INFLUENCES OF FOREST COVER TYPE AND STRUCTURE ON SEASONAL AND DAILY HABITAT USE OF WILD TURKEYS IN SOUTHERN GEORGIA

by

STEVEN MICHAEL JUHAN JR.

(Under the direction of John P. Carroll)

ABSTRACT

Information regarding wild turkey (*Meleagris gallopavo*) habitat use on northern bobwhite (*Colinus virginianus*) plantations in the Southeast is limited. These plantations are largely comprised of low-basal area upland pine forests that are frequently burned or otherwise manipulated as required for northern bobwhite management. This management creates unique forest structure and often relegates mast-producing hardwood species to narrow drainage areas such as creek bottoms and swamp margins. Using radio telemetry on three southern Georgia bobwhite plantations, I investigated seasonal and daily habitat use in relation to forest cover type and structure. I found that hen turkeys preferred hardwood drain cover types in nearly all seasons while gobblers preferred stands of low-density upland pine. Hens were located in areas of higher stem densities and higher basal areas than were gobblers. Stem densities and basal areas were highest at locations of nonnesting hens. If bobwhite and wild turkey management are to occur conjointly, forest cover type and structural diversity must be an important consideration.

INDEX WORDS: Wