locations	2.76	9.54	63.61	2.74	8.13	0.30	12.93	**
Coyote	Both	Annual	Home range	4.07	13.25	54.52	8.07	8.57	1.68	9.85	
Coyote	Both	Annual	Locations	2.43	12.02	54.56	9.43	10.34	0.49	10.74	*
Coyote	Female	Spring	Home range	4.42	15.18	47.75	12.15	9.97	1.38	9.16	
Coyote	Female	Spring	Locations	1.91	14.16	49.75	13.47	12.58	0.17	7.96	
Coyote	Male	Spring	Home range	2.60	9.52	65.84	3.75	6.63	0.64	11.02	
Coyote	Male	Spring	Locations	2.67	8.39	61.31	3.55	7.62	0.07	16.40	**
Coyote	Both	Spring	Home range	3.56	12.52	56.26	8.20	8.40	1.03	10.04	
Coyote	Both	Spring	Locations	2.27	11.44	55.19	8.80	10.25	0.12	11.93	**
Coyote	Female	Summer	Home range	3.34	13.55	52.74	8.83	10.55	0.86	10.14	
Coyote	Female	Summer	Locations	2.18	14.38	51.09	10.52	12.54	0.32	8.96	
Coyote	Male	Summer	Home range	3.19	11.49	62.43	3.78	8.78	0.26	10.06	
Coyote	Male	Summer	Locations	3.88	12.41	55.04	3.43	12.04	0.20	13.00	
Coyote	Both	Summer	Home range	3.27	12.67	56.90	6.66	9.79	0.60	10.10	
Coyote	Both	Summer	Locations	2.97	13.47	52.91	7.25	12.31	0.26	10.82	
Coyote	Female	Fall	Home range	4.08	13.83	52.30	7.44	12.76	1.91	7.68	
Coyote	Female	Fall	Locations								
Coyote	Male	Fall	Home range	1.98	5.67	76.35	2.44	2.45	0.10	11.01	
Coyote	Male	Fall	Locations								
Coyote	Both	Fall	Home range	3.38	11.11	60.32	5.77	9.32	1.31	8.79	
Coyote	Both	Fall	Locations								
Coyote	Female	Winter	Home range	3.94	12.63	48.62	12.90	11.27	1.06	9.58	
Coyote	Female	Winter	Locations	2.61	10.24	45.26	17.56	13.72	0.18	10.43	
Coyote	Male	Winter	Home range	4.66	11.45	64.07	2.34	3.97	3.36	10.16	
Coyote	Male	Winter	Locations	3.94	10.95	65.58	3.16	7.11	0.72	8.54	
Coyote	Both	Winter	Home range	4.26	12.10	55.64	8.10	7.95	2.11	9.84	
Coyote	Both	Winter	Locations	3.22	10.56	54.50	11.02	10.71	0.43	9.57	

** Selection significant at α = 0.05

* Selection significant at α = 0.1

A: Mixed forest, B: Deciduous forest, C: Mature Pine, D: Riparian, E: Grassland, F: Agri/urban/barren, G: Young Pine

Coyotes displayed significant levels of second order habitat selection during winter. Coyotes selected agri/urban, mixed forest, and riparian habitat types more than expected, and riparian, grassland, young pine and mature pine less than expected. Coyotes did not display significant levels of third order habitat selection during winter (Table 2.12, 2.14, and 2.15).

Raccoons

On the second order level, raccoons in general displayed significant levels of habitat selection on an annual basis. Female raccoons did not display significant levels of habitat selection at this level while selection by male raccoons was marginally non-significant (P = 0.051), however there is probably some biological significance to the habitat selection displayed by male raccoons during this period. In general raccoons included Agri/urban habitat in their home ranges more than expected. Male raccoons included higher than expected proportions of the grassland and Agri/urban habitat type in their home ranges. On the third order level, raccoons in general and male and female raccoons displayed significant degrees of habitat selection on an annual basis. Raccoons in general included high proportions of riparian and Agri/urban habitat in their home ranges. Female raccoons displayed significant third order habitat selection, selecting riparian and Agri/urban habitat types more than expected. Male raccoons selected high proportions of grassland habitat within their home ranges (Table 2.12, 2.16, and 2.17) (Appendix 2, 3, 4, 5, 6, 7).

Table 2.16: *Second and third order habitat selection, as determined for raccoons in the Pineywoods of East Texas, from January 2009 to September 2011*

Second order selection (home range relative to site)

Species	**Sex**	**Season**	**λ**	**χ^2**	**df**	***P***	**Ranked habitat sequence (most to least used)**
Raccoon	Both	Annual	0.499	19.438	6	0.003	C>G>E>>>F>B>A>D
Raccoon	Female	Annual	0.483	8.722	6	0.190	G>C>E>A>D>F>B
Raccoon	Male	Annual	0.457	12.526	6	0.051	C>E>G>F>B>A>D
Raccoon	Both	Fall	0.375	16.663	6	0.011	C>G>E>D>B>A>F
Raccoon	Female	Fall	0.058	22.815	6	0.001	G>C>D>B>F>E>A
Raccoon	Male	Fall	0.394	8.387	6	0.211	C>G>E>A>B>D>F
Raccoon	Both	Spring	0.382	28.863	6	0.000	C>G>E>F>D>A>B
Raccoon	Female	Spring	0.279	16.574	6	0.011	G>C>E>F>A>D>B
Raccoon	Male	Spring	0.264	22.639	6	0.001	C>G>E>F>B>D>A
Raccoon	Both	Summer	0.504	16.460	6	0.011	C>G>E>F>B>A>D
Raccoon	Female	Summer	0.321	11.367	6	0.078	G>C>E>A>B>D>F
Raccoon	Male	Summer	0.384	13.390	6	0.037	C>>>G>E>F>B>A>D
Raccoon	Both	Winter	0.437	19.867	6	0.003	G>C>D>E>F>B>A
Raccoon	Female	Winter	0.266	11.912	6	0.064	D>G>C>A>E>B>F
Raccoon	Male	Winter	0.322	16.998	6	0.009	C>G>E>D>F>B>A

Third order selection (locations relative to home range)

Species	**Sex**	**Season**	**λ**	**χ^2**	**df**	***P***	**Ranked habitat sequence (most to least used)**
Raccoon	Both	Annual	0.116	60.207	6	0.000	C>G>D>B>E>F>A
Raccoon	Female	Annual	0.055	34.749	6	0.000	C>G=B=D>E>F>A
Raccoon	Male	Annual	0.070	42.550	6	0.000	C>G>>>E>B>D>A>F
Raccoon	Both	Fall	0.038	39.301	6	0.000	C>G>B>E>D>F>A
Raccoon	Female	Fall	*	*	*	*	*
Raccoon	Male	Fall	*	*	*	*	*
Raccoon	Both	Spring	0.057	85.963	6	0.000	C>G>B>D>E>>>F>A
Raccoon	Female	Spring	0.017	52.907	6	0.000	D>C>G>B>E>>>F>A
Raccoon	Male	Spring	0.031	58.868	6	0.000	C>G>>>B>D>E>F>A
Raccoon	Both	Summer	0.104	52.009	6	0.000	C>G>>>B>E=D>A=F
Raccoon	Female	Summer	0.085	24.617	6	0.000	C>G>E>B>A>D>F
Raccoon	Male	Summer	0.048	39.395	6	0.000	C>G>B>D>F>A>E
Raccoon	Both	Winter	0.202	32.024	6	0.000	C>G>>>D>B>E>F>A
Raccoon	Female	Winter	0.042	25.318	6	0.000	C>G>D>>>B>E>F>A
Raccoon	Male	Winter	0.129	24.583	6	0.000	C>G>B>F>A=D=E

A = Mixed forest, B = Deciduous forest, C = Mature pine, D = Riparian zone, E = Grassland
F = Agri / urban habitat, G = Young pine

Sequence = Ranking sequence according to t - tests

Symbols separated by >, those to the left are more highly ranked than those to the right

Symbols separated by >>>, the habitat type to the left is selected significantly more than the one to its immediate right at α = 0.05.

Symbols separated by =, both habitat type are of equal rank

* No data available or sample size too small

Table 2.17: *Mean percentage of location relative to habitat contribution to home range (third order habitat selection) by raccoons in the Pineywoods of East Texas from January 2009 - August 2011*

	Sex	**Season**	**Source**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Sig**
Raccoon	Female	Annual	Home range	0.85	4.72	69.37	5.54	6.56	0.23	12.72	
Raccoon	Female	Annual	Locations	0.23	5.39	75.31	5.81	3.26	0.12	9.88	**
Raccoon	Male	Annual	Home range	0.72	6.67	74.66	2.96	5.23	0.70	9.06	
Raccoon	Male	Annual	Locations	0.43	3.53	77.79	2.84	4.06	0.27	11.09	**
Raccoon	Both	Annual	Home range	0.78	5.83	72.40	4.07	5.80	0.50	10.63	
Raccoon	Both	Annual	Locations	0.34	4.33	76.73	4.11	3.72	0.20	10.57	**
Raccoon	Female	Spring	Home range	0.70	7.75	66.72	7.08	5.75	0.24	11.76	
Raccoon	Female	Spring	Locations	0.67	9.35	63.95	9.45	4.00	0.00	12.58	**
Raccoon	Male	Spring	Home range	0.73	5.13	76.95	2.47	5.72	0.23	8.77	
Raccoon	Male	Spring	Locations	0.16	3.89	78.58	3.63	4.51	0.12	9.10	**
Raccoon	Both	Spring	Home range	0.72	6.26	72.52	4.47	5.73	0.23	10.06	
Raccoon	Both	Spring	Locations	0.38	6.26	72.24	6.16	4.29	0.07	10.61	**
Raccoon	Female	Summer	Home range	1.50	6.27	70.04	3.19	7.69	0.18	12.14	
Raccoon	Female	Summer	Locations	1.10	5.05	75.86	1.97	4.46	0.18	11.38	**
Raccoon	Male	Summer	Home range	0.91	4.89	78.51	2.78	4.76	0.16	8.01	
Raccoon	Male	Summer	Locations	0.10	3.55	82.60	1.35	4.56	0.16	7.67	**
Raccoon	Both	Summer	Home range	1.15	5.46	74.98	2.95	5.98	0.17	9.73	
Raccoon	Both	Summer	Locations	0.54	4.20	79.67	1.62	4.52	0.17	9.28	**
Raccoon	Female	Fall	Home range	0.35	4.72	73.13	3.93	3.58	0.15	14.13	
Raccoon	Female	Fall	Locations	1.30	6.28	72.93	1.87	1.80	0.00	15.82	
Raccoon	Male	Fall	Home range	0.70	7.64	75.42	3.38	3.80	0.39	8.67	
Raccoon	Male	Fall	Locations	0.00	7.80	85.93	0.95	0.65	0.00	4.67	
Raccoon	Both	Fall	Home range	0.54	6.27	74.34	3.64	3.69	0.28	11.24	
Raccoon	Both	Fall	Locations	0.76	6.92	78.35	1.49	1.32	0.00	11.17	**
Raccoon	Female	Winter	Home range	1.04	6.01	67.56	7.84	4.41	0.31	12.83	
Raccoon	Female	Winter	Locations	1.70	3.10	65.46	10.13	1.79	0.00	17.82	**
Raccoon	Male	Winter	Home range	0.60	7.25	68.99	6.19	5.04	0.95	10.98	
Raccoon	Male	Winter	Locations	0.31	12.40	66.15	3.91	1.60	0.94	14.68	**
Raccoon	Both	Winter	Home range	0.77	6.78	68.45	6.81	4.81	0.71	11.67	
Raccoon	Both	Winter	Locations	0.87	8.68	65.88	6.40	1.68	0.57	15.94	**

** Selection significant at $\alpha = 0.05$

* Selection significant at $\alpha = 0.1$

A: Mixed forest, B: Deciduous forest, C: Mature Pine, D: Riparian, E: Grassland, F: Agri/urban/barren, G: Young Pine

In fall, raccoons in general and female raccoons displayed significant levels of second order habitat selection. During this period, raccoons included a lower proportion of the deciduous forest habitat type in their home ranges. Female raccoons included a high proportion of riparian and Agri/urban habitat in their home ranges during this period. On the third order level there were only sufficient data to analyze the habitat selection of raccoons in general. During this period raccoons selected proportionally more agri/urban habitat than would have been expected (Table 2.12, 2.16, and 2.17).

In spring all categories of raccoons displayed significant levels of second order habitat selection. Raccoons in general included higher proportions of the agri/urban habitat type and lower proportions of the deciduous habitat type in their home ranges. Female raccoons selected higher proportions of young pine and agri/urban habitat types, and lower proportions of mature pine, riparian deciduous forest habitat types than expected in their home ranges. Male raccoons selected more agri/urban habitat and less riparian habitat than expected within their home ranges. On the third order level, all types of raccoons displayed significant levels of habitat selection. Raccoons in general included higher proportions of riparian and agri/urban habitat types in their home ranges. Female raccoons included higher than expected proportions of riparian and agri/urban habitat types within their home ranges. Male raccoons displayed higher levels of selection for riparian and agri/urban habitat types within their home ranges (Table 2.12, 2.16, and 2.17).

In summer raccoons in general and male raccoons showed significant levels of second and third order habitat selection. On the second order level, raccoons in general selected higher proportions of grassland and agri/urban habitat, and lower proportions of deciduous forest and riparian habitat within their home ranges. Male raccoons selected agri/urban habitat more than expected and deciduous forest and riparian habitat less than expected during this period. All categories of raccoons displayed significant levels of third order habitat selection during summer. Raccoons in general selected grassland and riparian habitat types to the same degree, in addition they selected mixed forest and agri/urban habitats to the same degree. Female raccoons selected grasslands and mixed forest more than expected, but selected deciduous forest and riparian zones less than expected. Male raccoons selected riparian areas and agri/urban habitats more than expected during this period (Table 2.12, 2.16, and 2.17).

In winter, raccoons in general and male raccoons displayed significant levels of second order habitat selection. In general, raccoons selected the young pine, riparian and Agri/urban habitat types more than expected, whilst they selected deciduous forest habitat less than expected. Male raccoons selected grassland riparian and Agri/urban habitats more than expected and deciduous forest less than expected. All categories of raccoons displayed significant levels of third order habitat selection in winter. Raccoons in general selected riparian and Agri/urban habitat types more than expected and deciduous forest and mixed forest less than expected. Female raccoons selected riparian and Agri/urban habitat types more than expected and deciduous forest and mixed forest less than expected. Male raccoons selected Agri/urban and mixed forest habitat types more than expected and riparian and grassland habitat types less than expected (Table 2.12, 2.16, and 2.17).

To determine whether the mesopredators selected similar habitats to those selected by wild turkeys for nesting (Table 2.18), I compared the nest site habitat selection displayed by female wild turkeys in the study sites to the habitat selection displayed by bobcats, coyotes and raccoons with respect to the study sites (Table 2.19). These comparisons were only made for the spring season. Turkeys selected young pine (G) and mature pine (C) habitat components for nests. Male bobcats and the combined grouping of male and female coyotes used vegetation types in proportion to their availability. Female bobcats, male coyotes and raccoons displayed significant levels of selection for those types of habitat that wild turkeys preferred for nesting.

Discussion

Home range and core area

The home ranges of bobcats, coyotes and raccoons in the Pineywoods of east Texas do not seem to comply with the expectation that home range sizes of mesopredators should scale with body size (Lindstedt et al. 1986, Makarieva et al. 2005, Woodward et al. 2005). Here I found that bobcats and coyotes had statistically similar home ranges and core areas. However, despite there being no statistical difference between the range sizes

Table 2.18: *Habitats used by wild turkeys for nesting relative to the habitats available in the study sites in the Pineywoods of East Texas from January 2009 to August 2011*

Habitats	**Nest Habitats**	**Study site Habitats**
Mixed Forest	4.55	1.20
Deciduous forest	6.72	6.92
Mature Pine	77.67	76.28
Riparian	0.00	1.42
Grassland	0.00	3.67
Agr/Urban/Barren	0.00	0.06
Young Pine	11.07	10.44

Table 2.19: *Habitat selection, determined by compositional analysis, comparing the habitats selected as nest sites by eastern wild turkeys and bobcats, coyotes and raccoons, in the Pineywoods of east Texas, from January 2009 to September 2011.*

Species	**Sex**	**λ**	**χ^2**	***P***	**df**	**Sequence**
Turkey	Female	0.00	417.99	0.00	6	G>C>B>A>F>>>D>>>E
Bobcat	Both	0.44	16.24	0.01	6	D>G>A>C>B>E>F
	Male	0.58	6.52	0.37	6	D>A>G>E>B>C>F
	Female	0.12	17.02	0.01	6	G>>>C>D>B>A>F>E
Coyote	Both	0.58	9.26	0.16	6	E>C>G>B>D>A>F
	Male	0.05	23.89	0.00	6	G>>>C>E>A>B>D>F
	Female	0.07	23.98	0.00	6	E>B>D>C>G>F>A
Raccoon	Both	0.07	80.66	0.00	6	C>G>>>D>F>E>B>A
	Male	0.04	55.96	0.00	6	C>G>>>F>D>E>B>A
	Female	0.00	73.88	0.00	6	C>G>D>E>B>F>A

A = Mixed forest, B = Deciduous forest, C = Mature pine, D = Riparian zone, E = Grassland
F = Agri / urban habitat, G = Young pine
Sequence = Ranking sequence according to t - tests
Symbols separated by >, those to the left are more highly ranked than those to the right
Symbols separated by >>>, the habitat type to the left is selected significantly more than the one to its' immediate right at $\alpha = 0.05$.
Symbols separated by =, both habitat type are of equal rank

of bobcats and coyotes, they seemed to differ substantially in extent, with bobcat home ranges averaging 2766 ha on an annual basis while coyote home ranges averaged 4844 ha. It seems therefore that there is quite a discrepancy in the home range sizes of these mesopredators. In a similar fashion, but not to the same extent, the core areas used by bobcats were substantially smaller than those estimated for coyotes. When compared to bobcats and coyotes, I found that raccoons had significantly smaller home ranges and core areas than either of the other mesopredators. Despite being similar in body size, bobcats and raccoons had substantially different home range sizes and core areas; this is likely to be due to differing feeding strategies and levels of relative resource availability for the two species. Bobcats were carnivorous whilst raccoons were omnivorous (Section 3). In this case it seems that bobcat home ranges are so much larger than those of raccoons because of their dietary requirements – they are obligate carnivores whereas raccoons are omnivores, and obligate carnivores require much larger home ranges, relative to their body size, than do facultative carnivores / omnivores (Gittleman and Harvey 1982). This may also explain the seasonal increase in bobcat home range sizes, and the non-statistically significant increase in coyote home ranges (Table 2.3), that seemed to expand in conjunction with the reduction in small mammal numbers (Section 3). Based on the expectation that home range sizes scale with body size I expected that coyotes would have the largest home ranges and this is borne out my study.

Coyotes, bobcats and raccoons live in sympatry over a large portion of their range throughout North America. Several studies have been conducted to investigate the home ranges of these mesopredators in the southeastern US (Chamberlain et al. 2000, Chamberlain and Leopold 2002, Chamberlain et al. 2003b, Cochrane et al. 2006, Fricke 2012). The home ranges of bobcats, coyotes and raccoons from the Pineywoods are larger than those estimated in other studies in the southeast (Chamberlain et al. 2000, Chamberlain and Leopold 2002, Chamberlain et al. 2003b, Cochrane et al. 2006, Fricke 2012). The extent of mesopredator home ranges scale with prey / food availability (Gittleman and Harvey 1982, Carbone and Gittleman 2002). It seems that the reason for the large home range sizes of mesopredators in the Pineywoods of east Texas may be linked to the relative paucity of the area in terms of prey productivity (Section 3). To ascertain the veracity of this would require similar estimates of seasonal small mammal numbers from other areas in the southeast, and a quantification of seasonal fruit production from the Pineywoods relative to other areas in the southeast.

Spatial partitioning between species

I expected that, despite all three species of mesopredator occurring on both study sites, individual species would use the space differentially to minimize the likelihood of encountering one another. This expectation was partially borne out in my study. I found that bobcats and coyotes overlap in terms of space use to a greater extent than do either bobcats and raccoons or coyotes and raccoons. Despite this distinction, the UDOI values for all species interactions were at the low end of the index scale (0 – 1). The values indicate that there is overlap between species as I expected on study sites on which the species live sympatrically. The degree to which the UDOI values indicate species overlap in space use is indicative of differential space use.

An alternative explanation for the overlap among species related to the population density of mesopredators in the Pineywoods of east Texas. Bobcat and coyotes densities in this area during the study were low (Davis 2011), with relatively large home range sizes. The consequence of this was that although the home ranges between species overlapped substantially, the likelihood of encounters were low and this resulted in the relatively small UDOI values.

Avoidance of one another is a mechanism by which subordinate predators can avoid aggressive interactions with dominant predators. This avoidance is usually manifested by differential partitioning of the area of sympatry either temporally or spatially (Carothers and Jaksić 1984, Durant 2000, Atwood et al. 2011). It seems therefore that my study concurs with the contention that sympatric mesopredators show differential space use patterns.

Intraspecific home range overlap

I predicted that there would be a high degree of home range overlap between individuals of the same species due to similar resource requirements. My results show a degree of ambiguity in terms of all mesopredator species. Using the UDOI index, I found that individuals within the same species have relatively low levels of overlap in terms of space use. However, using the percentage overlap method, I found that there was a far higher degree of overlap than suggested by UDOI. I suggest that this is a result of the difference in the analysis methods – the percentage overlap method is intuitively the easiest to interpret and makes sense, but does not take into consideration the utilization distribution of the individual within the home range. The UDOI index is based on the utilization distribution. My results here agree with Fieberg and Kochanny (2005) insofar as although individuals within the same species seem to have relatively large areas of overlap, in reality, the likelihood of animals occurring in the same area is relatively small.

Using the UDOI index, bobcats seemed to have the lowest level of overlap, in terms of space use, whereas raccoons and coyotes had similar levels of overlap. Coyotes had the highest level of overlap, but even this was at the low end of the UDOI scale. The low degree of spatial overlap within the same species, although not predicted, was expected. Individuals within the same species have very similar resource requirements and occupation of the same area would result in competition for resources (Pianka 2000). It seems that within all three species of mesopredator, despite there being relatively high levels of percentage home range overlap, there is a high degree of spatial partitioning within species. The difference between the degree of overlap between bobcats and raccoons and coyotes, may be explained by the differences in their diets. Bobcats being carnivorous have a more limited diet than do either coyotes or raccoons (Section 3). The consequence of this was probably manifested by the low degree of spatial overlap between bobcats. Conversely, the diverse diets of coyotes and raccoons (Section 3) were likely less limiting and consequently there was a higher degree of spatial overlap between individuals of these species.

Mesopredator Habitat Selection

My prediction that bobcats, coyotes and raccoons should display differential selection for the vegetation within the study sites was confirmed. However, my thought that there would be a seasonal variation in the vegetation type selected by any of the species, was only confirmed for bobcats.

Because of their dominance in terms of percentage contribution to the overall vegetative cover (Table 2.1), I thought that it was likely that the two pine vegetation types would be important components of all species selection. This was borne out by my analysis, but the degree of selection for these types of vegetation were surprisingly low for bobcats and coyotes on the second order level (the contribution of pine vegetation types in home ranges was surprisingly low relative to their availability within the study sites). However, on the second order level, raccoons selected the pine vegetation types in order of their contribution to the study sites.

Bobcats displayed a seasonal variation in selection for vegetation types. This phenomenon may relate to the differential selection criteria that male and female solitary felids use upon which to select habitats. Female solitary felids select habitats based on resource availability whereas males select habitats based on the distribution of females (Sandell 1989). Of particular interest is the differential selection between male and female bobcats in spring. Females preferred the pine plantation vegetation type during this period, whereas males seemed to use mixed and deciduous forests more at this time. Seasonal variations in habitat selection by bobcats have been noted in a number of areas throughout the U.S. (Heller and Fendley 1982, Rolley and Warde 1985, Koehler and Hornocker 1989). These variations have been attributed to changing prey abundance, climate and behavior (possibly attributable to breeding). Although there is no strict breeding and kitten rearing season for bobcats in east Texas, there is a period during which most of the births occur and consequently a synchronous period of when most kitten rearing takes place (Schmidly and Davis 2004). Similar to Mississippi (Chamberlain et al. 2003b), this period of increased rearing of young, takes place in the warmer months, corresponding to the spring in my study.

A consistent trend in the selection of vegetation types by both bobcats and coyotes was an avoidance of the agri/urban habitat type. This is unsurprising because these areas are greatly modified and are predominantly near to human habitations, which mesopredators tend to avoid (Jantz 2011). Where this ‘vegetation type’ was situated away from human habitation, it was usually devoid of vegetation and unlikely to provide resources that might motivate use by either bobcats or coyotes.

Coyotes used the grassland vegetation type far more than anticipated based on the contribution of this vegetation type to the overall land cover. Statistical evidence could only confirm preference for the grassland habitat for coyotes on an annual basis and in spring for the combination of both sexes and for male coyotes. However, despite the lack of statistical verification, the consistency with which the grassland habitat type was ranked highest suggests that there may be a biologically significant reason for this. It seems likely that the motivation for the selection of this habitat type would be resource availability. If this is the case, the use of grasslands might be motivated by the use of these areas by eastern cottontail rabbits (*Sylvilagus floridanus*) (Schmidly and Davis 2004) (a frequently used prey item – personal observation) for feeding. White tailed deer (*Odocoileus virginianus*) also venture out into grasslands to feed. White tailed deer are a preferred prey species of coyotes in east Texas (Section 3). In addition to this, it is likely that such grasslands border on road which coyotes use as travel corridors (Atwood et al. 2004). An implication resulting from this is the increased likelihood of coyotes encountering wild turkey poults because Isabelle (2011) found that eastern wild turkeys used this type of habitat during brood rearing, and coyotes selected this grassland vegetation type during spring and summer.

The availability of free water on the study sites was predominantly confined to small annual and perennial streams within streamside management zones (SMZ). These narrow (prescribed as approximately 15 m) (Service 2012) are the only areas where hardwood trees occur on the study sites, and consequently are the only areas that produce hard mast upon which raccoons may forage in the winter(Johnson 1970). Although, it is widely acknowledged that hardwood habitats are important to raccoons and selected by raccoons (Kaufmann 1982), these areas may be of limited value to raccoons on the study sites because these areas are so limited in scale that the value of their production is negligible in terms of raccoon diets (Section 3).

In many cases log piles were left after the thinning of pine stands. These log piles were situated in areas that I classified as agri / urban – being in clear cuts or on the verge of modified areas. In many cases raccoons used these log piles as dens. This might account for the seemingly high degree of use of agri / urban habitat types by raccoons. It seems that raccoons in the Pineywoods have adapted to the altered vegetation of the area. This is evidenced by the persistence of relatively high numbers of raccoons on timber sites. I concur with Chamberlain (2002) that, despite not being the typical habitat for raccoons, pine plantations can provide high quality habitat for raccoons. The understory if the pine plantations in the Pineywoods was supported large numbers of woody saplings and vines such as black berries (*Rubus fruticosus*), muscadine grapes (*Vitis rotundifolia*), and American beautyberries (*Callicarpa Americana*) (personal observation). Raccoons readily consumed fruits as components of their diets (Chamberlain et al. 2003a) (Section 3) when they became available. It is therefore likely that pine stands provided quality foraging habitat for raccoons especially during seasons when soft mast was produced (Chamberlain et al. 2003a).

Eastern wild turkey nest site selection relative to mesopredator vegetation type selection

I predicted that wild turkeys should select different vegetation types for nesting than those selected by the mesopredators that prey on them. My findings here are in direct contradiction of this prediction.

I based the habitat selection by wild turkeys for nest sites relative to the habitat composition of the study sites, and work on the nesting ecology of wild turkeys on the same sites (Isabelle 2010). Wild turkeys were observed to nest in three of the seven possible vegetation types within the study sites (Table 2.18). The selection hierarchy reflected this insofar as it classified the level of selection for vegetation type as highly significant. It was clear from these data that wild turkeys selected pine plantations and mature pine primarily for their nests. Relative to other studies in the US southeast, wild turkeys in east Texas nested further from man-made edges, such as track verges (Isabelle 2010). Whereas eastern wild turkeys nested within 25 m of edges in Georgia (Sisson et al. 1990), and within 10 m of edges in Mississippi (Seiss et al. 1990), wild turkeys in east Texas nested approximately 100 m away from edges (Campo 1989, Isabelle 2010). Equally clear, was my finding that wild turkeys avoided riparian areas and grasslands for their nests.

Bobcats, coyotes and raccoons showed significant levels of preference for specific vegetation types. From this analysis it was clear that, during spring, female bobcats and male coyotes preferentially selected the same types of vegetation that eastern wild turkeys selected for nesting, in the same hierarchical order, young pine followed by mature pine. Male and female raccoons selected the same vegetation types; however they selected them in the opposite order, mature pine, then young pine.

Despite the apparent overlap between turkey nest site and seasonal mesopredator habitat selection, there were factors that might have ameliorated the increased exposure to predation that might have been expected under such circumstances. The scale at which my analysis was undertaken may have masked the influence of fine scale habitat aspects that wild turkeys used to select nest sites. The nature of the understory is what determined where wild turkeys nested in forested habitats (Holbrook et al. 1985, Lazarus and Porter 1985, Holbrook et al. 1987, Schmutz et al. 1989, Isabelle 2010). Wild turkeys selected areas with high shrub density and ground cover to provide camouflage against predation (Lutz and Crawford 1987, Schmutz et al. 1989, Seiss et al. 1990, Isabelle 2010). In addition, eastern wild turkeys appeared to select nest sites in forest stands that had recently been burned or thinned, the result of which was that nest sites were located in vegetation of high structural diversity (Swanson et al. 1996, Isabelle 2010).

Using the spatial and temporal scale of my analysis, it seemed that nesting wild turkeys in east Texas were exposed to a triple threat of predation from the three mesopredators in question. It is unclear what the effect of such exposure was (Isabelle 2010). Intuitively it seemed that if a prey species were exposed to multiple predators, there would be an additive effect (Sih et al. 1998) and consequently an increase in predation on wild turkey nests and incubating hens. However, this was not necessarily the case, in most studies, it seemed that despite increased exposure, the influence of the predators on each other had a dampening effect on the degree to which prey were effected (Sih et al. 1998). This was the case when there were clear instances of intra-guild predation (predators preying on predators), or where behavioral interactions such as interference or avoidance of intra-guild predation reduced the predation rates on prey (Sih et al. 1998). In most instances this process was only seen as applicable to invertebrate communities, however, over the last two decades, evidence has come to the fore that this interaction may hold for large terrestrial species (Palomares et al. 1995, Barnowe-Meyer et al. 2010).

In the case of the relationship between wild turkeys nesting and their exposure to bobcats, coyotes and raccoons, theory suggested that the influence of the presence of coyotes (the *de facto* top carnivore) had a dampening effect on the influence of both bobcats and raccoons on the wild turkey nests, because coyotes preyed on both bobcats (Fedriani et al. 2000) and raccoons (Gehrt and Fritzell 1997, Chapter 3). Additionally, bobcats preyed on raccoons (Fritts and Sealander 1978, McLean et al. 2005, Baker et al. 2008, Chapter 3), and may have influenced the behavior of raccoons relative to preying on wild turkey nests. Therefore, the complex dynamics of the space use of three mesopredators in east Texas may have reduced the effects of predation by these mesopredators on wild turkeys.

Management Recommendations

At the scale at which my study was conducted, the three species of mesopredators selected the same vegetation types, during the spring and summer that eastern wild turkeys selected for nesting. Despite this the nest success of wild turkeys in this area were similar to those recorded elsewhere (Isabelle 2010). To verify the nature of predation on the eastern wild turkeys in the Pineywoods of east Texas will require a more fine scale monitoring approach. In areas where wild turkeys are known to persist, attempts should be made to capture and fit radio transmitters to several wild turkey hens. In cases where more wild turkey releases are planned, the females should be fitted with radio transmitters. Monitoring teams should be employed to locate and monitor the wild turkeys and locate wild turkey nests during the nesting period. The nests should be located and monitoring systems should be rigged to monitor the nests during the incubation period, this is the only way to confirm whether and which mesopredators are responsible for preying on wild turkey nests. Simultaneous to this, mesopredator monitoring should be implemented across the study sites to determine whether mesopredator density is higher in the vicinity of nests than other areas on the study site. In addition, flush counts to assess the success of female turkeys rearing poults to the flight stage should be conducted. If suitable sites can be found, the influence of prescriptive burning versus fire exclusion on nesting success and nest predation should be monitored.

3 - PREY SELECTION BY THREE MESOPREDATORS THAT ARE THOUGHT TO PREY ON EASTERN WILD TURKEYS (*MELEAGRIS GALLOPAVO SYLVESTRIS*) IN THE PINEYWOODS OF EAST TEXAS

Summary

Efforts to reintroduce eastern wild turkeys (*Meleagris gallopavo sylvestris*) to the Pineywoods of east Texas have achieved limited success. Predation, especially during the nesting and poult rearing seasons, is thought to be a major factor in the failure of wild turkeys to recruit and reestablish themselves in east Texas. I investigated prey population dynamics and prey selection, using scat analysis, of three mesopredators, bobcats (*Lynx rufus*), coyotes (*Canis latrans*) and raccoons (*Procyon lotor*) thought to prey on wild turkeys from January 2009 to August 2011. I investigated seasonal population dynamics of small mammals (Rodentia) using capture mark recapture techniques and spotlight surveys and track plate counts to investigate the seasonal dynamics of eastern cottontails (*Sylvilagus floridanus*; Lagomorpha). I found no evidence in 1764 scats that the three focal mesopredators preyed upon wild turkeys. I did however find remains of other avian species, chicken (*Gallus domesticus*) and Northern cardinal (*Cardinalis cardinalis*) in scats. Small mammals such as hispid cotton rats (*Sigmodon hispidus*) and fulvous harvest mice (*Reithrodontomys fulvescens*) and lagomorphs contributed substantially to diets of these mesopredators. Small mammal numbers, on each capture grid, varied seasonally tending to be at their highest during winter, declining spring through summer, and recovering during fall. Hispid cotton rat numbers, however, decreased between winter and spring, increased between spring and summer and declined in fall. Eastern cottontail rabbit relative abundance did not seem to fluctuate seasonally. Diets of mesopredators were most diverse in summer when small mammal populations declined. Bobcats increased use of small mammals during summer, whereas coyotes and raccoons diversified their diets to include seasonal fruits such as blackberries (*Rubus fruticosus*) and muscadine grapes (*Vitis rotundifolia*). The decline in the small mammal populations and the increase in diversity of mesopredator diets coincided with the wild turkey nesting and poult rearing season. This combination of factors indicated that the threat posed to wild turkeys by mesopredators was elevated during the turkey nesting and poult rearing season, although there was no evidence of this occurring during my study. I suggest that video monitoring radio transmittered wild turkeys whilst they incubate nests to identify nest predators. To identify predators of poults I suggest capture of newly hatched poults to fit them with lightweight radio transmitters, associated with close monitoring and follow up, in the case of poult mortalities being detected, to try to identify the poult predators. Further, I suggest that improving nesting habitat by implementing a regular burning regime would mitigate against high levels of nest predation, by reducing prey availability and improving nesting cover within the burned stands.

Keywords: Wild turkey (*Meleagris gallopavo*), small mammals, mesopredators, capture mark recapture, spotlight count, track plate count, scat analysis.

Introduction

There is an ongoing attempt to reestablish a viable population of eastern wild turkeys (*Meleagris gallopavo silvestris*) in the Pineywoods of east Texas (Lopez et al. 2000, Isabelle 2010). Whereas most attempts to reestablish populations of wild turkeys, throughout the United States, have been successful, this is not the case in east Texas (Newman 1945, Boyd and Oglesby 1975, Lopez et al. 2000, Isabelle 2010). Reasons for the failure of wild turkey reintroductions could include: habitat fragmentation, habitat modification, weather conditions, poor reproductive performance, translocation and release stress, and predation (Kennamer et al. 1992, Wakeling et al. 2001).

Many reasons, including predation by mammalian mesopredators, such as bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and raccoons (*Procyon lotor*), have been advanced to explain the limited success of the east Texas wild turkey reintroduction programs. There is substantial evidence that predation may be the primary cause of mortality for wild turkeys apart from adult gobblers (Speake 1980, Hamilton and Vangilder 1992, Miller and Leopold 1992, Hughes et al. 2005, Kennamer 2005).

Several authors have suggested that the aforementioned mesopredator species commonly prey upon wild turkeys (Lovell et al. 1995, Spohr 2001, Nguyen et al. 2003, Holdstock et al. 2006). Female eastern wild turkeys, their eggs and poults are particularly susceptible to predation during spring and early summer when female wild turkeys incubate nests and rear broods, particularly during the flightless period (Speake 1980, Lopez et al. 2000). Predation may have a limiting effect on the recruitment potential of low-density populations (Messier and Crête 1985, Newsome et al. 1989, Trout and Tittensor 1989, Kot et al. 1993, Terborgh et al. 2001), such as the reintroduced population of eastern wild turkeys in East Texas. Approximately half of all wild turkey nests are either depredated or abandoned, and more than 50% of all poults die within the first two weeks after hatching, in most cases due to predation (Miller and Leopold 1992). Coyotes, bobcats and raccoons live in sympatry over a large portion of their range throughout North America. This is the case in east Texas where they form part of the mesopredator assemblage that also includes red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargentus*), long-tailed weasels (*Mustela frenata*), American mink (*Mustela vison*), American badgers (*Taxidea taxus*), eastern spotted skunks (*Spilogale putorius*), striped skunks (*Memphitis memphitis*) and Virginia opossums (*Didelphis virginiana*) (Schmidly and Davis 2004). Bobcats are primarily carnivorous (Anderson 1985, Anderson 2003), whereas coyotes and raccoons are more omnivorous (Schmidly and Davis 2004). Small mammals (Litvaitis and Harrison 1989, Fedriani et al. 2000, Bartoszewicz et al. 2008) and lagomorphs (Baker et al. 1945, Fedriani et al. 2000, Baker et al. 2001, Anderson 2003, Bekoff 2003, Gehrt 2003, Schmidly and Davis 2004, Azevedo et al. 2006) contribute important components of the diet of these mesopredators. Behavioral mechanisms, including diet selection and space use are likely to facilitate co-existence among mesopredators (Wang and Macdonald 2009).

Feeding habits of predators reflect the availability of suitable prey and the adaptations that enable individual predators to subdue and consume prey (Krebs 1978, Sunquist and

Sunquist 1989). Investigation of the feeding habits of mesopredators can shed light on inter-specific competition, niche separation, and their possible impacts on species that form part of their prey base. The extent of niche differentiation and resource partitioning determines whether species can co-exist or competitively exclude each other (Pianka 1973, Carvalho and Gomes 2004, Merwe et al. 2009). An important mode of resource partitioning is the degree of dietary overlap between sympatric species (Hayward and Kerley 2008, Merwe et al. 2009). The overlap is constrained not only by the species' physical ability to obtain food, but also by the spatial and temporal availability of food (Azevedo et al. 2006, Merwe et al. 2009).

A number of mechanisms affect mesopredator prey selection. Predators display a functional response by altering their consumption of a prey species in response to prey abundance and availability (Holling 1959, Boutin 1995, Baker et al. 2001). This assumes that the predators can track prey abundance temporally, and that proportional use of prey is dependent on prey availability (Pianka 2000, Begon et al. 2006, Sinclair et al. 2006). The form of the relationship relates to the characteristics of both the predators and the prey that affect encounter rates, capture probability and point of satiation (Baker et al. 2001).

Predators respond behaviorally to variations in prey populations. The changes in food availability as a result of a decline in the prey populations often cause predators to alter their diets from selective to opportunistic ones (Dunn 1977, Jędrzejewska and

Jędrzejewski 1998, Schmidt and Ostfeld 2003;2008). Temporal variation in resource availability is a fundamental feature of the natural environment (Holt 2008). Consumers respond markedly to the variation in resource availability (Holt 2008). Populations of small mammals are known to vary seasonally (O'Connell 1989), where such seasonal variation has been demonstrated for various small mammal species in North America (Odum 1955, Packard 1968, Joule and Jameson 1972, Grant et al. 1985). It is likely, therefore, that mesopredators alter prey selection relative to small mammals as seasonal availability changes.

Little is known about the mesopredator assemblage and its dynamics in East Texas. To gain insight into the effect of predation by mesopredators on eastern wild turkeys, in the Pineywoods of east Texas, I investigated the following questions;

1. Do wild turkeys contribute to the diets of bobcats, coyotes and raccoons?
2. Do mesopredator diets vary seasonally?
3. To what extent do mesopredator diets overlap?
4. Is there a fluctuation in the seasonal availability of prey for the mesopredators?
5. If there is a seasonal fluctuation in small mammal populations, do predators respond functionally to the seasonal changes in prey availability?
6. If there is a seasonal fluctuation in small mammal populations, do the low points coincide with the nesting season of the wild turkeys?

Study area

I conducted this study in the Pineywoods of east Texas. The Pineywoods stretch across east Texas, northwestern Louisiana and southwestern Arkansas. It is the western extent of the Southeastern coastal plain and the vegetation communities bear close resemblance to the southeastern mixed forest and southeastern conifer forest vegetation types. Little of the original longleaf pine (*Pinus palustris*) forests remain, and have been largely replaced by even-aged loblolly pine (*Pinus taeda*) plantations. Much of the natural vegetation of the Pineywoods has been compromised due to the planting of pine plantations and the exclusion of fire (Omernik et al. 2008).

The Pineywoods are a continuation of the forests from adjacent states (Murphy 1976) (Murphy 1976). The eastern most region of Texas is characterized by a mixture of extensive pine and mixed pine and hardwood forests. The topography is that of gently rolling hills with swampy low-lying areas. Historically these pine forests were successional to hardwood forests (Landers Jr 1987.).

Commercial forestry in the region has increased since the 1992 forest surveys were completed (Kelly 1992a;b). In 1992, the USFS estimated that 67.5 % of the land in this part of East Texas was comprised of two dominant forest types: - loblolly pine (*Pinus taeda*)/ shortleaf pine (*Pinus echinata*) and longleaf pine / slash pine (*Pinus elliottii*). Estimates in 2003 indicate that there had been a marginal increase in the area under commercial forestry, from 4.78 million hectares in 1992, to 4.82 million hectares in 2003

(Rudis and Station 2008). Significantly, the amount of land under pine (*Pinus*) had increased by 30% to 2.27 million hectares between 1992 and 2002 (U.S. Department of Agriculture 2002, Rudis and Station 2008). It is likely that the percentage of land dedicated to softwood timber production will continue to increase (Haynes 2002). The remaining landscape supported a combination of woodland types including; oak (*Quercus* spp.)/ hickory (*Carya* spp.), oak/ gum (*Nyssa* spp.)/ cypress (*Taxodium* spp.), and oak/ pine mix (Murphy 1976, Kelly 1992a;b, Sivanpillai et al. 2005).

The nature of ownership is such that private land owners account for 63% of the ownership, with large portions of this land being in relatively small parcels of 0.4 to 3.6 ha. The consequence of the small parcel sizes is an increased degree of forest fragmentation (U.S. Department of Agriculture 2002). The habitat available for wild turkeys is substantially modified from that in which they used to occur. With the increase in timber plantations, continued habitat modification and increasing urbanization and turkey habitat is increasingly more fragmented now than in the past.

The mean annual rainfall in the Pineywoods is 1,192 millimeters (mm), with a monthly mean that varies between a low of 55 mm in July and 116.4 mm in May. The mean annual minimum temperature is 12.8° Celsius (C) and the mean annual maximum temperature is 25.5° C. The mean maximum temperature in the summer is 35° C (Sivanpillai et al. 2005). During my study, the mean annual temperature was 19.4° C, the minimum temperature recorded was – 5.3° C, and the maximum temperature was

38° C (NOAA 2012). The mean annual rainfall during my study was 1015 mm, with the highest rainfall occurring in 2009 (1243 mm) and the lowest in 2011 (832 mm) (NOAA 2012).

I conducted this study in the Nacogdoches and Angelina counties in east Texas, from January 2009 to September 2011. The two properties that formed the core of the study site are the Winston 8 Ranch (33 77 10 N, 348 64 10 W) (1360 ha, owned by Mr. Simon Winston) and the Cottingham Hunting Club Property (37 23 02 N, 347 83 15 W) (5000 ha, owned by Hancock Forest Management). I selected these properties because they were the only properties known to harbor populations of radio tagged eastern wild turkeys. Additionally, several wild turkey reintroductions have been attempted in these counties (Isabelle 2010).

Wild turkeys were released on the Winston 8 ranch in 2002 (1 male, 11 females) and 2003 (2 males, 7 females). From February 2007 to February 2008, a further 83 wild turkeys (66 female, 17 male) were released on the Winston 8 Ranch as part of a 'super-stocking' (Lopez et al. 2000) program (Isabelle 2010). The Cottingham Hunting club was not used as a 'super-stocking' site. In 1990, 15 wild turkeys were released about 3 km from the site and it seems that they continue to exist and nest on this property (Isabelle 2010).

Methods

To compare the biology of three species of mesopredator, prey species and the wild turkey it was necessary to select a data collection schedule that is relevant to all species. Therefore, I used the natural (solstices and equinoctial) seasons (winter: 21 December to 20 March, spring: 21 March to 20 June, summer: 21 June to 20 September, fall: 21 September to 20 December). Not only is this schedule relevant to all the mesopredators, but it also accommodates possible prey species, including eastern wild turkeys.

Mesopredator dietary analysis

I used scat analysis to analyze the diets of the mesopredators for this study (Putman 1984). It is possible to distinguish coyote, bobcat and raccoon scat based on the appearance (Toweill and Anthony 1988). Bobcats (Baker et al. 2001) and coyotes (Toweill and Anthony 1988) regularly defecate on paths and road verges, and I collected coyote and bobcat scats opportunistically whilst travelling the roads of the study sites. Bobcats and coyotes use roads as travel lanes and hunting areas (Bradley and Fagre 1988). My deliberate use of roads within the study sites for the collection of scats meant that the collection of scats was non-random with respect to microhabitat (Neale and Sacks 2001). Although my collection protocol was not randomized, the sample was likely to be a random sample of the diet of these species. I walked drainage lines and creek beds every two weeks for the duration of the study, from January 2009 to August 2011, searching for raccoon scats. Raccoon latrine sites are usually located near den sites and at the base of trees and on fallen logs, especially where these form bridges across drainages (Stains 1956, Gehrt 2003). I paid particular attention to these types of areas while searching for raccoon scats.

After collection, I placed the each scat sample in a paper bag and allowed it to air dry (Toweill and Anthony 1988, Carrera et al. 2008). I stored the scats in their paper bags for later analysis. I transferred scat samples from the paper bags into small nylon material (chiffon) sachets. I sealed the individual scats into the sachets with small zip ties, and marked each sachet with a unique identification number that related the sample to the species, date and location of collection. I washed each scat sample in its' nylon sachet to separate the identifiable macroscopic remains within the scat from the microscopic contents that washed out of the sachet (Toweill and Anthony 1988). I washed each scat sample individually to prevent migration of hairs and other diet items, and then hung the washed sachets to dry.

I separated the remaining macroscopic particles in each sample into four separate categories; bones and teeth, hair, plant material and insects, for identification. I used osteological and hair keys, samples from the study sites and reference books to identify sample contents (Toweill and Anthony 1988). I used the microscopic characteristics (cuticular scale patterns and medullary shapes) of the hairs from each scat sample to identify the species from which they originated (Prugh 2005). I made impressions of the cuticular scale patterns on microscope slides using a gelatin and methyl blue mixture (Melville et al. 2004). I examined the resultant impressions under a compound microscope and compared them to keys and reference slides to identify hair origins. In addition, I compared the medulla shapes of hairs from the scat sample to the key of hair of Texas Mammals (Debelica and Thies 2009). I compared tooth and bone remains to reference material housed in the Texas Cooperative Wildlife Collection (Department of Wildlife and Fisheries Sciences, Texas A&M University 2258. College Station, Texas 77843). Where I could not identify the origin of the sample, I consulted specialist taxonomists to assist with identification.

Prey population monitoring

Small mammals

I used live trapping grids combined with capture, mark and recapture (CMR) methodologies to estimate the small mammal population dynamics (Parmenter et al. 2003, Edalgo and Anderson 2007, Reed et al. 2007, Wiewel et al. 2007). I set 100 Sherman live traps in a 10 x 10 trap grid formation with 15 m between each trap. Each year I randomly selected six of a possible 29 (11 on Cottingham, 18 on Winston) known (from previous nesting seasons, Isabelle 2010) one year old wild turkey nest locations (three on each study site) for grid placement. I also selected six random locations (three on each study site) for a total of 12 grid CMR surveys every season; resulting in 24 survey grids for the study. Each year I changed the location of the trapping grids ensuring that each grid was at least one kilometer from the previous grid location to maintain independence. I baited the traps with a mixture of rolled oats and peanut butter, and sampled each grid for seven consecutive nights each season. I marked each animal that I captured with a uniquely numbered Passive Integrated Transponder (PIT) tag (Biomark®).

Hispid cotton rats were that largest small mammal species that I anticipated capturing. They were likely to have the largest home ranges because home ranges scale with body size for mammals (Lindstedt et al. 1986). I used estimates of the home ranges of hispid cotton rats (0.5 ha) from south Texas (Cameron and Spencer 1985) as the basis for the minimum grid spacing. This protocol allowed me to compare estimates of small mammal populations in areas used by eastern wild turkeys for nesting to random locations on the study sites.

During an initial period of sampling I found that I continued to capture unmarked animals throughout the seven days of exposure, and I had a low recapture rate. To ensure that I could apply the robust design model (Pollock 1982) which requires recaptures within the secondary sampling period, I maintained this sampling period throughout my study. The application of the robust design model requires a mean capture probability of 10% per sampling period (Pollock 1982). In addition to this, Pollock (1982) suggested that the minimum number of sampling periods is three primary periods divided into at least five secondary periods.

To try to prevent red imported fire ants (*Solenopsis invicta*) from preying on captured animals, I treated each trap location with a commercial insecticide (Talstar Granules, FMC Corporation, Agricultural Products Group, 1735 Market Street, Philadelphia, PA 19103). This product was non-toxic to small mammals and had no inhibitory effect on small mammals entering the traps (http://www.doyourownpestcontrol.com/SPEC/MSDS/talstarone.pdf). I treated the trap sites with the insecticide each season to ensure that any effect of the insecticide on small mammals was consistent over time.

I repeated the CMR protocol seasonally (4 iterations per year) on the same locations on each study site. I used the records of small mammal captures and recaptures to estimate the small mammal populations, of the three most abundant small mammal species, fulvous harvest mice (*Reithrodontomys fulvescens*), hispid cotton rats (*Sigmodon hispidus*) and white footed mice (*Peromyscus leucopus*), for each trapping grid using the robust design method in program MARK (White and Burnham 1999).

Lagomorphs

I used spotlight counts and track plate surveys to investigate seasonal variation in the eastern cottontail (*Sylvilagus floridanus*) abundance on two study sites in the Pineywoods of East Texas. I implemented track plate surveys in conjunction with night time road spotlight counts (Williams et al. 2012, Malaney and Frey 2006). I implemented two complimentary monitoring protocols for the cottontail rabbits because track plates have not been validated as an effective method for monitoring the change in relative abundance of lagomorphs (Ray and Zielinski 2008).

I conducted the spotlight counts according to a distance sampling protocol (Buckland et al. 1993), using a laser range finder to measure distance (m) from the vehicle to the animal of interest, and a compass to measure the bearing of the road and the bearing to the animal of interest. I established one spotlight route on each study site. While conducting spotlight counts, I was accompanied by a second observer; both of us were equipped with spotlights. We travelled the spotlight route on each study site, immediately after sunset, counting all the cottontails that we saw and recording the distances and bearings to the cottontails and the bearings along the road. Each spotlight route was approximately 20 km long (18.98 km on Cottingham, 21.96 km on Winston). I travelled each route every alternate evening for 14 days (7 iterations per study site) each season. I conducted consecutive iterations of the spotlight counts on each study site travelling in the opposite direction to that of the previous count. I travelled the routes at an average speed of 10 km/h. I delayed spotlight counts in inclement weather. When this occurred, I implemented the count on the next possible evening (Fletcher et al. 1999).

I set up the track plate survey with 25 track plates on each site, in two parallel lines (12 and 13 track plates) relative to access tracks on the study sites. Each track plate was located a minimum of 150 m from the tracks' verge. I made the track plates by covering one side of plywood backing plates (0.5 x 0.5 m) with Biofoam® (Hooper and Rea 2009) to create an impression surface. Biofoam® is orthotic foam and accepts and retains track impressions even after exposure to rain. The track-plates were oriented in two parallel lines of 12 and 13 track-plates. Each track plate was placed more than one eastern cottontail rabbit home range diameter away from the nearest track plate (Hamm et al. 2003, Ray and Zielinski 2008). The home range estimated for these cottontail rabbits was 5.95 ha (Bond et al. 2001) – therefore the minimum distance between track plates, based on this estimate, should have been 275 m. However, I used a spacing of 320 m between consecutive and opposite track plates to ensure that each track plate could be considered an independent sample unit. There were no home range estimates for eastern cottontail rabbits in east Texas; I therefore based the track plate spacing on home range estimates for eastern cottontail rabbits in Mississippi (Bond et al. 2001). I conducted my track plate survey on a site wise and seasonal basis.

I deployed the track plates simultaneously on both sites and exposed them for 14 consecutive days. During the exposure period, I checked the track plates every alternate day and marked any fresh track impressions with map pins. I recorded new sets of track impressions on seven occasions on each study site during the period for which the track plates were exposed. I did not quantify the number of eastern cottontail rabbit track impressions every time that I checked the track plates, rather I recorded the incidence of a species leaving tracks on a track plate as a detection (Sargeant et al. 1998, Ray and Zielinski 2008).

Analyses

Mesopredator diet

I estimated the relative frequency of each prey item within the mesopredator scats by species. I estimated the relative frequencies for each species relative to, study site, year and season. I calculated the number of items that I found in the scats by species and calculated a frequency of occurrence relative to the number of items identified within the scat sample for that species. I represented each item that I found within the scat samples as a percentage of the total number of items recorded for that mesopredator species, on an annual, seasonal and site wise basis. I assumed that records of hairs from the species from which the scat originated (i.e. the focal mesopredator), were as a result of grooming and I excluded those records from the total upon which I based the percentage contribution of items to the diets of the mesopredators (Leopold and Krausman 1986, Corbett 1989, Reynolds and Aebischer 1991, Jethva and Jhala 2004). I used χ^2 analysis using contingency tables to detect overall differences among categories of dietary components among and within species, between years, between site and between seasons (Fedriani et al. 2000). As far as possible I retained all categories of prey for these analyses. This type of analysis is sensitive to low expected values and where it was likely that the analysis would be confounded by low frequencies, I grouped closely related taxa (Table 3.1) (Fedriani et al. 2000).

I calculated the Shannon-Wiener index of dietary diversity for each mesopredator species on an annual and seasonal basis (Jethva and Jhala 2004). The Shannon-Wiener

Table 3.1: *Categories of prey used in Chi-Square analysis of the diets of bobcats* (Lynx rufus)*, coyotes* (Canis latrans) *and raccoons* (Procyon lotor) *in the Pineywoods of east Texas, from January 2009 to August 2011*

Species	Comparison	Season	Armadillo	Beauty berry	Bird	Choke cherry	Corn	Crawfish	Eastern wood rat	Feral hog	Fish	Green brier	Gray fox
All	Coyote vs Bobcat	Annual	x		x				x	x			
All	Coyote vs Bobcat	Fall			x				x	x			
All	Coyote vs Bobcat	Spring	x		x				x	x	x		
All	Coyote vs Bobcat	Summer	x		x				x	x			
All	Coyote vs Bobcat	Winter			x				x	x			
All	Raccoon vs Bobcat	Annual	x	x	x	x			x	x	x	x	
All	Raccoon vs Bobcat	Fall			x				x				
All	Raccoon vs Bobcat	Spring	x		x			x	x	x			
All	Raccoon vs Bobcat	Summer	x	x	x	x			x	x	x	x	
All	Raccoon vs Bobcat	Winter			x				x	x			
All	Raccoon vs coyote	Annual	x	x	x	x			x	x	x	x	
All	Raccoon vs coyote	Fall			x				x	x			
All	Raccoon vs coyote	Spring	x		x				x	x	x		
All	Raccoon vs coyote	Summer	x	x	x	x			x	x	x	x	
All	Raccoon vs coyote	Winter	x		x			x	x	x			
Bobcat	Ann vs Fall		x		x				x	x	x		
Bobcat	Ann vs spring		x		x				x	x	x		
Bobcat	Ann vs summer		x		x				x	x	x		
Bobcat	Ann vs winter		x		x				x	x	x		
Bobcat	Fall vs Spring		x		x				x	x	x		
Bobcat	Fall vs summer		x		x				x	x			
Bobcat	Fall vs winter				x				x	x			
Bobcat	Spring vs Summer		x		x				x	x	x		
Bobcat	Spring vs winter		x		x				x	x	x		
Bobcat	Summer vs Winter		x		x				x	x			
Coyote	Ann vs Fall		x		x	x			x	x	x	x	
Coyote	Ann vs spring		x		x				x	x	x		
Coyote	Ann vs summer		x		x	x			x	x	x	x	
Coyote	Ann vs winter		x		x				x	x	x	x	
Coyote	Fall vs Spring		x		x				x	x	x	x	
Coyote	Fall vs summer		x		x	x			x	x	x	x	
Coyote	Fall vs winter		x		x				x	x	x	x	
Coyote	Spring vs Summer		x		x				x	x	x	x	
Coyote	Spring vs winter		x		x				x	x	x		
Coyote	Summer vs Winter		x		x				x	x	x	x	
Raccoon	Ann vs Fall			x	x	x			x	x		x	
Raccoon	Ann vs spring		x		x			x		x	x		
Raccoon	Ann vs summer		x	x	x	x		x		x	x	x	x
Raccoon	Ann vs winter		x		x		x	x		x	x		x
Raccoon	Fall vs Spring		x		x			x		x	x		
Raccoon	Fall vs summer		x	x	x	x				x	x	x	
Raccoon	Fall vs winter			x	x		x	x		x			x
Raccoon	Spring vs Summer		x	x	x	x		x	x	x	x	x	
Raccoon	Spring vs winter		x		x		x	x		x	x		x
Raccoon	Summer vs Winter		x	x	x	x	x	x		x	x	x	x

Table 3.1: (Continued)

Species	**Comparison**	**Season**	**HCR**	**Insect**	**Rabbit**	**Meso**	**Mouse**	**Mulberry**	**Grape**	**Non**	**Norway Rat**	**Persimone**	**Plant**
All	Coyote vs Bobcat	Annual	x	x	x	x	x			x			x
All	Coyote vs Bobcat	Fall	x	x	x		x						x
All	Coyote vs Bobcat	Spring	x	x	x	x	x			x			
All	Coyote vs Bobcat	Summer	x	x	x	x	x						x
All	Coyote vs Bobcat	Winter	x	x	x	x	x						
All	Raccoon vs Bobcat	Annual	x	x	x	x	x		x	x			x
All	Raccoon vs Bobcat	Fall	x	x	x		x						x
All	Raccoon vs Bobcat	Spring	x	x	x	x	x				x		x
All	Raccoon vs Bobcat	Summer	x	x	x	x	x		x				x
All	Raccoon vs Bobcat	Winter	x	x	x	x	x				x		x
All	Raccoon vs coyote	Annual	x	x	x	x	x		x	x		x	x
All	Raccoon vs coyote	Fall	x		x	x	x			x			x
All	Raccoon vs coyote	Spring	x	x	x	x	x			x			x
All	Raccoon vs coyote	Summer	x	x	x	x	x		x			x	x
All	Raccoon vs coyote	Winter	x	x	x	x	x			x	x		x
Bobcat	Ann vs Fall		x	x	x	x	x						x
Bobcat	Ann vs spring		x	x	x	x	x						x
Bobcat	Ann vs summer		x	x	x	x	x						x
Bobcat	Ann vs winter		x	x	x	x	x						x
Bobcat	Fall vs Spring		x	x	x	x	x						
Bobcat	Fall vs summer		x	x	x	x	x						x
Bobcat	Fall vs winter		x	x	x	x	x						
Bobcat	Spring vs Summer		x	x	x	x	x						x
Bobcat	Spring vs winter		x	x	x	x	x						
Bobcat	Summer vs Winter		x	x	x	x	x						x
Coyote	Ann vs Fall		x	x	x	x	x		x	x		x	x
Coyote	Ann vs spring		x	x	x	x	x			x			x
Coyote	Ann vs summer		x	x	x	x	x		x	x		x	x
Coyote	Ann vs winter		x	x	x	x	x			x			x
Coyote	Fall vs Spring		x	x	x	x	x			x			x
Coyote	Fall vs summer		x	x	x	x	x	x	x	x		x	x
Coyote	Fall vs winter		x	x	x	x	x			x			x
Coyote	Spring vs Summer		x	x	x	x	x			x			x
Coyote	Spring vs winter		x	x	x	x	x			x			x
Coyote	Summer vs Winter		x	x	x	x	x			x			x
Raccoon	Ann vs Fall		x	x	x		x				x		x
Raccoon	Ann vs spring		x	x	x		x			x			x
Raccoon	Ann vs summer		x	x	x		x		x	x		x	x
Raccoon	Ann vs winter		x	x	x		x			x			x
Raccoon	Fall vs Spring		x	x	x		x			x			x
Raccoon	Fall vs summer		x	x	x				x	x		x	x
Raccoon	Fall vs winter		x	x	x					x			x
Raccoon	Spring vs Summer		x	x	x		x		x	x			x
Raccoon	Spring vs winter		x	x	x					x			x
Raccoon	Summer vs Winter		x	x	x				x			x	x

Table 3.1: (Continued)

Species	**Comparison**	**Season**	**Raccoon**	**Rat**	**Rubus**	**Rye grass**	**Sheep**	**Small mammal**	**Snake**	**Snails**	**Squirrel**	**Various**	**White tailed deer**
All	Coyote vs Bobcat	Annual		x				x				x	x
All	Coyote vs Bobcat	Fall	x									x	x
All	Coyote vs Bobcat	Spring			x							x	x
All	Coyote vs Bobcat	Summer						x	x				x
All	Coyote vs Bobcat	Winter						x				x	x
All	Raccoon vs Bobcat	Annual			x			x			x	x	x
All	Raccoon vs Bobcat	Fall		x					x			x	x
All	Raccoon vs Bobcat	Spring			x							x	x
All	Raccoon vs Bobcat	Summer							x		x		x
All	Raccoon vs Bobcat	Winter		x							x		x
All	Raccoon vs coyote	Annual			x			x				x	x
All	Raccoon vs coyote	Fall										x	x
All	Raccoon vs coyote	Spring			x							x	x
All	Raccoon vs coyote	Summer			x								x
All	Raccoon vs coyote	Winter										x	x
Bobcat	Ann vs Fall							x	x			x	x
Bobcat	Ann vs spring							x	x			x	x
Bobcat	Ann vs summer							x	x			x	x
Bobcat	Ann vs winter							x	x			x	x
Bobcat	Fall vs Spring				x		x	x	x				x
Bobcat	Fall vs summer							x	x				x
Bobcat	Fall vs winter							x	x				x
Bobcat	Spring vs Summer						x	x	x				x
Bobcat	Spring vs winter				x		x	x	x				x
Bobcat	Summer vs Winter							x	x				x
Coyote	Ann vs Fall				x			x				x	x
Coyote	Ann vs spring				x			x				x	x
Coyote	Ann vs summer				x			x				x	x
Coyote	Ann vs winter							x				x	x
Coyote	Fall vs Spring				x							x	x
Coyote	Fall vs summer											x	x
Coyote	Fall vs winter											x	x
Coyote	Spring vs Summer				x							x	x
Coyote	Spring vs winter											x	x
Coyote	Summer vs Winter											x	x
Raccoon	Ann vs Fall											x	x
Raccoon	Ann vs spring				x							x	x
Raccoon	Ann vs summer				x							x	x
Raccoon	Ann vs winter							x		x			x
Raccoon	Fall vs Spring			x	x								x
Raccoon	Fall vs summer				x			x					x
Raccoon	Fall vs winter							x		x			x
Raccoon	Spring vs Summer				x								x
Raccoon	Spring vs winter				x	x		x		x			x
Raccoon	Summer vs Winter				x	x		x		x			x

x : category included in
comparison
Meso : Mesopredator
Non : Items that did not fit into other categories
Grape : Muscadine grape

diversity index (*H*) calculates a score between 0 - 5 with low a low level of diversity tending towards a zero score and increasing as the diversity increases (May 1975). I used the following equation:

$$H = -\sum_{i=1}^{s} P_i \ln P_i$$

Where *s* is the total number of items in the diet, *P* is the proportional contribution of item *i* to the diet of the mesopredator (Begon et al. 2006).

I calculated dietary overlap using Pianka's index (*O*) (Pianka 1973, Fedriani et al. 2000, Glen and Dickman 2008), on an annual and seasonal basis for each pair of species (bobcat and coyote, bobcat and raccoon, coyote and raccoon). I used the following equation:

$$O_{jk} = \sum P_{ij}P_{ik}/(\sum P_{ij}^2 P_{ik}^2)^{1/2}$$

Where P_{ij} is the proportion of item *i* in the diet of mesopredator *j*, and P_{ik} is the proportion of item *i* in the diet of mesopredator *k* (Pianka 1973, Fedriani et al. 2000). Calculation of Pianka's index results in values between zero (indicating no overlap) and one (indicating complete overlap) (Pianka 1973, Glen and Dickman 2008). Overlap index values > 0.6 were considered biologically significant (Pianka 1976, Wallace Jr 1981, Bethea et al. 2006).

Prey populations

Small mammals

I calculated the minimum known alive (the number of different individuals captured) (Krebs 1966, Merritt et al. 2001) value for each species on each grid, during each season. I used these data and examined differences between years, seasons, study sites, nest site versus random site and species using a fixed effects analysis of variance (ANOVA). I used Pollock's Robust Design in program MARK (White and Burnham 1999) to estimate the population sizes of the three most commonly captured species; fulvous harvest mice, hispid cotton rats and white footed mice. I divided the sampling effort into a primary sampling interval (the seasonal samples) and the secondary sampling interval (subdivisions of the primary sampling interval) (Pollock 1982). The primary sampling intervals consisted of seven consecutive days of trap grid exposure per season; the secondary sample was the individual days of exposure within the seven day primary period. The classical robust design method assumes random immigration and emigration between primary sampling intervals and closure within the primary sampling intervals. I used the population estimates from program MARK for each of these species and used fixed effects ANOVA to compare the population size on the basis of year, study site, season and nest site versus random site.

Lagomorphs

Spotlight counts

I used the spotlight count data to calculate a spotlight count index. I calculated the number of eastern cottontail rabbit detections per kilometer per night and used this as a measure of relative eastern cottontail rabbit abundance. I used a log transformation to normalize the index values. I then used the transformed index values calculated by this method in fixed effects ANOVA and compared the index values between years, study sites and seasons. I used linear regression to determine whether there was a correlation between the spotlight and track plate indices (Schmidt et al. 2011).

Track plate surveys

I used the track plate data to calculate a track plate index. I divided the number track plate visitations per unit time by the number of track plates (Drennan et al. 1998, Dijak and Thompson III 2000) (Wilson and Delahay 2001, Crooks 2002, Glennon et al. 2002, Lenth et al. 2008). I calculated this index on a site and seasonal basis. I used a log transformation to normalize the index values. I used the transformed index values in fixed effects ANOVA to compare the indices on the basis of year, study site and season (Gentry and Vierling 2007). I used the full logistic regression model, including the variables; year, study site and season relative to detection of eastern cottontail rabbit tracks on track plates. I validated this model using a Hosmer-Lemeshow test and a likelihood ratio test.

Results

Mesopredator diets

I collected and analyzed 1764 mesopredator scats from January 2009 to August 2011 (bobcat; total = 637, fall = 27, spring = 160, summer = 152, winter = 298), (coyote; total = 841, fall = 54, spring = 235, summer = 252, winter = 299) (raccoon; total = 286, fall = 28, spring = 123, summer = 71, winter = 64). I identified 3383 individual items (bobcat = 976, coyote = 1688, raccoon = 719). A basic measure of dietary richness, number of items per scat (bobcat = 1.53, coyote = 2.01, raccoon = 2.47) showed that bobcats had the most restricted diets.

Bobcats

I identified 40 types of ingesta, including vegetable matter, insects, fish, birds, reptiles and mammals in bobcat scats (Table 3.2). The items that I found most frequently in the diets of bobcats were; lagomorphs 29% (eastern cottontail rabbits; 25%, swamp rabbits (*Sylvilagus aquaticus*); 4%), hispid cotton rats (25%), white tailed deer (*Odocoileus virginianus*) (9%), and eastern wood rats (*Neotoma floridana*) 7% (Table 3.2). I found no identifiable eastern wild turkey remains in bobcat scats despite there being domestic chicken (*Gallus domesticus*), Northern cardinal (*Cardinalis cardinalis*), woodpecker (*Picoides sp.*) and remnants from other unidentified (from feathers or bone) birds in the samples. Seasonally, the items that I found most frequently in bobcat scats were eastern cottontail rabbits (fall; 38%, spring; 30 %), and hispid cotton rats (summer; 20 %, winter; 32 %). I found no difference in bobcat diets between study sites ($\chi^2 = 2.89$, df =

Table 3.2*: The occurrence of dietary items in the bobcat* (Lynx rufus) *scats collected in the Pineywoods of east Texas from January 2009 to August 2011*

Type	**Species**	**Common Name**	**Annual**		**2009**		**2010**		**2011**		**Fall**		**Spring**		**Summer**		**Winter**	
			n	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***
Bird	*Cardinalis cardinalis*	Cardinal	1	0.1	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Gallus gallus domesticus	Chicken	24	2.5	16	2.5	6	2.9	2	1.7	4	10.3	5	2.0	7	3.0	8	1.8
	Picoides sp.	Woodpecker	1	0.1	0	0.0	1	0.5	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
		Unidentified bird	2	0.2	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	1	0.2
Fish			2	0.2	2	0.3	0	0.0	0	0.0	0	0.0	2	0.8	0	0.0	0	0.0
Insects			19	2.0	9	1.4	3	1.5	7	5.9	2	5.1	12	4.9	1	0.4	4	0.9
Mammals	*Odocoileus virginianus*	White tailed deer	88	9.1	64	10.0	16	7.8	8	6.7	3	7.7	26	10.6	38	16.4	21	4.7
	Ovis aries	Sheep	1	0.1	0	0.0	0	0.0	1	0.8	0	0.0	1	0.4	0	0.0	0	0.0
	Sus scrofa	Hog	12	1.2	8	1.3	3	1.5	1	0.8	0	0.0	4	1.6	2	0.9	6	1.3
	Dasypus novemcinctus	Armadillo	4	0.4	2	0.3	2	1.0	0	0.0	0	0.0	1	0.4	3	1.3	0	0.0
	Lynx rufus	Bobcat	9	*	6	*	2	*	1	*	0	*	2	*	2	*	5	*
	Felis sylvestris catus	Domestic cat	3	0.3	2	0.3	1	0.5	0	0.0	0	0.0	1	0.4	0	0.0	2	0.4
	Urocyon cinereoargenteus	Gray fox	7	0.7	4	0.6	1	0.5	2	1.7	0	0.0	2	0.8	1	0.4	4	0.9
	Didelphis virginiana	Opossum	3	0.3	2	0.3	1	0.5	0	0.0	0	0.0	1	0.4	0	0.0	2	0.4
	Procyon lotor	Raccoon	29	3.0	19	3.0	5	2.5	5	4.2	0	0.0	9	3.7	11	4.7	9	2.0
	Vulpes vulpes	Red fox	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	1	0.4	0	0.0
	Sylvilagus floridanus	Eastern cottontail	245	25.3	136	21.3	58	28.4	51	42.9	15	38.5	73	29.8	42	18.1	115	25.5
	Sylvilagus aquaticus	Swamp rabbit	41	4.2	19	3.0	19	9.3	3	2.5	1	2.6	13	5.3	5	2.2	22	4.9
	Sciurus niger	Eastern fox squirrel	3	0.3	2	0.3	1	0.5	0	0.0	0	0.0	0	0.0	1	0.4	2	0.4
	Sciurus carolinensis	Eastern gray squirrel	1	0.1	0	0.0	1	0.5	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Neotoma floridana	Eastern wood rat	69	7.1	48	7.5	17	8.3	4	3.4	3	7.7	14	5.7	15	6.5	37	8.2
	Sigmodon hispidus	Hispid Cotton Rat	246	25.4	182	28.4	40	19.6	24	20.2	6	15.4	47	19.2	47	20.3	146	32.4
	Rattus norvegicus	Norway rat	6	0.6	2	0.3	3	1.5	1	0.8	0	0.0	2	0.8	1	0.4	3	0.7
	Rattus rattus	Rat	2	0.2	0	0.0	0	0.0	0	0.0	1	2.6	0	0.0	0	0.0	1	0.2
	Peromyscus gossypinus	Cotton mouse	20	2.1	16	2.5	4	2.0	0	0.0	0	0.0	4	1.6	7	3.0	9	2.0
	Peromyscus leucopus	White footed mouse	21	2.2	15	2.3	3	1.5	3	2.5	1	2.6	6	2.4	2	0.9	12	2.7
	Ochrotomys nutalli	Golden mouse	7	0.7	6	0.9	1	0.5	0	0.0	0	0.0	0	0.0	2	0.9	5	1.1
	Reithrodontomys humulis	Eastern harvest Mouse	20	2.1	19	3.0	1	0.5	0	0.0	0	0.0	3	1.2	9	3.9	8	1.8
	Reithrodontomys fulvescens	Fulvous harvest mouse	34	3.5	26	4.1	7	3.4	1	0.8	1	2.6	4	1.6	10	4.3	19	4.2
Snake	*Coluber spp.*	Racer species	1	0.1	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
	Nerodia spp.	Water snake species	1	0.1	1	0.2	0	0.0	0	0.0	1	2.6	0	0.0	0	0.0	0	0.0
	Agkistrodon piscivorus	Cotton mouth	1	0.1	1	0.2	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0
	Crotalus horridus	Timber rattle snake	1	0.1	0	0.0	1	0.5	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
Plant	*Callicarpa americana*	Beauty berry	1	0.1	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
	Rubus fruticosus	Black berry	2	0.2	1	0.2	0	0.0	1	0.8	0	0.0	2	0.8	0	0.0	0	0.0
	Prunus virginiana	Choke cherry	2	0.2	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	2	0.9	0	0.0
		Grass	35	3.6	21	3.3	9	4.4	5	4.2	1	2.6	11	4.5	11	4.7	12	2.7
	Smilax rotundifolia	Green briar	2	0.2	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0	2	0.9	0	0.0
	Vitis rotundifolia	Muscadine	7	0.7	7	1.1	0	0.0	0	0.0	0	0.0	0	0.0	7	3.0	0	0.0
	Pyrus spp.	Pear	1	0.1	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0

21, *P* = 0.175). Bobcat diets did not vary between 2010 and 2011 (χ^2 = 16.21, df = 13, *P* = 0.238), but varied between 2009 and 2010 (χ^2 = 22.92, df = 13, *P* = 0.043), and between 2009 and 2011 (χ^2 = 47.98, df = 14, *P* < 0.001). Annual bobcat diet did not differ from fall or spring diet; however, it differed from summer and winter diet (Table 3.3). Spring and fall diets were similar (Table 3.3). The diversity value for bobcat diets varied (fall; *H* = 1.93, summer; *H* = 2.47) (Table 3.4).

Coyotes

I identified 49 types of ingesta, including vegetable matter, insects, fish, birds, reptiles and miscellaneous man-made goods, in coyote scats (Table 3.5). The items that I found most frequently in coyote scats were mammals (white tailed deer; 18%, eastern cottontail rabbit; 13 %, hispid cotton rat; 10%, feral hogs (*Sus scrofa*); 9%), and plants (blackberry (*Rubus fruticosus*); 11%, muscadine grapes (*Vitis rotundifolia*); 5%). I found no eastern wild turkey remains in coyote scats, despite finding domestic chicken, northern cardinal, mourning dove (*Zenaida macroura*) and remnants of other unidentified (from feathers or bone) birds in the samples. Seasonally, the most important mammalian prey were; white tailed deer (summer; 10%), and eastern cottontail rabbit (winter; 15%, fall; 11%, spring; 18%). Plant species in scats varied seasonally, blackberry (spring; 27%) and muscadine grapes (summer; 14%) (Table 3.5). Coyote diets differed between sites (χ^2 = 43.97, df = 14, *P* < 0.001) and years (2009 vs 2010; χ^2 = 75.37, df = 17, *P* < 0.001 : 2009 vs 2011; χ^2 = 120.77, df = 17, *P* < 0.001 : 2010 vs 2011; χ^2 = 119.79, df = 17, *P* < 0.001). Annual diets differed from seasonal

Table 3.3: *Chi- square test results comparing the seasonal diets of three mesopredators in the Pineywoods of east Texas from January 2009 to August 2011*

Species	**Seasons compared**	χ^2	**df**	***P* value**
Bobcat	Annual vs Fall	19.44	14	0.1489
Bobcat	Annual vs Spring	19.69	14	0.1403
Bobcat	Annual vs Summer	39.51	14	0.0003036
Bobcat	Annual vs Winter	29.30	14	0.009521
Bobcat	Fall vs Spring	15.17	14	0.3669
Bobcat	Fall vs Summer	27.18	12	0.00729
Bobcat	Fall vs Winter	32.92	10	0.0002806
Bobcat	Spring vs Summer	39.55	14	0.0002998
Bobcat	Spring vs Winter	50.25	14	5.54E-06
Bobcat	Summer vs Winter	68.82	12	5.31E-10
Coyote	Annual vs Fall	68.79	19	1.46E-07
Coyote	Annual vs Spring	205.29	15	2.20E-16
Coyote	Annual vs Summer	165.66	19	2.20E-16
Coyote	Annual vs Winter	223.84	16	2.20E-16
Coyote	Fall vs Spring	211.73	15	2.20E-16
Coyote	Fall vs Summer	72.80	18	1.51E-08
Coyote	Fall vs Winter	152.12	13	2.20E-16
Coyote	Spring vs Summer	342.26	15	2.20E-16
Coyote	Spring vs Winter	260.34	13	2.20E-16
Coyote	Summer vs Winter	322.28	14	2.20E-16
Raccoon	Annual vs Fall	73.88	13	1.54E-10
Raccoon	Annual vs Spring	66.16	13	4.06E-09
Raccoon	Annual vs Summer	31.18	19	0.03861
Raccoon	Annual vs Winter	68.97	15	6.82E-09
Raccoon	Fall vs Spring	167.34	13	2.20E-16
Raccoon	Fall vs Summer	45.83	16	0.0001035
Raccoon	Fall vs Winter	83.43	13	2.48E-12
Raccoon	Spring vs Summer	97.84	17	2.23E-13
Raccoon	Spring vs Winter	120.73	16	2.20E-16
Raccoon	Summer vs Winter	106.31	20	9.20E-14

Table 3.4: *Shannon Wiener Diversity Index (H) values for the diets of three mesopredators in the Pineywoods of east Texas from January 2009 to August 2011*

Species	**Season**	***H***
Bobcat	Annual	2.35
Bobcat	Fall	1.93
Bobcat	Spring	2.29
Bobcat	Summer	2.47
Bobcat	Winter	2.13
Coyote	Annual	2.71
Coyote	Fall	2.44
Coyote	Spring	2.12
Coyote	Summer	2.90
Coyote	Winter	2.09
Raccoon	Annual	2.75
Raccoon	Fall	2.43
Raccoon	Spring	1.96
Raccoon	Summer	2.83
Raccoon	Winter	2.31

Table 3.5*: The occurrence of dietary items in the coyote* (Canis latrans) *scats collected in the Pineywoods of east Texas from January 2009 to August 2011*

Type	**Species**	**Common Name**	**Annual**		**Cottingham**		**Winston**		**2009**		**2010**		**2011**		**Fall**		**Spring**		**Summer**		**Winter**	
			n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Bird	*Cardinalis cardinalis*	Cardinal	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Gallus gallus domesticus	Chicken	41	2.5	37	2.7	4	1.0	15	1.5	19	4.8	7	2.6	5	5.2	3	0.6	12	2.1	21	4.4
	Zenaida macroura	Mourning dove	2	0.1	0	0.0	0	0.0	1	0.1	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	2	0.4
	Unidentified Bird	Unidentified Bird	10	0.6	9	0.7	1	0.2	5	0.5	4	1.0	1	0.4	2	2.1	4	0.8	4	0.7	0	0.0
Fish			2	0.1	2	0.1	0	0.1	2	0.2	0	0.0	0	0.0	0	0.0	1	0.2	1	0.2	0	0.0
Insect			70	4.2	60	4.4	10	1.5	25	2.5	10	2.5	35	12.9	0	0.0	55	10.6	11	2.0	4	0.8
Mammal	*Odocoileus virginianus*	White tailed deer	292	17.7	230	16.9	62	5.9	170	17.2	70	17.8	52	19.1	22	22.7	79	15.3	55	9.8	136	28.5
	Equus caballus	Horse	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0
	Sus scrofa	Hog	145	8.8	137	10.1	8	3.5	92	9.3	26	6.6	27	9.9	6	6.2	26	5.0	27	4.8	86	18.0
	Ovis aries	Sheep	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	1	0.2	0	0.0	0	0.0
	Lynx rufus	Bobcat	5	0.3	2	0.1	3	0.1	3	0.3	2	0.5	0	0.0	0	0.0	1	0.2	4	0.7	0	0.0
	Canis latrans	Coyote	34	*	28	*	6	*	21	*	9	*	4	*	1	*	13	*	9	*	11	*
	Urocyon cinereoargenteus	Gray fox	9	0.5	8	0.6	1	0.2	5	0.5	3	0.8	1	0.4	0	0.0	1	0.2	4	0.7	4	0.8
	Didelphis virginiana	Opossum	2	0.1	2	0.1	0	0.1	1	0.1	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	1	0.2
	Procyon lotor	Raccoon	38	2.3	26	1.9	12	0.7	16	1.6	12	3.1	10	3.7	1	1.0	9	1.7	15	2.7	13	2.7
	Dasypus novemcinctus	Armadillo	21	1.3	13	1.0	8	0.3	7	0.7	12	3.1	2	0.7	0	0.0	7	1.4	13	2.3	1	0.2
	Lepus californicus	Black tailed Jack Rabbit	2	0.1	1	0.1	1	0.0	1	0.1	1	0.3	0	0.0	0	0.0	1	0.2	0	0.0	1	0.2
	Sylvilagus floridanus	Eastern cotton tail	218	13.2	189	13.9	29	4.9	120	12.2	43	10.9	55	20.2	11	11.3	94	18.2	43	7.7	70	14.7
	Sylvilagus aquaticus	Swamp rabbit	21	1.3	17	1.3	4	0.4	9	0.9	6	1.5	6	2.2	0	0.0	8	1.5	7	1.2	6	1.3
	Neotoma floridana	Eastern wood rat	33	2.0	23	1.7	10	0.6	21	2.1	9	2.3	3	1.1	1	1.0	10	1.9	8	1.4	14	2.9
	Rattus norvegicus	Norway rat	1	0.1	1	0.1	0	0.0	1	0.1	0	*0.0*	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Sigmodon hispidus	Hispid cotton rat	162	9.8	128	9.4	34	3.3	116	11.8	32	8.1	14	5.1	11	11.3	42	8.1	49	8.7	60	12.6
	Peromyscus gossypinus	Cotton mouse	11	0.7	10	0.7	1	0.3	9	0.9	1	0.3	1	0.4	1	1.0	2	0.4	5	0.9	3	0.6
	Peromyscus leucopus	White footed mouse	9	0.5	7	0.5	2	0.2	6	0.6	3	0.8	0	0.0	0	0.0	2	0.4	3	0.5	4	0.8
	Ochrotomys nutalli	Golden mouse	5	0.3	4	0.3	1	0.1	3	0.3	2	0.5	0	0.0	0	0.0	0	0.0	4	0.7	1	0.2
	Reithrodontomys humulis	Eastern Harvest mouse	14	0.8	13	1.0	1	0.3	13	1.3	0	0.0	1	0.4	0	0.0	2	0.4	8	1.4	4	0.8
	Reithrodontomys fulvescens	Fulvous harvest mouse	27	1.6	22	1.6	5	0.6	21	2.1	4	1.0	2	0.7	3	3.1	3	0.6	10	1.8	11	2.3
	Mus muscullus	House mouse	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0
	Geomys breviceps	Baird's Pocket Gopher	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0

Table 3.5: (Continued)

Type	**Species**	**Common Name**	**Annual**		**Cottingham**		**Winston**		**2009**		**2010**		**2011**		**Fall**		**Spring**		**Summer**		**Winter**	
			n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Plant	*Callicarpa americana*	Beauty berry	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0
	Rubus fruticosus	Black berry	174	10.6	148	10.9	26	3.8	114	11.6	21	5.3	39	14.3	0	0.0	141	27.3	33	5.9	0	0.0
	Prunus virginiana	Choke cherry	37	2.2	32	2.4	5	0.8	26	2.6	11	2.8	0	0.0	3	3.1	0	0.0	34	6.1	0	0.0
	Zea mays	Corn	1	0.1	1	0.1	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0
		Grass	90	5.5	67	4.9	23	1.7	63	6.4	19	4.8	8	2.9	3	3.1	20	3.9	42	7.5	25	5.2
	Smilax rotundifolia	Green briar	58	3.5	58	4.3	0	1.5	40	4.1	17	4.3	1	0.4	7	7.2	1	0.2	49	8.7	1	0.2
	Morus nigra	Mulberry	9	0.5	9	0.7	0	0.2	5	0.5	4	1.0	0	0.0	6	6.2	0	0.0	3	0.5	0	0.0
	Vitis rotundifolia	Muscadine	86	5.2	64	4.7	22	1.7	54	5.5	31	7.9	1	0.4	5	5.2	0	0.0	81	14.4	5	1.0
	Pyrus spp.	Pear	1	0.1	0	0.0	1	0.0	0	0.0	1	0.3	0	0.0	1	1.0	0	0.0	0	0.0	0	0.0
	Ampelopsis arborea	Peppervine	5	0.3	4	0.3	1	0.1	0	0.0	5	1.3	0	0.0	0	0.0	0	0.0	5	0.9	0	0.0
	Diospyros virginiana	Persimone	21	1.3	19	1.4	2	0.5	11	1.1	10	2.5	0	0.0	8	8.2	0	0.0	13	2.3	0	0.0
		Plant unknown	8	0.5	3	0.2	5	0.1	0	0.0	8	2.0	0	0.0	0	0.0	0	0.0	8	1.4	0	0.0
	Ligustrum vulgare	Privet	1	0.1	0	0.0	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0
	Cucurbita spp.	Pumpkin	1	0.1	0	0.0	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0
	Citrullus lanatus	Watermelon	4	0.2	1	0.1	3	0.0	1	0.1	2	0.5	1	0.4	0	0.0	0	0.0	4	0.7	0	0.0
Reptile		Lizard unknown	1	0.1	1	0.1	0	0.0	0	0.0	1	0.3	0	0.0	1	1.0	0	0.0	0	0.0	0	0.0
		Snakes unknown	2	0.1	2	0.1	0	0.1	1	0.1	0	0.0	1	0.4	0	0.0	2	0.4	0	0.0	0	0.0
Miscellaneous		Leather	2	0.1	2	0.1	0	0.1	2	0.2	0	0.0	0	0.0	0	0.0	2	0.4	0	0.0	0	0.0
		Latex	1	0.1	1	0.1	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
		Plastic	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2

diets, and seasonal diets differed from one another (Table 3.3). The diversity value for coyote diets varied (winter; $H = 2.08$, summer; $H = 2.90$) (Table 3.4).

Raccoons

I identified 41 types of ingesta including vegetable matter, insects, fish, birds, mammals, reptiles, aquatic invertebrates and man made goods in raccoon scats (Table 3.6). The components that I found most frequently were insects (19%), mammals (Eastern cottontail rabbits; 8%, white tailed deer; 6%, hispid cotton rat; 6%), plants (blackberry; 18%, corn (*Zea mays*); 5%, muscadine grapes; 3%), and crawfish (*Cambarus* sp.; 3%). I found no identifiable remains of eastern wild turkeys in raccoon scats, despite there being remnants of domestic chicken, woodpecker, and other unidentified (from feathers or bone) birds in the samples. Seasonally the most important items in raccoon scats were beauty berry (*Callicarpa americana*) (fall; 23%), blackberry (spring; 36%, summer; 15%) and insects (winter; 24%). Hispid cotton rat remains occurred most (7%) during spring and summer. Raccoon diets did not differ between sites ($\chi^2 = 19.03$, df = 11, $P = 0.061$). Raccoon diets differed between years (2009 vs 2010; $\chi^2 = 23.17$, df = 12, $P = 0.026$: 2009 vs 2011; $\chi^2 = 45.34$, df = 12, $P < 0.001$: 2010 vs 2011; $\chi^2 = 67.62$, df = 12, $P < 0.001$). Annual diets differed from seasonal diets, and seasonal diets differed (Table 3.3). The Shannon-Wiener diversity index for raccoon diets varied (spring; $H = 1.96$, summer; $H = 2.83$) (Table 3.4).

Table 3.6*: The occurrence of dietary items in the raccoon* (Procyon lotor) *scats collected in the Pineywoods of east Texas from January 2009 to August 2011*

Type	**Species**	**Common name**	**Annual**		**2009**		**2010**		**2011**		**Fall**		**Spring**		**Summer**		**Winter**	
			n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Bird	*Gallus gallus domesticus*	Chicken	8	1.4	5	1.7	2	1.7	1	0.7	1	1.8	1	0.4	5	3.5	1	0.8
	Picoides sp.	Woodpecker	1	0.2	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
		Unidentified bird	5	0.9	2	0.7	1	0.8	2	1.5	0	0.0	2	0.8	1	0.7	2	1.7
Fish		Unidentified fish	4	0.7	3	1.0	1	0.8	0	0.0	0	0.0	1	0.4	3	2.1	0	0.0
Insect		Unidentified insect	104	18.7	43	14.3	13	11.0	48	35.3	1	1.8	59	24.5	16	11.2	28	23.7
Mammal	*Odocoileus virginianus*	White tailed deer	35	6.3	16	5.3	15	12.7	4	2.9	5	8.9	11	4.6	7	4.9	15	12.7
	Sus scrofa	Feral hog	9	1.6	5	1.7	2	1.7	2	1.5	0	0.0	4	1.7	2	1.4	3	2.5
	Dasypus novemcinctus	Armadillo	11	2.0	6	2.0	4	3.4	1	0.7	0	0.0	8	3.3	3	2.1	0	0.0
	Procyon lotor	Raccoon	162	*	84	*	42	*	36	*	11	*	90	*	45	*	16	*
	Urocyon cinereoargenteus	Gray fox	1	0.2	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Sylvilagus floridanus	Eastern cottontail	47	8.5	21	7.0	5	4.2	21	15.4	2	3.6	24	10.0	9	6.3	12	10.2
	Sylvilagus aquaticus	Swamp rabbit	2	0.4	1	0.3	1	0.8	0	0.0	0	0.0	0	0.0	2	1.4	0	0.0
	Neotoma floridana	Eastern wood rat	4	0.7	1	0.3	3	2.5	0	0.0	1	1.8	2	0.8	1	0.7	0	0.0
	Rattus norvegicus	Norway rat	1	0.2	0	0.0	1	0.8	0	0.0	1	1.8	0	0.0	0	0.0	0	0.0
	Sigmodon hispidus	Hispid cotton rat	32	5.8	22	7.3	6	5.1	4	2.9	1	1.8	18	7.5	10	7.0	3	2.5
	Reithrodontomys fulvescens	Fulvous harvest mouse	3	0.5	1	0.3	2	1.7	0	0.0	1	1.8	1	0.4	1	0.7	0	0.0
	Ochrotomys nutalli	Golden mouse	1	0.2	1	0.3	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0

Comparison of mesopredators

The diets of bobcats, coyotes and raccoons differed statistically from each other annually and in all seasons (Table 3.7). Despite this, Pianka's Overlap index values indicated that diets of mesopredators overlapped to varying degrees of biological significance (annually: bobcat vs coyotes; O = 0.72, coyote vs raccoon; O = 0.69, bobcat vs raccoon; O = 0.4) (Table 3.7). The greatest dietary overlap between bobcats and coyotes (O = 0.68), and bobcats and raccoons (O = 0.45) occurred in summer. The greatest degree of dietary overlap between coyotes and raccoons occurred in spring (O = 0.88). The overlap between the diets of raccoons and bobcats was lowest (fall; O = 0.19, to summer; O = 0.45). The dietary overlap index between bobcats and coyotes had the narrowest range (fall; O = 0.58, to annual; O = 0.72). The overlap index between coyotes and raccoons varied most (fall; O = 0.3, spring; O = 0.88) (Table 3.7).

The mammals that occurred most in mesopredator scats were eastern cottontail rabbits, hispid cotton rats and white tailed deer (Table 3.2, 3.5, 3.6). Plant matter occurred infrequently in bobcat scats. I found that blackberries and muscadine grapes most frequently occurred in coyote and raccoon scats.

Prey

Small mammals

Seasonal small mammal trapping for 67200 trap nights from January 2009 to December 2010 resulted capture of 1922 individual small mammals of seven species (Table 3.8).

Table 3.7: *Chi-square tests result and the associated Pianka dietary overlap (O) values for three three mesopredators in the Pineywoods of east Texas from January 2009 to August 2011*

Species Compared	**Season**	χ^2	**df**	***P***	***O***
Bobcat vs Coyote	Annual	570.29	14	2.20E-16	0.72
Bobcat vs Coyote	Fall	42.13	10	7.11E-06	0.58
Bobcat vs Coyote	Spring	144.08	13	2.20E-16	0.65
Bobcat vs Coyote	Summer	148.51	12	2.20E-16	0.68
Bobcat vs Coyote	Winter	243.47	10	2.20E-16	0.58
Raccoon vs Coyote	Annual	471.35	20	2.20E-16	0.69
Raccoon vs Coyote	Fall	30.53	10	0.0007001	0.30
Raccoon vs Coyote	Spring	87.79	14	9.92E-13	0.88
Raccoon vs Coyote	Summer	107.82	17	3.10E-15	0.76
Raccoon vs Coyote	Winter	326.97	14	2.20E-16	0.40
Bobcat vs Raccoon	Annual	746.07	20	2.20E-16	0.41
Bobcat vs Raccoon	Fall	58.35	10	7.44E-09	0.19
Bobcat vs Raccoon	Spring	206.39	14	2.20E-16	0.39
Bobcat vs Raccoon	Summer	180.47	18	2.20E-16	0.45
Bobcat vs Raccoon	Winter	344.24	11	2.20E-16	0.27

Table 3.8: *The number of small mammals captured during a capture, mark, recapture survey in the Pineywoods of east Texas, from January 2009 to December 2010*

Common name	**Scientific name**	**Total captures**
White footed mouse	*Peromyscus leucopus*	563
Short tailed shrew	*Blarina carolinensis*	42
Hispid Cotton Rat	*Sigmodon hispidus*	276
Fulvous Harvest Mouse	*Reithrodontomys fulvescens*	863
Golden mouse	*Ochrotomys nuttalli*	76
Eastern wood rat	*Neotoma floridana*	12
Cotton mouse	*Peromyscus gossypinus*	90
Total		1922

The species that I captured most frequently were fulvous harvest mice (*Rheithrodotomys fulvescens*; 44.9%), white footed mice (*Peromyscus leucopus*; 29.3%) and hispid cotton rats (*Sigmodon hispidus*; 14.4%). The remaining 11.4% of captures consisted of cotton mice (*Peromyscus gossypinus*), golden mice (*Ochrotomys nuttalli*), Southern short-tailed shrew (*Blarina carolinensis*), and Eastern wood rat (*Neotoma floridana*). Numbers of small mammals (excluding hispid cotton rats) declined from winter, through spring and summer, after which all species, apart from harvest mice, increased in fall (Figure 3.1, Table 3.9 - 15) (minimum known alive). Hispid cotton rat numbers declined in spring, increased in summer, and declined between summer and fall (Figure 3.1). There was no difference in the number of small mammals that I captured between years ($F = 0.117$, df = 1, $P = 0.733$), study sites ($F = 0.108$, df = 1, $P = 0.743$), or grid type (nest or random) ($F = 2.233$, df = 1, $P = 0.136$). I detected differences in the number of small mammals captured between seasons ($F = 16.37$, df = 3, $P < 0.001$), (winter; $n = 855$: summer; 330, Tukey HSD difference = -1.045, $P < 0.001$), (winter ; 855 : fall; 250, Tukey HSD difference = -1.393, $P < 0.001$), (spring; 678 : summer; 330, Tukey HSD difference = -0.701, $P = 0.009$), (spring; 678 : fall; 250, Tukey HSD difference = -1.05, $P < 0.001$). There were differences between the number of species captured ($F = 25.01$, df = 5, $P < 0.001$).

I estimated the population size of the three most commonly captured small mammal species; fulvous harvest mice (range 0 - 49), hispid cotton rats (range 0 - 28) and white footed mice (range 0 - 32), for each small mammal grid, and derived the mean

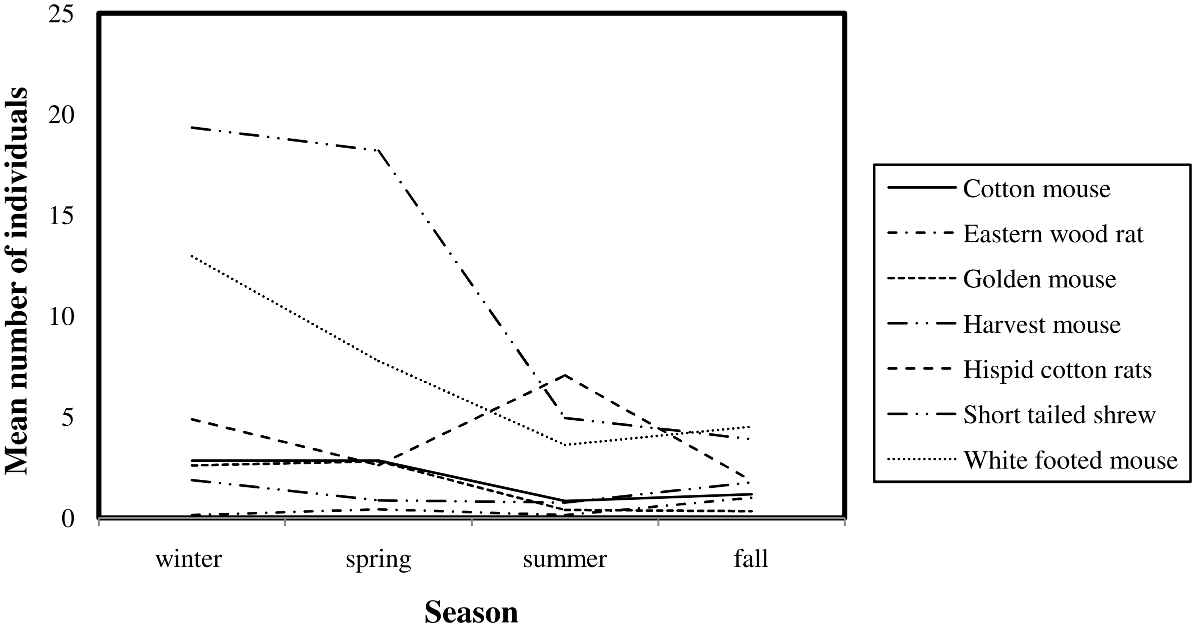

Figure 3.1: Trends in seasonal numbers of small mammals captured during a capture mark recapture survey in the Pineywoods of east Texas, from January 2009 to December 2010

Table 3.9: *Seasonal captures of Cotton mice (*Peromyscus gossypinus*), during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Cotton Mouse	Both	Both	Both	34	34	10	14	90
Cotton Mouse	Cottingham	Both	Both	10	1	5	11	27
Cotton Mouse	Winston	Both	Both	24	33	5	3	63
Cotton Mouse	Both	Both	Nest	20	19	2	7	48
Cotton Mouse	Cottingham	Both	Nest	2	0	0	5	7
Cotton Mouse	Winston	Both	Nest	18	19	2	2	41
Cotton Mouse	Both	Both	Random	14	15	8	7	44
Cotton Mouse	Cottingham	Both	Random	8	1	5	6	20
Cotton Mouse	Winston	Both	Random	6	14	3	1	24
Cotton Mouse	Both	2009	Both	0	0	0	2	2
Cotton Mouse	Cottingham	2009	Both	0	0	0	1	1
Cotton Mouse	Winston	2009	Both	0	0	0	1	1
Cotton Mouse	Both	2009	Nest	0	0	0	0	0
Cotton Mouse	Cottingham	2009	Nest	0	0	0	0	0
Cotton Mouse	Winston	2009	Nest	0	0	0	0	0
Cotton Mouse	Both	2009	Random	0	0	0	2	2
Cotton Mouse	Cottingham	2009	Random	0	0	0	1	1
Cotton Mouse	Winston	2009	Random	0	0	0	1	1
Cotton Mouse	Both	2010	Both	34	34	10	12	90
Cotton Mouse	Cottingham	2010	Both	10	1	5	10	26
Cotton Mouse	Winston	2010	Both	24	33	5	2	64
Cotton Mouse	Both	2010	Nest	20	19	2	7	48
Cotton Mouse	Cottingham	2010	Nest	2	0	0	5	7
Cotton Mouse	Winston	2010	Nest	18	19	2	2	41
Cotton Mouse	Both	2010	Random	14	15	8	5	42
Cotton Mouse	Cottingham	2010	Random	8	1	5	5	19
Cotton Mouse	Winston	2010	Random	6	14	3	0	23

Table 3.10: *Seasonal captures of eastern wood rats (*Neotoma floridana*), during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	Site	Year	Nest	Winter	Spring	Summer	Fall	Total
Eastern wood rat	Both	Both	Both	1	3	1	7	12
Eastern wood rat	Cottingham	Both	Both	0	0	1	3	4
Eastern wood rat	Winston	Both	Both	1	3	0	4	8
Eastern wood rat	Both	Both	Nest	0	2	0	3	5
Eastern wood rat	Cottingham	Both	Nest	0	0	0	0	0
Eastern wood rat	Winston	Both	Nest	0	2	0	3	5
Eastern wood rat	Both	Both	Random	1	1	1	4	7
Eastern wood rat	Cottingham	Both	Random	0	0	1	3	4
Eastern wood rat	Winston	Both	Random	1	1	0	1	3
Eastern wood rat	Both	2009	Both	0	1	0	2	3
Eastern wood rat	Cottingham	2009	Both	0	0	0	1	1
Eastern wood rat	Winston	2009	Both	0	1	0	1	2
Eastern wood rat	Both	2009	Nest	0	1	0	0	1
Eastern wood rat	Cottingham	2009	Nest	0	0	0	0	0
Eastern wood rat	Winston	2009	Nest	0	1	0	0	1
Eastern wood rat	Both	2009	Random	0	0	0	2	2
Eastern wood rat	Cottingham	2009	Random	0	0	0	1	1
Eastern wood rat	Winston	2009	Random	0	0	0	1	1
Eastern wood rat	Both	2010	Both	1	2	1	5	9
Eastern wood rat	Cottingham	2010	Both	0	0	1	2	3
Eastern wood rat	Winston	2010	Both	1	2	0	3	6
Eastern wood rat	Both	2010	Nest	0	1	0	3	4
Eastern wood rat	Cottingham	2010	Nest	0	0	0	0	0
Eastern wood rat	Winston	2010	Nest	0	1	0	3	4
Eastern wood rat	Both	2010	Random	1	1	1	2	5
Eastern wood rat	Cottingham	2010	Random	0	0	1	2	3
Eastern wood rat	Winston	2010	Random	1	1	0	0	2

Table 3.11: *Seasonal captures of golden mice (*Ochrotomys nuttalli*), during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Golden mouse	Both	Both	Both	39	42	6	5	76
Golden mouse	Cottingham	Both	Both	27	31	5	5	57
Golden mouse	Winston	Both	Both	12	11	1	0	19
Golden mouse	Both	Both	Nest	23	24	4	5	48
Golden mouse	Cottingham	Both	Nest	18	20	3	5	41
Golden mouse	Winston	Both	Nest	5	4	1	0	7
Golden mouse	Both	Both	Random	16	18	2	0	28
Golden mouse	Cottingham	Both	Random	9	11	2	0	16
Golden mouse	Winston	Both	Random	7	7	0	0	12
Golden mouse	Both	2009	Both	28	33	6	2	54
Golden mouse	Cottingham	2009	Both	21	27	5	2	44
Golden mouse	Winston	2009	Both	7	6	1	0	10
Golden mouse	Both	2009	Nest	15	20	4	2	33
Golden mouse	Cottingham	2009	Nest	12	16	3	2	28
Golden mouse	Winston	2009	Nest	3	4	1	0	5
Golden mouse	Both	2009	Random	13	13	2	0	21
Golden mouse	Cottingham	2009	Random	9	11	2	0	16
Golden mouse	Winston	2009	Random	4	2	0	0	5
Golden mouse	Both	2010	Both	11	9	0	3	22
Golden mouse	Cottingham	2010	Both	8	4	0	3	15
Golden mouse	Winston	2010	Both	3	5	0	0	7
Golden mouse	Both	2010	Nest	8	4	0	3	15
Golden mouse	Cottingham	2010	Nest	6	4	0	3	13
Golden mouse	Winston	2010	Nest	2	0	0	0	2
Golden mouse	Both	2010	Random	3	5	0	0	7
Golden mouse	Cottingham	2010	Random	0	0	0	0	0
Golden mouse	Winston	2010	Random	3	5	0	0	7

Table 3.12: *Seasonal captures of fulvous harvest mice* (Reithrodontomys fulvescens)*, during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Harvest mouse	Both	Both	Both	406	382	104	82	863
Harvest mouse	Cottingham	Both	Both	155	110	56	40	324
Harvest mouse	Winston	Both	Both	251	272	48	42	539
Harvest mouse	Both	Both	Nest	195	185	42	31	404
Harvest mouse	Cottingham	Both	Nest	77	71	30	20	179
Harvest mouse	Winston	Both	Nest	118	114	12	11	225
Harvest mouse	Both	Both	Random	211	197	62	51	459
Harvest mouse	Cottingham	Both	Random	78	39	26	20	145
Harvest mouse	Winston	Both	Random	133	158	36	31	314
Harvest mouse	Both	2009	Both	95	183	62	41	332
Harvest mouse	Cottingham	2009	Both	29	63	31	12	105
Harvest mouse	Winston	2009	Both	66	120	31	29	227
Harvest mouse	Both	2009	Nest	49	106	21	4	153
Harvest mouse	Cottingham	2009	Nest	25	50	18	3	77
Harvest mouse	Winston	2009	Nest	24	56	3	1	76
Harvest mouse	Both	2009	Random	46	77	41	37	179
Harvest mouse	Cottingham	2009	Random	4	13	13	9	28
Harvest mouse	Winston	2009	Random	42	64	28	28	151
Harvest mouse	Both	2010	Both	311	199	42	41	531
Harvest mouse	Cottingham	2010	Both	126	47	25	28	219
Harvest mouse	Winston	2010	Both	185	152	17	13	312
Harvest mouse	Both	2010	Nest	146	79	21	27	251
Harvest mouse	Cottingham	2010	Nest	52	21	12	17	102
Harvest mouse	Winston	2010	Nest	94	58	9	10	149
Harvest mouse	Both	2010	Random	165	120	21	14	280
Harvest mouse	Cottingham	2010	Random	74	26	13	11	117
Harvest mouse	Winston	2010	Random	91	94	8	3	163

Table 3.13: *Seasonal captures of hispid cotton rats* (Sigmodon hispidus)*, during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Hispid Cotton Rat	Both	Both	Both	88	47	127	33	276
Hispid Cotton Rat	Cottingham	Both	Both	19	7	32	15	71
Hispid Cotton Rat	Winston	Both	Both	69	40	95	18	205
Hispid Cotton Rat	Both	Both	Nest	22	11	25	12	68
Hispid Cotton Rat	Cottingham	Both	Nest	4	2	11	8	24
Hispid Cotton Rat	Winston	Both	Nest	18	9	14	4	44
Hispid Cotton Rat	Both	Both	Random	66	36	102	21	208
Hispid Cotton Rat	Cottingham	Both	Random	15	5	21	7	47
Hispid Cotton Rat	Winston	Both	Random	51	31	81	14	161
Hispid Cotton Rat	Both	2009	Both	51	29	64	16	151
Hispid Cotton Rat	Cottingham	2009	Both	4	2	17	5	27
Hispid Cotton Rat	Winston	2009	Both	47	27	47	11	124
Hispid Cotton Rat	Both	2009	Nest	14	7	12	5	37
Hispid Cotton Rat	Cottingham	2009	Nest	3	2	9	4	17
Hispid Cotton Rat	Winston	2009	Nest	11	5	3	1	20
Hispid Cotton Rat	Both	2009	Random	37	22	52	11	114
Hispid Cotton Rat	Cottingham	2009	Random	1	0	8	1	10
Hispid Cotton Rat	Winston	2009	Random	36	22	44	10	104
Hispid Cotton Rat	Both	2010	Both	37	18	63	17	125
Hispid Cotton Rat	Cottingham	2010	Both	15	5	15	10	44
Hispid Cotton Rat	Winston	2010	Both	22	13	48	7	81
Hispid Cotton Rat	Both	2010	Nest	8	4	13	7	31
Hispid Cotton Rat	Cottingham	2010	Nest	1	0	2	4	7
Hispid Cotton Rat	Winston	2010	Nest	7	4	11	3	24
Hispid Cotton Rat	Both	2010	Random	29	14	50	10	94
Hispid Cotton Rat	Cottingham	2010	Random	14	5	13	6	37
Hispid Cotton Rat	Winston	2010	Random	15	9	37	4	57

Table 3.14: *Seasonal captures of short tailed shrew* (Blarina carolinensis)*, during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Shrew	Both	Both	Both	15	7	6	14	42
Shrew	Cottingham	Both	Both	15	7	5	13	40
Shrew	Winston	Both	Both	0	0	1	1	2
Shrew	Both	Both	Nest	5	1	2	12	20
Shrew	Cottingham	Both	Nest	5	1	1	11	18
Shrew	Winston	Both	Nest	0	0	1	1	2
Shrew	Both	Both	Random	10	6	4	2	22
Shrew	Cottingham	Both	Random	10	6	4	2	22
Shrew	Winston	Both	Random	0	0	0	0	0
Shrew	Both	2009	Both	0	2	6	1	9
Shrew	Cottingham	2009	Both	0	2	5	1	8
Shrew	Winston	2009	Both	0	0	1	0	1
Shrew	Both	2009	Nest	0	0	2	0	2
Shrew	Cottingham	2009	Nest	0	0	1	0	1
Shrew	Winston	2009	Nest	0	0	1	0	1
Shrew	Both	2009	Random	0	2	4	1	7
Shrew	Cottingham	2009	Random	0	2	4	1	7
Shrew	Winston	2009	Random	0	0	0	0	0
Shrew	Both	2010	Both	15	5	0	13	33
Shrew	Cottingham	2010	Both	15	5	0	12	32
Shrew	Winston	2010	Both	0	0	0	1	1
Shrew	Both	2010	Nest	5	1	0	12	18
Shrew	Cottingham	2010	Nest	5	1	0	11	17
Shrew	Winston	2010	Nest	0	0	0	1	1
Shrew	Both	2010	Random	10	4	0	1	15
Shrew	Cottingham	2010	Random	10	4	0	1	15
Shrew	Winston	2010	Random	0	0	0	0	0

Table 3.15: *Seasonal captures of white footed mouse* (Peromyscus leucopus)*, during a small mammal capture, mark, recapture survey, in the Pineywoods of east Texas, from January 2009 to December 2010*

Species	**Site**	**Year**	**Nest**	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
White footed mouse	Both	Both	Both	272	163	76	95	563
White footed mouse	Cottingham	Both	Both	169	108	49	70	375
White footed mouse	Winston	Both	Both	103	55	27	25	188
White footed mouse	Both	Both	Nest	141	93	36	32	291
White footed mouse	Cottingham	Both	Nest	85	56	22	24	185
White footed mouse	Winston	Both	Nest	56	37	14	8	106
White footed mouse	Both	Both	Random	131	70	40	63	272
White footed mouse	Cottingham	Both	Random	84	52	27	46	190
White footed mouse	Winston	Both	Random	47	18	13	17	82
White footed mouse	Both	2009	Both	121	109	59	43	303
White footed mouse	Cottingham	2009	Both	67	68	39	25	179
White footed mouse	Winston	2009	Both	54	41	20	18	124
White footed mouse	Both	2009	Nest	66	61	27	10	159
White footed mouse	Cottingham	2009	Nest	35	32	17	8	90
White footed mouse	Winston	2009	Nest	31	29	10	2	69
White footed mouse	Both	2009	Random	55	48	32	33	144
White footed mouse	Cottingham	2009	Random	32	36	22	17	89
White footed mouse	Winston	2009	Random	23	12	10	16	55
White footed mouse	Both	2010	Both	151	54	17	52	260
White footed mouse	Cottingham	2010	Both	102	40	10	45	196
White footed mouse	Winston	2010	Both	49	14	7	7	64
White footed mouse	Both	2010	Nest	75	32	9	22	132
White footed mouse	Cottingham	2010	Nest	50	24	5	16	95
White footed mouse	Winston	2010	Nest	25	8	4	6	37
White footed mouse	Both	2010	Random	76	22	8	30	128
White footed mouse	Cottingham	2010	Random	52	16	5	29	101
White footed mouse	Winston	2010	Random	24	6	3	1	27

populations for each species (year, season, study site, grid type) (Table 3.16 – 18). There were no differences in the fulvous harvest mouse populations between study sites ($F = 0.757$, df = 1, $P = 0.387$), years ($F = 0.436$, df = 1, $P = 0.511$), and grid types ($F = 0.351$, df = 1, $P = 0.556$) (Table 3.9). I found differences in fulvous harvest mice numbers between seasons ($F = 18.34$, df = 3, $P < 0.001$) (Figure 3.2) (winter; $\bar{x} = 20.5$, SE = 2.86 : summer; $\bar{x} = 5.4$, SE = 0.95 : Tukey HSD difference = -0.241, $P < 0.001$), (winter; $\bar{x} = 20.5$, SE = 2.86 : fall; $\bar{x} = 4.3$, SE = 0.97 : Tukey HSD difference = -2.574, $P < 0.001$), (spring; $\bar{x} = 19.1$, SE = 2.91: summer; $\bar{x} = 5.4$, SE = 0.95 : Tukey HSD difference = -1.966, $P < 0.001$), and (spring; $\bar{x} = 19.1$, SE = 2.91: fall; $\bar{x} = 4.3$, SE = 0.97: Tukey HSD = -2.30, $P < 0.001$). There were no differences in my estimated hispid cotton rat populations (study sites; $F = 1.081$, df = 1, $P = 0.305$) (years; $F = 1.105$, df= 1, $P = 0.299$) (Table 3.16). The populations differed between grid types (nest; $\bar{x} = 3.2$, SE = 0.47: random; $\bar{x} = 7.6$, SE = 1.36) ($F = 5.914$, df = 1, $P = 0.02$), and between seasons ($F = 4.476$, df = 3, $P = 0.009$) (summer; $\bar{x} = 9.7$, SE = 2.32 : fall; $\bar{x} = 2.6$, SE = 0.77 : Tukey HSD difference = -1.481, $P = 0.008$). There were no differences in my estimates of white footed mouse populations between years ($F = 0.308$, df = 1, $P = 0.581$), or grid types ($F = 0.107$, df = 1, $P = 0.744$) (Table 3.11). I detected differences between study sites ($F = 6.201$, df = 1, $P = 0.015$) (Cottingham; $\bar{x} = 9.8$, SE = 1.29 : Winston; $\bar{x} = 5.8$, SE = 0.84), and seasons ($F = 12.19$, df = 3, $P < 0.001$) (winter; $\bar{x} = 14.3$, SE = 1.83: spring $\bar{x} = 7.76$, SE = 1.37 : Tukey HSD difference = -0.953, $P = 0.02$), (winter; $\bar{x} = 14.29$, SE = 1.83 : summer; $\bar{x} = 4.0$, SE = 0.73 : Tukey HSD difference

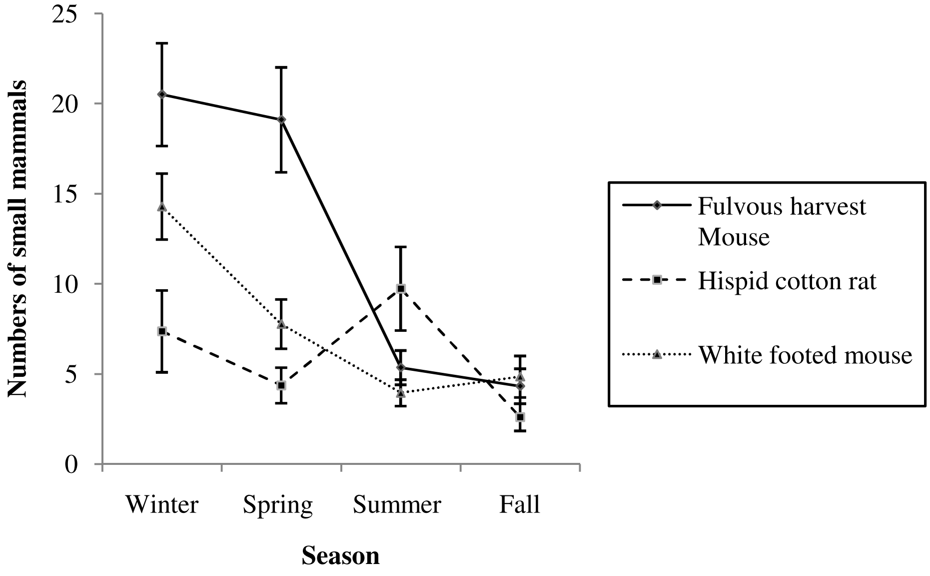

Figure 3.2: Mean population numbers (± 1 se) for the three most abundant small mammals captured in the Pineywoods of east Texas, from January 2009 to December 2010

Table 3.16: *Estimates of the population of fulvous harvest mice* (Reithrodontomys fulvescens) *in the Pineywoods of east Texas from January 2009 to December 2010*

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
Harvest Mouse	Both	All	All	Both	79	1.4	12.4
Harvest Mouse	Cottingham	All	All	Both	35	1.6	10.5
Harvest Mouse	Winston	All	All	Both	44	2.1	14.0
Harvest Mouse	Both	2009	All	Both	31	1.7	12.3
Harvest Mouse	Cottingham	2009	All	Both	11	2.7	12.4
Harvest Mouse	Winston	2009	All	Both	20	2.3	12.3
Harvest Mouse	Both	2010	All	Both	48	2.0	12.5
Harvest Mouse	Cottingham	2010	All	Both	24	2.0	9.6
Harvest Mouse	Winston	2010	All	Both	24	3.3	15.3
Harvest Mouse	Both	All	All	Nest	39	1.9	11.7
Harvest Mouse	Cottingham	All	All	Nest	19	2.1	10.8
Harvest Mouse	Winston	All	All	Nest	20	3.1	12.6
Harvest Mouse	Both	2009	All	Nest	15	2.8	11.9
Harvest Mouse	Cottingham	2009	All	Nest	7	4.0	14.0
Harvest Mouse	Winston	2009	All	Nest	8	4.0	10.0
Harvest Mouse	Both	2010	All	Nest	24	2.6	11.6
Harvest Mouse	Cottingham	2010	All	Nest	12	2.4	8.9
Harvest Mouse	Winston	2010	All	Nest	12	4.6	14.3
Harvest Mouse	Both	All	All	Random	40	2.0	13.1
Harvest Mouse	Cottingham	All	All	Random	16	2.5	10.1
Harvest Mouse	Winston	All	All	Random	24	2.8	15.1
Harvest Mouse	Both	2009	All	Random	16	2.1	12.8
Harvest Mouse	Cottingham	2009	All	Random	4	2.2	9.5
Harvest Mouse	Winston	2009	All	Random	12	2.7	13.8
Harvest Mouse	Both	2010	All	Random	24	3.0	13.4
Harvest Mouse	Cottingham	2010	All	Random	12	3.3	10.3
Harvest Mouse	Winston	2010	All	Random	12	5.0	16.4
Harvest Mouse	Both	All	Winter	Both	20	2.9	20.5
Harvest Mouse	Cottingham	All	Winter	Both	9	3.8	17.8
Harvest Mouse	Winston	All	Winter	Both	11	4.2	22.7
Harvest Mouse	Both	2009	Winter	Both	8	2.5	11.8
Harvest Mouse	Cottingham	2009	Winter	Both	3	4.7	9.7
Harvest Mouse	Winston	2009	Winter	Both	5	3.2	13.0
Harvest Mouse	Both	2010	Winter	Both	12	3.6	26.3
Harvest Mouse	Cottingham	2010	Winter	Both	6	4.6	21.8
Harvest Mouse	Winston	2010	Winter	Both	6	5.3	30.8

Table 3.16: (Continued)

Species	Site	Year	Season	Nest	*n*	SE	Mean
Harvest Mouse	Cottingham	All	Spring	Random	4	2.8	9.8
Harvest Mouse	Winston	All	Spring	Random	6	6.6	26.7
Harvest Mouse	Both	2009	Spring	Random	4	6.5	19.8
Harvest Mouse	Cottingham	2009	Spring	Random	1	0.0	13.0
Harvest Mouse	Winston	2009	Spring	Random	3	8.5	22.0
Harvest Mouse	Both	2010	Spring	Random	6	7.3	20.0
Harvest Mouse	Cottingham	2010	Spring	Random	3	3.7	8.7
Harvest Mouse	Winston	2010	Spring	Random	3	11.1	31.3
Harvest Mouse	Both	All	Summer	Both	20	1.0	5.4
Harvest Mouse	Cottingham	All	Summer	Both	9	1.4	6.2
Harvest Mouse	Winston	All	Summer	Both	11	1.3	4.6
Harvest Mouse	Both	2009	Summer	Both	8	1.7	8.1
Harvest Mouse	Cottingham	2009	Summer	Both	3	2.2	10.3
Harvest Mouse	Winston	2009	Summer	Both	5	2.4	6.8
Harvest Mouse	Both	2010	Summer	Both	12	0.7	3.5
Harvest Mouse	Cottingham	2010	Summer	Both	6	1.1	4.2
Harvest Mouse	Winston	2010	Summer	Both	6	1.0	2.8
Harvest Mouse	Both	All	Summer	Nest	10	1.2	4.3
Harvest Mouse	Cottingham	All	Summer	Nest	5	1.9	6.0
Harvest Mouse	Winston	All	Summer	Nest	5	1.2	2.6
Harvest Mouse	Both	2009	Summer	Nest	4	2.4	5.5
Harvest Mouse	Cottingham	2009	Summer	Nest	2	3.0	9.0
Harvest Mouse	Winston	2009	Summer	Nest	2	1.0	2.0
Harvest Mouse	Both	2010	Summer	Nest	6	1.3	3.5
Harvest Mouse	Cottingham	2010	Summer	Nest	3	2.0	4.0
Harvest Mouse	Winston	2010	Summer	Nest	3	2.1	3.0
Harvest Mouse	Both	All	Summer	Random	10	1.5	6.4
Harvest Mouse	Cottingham	All	Summer	Random	4	2.4	6.5
Harvest Mouse	Winston	All	Summer	Random	6	2.0	6.3
Harvest Mouse	Both	2009	Summer	Random	4	1.9	10.8
Harvest Mouse	Cottingham	2009	Summer	Random	1	0.0	13.0
Harvest Mouse	Winston	2009	Summer	Random	3	2.5	10.0
Harvest Mouse	Both	2010	Summer	Random	6	0.9	3.5
Harvest Mouse	Cottingham	2010	Summer	Random	3	1.5	4.3
Harvest Mouse	Winston	2010	Summer	Random	3	0.9	2.7
Harvest Mouse	Both	All	Fall	Both	19	1.0	4.3
Harvest Mouse	Cottingham	All	Fall	Both	8	1.4	4.9

Table 3.17: *Estimates of the population of hispid cotton rat* (Sigmodon hispidus) *in the Pineywoods of east Texas from January 2009 to December 2010*

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
Hispid Cotton Rat	Both	All	All	Both	43	1.0	6.1
Hispid Cotton Rat	Cottingham	All	All	Both	11	0.8	4.1
Hispid Cotton Rat	Winston	All	All	Both	32	1.2	6.8
Hispid Cotton Rat	Both	2009	All	Both	19	1.8	7.2
Hispid Cotton Rat	Cottingham	2009	All	Both	3	0.3	2.3
Hispid Cotton Rat	Winston	2009	All	Both	16	2.0	8.1
Hispid Cotton Rat	Both	2010	All	Both	24	1.0	5.2
Hispid Cotton Rat	Cottingham	2010	All	Both	8	1.1	4.8
Hispid Cotton Rat	Winston	2010	All	Both	16	1.4	5.4
Hispid Cotton Rat	Both	All	All	Nest	15	0.5	3.2
Hispid Cotton Rat	Cottingham	All	All	Nest	3	0.3	2.3
Hispid Cotton Rat	Winston	All	All	Nest	12	0.6	3.4
Hispid Cotton Rat	Both	2009	All	Nest	7	0.6	3.3
Hispid Cotton Rat	Cottingham	2009	All	Nest	3	0.3	2.3
Hispid Cotton Rat	Winston	2009	All	Nest	4	0.9	4.0
Hispid Cotton Rat	Both	2010	All	Nest	8	0.7	3.1
Hispid Cotton Rat	Cottingham	2010	All	Nest	*	*	*
Hispid Cotton Rat	Winston	2010	All	Nest	8	0.7	3.1
Hispid Cotton Rat	Both	All	All	Random	28	1.4	7.6
Hispid Cotton Rat	Cottingham	All	All	Random	8	1.1	4.8
Hispid Cotton Rat	Winston	All	All	Random	20	1.8	8.8
Hispid Cotton Rat	Both	2009	All	Random	12	2.6	9.5
Hispid Cotton Rat	Cottingham	2009	All	Random	*	*	*
Hispid Cotton Rat	Winston	2009	All	Random	12	2.6	9.5
Hispid Cotton Rat	Both	2010	All	Random	16	1.3	6.3
Hispid Cotton Rat	Cottingham	2010	All	Random	8	1.1	4.8
Hispid Cotton Rat	Winston	2010	All	Random	8	2.4	7.8
Hispid Cotton Rat	Both	All	Winter	Both	11	2.3	3.4
Hispid Cotton Rat	Cottingham	All	Winter	Both	3	2.2	5.7
Hispid Cotton Rat	Winston	All	Winter	Both	8	3.1	8.0

Table 3.17: (Continued)

Species	Site	Year	Season	Nest	*n*	SE	Mean
Hispid Cotton Rat	Both	2009	Winter	Both	5	4.8	9.0
Hispid Cotton Rat	Cottingham	2009	Winter	Both	1	0.0	3.0
Hispid Cotton Rat	Winston	2009	Winter	Both	4	5.9	10.5
Hispid Cotton Rat	Both	2010	Winter	Both	6	1.7	6.0
Hispid Cotton Rat	Cottingham	2010	Winter	Both	2	3.0	7.0
Hispid Cotton Rat	Winston	2010	Winter	Both	4	2.3	5.5
Hispid Cotton Rat	Both	All	Winter	Nest	4	0.9	4.0
Hispid Cotton Rat	Cottingham	All	Winter	Nest	1	0.0	3.0
Hispid Cotton Rat	Winston	All	Winter	Nest	3	1.2	4.3
Hispid Cotton Rat	Both	2009	Winter	Nest	2	1.5	4.5
Hispid Cotton Rat	Cottingham	2009	Winter	Nest	1	0.0	3.0
Hispid Cotton Rat	Winston	2009	Winter	Nest	1	0.0	6.0
Hispid Cotton Rat	Both	2010	Winter	Nest	2	1.5	3.5
Hispid Cotton Rat	Cottingham	2010	Winter	Nest	0	0.0	0.0
Hispid Cotton Rat	Winston	2010	Winter	Nest	2	1.5	3.5
Hispid Cotton Rat	Both	All	Winter	Random	7	3.4	9.3
Hispid Cotton Rat	Cottingham	All	Winter	Random	2	3.0	7.0
Hispid Cotton Rat	Winston	All	Winter	Random	5	4.8	10.2
Hispid Cotton Rat	Both	2009	Winter	Random	3	8.0	12.0
Hispid Cotton Rat	Cottingham	2009	Winter	Random	0	0.0	0.0
Hispid Cotton Rat	Winston	2009	Winter	Random	3	8.0	12.0
Hispid Cotton Rat	Both	2010	Winter	Random	4	2.2	7.3
Hispid Cotton Rat	Cottingham	2010	Winter	Random	2	3.0	7.0
Hispid Cotton Rat	Winston	2010	Winter	Random	2	4.5	7.5
Hispid Cotton Rat	Both	All	Spring	Both	11	1.0	4.4
Hispid Cotton Rat	Cottingham	All	Spring	Both	3	0.9	2.3
Hispid Cotton Rat	Winston	All	Spring	Both	8	1.3	5.1
Hispid Cotton Rat	Both	2009	Spring	Both	5	1.5	6.0
Hispid Cotton Rat	Cottingham	2009	Spring	Both	1	0.0	2.0
Hispid Cotton Rat	Winston	2009	Spring	Both	4	1.5	7.0
Hispid Cotton Rat	Both	2010	Spring	Both	6	1.3	3.0
Hispid Cotton Rat	Cottingham	2010	Spring	Both	2	1.5	2.5

Table 3.17: (Continued)

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
Hispid Cotton Rat	Winston	2010	Spring	Both	4	1.7	3.3
Hispid Cotton Rat	Both	All	Spring	Nest	4	0.9	2.8
Hispid Cotton Rat	Cottingham	All	Spring	Nest	1	0.0	2.0
Hispid Cotton Rat	Winston	All	Spring	Nest	3	1.5	3.0
Hispid Cotton Rat	Both	2009	Spring	Nest	2	1.5	3.5
Hispid Cotton Rat	Cottingham	2009	Spring	Nest	1	0.0	2.0
Hispid Cotton Rat	Winston	2009	Spring	Nest	1	0.0	5.0
Hispid Cotton Rat	Both	2010	Spring	Nest	2	1.0	2.0
Hispid Cotton Rat	Cottingham	2010	Spring	Nest	*	*	*
Hispid Cotton Rat	Winston	2010	Spring	Nest	2	1.0	2.0
Hispid Cotton Rat	Both	All	Spring	Random	7	1.4	5.3
Hispid Cotton Rat	Cottingham	All	Spring	Random	2	1.5	2.5
Hispid Cotton Rat	Winston	All	Spring	Random	5	1.7	6.4
Hispid Cotton Rat	Both	2009	Spring	Random	3	1.9	7.7
Hispid Cotton Rat	Cottingham	2009	Spring	Random	*	*	*
Hispid Cotton Rat	Winston	2009	Spring	Random	3	1.9	7.7
Hispid Cotton Rat	Both	2010	Spring	Random	4	1.7	3.5
Hispid Cotton Rat	Cottingham	2010	Spring	Random	2	1.5	2.5
Hispid Cotton Rat	Winston	2010	Spring	Random	2	3.5	4.5
Hispid Cotton Rat	Both	All	Summer	Both	11	2.3	9.7
Hispid Cotton Rat	Cottingham	All	Summer	Both	3	1.5	5.0
Hispid Cotton Rat	Winston	All	Summer	Both	8	2.9	11.5
Hispid Cotton Rat	Both	2009	Summer	Both	5	4.6	9.8
Hispid Cotton Rat	Cottingham	2009	Summer	Both	1	0.0	2.0
Hispid Cotton Rat	Winston	2009	Summer	Both	4	5.4	11.8
Hispid Cotton Rat	Both	2010	Summer	Both	6	2.4	9.7
Hispid Cotton Rat	Cottingham	2010	Summer	Both	2	0.5	6.5
Hispid Cotton Rat	Winston	2010	Summer	Both	4	3.4	11.3
Hispid Cotton Rat	Both	All	Summer	Nest	4	1.0	3.8
Hispid Cotton Rat	Cottingham	All	Summer	Nest	1	0.0	2.0
Hispid Cotton Rat	Winston	All	Summer	Nest	3	1.2	4.3
Hispid Cotton Rat	Both	2009	Summer	Nest	2	0.0	2.0

Table 3.17: (Continued)

Species	Site	Year	Season	Nest	*n*	SE	Mean
Hispid Cotton Rat	Cottingham	2009	Summer	Nest	1	0.0	2.0
Hispid Cotton Rat	Winston	2009	Summer	Nest	1	0.0	2.0
Hispid Cotton Rat	Both	2010	Summer	Nest	2	0.5	5.5
Hispid Cotton Rat	Cottingham	2010	Summer	Nest	1	0.0	6.0
Hispid Cotton Rat	Winston	2010	Summer	Nest	1	0.0	5.0
Hispid Cotton Rat	Both	All	Summer	Random	7	2.9	13.1
Hispid Cotton Rat	Cottingham	All	Summer	Random	2	0.5	6.5
Hispid Cotton Rat	Winston	All	Summer	Random	5	3.4	15.8
Hispid Cotton Rat	Both	2009	Summer	Random	3	6.0	15.0
Hispid Cotton Rat	Cottingham	2009	Summer	Random	*	*	*
Hispid Cotton Rat	Winston	2009	Summer	Random	3	6.0	15.0
Hispid Cotton Rat	Both	2010	Summer	Random	4	3.2	11.8
Hispid Cotton Rat	Cottingham	2010	Summer	Random	2	0.5	6.5
Hispid Cotton Rat	Winston	2010	Summer	Random	2	2.0	17.0
Hispid Cotton Rat	Both	All	Fall	Both	10	0.8	2.6
Hispid Cotton Rat	Cottingham	All	Fall	Both	2	2.0	3.0
Hispid Cotton Rat	Winston	All	Fall	Both	8	0.9	2.5
Hispid Cotton Rat	Both	2009	Fall	Both	4	1.7	3.3
Hispid Cotton Rat	Cottingham	2009	Fall	Both	*	*	*
Hispid Cotton Rat	Winston	2009	Fall	Both	4	1.7	3.3
Hispid Cotton Rat	Both	2010	Fall	Both	6	0.8	2.2
Hispid Cotton Rat	Cottingham	2010	Fall	Both	2	2.0	3.0
Hispid Cotton Rat	Winston	2010	Fall	Both	4	0.8	1.8
Hispid Cotton Rat	Both	All	Fall	Nest	3	1.0	2.0
Hispid Cotton Rat	Cottingham	All	Fall	Nest	*	*	*
Hispid Cotton Rat	Winston	All	Fall	Nest	3	1.0	2.0
Hispid Cotton Rat	Both	2009	Fall	Nest	1	0.0	3.0
Hispid Cotton Rat	Cottingham	2009	Fall	Nest	*	*	*
Hispid Cotton Rat	Winston	2009	Fall	Nest	1	0.0	3.0
Hispid Cotton Rat	Both	2010	Fall	Nest	2	1.5	1.5
Hispid Cotton Rat	Cottingham	2010	Fall	Nest	*	*	*

Table 3.18: *Estimates of the population of white footed mouse* (Peromyscus leucopus) *in the Pineywoods of east Texas from January 2009 to December 2010*

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
White footed mouse	Both	All	All	Both	83	0.8	7.8
White footed mouse	Cottingham	All	All	Both	43	1.3	9.8
White footed mouse	Winston	All	All	Both	40	0.8	5.8
White footed mouse	Both	2009	All	Both	43	0.9	7.8
White footed mouse	Cottingham	2009	All	Both	23	1.4	8.9
White footed mouse	Winston	2009	All	Both	20	1.1	6.3
White footed mouse	Both	2010	All	Both	40	1.3	7.8
White footed mouse	Cottingham	2010	All	Both	20	2.2	10.5
White footed mouse	Winston	2010	All	Both	20	1.3	5.1
White footed mouse	Both	All	All	Nest	43	1.1	7.8
White footed mouse	Cottingham	All	All	Nest	23	1.6	8.9
White footed mouse	Winston	All	All	Nest	20	1.4	6.7
White footed mouse	Both	2009	All	Nest	19	1.4	8.5
White footed mouse	Cottingham	2009	All	Nest	11	1.7	8.8
White footed mouse	Winston	2009	All	Nest	8	2.4	8.1
White footed mouse	Both	2010	All	Nest	24	1.6	7.3
White footed mouse	Cottingham	2010	All	Nest	12	2.7	8.9
White footed mouse	Winston	2010	All	Nest	12	1.8	5.7
White footed mouse	Both	All	All	Random	40	1.2	7.7
White footed mouse	Cottingham	All	All	Random	20	2.1	10.6
White footed mouse	Winston	All	All	Random	20	0.8	4.8
White footed mouse	Both	2009	All	Random	24	1.2	7.1
White footed mouse	Cottingham	2009	All	Random	12	2.3	9.1
White footed mouse	Winston	2009	All	Random	12	0.8	5.1
White footed mouse	Both	2010	All	Random	16	2.4	8.5
White footed mouse	Cottingham	2010	All	Random	8	4.0	12.8
White footed mouse	Winston	2010	All	Random	8	1.8	4.3
White footed mouse	Both	All	Winter	Both	21	1.8	14.3
White footed mouse	Cottingham	All	Winter	Both	11	3.1	16.6
White footed mouse	Winston	All	Winter	Both	10	1.7	11.8
White footed mouse	Both	2009	Winter	Both	11	1.9	10.9

Table 3.18: (Continued)

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
White footed mouse	Cottingham	2009	Winter	Both	6	3.2	11.3
White footed mouse	Winston	2009	Winter	Both	5	2.2	10.4
White footed mouse	Both	2010	Winter	Both	10	2.8	18.0
White footed mouse	Cottingham	2010	Winter	Both	5	4.2	22.8
White footed mouse	Winston	2010	Winter	Both	5	2.7	13.2
White footed mouse	Both	All	Winter	Nest	11	2.5	15.4
White footed mouse	Cottingham	All	Winter	Nest	6	4.1	16.3
White footed mouse	Winston	All	Winter	Nest	5	2.9	14.2
White footed mouse	Both	2009	Winter	Nest	5	3.0	13.0
White footed mouse	Cottingham	2009	Winter	Nest	3	4.7	12.0
White footed mouse	Winston	2009	Winter	Nest	2	4.5	14.5
White footed mouse	Both	2010	Winter	Nest	6	3.9	17.3
White footed mouse	Cottingham	2010	Winter	Nest	3	6.6	20.7
White footed mouse	Winston	2010	Winter	Nest	3	4.6	14.0
White footed mouse	Both	All	Winter	Random	10	2.8	13.1
White footed mouse	Cottingham	All	Winter	Random	5	5.1	16.8
White footed mouse	Winston	All	Winter	Random	5	1.5	9.4
White footed mouse	Both	2009	Winter	Random	6	2.6	9.2
White footed mouse	Cottingham	2009	Winter	Random	3	5.5	10.7
White footed mouse	Winston	2009	Winter	Random	3	0.7	7.7
White footed mouse	Both	2010	Winter	Random	4	4.7	19.0
White footed mouse	Cottingham	2010	Winter	Random	2	5.0	26.0
White footed mouse	Winston	2010	Winter	Random	2	3.0	12.0
White footed mouse	Both	All	Spring	Both	21	1.4	7.8
White footed mouse	Cottingham	All	Spring	Both	11	2.2	9.9
White footed mouse	Winston	All	Spring	Both	10	1.4	5.4
White footed mouse	Both	2009	Spring	Both	11	2.3	9.6
White footed mouse	Cottingham	2009	Spring	Both	6	3.7	11.5
White footed mouse	Winston	2009	Spring	Both	5	5.6	7.2
White footed mouse	Both	2010	Spring	Both	10	1.2	5.8
White footed mouse	Cottingham	2010	Spring	Both	5	1.9	8.0

Table 3.18: (Continued)

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
White footed mouse	Winston	2010	Spring	Both	5	0.4	3.6
White footed mouse	Both	All	Spring	Nest	11	1.4	8.4
White footed mouse	Cottingham	All	Spring	Nest	6	1.6	9.3
White footed mouse	Winston	All	Spring	Nest	5	2.5	7.2
White footed mouse	Both	2009	Spring	Nest	5	1.9	11.2
White footed mouse	Cottingham	2009	Spring	Nest	3	1.9	10.7
White footed mouse	Winston	2009	Spring	Nest	2	5.0	12.0
White footed mouse	Both	2010	Spring	Nest	6	1.5	6.0
White footed mouse	Cottingham	2010	Spring	Nest	3	2.4	8.0
White footed mouse	Winston	2010	Spring	Nest	3	0.6	4.0
White footed mouse	Both	All	Spring	Random	10	2.5	7.1
White footed mouse	Cottingham	All	Spring	Random	5	4.7	10.6
White footed mouse	Winston	All	Spring	Random	5	0.6	3.6
White footed mouse	Both	2009	Spring	Random	6	4.0	8.2
White footed mouse	Cottingham	2009	Spring	Random	3	8.0	12.3
White footed mouse	Winston	2009	Spring	Random	3	1.0	4.0
White footed mouse	Both	2010	Spring	Random	4	2.2	5.5
White footed mouse	Cottingham	2010	Spring	Random	2	4.0	8.0
White footed mouse	Winston	2010	Spring	Random	2	0.0	3.0
White footed mouse	Both	All	Summer	Both	21	0.7	4.0
White footed mouse	Cottingham	All	Summer	Both	11	1.3	4.9
White footed mouse	Winston	All	Summer	Both	10	0.4	2.9
White footed mouse	Both	2009	Summer	Both	11	1.1	5.7
White footed mouse	Cottingham	2009	Summer	Both	6	1.9	7.3
White footed mouse	Winston	2009	Summer	Both	5	0.6	3.8
White footed mouse	Both	2010	Summer	Both	10	0.3	2.0
White footed mouse	Cottingham	2010	Summer	Both	5	0.6	2.0
White footed mouse	Winston	2010	Summer	Both	5	0.3	2.0
White footed mouse	Both	All	Summer	Nest	11	1.1	3.8
White footed mouse	Cottingham	All	Summer	Nest	6	2.0	4.3
White footed mouse	Winston	All	Summer	Nest	5	0.6	3.2

Table 3.18: (Continued)

Species	**Site**	**Year**	**Season**	**Nest**	***n***	**SE**	**Mean**
White footed mouse	Cottingham	2010	Fall	Nest	3	1.2	5.3
White footed mouse	Winston	2010	Fall	Nest	3	0.7	2.3
White footed mouse	Both	All	Fall	Random	10	2.2	6.3
White footed mouse	Cottingham	All	Fall	Random	5	3.8	9.2
White footed mouse	Winston	All	Fall	Random	5	1.7	3.4
White footed mouse	Both	2009	Fall	Random	6	1.2	5.5
White footed mouse	Cottingham	2009	Fall	Random	3	1.3	5.7
White footed mouse	Winston	2009	Fall	Random	3	2.2	5.3
White footed mouse	Both	2010	Fall	Random	4	5.6	7.5
White footed mouse	Cottingham	2010	Fall	Random	2	9.5	14.5
White footed mouse	Winston	2010	Fall	Random	2	0.5	0.5

= -1.733, $P < 0.001$) and (winter; $\bar{x} = 14.3$, SE = 1.83 : fall; $\bar{x} = 4.9$, SE = 1.15 : Tukey HSD difference = -1.599, $P < 0.001$).

Lagomorphs

I conducted 70 spotlight counts totaling 1432.9 km (Cottingham; 768.6 km, Winston; 664.3 km) for eastern cottontail rabbits over two routes (one on each study site) seasonally from April 2010 to August 2011. For five seasons I recorded 132 eastern cottontail rabbits (Cottingham; 100, Winston; 32). I converted the counts to a seasonal index of eastern cottontail rabbits per kilometer (R/km) (range 0 - 0.47) (Table 3.19). I found no difference in the number of eastern cottontail rabbits between years ($F = 1.168$, df = 1, $P = 0.284$), season ($F = 1.403$, df = 3, $P = 0.25$), or site ($F = 1.98$, df = 1, $P = 0.164$). Despite there being no statistical difference in the spotlight index value between sites, the values for Cottingham ($\bar{x} = 0.2$ R / km, SE = 0.02) were higher than those for Winston ($\bar{x} = 0.04$ R / km, SE = 0.01) (Figure 3.3).

I conducted track-plate surveys for lagomorphs over the same period as the spotlight counts, 3500 track-plate nights over five seasons from April 2010 to August 2011. I recorded 121 eastern cottontail rabbit track plate detections, (Cottingham; 73, Winston; 48). I converted these to an index of detections per track plate (RT/TP) (range 0 - 0.2) (Table 3.20). I found no difference in track-plate index between years ($F = 0.039$, df = 1, $P = 0.845$), seasons ($F = 0.783$, df = 3, $P = 0.508$), or sites ($F = 0.832$, df = 1, $P = 0.365$). Despite there being no statistical difference in the track plate index values

Table 3.19: *Spotlight index values (rabbits per kilometer) for detections of eastern cottontail* rabbits (Sylvilagus floridanus)*, in the Pineywoods of east Texas from spring 2010 to summer 2011*

Species	**Site**	**Season**	***n***	**SE**	**Spotlight index**
Eastern cottontail rabbit	Both	All	70	0.01	0.10
Eastern cottontail rabbit	Cottingham	All	35	0.02	0.15
Eastern cottontail rabbit	Winston	All	35	0.01	0.04
Eastern cottontail rabbit	Both	Fall	14	0.02	0.05
Eastern cottontail rabbit	Winston	Fall	7	0.03	0.04
Eastern cottontail rabbit	Cottingham	Fall	7	0.03	0.06
Eastern cottontail rabbit	Both	Spring	28	0.02	0.10
Eastern cottontail rabbit	Winston	Spring	14	0.02	0.06
Eastern cottontail rabbit	Cottingham	Spring	14	0.03	0.15
Eastern cottontail rabbit	Both	Summer	14	0.05	0.13
Eastern cottontail rabbit	Winston	Summer	7	0.01	0.01
Eastern cottontail rabbit	Cottingham	Summer	7	0.06	0.26
Eastern cottontail rabbit	Both	Winter	14	0.02	0.87
Eastern cottontail rabbit	Winston	Winter	7	0.02	0.04
Eastern cottontail rabbit	Cottingham	Winter	7	0.04	0.14

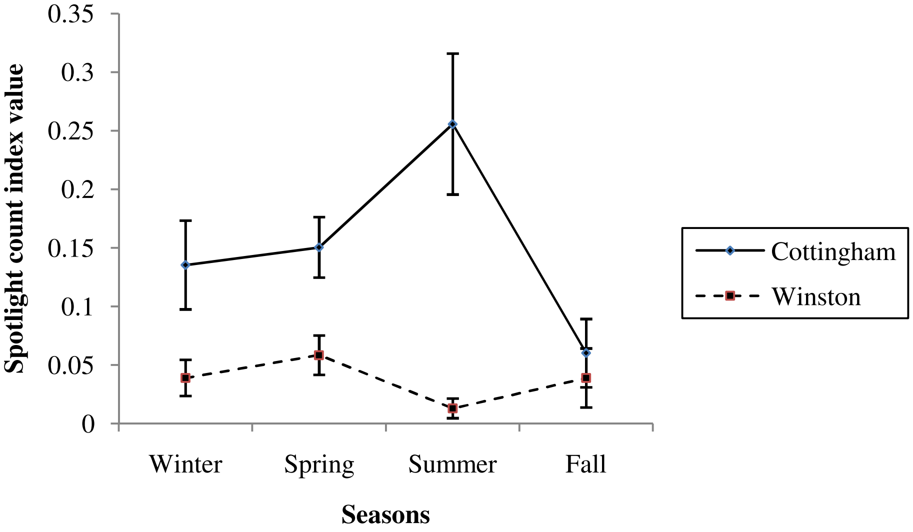

Figure 3.3: Spotlight count index (rabbits / km) (± 1 se) for two study sites in the Pineywoods of east Texas from April 2010 to August 2011

Table 3.20: *Track plate index (rabbit impressions per track plate) for detections of eastern cottontail rabbits* (Sylvilagus floridanus)*, in the Pineywoods of east Texas from spring 2010 to summer 2011*

Cottontail	**Site**	**Season**	***n***	**SE**	**Track index**
Cottontail	Both	All	70	0.01	0.07
Cottontail	Cottingham	All	35	0.01	0.08
Cottontail	Winston	All	35	0.01	0.06
Cottontail	Both	Fall	14	0.01	0.05
Cottontail	Winston	Fall	7	0.01	0.05
Cottontail	Cottingham	Fall	7	0.02	0.06
Cottontail	Both	Spring	28	0.01	0.06
Cottontail	Winston	Spring	14	0.02	0.05
Cottontail	Cottingham	Spring	14	0.02	0.07
Cottontail	Both	Summer	14	0.02	0.08
Cottontail	Winston	Summer	7	0.02	0.04
Cottontail	Cottingham	Summer	7	0.02	0.13
Cottontail	Both	Winter	14	0.01	0.09
Cottontail	Winston	Winter	7	0.02	0.08
Cottontail	Cottingham	Winter	7	0.01	0.10

between sites, the index values for Cottingham ($\bar{x}$ = 0.08 RT/TP, SE = 0.01) were higher than those for Winston ($\bar{x}$ = 0.06 RT/TP, SE = 0.01) (Figure 3.4).

I used logistic regression to model the influence of the variables; year, study site and season on detection of lagomorph on the track-plates. There was no difference between the full model and the null model ($\chi^2 = 6.89$, df = 8, $P = 0.55$). The likelihood ratio test confirmed this (Log Likelihood = -434.05, df = 5, $P = 0.037$). The only variable that effected detection of track on track plates was study site ($Z = -2.344$, df = 1, $P = 0.091$) (Table 3.21). There was no correlation between the spotlight index and the track-plate index ($F = 1.349$, $P = 0.25$, $r^2 = 0.02$).

Discussion

My results indicate that bobcats, coyotes and raccoons do not prey extensively on eastern wild turkeys in the Pineywoods of east Texas, but their diets varied seasonally and overlapped quite substantially. The availability of prey varied seasonally and bobcats responded functionally to this variation in prey availability while coyotes and raccoons varied their diets opportunistically. The seasonal decline in many of the small mammal populations coincided with the onset of the eastern wild turkey nesting and brood rearing season (Isabelle 2010).

Bobcats, coyotes and raccoons had diverse diets in the Pineywoods of east Texas. Scat samples showed that their diets contained a variety of mammals, insects, birds, plants

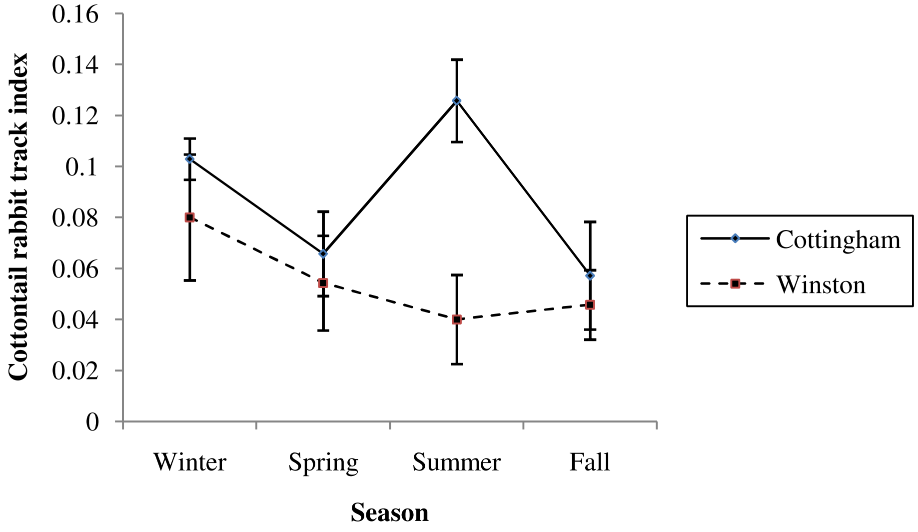

Figure 3.4: Eastern cottontail rabbit track index (tracks/plate/night) (± 1 se) calculated for two study sites in the Pineywoods of east Texas from April 2010 to August 2011

Table 3.21: *Confidence intervals from logistic regression of the variables associated with the likelihood of detecting eastern cotton tail rabbit* (Sylvilagus floridanus) *tracks on track plates in the Pineywoods of east Texas from Spring 2010 to Summer 2011*

Variable	**Lower**	**Upper**	***Z***	**df**	***P***	
(Intercept)	-2.838	-1.353	-5.54	1	2.97E-08	***
Site = Winston	-0.834	-0.077	-2.34	1	0.0191	*
2011	-0.629	0.629	0.00	1	1	
Spring	-1.042	0.109	-1.56	1	0.1179	
Summer	-0.929	0.711	-0.26	1	0.7952	
Fall	-1.496	0.241	-1.41	1	0.1598	

* P value less than 0.05
*** P value less than 0.001

and reptiles. Despite this, I found no conclusive evidence that any of these mesopredators preyed on eastern wild turkeys. This agreed with other mesopredator studies, that used scat analysis, in the Southeast that have found limited support for the allegation that mesopredators prey on wild turkeys (Wagner and Hill 1994, Chamberlain and Leopold 1999, Leopold and Chamberlain 2002). Even in areas with abundant populations of wild turkeys the contribution of wild turkeys to the diet of mesopredators was minimal (Wagner and Hill 1994).

A number of reasons have been posited as to why researchers might fail to detect wild turkey remains in scats. The first is that the causative factor of turkey mortality has been misidentified (Houchin 2005), and that mesopredators are not responsible for wild turkey mortalities. This seems unlikely, based on the consistency with which researchers have reported that mesopredators regularly prey on wild turkeys (Speake et al. 1985, Swank et al. 1985, Kurzejeski et al. 1987, Miller et al. 1998, Isabelle 2010). A second possibility is that mesopredators do not ingest high proportions of the non-food portions (feathers, beaks, bones, feet and feet scales), that are useful for identification purposes, of wild turkeys (Houchin 2005). I am not aware of studies to investigate feeding behavior of mesopredators relative to wild turkey that suggest differential feeding behavior relative to wild turkeys. If mesopredators avoid ingesting wild turkey feathers, the extent of wild turkey predation might be under-estimated, but, where wild turkeys occur in high densities, researchers would still detect wild turkey remains in scats (Wagner and Hill 1994, Chamberlain and Leopold 1999, Leopold and Chamberlain

2002). A third possibility is that an increase in gastric retention time of ingesta associated with the consumption of high protein dietary components, such as wild turkeys, might increase the extent to which feathers were digested and hence reduce the detectability of these in scats (Houchin 2005).

Despite finding evidence of avian remains in the scat samples, I found no feathers or bone or beak fragments that I could attribute to eastern wild turkeys in the scats. It is therefore unlikely that mesopredators preyed extensively on adult eastern wild turkeys in the Pineywoods of east Texas. My lack of evidence of wild turkey remains in mesopredator scats from the Pineywoods was not surprising because eastern wild turkeys are not abundant in east Texas (Isabelle 2010). Taken at face value my data suggest that mesopredators were not an important cause of mortality to adult eastern wild turkeys in the Pineywoods of east Texas. What is clear from my data is that wild turkeys did not contribute substantially to the diets of the focal mesopredators.

When mesopredators prey on large eggs, it is unusual for them to ingest entire egg shells (Larivière 1999) (personal observation). The ramification of this was that even if mesopredators consumed large numbers of eggs, it would be unlikely that I would have found a high number of egg shell fragments in scats. It is also unlikely that I would have detected poults younger than one week old in scats (Wagner and Hill 1994). Despite the lack of evidence, it is still possible that mesopredators preyed on eastern wild turkey eggs and poults, particularly as Isabelle (2010) found evidence of this and all three were observed depredating artificial wild turkey nests in a concurrent study (Section 4).

Numerous investigations into the causes of wild turkey mortality indicate that predation is the most important cause of such mortality (Speake et al. 1985, Swank et al. 1985, Kurzejeski et al. 1987, Miller et al. 1998, Isabelle 2010). Many of these investigations into the cause specific mortality of wild turkeys relied on using field sign to verify the cause of wild turkey mortality (Speake et al. 1985, Swank et al. 1985, Kurzejeski et al. 1987, Miller et al. 1998, Isabelle 2010). The validity of identifying predators from field sign has been called into question for several reasons including; inter-specific overlap and intra-specific variation in patterns of nest destruction, unexpected predators, egg size, stage of development, experience of researchers, partial nest depredation, multi-predator visits, and parental activity at the depredated nests (Larivière 1999).

Based on the above, it seems that there is conflicting evidence relating to the importance of predation by mesopredators on wild turkeys. It seems that wild turkeys do not contribute greatly to the diets of mesopredators in the current study or in others (Wagner and Hill 1994, Chamberlain and Leopold 1999, Leopold and Chamberlain 2002), however, mesopredators have been reported as responsible for a high proportion of wild turkey mortalities (Speake et al. 1985, Swank et al. 1985, Kurzejeski et al. 1987, Miller et al. 1998, Isabelle 2010). It seems that the conflict arises from differential research methodologies and different points of departure relative to the research question at hand. The apparent conflict need not confound either argument. I suggest that although mesopredators seem to be responsible for a high proportion of wild turkey mortalities, wild turkeys were not an important dietary resource for the bobcats, coyotes or raccoons during this study.

In general, the small mammal populations in the Pineywoods of east Texas declined from spring into summer during 2009 and 2010. Small mammals contributed greatly to the diets of bobcats, coyotes and raccoons. During spring and summer, the mesopredators increased diversity in their diets. Increased diversity in predators' diets has been linked to resource limitation in terms of food availability (Clavero et al. 2003). The decline in prey availability occurred while eastern wild turkeys in the Pineywoods of east Texas were nesting and raising poults through the flightless phase. In east Texas, eastern wild turkeys nest from the 26th of March to the 28th of June (Isabelle 2010). The synchronicity between the decline in prey populations and the nesting of wild turkeys might have amplified the threat posed to wild turkey nests and flightless poults by mesopredators especially considering that mesopredators diversified their diets during this period. However there was no evidence from scat samples that this occurred.

Assemblages of predators that live in sympatry are likely to display variability in dietary breadth and overlap consistent with principles of resource partitioning (Azevedo et al. 2006). The degree of dietary overlap between mesopredators varies seasonally (Major and Sherburne 1987, Chamberlain and Leopold 1999, Fedriani et al. 2000, Azevedo et al. 2006), and this was the case for bobcats, coyotes and raccoons in the Pineywoods. Levels of dietary overlap between bobcats and coyotes were marginally lower than what was considered biologically significant in fall and winter. In spring and summer the degree of overlap increased to biologically significant levels. Similar patterns of seasonal variation in dietary overlap between bobcats and coyotes have been observed in central Mississippi (Chamberlain and Leopold 1999) and California (Fedriani et al. 2000). A similar trend was evident between coyotes and raccoons, in this case the seasonal change in significance of overlap was more pronounced. There was no biologically significant overlap in winter or fall. However, in spring and summer the level of overlap was biologically significant (Pianka overlap values > 0.6). The great change in overlap was probably due to their selection of fruit when they became available. Few studies have investigated the dietary overlap between coyotes and raccoons. Where comparisons have been made, they have been conducted on an annual basis and the result showed little overlap between the diets of raccoons and coyotes (Azevedo et al. 2006). Although a trend of increasing dietary overlap was evident between bobcats and raccoons the level of overlap was never biologically significant. The increase in dietary overlap between mesopredator species in spring and summer, combined with their high dietary diversity index values in summer may be indicative of seasonal resource limitation in terms of food availability (Clavero et al. 2003).

Small mammal populations fluctuate numerically over several temporal scales. Two primary trends have been described. Cyclic variations are characterized by populations that gradually increase to a peak over a number of years and then decline precipitously (Krebs and Myers 1974, Fuller 1977, Krebs 1979, Mihok and Fuller 1981, Jensen 1982).

The low period of this cycle often extends over several years. The second trend is termed non-cyclic; these populations are characterized by seasonal fluctuations in population numbers. In non-cyclic populations, the variations in numbers are not as drastic as those of cyclic populations (Hansson and Henttonen 1985).

The populations of small mammals seemed to vary on a seasonal, non-cyclic basis, in the Pineywoods of east Texas during 2009 and 2010. Small mammal populations were at their highest in winter and declined slightly in spring; they then dropped substantially in summer and started to recover in fall. This generalization held for fulvous harvest mice and white footed mice, two of the three species that I captured most frequently. The trend for hispid cotton rats differed from both fulvous harvest mice and white footed mice, insofar as the population estimates were low in winter, increased through spring and peaked in summer, after which the populations seemed to decline in to the fall. My results agreed with past studies of similar species in the southeastern United States (Pournelle 1952, McCarley 1954, Odum 1955, Packard 1968, Joule and Jameson 1972, Grant et al. 1985). I confirmed that different small mammal species' populations in east Texas fluctuated differently under the same environmental conditions (Brown and Heske 1990, Windberg 1998). Odum (1955) suggested that the difference in seasonal fluctuation between *Peromyscus* species and hispid cotton rats was related to differential adaptation to high temperatures. Whereas *Peromyscus* populations seemed to decline during the summer, hispid cotton rats seemed to display a 'northern type' seasonal cycle of abundance with their reproduction being inhibited by low temperature rather than high temperature (Odum 1955).

The composition of some small mammal communities is known to be affected by recent climatological events (French et al. 1976, Grant et al. 1985, Schmidt and Ostfeld 2008). My study of small mammals spanned 2009 and 2010, this period has been associated with the onset of a 500 year drought in Texas from 2010 – 2011 (http://www.jsg.utexas.edu/ciess/files/Water_Forum_01_Stermolle.pdf). The mechanism of the influence of harsh weather on small mammal populations occurs indirectly through the impact of the climate on the productivity of vegetation (Grant et al. 1985). Despite the potential for a general decline in the small mammal populations in 2010, I found no evidence of this. There was no difference between any of the focal small mammal populations between 2009 and 2010. These results echo those of Grant (1985) who found that neither temperature nor precipitation had a detectable effect on hispid cotton rats or white footed mice. In his study, Grant (1985) found that fulvous harvest mouse populations were influenced by temperature fluctuations, but were not impacted by precipitation. This seems to be the case in the Pineywoods where I found that fulvous harvest mouse numbers declined consistently during the hotter months. It is unlikely that the full effect of the Texas drought of 2010 – 2011, on the small mammals, was fully identified in the course of my study, because the full effect would only have been evident in 2011, after monitoring had ceased.

Bobcats, coyotes and raccoons all preyed on small mammals to varying degrees. The only small mammal species that contributed substantially to the diets of any of the mesopredators was the hispid cotton rat, which was one of the primary prey items used by bobcats and was well represented in scat samples in all seasons. It seemed that the other small mammals were preyed opportunistically by all three mesopredator species. Mesopredators are known to have a limiting effect on hispid cotton rats, especially in areas where fire is excluded (Conner et al. 2011). This may be the case in the Pineywoods, especially on commercial timber sites where fire has been excluded as a management tool. It is unknown whether mesopredators limit other small mammals.

Mesopredators seemed to respond to the variation in prey availability in two ways. Bobcats responded functionally to changes in hispid cotton rat availability by increasing predation on this species when the population increased. The functional response is a more complex relationship between the abundance and use of prey species than the typical diet optimization model. The rate at which a predator preys on the preferred prey varies according to the prey population density (Holling 1959, Baker et al. 2001). This was similar to the trend observed in Georgia (Baker et al. 2001). Coyotes and raccoons were opportunistic, generalist predators, varying their selections of food items relative to their availability (Bekoff 2003, Gehrt 2003). During spring and summer, coyote and raccoon diets contained a large percentage of fruit. Locating and consuming fruit required less energy relative to searching for other prey; hence coyotes and raccoons probably improved foraging efficiency by altering their prey selection to include a high proportion of fruit when they were abundant (MacArthur and Pianka 1966, Norberg 1977, Chamberlain and Leopold 1999).

Predator home ranges are known to scale in relation to prey availability (Gittleman and Harvey 1982, Fuller and Sievert 2001). This is the case for bobcats (Litvaitis et al. 1986, Anderson 2003), coyotes (Laundre and Keller 1984, Gese et al. 1988, Bekoff 2003), and raccoons (Gehrt and Fritzell 1997, Gehrt 2003). This phenomenon was evident in my study where bobcat and coyote home ranges increased in extent, seasonally from winter, through spring and summer, into fall (Section 2), seemingly tracking the availability of mammalian prey resource. Bobcats expanded their home ranges as small mammal numbers declined. Despite the seasonal increase in availability of fruit, which coyote used in accordance with its availability, coyotes expanded their home ranges over the period of small mammal decline. Coyotes are thought to exhibit strong omnivory to withstand environmental stresses (Chamberlain and Leopold 1999), this was evident in my study too. Despite using fruit to supplement their diets, the availability of this resource may not be sufficient to buffer the coyotes against reduced availability of mammalian prey. Unlike coyotes, raccoons in my study did not increase their home ranges seasonally (Section 2). This is consistent with other studies (Chamberlain et al. 2002, Chamberlain and Leopold 2002, Beasley et al. 2007). It seems that unlike bobcats and coyotes, raccoons were able to compensate for seasonal variation in the availability of certain dietary components by including additional items, such as insects and other arthropod prey, in their diets that became seasonally available, without expanding their home ranges (Beasley et al. 2007).

Management Implications

My results show that mesopredator diets vary seasonally in the Pineywoods of east Texas. In the period from spring to summer, the mesopredators increase the diversity of their diets in synchrony with a general decline in the small mammal populations. During the same period, eastern wild turkeys nest and raise their poults. Although the evidence is circumstantial, this suggests that mesopredators might prey on wild turkey nests and poults during this period. Many authors including Isabelle (2010), who conducted an investigation into the nesting ecology of eastern wild turkeys in east Texas, have suggested that the likely cause of nest failure and poult mortality in wild turkeys is predation by mesopredators. I found no evidence of mesopredators preying on eastern wild turkeys, their eggs or their poults in the Pineywoods of east Texas. Despite concerns about the integrity of eastern wild turkey nests and poults being compromised by monitoring nests and poults directly, this remains the only way to confirm whether mesopredators are the mortality agents of greatest concern. Under these circumstances, I suggest that a program of photographic surveillance of live eastern wild turkey nests be undertaken. In addition to this, I suggest that young poults be fitted with transmitters and be closely monitored, when mortalities occur, immediate follow up would be required to determine the cause of mortality (Hubbard et al. 1999). It is well established that wild turkeys suffer substantial losses during the nesting and poult rearing season throughout their range (Vangilder 1992). It may therefore be preferable to try to mitigate against losses by focusing on habitat improvement rather than concentrating on the identification of specific mortality agents. By manipulating the habitat, managers can reduce predator-prey encounters (Leopold and Chamberlain 2002). To achieve this, a combination of thinning and burning should be implemented to increase and improve nesting habitat. Isabelle (2011) suggested a 1- 3 year rotation of burning to create a mosaic of vegetation composition and structure. Chamberlain (1999) suggested that burning of pine forests every 3-4 years would be effective to improve nesting success in wild turkeys. In addition to improving the nesting habitat, burning stands prior to the onset of nesting season reduces the number of hispid cotton rats within the burned patch (Conner et al. 2011). This reduction is achieved by two mechanisms, there is direct mortality of hispid cotton rats as a result of the burn, and in addition many of the cotton rats emigrate from the burned area (Conner et al. 2011 440). Raccoons are the mesopredators that are most likely to prey on wild turkey nests (Miller and Leopold 1992, Section 4). Raccoons are less likely to use stands burned in the period between nesting seasons, than unburned stands (Jones et al. 2004). The implication of this is that the application of burning improves the habitat for the establishment of wild turkey nests, it reduces the incidence of one of the preferred prey species within areas that are used as nesting habitat and it reduces the number of raccoons in the stands that are likely to be used for nests. The consequence of this is that the number of incidents of mesopredators encountering wild turkey nests would be reduced and hence the likelihood of nest success would be increased.

4 - ARTIFICIAL NESTS USED TO IDENTIFY POSSIBLE NEST PREDATORS OF EASTERN WILD TURKEYS (*MELEAGRIS GALLOPAVO SILVESTRIS*) IN THE PINEYWOODS OF EAST TEXAS

Summary

I monitored artificial Eastern wild turkey (*Meleagris gallopavo silvestris*) nests, using time lapse and motion sensitive trail cameras to determine what nest predators were likely to be responsible for preying on wild turkey nests in the Pineywoods of east Texas. Sixty one percent of all artificial nests were preyed on. Raccoons (*Procyon lotor*) preyed on 35% of artificial nests while American crows (*Corvus brachyrhynchos*) preyed on 48% of artificial nests. There was a seasonal increase in the number of artificial nests preyed upon from spring to summer. Mammalian mesopredators (raccoons and opossums (*Didelphis virginiana*)) were responsible for this increase, suggesting an increase in search effort by mesopredators that coincided with increased dietary diversity in a period of reduced prey resources. Predators other than mesopredators; American crows, woodpeckers (*Picoides* sp.), armadillos (*Dasypus novemcinctus*) and snakes, were responsible for 53.4% of all predation on artificial wild turkey nests, with crows being the most important of these. American crows located and preyed on artificial nests more quickly after nest deployment than other nest predators. I suggest video monitoring of live eastern wild turkey nests to confirm the identity of nest predators. In addition, a program of conditioned taste aversion of the predators to eggs

should be implemented to try to reduce the incidence of nest predation on eastern wild turkey nests.

Key words: Artificial nests, eastern wild turkey (*Meleagris gallopavo silvestris*), Pineywoods, nest predators, raccoons (*Procyon lotor*), crows (*Corvus brachyrhynchos*)

Introduction

The degree to which predators affect their prey resources is central to the study of ecology (Begon et al. 2006), in addition to this, it is of overriding importance when considering the control of abundant prey or the conservation of endangered prey (Macdonald et al. 1999), or prey of ecological, economic or recreational importance. The effects of predation can be the difference between persistence or local extinction of rare prey (Caughley and Sinclair 1994, Macdonald et al. 1999). The effects of predation may interact with other causes of mortality such as hunting by humans, where the additive effect may cause the collapse of such prey populations (Macdonald et al. 1999). Nesting by eastern wild turkeys (*Meleagris gallopavo silvestris*) is confined to the spring months (late March to late June) (Healy 1992, Isabelle 2010). Poor nest survival is one of the primary limitations to the successful recruitment of bird species (Dreibelbis et al. 2008), where the main cause of nest mortality in avian species is often cited as predation (Ricklefs 1969, Rotenberry 1989, Martin 1993a, Mezquida 2001;2003). This factor is influential with regard to ground nesting birds (Ricklefs 1969, Dreibelbis et al. 2008) which are particularly vulnerable to mammalian, avian, and reptilian predation

(Marcstrom et al. 1988, Newton 1993, Fletcher et al. 2010). Being a ground nesting species, this is relevant to wild turkeys because nesting hens, nests and young poults are especially vulnerable to predation (Glidden 1975, Speake 1980, Miller and Leopold 1992). Precocial bird species like wild turkeys have a relatively long incubation period, approximately 26 days (Williams Jr et al. 1971, Healy 1992), where incubating wild turkey hens are vulnerable to predation for an extended period. Wild turkeys are not known to display any defensive behaviors against predators, rather they have evolved various adaptations to counter predator pressure, such as large body size, being long-lived, roosting in trees, formation of flocks, large clutch sizes, and preference of open habitat (Leopold and Chamberlain 2002).

The wild turkey is the largest game bird in the USA and was native to at least 39 of the states in the continental USA (excluding Alaska) and is of great cultural and financial value throughout its' range (Kennamer et al.1992). Wild turkeys were pushed to the brink of extinction through habitat loss and hunting (Kennamer et al.1992 , Lopez et al. 2000). Attempts to restore the wild turkey have generally been successful (Kennamer et al.), but this has not been the case in the Pineywoods of east Texas (Boyd and Oglesby 1975, Isabelle 2010). The Texas Parks and Wildlife Department have committed vast resources (financially and man-power) to the re-establishment of the eastern wild turkey in east Texas. Whereas most attempts to reestablish populations of wild turkeys, throughout the United States, have been successful, this is not the case in east Texas (Newman 1945, Boyd and Oglesby 1975, Lopez et al. 2000, Isabelle 2010). Reasons for the failure of wild turkey reintroductions could include: habitat fragmentation, habitat modification, weather conditions, poor reproductive performance, translocation and release stress, and predation (Kennamer et al. 1992, Wakeling et al. 2001). Despite reintroduced turkeys achieving nesting success rates comparable to those in areas where wild turkeys have been successfully reintroduced (Vangilder 1992, Isabelle 2010), their attempts seem to have failed to result in the establishment of a self-sustaining population.

Variation in wild turkey nest success has been attributed to a variety of factors including weather (Roberts et al. 1995, Roberts and Porter 1998, Lowrey et al. 2001), and nest site habitat (Seiss et al. 1990, Badyaev 1995), however, nest predation has been cited as the most important factor limiting nest success (Vander Haegen et al. 1988, Vangilder 1992, George 1997, Paisley et al. 1998, Kelly 2001). The influence of predation, by mesopredators, on the survival of eastern wild turkey nests in the Pineywoods, is not well understood. There is little evidence that typical mesopredators preyed on adult wild turkeys in this region (Section 3). However, there is evidence that eastern wild turkey nests, in this region, are frequently preyed on by a variety of predators (Campo 1989, George 1997, Kelly 2001, Isabelle 2010).

When searching for prey, predators adopt a search image (Guilford and Dawkins 1987, Nams 1997, Jackson and Li 2004), a transitory filtering of visual stimuli that enables an animal to focus on finding a particular type of prey (Lawrence 2005). This allows predators to increase their probability of locating specific prey types (Begon et al. 2006). Traditionally search images have been related to visual cues that predators home in on; the concept has more recently been expanded to include olfactory cues (Nams 1997). Visual cues that mesopredators might use to locate wild turkey nests include a sitting hen, eggs and a particular type of vegetation configuration. Olfactory cues might include; the scent of the wild turkey, the eggs, excreta from the female, and scent of the newly hatched poults and the broken eggs (Rangen et al. 2000).

To determine the extent to which predation effected the recruitment of wild turkeys, it was necessary to establish which predators were responsible for preying on eastern wild turkey nests. Eastern wild turkeys, in this region, were thought to be especially susceptible to being flushed from their nests and they might not have returned to resume incubation of the eggs after such disturbances (Still Jr and Baumann Jr 1990). Because of the possibility that wild turkeys might abandon their nests and due to the low density and poor recruitment (Isabelle 2010) of this subpopulation, it was not appropriate to monitor live nests for fear of compromising the recruitment of the wild turkeys.

Artificial nests are known to differ from natural nests with regard to the level of predation. Some studies have found that artificial nests are subjected to higher (Chamberlain et al. 1995, Davison and Bollinger 2000), and lower (Bechet et al. 1998, Sloan et al. 1998, Wilson et al. 1998, Zanette 2002) levels of predation than real nests. A variety of factors have been shown to influence the rate of predation on nests and differences between artificial nests and real nests influence the rates of predation on either real or artificial nests. The primary difference that effects the response of a nest predator and the incidence of nest predation is the presence of a female on the nest (Martin 1987, Wilson et al. 1998). There is no conclusive evidence that artificial nests and natural nests show a consistent trend or relationship to one another in terms of predation rate (Mezquida 2003). Artificial nests are useful to identify potential nest predators (Wilson et al. 1998).

There are several shortcomings related to the use of artificial nests as a basis from which to infer the fates and predators of real wild turkey nests (Major and Kendal 1996, Buler and Hamilton 2000, Zanette 2002). Differential egg characteristics have been demonstrated to effect predation rates (Lindell 2000). For example – size may prevent certain predators from preying on the surrogate eggs, the scent signature of the surrogates may be different than real eggs, and different optical signature between real eggs and the surrogate eggs may exist (Major and Kendal 1996). The nest characteristics may also vary between real and artificial nests. Artificial nests are often located in habitats not selected for by focal species when placing nests, where inferences regarding predation pressures are limited. Studies using artificial nests set out in transects have shown that artificial nest depredations are related to those in close proximity to them. Frequent nest visits have been shown to increase the rate of predation on artificial nests (Major and Kendal 1996). The absence of a female incubating artificial nests, have also resulted in the alteration of audio and visual cues that predators might have used to locate nests (Wilson et al. 1998). Various authors have identified differential predation rates on real and artificial nests. The predation rate on artificial nests has been found to be higher than on real nests (Salonen and Penttinen 1988, MaCivor et al. 1990, Roper 1992, Major and Kendal 1996) for a variety of species.

Where the study species is rare it is often not possible to find enough real nests to assess factors that influence nest predation (Reitsma et al. 1990). When the influence of monitoring live nests might compromise the success of nests it is not ethical to monitor real nests. Under these circumstances I decided that the use of artificial nests was the only means to gain insight into variables that might influence predation on eastern wild turkey nests in the Pineywoods.

With the above provisos in mind, I developed an artificial nest experiment to determine;

1) Which predators prey on artificial wild turkey nests,
2) Whether the sites selected by wild turkeys for nests were less susceptible to predation than random locations,
3) Whether nest predators formed a specific search image for artificial nests during seasons associated with nesting,
4) Whether there was differential seasonal predation on artificial nests, and
5) Whether the presence of a surrogate for the wild turkey hen (visual cue), at the nest, would influence predation on the nest.

Study area

I conducted this study in the Pineywoods of east Texas. The Pineywoods stretch across east Texas, northwestern Louisiana and southwestern Arkansas. It is the western extent of the Southeastern coastal plain and the vegetation communities bear close resemblance to the southeastern mixed forest and southeastern conifer forest vegetation types. Little of the original longleaf pine (*Pinus palustris*) forests remain, and have been largely replaced by even-aged loblolly pine (*Pinus taeda*) plantations. Much of the natural vegetation of the Pineywoods has been compromised due to the planting of pine plantations and the exclusion of fire (Omernik et al.2008).

The Pineywoods are a continuation of the forests from adjacent states (Murphy 1976). The eastern most region of Texas is characterized by a mixture of extensive pine and mixed pine and hardwood forests. The topography is that of gently rolling hills with swampy low-lying areas. Historically these pine forests were successional to hardwood forests (Landers Jr 1987.).

Commercial forestry in the region has increased since the 1992 forest surveys were completed (Kelly 1992a;b). In 1992, the USFS estimated that 67.5 % of the land in this part of East Texas was comprised of two dominant forest types: - loblolly pine (*Pinus taeda*)/ shortleaf pine (*Pinus echinata*) and longleaf pine / slash pine (*Pinus elliottii*). Estimates in 2003 indicate that there had been a marginal increase in the area under commercial forestry, from 4.78 million hectares in 1992, to 4.82 million hectares in 2003

(Rudis and Station 2008). Significantly, the amount of land under pine (*Pinus*) had increased by 30% to 2.27 million hectares between 1992 and 2002(U.S. Department of Agriculture 2002, Rudis and Station 2008). It is likely that the percentage of land dedicated to softwood timber production will continue to increase (Haynes 2002). The remaining landscape supported a combination of woodland types including; oak (*Quercus* spp.)/ hickory (*Carya* spp.), oak/ gum (*Nyssa* spp.)/ cypress (*Taxodium* spp.), and oak/ pine mix (Murphy 1976, Kelly 1992a;b, Sivanpillai et al. 2005).

The nature of ownership is such that private land owners account for 63% of the ownership, with large portions of this land being in relatively small parcels of 0.4 to 3.6 ha. The consequence of the small parcel sizes is an increased degree of forest fragmentation (U.S. Department of Agriculture 2002). The habitat available for wild turkeys is substantially modified from that in which they used to occur. With the increase in timber plantations, continued habitat modification and increasing urbanization and turkey habitat is increasingly more fragmented now than in the past.

The mean annual rainfall in the Pineywoods is 1,192 millimeters (mm), with a monthly mean that varies between a low of 55 mm in July and 116.4 mm in May. The mean annual minimum temperature is 12.8° Celsius (C) and the mean annual maximum temperature is 25.5° C. The mean maximum temperature in the summer is 35° C (Sivanpillai et al. 2005). During my study, the mean annual temperature was 19.4° C, the minimum temperature recorded was – 5.3° C, and the maximum temperature was

38° C (NOAA 2012). The mean annual rainfall during my study was 1015 mm, with the highest rainfall occurring in 2009 (1243 mm) and the lowest in 2011 (832 mm) (NOAA 2012).

I conducted this study in the Nacogdoches and Angelina counties in east Texas, from January 2009 to September 2011. The two properties that formed the core of the study site are the Winston 8 Ranch (33 77 10 N, 348 64 10 W) (1360 ha, owned by Mr. Simon Winston) and the Cottingham Hunting Club Property (37 23 02 N, 347 83 15 W) (5000 ha, owned by Hancock Forest Management). I selected these properties because they were the only properties known to harbor populations of radio tagged eastern wild turkeys. Additionally, several wild turkey reintroductions have been attempted in these counties (Isabelle 2010).

Wild turkeys were released on the Winston 8 ranch in 2002 (1 male, 11 females) and 2003 (2 males, 7 females). From February 2007 to February 2008, a further 83 wild turkeys (66 female, 17 male) were released on the Winston 8 Ranch as part of a 'super-stocking' (Lopez et al. 2000) program (Isabelle 2010). The Cottingham Hunting club was not used as a 'super-stocking' site. In 1990, 15 wild turkeys were released about 3 km from the site and it seems that they continue to exist and nest on this property (Isabelle 2010).

Methods

To investigate whether mesopredators form a specific search image for eastern wild turkey nests, I implemented a manipulative experiment using artificial wild turkey nests and time-lapse photography. I developed an experimental protocol try to obviate most problems previously identified with artificial nest studies, by leaving no human scent, not revisiting the artificial nest sites while they are ‘active’, using a surrogate for the presence of a wild turkey female, adding wild turkey scent cues (addition of real wild turkey feathers to the artificial nests), and using nest sites that are known to have been used by wild turkeys in the past. Because chicken eggs are smaller than wild turkey eggs they did not limit the ability of the predators’ ability to consume the eggs. I avoided deploying the artificial nests in a systematic pattern so there was little likelihood that predators were able to follow a ‘nest line’.

I conducted this experiment seasonally from spring 2009 to fall 2011. I used the natural (solstices and equinoctial) seasons (winter: 21 December to 20 March, spring: 21 March to 20 June, summer: 21 June to 20 September, fall: 21 September to 20 December). Two of the natural seasons, spring and summer, coincided with the nesting season for eastern wild turkeys in the Pineywoods (Isabelle 2010). This seasonal approach allowed me to assess whether the mesopredators formed a seasonal search image for artificial wild turkey nests or whether they encounter the artificial wild turkey nests randomly as a result of their movements in their home ranges.

Unlike live nests, the use of artificial nests lends itself to manipulation (Reitsma et al. 1990, Rangen et al. 2000), monitoring artificial nests in areas not usually selected for nesting and monitoring artificial nests outside the natural nesting season. I positioned artificial nests on the sites of one-year-old wild turkey nesting sites (historic nest sites) (the nest sites were based on sites recorded for turkey nests being monitored in a parallel study on the nesting ecology of eastern wild turkeys in the Pineywoods of east Texas) (Isabelle 2010). I positioned ten artificial nests on one year old nesting sites and ten artificial wild turkey nests on random locations throughout the study sites for 14 days. One remote camera was destroyed by logging activities during winter 2010. Consequently, after this I only monitored 19 artificial nests. The artificial nests were divided between two sites, initially 10 artificial nests of the Winston site and 10 on the Cottingham site.

Each year I randomly selected ten of a possible 29 (11 on Cottingham, 18 on Winston) known (from previous nesting seasons, Isabelle 2010) one year old wild turkey nest locations (five on each study site) for artificial nest placement. I randomly selected ten locations (five on each study site), using GIS, for the placement of the random artificial nest sites. I identified each of the random locations on the ground and then set-up the artificial nest in the nearest position that approximated a typical wild turkey nest setting – areas with a dense understory and high shrub densities (Holbrook et al. 1987, Campo 1989, Schmutz et al. 1989, Isabelle 2010). I changed the locations used for artificial nests each year. This facilitated a comparison between the predators preying on artificial wild turkey nests in turkey nesting areas with artificial wild turkey nests positioned outside nesting areas. From this it was possible for me to determine whether the predators searched specific areas for wild turkey nests. I deployed the artificial nests and then left them for the entire 14 day exposure period to obviate problems associated with predators cuing on human movements to and from the nest sites.

The 14 day exposure protocol was approximately half the length of time that it takes a wild turkey to incubate its clutch (Ransom Jr et al. 1987, Campo 1989, Isabelle 2010). The total exposure period of wild turkey eggs is likely to be greater even than that because a portion of the eggs are exposed during the laying period prior to the onset of incubation. I did not leave the eggs in place for more than 14 days because of the risk of skewing the results due to the eggs rotting and consequently changing the olfactory signature. I did not replace the eggs during the exposure period because this would have compromised the nests by leaving a second 'set' of human olfactory and visual cues for predators.

I positioned decoys representing 'sitting wild turkey females' on five of the artificial nests on the historical wild turkey nesting sites and five decoys representing 'sitting wild turkey females' on the artificial wild turkey nests in random areas. This facilitated my estimation of the influence of the presence of an 'adult' wild turkey surrogate on the incidence of predation on artificial wild turkey nests. I repeated this in each season to investigate if mesopredators form a seasonal search image for artificial wild turkey nests or if they encounter the artificial wild turkey nests randomly as a result of their movements in their home ranges.

I baited the artificial nests with 12 unwashed domestic chicken (*Gallus domesticus*) eggs, to simulate wild turkey eggs (Yahner and Mahan 1996, Hernandez et al. 1997b). I considered using unwashed turkey eggs as a surrogate for the presence of wild turkey eggs in the artificial nests, however, turkey eggs were not available year round and chicken eggs have been found to be suitable surrogates for wild turkey eggs (Yahner and Mahan 1996). It was preferable to use the same type of egg in the artificial nests year round rather than changing the egg types.

I positioned time lapse / motion detecting camera (Reconyx™ RM45) such that they would be triggered once every 5 minutes or by the movement of any animals near the artificial nest bowl. Using a time-lapse / motion detecting camera prevented me from missing predation events during periods when there was no detectable difference between the ambient temperature and any animal that passed through the infrared beam, particularly reptiles. Using remote cameras allowed me to unambiguously identify those nest predators responsible for predating artificial wild turkey nests. In addition, I was able to identify both primary and secondary predation events at artificial nests. A secondary predation occurred when a nest was depredated, but fewer than 12 eggs were consumed by a predator during its first visit to the nest and another nest predator discovered and depredated more of the eggs.

Analyses

Where artificial nests were preyed on I recorded the nest predator and the level of predation, full predation (all eggs consumed or broken) or partial predation (fewer than 12 eggs consumed or broken). I calculated the percentage of nest predation events that involved total predations and partial predations relative to species of predator and relative to type of predator (mesopredator / other type of predator).

I recorded the time to predation (from the time of deployment) for each artificial nest. I used fixed effects analysis of variance (ANOVA) to determine whether the time to predation of artificial nests varied relative to type of predator, year, season, study site, historic nest site and presence of wild turkey decoy.

I used logistic regression including all variables to investigate the relationship between the likelihood of predation on artificial nests. My variables for this analysis included; year, season, study site, nest site, and presence of a surrogate for a female turkey (Vander Haegen and Degraaf 1996, Vander Haegen et al. 2002). I used logistic regression including all variables to investigate the relationship between the likelihood of artificial wild turkey nests being preyed on by mesopredators rather than other predators. My variables for this analysis were; year, season, study site, nest site, the presence of a surrogate for a female turkey, and time to predation (time of deployment to time of predation). I used likelihood ratio and Hosmer-Lemeshow tests to determine the suitability of the models and odds ratios (OR) to identify the influence of main effects

(Yahner and Wright 1985, Vander Haegen and Degraaf 1996). I used OR to reflect the influence of each of the significant variables to likelihood of an artificial nest being preyed on.

Results

I monitored 20 artificial eastern wild turkey nests (artificial nests) seasonally from spring 2009 to spring 2010, and 19 artificial nests from spring 2010 to summer 2011. The species that depredated artificial wild turkey nests in the Pineywoods included; nine-banded armadillo (*Dasypus novemcinctus*) (0.85%), bobcat (*Lynx rufus*) (0.85%), coyote (*Canis latrans*) (0.85%), gray fox (*Urocyon cinereoargenteus*) (1.7%), Virginia opossum (*Didelphis virginiana*) (8.55%), raccoons (35%), American crows (*Corvus brachyrhynchos*) (48%), woodpecker (*Picoides sp*.) (0.85%), snake (unidentified species) (0.85%), and unknown nest predator (2.5%) (Table 4.1). The mean time to predation on artificial wild turkey nests for mesopredators were; raccoons (6.46 days; n = 41, SE = 0.72), and opossums (9.03 days; n = 10, SE = 1.65). American crows discovered and preyed on artificial wild turkey nests relatively quickly ($\bar{x}$ = 4.3 days, n = 58, SE = 0.56) (Table 4.2).

Approximately 61% of the 194 artificial nests monitored between spring 2009 and fall 2011 were depredated. On the Winston site 53% of artificial nests were depredated, compared to 69% on Cottingham (Table 4.3). In 2011, 85% of all artificial nests were depredated compared with 56.7% in 2009, and 62.5% in 2010 (Table 4.3). Sixty seven

Table 4.1: *Predators responsible for preying on artificial wild turkey nests, in the Pineywoods of east Texas from spring 2009 to fall 2011*

Predator	**Entire Study**	**Seasonal Predation**			
		Winter	**Spring**	**Summer**	**Fall**
Armadillo	1	0	1	0	0
Bobcat	1	1	0	0	0
Coyote	1	0	0	1	0
Crow	57	16	18	16	7
Gray Fox	2	0	2	0	0
Oppossum	10	1	0	6	3
Raccoon	41	2	11	22	6
Snake	1	0	1	0	0
Wood Pecker	1	0	0	1	0
Unknown	3	1	0	2	0
Total	**118**	**21**	**33**	**48**	**16**

Table 4.2: *Time to predation for the predators of artificial nests in the Pineywoods of east Texas, from spring 2009 to fall 2011*

Predator	**Study site**	**Year**	**Season**	***n***	**SE**	**Time to Predation (Days)**
Raccoon	Cottingham	2009	Fall	2	2.5	4.5
Raccoon	Cottingham	2009	Spring	2	1	2.0
Raccoon	Cottingham	2009	Summer	4	3.2	7.5
Crow	Winston	2009	Fall	1	*	12.0
Crow	Winston	2009	Summer	1	*	8.0
Oppossum	Winston	2009	Fall	1	*	11.0
Oppossum	Winston	2009	Summer	1	*	3.0
Raccoon	Winston	2009	Fall	1	*	3.0
Raccoon	Winston	2009	Spring	1	*	1.0
Raccoon	Winston	2009	Summer	2	2.8	5.0
Coyote	Cottingham	2010	Summer	1	*	4.2
Crow	Cottingham	2010	Fall	2	1.37	5.5
Crow	Cottingham	2010	Spring	4	0.41	3.9
Crow	Cottingham	2010	Summer	3	0.85	2.3
Crow	Cottingham	2010	Winter	3	2.8	7.6
Oppossum	Cottingham	2010	Fall	1	*	5.4
Raccoon	Cottingham	2010	Winter	1	*	13.4
Bobcat	Winston	2010	Winter	1	*	11.5
Crow	Winston	2010	Spring	1	*	3.0
Crow	Winston	2010	Summer	1	*	13.0
Crow	Winston	2010	Winter	1	*	13.0
Oppossum	Winston	2010	Fall	1	*	1.3
Oppossum	Winston	2010	Summer	1	*	13.9
Raccoon	Winston	2010	Fall	1	*	12.7
Raccoon	Winston	2010	Summer	3	2.79	7.0
Crow	Cottingham	2011	Spring	1	*	0.4
Crow	Cottingham	2011	Summer	2	0.04	1.9
Crow	Cottingham	2011	Winter	2	0.04	1.2
Raccoon	Cottingham	2011	Spring	3	1.97	4.6
Raccoon	Cottingham	2011	Summer	2	0.39	3.2
Raccoon	Cottingham	2011	Winter	1	*	3.7
Crow	Winston	2011	Spring	3	1.32	2.8
Crow	Winston	2011	Summer	1	*	0.2
Crow	Winston	2011	Winter	3	3.99	5.0
Gray Fox	Winston	2011	Spring	1	*	8.2
Oppossum	Winston	2011	Summer	1	*	13.0
Oppossum	Winston	2011	Winter	1	*	2.8
Raccoon	Winston	2011	Summer	2	3.99	9.9
All	Cottingham	2009	Fall	2	2.5	4.5

Table 4.2: *(Continued)*

Predator	**Study site**	**Year**	**Season**	***n***	**SE**	**Time to Predation (Days)**
All	Cottingham	2009	Summer	4	3.2	7.5
All	Cottingham	2010	Fall	3	0.79	5.4
All	Cottingham	2010	Spring	4	0.41	3.4
All	Cottingham	2010	Summer	4	0.77	2.7
All	Cottingham	2010	Winter	4	2.46	9.0
All	Cottingham	2011	Spring	4	1.76	3.6
All	Cottingham	2011	Summer	4	0.42	2.5
All	Cottingham	2011	Winter	3	0.83	2.1
All	Cottingham	2009	All	8	2.36	5.4
All	Cottingham	2010	All	15	0.93	5.1
All	Cottingham	2011	All	11	0.66	2.8
All	Winston	2009	Fall	4	2.18	9.5
All	Winston	2009	Spring	1	*	1.0
All	Winston	2009	Summer	4	1.31	5.3
All	Winston	2010	Fall	2	5.69	7.0
All	Winston	2010	Spring	1	*	3.0
All	Winston	2010	Summer	5	2.2	9.6
All	Winston	2010	Winter	2	0.73	12.3
All	Winston	2011	Spring	4	1.65	4.1
All	Winston	2011	Summer	4	3.22	8.2
All	Winston	2011	Winter	4	2.88	4.4
All	Winston	2009	All	9	1.44	6.7
All	Winston	2010	All	10	1.6	9.0
All	Winston	2011	All	12	1.5	5.6
Coyote	Cottingham	2010	All	1	*	4.2
Crow	Cottingham	2010	All	12	0.9	4.5
Crow	Cottingham	2011	All	5	0.28	1.3
Oppossum	Cottingham	2010	All	1	*	5.4
Raccoon	Cottingham	2009	All	8	1.8	5.4
Raccoon	Cottingham	2010	All	1	*	13.4
Raccoon	Cottingham	2011	All	6	0.93	4.0
Bobcat	Winston	2010	All	1	*	11.5
Crow	Winston	2009	All	3	1.33	10.7
Crow	Winston	2010	All	3	3.32	9.7
Crow	Winston	2011	All	7	1.73	3.4
Gray Fox	Winston	2011	All	1	*	8.2
Oppossum	Winston	2009	All	2	4	7.0
Oppossum	Winston	2010	All	2	6.27	7.6
Oppossum	Winston	2011	All	2	5.11	7.9
Raccoon	Winston	2009	All	4	1.26	3.5
Raccoon	Winston	2010	All	4	2.43	8.4
Raccoon	Winston	2011	All	2	3.99	9.9

Table 4.3: *The number of artificial wild turkey nests preyed upon by a variety of nest predators in the Pineywoods of east Texas from spring 2009 to fall 2011*

Study Site	**Year**	**Season**	**Number of nests**	**Nests Preyed on**	**% Nests Preyed on**	**Bob**	**Coy**	**Rac**	**Opo**	**Gray Fox**	**Arm**	**Crow**	**W. Peck**	**Snake**	**?**
Cottingham	2009	Annual	30	16	53.3			14	1						1
Winston	2009	Annual	30	13	43.3			7	2			3			1
Both	**2009**	**Annual**	**60**	**29**	**48.3**			**21**	**3**			**3**			**2**
Cottingham	2009	Fall	10	4	40.0			4							
Winston	2009	Fall	10	4	40.0			1	1			2			
Both	**2009**	**Fall**	**20**	**8**	**40.0**			**5**	**1**			**2**			
Cottingham	2009	Spring	10	3	30.0			3							
Winston	2009	Spring	10	2	20.0			2							
Both	**2009**	**Spring**	**20**	**5**	**25.0**			**5**							
Cottingham	2009	Summer	10	9	90.0			7	1						1
Winston	2009	Summer	10	7	70.0	1	1	4	1			1			1
Both	**2009**	**Summer**	**20**	**18**	**90.0**	**1**	**1**	**11**	**2**			**1**			**2**
Cottingham	2010	Annual	37	25	67.6			2	2		1	19			
Winston	2010	Annual	40	16	40.0	1		4	3			7	1		
Both	**2010**	**Annual**	**77**	**41**	**53.2**	**1**	**1**	**6**	**5**		**1**	**26**	**1**		
Cottingham	2010	Fall	9	5	55.6				1			4			
Winston	2010	Fall	10	3	30.0			1	1			1			
Both	**2010**	**Fall**	**19**	**8**	**42.1**			**1**	**2**			**5**			
Cottingham	2010	Spring	9	8	88.9			1			1	6			
Winston	2010	Spring	10	3	30.0							3			
Both	**2010**	**Spring**	**19**	**11**	**57.9**			**1**			**1**	**9**			
Cottingham	2010	Summer	9	6	66.7		1		1			4			
Winston	2010	Summer	10	8	80.0			3	2			2	1		
Both	**2010**	**Summer**	**19**	**14**	**73.7**		**1**	**3**	**3**			**6**	**1**		
Cottingham	2010	Winter	10	6	60.0			1				5			
Winston	2010	Winter	10	2	20.0	1						1			
Both	**2010**	**Winter**	**20**	**8**	**40.0**	**1**		**1**				**6**			
Cottingham	2011	Annual	27	24	88.9			7				16			1
Winston	2011	Annual	30	24	80.0			7	2	2		12		1	
Both	**2011**	**Annual**	**57**	**48**	**84.2**			**14**	**2**	**2**		**28**		**1**	**1**
Cottingham	2011	Spring	9	8	88.9			3				5			
Winston	2011	Spring	10	9	90.0			2		2		4		1	
Both	**2011**	**Spring**	**19**	**17**	**89.5**			**5**		**2**		**9**		**1**	
Cottingham	2011	Summer	9	9	100.0			3				6			
Winston	2011	Summer	10	9	90.0			5	1			3			
Both	**2011**	**Summer**	**19**	**18**	**94.7**			**8**	**1**			**9**			
Cottingham	2011	Winter	9	7	77.8			1				5			1
Winston	2011	Winter	10	6	60.0				1			5			
Both	**2011**	**Winter**	**19**	**13**	**68.4**			**1**	**1**			**10**			**1**

Bob = bobcat, Coy = coyote, Rac = Raccoon, Opo = opossum, Arm = armadillo, W.Peck = wood pecker, ? = unknown percent of artificial nests that I deployed on historic wild turkey nest sites were depredated compared to 54% of randomly located artificial nests (Table 4.4). I found that 86.3% of artificial nests were depredated in summer compared with fall (55%), spring (54.3%), and winter (69%) (Table 4.3).

I found that site (Winston) ($Z = -2.69$, $df = 1$, $P = 0.007$), year (2011) ($Z = 4.19$, $df = 1$, P < 0.001), nest site ($Z = 2.09$, $df = 1$, $P = 0.036$), and season (summer) ($Z = 3.30$, $df = 1$, $P < 0.001$), influenced whether artificial nests were depredated (Table 4.5). Using the Hosmer-Lemeshow goodness of fit test, I failed to detect a significant difference between the full model and the null model ($\chi^2 = 7.95$, $df = 8$, $P = 0.44$), this indicated that the model fit the data. I found further support for the plausibility of the model using a likelihood ratio test (Log Likelihood = -02.94, $df = 9$, $P < 0.001$). The OR indicated that the Winston study site, the year 2011, nest sites and the season 'summer' were variables that influenced the likelihood of artificial nests being depredated (Table 4.6). Between spring 2009 and fall 2011, 118 artificial nests were depredated, 46.6% (n = 55) by mesopredators (bobcats, coyotes, gray foxes, opossums, and raccoons) and 53.4% (n = 63) by other species (armadillos, crows, woodpeckers, snakes, unknown). In 2009, 82.8% (n = 24) of artificial nests that were depredated were preyed on by mesopredators, in 2010, 31.7% (n = 13) were preyed on by mesopredators and in 2011, 37.5% (n = 18) were preyed on by mesopredators. Thirty nine percent (n = 21) of artificial nests on historic nest locations were depredated by mesopredators, whereas 54% (n = 35) of artificial nests positioned at random locations were depredated by

Table 4.4: *Incidence of predation on artificial wild turkey nests on historic wild turkey nest sites in the Pineywoods of east Texas from spring 2009 to fall 2011*

Study Site	**Year**	**Season**	**No nests**	**Nests Preyed on**	**% Nests Preyed on**	**Bob**	**Coy**	**Rac**	**Opo**	**Gray fox**	**Crow**
Cottingham	2009	Annual	15	8	53.3			8			
Winston	2009	Annual	15	9	60.0			4	2		3
Both	**2009**	**Annual**	**30**	**17**	**56.7**			**12**	**2**		**3**
Cottingham	2009	Fall	5	2	40.0			2			
Winston	2009	Fall	5	4	80.0			1	1		2
Both	**2009**	**Fall**	**10**	**6**	**60.0**			**3**	**1**		**2**
Cottingham	2009	Spring	5	2	40.0			2			
Winston	2009	Spring	5	1	20.0			1			
Both	**2009**	**Spring**	**10**	**3**	**30.0**			**3**			
Cottingham	2009	Summer	5	4	80.0			4			
Winston	2009	Summer	5	4	80.0			2	1		1
Both	**2009**	**Summer**	**10**	**8**	**80.0**			**6**	**1**		**1**
Cottingham	2010	Annual	20	15	75.0		1	1	1		12
Winston	2010	Annual	20	10	50.0	1		4	2		3
Both	**2010**	**Annual**	**40**	**25**	**62.5**	**1**	**1**	**5**	**3**		**15**
Cottingham	2010	Fall	5	3	60.0				1		2
Winston	2010	Fall	5	2	40.0			1	1		
Both	**2010**	**Fall**	**10**	**5**	**50.0**			**1**	**2**		**2**
Cottingham	2010	Spring	5	4	80.0						4
Winston	2010	Spring	5	1	20.0						1
Both	**2010**	**Spring**	**10**	**5**	**50.0**						**5**
Cottingham	2010	Summer	5	4	80.0		1				3
Winston	2010	Summer	5	5	100.0			3	1		1
Both	**2010**	**Summer**	**10**	**9**	**90.0**		**1**	**3**	**1**		**4**
Cottingham	2010	Winter	5	4	80.0			1			3
Winston	2010	Winter	5	2	40.0	1					1
Both	**2010**	**Winter**	**10**	**6**	**60.0**	**1**		**1**			**4**
Cottingham	2011	Annual	12	11	91.7			6			5
Winston	2011	Annual	15	12	80.0			2	2	1	7
Both	**2011**	**Annual**	**27**	**23**	**85.2**			**8**	**2**	**1**	**12**
Cottingham	2011	Spring	4	4	100.0			3			1
Winston	2011	Spring	5	4	80.0					1	3
Both	**2011**	**Spring**	**9**	**8**	**88.9**			**3**		**1**	**4**
Cottingham	2011	Summer	4	4	100.0			2			2
Winston	2011	Summer	5	4	80.0			2	1		1
Both	**2011**	**Summer**	**9**	**8**	**88.9**			**4**	**1**		**3**
Cottingham	2011	Winter	4	3	75.0			1			2
Winston	2011	Winter	5	4	80.0				1		3
Both	**2011**	**Winter**	**9**	**7**	**77.8**			**1**	**1**		**5**

Bob = bobcat, Coy = coyote, Rac = raccoon, Opo = opossum,

Table 4.5: *95 % confidence intervals for variables related to artificial wild turkey nest predation, in the Pineywoods of east Texas, from spring 2009 to fall 2011*

Variable	**Lower**	**Upper**	***Z***	**df**	***P***	**Significance**
(Intercept)	-1.349	0.599	-0.735	1	0.462	
Site = Winston	-1.633	-0.266	-2.695	1	0.007	**
2010	-0.227	1.359	1.383	1	0.167	
2011	1.289	3.488	4.188	1	<0.001	***
Historic nest site	0.055	1.407	2.096	1	0.036	*
Spring	-0.788	1.053	0.275	1	0.783	
Summer	0.715	2.738	3.298	1	<0.001	***
Winter	-1.655	0.551	-0.966	1	0.334	
Decoy present	-1.069	0.276	-1.142	1	0.253	

* significant at $\alpha = 0.05$

** significant at $\alpha = 0.01$

*** significant at $\alpha = 0.001$

Table 4.6: *95% confidence intervals for the coefficients of variables that were found to have a significant influence on the likelihood of artificial nests being preyed on in the Pineywoods of east Texas from spring 2009 to fall 2011*

Variable	**Lower**	**Upper**	**Odds ratio**	**Significance**
(Intercept)	0.2594827	1.819841	0.696	
Winston	0.1953569	0.766076	0.392	*
2010	0.7967226	3.893994	1.746	
2011	3.6284206	32.735385	10.344	*
Nest site	1.0560133	4.083403	2.056	*
Spring	0.4545844	2.866796	1.137	
Summer	2.044905	15.451862	5.431	*
Winter	0.1911725	1.735692	0.582	
Decoy present	0.3434631	1.317754	0.677	

* significant variables

mesopredators. The variables; year (2010) (Z = -3.95, *df* = 1, $P < 0.001$), year (2011) (Z = -2.76, *df* = 1, $P = 0.006$), nest site (Z = 2.31, *df*= 1, $P = 0.02$), and time to predation (Z = 3.20, *df* = 1, $P = 0.001$), influenced whether an artificial nest was depredated by a mesopredator or another type of predator (Table 4.7). Using a Hosmer-Lemeshow test, there was no difference between the full model and the null model ($\chi^2 = 9.35$, *df* = 8, P = 0.31) which indicated that the model fit the data. I found further evidence for the fit of the model using a likelihood ratio test (Log Likelihood = -57.44, *df* = 9, $P < 0.001$). The variables associated with whether mesopredators or other predators preyed on artificial nests were; years 2010 and 2011, nest site, and time to predation (Table 4.8). Time to predation influenced whether a mesopredator or another predator preyed on an artificial nest. The mean time between my deploying an artificial nest and a mesopredator preying on the nest was 6.75 days (n = 57, SE = 0.63 days), whereas the mean time for other predators was 4.6 days (n = 60, SE = 0.56 days).

The mean time to predation in 2009 was 6.1 days (n = 29, SE = 0.92), in 2010 it was 6.98 days (n = 41, SE = 0.75), and in 2011 it was 4.2 days (n = 47, SE = 0.57). The relationship between time to predation and year (F = 8.14, *df* = 2, $P < 0.001$), indicated that differences existed between the time to predation between 2009 and 2010 (Tukey HSD difference = 3.71, $P = 0.002$), and between 2010 and 2011 (Tukey HSD = -2.92, P = 0.006). There was a difference between the time to predation for mesopredators and other nest predators (F = 6.4, *df*= 1, $P = 0.013$). The mean time to predation on Winston was 7.03 days (n = 53, SE = 0.66), whereas on Cottingham it was 4.49 days (n = 64, SE

Table 4.7: *95% confidence intervals relative to variables that might influence whether an artificial nest is preyed on by a mesopredator or another type of predator in the Pineywoods of east Texas from spring 2009 to fall 2011*

Variables	**Lower**	**Upper**	***Z***	***P***	**sig**
(Intercept)	-1.228	2.246	0.513	0.608	
Winston	-1.174	0.782	-0.361	0.718	
2010	-4.776	-1.672	-3.950	0.000	***
2011	-3.332	-0.609	-2.759	0.006	**
Nest site	0.207	2.200	2.308	0.021	*
Time to predation	0.091	0.352	3.198	0.001	**
Spring	-1.972	1.373	-0.353	0.724	
Summer	-1.076	2.060	0.616	0.538	
Winter	-3.393	0.459	-1.456	0.145	
Decoy present	-1.424	0.433	-1.042	0.297	

* significant at $\alpha = 0.05$
** significant at $\alpha = 0.01$
*** significant at $\alpha = 0.001$

Table 4.8: *95% confidence intervals for coefficients of variables that were found to have a significant influence on whether artificial wild turkey nests were preyed upon by mesopredators or another type of predator in the Pineywoods of east Texas from spring 2009 to fall 2011*

Variables	**Lower**	**Upper**	**Coefficient**	**Significance**
(Intercept)	0.293	9.447	1.563	
Winston	0.309	2.185	0.836	
2010	0.008	0.188	0.045	*
2011	0.036	0.544	0.155	*
Nest site	1.230	9.022	3.202	*
Time to predation	1.095	1.422	1.236	*
Spring	0.139	3.946	0.743	
Summer	0.341	7.848	1.626	
Winter	0.034	1.582	0.244	
Decoy present	0.241	1.542	0.612	

* significant variables

= 0.52). There was a difference between the time to predation relative to the study site (*F* = 7.91. *df* = 1, *P* = 0.006). There was no effect of season (*F* = 0.141, *df* = 3, *P* = 0.93), nest site (*F* = 0.203, *df* = 1, *P* = 0.65), or the presence of a decoy (*F* = 2.58, *df* = 1, *P* = 0.11).

Artificial nests were completely depredated during the first visit by a nest predator in 31% of cases. In 68% of artificial nest predations, secondary predation took place. In one instance of artificial nest predation, five of the eggs were eaten, the rest of the eggs were left in place and were intact when I removed the artificial nest. Only five percent of secondary predations were affected by species other than those that had initially preyed upon the artificial nests. In three instances (raccoons = 2, gray fox = 1) mesopredators were the secondary predator on artificial nests that crows had depredated initially, and in one instance a crow was secondary predator to an artificial nest depredated by a snake. I found there to be little delay between primary and secondary predations ($\bar{x}$ = 0.96 days, *n* = 80, SE = 0.19). The mean times to secondary predation were 0.84 days (*n* = 28, SE = 0.25) raccoons, 0.68 days (*n* = 10, SE = 0.1) opossums, and 0.59 days (*n* = 33, SE = 0.16) crows. In 76% (*n* = 72) of predations on artificial nests by mesopredators, there were instances of secondary predation, 60% (*n* = 38) of primary predation events by other predators were followed up by secondary predation. On 70% (*n* = 28) of the occasions that raccoons preyed on artificial nests, the nest was not completely depredated in the first predation bout, while 63% (*n* = 36) of artificial nest predations by crows were followed by secondary predations.

Discussion

I found that crows were the nest predators that most frequently depredated artificial wild turkey nests in the Pineywoods of east Texas. Of the mesopredators, raccoons and opossums were the species most likely to prey on the artificial nests. There did not seem to be a difference in the incidence of predation on historic wild turkey nest sites relative to random locations. The presence of a surrogate for the presence of a wild turkey female did not seem to influence the rate of predation on artificial wild turkey nests.

It does not appear that the mesopredators form a seasonal search image for the artificial nests. In summer, a greater proportion of artificial nests were preyed on than in other seasons. The above may seem contradictory, however if a search image is defined as a predator having a preconceived set of characteristics, be those visual (Jackson and Li 2004) or olfactory (Nams 1997), that it relates to a certain preferred prey resource, it uses this 'image' to guide its search for prey (Hoi and Winkler 1994). That being the case, then it is possible for a predator not to have a search image for a prey resource, yet still exhibit seasonal variation in terms of use of that resource.

Results from artificial nest experiments are seldom representative of the trends in the nesting ecology of the species to which inference is drawn (Chamberlain et al. 1995, Bechet et al. 1998, Sloan et al. 1998, Wilson et al. 1998, Davison and Bollinger 2000, Zanette 2002, Mezquida 2003). Isabelle (2010) found that wild turkeys in the Pineywoods of east Texas had a nest success of approximately 38%, while other researchers in the region found that wild turkeys nest success was approximately 30%

(George 1997, Eichler 1999, Lopez et al. 2000, Kelly 2001). I found that the predation rate on artificial nests was 61% (39% survival rate) and when I considered the predation of artificial nests in the spring (nesting season) I found that the predation rate was 58% (42% survival rate). The incidence of predation on artificial nests in my study seems, therefore, to be comparable to those of real wild turkey nests in the Pineywoods of east Texas. These results lend support to the assertion that predation rates on artificial ground nests baited with chicken eggs are comparable to the predation rates by nest predators on natural nests of ground nesting birds (Redmond et al. 1982, Yahner et al. 1993, Yahner and Mahan 1996).

Crows preyed on artificial nests most frequently during my study. The degree to which crows preyed on artificial wild turkey nests was higher in the Pineywoods than in other studies (Davis 1959, Baker 1978, Pharris and Goetz 1980, Miller 1992, Hernandez et al. 1997b). From year to year, the incidence of predation on artificial nests by crows increased. This might be attributable to natural variability in the degree to which various nest predators prey on nests (Buler and Hamilton 2000, Mezquida 2003) (Bayne et al. 1997). Although, I changed location of artificial nest sites on an annual basis, I used the same sites each season throughout the year and this may have provided sufficient exposure for resident crows to cue in on my placement of the artificial nests (Wilson et al. 1998).

Corvids such as American crows primarily use visual cues to locate nests (Santisteban et al. 2002). The presence of wild turkey hens on live nests camouflages eggs from avian predators. Despite this, corvids have been recorded preying on active wild turkey nests (Dreibelbis et al. 2008). Wild turkeys cover their newly laid eggs prior to the onset of incubation, but once incubation commences, when hens leave the nest for short periods to forage, they do not camouflage the eggs (Healy 1992). I made no attempt to obscure the eggs within the nest bowls; the consequence of this was that the eggs may have been an obvious target for visual predators. The high visibility of the eggs within the nest bowls and the concomitant high incidence of crows depredating artificial nests, in my study, might be an important aspect that differentiated between predators of artificial wild turkey nests and those of real nests. The relatively short time that crows took to detect artificial nests is probably also a consequence of the obvious artificial nest set-up in absence of a female turkey.

American crows are known to depredate ground nests (Hernandez et al. 1997a), more specifically they have been identified as depredating wild turkey nests (Miller and Leopold 1992). Although crows have been identified as nest predators of turkey nests they have seldom been identified among the most important predators on artificial wild turkey nests (Davis 1959, Baker 1978, Pharris and Goetz 1980, Miller and Leopold 1992). This was surprising, considering the extent to which crows depredated the artificial nests in my study. Few previous studies have monitored artificial nests using remote cameras; in most cases researchers have inferred nest predators from evidence in the nest bowls (Davis 1959, Baker 1978). The identification of nest predators from nest remains is not reliable (Larivière 1999). The consequence of this is that the incidence of crows preying on artificial nests, to date, may have been under-reported. The reason for this is that when crows depredate an artificial nest, they often remove entire eggs and seldom leave any eggshells with characteristic marks from which researchers could identify the nest predator (Appendix 8). Many other nest predators are known to remove eggs entirely (Larivière 1999). It is possible that incidents of nest predation by crows were attributed to other nest predators. If this is the case, crows may play a greater role in depredating wild turkey nests than previously thought. Premised on this, crows are likely to detrimentally affect the efforts to reintroduce wild turkeys in east Texas, especially considering that the numbers of American crows seem to be recovering from their decline (Reed et al. 2009) (http://www.birdsource.org/gbbc/press/news-stories/2011summary/, accessed 08/07/2012) due to West Nile Virus (Ladeau et al. 2008).

The diversity of mammalian species that preyed on artificial wild turkey nests was similar to that of other studies United States (Miller and Leopold 1992) and more specifically to those in the southeast (Lovell et al. 1995). Raccoons and opossums were the mammalian mesopredators that preyed most frequently on artificial wild turkey nests in the Pineywoods. Although I recorded bobcats and coyotes at artificial nests, the instances of predation on artificial nests by these mesopredators was limited to one incident in the case of each species. Many studies have reported that mammalian mesopredators kill adult wild turkeys, especially hens whilst they are incubating nests (Glidden 1975, Speake 1980, Miller and Leopold 1992). Despite this, no wild turkey remains were found in the scats of bobcats, coyotes or raccoons on these study sites, during the same period, in the Pineywoods of east Texas (Section 3). The reason for the lack of evidence of predation by the focal mesopredators on eastern wild turkeys in this study may be attributable to the combination of a low density of mesopredators (Davis 2011), and the low density of eastern wild turkeys (Isabelle 2010) in the region. The consequence of these low densities was to decrease the likelihood of mesopredators both detecting and preying on nesting wild turkeys and their eggs.

Wild turkeys select nest sites that allow them to conceal themselves from predators (Holbrook et al. 1985, Lazarus and Porter 1985, Holbrook et al. 1987, Schmutz et al. 1989, Porter 1992, Martin 1993b, Isabelle 2010). I found that during spring the rate of predation on historic nest sites was similar to that for all artificial nest sites. However, when I assessed the degree of predation on historic nest sites over all seasons, the level to which nest sites were depredated was higher than that for other sites. This was probably partially due to the phenology of the plants in the region (Chenault 1940, Halls 1973) that formed a dense shrubby understory during the spring months. The dense understory served as cover for the artificial nests. As the seasons proceeded, the herbaceous plants senesced and probably provided less nesting cover than during the spring. Although early season wild turkey nests may have little vegetative cover, they are likely to be subjected to a lower incidence of predation because the availability of prey for mesopredators, in early spring, had not yet declined (Section 3) and consequently the mesopredators were unlikely to need to diversify their prey use and increase their search effort.

Whether predators form specific search images for prey resources is an area of much debate in ecology (Guilford and Dawkins 1987). Predators respond behaviorally to temporal changes in availability and abundance of prey (Lima 2002). With regard to the implications for predation on artificial wild turkey nests, the development of a seasonal search image would suggest that predators have developed specific visual (Jackson and Li 2004) and olfactory (Nams 1997) criteria for which they search (Hoi and Winkler 1994) during the nesting season. If mesopredators formed a search image for turkey nests in the Pineywoods of east Texas, I would have expected them to home in on the artificial nests during the nesting season (spring in the case of my seasonality). If the mesopredators were foraging opportunistically, I would have expected an increase in predation on artificial nests during a period of resource depletion (summer) - which is what happened in my study. Without having the other seasons as reference, I would not have been able to distinguish this difference.

Late season nest attempts by wild turkeys are less successful than those initiated early in the season (Rumble and Hodorff 1993). Late nesting season for wild turkeys coincided with the summer season in my analysis. I found the highest incidence of artificial nest predation during this period. Additionally, whereas other seasons had relatively low incidence of depredations by mesopredators, the incidence of artificial nest predation by mesopredators (raccoons and opossums) was highest in summer. This period coincided with when mesopredators had the highest dietary diversity and when small mammal populations were at their lowest (Section 3). Although raccoon home ranges displayed no seasonal variation in size, both bobcats and coyotes had their largest home ranges in summer (Section 2). It seems that the late nesting season increase in incidence of artificial nest predation could be a consequence of a general decline in prey availability for mesopredators and the increase in their search effort (Knick 1990, Hoi and Winkler 1994, Schmidt 2008).

I thought that there would be a difference between artificial wild turkey nests with and without a wild turkey decoy as a surrogate for the presence of a wild turkey hen. I anticipated that the effect of the decoy would have been to reduce the incidence of predation on artificial nests because it increased level of camouflage to the eggs from both avian and terrestrial predators. In addition, the physical presence of the decoy was unfamiliar to predators and might have caused them to be more cautious when approaching the artificial nests. This was not the case; there was no difference in the incidence of predation on artificial wild turkey nests based on the presence or absence of wild turkey decoys. Differences predation rates between artificial nests and real nests are likely to be the consequence of cues that are not merely the physical presence of a surrogate for a hen at the nest site.

Management Implications

It was clear from my study that predation on artificial nests was extensive on both study sites, and certainly indicates that nest predation may contribute to reduced productivity of eastern wild turkeys in the Pineywoods of east Texas. The implication of this is, to confirm which predators are responsible for preying on eastern wild turkey nests it is necessary to monitor live wild turkey nests. To this end I suggest an ongoing program of monitoring of transmittered female eastern wild turkeys in conjunction with future releases to locate nests with the view of monitoring them with nest cameras. If no future relocations are planned, attempts should be made to capture extant female wild turkeys, fit them with radio transmitters, and monitor their nests to determine what predators are responsible for preying on the nests. In addition, I suggest the implementation of a program of conditioned taste aversion (CTA) (Reynolds 1999, Baker et al. 2008, Edmiston and Rollins 2010). This is a program of training the resident predators to associate a certain prey type with a noxious taste and uncomfortable experience (Reynolds 1999, Macdonald and Baker 2004) (Hoover and Conover 2000). A further benefit of CTA is that, if implemented correctly, it can be effective against both mammalian and corvid nest predators (Dimmick and Nicolaus 1990, Caffrey 1994, Avery et al. 1995, Cox et al. 2004, Edmiston and Rollins 2010). The only proviso to the implementation of CTA for corvids is that aversive conditioning eggs should be set out for at least three weeks prior to the onset of wild turkey nesting season to ensure that crows only encounter treated eggs and learn to avoid them (Avery et al. 1995). The effect of such CTA for crows is localized and consequently requires a substantial effort on the part of management staff (Dimmick and Nicolaus 1990, Caffrey 1994, Avery et al. 1995, Cox et al. 2004). For crows, in addition to CTA, the positioning of effigies of crow carcasses has been found to be effective in reducing predation by crows at least tern (*Sterna antillarum)* colonies (Caffrey 1994, Avery et al. 1995). Conditioned taste aversion is not compatible with the simultaneous removal of predators because its success is reliant on a stable resident predator population being trained to avoid specific prey resources. In this case the application of CTA would require the deployment of artificial nests baited with eggs dosed with the substance that causes the aversion reaction in the predator community. To determine the effect of the program, monitoring of live wild turkey nests and subsequent nest success would be required.

5 - SUMMARY

The wild turkey is a culturally significant game bird throughout the United States. (Kennamer et al. 1992). Historically, eastern wild turkeys occupied approximately 12 million hectares in east Texas (Campo 1989), overharvesting of both turkeys and timber led to a precipitous decline of the eastern sub-species in this region (Newman 1945, Campo 1989, Isabelle 2010). Early attempts to reintroduce wild turkeys to east Texas (prior to 1979) were unsuccessful (Newman 1945, Mosby 1975). Subsequently, >7000 wild caught eastern wild turkeys, from several states, have been released in east Texas (Texas Parks and Wildlife (TPWD), Unpublished data) (Isabelle 2010). Despite these attempts to restore the eastern wild turkey to east Texas, recent estimates indicate that the extant population is approximately 15000 individuals, distributed across east Texas in fragmented sub-populations that are susceptible to local extinction (Tapley et al. 2006, Seidel 2010).

Many reasons have been advanced to explain the limited success of the east Texas wild turkey reintroduction programs. There is substantial evidence that predation, by mesopredators, is the primary cause of mortality for all wild turkeys apart from adult gobblers (Speake 1980, Hamilton and Vangilder 1992, Miller and Leopold 1992, Hughes et al. , Kennamer 2005). One of the reasons for the failure of the reintroduction program may therefore be predation by mammalian mesopredators. The influence of mesopredators on eastern wild turkeys in the Pineywoods is not well understood. My study aimed to clarify the likely impact of mesopredators on the reintroduced population of eastern wild turkeys in east Texas.

Three aspects of the ecology of the Pineywoods needed consideration to clarify the influence of mesopredators on eastern wild turkeys in the region;

1) Spatial ecology, including home range use and habitat selection, by mesopredators, especially during the nesting and brood rearing season in spring and early summer, when wild turkeys are thought to be particularly vulnerable to predation (Miller and Leopold 1992, Vangilder and Kurzejeski 1995).
2) Prey selection by the focal mesopredators, to determine whether wild turkeys contribute to the diets of the mesopredators. Predators respond behaviorally to variations in prey populations. Seasonal changes in food availability as a result of a decline in the prey populations often cause predators to alter their diets from selective to opportunistic ones (Dunn 1977, Jędrzejewska and Jędrzejewski 1998, Schmidt and Ostfeld 2003;2008), a consequence of which might be increased predation on wild turkeys.
3) Identification of predators responsible for depredating eastern wild turkey nests. Ground nests and the hens incubating these nests are particularly vulnerable to predation and a consequence of this is poor nest survival (Ricklefs 1969, Dreibelbis et al. 2008).

To address these areas of concern, I undertook three investigations;

1) Home range and habitat selection :- Complex spatial interactions between mesopredators result in a reduced threat to the survival of wild turkey nests in East Texas
2) Prey selection :- Prey Selection by three mesopredator that are thought to prey on eastern wild turkeys (*Meleagris gallopavo sylvestris*) in the Pineywoods of East Texas
3) Nest predators :- Artificial nests used to identify possible nest predators of eastern wild turkeys (*Meleagris gallopavo silvestris*) in the Pineywoods of east Texas

Home Range and Habitat Selection

The home ranges of bobcats averaged 2766 ha (core 598 ha) on an annual basis, with the home ranges of male bobcats being consistently larger than those of females on both an annual and seasonal basis. Bobcat home ranges and core areas varied seasonally, seeming to gradually increase from winter through spring, summer and reaching the largest sizes in fall. Coyote home ranges were larger than those of bobcats or raccoons. The annual average home range of coyotes was 4844 ha (core 852 ha), with male home ranges not differing substantially from those of females. Coyotes displayed a similar seasonal variation in home range size to those of bobcats with home ranges and core areas increasing in extent from winter through to the following fall. Raccoons had the smallest home ranges with an annual average of 407 ha (core 68 ha). There was little difference between the home range and core area sizes of male and female raccoons, and, unlike bobcats and coyotes, there was no seasonal difference in the home ranges of raccoons. The home ranges of individuals within the same species overlap, but perhaps not to the extent suggested by the merely by looking at the outermost contour of the home ranges. The home ranges of bobcats and coyotes overlapped to a greater extent than the home ranges of coyotes and raccoons or bobcats and raccoons. Bobcats and coyotes included a surprisingly high proportion of the agri/urban vegetation type in their home ranges, but tended to avoid those vegetation types within their home ranges. Seasonally the degree to which bobcats selected vegetation types varied. In fall bobcats seemed to use the mixed forest more than expected and the grasslands less than expected. In spring female bobcats used young pine and riparian areas more than expected while male bobcats used the vegetation in accordance with its availability. In summer bobcats used mixed and deciduous forest vegetation more than expected. In winter, female bobcats used young pine and grasslands more than expected, while male bobcats used the vegetation in accordance with its availability. On an annual basis and in spring, coyotes selected the grassland vegetation type more than expected. In seasons other than spring, coyotes seemed to use the vegetation types approximately in proportion to their availability. On an annual basis, female raccoons used riparian and agri/urban vegetation more than expected while male raccoons used the grassland vegetation type more than expected. In fall, raccoons used more agri/urban vegetation than expected. In spring raccoons used more riparian and agri/urban vegetation more than expected. In summer, female raccoons used grasslands and mixed forests more than expected, but used deciduous and riparian vegetation less than expected. In this period, male raccoons used riparian and agri/urban vegetation more than expected. In winter, female raccoons used riparian and agri/urban vegetation more than expected whilst using mixed and deciduous forests less than expected. In this period, male raccoons used mixed and agri/urban vegetation more than expected and riparian and grassland vegetation less than expected. During the nesting season, bobcats, coyotes and raccoons selected young pine and mature pine vegetation, the same vegetation types that wild turkeys used for nesting.

Prey selection

Bobcats were the most carnivorous of the three mesopredators, and the most frequently occurring prey species in bobcat diets were hispid cotton rats and eastern cottontail rabbits (*Sylvilagus floridanus*). Bobcats included a variety of other mammalian, avian and reptilian prey in their diets. Bobcat diets varied seasonally, and were most diverse in summer. Coyotes had omnivorous dietary habits, consuming fruits such as blackberries (*Rubus fruticosus*) as they became available. The most important mammalian prey species, for coyotes, were white tailed deer (*Odocoileus virginianus*), although they did prey on eastern cottontails and hispid cotton rats. Coyote diets varied seasonally and were most diverse in summer. Raccoons were omnivorous, using seasonal food resources including fruits, mammals, birds, aquatic invertebrates, and insects, as they became available. Raccoon diets varied seasonally and were most diverse in summer. The degree of overlap between the diets of mesopredators varied seasonally. The overlaps between bobcat and coyote diets were biologically significant in all seasons, except for fall when the overlap was slightly lower than what was considered biologically significant. The highest degree of dietary overlap between bobcats and coyotes occurred in summer. The diet overlap between bobcats and raccoons was never biologically significant, but the degree of overlap did vary seasonally, with the greatest degree of overlap occurring in summer. Coyotes and raccoons displayed the greatest variability in dietary overlap, with the least overlap in fall and the greatest overlap in spring. White tailed deer, eastern cottontail rabbits and hispid cotton rats occurred frequently in the diets of all three mesopredators. Blackberries and muscadine grapes (*Vitis rotundifolia*) occurred in the diets of both coyotes and raccoons. There was no evidence, from scat analysis, that eastern wild turkeys were preyed on by these mesopredators.

Small mammal numbers fluctuated seasonally, however there was no variation annually, between study sites, or between historic nest sites and random sites. In most cases small mammal numbers declined from winter through spring and summer, and started to recover in fall. The only exception to this was the hispid cotton rat numbers which declined from winter to spring, increased from spring to summer and declined again in fall.

Spotlight and track-plate indices showed that there was no seasonal difference in relative abundance of lagomorphs. Both indices showed that there was a difference in the relative abundance of lagomorphs between study sites, with the Winston study site consistently having a lower relative abundance of lagomorphs.

Nest Predators

I found that a variety of species depredated artificial eastern wild turkey nests in the Pineywoods. American crows (*Corvus brachyrhynchos*) were responsible for the most artificial nest depredations. Raccoons were the mesopredators responsible for the most predations on artificial nests. The highest number of artificial nest depredations occurred in summer, and unlike other seasons when crows were responsible for the majority of depredations; the mesopredators (raccoons and opossums (*Didelphis virginiana*)) were responsible for the most depredations in summer. American crows discovered and preyed on artificial wild turkey nests sooner than other nest predators. In most (68%) cases of artificial nest predation, the initial predator did not consume all of the eggs during the first visit to an artificial nest. In most cases, the contents of the artificial nests were consumed over several bouts. The mean time period between primary and secondary predation events was approximately one day. In all but 5% of cases, secondary artificial nest predations were committed by the same species that initially depredated the artificial nests.

Conclusions

There seems to be a profound synchrony between results from the three components of my study. The home range sizes of bobcats and coyotes increased seasonally (Section 2) in synchrony with a general decline in numbers of small mammals (Section 3). American crows were responsible for the most depredations on artificial wild turkey nests (Section 4) and consequently may have a detrimental effect on efforts to reestablish wild turkeys in east Texas. The highest level of predation by mesopredators on artificial wild turkey nests occurred in summer (Section 4), at the same time as all mesopredators had the highest levels of dietary diversity (Section 3), and when coyote and bobcat home ranges were largest (Section 2). There was no evidence of mesopredators preying on eastern wild turkeys from my analysis of mesopredator scats (Section 3). Raccoons were the mesopredators that preyed most on artificial wild turkey nests (Section 4), and even when they had their greatest effect it was asynchronous with the peak wild turkey nesting season (Isabelle 2010). This indicated that raccoons encountered artificial nests opportunistically whilst foraging rather than actively hunting for the nests.

My study lends further credence to the contention that if mesopredators do prey on eastern wild turkeys, they are not a preferred prey and predations on wild turkeys by mesopredators are likely to be sporadic, opportunistic events. Although I have little doubt that mesopredators preyed on wild turkeys in the Pineywoods of east Texas, I suggest that these were rare events where the mesopredators opportunistically encountered wild turkeys whilst foraging, rather than focused attempts to hunt for wild turkeys. Throughout their range, wild turkeys have evolved in the presence of these mesopredators (Leopold and Chamberlain 2002) and, in most areas, wild turkeys have re-established well (Kennamer et al. 1992, Tapley et al. 2006). I conclude that although mesopredators probably preyed on wild turkeys, their eggs, and their poults, in the Pineywoods, the influence of mesopredators on these sub-populations of eastern wild turkeys was probably not the causal factor behind the limited success of the reintroduction program.

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APPENDIX 1

Appendix 1: Estimates of home ranges (ha) of individual animals according to different methods in the Pineywoods of east Texas from January 2009 to August 2011

Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href 85	Href 85	Href 85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Bobcat	male	Winston	546	VHF	2010/11	Annual	4991.45	2304.19	519.18	5647.68	1709.77	7357.46	*	*	*	*
Bobcat	male	Winston	546	VHF	2010	Annual	4824.01	2526.75	510.72	6114.33	1712.23	7826.56	*	*	*	*
Bobcat	male	Winston	546	VHF	2011	Annual	1394.18	753.85	244.35	1409.02	505.79	1914.81	*	*	*	*
Bobcat	male	Winston	546	VHF	2010	Fall	1957.01	1309.30	370.13	7606.84	2316.14	9922.98	*	*	*	*
Bobcat	male	Winston	546	VHF	2010	Spring	2717.65	1807.41	484.45	6872.11	2476.30	9348.41	*	*	*	*
Bobcat	male	Winston	546	VHF	2011	Spring	1166.94	549.75	159.01	1427.12	468.51	1895.63	*	*	*	*
Bobcat	male	Winston	546	VHF	2010	Summer	3696.69	1853.65	312.35	6267.45	1397.21	7664.66	*	*	*	*
Bobcat	male	Winston	546	VHF	2010	Winter	1120.12	1223.18	351.79	1992.23	684.51	2676.74	*	*	*	*
Bobcat	male	Winston	546	VHF	2011	Winter	358.19	462.30	193.50	695.27	279.91	975.18	*	*	*	*
Bobcat	male	Winston	556	VHF	2010	Annual	3193.24	1165.33	264.68	1713.54	373.41	2086.95	*	*	*	*
Bobcat	male	Winston	556	VHF	2011	Annual	1597.94	888.71	195.29	1680.97	357.61	2038.57	*	*	*	*
Bobcat	male	Winston	556	VHF	2010/11	Annual	3573.15	1184.36	234.95	1688.61	344.05	2032.67	*	*	*	*
Bobcat	male	Winston	556	VHF	2010	Fall	2043.71	1757.29	496.12	3203.46	835.20	4038.67	*	*	*	*
Bobcat	male	Winston	556	VHF	2010	Spring	1162.96	1046.93	307.61	1443.69	431.94	1875.64	*	*	*	*
Bobcat	male	Winston	556	VHF	2011	Spring	1058.16	1282.07	431.79	1385.10	471.87	1856.97	*	*	*	*
Bobcat	male	Winston	556	VHF	2010	Summer	1004.84	1119.96	267.95	1530.70	370.15	1900.85	*	*	*	*
Bobcat	male	Winston	556	VHF	2011	Summer	993.96	1128.76	269.85	1911.17	431.29	2342.46	*	*	*	*
Bobcat	male	Winston	556	VHF	2010	Winter	384.54	370.56	122.98	607.75	175.94	783.68	*	*	*	*
Bobcat	male	Winston	556	VHF	2011	Winter	858.49	314.13	75.26	1099.72	231.94	1331.66	*	*	*	*
Bobcat	female	Winston	576	VHF	2010	Annual	2843.81	1531.87	415.55	2141.52	584.78	2726.31	*	*	*	*
Bobcat	female	Winston	576	VHF	2010	Spring	1787.85	1720.75	552.55	1943.97	625.90	2569.87	*	*	*	*
Bobcat	female	Winston	576	VHF	2010	Summer	1412.77	760.57	210.85	1417.12	397.38	1814.50	*	*	*	*
Bobcat	female	Winston	576	VHF	2010	Winter	1348.21	2557.06	1014.95	2051.30	874.92	2926.21	*	*	*	*
Coyote	female	Winston	585	VHF	2010	Annual	6344.93	1349.87	268.90	8094.53	2141.24	10235.77	*	*	*	*
Coyote	female	Winston	585	VHF	2011	Annual	7809.37	1090.23	183.84	5304.16	657.71	5961.87	*	*	*	*
Coyote	female	Winston	585	VHF	2010/11	Annual	11161.66	1927.47	261.02	7801.32	1473.23	9274.55	*	*	*	*
Coyote	female	Winston	585	VHF	2010	Fall	5046.08	766.76	162.64	11035.69	1868.19	12903.88	*	*	*	*
Coyote	female	Winston	585	VHF	2010	Spring	1852.66	1095.50	296.93	2785.92	760.90	3546.82	*	*	*	*
Coyote	female	Winston	585	VHF	2011	Spring	3327.10	888.17	208.53	6789.85	1098.11	7887.96	*	*	*	*
Coyote	female	Winston	585	VHF	2010	Summer	2263.44	549.21	120.66	5544.75	1085.63	6630.38	*	*	*	*
Coyote	female	Winston	585	VHF	2011	Winter	1557.86	542.95	108.51	1553.37	304.47	1857.85	*	*	*	*
Coyote	female	Winston	595	VHF	2010	Annual	9809.67	6212.96	1410.26	9401.93	2249.79	11651.72	*	*	*	*
Coyote	female	Winston	595	VHF	2011	Annual	1684.73	392.38	88.52	725.21	145.09	870.31	*	*	*	*
Coyote	female	Winston	595	VHF	2010/11	Annual	9809.67	2012.43	286.10	7198.47	709.33	7907.81	*	*	*	*
Coyote	female	Winston	595	VHF	2010	Fall	2274.52	1983.37	374.09	5414.36	933.21	6347.57	*	*	*	*
Coyote	female	Winston	595	VHF	2010	Spring	4093.36	4279.71	1285.75	5823.09	1671.20	7494.28	*	*	*	*
Coyote	female	Winston	595	VHF	2011	Spring	603.02	587.40	148.64	537.06	135.29	672.35	*	*	*	*
Coyote	female	Winston	595	VHF	2010	Summer	6249.55	3757.52	1314.11	8664.86	3655.23	12320.10	*	*	*	*
Coyote	female	Winston	595	VHF	2011	Summer	125.93	363.54	140.81	335.87	133.17	469.04	*	*	*	*
Coyote	female	Winston	595	VHF	2011	Winter	1213.25	94.32	22.46	894.40	146.98	1041.38	*	*	*	*
Coyote	female	Winston	605	VHF	2010	Annual	1234.99	688.89	158.49	684.05	153.57	837.62	*	*	*	*

APPENDIX 1

Appendix 1: Estimates of home ranges (ha) of individual animals according to different methods in the Pineywoods of east Texas from January 2009 to August 2011

Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Coyote	female	Winston	605	VHF	2010	Fall	283.68	466.58	151.47	430.54	143.95	574.49	*	*	*	*
Coyote	female	Winston	605	VHF	2010	Spring	890.21	713.29	152.79	684.31	150.75	835.07	*	*	*	*
Coyote	female	Winston	605	VHF	2010	Summer	416.12	431.33	125.83	413.15	120.06	533.21	*	*	*	*
Coyote	female	Winston	605	VHF	2010	Winter	441.52	800.70	259.03	675.63	226.42	902.06	*	*	*	*
Raccoon	female	Winston	31	VHF	2010	Annual	449.12	105.88	18.89	288.30	82.33	370.63	*	*	*	*
Raccoon	female	Winston	31	VHF	2009	Fall	179.42	45.84	6.43	238.29	41.58	279.88	*	*	*	*
Raccoon	female	Winston	31	VHF	2010	Spring	164.47	98.67	19.05	271.69	99.83	371.53	*	*	*	*
Raccoon	female	Winston	31	VHF	2010	Winter	160.39	47.14	6.39	227.49	69.02	296.51	*	*	*	*
Raccoon	male	Winston	40	VHF	2009	Annual	2168.58	67.87	11.59	514.15	48.41	562.55	*	*	*	*
Raccoon	male	Winston	40	VHF	2010	Annual	412.71	103.96	32.86	215.88	46.24	262.12	*	*	*	*
Raccoon	male	Winston	40	VHF	2009/10	Annual	2375.38	138.55	22.33	409.97	55.82	465.79	*	*	*	*
Raccoon	male	Winston	40	VHF	2009	Fall	93.63	27.69	6.00	100.49	19.96	120.45	*	*	*	*
Raccoon	male	Winston	40	VHF	2010	Fall	172.73	155.17	48.74	187.15	57.15	244.30	*	*	*	*
Raccoon	male	Winston	40	VHF	2009	Spring	626.44	134.15	31.44	441.82	88.39	530.20	*	*	*	*
Raccoon	male	Winston	40	VHF	2010	Spring	311.83	197.83	45.76	274.55	68.29	342.84	*	*	*	*
Raccoon	male	Winston	40	VHF	2009	Summer	1113.94	26.60	4.16	324.20	43.29	367.48	*	*	*	*
Raccoon	male	Winston	40	VHF	2010	Summer	192.90	80.90	14.93	154.66	42.00	196.67	*	*	*	*
Raccoon	male	Winston	40	VHF	2009	Winter	170.06	398.07	113.08	539.25	176.62	715.87	*	*	*	*
Raccoon	male	Winston	40	VHF	2010	Winter	143.29	61.65	13.75	163.06	36.88	199.94	*	*	*	*
Raccoon	male	Winston	40	VHF	2011	Winter	149.14	74.65	15.14	197.97	59.60	257.58	*	*	*	*
Raccoon	male	Winston	122	VHF	2009	Annual	670.43	47.57	9.75	269.14	28.92	298.05	*	*	*	*
Raccoon	male	Winston	122	VHF	2010	Annual	816.06	338.64	85.98	928.09	189.94	1118.03	*	*	*	*
Raccoon	male	Winston	122	VHF	2009/10	Annual	1190.44	216.90	30.67	1058.05	259.33	1317.38	*	*	*	*
Raccoon	male	Winston	122	VHF	2009	Fall	567.52	199.41	41.60	1179.70	401.42	1581.12	*	*	*	*
Raccoon	male	Winston	122	VHF	2010	Fall	67.00	44.47	2.19	139.61	53.85	193.46	*	*	*	*
Raccoon	male	Winston	122	VHF	2009	Spring	45.34	39.40	5.78	40.26	7.52	47.78	*	*	*	*
Raccoon	male	Winston	122	VHF	2010	Spring	277.42	260.35	60.05	363.15	87.24	450.39	*	*	*	*
Raccoon	male	Winston	122	VHF	2009	Summer	70.09	25.86	2.10	49.43	8.91	58.34	*	*	*	*
Raccoon	male	Winston	122	VHF	2010	Summer	664.23	306.78	98.23	1257.22	351.00	1608.23	*	*	*	*
Raccoon	male	Winston	122	VHF	2010	Winter	390.94	592.11	229.35	845.48	323.48	1168.95	*	*	*	*
Raccoon	female	Winston	172	VHF	2009	Annual	447.15	250.37	54.37	328.53	68.86	397.39	*	*	*	*
Raccoon	female	Winston	172	VHF	2010	Annual	719.17	1335.84	339.87	545.70	99.15	644.85	*	*	*	*
Raccoon	female	Winston	172	VHF	2009/10	Annual	1012.97	375.66	66.05	535.84	94.58	630.43	*	*	*	*
Raccoon	female	Winston	172	VHF	2009	Fall	55.17	98.99	26.73	79.08	22.02	101.09	*	*	*	*
Raccoon	female	Winston	172	VHF	2009	Spring	263.66	296.34	95.57	421.92	160.86	582.78	*	*	*	*
Raccoon	female	Winston	172	VHF	2010	Spring	603.24	74.44	7.90	528.43	89.53	617.96	*	*	*	*
Raccoon	female	Winston	172	VHF	2009	Summer	398.94	175.29	38.00	312.86	55.75	368.61	*	*	*	*
Raccoon	female	Winston	172	VHF	2010	Winter	106.30	68.17	20.46	132.88	41.26	174.13	*	*	*	*
Raccoon	female	Winston	243	VHF	2009	Annual	617.93	141.79	23.96	280.89	55.94	336.83	*	*	*	*
Raccoon	female	Winston	243	VHF	2010	Annual	920.43	123.81	30.36	280.60	60.59	341.19	*	*	*	*

APPENDIX 1

Appendix 1: Estimates of home ranges (ha) of individual animals according to different methods in the Pineywoods of east Texas from January 2009 to August 2011

Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Raccoon	female	Winston	243	VHF	2009/10	Annual	1962.34	175.90	39.88	277.00	77.20	354.20	*	*	*	*
Raccoon	female	Winston	243	VHF	2009	Fall	93.91	50.57	9.79	99.65	19.17	118.82	*	*	*	*
Raccoon	female	Winston	243	VHF	2009	Spring	231.25	283.24	89.14	282.56	86.02	368.58	*	*	*	*
Raccoon	female	Winston	243	VHF	2010	Spring	180.61	94.39	17.81	174.00	45.32	219.33	*	*	*	*
Raccoon	female	Winston	243	VHF	2009	Summer	535.96	81.09	11.25	335.83	55.43	391.26	*	*	*	*
Raccoon	female	Winston	243	VHF	2010	Summer	131.56	56.40	8.87	129.58	37.36	166.94	*	*	*	*
Raccoon	female	Winston	243	VHF	2010	Winter	549.00	236.66	56.99	556.12	150.73	706.85	*	*	*	*
Raccoon	male	Winston	302	VHF	2009	Annual	806.73	51.20	10.48	219.28	30.08	249.36	*	*	*	*
Raccoon	male	Winston	302	VHF	2010	Annual	498.95	134.33	37.92	209.07	63.95	273.02	*	*	*	*
Raccoon	male	Winston	302	VHF	2009/10	Annual	1504.64	142.50	26.98	239.52	55.20	294.71	*	*	*	*
Raccoon	male	Winston	302	VHF	2009	Fall	189.28	49.16	9.59	162.78	30.95	193.73	*	*	*	*
Raccoon	male	Winston	302	VHF	2010	Fall	120.76	204.08	83.53	207.71	90.36	298.07	*	*	*	*
Raccoon	male	Winston	302	VHF	2009	Spring	102.96	68.82	9.02	137.25	26.04	163.29	*	*	*	*
Raccoon	male	Winston	302	VHF	2010	Spring	217.19	133.65	46.76	193.43	66.64	260.06	*	*	*	*
Raccoon	male	Winston	302	VHF	2009	Summer	264.03	26.91	3.59	125.77	16.53	142.30	*	*	*	*
Raccoon	male	Winston	302	VHF	2010	Summer	134.73	107.30	26.91	148.06	53.25	201.31	*	*	*	*
Raccoon	male	Winston	302	VHF	2010	Winter	1177.88	80.69	17.88	862.70	162.48	1025.18	*	*	*	*
Raccoon	male	Winston	302	VHF	2011	Winter	112.92	105.80	35.61	106.22	35.13	141.34	*	*	*	*
Raccoon	female	Winston	323	VHF	2011	Annual	40.36	30.67	7.42	38.43	6.94	45.36	*	*	*	*
Raccoon	female	Winston	323	VHF	2011	Spring	27.21	35.47	10.91	31.25	8.20	39.45	*	*	*	*
Raccoon	female	Winston	323	VHF	2011	Summer	8.36	14.80	1.81	18.08	2.23	20.31	*	*	*	*
Raccoon	female	Winston	323	VHF	2011	Winter	14.73	11.69	1.81	17.60	4.75	22.35	*	*	*	*
Raccoon	male	Winston	693	VHF	2011	Annual	81.46	22.30	3.94	57.47	11.21	68.68	*	*	*	*
Raccoon	male	Winston	693	VHF	2011	Spring	41.15	42.71	9.71	*	*	*	*	*	*	*
Raccoon	male	Winston	693	VHF	2011	Summer	4.84	*	*	7.36	1.62	8.98	*	*	*	*
Raccoon	male	Winston	693	VHF	2011	Winter	48.28	22.37	3.12	71.67	13.87	85.54	*	*	*	*
Raccoon	male	Winston	703	VHF	2011	Annual	409.46	331.17	112.33	385.88	129.12	515.00	*	*	*	*
Raccoon	male	Winston	703	VHF	2011	Spring	351.55	337.42	107.67	424.19	147.27	571.47	*	*	*	*
Raccoon	male	Winston	703	VHF	2011	Summer	142.31	124.10	30.34	245.17	70.56	315.73	*	*	*	*
Raccoon	male	Winston	703	VHF	2011	Winter	180.31	183.11	37.30	357.21	84.09	441.30	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2010	Annual	3248.55	751.66	141.86	1628.16	267.32	1895.48	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2011	Annual	1069.88	604.85	122.60	714.40	146.59	860.99	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2010/11	Annual	3392.85	771.48	137.63	1161.10	194.06	1355.16	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2010	Fall	690.64	680.59	191.98	1002.45	309.15	1311.60	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2010	Spring	869.61	679.20	201.66	1150.74	285.47	1436.21	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2011	Spring	828.44	479.43	71.96	702.62	111.12	813.75	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2010	Summer	1063.12	306.60	77.38	1779.40	316.99	2096.39	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2011	Summer	242.99	531.84	160.68	545.20	165.52	710.72	*	*	*	*
Bobcat	female	Cottingham	494	VHF	2011	Winter	427.70	467.82	105.10	471.58	106.29	577.87	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2010	Annual	999.47	679.88	212.69	649.87	204.01	853.88	*	*	*	*

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Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Bobcat	female	Cottingham	503	VHF	2011	Annual	1003.51	179.23	32.34	1036.32	167.90	1204.22	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2010/11	Annual	2350.00	424.38	115.97	1339.47	393.22	1732.69	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2010	Fall	372.27	812.46	287.49	573.91	221.54	795.45	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2010	Spring	720.62	436.69	149.42	746.71	218.09	964.80	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2011	Spring	519.27	*	*	711.23	91.01	802.24	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2010	Summer	243.15	417.94	121.16	444.97	126.29	571.26	*	*	*	*
Bobcat	female	Cottingham	503	VHF	2011	Winter	982.15	980.88	363.22	1212.64	432.68	1645.32	*	*	*	*
Bobcat	female	Cottingham	516	VHF	2010	Annual	2405.68	1042.99	194.74	1458.52	251.71	1710.23	*	*	*	*
Bobcat	female	Cottingham	564	VHF	2010	Annual	1211.07	1271.10	452.10	1284.34	460.55	1744.89	*	*	*	*
Bobcat	female	Cottingham	564	VHF	2011	Annual	2034.26	601.83	220.53	931.56	303.52	1235.09	*	*	*	*
Bobcat	female	Cottingham	564	VHF	2010/11	Annual	2754.34	942.22	321.51	1218.86	385.22	1604.08	*	*	*	*
Bobcat	female	Cottingham	564	VHF	2011	Spring	353.84	362.05	117.33	531.42	153.82	685.24	*	*	*	*
Bobcat	female	Cottingham	564	VHF	2011	Winter	412.32	408.44	184.31	569.19	252.21	821.40	*	*	*	*
Bobcat	male	Cottingham	754	VHF	2011	Annual	4059.44	841.95	246.36	3211.47	1063.97	4275.44	*	*	*	*
Bobcat	male	Cottingham	754	VHF	2011	Spring	1426.51	1846.90	700.97	2507.47	951.03	3458.50	*	*	*	*
Coyote	male	Cottingham	624	VHF	2010	Annual	702.23	1158.63	424.11	805.27	338.11	1143.38	*	*	*	*
Coyote	male	Cottingham	624	VHF	2010	Spring	401.05	1289.29	427.37	650.57	237.22	887.79	*	*	*	*
Coyote	male	Cottingham	674	VHF	2010	Annual	1232.43	1049.04	346.85	1121.84	364.20	1486.04	*	*	*	*
Coyote	male	Cottingham	674	VHF	2011	Annual	879.07	557.11	152.18	798.52	246.99	1045.51	*	*	*	*
Coyote	male	Cottingham	674	VHF	2010/11	Annual	1516.15	840.93	234.91	1014.21	298.51	1312.72	*	*	*	*
Coyote	male	Cottingham	674	VHF	2010	Fall	664.53	1431.97	525.18	992.61	401.62	1394.23	*	*	*	*
Coyote	male	Cottingham	674	VHF	2010	Spring	546.29	604.46	166.50	813.65	246.70	1060.35	*	*	*	*
Coyote	male	Cottingham	674	VHF	2011	Spring	579.26	309.59	92.68	654.48	205.22	859.70	*	*	*	*
Coyote	male	Cottingham	674	VHF	2010	Summer	882.05	1907.45	595.42	1377.19	435.71	1812.90	*	*	*	*
Coyote	male	Cottingham	674	VHF	2011	Winter	675.09	624.56	220.96	853.05	315.72	1168.77	*	*	*	*
Coyote	male	Cottingham	763	VHF	2011	Annual	27081.13	3696.75	845.93	94213.31	22621.70	116835.01	*	*	*	*
Raccoon	male	Cottingham	32	VHF	2009	Annual	638.46	203.89	58.27	630.68	154.31	784.99	*	*	*	*
Raccoon	male	Cottingham	32	VHF	2009	Spring	237.17	401.16	118.62	370.01	110.96	480.97	*	*	*	*
Raccoon	male	Cottingham	32	VHF	2009	Summer	430.84	63.70	10.75	1401.04	443.20	1844.25	*	*	*	*
Raccoon	male	Cottingham	32	VHF	2009	Winter	173.85	337.99	119.80	279.99	103.32	383.32	*	*	*	*
Raccoon	male	Cottingham	131	VHF	2009	Annual	2026.32	223.75	44.57	675.50	114.87	790.37	*	*	*	*
Raccoon	male	Cottingham	131	VHF	2009	Fall	123.47	250.56	64.27	289.45	69.55	358.99	*	*	*	*
Raccoon	male	Cottingham	131	VHF	2009	Spring	281.92	242.69	68.24	278.75	76.86	355.61	*	*	*	*
Raccoon	male	Cottingham	131	VHF	2009	Summer	682.11	113.13	25.97	571.73	102.47	674.20	*	*	*	*
Raccoon	male	Cottingham	131	VHF	2009	Winter	194.19	300.38	79.67	263.02	66.08	329.09	*	*	*	*
Raccoon	female	Cottingham	139	VHF	2009	Annual	523.35	35.45	6.16	131.94	17.83	149.76	*	*	*	*
Raccoon	female	Cottingham	139	VHF	2009	Fall	252.76	38.20	7.72	645.93	129.85	775.79	*	*	*	*
Raccoon	female	Cottingham	139	VHF	2009	Spring	69.94	39.99	14.16	*	*	*	*	*	*	*
Raccoon	female	Cottingham	139	VHF	2009	Summer	504.22	14.53	2.38	108.95	14.84	123.78	*	*	*	*

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Appendix 1: Estimates of home ranges (ha) of individual animals according to different methods in the Pineywoods of east Texas from Jamuary 2009 to August 2011

Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV 0.95	LSCV 0.5	Href85 0.95	Href85 0.5	Href85 Total	Href85 Random		LSCV Random	
													0.95	0.5	0.95	0.5
Raccoon	female	Cottingham	139	VHF	2009	Winter	113.64	35.98	5.02	149.09	32.09	181.19	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2009	Annual	626.72	80.73	11.39	235.29	24.76	260.05	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2009	Fall	76.30	61.95	13.90	190.89	69.40	260.29	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2010	Fall	178.86	261.36	65.15	354.47	91.83	446.30	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2009	Spring	83.74	31.03	4.18	88.30	15.76	104.05	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2010	Spring	107.99	34.37	3.48	146.82	34.23	181.04	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2009	Summer	30.10	14.87	2.27	*	*	*	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2010	Summer	410.17	36.46	5.60	557.17	80.33	637.50	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2009	Winter	113.05	36.22	5.03	165.90	32.38	198.29	*	*	*	*
Raccoon	female	Cottingham	183	VHF	2010	Winter	57.77	50.72	11.97	138.68	36.03	174.72	*	*	*	*
Raccoon	male	Cottingham	214	VHF	2009	Annual	772.27	73.85	12.32	300.10	47.82	347.91	*	*	*	*
Raccoon	male	Cottingham	214	VHF	2009	Spring	254.21	37.61	5.63	134.28	31.67	165.95	*	*	*	*
Raccoon	male	Cottingham	214	VHF	2009	Summer	646.38	87.45	9.66	390.33	75.35	465.68	*	*	*	*
Raccoon	male	Cottingham	214	VHF	2009	Winter	53.72	19.16	2.40	151.69	26.68	178.37	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2009/10	Annual	1078.12	741.74	230.56	648.84	188.25	837.09	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2010	Fall	196.62	419.71	125.51	561.54	175.19	736.73	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2009	Spring	59.71	53.14	10.82	88.05	15.19	103.24	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2010	Spring	183.16	341.75	108.84	269.25	91.73	360.98	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2009	Summer	542.83	1135.41	251.56	194.46	35.60	230.06	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2010	Summer	150.02	42.51	3.69	241.61	87.09	328.70	*	*	*	*
Raccoon	male	Cottingham	225	VHF	2011	Winter	87.64	187.77	32.10	156.20	23.59	179.79	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009	Annual	1373.74	70.14	5.41	395.23	83.46	478.69	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2010	Annual	446.25	116.56	18.30	342.64	43.68	386.32	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009/10	Annual	1454.62	109.48	21.71	389.12	90.39	479.51	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009	Fall	273.83	233.49	75.43	314.63	93.55	408.18	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2010	Fall	12.86	16.44	4.64	*	*	*	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009	Spring	155.05	26.99	0.88	180.16	53.72	233.88	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2010	Spring	303.87	284.93	71.07	417.61	101.33	518.94	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009	Summer	1073.04	106.00	14.51	461.84	93.69	555.53	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2010	Summer	76.60	108.67	28.68	123.53	30.80	154.33	*	*	*	*
Raccoon	male	Cottingham	234	VHF	2009	Winter	342.04	855.54	267.13	565.36	180.90	746.26	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009	Annual	1073.57	180.87	40.48	603.00	111.96	714.96	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2010	Annual	641.40	114.62	20.61	288.95	53.41	342.36	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009/10	Annual	2127.41	204.25	35.29	569.58	89.66	659.24	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009	Fall	101.70	32.43	4.84	139.90	26.81	166.71	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009	Spring	350.22	263.78	54.61	439.00	97.31	536.31	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2010	Spring	119.73	69.67	20.68	163.15	37.59	200.74	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009	Summer	471.78	54.64	4.17	350.27	85.32	435.60	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2010	Summer	491.19	50.02	9.72	742.39	131.02	873.40	*	*	*	*
Raccoon	female	Cottingham	273	VHF	2009	Winter	439.95	1078.68	396.84	763.85	303.81	1067.66	*	*	*	*

APPENDIX 1

Appendix 1: Estimates of home ranges (ha) of individual animals according to different methods in the Pineywoods of east Texas from January 2009 to August 2011

Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Raccoon	male	Cottingham	283	VHF	2009	Annual	1774.46	100.86	22.59	332.18	57.46	389.64	*	*	*	*
Raccoon	male	Cottingham	283	VHF	2009	Spring	67.29	46.06	9.66	85.20	26.35	111.55	*	*	*	*
Raccoon	male	Cottingham	283	VHF	2009	Summer	108.18	54.93	10.85	106.20	26.64	132.84	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009	Annual	897.27	75.74	17.22	297.59	50.51	348.10	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2010	Annual	215.93	130.38	24.08	116.17	22.24	138.41	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009/10	Annual	1167.97	43.58	6.91	252.12	41.41	293.53	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009	Fall	19.42	12.84	2.69	*	*	*	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2010	Fall	30.27	36.29	4.56	55.17	19.14	74.31	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009	Spring	45.52	48.20	16.72	58.33	22.49	80.82	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2010	Spring	49.73	92.89	23.90	76.17	22.11	98.29	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009	Summer	727.69	45.87	9.08	306.73	49.08	355.81	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2010	Summer	126.32	203.00	48.02	176.99	37.47	214.46	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2009	Winter	361.15	327.96	79.68	494.62	117.49	612.11	*	*	*	*
Raccoon	female	Cottingham	293	VHF	2010	Winter	3.00	5.65	0.14	*	*	*	*	*	*	*
Raccoon	female	Cottingham	712	VHF	2011	Annual	580.45	48.93	8.24	226.73	46.06	272.79	*	*	*	*
Raccoon	female	Cottingham	712	VHF	2011	Spring	203.18	48.27	6.46	187.24	36.81	224.06	*	*	*	*
Raccoon	female	Cottingham	712	VHF	2011	Winter	404.19	31.20	4.54	382.38	68.35	450.73	*	*	*	*
Raccoon	male	Cottingham	723	VHF	2011	Annual	493.13	402.72	147.16	492.10	173.50	665.60	*	*	*	*
Raccoon	male	Cottingham	723	VHF	2011	Spring	442.31	578.69	201.64	645.90	224.89	870.79	*	*	*	*
Raccoon	male	Cottingham	723	VHF	2011	Winter	233.85	334.51	113.40	370.68	127.44	498.12	*	*	*	*
Raccoon	male	Cottingham	743	VHF	2011	Annual	211.67	85.82	16.43	196.89	52.95	249.83	*	*	*	*
Raccoon	male	Cottingham	743	VHF	2011	Spring	176.82	80.26	14.58	191.63	53.07	244.69	*	*	*	*
Raccoon	male	Cottingham	743	VHF	2011	Winter	70.54	36.60	7.84	133.22	26.48	159.70	*	*	*	*
Bobcat	male	Cottingham	410	GPS	2009	Annual	3666.41	*	*	1734.18	808.06	2542.24	2220.85	998.98	1464.51	0.15
Bobcat	male	Cottingham	410	GPS	2009	Fall	1473.27	*	*	1050.52	414.49	1465.00	1220.22	468.16	947.98	0.09
Bobcat	male	Cottingham	410	GPS	2009	Spring	2516.37	*	*	1964.02	585.38	2549.40	2134.50	623.66	1565.11	0.16
Bobcat	male	Cottingham	410	GPS	2009	Summer	3502.11	*	*	1934.44	795.72	2730.16	3263.11	1151.72	1236.53	0.12
Bobcat	male	Cottingham	420	GPS	2009	Annual	3998.89	*	*	1861.48	547.08	2408.57	2206.14	665.08	1686.04	0.17
Bobcat	male	Cottingham	420	GPS	2009	Fall	1503.16	*	*	1147.00	329.53	1476.53	1591.36	443.61	1554.32	0.16
Bobcat	male	Cottingham	420	GPS	2009	Spring	2092.30	*	*	1561.55	540.96	2102.51	2125.16	738.24	1882.85	0.19
Bobcat	male	Cottingham	420	GPS	2009	Summer	3883.20	*	*	2230.21	743.33	2973.54	2589.29	1057.34	1824.37	0.18
Bobcat	male	Cottingham	430	GPS	2009	Annual	2065.48	*	*	1184.81	386.41	1571.22	1426.08	469.28	1018.80	0.10
Bobcat	male	Cottingham	430	GPS	2009	Spring	808.73	*	*	545.11	153.24	698.34	563.58	198.87	328.86	0.03
Bobcat	male	Cottingham	430	GPS	2009	Summer	1870.78	*	*	1250.00	455.07	1705.07	1612.44	559.02	1391.50	0.14
Bobcat	male	Cottingham	440	GPS	2009	Annual	10923.39	*	*	6583.77	1177.59	7761.36	8028.35	1751.62	2399.45	0.24
Bobcat	male	Cottingham	440	GPS	2009	Fall	7304.96	*	*	6429.18	1647.54	8076.73	9569.35	3007.13	779.95	0.08
Bobcat	male	Cottingham	440	GPS	2009	Spring	1394.60	*	*	975.96	276.20	1252.16	1134.96	304.97	723.47	0.07
Bobcat	male	Cottingham	440	GPS	2009	Summer	6983.12	*	*	4003.11	741.69	4744.80	4692.96	1098.95	1057.05	0.11
Bobcat	male	Cottingham	440	GPS	2009	Winter	1805.07	*	*	1152.21	217.32	1369.53	1126.78	294.11	40.99	0.00
Bobcat	female	Winston	360	GPS	2010	Annual	1205.69	*	*	702.77	212.43	915.20	784.44	249.93	526.89	0.05

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Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Bobcat	female	Winston	360	GPS	2010	Spring	1038.94	*	*	703.45	253.87	957.33	841.61	336.99	498.33	0.05
Bobcat	female	Winston	360	GPS	2010	Summer	1082.98	*	*	806.30	227.23	1033.53	994.19	310.78	656.62	0.07
Bobcat	female	Winston	360	GPS	2010	Winter	719.15	*	*	438.41	149.49	587.90	475.99	152.02	326.93	0.03
Bobcat	male	Cottingham	370	GPS	2010	Annual	8424.11	*	*	3821.97	1089.04	4911.01	4326.12	1348.12	2958.51	0.30
Bobcat	male	Cottingham	370	GPS	2010	Spring	6451.52	*	*	3738.81	840.76	4579.57	4360.71	1034.60	2088.38	0.21
Bobcat	male	Cottingham	370	GPS	2010	Summer	5587.77	*	*	3676.08	933.88	4609.96	4379.37	1202.78	2676.59	0.27
Bobcat	male	Cottingham	370	GPS	2010	Winter	1958.26	*	*	741.52	183.54	925.06	1130.55	284.53	819.58	0.08
Bobcat	male	Winston	370	GPS	2011	Annual	7291.62	*	*	6296.88	2098.12	8395.00	8551.64	3175.64	9626.67	0.96
Bobcat	male	Winston	370	GPS	2011	Spring	4635.85	*	*	3181.05	1137.81	4318.86	3942.37	1565.22	2759.71	0.28
Bobcat	male	Winston	370	GPS	2011	Summer	4296.92	*	*	3061.47	292.53	3354.00	4587.07	690.86	5623.39	0.56
Bobcat	female	Cottingham	410	GPS	2011	Annual	289.23	*	*	55.98	0.45	56.43	*	*	*	*
Bobcat	female	Cottingham	410	GPS	2011	Spring	37.38	*	*	*	*	*	*	*	*	*
Bobcat	female	Cottingham	410	GPS	2011	Winter	235.18	*	*	157.64	43.87	201.51	156.98	52.66	182.41	0.02
Bobcat	male	Cottingham	420	GPS	2011	Annual	4136.35	*	*	1908.11	543.29	2451.40	2235.39	702.14	1333.22	0.13
Bobcat	male	Cottingham	420	GPS	2011	Spring	3462.21	*	*	1840.44	538.57	2379.01	2395.45	718.67	1923.50	0.19
Bobcat	male	Cottingham	420	GPS	2011	Summer	1793.63	*	*	1078.84	330.24	1409.08	1303.30	399.49	767.85	0.08
Bobcat	male	Cottingham	420	GPS	2011	Winter	2428.49	*	*	1897.92	366.95	2264.88	2288.97	558.64	1235.57	0.12
Bobcat	female	Winston	440	GPS	2011	Annual	5829.48	*	*	1728.44	500.55	2228.99	2190.81	632.52	968.90	0.10
Bobcat	female	Winston	440	GPS	2011	Fall	3481.42	*	*	1885.48	537.44	2422.92	2221.51	792.37	1080.92	0.11
Bobcat	female	Winston	440	GPS	2011	Spring	2253.56	*	*	1389.82	449.11	1838.92	1856.53	582.98	1196.14	0.12
Bobcat	female	Winston	440	GPS	2011	Summer	3064.97	*	*	1750.61	535.92	2286.53	2313.65	750.70	1378.92	0.14
Coyote	male	Cottingham	450	GPS	2009	Annual	13736.08	*	*	5762.26	660.47	6422.73	7334.56	982.00	2299.11	0.23
Coyote	male	Cottingham	450	GPS	2009	Spring	13736.08	*	*	9636.72	1875.10	11511.82	7559.11	2184.29	3791.64	0.38
Coyote	male	Cottingham	450	GPS	2009	Summer	997.29	*	*	600.85	297.41	898.26	834.61	391.98	783.99	0.08
Coyote	male	Cottingham	470	GPS	2009	Annual	25269.95	*	*	12913.92	2601.78	15515.70	14522.45	3356.39	16105.80	1.61
Coyote	male	Cottingham	470	GPS	2009	Fall	10135.45	*	*	6526.46	1769.68	8296.13	9591.30	3338.54	899.60	0.09
Coyote	male	Cottingham	470	GPS	2009	Spring	12560.64	*	*	7389.84	1172.64	8562.48	6881.45	1417.08	1379.37	0.14
Coyote	male	Cottingham	470	GPS	2009	Summer	23387.21	*	*	15282.76	3943.47	19226.23	17587.80	5565.98	19521.36	1.95
Coyote	Female	Cottingham	480	GPS	2009	Annual	12511.12	*	*	5835.58	1435.15	7270.73	7653.50	2192.51	8494.18	0.85
Coyote	Female	Cottingham	480	GPS	2009	Fall	9699.11	*	*	7724.20	1881.09	9605.29	9976.92	3659.83	928.61	0.09
Coyote	Female	Cottingham	480	GPS	2009	Spring	6762.08	*	*	4577.35	879.84	5457.19	4705.23	1268.23	278.98	0.03
Coyote	Female	Cottingham	480	GPS	2009	Summer	8005.15	*	*	4761.95	1136.32	5898.27	6317.19	1739.07	1571.97	0.16
Coyote	male	Cottingham	380	GPS	2010	Annual	3170.11	*	*	216.87	216.87	433.75	713.28	282.81	565.68	0.06
Coyote	male	Cottingham	380	GPS	2010	Spring	1865.38	*	*	745.58	160.55	906.13	856.96	220.08	257.11	0.03
Coyote	male	Cottingham	380	GPS	2010	Summer	941.43	*	*	641.84	201.07	842.91	704.08	231.38	277.88	0.03
Coyote	male	Cottingham	380	GPS	2010	Winter	1678.15	*	*	727.43	161.07	888.50	912.30	264.80	571.86	0.06
Coyote	female	Cottingham	390	GPS	2010	Annual	9744.59	*	*	2802.65	405.57	3208.22	3751.30	588.22	1142.92	0.11
Coyote	female	Cottingham	390	GPS	2010	Spring	2700.64	*	*	841.38	212.76	1054.14	884.20	242.85	694.18	0.07
Coyote	female	Cottingham	390	GPS	2010	Summer	982.42	*	*	673.26	205.96	879.22	755.73	338.55	464.68	0.05
Coyote	female	Cottingham	390	GPS	2010	Winter	9744.59	*	*	6390.80	1482.42	7873.22	8882.39	2335.39	768.15	0.08

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Species	Sex	Site	FRQ	Type	Year	Season	MCP	LSCV	LSCV	Href85	Href85	Href85	Href85 Random		LSCV Random	
								0.95	0.5	0.95	0.5	Total	0.95	0.5	0.95	0.5
Coyote	male	Winston	730	GPS	2010	Annual	17840.21	*	*	9582.47	2540.95	12123.42	12950.06	3980.86	1400.32	0.14
Coyote	male	Winston	730	GPS	2010	Spring	14004.37	*	*	6422.09	1107.28	7529.37	9135.40	2092.73	2449.66	0.24
Coyote	male	Winston	730	GPS	2010	Summer	4410.27	*	*	3645.21	642.99	4288.20	4841.12	1174.91	5573.35	0.56
Coyote	male	Winston	730	GPS	2010	Winter	1974.90	*	*	964.00	163.14	1127.15	1737.98	330.38	2033.27	0.20
Coyote	female	Winston	740	GPS	2010	Annual	4923.85	*	*	1469.18	216.03	1685.21	1874.35	281.50	3110.30	0.31
Coyote	female	Winston	740	GPS	2010	Spring	3293.11	*	*	870.70	164.97	1035.67	842.50	192.96	289.33	0.03
Coyote	female	Winston	740	GPS	2010	Summer	1682.60	*	*	580.36	113.53	693.89	908.83	218.20	201.74	0.02
Coyote	female	Winston	740	GPS	2010	Winter	3714.69	*	*	2257.16	284.35	2541.51	3363.40	486.56	3570.89	0.36
Coyote	female	Cottingham	380	GPS	2011	Annual	770.70	*	*	296.86	78.57	375.43	254.86	82.41	3772.63	0.38
Coyote	female	Cottingham	380	GPS	2011	Spring	649.95	*	*	294.26	63.23	357.49	316.52	76.65	126.85	0.01
Coyote	female	Cottingham	380	GPS	2011	Summer	569.76	*	*	274.64	71.67	346.31	343.95	91.60	246.43	0.02
Coyote	female	Cottingham	380	GPS	2011	Winter	677.97	*	*	261.46	70.63	332.10	239.37	79.10	131.08	0.01
Coyote	male	Winston	390	GPS	2011	Annual	1502.95	*	*	942.57	275.05	1217.62	1085.03	347.41	361.21	0.04
Coyote	male	Winston	390	GPS	2011	Spring	1242.84	*	*	762.61	199.25	961.86	856.77	270.85	513.06	0.05
Coyote	male	Winston	390	GPS	2011	Summer	617.27	*	*	476.49	87.64	564.13	407.06	86.56	33.62	0.00
Coyote	male	Winston	390	GPS	2011	Winter	1384.57	*	*	1082.92	318.13	1401.04	1159.91	379.95	612.57	0.06
Coyote	male	Cottingham	510	GPS	2011	Annual	13310.40	*	*	5098.27	610.65	5708.92	9343.16	1607.60	12139.53	1.21
Coyote	male	Cottingham	510	GPS	2011	Spring	5.04	*	*	*	*	*	*	*	*	*
Coyote	male	Cottingham	510	GPS	2011	Winter	13310.40	*	*	9873.30	2020.03	11893.32	17842.17	4667.47	22057.63	2.21

MCP : Minimum convex polygon

LSCV: Least Squares Cross Validation

Href 85: 85% of Reference band width

Href 85 Random : 85 % of refernce bandwidth using a random seletion of locations

LSCV Random : Home range using least squares cross validation on a random selection of locations

Appendix 2 : Annual Habitat Selection (individual comparison t-test results)

Bobcat : All Second order habitat selection

λ	0.3029
χ^2	26.2722
P	0.0002
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	2.3336	4.3585	-2.3432	0.6016	-2.0087	2.9805	0.4166	-3.6755	-1.6518	-4.6422	-0.1779	-4.4177	-4.0020	-3.2226	-3.6574	2.6323	-0.6323	4.0651	-2.0544	2.7783	2.7175
df	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Mean	0.8608	1.0661	-0.6818	0.1159	-0.9448	0.7700	0.2052	-1.5426	-0.7449	-1.8056	-0.0909	-1.7478	-0.9502	-2.0109	-0.2961	0.7977	-0.2630	1.4517	-1.0607	0.6541	1.7148
SE	0.3689	0.2446	0.2910	0.1927	0.4703	0.2583	0.4926	0.4197	0.4510	0.3890	0.5109	0.3956	0.2374	0.6240	0.0810	0.3030	0.4159	0.3571	0.5163	0.2354	0.6310
P	0.0296	0.0003	0.0290	0.5539	0.0576	0.0071	0.6812	0.0014	0.1134	0.0001	0.8605	0.0002	0.0006	0.0041	0.0015	0.0156	0.5340	0.0006	0.0526	0.0113	0.0129

Bobcat : All Third order habitat selection

λ	0.3787
χ^2	20.3935
P	0.0024
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.3075	0.0624	1.0540	1.1335	3.9914	0.0147	-0.3467	1.5044	0.8187	5.4405	-0.3918	1.4119	1.3641	4.6523	-0.1314	-0.1123	3.6177	-1.3838	2.9205	-1.2440	-4.8511
df	20	20	20	20	18	20	20	20	20	18	20	20	20	18	20	20	18	20	18	20	18
Mean	0.1256	0.0241	0.5493	0.4928	2.1153	0.0067	-0.1015	0.4237	0.3672	2.0865	-0.1189	0.5253	0.4688	1.9776	-0.0174	-0.0565	1.6150	-0.5426	1.4976	-0.4861	-1.9758
SE	0.4084	0.3857	0.5212	0.4348	0.5300	0.4554	0.2928	0.2817	0.4485	0.3835	0.3035	0.3720	0.3436	0.4251	0.1322	0.5031	0.4464	0.3921	0.5128	0.3908	0.4073
P	0.7616	0.9509	0.3045	0.2704	0.0009	0.9884	0.7324	0.1481	0.4226	0.0000	0.6993	0.1733	0.1877	0.0002	0.8967	0.9117	0.0020	0.1817	0.0091	0.2279	0.0001

Bobcat : female second order selection

λ	0.3779
χ^2	9.7307
P	0.1365
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	2.0929	1.6616	-0.5591	0.2243	0.7715	0.8497	-0.8835	-2.1444	-1.5508	-1.6691	-1.1619	-1.5492	-1.6678	-0.1982	-2.4665	0.6299	1.1516	1.1520	0.5206	0.7903	-0.1405
df	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Mean	1.5636	0.7011	-0.2696	0.0872	0.5149	0.3796	-0.8625	-1.8332	-1.4765	-1.0487	-1.1840	-0.9707	-0.6140	-0.1862	-0.3215	0.3567	0.7845	0.6492	0.4277	0.2925	-0.1353
SE	0.7471	0.4220	0.4822	0.3886	0.6674	0.4468	0.9762	0.8549	0.9521	0.6283	1.0190	0.6266	0.3681	0.9397	0.1303	0.5664	0.6812	0.5635	0.8217	0.3701	0.9625
P	0.0659	0.1310	0.5898	0.8275	0.4602	0.4175	0.3999	0.0606	0.1554	0.1294	0.2752	0.1557	0.1297	0.8473	0.0358	0.5444	0.2792	0.2790	0.6152	0.4497	0.8913

Bobcat : female third order selection

λ	0.2493
χ^2	12.5030
P	0.0516
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.0061	-0.7984	0.6052	1.1309	2.0723	-0.8636	-0.7599	0.9484	0.8136	4.3566	-0.8708	1.3527	2.0416	3.2197	-0.7804	0.1549	1.8675	-1.4341	0.5338	-1.9075	-3.0454
df	8	8	8	8	6	8	8	8	8	6	8	8	8	6	8	8	6	8	6	8	6
Mean	-0.0045	-0.5441	0.6810	0.8845	1.7990	-0.6760	-0.5396	0.6855	0.8890	2.1452	-0.6714	1.2251	1.4286	2.0240	-0.1319	0.2035	1.2687	-1.3570	0.4487	-1.5605	-2.1040
SE	0.7444	0.6815	1.1252	0.7821	0.8681	0.7827	0.7100	0.7228	1.0927	0.4924	0.7711	0.9057	0.6997	0.6286	0.1690	1.3140	0.6794	0.9462	0.8405	0.8181	0.6909
P	0.9953	0.4477	0.5618	0.2908	0.0836	0.4130	0.4691	0.3707	0.4394	0.0048	0.4092	0.2132	0.0755	0.0181	0.4576	0.8807	0.1111	0.1894	0.6127	0.0929	0.0226

Bobcat : Male second order selection

λ	0.1559
χ^2	22.3021
P	0.0011
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	1.6720	5.1975	-3.0344	0.8542	-5.1717	3.9650	5.3930	-3.9854	-0.9703	-5.7299	4.1286	-5.4064	-4.1195	-6.4664	-2.5901	4.2355	-3.0722	5.6592	-5.6663	3.3273	6.0835
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	0.2752	1.3702	-1.0253	0.1398	-2.1612	1.0953	1.0950	-1.3004	-0.1353	-2.4364	0.8201	-2.3955	-1.2304	-3.5314	-0.2750	1.1651	-1.1359	2.1205	-2.3010	0.9554	3.2564
SE	0.1646	0.2636	0.3379	0.1637	0.4179	0.2762	0.2030	0.3263	0.1395	0.4252	0.1986	0.4431	0.2987	0.5461	0.1062	0.2751	0.3697	0.3747	0.4061	0.2871	0.5353
P	0.1227	0.0003	0.0114	0.4112	0.0003	0.0022	0.0002	0.0021	0.3528	0.0001	0.0017	0.0002	0.0017	0.0000	0.0251	0.0014	0.0106	0.0001	0.0001	0.0067	0.0001

Bobcat: Male third order selection

λ	0.3296
χ^2	13.3196
P	0.0382
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.9753	0.1494	1.4529	1.1823	2.8040	0.1444	-1.1899	1.7574	0.1911	3.4641	-1.6234	1.6324	1.7807	3.2249	0.0394	-1.1344	2.4731	-2.2009	3.1401	-2.5203	-3.6227
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	0.6668	0.0735	1.3521	0.7258	3.2862	0.0843	-0.5933	0.6853	0.0589	2.6194	-0.5825	1.2786	0.6522	3.2127	0.0108	-0.6263	1.9341	-1.2678	2.5604	-0.6415	-3.2019
SE	0.6837	0.4921	0.9306	0.6138	1.1720	0.5837	0.4986	0.3899	0.3083	0.7561	0.3588	0.7832	0.3663	0.9962	0.2737	0.5521	0.7821	0.5760	0.8154	0.2545	0.8838
P	0.3504	0.8840	0.1742	0.2620	0.0172	0.8878	0.2591	0.1066	0.8519	0.0053	0.1328	0.1309	0.1026	0.0081	0.9693	0.2807	0.0309	0.0500	0.0094	0.0285	0.0040

Coyote : All second order selection

λ	0.1304
χ^2	34.6335
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	4.7056	6.5173	0.5954	3.1016	-1.9485	5.9285	5.6958	-0.9179	0.4623	-2.8522	5.0365	-3.0017	-2.0602	-3.9174	-3.4053	1.3358	-1.9572	2.6068	-4.1401	1.4000	3.5034
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	0.5622	1.5244	0.2152	0.7005	-0.9005	1.2198	0.9622	-0.3470	0.1383	-1.4627	0.6576	-1.3092	-0.8240	-2.4249	-0.3047	0.4853	-1.1157	1.0046	-1.6010	0.5193	2.1203
SE	0.1195	0.2339	0.3615	0.2258	0.4621	0.2057	0.1689	0.3780	0.2991	0.5128	0.1306	0.4362	0.3999	0.6190	0.0895	0.3633	0.5701	0.3854	0.3867	0.3709	0.6052
P	0.0002	0.0000	0.5599	0.0069	0.0691	0.0000	0.0000	0.3723	0.6501	0.0115	0.0001	0.0084	0.0560	0.0012	0.0036	0.2003	0.0680	0.0191	0.0008	0.1806	0.0029

Coyote : All third order selection

λ	0.4986
χ^2	11.8326
P	0.0658
df	6

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.3220	-2.2727	-0.8140	-1.2024	1.7213	-2.2270	-1.5373	-0.0127	-0.5073	2.4855	-1.3886	0.7082	0.0442	2.8229	0.5559	-0.9936	2.5887	-0.5631	2.9289	0.0927	-2.8599
df	16	16	16	16	14	16	16	16	16	14	16	16	16	14	16	16	14	16	14	16	14
Mean	-0.3717	-0.6526	-0.3773	-0.6313	0.8724	-0.5870	-0.2809	-0.0056	-0.2596	1.2521	-0.2153	0.2752	0.0213	1.5623	0.0656	-0.2539	1.3825	-0.2096	1.7375	0.0443	-1.4667
SE	0.2812	0.2871	0.4636	0.5250	0.5068	0.2636	0.1827	0.4446	0.5116	0.5038	0.1550	0.3886	0.4822	0.5534	0.1180	0.2556	0.5340	0.3723	0.5932	0.4776	0.5128
P	0.2048	0.0372	0.4276	0.2467	0.1072	0.0407	0.1438	0.9900	0.6188	0.0262	0.1840	0.4890	0.9653	0.0136	0.5860	0.3352	0.0214	0.5812	0.0110	0.9273	0.0126

Coyote : Female second order habitat selection

λ	0.0009
χ^2	62.6603
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	5.0452	9.1982	0.5626	1.9479	-8.1781	8.5386	6.4874	-0.8510	-0.9641	-8.4891	6.3100	-2.5656	-3.8331	-14.3090	-2.8364	0.3853	-2.7953	2.2570	-7.9331	3.1772	10.8965
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	0.7585	1.9827	0.2923	0.4599	-1.2865	1.5704	1.2242	-0.4662	-0.2986	-2.0450	0.8119	-1.6904	-1.5228	-3.2693	-0.4123	0.1676	-1.5788	1.2781	-1.7465	1.1104	2.8569
SE	0.1503	0.2156	0.5196	0.2361	0.1573	0.1839	0.1887	0.5478	0.3097	0.2409	0.1287	0.6589	0.3973	0.2285	0.1454	0.4351	0.5648	0.5663	0.2202	0.3495	0.2622
P	0.0010	0.0000	0.5891	0.0873	0.0000	0.0000	0.0002	0.4195	0.3632	0.0000	0.0002	0.0334	0.0050	0.0000	0.0219	0.7101	0.0234	0.0540	0.0000	0.0131	0.0000

Coyote : Female third order habitat selection

λ	0.3898
χ^2	8.4784
P	0.2051
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.0387	-1.6151	-0.7851	-0.9988	0.4287	-1.4172	-1.0509	-0.0642	-0.3458	1.4224	-0.7801	0.4653	0.0335	1.6009	1.0311	-0.7781	0.9297	-0.3121	1.1806	0.1034	-1.5538
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	-0.5443	-0.8611	-0.5898	-0.8346	0.1676	-0.7582	-0.3168	-0.0455	-0.2903	0.7119	-0.2139	0.2713	0.0265	1.0287	0.1029	-0.2449	0.7574	-0.1684	1.0022	0.0765	-0.9258
SE	0.5240	0.5332	0.7512	0.8356	0.3910	0.5350	0.3014	0.7080	0.8395	0.5005	0.2742	0.5831	0.7901	0.6426	0.0998	0.3147	0.8147	0.5395	0.8489	0.7395	0.5958
P	0.3293	0.1450	0.4550	0.3471	0.6795	0.1942	0.3240	0.9504	0.7384	0.1927	0.4578	0.6541	0.9741	0.1481	0.3327	0.4589	0.3797	0.7629	0.2717	0.9202	0.1588

Coyote : Male second order habitat selection

λ	0.1854
χ^2	13.4810
P	0.0360
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	2.0733	2.7532	0.2405	2.4563	-0.4772	2.3811	2.5339	-0.3864	1.2693	-0.7746	2.0948	-1.5657	-0.0592	-1.1846	-2.0850	1.3982	-0.5683	1.3088	-1.7735	-0.2328	1.0527
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	0.3413	1.0088	0.1285	0.9711	-0.4662	0.8253	0.6675	-0.2129	0.6297	-0.8076	0.4840	-0.8804	-0.0378	-1.4751	-0.1835	0.8426	-0.5947	0.6968	-1.4373	-0.1457	1.2915
SE	0.1646	0.3664	0.5343	0.3953	0.9771	0.3466	0.2634	0.5508	0.4961	1.0426	0.2310	0.5623	0.6382	1.2452	0.0880	0.6026	1.0464	0.5324	0.8104	0.6260	1.2269
P	0.0768	0.0284	0.8169	0.0437	0.6478	0.0488	0.0390	0.7106	0.2449	0.4639	0.0744	0.1614	0.9544	0.2748	0.0755	0.2047	0.5876	0.2319	0.1194	0.8226	0.3275

Coyote : Male third order habitat selection

λ	0.0419
χ^2	25.3856
P	0.0003
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.8990	-1.8463	-0.3429	-0.6694	1.5045	-3.5471	-1.0867	0.0449	-0.3578	1.8278	-1.2540	0.5000	0.0276	2.0911	0.1607	-0.6183	2.8807	-0.4413	2.9063	0.0274	-2.1790
df	7	7	7	7	5	7	7	7	7	5	7	7	7	5	7	7	5	7	5	7	5
Mean	-0.2315	-0.4832	-0.2048	-0.4661	1.4811	-0.4480	-0.2517	0.0267	-0.2346	1.7187	-0.2164	0.2784	0.0171	2.0232	0.0352	-0.2613	1.9224	-0.2431	2.3725	0.0181	-1.9339
SE	0.2575	0.2617	0.5973	0.6963	0.9844	0.1263	0.2316	0.5944	0.6556	0.9403	0.1726	0.5567	0.6193	0.9675	0.2193	0.4226	0.6673	0.5510	0.8164	0.6611	0.8875
P	0.3985	0.1074	0.7417	0.5247	0.1928	0.0094	0.3132	0.9654	0.7310	0.1271	0.2501	0.6324	0.9787	0.0908	0.8769	0.5559	0.0346	0.6723	0.0335	0.9789	0.0812

Raccoon : all second order habitat selection

λ	0.4995
χ^2	19.4375
P	0.0035
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.0543	-3.3207	0.3905	-2.4478	-0.4314	-3.3141	-2.9462	0.3497	-2.3832	-0.3546	-2.7497	2.6492	0.4116	2.2264	0.4197	-2.9035	-0.7702	-2.8149	2.1662	-0.3289	-2.2138
df	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Mean	-0.0566	-2.1981	0.3690	-2.0143	-0.4223	-2.1421	-2.1415	0.4256	-1.9577	-0.3657	-2.0855	2.5671	0.1838	1.7758	0.0560	-2.3833	-0.7913	-2.5111	1.5920	-0.1278	-1.7198
SE	1.0419	0.6619	0.9452	0.8229	0.9789	0.6464	0.7269	1.2171	0.8214	1.0314	0.7585	0.9690	0.4465	0.7976	0.1334	0.8208	1.0275	0.8921	0.7349	0.3886	0.7768
P	0.9571	0.0026	0.6993	0.0212	0.6696	0.0026	0.0066	0.7293	0.0245	0.7257	0.0105	0.0133	0.6839	0.0345	0.6780	0.0073	0.4479	0.0090	0.0393	0.7448	0.0355

Raccoon : All third order habitat selection

λ	0.1165
χ^2	60.2067
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-3.1936	-7.5215	-5.0030	-3.0443	-0.1092	-5.3881	-3.1738	-0.8125	1.2677	3.8685	-2.4270	2.4835	4.1817	6.2609	1.3954	1.0742	7.1857	-2.0674	2.3552	-4.0224	-6.0541
df	18	22	16	21	13	22	23	15	22	13	23	18	26	15	27	18	12	18	15	26	15
Mean	-3.9640	-5.8373	-4.8592	-2.8277	-0.1439	-5.1695	-2.3599	-0.7633	1.4919	4.1579	-1.7490	1.3385	3.2171	6.1370	0.5019	0.8838	6.2213	-1.0989	3.5061	-3.0083	-6.0682
SE	1.2412	0.7761	0.9713	0.9288	1.3176	0.9594	0.7435	0.9395	1.1769	1.0748	0.7206	0.5389	0.7693	0.9802	0.3597	0.8228	0.8658	0.5315	1.4887	0.7479	1.0023
P	0.0050	0.0000	0.0001	0.0062	0.9147	0.0000	0.0042	0.4292	0.2182	0.0019	0.0235	0.0231	0.0003	0.0000	0.1743	0.2969	0.0000	0.0534	0.0325	0.0004	0.0000

Raccoon : Female second order habitat selection

λ	0.4834
χ^2	8.7218
P	0.1898
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.7791	-1.7102	0.4690	-0.8119	0.7212	-1.9240	-2.0937	-0.1943	-1.5036	-0.0605	-2.1707	1.3387	0.3270	1.9794	-0.8623	-1.4029	0.2509	-1.5638	1.9831	-0.6173	-2.1910
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	1.0727	-1.4069	0.6844	-1.0910	0.9774	-1.5888	-2.4795	-0.3883	-2.1636	-0.0953	-2.6615	2.0913	0.3159	2.3843	-0.1819	-1.7754	0.2930	-2.2732	2.0684	-0.4978	-2.5662
SE	1.3769	0.8227	1.4591	1.3438	1.3553	0.8258	1.1843	1.9979	1.4390	1.5743	1.2261	1.5621	0.9660	1.2045	0.2110	1.2655	1.1680	1.4536	1.0430	0.8065	1.1713
P	0.4524	0.1153	0.6482	0.4341	0.4859	0.0806	0.0603	0.8495	0.1608	0.9528	0.0527	0.2077	0.7498	0.0733	0.4069	0.1882	0.8065	0.1462	0.0729	0.5496	0.0509

Raccoon : Female third order habitat selection

λ	0.0553
χ^2	34.7492
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-2.3722	-5.5867	-3.9087	-2.4068	-1.1476	-2.9413	-1.5409	0.3775	1.1374	3.0068	-0.5074	0.6471	2.2819	3.3708	1.4056	1.6506	3.8877	0.1842	1.5836	-2.0617	-3.1846
df	8	10	7	9	5	10	9	5	8	4	9	7	10	5	11	7	5	7	5	10	5
Mean	-4.5261	-5.8939	-5.5187	-3.6803	-1.9682	-4.8044	-1.8246	0.1363	2.4665	5.4672	-0.5064	0.2834	3.1251	5.9714	1.0930	1.8762	5.9235	0.0598	3.3839	-2.7002	-5.9101
SE	1.9079	1.0550	1.4119	1.5291	1.7151	1.6335	1.1841	0.3612	2.1685	1.8183	0.9979	0.4380	1.3695	1.7715	0.7776	1.1367	1.5236	0.3246	2.1368	1.3097	1.8558
P	0.0451	0.0002	0.0058	0.0395	0.3031	0.0148	0.1577	0.7213	0.2883	0.0397	0.6241	0.5382	0.0456	0.0199	0.1874	0.1428	0.0116	0.8591	0.1741	0.0662	0.0244

Raccoon : Male second order habitat selection

λ	0.4571
χ^2	12.5257
P	0.0512
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.6004	-2.8592	0.1037	-2.6225	-1.0861	-2.6744	-2.0093	0.6669	-1.8188	-0.4039	-1.6909	2.3146	0.2516	1.2180	1.4374	-2.5819	-1.0205	-2.3236	1.1864	0.4597	-1.0422
df	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Mean	-0.9035	-2.7915	0.1325	-2.7068	-1.4721	-2.5571	-1.8879	1.0361	-1.8033	-0.5685	-1.6536	2.9240	0.0847	1.3194	0.2344	-2.8393	-1.6046	-2.6896	1.2347	0.1497	-1.0850
SE	1.5050	0.9763	1.2784	1.0321	1.3553	0.9561	0.9396	1.5534	0.9914	1.4076	0.9779	1.2633	0.3366	1.0833	0.1631	1.0997	1.5723	1.1575	1.0408	0.3257	1.0411
P	0.5572	0.0119	0.9188	0.0192	0.2946	0.0173	0.0628	0.5149	0.0890	0.6920	0.1115	0.0352	0.8048	0.2420	0.1711	0.0208	0.3237	0.0346	0.2539	0.6523	0.3138

APPENDIX 3

Appendix 3 : Fall Habitat Selection (individual comparison t-test results)

Bobcat : All fall second order habitat selection

λ	0.1913
χ^2	13.2313
P	0.0395
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.4976	-0.0098	-1.6060	-0.6727	-2.1624	-0.0656	0.8146	-3.6243	-1.1808	-1.4640	0.6976	-2.4670	-1.7189	-1.3151	-0.8579	2.2293	-0.2155	2.4154	-1.0054	1.5471	1.2807
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	-0.4203	-0.0111	-1.5787	-0.6839	-1.7895	-0.0732	0.4091	-1.1584	-0.2636	-1.3693	0.3470	-1.5675	-0.6727	-1.7784	-0.0621	0.8948	-0.2109	1.5054	-1.1057	0.6106	1.7163
SE	0.8447	1.1337	0.9830	1.0167	0.8276	1.1165	0.5022	0.3196	0.2232	0.9353	0.4975	0.6354	0.3914	1.3523	0.0724	0.4014	0.9785	0.6233	1.0998	0.3947	1.3402
P	0.6340	0.9924	0.1523	0.5227	0.0674	0.9495	0.4421	0.0085	0.2763	0.1866	0.5080	0.0430	0.1293	0.2299	0.4194	0.0610	0.8355	0.0464	0.3482	0.1658	0.2411

Bobcat : All fall third order habitat selection

λ	0.1769
χ^2	12.1238
P	0.0593
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.0716	-0.3945	0.0546	0.4696	2.2453	-0.2752	-0.6044	0.1651	0.4047	1.9943	-0.5474	0.8596	1.2731	2.6683	0.3271	0.1517	1.4555	-0.8418	1.5393	-1.2048	-2.2220
df	5	5	5	5	4	5	6	6	6	4	6	6	6	4	6	6	4	6	4	6	4
Mean	-0.0832	-0.3835	0.0777	0.5110	2.0107	-0.3063	-0.5601	0.1355	0.2781	2.1159	-0.4952	0.6956	0.8382	2.1597	0.0649	0.1426	1.6025	-0.6308	1.5059	-0.7733	-2.0455
SE	1.1617	0.9721	1.4228	1.0884	0.8955	1.1129	0.9266	0.8211	0.6872	1.0610	0.9047	0.8093	0.6584	0.8094	0.1983	0.9402	1.1010	0.7493	0.9783	0.6419	0.9206
P	0.9457	0.7095	0.9586	0.6584	0.0881	0.7942	0.5677	0.8743	0.6997	0.1169	0.6039	0.4230	0.2501	0.0559	0.7547	0.8844	0.2192	0.4321	0.1986	0.2736	0.0904

Raccoon : All fall second order habitat selection

λ	0.3753
χ^2	16.6626
P	0.0106
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.6960	-3.1584	-0.7338	-1.6927	0.2410	-3.2471	-2.2101	-0.2448	-0.7434	0.6395	-2.3165	1.7008	1.7778	3.3594	0.1955	-0.3877	1.0728	-1.8480	1.3272	-1.8369	-3.5123
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	-0.6307	-2.9690	-0.9220	-1.3795	0.3093	-2.9339	-2.3383	-0.2913	-0.7488	0.9400	-2.3032	2.0469	1.5894	3.2783	0.0350	-0.4575	1.2313	-2.0119	1.6888	-1.5544	-3.2432
SE	0.9062	0.9400	1.2566	0.8150	1.2835	0.9036	1.0580	1.1902	1.0073	1.4698	0.9943	1.2035	0.8940	0.9758	0.1792	1.1801	1.1477	1.0887	1.2724	0.8462	0.9234
P	0.4964	0.0061	0.4737	0.1099	0.8126	0.0051	0.0420	0.8098	0.4680	0.5315	0.0341	0.1083	0.0944	0.0040	0.8475	0.7034	0.2993	0.0832	0.2031	0.0849	0.0029

Raccoon : All fall third order habitat selection

λ	0.0378
χ^2	39.3006
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-2.9865	-5.5592	-0.2876	-0.3351	-0.0664	-2.4403	-1.8855	2.4421	2.3590	2.0531	-0.1551	3.6177	3.9760	6.9883	1.8558	-0.1167	0.5399	-3.3624	1.0032	-1.9515	-5.7092
df	8	8	6	8	3	8	9	7	8	4	9	7	9	4	11	6	4	7	3	9	4
Mean	-4.8779	-6.7816	-0.6067	-0.7762	-0.1061	-4.4169	-2.4493	4.3941	4.1016	4.4876	-0.2732	6.3650	6.3094	7.6279	2.6775	-0.3901	1.2854	-6.3278	2.5849	-4.2042	-7.6346
SE	1.6333	1.2199	2.1098	2.3167	1.5986	1.8100	1.2990	1.7993	1.7387	2.1857	1.7613	1.7594	1.5869	1.0915	1.4428	3.3423	2.3806	1.8819	2.5767	2.1544	1.3372
P	0.0174	0.0005	0.7834	0.7462	0.9513	0.0405	0.0920	0.0446	0.0460	0.1093	0.8802	0.0085	0.0032	0.0022	0.0905	0.9109	0.6179	0.0120	0.3897	0.0828	0.0047

Raccoon : Female second order habitat selection

λ	0.0577
χ^2	22.8154
P	0.0009
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.1711	-2.5275	-1.1623	-0.5443	-0.3737	-2.9680	-1.4467	-0.7564	0.8282	0.2780	-1.9669	0.6372	1.7279	1.6448	-0.9901	1.0025	0.8026	-0.8626	-0.1851	-2.0756	-1.9339
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	-1.3695	-3.5014	-2.2608	-0.4731	-0.8924	-3.7667	-2.1320	-0.8913	0.8964	0.4771	-2.3973	1.2407	3.0284	2.6091	-0.2653	1.7877	1.3684	-1.5059	-0.4193	-3.2936	-2.8743
SE	1.1694	1.3854	1.9451	0.8691	2.3881	1.2691	1.4737	1.1783	1.0823	1.7164	1.2188	1.9471	1.7526	1.5863	0.2679	1.7832	1.7049	1.7459	2.2650	1.5868	1.4863
P	0.2799	0.0394	0.2832	0.6031	0.7197	0.0209	0.1912	0.4741	0.4349	0.7891	0.0899	0.5443	0.1276	0.1440	0.3551	0.3495	0.4486	0.4169	0.8584	0.0766	0.0944

Raccoon : Female third order habitat selection

λ	0.0000
χ^2	70.0893
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.7600	-2.6162	0.1906	0.0516	-0.1878	-1.1166	-2.1395	1.2666	0.8892	1.3584	-1.0390	2.5189	2.0382	6.2807	1.4369	-0.0432	-0.5875	-2.3397	1.0629	-0.8857	-4.4610
df	4	4	3	4	2	4	5	4	4	3	5	4	4	3	6	3	3	4	2	4	3
Mean	-1.7037	-5.1178	0.5287	0.1998	-0.4156	-2.9616	-4.1892	2.7606	1.9035	2.9791	-2.3530	6.0716	5.3177	6.9870	3.0563	-0.1897	-0.7125	-6.2602	3.4271	-3.1614	-7.1266
SE	2.2417	1.9562	2.7742	3.8718	2.2133	2.6523	1.9581	2.1795	2.1408	2.1931	2.2646	2.4105	2.6091	1.1125	2.1271	4.3866	1.2127	2.6757	3.2243	3.5695	1.5975
P	0.4896	0.0590	0.8610	0.9613	0.8684	0.3267	0.0854	0.2740	0.4242	0.2675	0.3464	0.0654	0.1112	0.0082	0.2008	0.9682	0.5982	0.0794	0.3992	0.4258	0.0210

Raccoon : Male second order habitat selection

λ	0.3938
χ^2	8.3866
P	0.2111
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.0144	-1.8888	0.1228	-1.6283	0.8815	-1.6689	-1.4434	0.1171	-1.2462	0.5682	-1.2798	1.4570	0.8732	2.6856	1.3380	-1.3748	0.6639	-1.3943	2.6887	-0.0302	-2.5906
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	0.0260	-2.4956	0.2680	-2.1852	1.3774	-2.1937	-2.5216	0.2420	-2.2112	1.3515	-2.2197	2.7636	0.3104	3.8731	0.3020	-2.4532	1.1094	-2.4617	3.5627	-0.0084	-3.5711
SE	1.8036	1.3213	2.1815	1.3421	1.5626	1.3144	1.7470	2.0665	1.7744	2.3787	1.7343	1.8968	0.3555	1.4422	0.2257	1.7845	1.6712	1.7656	1.3251	0.2791	1.3785
P	0.9889	0.0956	0.9053	0.1421	0.4037	0.1337	0.1869	0.9097	0.2480	0.5855	0.2365	0.1832	0.4080	0.0277	0.2177	0.2065	0.5255	0.2007	0.0276	0.9766	0.0321

Appendix 4 : Spring Habitat Selection (individual comparison t-test results)

Bobcat : All spring second order habitat selection

λ	0.2822
χ^2	25.3013
P	0.0003
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	3.1438	4.0557	-0.4821	0.2830	-1.7937	2.5698	1.8853	-1.4272	-1.9403	-3.2123	0.7334	-2.4113	-4.0664	-2.9282	-3.5437	0.6936	-0.8925	1.9696	-1.7095	2.8113	2.3901
df	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Mean	0.4997	1.0728	-0.2778	0.0508	-0.8694	0.7287	0.5731	-0.7775	-0.4488	-1.3691	0.2290	-1.3506	-1.0219	-1.9422	-0.3441	0.3287	-0.5916	1.0065	-0.9202	0.6778	1.5981
SE	0.1589	0.2645	0.5763	0.1797	0.4847	0.2835	0.3040	0.5448	0.2313	0.4262	0.3122	0.5601	0.2513	0.6633	0.0971	0.4739	0.6628	0.5110	0.5383	0.2411	0.6686
P	0.0053	0.0007	0.6352	0.7802	0.0888	0.0188	0.0748	0.1698	0.0673	0.0046	0.4723	0.0262	0.0007	0.0086	0.0022	0.4963	0.3833	0.0636	0.1036	0.0111	0.0274

Bobcat : All spring third order habitat selection

λ	0.3531
χ^2	20.8199
P	0.0020
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.5063	0.4376	1.0947	2.3509	3.3304	0.2346	-0.2125	1.0746	1.7230	3.5392	-0.3916	1.1017	1.7269	3.6092	-0.4728	0.4198	2.5414	-1.4689	1.8198	-1.7099	-3.9230
df	19	19	18	19	16	19	19	18	19	16	19	18	19	16	19	18	15	18	16	19	16
Mean	0.2883	0.2014	0.7841	1.0233	2.3875	0.1255	-0.0868	0.4827	0.7351	2.2653	-0.1628	0.5696	0.8219	2.1351	-0.0759	0.2783	1.7510	-0.6453	1.3122	-0.8978	-2.2418
SE	0.5693	0.4603	0.7163	0.4353	0.7169	0.5351	0.4086	0.4492	0.4266	0.6401	0.4156	0.5170	0.4759	0.5916	0.1606	0.6629	0.6890	0.4393	0.7211	0.5251	0.5714
P	0.6185	0.6666	0.2881	0.0297	0.0042	0.8171	0.8340	0.2967	0.1011	0.0027	0.6997	0.2851	0.1004	0.0024	0.6418	0.6796	0.0226	0.1591	0.0876	0.1036	0.0012

Bobcat : Female spring second order habitat selection

λ	0.2704
χ^2	10.4637
P	0.1064
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	2.1486	1.2856	0.1967	-0.0842	0.0044	0.5488	-0.1775	-0.3459	-1.6052	-1.3440	-0.7326	-0.2784	-1.7383	-0.5988	-2.1511	-0.2691	-0.2118	-0.0013	0.0427	0.8496	0.2688
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	0.7589	0.6498	0.2975	-0.0361	0.0035	0.2960	-0.1091	-0.4614	-0.7949	-0.7554	-0.4629	-0.3523	-0.6859	-0.6464	-0.3538	-0.3335	-0.2940	-0.0015	0.0395	0.3320	0.2925
SE	0.3532	0.5055	1.5124	0.4283	0.7831	0.5393	0.6143	1.3339	0.4952	0.5621	0.6318	1.2657	0.3946	1.0795	0.1645	1.2395	1.3882	1.1981	0.9252	0.3908	1.0884
P	0.0688	0.2395	0.8497	0.9353	0.9966	0.6002	0.8641	0.7396	0.1525	0.2209	0.4876	0.7888	0.1257	0.5682	0.0685	0.7956	0.8383	0.9990	0.9671	0.4236	0.7959

Bobcat : Female spring third order habitat selection

λ	0.0165
χ^2	32.8302
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.0916	-0.5252	-0.1043	3.0250	1.9049	-0.6087	-0.5113	-0.4222	1.3522	3.5555	-0.6906	0.4556	1.8931	3.5481	-0.9833	1.3864	3.0154	-0.6405	0.7321	-1.8502	-3.5876
df	7	7	6	7	5	7	7	6	7	5	7	6	7	5	7	6	4	6	5	7	5
Mean	-0.1059	-0.5047	-0.1334	1.3284	2.1446	-0.6771	-0.3989	-0.0491	1.4343	2.7355	-0.5712	0.3662	1.8332	2.4488	-0.1723	1.6037	2.5764	-0.5429	0.8763	-2.0055	-2.5655
SE	1.1559	0.9611	1.2788	0.4392	1.1258	1.1124	0.7802	0.1163	1.0607	0.7694	0.8271	0.8038	0.9683	0.6902	0.1753	1.1568	0.8544	0.8476	1.1969	1.0839	0.7151
P	0.9296	0.6157	0.9203	0.0192	0.1151	0.5620	0.6249	0.6876	0.2184	0.0163	0.5120	0.6647	0.1002	0.0164	0.3582	0.2149	0.0393	0.5455	0.4969	0.1067	0.0157

Bobcat : Male spring second order habitat selection

λ	0.2031
χ^2	19.1311
P	0.0039
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.9030	5.5241	-0.9697	0.4888	-1.5390	3.7057	3.0716	-2.2835	-1.0504	-2.6829	2.0794	-3.0997	-4.9556	-2.9571	-2.6901	1.6149	-1.2019	2.9448	-1.8849	4.2511	2.6124
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	0.3269	1.3548	-0.6614	0.1088	-1.4513	1.0171	1.0279	-0.9883	-0.2181	-1.7782	0.6903	-2.0161	-1.2460	-2.8060	-0.3376	0.7702	-0.7899	1.6785	-1.5601	0.9083	2.4684
SE	0.3620	0.2452	0.6820	0.2225	0.9430	0.2745	0.3346	0.4328	0.2076	0.6628	0.3320	0.6504	0.2514	0.9489	0.1255	0.4769	0.6572	0.5700	0.8277	0.2137	0.9449
P	0.3859	0.0002	0.3530	0.6346	0.1521	0.0035	0.0106	0.0433	0.3161	0.0213	0.0618	0.0101	0.0004	0.0130	0.0210	0.1346	0.2546	0.0133	0.0861	0.0014	0.0242

Bobcat : Male spring third order habitat selection

λ	0.4361
χ^2	9.9590
P	0.1264
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.7395	1.1193	1.3677	1.3588	2.6271	0.9012	0.1257	1.0662	1.3237	2.2612	0.0650	0.9611	0.7164	2.3581	-0.1281	-0.4075	1.4850	-1.3044	1.6282	-0.7184	-2.6001
df	11	11	11	11	10	11	11	11	11	10	11	11	11	10	11	11	10	11	10	11	10
Mean	0.4750	0.5360	1.1970	0.8788	2.5046	0.5057	0.0610	0.7221	0.4038	2.0387	0.0307	0.6611	0.3429	1.9840	-0.0303	-0.3182	1.3756	-0.6913	1.5223	-0.3731	-2.0858
SE	0.6423	0.4788	0.8753	0.6467	0.9534	0.5612	0.4851	0.6772	0.3051	0.9016	0.4721	0.6879	0.4786	0.8414	0.2362	0.7810	0.9263	0.5300	0.9349	0.5194	0.8022
P	0.4751	0.2868	0.1987	0.2014	0.0253	0.3868	0.9023	0.3092	0.2125	0.0473	0.9493	0.3572	0.4887	0.0401	0.9004	0.6915	0.1684	0.2187	0.1345	0.4875	0.0265

Coyote : All spring second order habitat selection

λ	0.3629
χ^2	17.2333
P	0.0085
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	b	c	d	e	f	g	c	d	e	f	g	d	e	f	g	e	f	g	f	g	g
t-statistic	2.9051	4.0421	1.1862	1.5261	-1.2902	3.3670	2.0268	0.0430	-0.1378	-2.4553	1.1778	-0.9525	-1.6034	-2.6567	-3.1377	-0.1319	-2.0127	0.5352	-2.4386	0.9623	2.2580
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	0.5808	1.2093	0.6028	0.5248	-0.5904	0.9295	0.6285	0.0220	-0.0560	-1.1713	0.3487	-0.6065	-0.6845	-1.7998	-0.2798	-0.0780	-1.1932	0.3267	-1.1153	0.4047	1.5200
SE	0.1999	0.2992	0.5082	0.3439	0.4576	0.2761	0.3101	0.5112	0.4064	0.4770	0.2961	0.6367	0.4269	0.6774	0.0892	0.5911	0.5929	0.6105	0.4573	0.4206	0.6731
P	0.0103	0.0009	0.2529	0.1465	0.2153	0.0039	0.0597	0.9663	0.8921	0.0259	0.2561	0.3550	0.1284	0.0172	0.0064	0.8967	0.0613	0.5999	0.0268	0.3502	0.0383

Coyote : All spring third order habitat selection

λ	0.3505
χ^2	17.8248
P	0.0067
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.7898	-1.4426	-0.1577	-1.7674	3.0753	-0.9760	-1.3569	0.8902	-2.6037	3.8385	-0.4390	1.2548	-0.8986	4.0458	0.6966	-1.6117	2.7004	-0.7695	4.6229	1.0691	-3.5757
df	16	16	15	16	13	16	16	15	16	13	16	15	16	13	16	15	13	15	13	16	13
Mean	-0.5070	-0.9139	-0.1073	-1.1781	2.2092	-0.7043	-0.4069	0.4021	-0.6711	2.7158	-0.1973	0.7314	-0.2642	2.9608	0.2096	-1.0074	2.4446	-0.5106	3.2738	0.4738	-2.6925
SE	0.6419	0.6335	0.6805	0.6666	0.7184	0.7217	0.2999	0.4517	0.2578	0.7075	0.4495	0.5829	0.2940	0.7318	0.3008	0.6251	0.9053	0.6636	0.7082	0.4432	0.7530
P	0.4412	0.1684	0.8768	0.0962	0.0089	0.3436	0.1937	0.3874	0.0192	0.0021	0.6665	0.2287	0.3822	0.0014	0.4961	0.1279	0.0182	0.4535	0.0005	0.3009	0.0034

Coyote : Female spring second order habitat selection

λ	0.0241
χ^2	33.5461
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	4.5993	11.1980	0.8983	1.6912	-7.1441	8.4330	5.0865	-0.3354	-0.5396	-6.8253	4.2796	-1.9067	-3.3046	-12.0848	-2.2712	-0.0172	-2.6980	1.5658	-5.6623	2.5146	8.5990
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	0.8198	1.9411	0.5833	0.5758	-1.2413	1.6039	1.1214	-0.2364	-0.2440	-2.0611	0.7841	-1.3578	-1.3653	-3.1824	-0.3372	-0.0075	-1.8246	1.0206	-1.8171	1.0281	2.8452
SE	0.1782	0.1733	0.6493	0.3405	0.1738	0.1902	0.2205	0.7050	0.4521	0.3020	0.1832	0.7121	0.4132	0.2633	0.1485	0.4381	0.6763	0.6518	0.3209	0.4089	0.3309
P	0.0018	0.0000	0.3952	0.1293	0.0001	0.0000	0.0009	0.7460	0.6042	0.0001	0.0027	0.0930	0.0108	0.0000	0.0528	0.9867	0.0272	0.1560	0.0005	0.0361	0.0000

Coyote : Female spring third order habitat selection

λ	0.5138
χ^2	5.9935
P	0.4239
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.2680	-1.4960	-0.3533	-1.9922	0.4213	-0.8701	-0.9304	1.3472	-1.5234	1.5305	0.2694	1.3162	-0.8002	1.6825	0.8239	-1.5066	0.5803	-0.6462	2.2327	1.0439	-1.2975
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	-1.3059	-1.6015	-0.4357	-1.9225	0.2501	-1.1193	-0.2955	0.8702	-0.6166	1.5560	0.1866	1.1658	-0.3211	1.8516	0.4821	-1.4868	0.6858	-0.6836	2.1727	0.8032	-1.3694
SE	1.0299	1.0705	1.2333	0.9650	0.5936	1.2864	0.3176	0.6460	0.4048	1.0167	0.6926	0.8857	0.4012	1.1005	0.5852	0.9869	1.1817	1.0579	0.9731	0.7695	1.0555
P	0.2405	0.1730	0.7330	0.0815	0.6846	0.4096	0.3794	0.2148	0.1662	0.1644	0.7944	0.2246	0.4467	0.1310	0.4338	0.1703	0.5777	0.5362	0.0561	0.3271	0.2306

Coyote : Male spring second order habitat selection

λ	0.4811
χ^2	5.8538
P	0.4398
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.8529	0.8360	0.7403	0.7175	0.1553	0.4164	0.1305	0.4013	0.2141	-0.2009	-0.2504	0.2251	0.1143	-0.2003	-2.2495	-0.1306	-0.4871	-0.4327	-0.3851	-0.4147	0.0241
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	0.3120	0.3860	0.6247	0.4675	0.1418	0.1708	0.0740	0.3127	0.1554	-0.1702	-0.1412	0.2387	0.0814	-0.2442	-0.2152	-0.1572	-0.4829	-0.4538	-0.3257	-0.2966	0.0291
SE	0.3658	0.4618	0.8438	0.6515	0.9131	0.4103	0.5671	0.7792	0.7261	0.8471	0.5637	1.0604	0.7123	1.2194	0.0957	1.2036	0.9914	1.0487	0.8458	0.7151	1.2084
P	0.4219	0.4308	0.4832	0.4963	0.8810	0.6896	0.8998	0.7002	0.8366	0.8465	0.8095	0.8284	0.9122	0.8469	0.0592	0.8997	0.6411	0.6782	0.7116	0.6907	0.9815

Coyote : Male spring third order habitat selection

λ	0.0127
χ^2	34.8994
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.4004	-0.3348	0.2782	-0.6617	7.4513	-0.3660	-1.0908	-0.2184	-2.6756	10.6738	-1.0201	0.3150	-0.7985	12.3092	-0.1771	-0.7836	5.4786	-0.3114	8.1081	0.7322	-9.4100
df	7	7	6	7	4	7	7	6	7	4	7	6	7	4	7	6	4	6	4	7	4
Mean	0.2128	-0.1654	0.1216	-0.4449	2.6703	-0.1949	-0.3783	-0.1063	-0.6578	2.4055	-0.4077	0.1865	-0.2795	2.6016	-0.0295	-0.4888	2.7124	-0.2011	2.9068	0.2500	-2.5397
SE	0.5315	0.4940	0.4369	0.6724	0.3584	0.5325	0.3468	0.4867	0.2458	0.2254	0.3997	0.5921	0.3500	0.2114	0.1663	0.6238	0.4951	0.6456	0.3585	0.3415	0.2699
P	0.7008	0.7476	0.7902	0.5294	0.0017	0.7252	0.3115	0.8343	0.0317	0.0004	0.3416	0.7634	0.4508	0.0003	0.8644	0.4631	0.0054	0.7660	0.0013	0.4878	0.0007

Raccoon : All Spring second order habitat selection

λ	0.3821
χ^2	28.8626
P	0.0001
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.0345	-4.3717	-0.0955	-2.1160	-0.7465	-4.4118	-3.7619	-0.1221	-2.4318	-0.6161	-3.8737	3.2713	1.7981	3.6104	0.5620	-2.4555	-0.6241	-3.4423	1.5328	-1.8187	-3.5941
df	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Mean	0.0367	-3.3761	-0.0905	-2.1585	-0.7143	-3.3045	-3.4128	-0.1272	-2.1952	-0.7510	-3.3412	3.2856	1.2176	2.6618	0.0716	-2.0680	-0.6238	-3.2140	1.4442	-1.1460	-2.5902
SE	1.0663	0.7723	0.9480	1.0201	0.9568	0.7490	0.9072	1.0425	0.9027	1.2189	0.8625	1.0044	0.6772	0.7373	0.1274	0.8422	0.9995	0.9337	0.9422	0.6301	0.7207
P	0.9728	0.0001	0.9246	0.0431	0.4614	0.0001	0.0008	0.9037	0.0214	0.5426	0.0006	0.0028	0.0826	0.0011	0.5785	0.0203	0.5375	0.0018	0.1362	0.0793	0.0012

Raccoon : All Spring third order habitat selection

λ	0.0570
χ^2	85.9631
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-2.9498	-9.8008	-3.9316	-3.1730	-0.9020	-4.7154	-3.6204	0.3588	1.2080	2.0932	-2.0775	1.3189	4.9830	8.1541	1.6368	1.6406	5.5026	-0.6370	4.9264	-3.6485	-4.2711
df	15	20	14	18	11	20	21	13	20	9	21	16	26	13	29	16	10	16	11	26	13
Mean	-3.9771	-6.8660	-5.4277	-3.5834	-0.7328	-5.4330	-3.2349	0.3942	1.4903	4.0303	-2.2653	1.2006	4.4302	6.8264	1.0324	1.7524	6.7552	-0.7117	5.8653	-3.6956	-6.0476
SE	1.3483	0.7006	1.3805	1.1293	0.8124	1.1522	0.8935	1.0989	1.2337	1.9255	1.0904	0.9102	0.8891	0.8372	0.6308	1.0681	1.2276	1.1172	1.1906	1.0129	1.4159
P	0.0099	0.0000	0.0015	0.0053	0.3864	0.0001	0.0016	0.7255	0.2412	0.0658	0.0502	0.2058	0.0000	0.0000	0.1125	0.1204	0.0003	0.5331	0.0005	0.0012	0.0009

Raccoon : Female Spring second order habitat selection

λ	0.2795
χ^2	16.5739
P	0.0110
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.3396	-2.2788	0.0607	-0.6050	-0.0617	-2.5151	-1.8281	-0.3042	-1.1538	-0.4026	-2.1825	1.2754	1.2413	1.6434	-0.8093	-0.7056	-0.1471	-1.4810	0.8400	-1.6374	-1.8272
df	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Mean	0.5460	-2.1333	0.1127	-0.8450	-0.1020	-2.3096	-2.6793	-0.4333	-1.3910	-0.6480	-2.8556	2.2460	1.2883	2.0313	-0.1763	-0.9577	-0.2147	-2.4223	0.7430	-1.4646	-2.2076
SE	1.6078	0.9361	1.8562	1.3967	1.6522	0.9183	1.4656	1.4246	1.2056	1.6094	1.3084	1.7610	1.0379	1.2360	0.2178	1.3572	1.4594	1.6356	0.8846	0.8945	1.2082
P	0.7400	0.0418	0.9526	0.5565	0.9518	0.0272	0.0925	0.7662	0.2710	0.6943	0.0497	0.2263	0.2382	0.1262	0.4341	0.4939	0.8855	0.1644	0.4173	0.1275	0.0926

Raccoon : Female Spring third order habitat selection

λ	0.0171
χ^2	52.9067
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-2.4494	-5.5669	-5.1515	-2.4917	-0.4205	-2.3202	-1.6917	-1.0778	0.0268	3.6910	-0.6495	-1.7405	2.5695	10.7238	1.3038	1.7732	8.2136	0.9829	8.7925	-1.0856	-2.6378
df	8	10	6	9	5	10	9	6	9	5	9	7	11	6	12	7	5	7	6	11	6
Mean	-4.0292	-6.1551	-6.9317	-4.4018	-0.4440	-4.3057	-2.2212	-0.3306	0.0315	6.0547	-1.2215	-0.5268	2.3022	7.5814	1.5564	1.6368	8.0489	1.4409	7.2200	-1.5114	-6.2881
SE	1.6450	1.1057	1.3456	1.7666	1.0557	1.8558	1.3130	0.3068	1.1755	1.6404	1.8807	0.3027	0.8960	0.7070	1.1937	0.9231	0.9799	1.4659	0.8212	1.3922	2.3839
P	0.0400	0.0002	0.0021	0.0343	0.6915	0.0428	0.1250	0.3225	0.9792	0.0141	0.5322	0.1253	0.0261	0.0000	0.2168	0.1195	0.0004	0.3584	0.0001	0.3009	0.0387

Raccoon : Male Spring second order habitat selection

λ	0.2640
χ^2	22.6386
P	0.0009
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.2222	-4.0310	-0.2029	-2.2426	-0.9516	-3.9056	-3.1676	0.0702	-1.9201	-0.4637	-2.9500	3.0226	1.2546	3.0426	1.9050	-2.1731	-0.6647	-2.9628	1.1973	-1.0037	-2.8109
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	-0.3527	-4.3264	-0.2459	-3.1629	-1.1825	-4.0652	-3.9737	0.1068	-2.8102	-0.8298	-3.7125	4.0806	1.1636	3.1439	0.2612	-2.9170	-0.9366	-3.8194	1.9804	-0.9024	-2.8827
SE	1.5875	1.0733	1.2119	1.4104	1.2427	1.0409	1.2545	1.5212	1.4636	1.7895	1.2585	1.3500	0.9275	1.0333	0.1371	1.3423	1.4091	1.2891	1.6541	0.8990	1.0256
P	0.8270	0.0010	0.8418	0.0394	0.3555	0.0013	0.0060	0.9449	0.0729	0.6491	0.0094	0.0081	0.2277	0.0078	0.0749	0.0451	0.5157	0.0092	0.2486	0.3304	0.0126

Raccoon : Male Spring third order habitat selection

λ	0.0313
χ^2	58.8683
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.6334	-9.2679	-1.8220	-1.9123	-0.7614	-5.1058	-3.3718	0.5045	1.3698	0.2956	-2.5013	1.7568	4.7427	4.0236	0.9638	0.9714	2.2103	-1.8294	1.6060	-4.1490	-3.3276
df	6	9	7	8	5	9	11	6	10	3	11	8	14	6	16	8	4	8	4	14	6
Mean	-3.9109	-7.6300	-4.1604	-2.6892	-1.0040	-6.6445	-4.0940	1.1266	2.8547	1.1764	-3.1498	2.7408	6.1324	6.1121	0.6357	1.8556	5.2695	-2.6310	4.0419	-5.4428	-5.8201
SE	2.3943	0.8233	2.2835	1.4062	1.3187	1.3013	1.2142	2.2330	2.0840	3.9799	1.2593	1.5602	1.2930	1.5191	0.6596	1.9102	2.3841	1.4382	2.5168	1.3118	1.7490
P	0.1535	0.0000	0.1112	0.0922	0.4808	0.0006	0.0062	0.6319	0.2007	0.7868	0.0294	0.1170	0.0003	0.0069	0.3495	0.3598	0.0916	0.1047	0.1836	0.0010	0.0159

Appendix 5 : Summer Habitat Selection (individual comparison t-test results)

Bobcat : All Summer second order habitat selection

λ	0.1552
χ^2	29.8118
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	3.2519	4.7079	-2.4521	1.5862	-1.8607	3.3279	1.9098	-4.7778	-1.6446	-3.8330	0.9915	-5.2651	-2.9988	-3.2544	-3.1747	3.3443	-0.1461	5.1586	-2.4247	2.1410	2.7465
df	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Mean	0.6232	1.2313	-0.7708	0.2608	-0.8427	0.9440	0.6081	-1.3940	-0.3624	-1.4659	0.3208	-2.0021	-0.9705	-2.0740	-0.2873	1.0316	-0.0719	1.7148	-1.1035	0.6832	1.7867
SE	0.1916	0.2615	0.3143	0.1644	0.4529	0.2837	0.3184	0.2918	0.2204	0.3824	0.3235	0.3803	0.3236	0.6373	0.0905	0.3085	0.4920	0.3324	0.4551	0.3191	0.6505
P	0.0054	0.0003	0.0269	0.1335	0.0825	0.0046	0.0755	0.0002	0.1208	0.0016	0.3372	0.0001	0.0090	0.0053	0.0063	0.0044	0.8858	0.0001	0.0284	0.0491	0.0150

Bobcat : All Summer third order habitat selection

λ	0.1491
χ^2	24.7415
P	0.0004
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.1310	0.1572	0.8979	0.6715	4.6333	0.3450	0.0724	2.1418	0.7391	5.2405	0.5822	1.1721	0.6981	4.3711	0.4786	-0.2471	4.2683	-1.0381	4.0479	-0.4852	-5.1025
df	12	12	12	12	11	12	12	12	12	11	12	12	12	11	12	12	11	12	11	12	11
Mean	0.0611	0.0832	0.4841	0.3655	4.0110	0.1917	0.0221	0.4230	0.3044	3.9277	0.1306	0.4009	0.2823	3.8132	0.1085	-0.1186	3.4909	-0.2924	3.5229	-0.1738	-3.7181
SE	0.4664	0.5293	0.5392	0.5443	0.8657	0.5558	0.3054	0.1975	0.4118	0.7495	0.2244	0.3421	0.4044	0.8724	0.2268	0.4802	0.8179	0.2817	0.8703	0.3581	0.7287
P	0.8979	0.8777	0.3869	0.5146	0.0007	0.7361	0.9435	0.0534	0.4740	0.0003	0.5712	0.2639	0.4984	0.0011	0.6408	0.8090	0.0013	0.3197	0.0019	0.6362	0.0003

Bobcat : Male Summer second order habitat selection

λ	0.0096
χ^2	46.5111
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	1.6139	6.3418	-1.3153	1.7404	-2.0854	4.8912	3.7543	-2.6702	-0.4550	-3.9909	2.9060	-3.7288	-3.9554	-4.2649	-1.9593	2.7765	-1.4743	3.7286	-3.4451	3.4994	3.9387
df	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Mean	0.4372	1.3762	-0.6802	0.3743	-1.3077	1.1877	0.9389	-1.1174	-0.0629	-1.7449	0.7505	-2.0563	-1.0018	-2.6839	-0.1884	1.0545	-0.6276	1.8679	-1.6821	0.8134	2.4955
SE	0.2709	0.2170	0.5171	0.2151	0.6271	0.2428	0.2501	0.4185	0.1382	0.4372	0.2583	0.5515	0.2533	0.6293	0.0962	0.3798	0.4257	0.5010	0.4883	0.2324	0.6336
P	0.1410	0.0001	0.2209	0.1158	0.0667	0.0009	0.0045	0.0256	0.6599	0.0032	0.0174	0.0047	0.0033	0.0021	0.0817	0.0215	0.1745	0.0047	0.0073	0.0067	0.0034

Bobcat : Male Summer third order habitat selection

λ	0.0208
χ^2	34.8567
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.4293	0.5471	1.0223	0.6462	4.5979	0.6338	0.2340	1.7507	0.3222	5.0394	0.9850	1.0230	0.1286	4.1387	0.3051	-0.5801	3.8431	-0.9633	4.2291	0.0559	-5.2723
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	0.2743	0.3443	0.7478	0.4149	4.5162	0.4415	0.0700	0.4735	0.1406	4.2419	0.1672	0.4035	0.0706	4.1718	0.0971	-0.3329	3.7683	-0.3064	4.1013	0.0266	-4.0747
SE	0.6389	0.6294	0.7315	0.6420	0.9822	0.6966	0.2993	0.2705	0.4365	0.8417	0.1697	0.3944	0.5488	1.0080	0.3183	0.5739	0.9805	0.3180	0.9698	0.4746	0.7729
P	0.6790	0.5992	0.3365	0.5362	0.0018	0.5439	0.8209	0.1181	0.7556	0.0010	0.3535	0.3362	0.9009	0.0033	0.7681	0.5778	0.0049	0.3636	0.0029	0.9568	0.0008

Coyote : All Summer second order habitat selection

λ	0.2911
χ^2	17.2760
P	0.0083
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.9858	4.1483	0.4101	0.2669	-0.8017	3.5830	3.5656	-0.0226	-0.6190	-1.3079	2.9776	-1.3181	-3.5917	-2.4822	-3.0564	-0.3104	-1.0243	0.9672	-1.1656	2.7570	2.0330
df	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Mean	0.2685	1.1203	0.2565	0.0841	-0.5026	0.8413	0.8518	-0.0120	-0.1843	-0.7711	0.5728	-0.8638	-1.0362	-1.6229	-0.2790	-0.1723	-0.7590	0.5849	-0.5867	0.7572	1.3439
SE	0.2723	0.2701	0.6253	0.3152	0.6269	0.2348	0.2389	0.5314	0.2978	0.5895	0.1924	0.6554	0.2885	0.6538	0.0913	0.5551	0.7410	0.6047	0.5034	0.2746	0.6610
P	0.3422	0.0011	0.6884	0.7937	0.4371	0.0033	0.0035	0.9823	0.5466	0.2136	0.0107	0.2102	0.0033	0.0275	0.0092	0.7612	0.3244	0.3511	0.2647	0.0163	0.0630

Coyote : All Summer third order habitat selection

λ	0.4572
χ^2	10.1739
P	0.1175
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.4770	-1.5191	-1.0860	-1.7216	2.2281	-1.5566	-0.4879	0.3262	-0.8938	3.1573	-0.7434	0.5269	-0.7498	3.3472	-0.6391	-1.3134	3.0906	-0.6590	3.4672	0.5598	-3.4640
df	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Mean	-0.9812	-1.0961	-0.7781	-1.4329	2.8326	-1.1787	-0.1149	0.2031	-0.4518	3.8137	-0.1975	0.3180	-0.3369	3.9286	-0.0826	-0.6548	3.6107	-0.4006	4.2655	0.2543	-4.0112
SE	0.6643	0.7215	0.7165	0.8323	1.2713	0.7572	0.2355	0.6226	0.5055	1.2079	0.2657	0.6035	0.4493	1.1737	0.1293	0.4986	1.1683	0.6079	1.2302	0.4542	1.1580
P	0.1654	0.1546	0.2988	0.1108	0.0458	0.1455	0.6344	0.7499	0.3890	0.0083	0.4715	0.6079	0.4678	0.0058	0.5348	0.2136	0.0094	0.5223	0.0047	0.5859	0.0047

Coyote : Female Summer second order habitat selection

λ	0.2446
χ^2	11.2646
P	0.0805
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	1.1379	3.6284	0.1264	0.5690	-0.2635	2.7378	3.1993	-0.4735	-0.4960	-0.6869	2.8230	-1.4673	-2.6145	-1.5681	-2.6982	0.2217	-0.3216	1.1607	-0.6912	1.8725	1.2115
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	0.4399	1.4150	0.1118	0.2597	-0.2711	1.0642	0.9752	-0.3281	-0.1802	-0.7109	0.6243	-1.3033	-1.1554	-1.6861	-0.3508	0.1479	-0.3829	0.9524	-0.5308	0.8045	1.3353
SE	0.3866	0.3900	0.8845	0.4564	1.0287	0.3887	0.3048	0.6929	0.3633	1.0350	0.2212	0.8882	0.4419	1.0752	0.1300	0.6672	1.1905	0.8206	0.7679	0.4296	1.1022
P	0.2926	0.0084	0.9030	0.5872	0.7998	0.0290	0.0151	0.6503	0.6351	0.5143	0.0257	0.1857	0.0347	0.1608	0.0307	0.8309	0.7572	0.2838	0.5117	0.1033	0.2650

Coyote : Female Summer third order habitat selection

λ	0.2672
χ^2	9.2373
P	0.1607
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.9711	-1.2149	-1.4004	-1.7149	1.7912	-1.2605	-0.8334	0.2597	-2.1123	2.3957	-0.8724	0.6192	-0.9322	2.7923	0.1403	-1.0639	2.3237	-0.6436	2.6408	1.1475	-2.7997
df	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mean	-0.8520	-1.1991	-0.5981	-1.5684	2.7686	-1.1787	-0.3470	0.2539	-0.7164	3.6207	-0.3266	0.6009	-0.3693	3.9677	0.0204	-0.9703	3.3668	-0.5805	4.3370	0.3897	-3.9473
SE	0.8774	0.9869	0.4271	0.9146	1.5457	0.9351	0.4164	0.9778	0.3391	1.5113	0.3744	0.9705	0.3962	1.4209	0.1453	0.9120	1.4489	0.9021	1.6423	0.3396	1.4099
P	0.3690	0.2700	0.2109	0.1372	0.1234	0.2543	0.4365	0.8038	0.0791	0.0536	0.4165	0.5586	0.3872	0.0315	0.8930	0.3283	0.0592	0.5437	0.0385	0.2949	0.0312

APPENDIX 5

Raccoon : All Summer second order habitat selection

λ	0.5037
χ^2	16.4599
P	0.0115
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.2660	-3.5579	0.1083	-1.8796	-0.9095	-3.4118	-3.1621	0.4168	-2.6417	-0.6238	-3.1602	3.0094	1.1715	2.8969	1.1871	-2.5367	-1.4500	-3.1491	1.6090	-0.9996	-2.7697
df	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Mean	-0.2295	-2.4569	0.1000	-1.7723	-0.7238	-2.3086	-2.2274	0.3295	-1.5428	-0.4943	-2.0791	2.5569	0.6846	1.7330	0.1483	-1.8723	-0.8238	-2.4086	1.0485	-0.5363	-1.5847
SE	0.8628	0.6905	0.9231	0.9429	0.7959	0.6767	0.7044	0.7905	0.5840	0.7924	0.6579	0.8496	0.5844	0.5982	0.1249	0.7381	0.5682	0.7648	0.6516	0.5365	0.5722
P	0.7926	0.0017	0.9147	0.0729	0.3725	0.0024	0.0044	0.6807	0.0146	0.5389	0.0044	0.0063	0.2534	0.0081	0.2473	0.0184	0.1606	0.0045	0.1213	0.3279	0.0109

Raccoon : All Summer third order habitat selection

λ	0.1042
χ^2	52.0095
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.5088	-7.2475	-0.0481	-0.2890	0.0155	-4.9132	-3.2518	1.7487	0.4872	1.6756	-2.1581	4.6156	4.1949	3.3976	1.6785	-0.3322	0.4118	-3.1495	-0.2404	-3.8826	-3.2121
df	13	15	10	13	6	15	18	11	17	6	18	12	20	7	22	12	7	12	7	20	7
Mean	-2.1945	-4.8474	-0.0537	-0.3319	0.0190	-3.9624	-2.3817	1.7826	0.6042	3.1783	-1.8658	4.1316	3.3932	4.2141	0.7673	-0.4478	0.7258	-3.3069	-0.3987	-2.8020	-3.9701
SE	1.4545	0.6688	1.1160	1.1484	1.2263	0.8065	0.7324	1.0194	1.2403	1.8968	0.8646	0.8951	0.8089	1.2403	0.4572	1.3480	1.7625	1.0500	1.6585	0.7217	1.2360
P	0.1553	0.0000	0.9626	0.7771	0.9881	0.0002	0.0044	0.1082	0.6324	0.1448	0.0447	0.0006	0.0004	0.0115	0.1074	0.7455	0.6928	0.0084	0.8169	0.0009	0.0148

Raccoon : Female Summer second order habitat selection

λ	0.3209
χ^2	11.3674
P	0.0777
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.0347	-1.4564	0.0442	-0.7651	0.1973	-1.6070	-1.2042	0.0242	-3.1205	0.2602	-1.5591	1.0374	0.0509	1.4744	-0.7035	-1.3511	0.2521	-1.3229	1.4612	-0.2397	-1.6689
df	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Mean	0.0478	-1.1377	0.0622	-1.0906	0.2790	-1.2808	-1.1855	0.0144	-1.1384	0.2313	-1.3285	1.1999	0.0471	1.4167	-0.1431	-1.1528	0.2168	-1.3429	1.3696	-0.1901	-1.5598
SE	1.3743	0.7812	1.4054	1.4255	1.4145	0.7970	0.9844	0.5964	0.3648	0.8887	0.8521	1.1566	0.9244	0.9609	0.2034	0.8532	0.8600	1.0152	0.9373	0.7933	0.9346
P	0.9730	0.1793	0.9657	0.4638	0.8480	0.1425	0.2592	0.9812	0.0123	0.8005	0.1534	0.3266	0.9605	0.1745	0.4995	0.2096	0.8066	0.2185	0.1780	0.8159	0.1295

Raccoon : Female Summer third order habitat selection

λ	0.0853
χ^2	24.6171
P	0.0004
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.5966	-4.8181	0.6086	-1.3340	0.9894	-2.7392	-2.1795	1.4570	-0.2447	2.5574	-1.2500	3.9550	1.8484	2.6358	1.2900	-0.9405	0.8502	-2.3351	0.4917	-1.4320	-2.4102
df	7	8	6	7	2	8	8	7	8	3	8	7	8	3	9	7	3	7	3	8	3
Mean	-1.1786	-4.5565	0.7362	-1.8376	1.8501	-3.1512	-2.7684	2.2186	-0.4993	4.1117	-1.9452	4.6042	2.2691	4.2533	1.3034	-1.8212	1.4237	-3.4960	1.0811	-1.4460	-4.3035
SE	1.9754	0.9457	1.2098	1.3774	1.8700	1.1504	1.2702	1.5227	2.0400	1.6078	1.5562	1.1641	1.2276	1.6137	1.0104	1.9365	1.6746	1.4971	2.1990	1.0097	1.7855
P	0.5695	0.0013	0.5651	0.2240	0.4268	0.0255	0.0609	0.1885	0.8128	0.0834	0.2466	0.0055	0.1017	0.0779	0.2292	0.3783	0.4577	0.0522	0.6567	0.1900	0.0950

Raccoon : Male Summer second order habitat selection

λ	0.3843
χ^2	13.3896
P	0.0372
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.3727	-3.4326	0.1002	-1.7598	-1.5743	-3.0814	-3.0924	0.4241	-1.8760	-0.8367	-2.7557	3.0299	1.5035	2.4890	2.5936	-2.1398	-2.1917	-2.9460	0.8917	-1.0559	-2.1398
df	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Mean	-0.4276	-3.3992	0.1270	-2.2592	-1.4402	-3.0428	-2.9716	0.5546	-1.8316	-1.0126	-2.6152	3.5262	1.1399	1.9590	0.3564	-2.3862	-1.5672	-3.1698	0.8191	-0.7835	-1.6026
SE	1.1474	0.9902	1.2678	1.2838	0.9148	0.9875	0.9609	1.3077	0.9764	1.2102	0.9490	1.1638	0.7582	0.7871	0.1374	1.1152	0.7151	1.0759	0.9185	0.7420	0.7489
P	0.7154	0.0045	0.9217	0.1019	0.1394	0.0088	0.0086	0.6784	0.0833	0.4179	0.0164	0.0097	0.1566	0.0271	0.0223	0.0519	0.0472	0.0114	0.3887	0.3102	0.0519

Raccoon : Male Summer third order habitat selection

λ	0.0483
χ^2	39.3949
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.5477	-5.1956	-0.6059	0.9233	-0.9537	-4.5022	-2.3864	1.4186	1.1372	0.4587	-1.8580	2.2775	4.0500	1.9527	1.4174	1.2050	0.0089	-1.9772	-0.7327	-4.1049	-1.8501
df	5	6	3	5	3	6	9	3	8	2	9	4	11	3	12	4	3	4	3	11	3
Mean	-3.4521	-5.1862	-1.3917	1.6206	-1.3619	-4.9074	-2.0543	0.9633	1.6597	1.9704	-1.7985	3.4052	4.2579	4.1749	0.3687	1.6633	0.0299	-3.0163	-1.8743	-3.8453	-3.6377
SE	2.2305	0.9982	2.2971	1.7551	1.4281	1.0900	0.8608	0.6790	1.4594	4.2954	0.9680	1.4952	1.0513	2.1381	0.2601	1.3803	3.3700	1.5256	2.5580	0.9368	1.9663
P	0.1824	0.0020	0.5874	0.3982	0.4106	0.0041	0.0408	0.2510	0.2884	0.6915	0.0961	0.0850	0.0019	0.1459	0.1818	0.2946	0.9935	0.1192	0.5168	0.0017	0.1614

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Appendix 6 : Winter Habitat Selection (individual comparison t-test results)

Bobcat : All Winter second order habitat selection

λ	0.2446
χ^2	18.3054
P	0.0055
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	1.0434	2.4005	-1.0077	-0.0805	-1.5901	1.3538	0.9553	-2.0605	-1.1803	-2.8972	0.3327	-2.4713	-1.9372	-2.1839	-2.4898	1.1276	-0.5730	2.1259	-1.7129	1.2544	1.7678
df	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Mean	0.3641	0.7807	-0.6025	-0.0345	-1.0167	0.5211	0.4166	-0.9666	-0.3986	-1.3808	0.1570	-1.3832	-0.8152	-1.7974	-0.2596	0.5680	-0.4142	1.1236	-0.9822	0.5556	1.5377
SE	0.3489	0.3252	0.5979	0.4289	0.6394	0.3849	0.4361	0.4691	0.3377	0.4766	0.4718	0.5597	0.4208	0.8230	0.1043	0.5037	0.7229	0.5285	0.5734	0.4429	0.8699
P	0.3173	0.0335	0.3335	0.9372	0.1378	0.2008	0.3583	0.0617	0.2608	0.0134	0.7451	0.0294	0.0766	0.0495	0.0284	0.2815	0.5773	0.0550	0.1124	0.2336	0.1025

Bobcat : All Winter third order habitat selection

λ	0.3089
χ^2	15.2700
P	0.0183
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.3177	-1.9656	-0.2602	-1.6034	1.2382	-1.7630	-1.4308	0.1266	-0.9575	2.3572	-1.6483	1.7430	0.5536	2.9968	-0.4828	-1.0624	1.7259	-1.7344	3.0507	-0.6955	-2.9462
df	12	12	12	12	10	12	12	12	12	10	12	12	12	10	12	12	10	12	10	12	10
Mean	-0.3511	-1.3298	-0.2589	-1.1183	1.6022	-1.4250	-0.9788	0.0921	-0.7672	2.4476	-1.0739	1.0709	0.2116	2.8563	-0.0952	-0.8593	1.6963	-1.1661	2.8702	-0.3068	-2.9323
SE	1.1050	0.6766	0.9950	0.6974	1.2939	0.8083	0.6841	0.7277	0.8012	1.0383	0.6515	0.6144	0.3822	0.9531	0.1972	0.8089	0.9828	0.6723	0.9408	0.4411	0.9953
P	0.7561	0.0729	0.7991	0.1348	0.2439	0.1033	0.1780	0.9013	0.3572	0.0401	0.1252	0.1069	0.5900	0.0134	0.6379	0.3090	0.1151	0.1084	0.0122	0.5000	0.0146

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Bobcat : Male Winter second order habitat selection

λ	0.0187
χ^2	27.8725
P	0.0001
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.6400	2.3761	-0.9200	-0.2865	-4.6158	2.3545	3.7601	-0.6427	-0.0949	-5.0129	3.5669	-1.8628	-1.7408	-5.0056	-1.2281	0.3979	-3.7334	1.7527	-3.9701	1.5683	4.7540
df	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mean	-0.1258	0.9631	-0.4538	-0.1719	-2.3240	0.8342	1.0889	-0.3280	-0.0461	-2.1981	0.9600	-1.4169	-1.1350	-3.2870	-0.1289	0.2819	-1.8702	1.2880	-2.1521	1.0061	3.1581
SE	0.1966	0.4053	0.4932	0.6001	0.5035	0.3543	0.2896	0.5103	0.4852	0.4385	0.2691	0.7606	0.6520	0.6567	0.1050	0.7085	0.5009	0.7348	0.5421	0.6415	0.6643
P	0.5458	0.0551	0.3930	0.7842	0.0036	0.0567	0.0094	0.5442	0.9275	0.0024	0.0118	0.1118	0.1324	0.0024	0.2654	0.7045	0.0097	0.1302	0.0074	0.1679	0.0031

Bobcat : Male Winter third order habitat selection

λ	0.2630
χ^2	9.3490
P	0.1549
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.2821	-1.4562	-0.7821	-1.8395	0.0371	-1.2778	0.0256	0.9147	-1.5125	1.2930	-0.4038	1.0730	-2.5341	1.4749	-0.2948	-1.7333	0.9582	-0.9466	1.6852	1.3080	-1.3854
df	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mean	-1.6373	-1.6285	-0.9600	-2.1310	0.0634	-1.7281	0.0089	0.6773	-0.4936	1.7008	-0.0908	0.6685	-0.5025	1.6919	-0.0997	-1.1710	1.0235	-0.7681	2.1944	0.4028	-1.7916
SE	1.2771	1.1183	1.2274	1.1585	1.7101	1.3524	0.3469	0.7405	0.3264	1.3154	0.2248	0.6230	0.1983	1.1471	0.3380	0.6756	1.0681	0.8114	1.3021	0.3080	1.2931
P	0.2471	0.1956	0.4639	0.1155	0.9716	0.2485	0.9804	0.3956	0.1812	0.2436	0.7004	0.3245	0.0444	0.1907	0.7781	0.1337	0.3750	0.3804	0.1429	0.2387	0.2152

Coyote : All Winter second order habitat selection

λ	0.1045
χ^2	24.8434
P	0.0004
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	2.3786	6.3243	0.5035	2.0180	-1.5474	5.9051	3.2837	-0.5870	0.4187	-2.8224	2.5023	-1.6109	-1.5955	-3.3353	-2.0559	0.8061	-2.1274	1.3182	-4.1280	1.1192	3.0178
df	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Mean	0.7295	1.5554	0.4012	0.8459	-1.1860	1.3027	0.8259	-0.3283	0.1164	-1.9154	0.5732	-1.1542	-0.7095	-2.7413	-0.2527	0.4447	-1.5872	0.9015	-2.0318	0.4568	2.4886
SE	0.3067	0.2459	0.7967	0.4192	0.7664	0.2206	0.2515	0.5592	0.2780	0.6787	0.2291	0.7165	0.4447	0.8219	0.1229	0.5517	0.7461	0.6839	0.4922	0.4082	0.8246
P	0.0387	0.0001	0.6255	0.0712	0.1528	0.0002	0.0082	0.5702	0.6843	0.0181	0.0313	0.1383	0.1417	0.0075	0.0669	0.4390	0.0593	0.2168	0.0021	0.2892	0.0129

Coyote : All Winter third order habitat selection

λ	0.4402
χ^2	9.0258
P	0.1721
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.8333	-1.3390	0.1242	-0.7944	1.5597	-0.5523	-0.7776	0.7001	-0.4291	2.0975	0.3766	0.8806	-0.0687	2.2554	0.8489	-1.1793	2.2497	-0.5783	2.9975	0.6009	-2.0671
df	10	10	10	10	9	10	10	10	10	9	10	10	10	9	10	10	9	10	9	10	9
Mean	-0.4729	-0.6646	0.1239	-0.7064	2.1257	-0.2785	-0.1917	0.5968	-0.2335	2.6554	0.1944	0.7885	-0.0418	2.8623	0.3861	-0.8303	2.0124	-0.4024	3.0638	0.4279	-2.4577
SE	0.5675	0.4964	0.9977	0.8893	1.3629	0.5043	0.2466	0.8524	0.5442	1.2660	0.5163	0.8954	0.6084	1.2691	0.4548	0.7041	0.8945	0.6958	1.0221	0.7122	1.1890
P	0.4241	0.2102	0.9036	0.4454	0.1533	0.5929	0.4548	0.4998	0.6769	0.0654	0.7144	0.3992	0.9466	0.0506	0.4158	0.2656	0.0510	0.5759	0.0150	0.5613	0.0687

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Raccoon : All Winter second order habitat selection

λ	0.4370
χ^2	19.8667
P	0.0029
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.6309	-3.3471	-2.1910	-1.9814	-0.7223	-3.5955	-2.4899	-1.4896	-1.5553	-0.2344	-2.4401	0.6565	1.2320	2.1474	-0.0752	0.2958	1.0375	-0.7295	1.2204	-1.3538	-2.2725
df	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Mean	-0.6712	-2.8573	-2.2239	-1.9926	-0.9605	-2.8725	-2.1862	-1.5527	-1.3215	-0.2894	-2.2013	0.6335	0.8647	1.8968	-0.0152	0.2312	1.2633	-0.6486	1.0321	-0.8799	-1.9120
SE	1.0638	0.8537	1.0150	1.0057	1.3299	0.7989	0.8780	1.0424	0.8497	1.2347	0.9022	0.9650	0.7018	0.8833	0.2016	0.7817	1.2177	0.8891	0.8457	0.6499	0.8414
P	0.5343	0.0028	0.0388	0.0596	0.4774	0.0015	0.0204	0.1499	0.1335	0.8168	0.0228	0.5180	0.2304	0.0425	0.9407	0.7701	0.3103	0.4730	0.2347	0.1890	0.0327

Raccoon : All Winter third order habitat selection

λ	0.2017
χ^2	32.0236
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.6496	-3.6268	-1.5649	-0.6503	-0.3104	-3.6409	-1.8247	-0.1138	0.9376	1.0740	-1.2600	2.1601	4.1514	2.1892	1.7114	0.7385	0.4585	-1.9256	0.0235	-3.5480	-1.9573
df	11	13	12	12	6	13	15	13	14	8	15	15	17	10	19	15	8	15	10	17	10
Mean	-3.3901	-5.4676	-2.4661	-1.3018	-0.8246	-5.2797	-3.2948	-0.2516	1.7444	2.0668	-2.5567	2.9855	5.1928	4.6048	1.6965	1.6752	1.4375	-2.8627	0.0486	-4.5018	-4.0907
SE	2.0551	1.5076	1.5759	2.0019	2.6564	1.4501	1.8056	2.2103	1.8604	1.9243	2.0292	1.3821	1.2509	2.1034	0.9913	2.2683	3.1355	1.4866	2.0664	1.2688	2.0900
P	0.1273	0.0031	0.1436	0.5278	0.7667	0.0030	0.0880	0.9111	0.3643	0.3141	0.2269	0.0474	0.0007	0.0534	0.1033	0.4716	0.6588	0.0733	0.9817	0.0025	0.0788

Raccoon : Female Winter second order habitat selection

λ	0.2662
χ^2	11.9121
P	0.0640
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	1.2091	-0.8986	-0.5380	0.9104	1.3583	-1.4690	-1.3929	-1.1999	-0.2199	0.4650	-1.4473	-0.2333	1.0969	1.7892	-0.7741	1.8157	2.1037	0.0958	0.7563	-1.3978	-1.9495
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	1.5310	-0.3782	-0.6877	1.1546	2.3741	-0.5820	-1.9092	-2.2187	-0.3764	0.8431	-2.1130	-0.3095	1.5328	2.7523	-0.2038	1.8423	3.0618	0.1057	1.2195	-1.7366	-2.9561
SE	1.2663	0.4209	1.2782	1.2683	1.7478	0.3962	1.3707	1.8491	1.7117	1.8131	1.4600	1.3268	1.3974	1.5383	0.2633	1.0147	1.4554	1.1025	1.6125	1.2424	1.5164
P	0.2612	0.3951	0.6052	0.3892	0.2114	0.1800	0.2011	0.2645	0.8315	0.6543	0.1858	0.8214	0.3046	0.1114	0.4611	0.1070	0.0685	0.9260	0.4712	0.1997	0.0871

Raccoon : Female Winter third order habitat selection

λ	0.0422
χ^2	25.3176
P	0.0003
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.9935	-3.2778	-2.0993	-0.2606	-0.4322	-2.7599	-2.0671	-1.5806	0.0872	0.8156	-1.1455	0.7167	2.3501	5.9601	0.6549	1.0741	1.1718	-1.0326	0.8583	-2.2683	-4.4894
df	6	7	6	6	3	7	6	5	5	3	6	6	6	3	7	6	3	6	3	6	3
Mean	-3.1501	-6.1554	-4.5786	-0.8952	-0.7782	-5.3246	-4.1606	-3.1868	0.2831	3.2436	-3.1736	1.2928	4.9762	7.7278	0.8308	3.6834	5.0806	-1.6072	2.4506	-5.2906	-7.8604
SE	3.1707	1.8779	2.1810	3.4349	1.8007	1.9293	2.0128	2.0162	3.2486	3.9768	2.7705	1.8037	2.1175	1.2966	1.2686	3.4292	4.3357	1.5564	2.8553	2.3324	1.7509
P	0.3588	0.0135	0.0806	0.8031	0.6948	0.0281	0.0842	0.1748	0.9339	0.4745	0.2956	0.5005	0.0571	0.0094	0.5335	0.3241	0.3259	0.3416	0.4538	0.0638	0.0206

Raccoon : Male Winter second order habitat selection

λ	0.3220
χ^2	16.9983
P	0.0093
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.1497	-3.4598	-1.9151	-3.1670	-1.5199	-3.6203	-1.8413	-0.9422	-1.6600	-0.5848	-1.7496	0.8482	0.6019	1.1187	0.3497	-0.6271	0.1077	-0.8048	0.7556	-0.5126	-1.1034
df	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Mean	-1.9925	-4.3448	-3.1456	-3.8810	-2.9613	-4.2468	-2.3524	-1.1531	-1.8885	-0.9688	-2.2543	1.1993	0.4638	1.3835	0.0980	-0.7354	0.1843	-1.1012	0.9197	-0.3658	-1.2855
SE	1.7330	1.2558	1.6425	1.2255	1.9484	1.1730	1.2775	1.2238	1.1376	1.6567	1.2885	1.4139	0.7706	1.2367	0.2803	1.1727	1.7102	1.3684	1.2172	0.7137	1.1651
P	0.2695	0.0038	0.0761	0.0069	0.1508	0.0028	0.0869	0.3621	0.1191	0.5680	0.1021	0.4106	0.5569	0.2821	0.7318	0.5407	0.9157	0.4344	0.4624	0.6162	0.2885

Raccoon : Male Winter third order habitat selection

λ	0.1289
χ^2	24.5827
P	0.0004
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.4524	-1.7290	0.0251	-0.8794	-0.1342	-2.1655	-0.9115	0.5606	1.1716	0.6132	-0.6889	2.1492	3.2833	0.8842	1.5703	0.0438	-0.3436	-1.6077	-0.4855	-2.6169	-0.6392
df	4	5	5	5	2	5	8	7	8	4	8	8	10	6	11	8	4	8	6	10	6
Mean	-3.7335	-4.5464	0.0499	-1.7862	-0.8894	-5.2194	-2.6323	1.9487	2.7223	1.1076	-2.0847	4.2831	5.3304	2.7552	2.2527	0.1357	-1.5097	-3.8251	-1.3740	-4.0008	-1.8580
SE	2.5706	2.6295	1.9828	2.0310	6.6260	2.4102	2.8877	3.4761	2.3235	1.8062	3.0263	1.9929	1.6235	3.1161	1.4346	3.0982	4.3941	2.3792	2.8303	1.5288	2.9070
P	0.2200	0.1444	0.9809	0.4194	0.9055	0.0826	0.3887	0.5926	0.2751	0.5729	0.5104	0.0639	0.0082	0.4106	0.1446	0.9661	0.7485	0.1466	0.6446	0.0257	0.5463

Appendix 7 : Spring habitat selection relative to study sites

Bobcat : All Spring habitat selection relative to study sites

λ	0.4440
χ^2	16.2374
P	0.0125
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.6807	0.4020	-0.2887	1.4850	1.3345	-0.3347	-0.3920	-1.2208	0.3886	0.6447	-1.1509	-0.7267	0.7233	1.4552	-3.5327	1.1176	1.8267	0.0369	0.3428	-1.3859	-2.3930
df	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Mean	0.6811	0.3471	-0.3469	0.9801	1.3450	-0.3145	-0.3341	-1.0280	0.2990	0.6639	-0.9957	-0.6940	0.6330	0.9979	-0.6616	1.3270	1.6919	0.0323	0.3649	-1.2946	-1.6596
SE	1.0007	0.8634	1.2013	0.6600	1.0079	0.9398	0.8521	0.8421	0.7693	1.0298	0.8651	0.9550	0.8751	0.6858	0.1873	1.1874	0.9262	0.8749	1.0646	0.9342	0.6935
P	0.5043	0.6922	0.7759	0.1540	0.1978	0.7415	0.6994	0.2371	0.7019	0.5269	0.2640	0.4763	0.4783	0.1619	0.0022	0.2777	0.0835	0.9709	0.7355	0.1818	0.0272

Bobcat : Female Spring habitat selection relative to study sites

λ	0.1191
χ^2	17.0207
P	0.0092
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.0641	-0.8675	-0.2840	5.9036	0.4724	-1.2185	-0.7923	-0.4539	0.5112	0.5922	-1.2326	0.3664	1.3556	2.4056	-3.2935	0.6105	0.9085	-0.8098	-0.0733	-1.6473	-2.9828
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	-0.1221	-1.4411	-0.7381	0.8641	0.7450	-2.2520	-1.3190	-0.6160	0.9862	0.8671	-2.1299	0.7030	2.3052	2.1861	-0.8109	1.6022	1.4831	-1.5139	-0.1191	-3.1161	-2.9970
SE	1.9044	1.6611	2.5988	0.1464	1.5771	1.8482	1.6647	1.3571	1.9293	1.4641	1.7280	1.9188	1.7005	0.9088	0.2462	2.6246	1.6325	1.8696	1.6256	1.8917	1.0047
P	0.9507	0.4144	0.7846	0.0006	0.6510	0.2625	0.4542	0.6636	0.6249	0.5723	0.2575	0.7249	0.2173	0.0471	0.0132	0.5608	0.3938	0.4447	0.9436	0.1435	0.0204

Bobcat : Male Spring habitat selection relative to study sites

λ	0.5806
χ^2	6.5235
P	0.3672
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.8799	1.7578	-0.1668	0.8991	1.1136	1.0233	0.3805	-1.1762	-0.2073	0.3435	-0.2239	-1.5774	-0.5497	0.1408	-2.0794	1.0397	1.5776	1.3190	0.3997	-0.1453	-0.7698
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	1.1115	1.4735	-0.2322	1.0239	1.6100	0.9077	0.3619	-1.3437	-0.0876	0.4984	-0.2038	-1.7056	-0.4495	0.1365	-0.5657	1.2561	1.8421	1.1399	0.5860	-0.1162	-0.7022
SE	1.2633	0.8382	1.3916	1.1388	1.4457	0.8870	0.9513	1.1424	0.4227	1.4512	0.9101	1.0813	0.8178	0.9694	0.2721	1.2082	1.1677	0.8642	1.4661	0.7996	0.9122
P	0.3977	0.1065	0.8705	0.3879	0.2892	0.3281	0.7108	0.2643	0.8396	0.7377	0.8269	0.1430	0.5935	0.8906	0.0618	0.3208	0.1430	0.2140	0.6970	0.8871	0.4576

Coyote : All Spring habitat selection relative to study sites

λ	0.5800
χ^2	9.2602
P	0.1595
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.9779	-1.4893	-0.5376	-1.8254	0.1859	-1.1064	-0.3642	0.5469	-1.5001	1.5593	-0.1439	0.6722	-1.0589	2.5345	0.2871	-1.3644	0.7908	-0.4538	2.9998	0.8247	-1.8650
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	-1.1978	-1.4954	-0.7380	-2.1290	0.1510	-1.3524	-0.2976	0.4598	-0.9312	1.3488	-0.1546	0.7573	-0.6337	1.6464	0.1429	-1.3910	0.8890	-0.6144	2.2800	0.7766	-1.5034
SE	1.2249	1.0041	1.3728	1.1663	0.8121	1.2224	0.8170	0.8407	0.6208	0.8650	1.0742	1.1267	0.5984	0.6496	0.4978	1.0195	1.1242	1.3540	0.7601	0.9416	0.8061
P	0.3427	0.1558	0.5982	0.0867	0.8548	0.2849	0.7205	0.5920	0.1531	0.1385	0.8873	0.5111	0.3054	0.0221	0.7777	0.1913	0.4406	0.6561	0.0085	0.4216	0.0806

APPENDIX 7

Coyote : Female Spring habitat selection relative to study sites

λ	0.0696
χ^2	23.9833
P	0.0005
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.7290	-1.2676	-0.9485	-2.3382	-0.8644	-0.6065	1.7189	0.4461	-1.2612	1.8883	1.3368	-0.1376	-4.3200	1.2790	0.8050	-0.7817	0.7414	0.4801	2.6301	1.8016	-0.3898
df	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mean	-2.7271	-1.9142	-2.1352	-3.3704	-0.7390	-1.1889	0.8129	0.5920	-0.6433	1.9881	1.5382	-0.2210	-1.4562	1.1752	0.7253	-1.2352	1.3961	0.9462	2.6314	2.1815	-0.4499
SE	1.5773	1.5100	2.2512	1.4415	0.8550	1.9605	0.4729	1.3271	0.5101	1.0529	1.1506	1.6063	0.3371	0.9188	0.9010	1.5802	1.8832	1.9710	1.0005	1.2108	1.1541
P	0.1221	0.2406	0.3707	0.0476	0.4126	0.5610	0.1239	0.6674	0.2428	0.0957	0.2180	0.8940	0.0025	0.2368	0.4441	0.4569	0.4797	0.6440	0.0302	0.1093	0.7068

Coyote : Male Spring habitat selection relative to study sites

λ	0.0505
χ^2	23.8937
P	0.0005
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	0.3098	-0.7382	0.7234	-0.3961	0.8163	-1.0086	-1.0079	0.2894	-1.1522	0.4249	-1.2381	1.2690	0.2499	2.3375	-2.4509	-1.3721	0.2653	-1.4358	1.5659	-0.6086	-2.6216
df	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mean	0.5227	-1.0242	0.8337	-0.7325	1.1523	-1.5364	-1.5469	0.3111	-1.2551	0.6296	-2.0590	1.8579	0.2917	2.1765	-0.5122	-1.5662	0.3185	-2.3701	1.8847	-0.8039	-2.6887
SE	1.6871	1.3875	1.1525	1.8490	1.4116	1.5233	1.5347	1.0749	1.0893	1.4819	1.6631	1.4641	1.1675	0.9311	0.2090	1.1415	1.2008	1.6507	1.2036	1.3208	1.0256
P	0.7657	0.4844	0.4929	0.7038	0.4412	0.3468	0.3471	0.7807	0.2871	0.6837	0.2556	0.2450	0.8098	0.0520	0.0440	0.2124	0.7985	0.1942	0.1613	0.5620	0.0343

APPENDIX 7

Raccoon : All Spring habitat selection relative to study sites

λ	0.0680
χ^2	80.6620
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.6113	-12.8879	-3.4431	-2.1480	-4.5852	-6.9657	-5.1252	-2.2678	-0.5369	-1.0470	-3.8021	3.0117	4.8057	12.9119	1.6736	1.7003	0.9211	-1.9868	-0.5232	-3.5572	-4.4119
df	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Mean	-1.5397	-6.1254	-3.3965	-2.0811	-2.5437	-5.1967	-4.5857	-1.8567	-0.5414	-1.0040	-3.6570	2.7290	4.0443	3.5817	0.9287	1.3153	0.8528	-1.8002	-0.4625	-3.1156	-2.6530
SE	0.9556	0.4753	0.9864	0.9689	0.5548	0.7460	0.8947	0.8188	1.0085	0.9589	0.9618	0.9061	0.8416	0.2774	0.5549	0.7736	0.9258	0.9061	0.8840	0.8758	0.6013
P	0.1180	0.0000	0.0018	0.0402	0.0001	0.0000	0.0000	0.0310	0.5955	0.3038	0.0007	0.0053	0.0000	0.0000	0.1050	0.0998	0.3646	0.0565	0.6048	0.0013	0.0001

Raccoon : Female Spring habitat selection relative to study sites

λ	0.0034
χ^2	73.8846
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.2866	-5.6604	-2.6401	-1.5829	-1.8124	-2.9457	-2.2733	-3.1601	-0.6221	0.2389	-1.4482	0.7627	2.0123	23.5227	0.9632	1.3277	1.9774	-0.0481	0.8956	-1.0863	-2.6582
df	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Mean	-2.1247	-5.4897	-4.3992	-2.9146	-1.7905	-4.4719	-3.3650	-2.2745	-0.7900	0.3342	-2.3472	1.0904	2.5750	3.6992	1.0178	1.4846	2.6088	-0.0726	1.1242	-1.5572	-2.6814
SE	1.6514	0.9698	1.6663	1.8414	0.9879	1.5181	1.4802	0.7198	1.2699	1.3989	1.6208	1.4296	1.2796	0.1573	1.0567	1.1182	1.3193	1.5111	1.2553	1.4335	1.0087
P	0.2225	0.0001	0.0216	0.1394	0.0950	0.0122	0.0422	0.0082	0.5455	0.8152	0.1732	0.4604	0.0672	0.0000	0.3545	0.2090	0.0714	0.9625	0.3881	0.2987	0.0209

Raccoon : Male Spring habitat selection relative to study sites

λ	0.0372
χ^2	55.9617
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-0.8753	-13.1785	-2.0442	-1.4460	-4.1118	-7.7375	-5.0327	-1.1444	-0.2229	-1.5799	-4.0632	3.6009	4.7239	7.3698	1.4641	1.0124	-0.4023	-3.0801	-1.3502	-4.0263	-3.5851
df	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mean	-1.0924	-6.6116	-2.6296	-1.4437	-3.1197	-5.7509	-5.5192	-1.5373	-0.3513	-2.0273	-4.6586	3.9819	5.1679	3.4919	0.8606	1.1859	-0.4900	-3.1213	-1.6759	-4.3072	-2.6313
SE	1.2480	0.5017	1.2864	0.9984	0.7587	0.7433	1.0967	1.3433	1.5762	1.2832	1.1465	1.1058	1.0940	0.4738	0.5878	1.1714	1.2181	1.0134	1.2412	1.0698	0.7339
P	0.3943	0.0000	0.0578	0.1675	0.0008	0.0000	0.0001	0.2693	0.8264	0.1337	0.0009	0.0024	0.0002	0.0000	0.1625	0.3264	0.6928	0.0072	0.1957	0.0010	0.0025

Turkey : Nest habitat selection relative to study sites

λ	0.0000
χ^2	417.9907
P	0.0000
df	6

Univariate tests (t-tests)

Numerator	A	A	A	A	A	A	B	B	B	B	B	C	C	C	C	D	D	D	E	E	F
Denominator	B	C	D	E	F	G	C	D	E	F	G	D	E	F	G	E	F	G	F	G	G
t-statistic	-1.8657	-1.7669	3.3584	4.1667	1.1208	-1.7413	-0.5926	52.9724	47.5266	31.9031	-0.6433	48.8794	133.5280	31.7967	-0.7349	5.0628	-156.8470	-48.2509	-22.6720	-97.1377	-31.0644
df	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mean	-2.3828	-2.4708	4.6995	5.7312	1.5643	-2.4971	-0.0881	7.0823	8.1140	3.9471	-0.1144	7.1704	8.2020	4.0352	-0.0263	1.0317	-3.1352	-7.1967	-4.1669	-8.2284	-4.0615
SE	1.2772	1.3984	1.3993	1.3755	1.3957	1.4341	0.1486	0.1337	0.1707	0.1237	0.1778	0.1467	0.0614	0.1269	0.0358	0.2038	0.0200	0.1492	0.1838	0.0847	0.1307
P	0.0890	0.1049	0.0064	0.0016	0.2862	0.1095	0.5654	0.0000	0.0000	0.0000	0.5332	0.0000	0.0000	0.0000	0.4778	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX 8


2011-05-18 4:30:00 PM T
28°C
RM45 RAPIDFIRE
RECONYX


2011-05-18 4:35:28 PM M 1/2
28°C
RM45 RAPIDFIRE
RECONYX

APPENDIX 8


2011-05-18 4:37:45 PM M 2/2
28°C
RECONYX
RM45 RAPIDFIRE


2011-05-18 5:01:36 PM M 1/2
28°C
RECONYX
RM45 RAPIDFIRE

APPENDIX 8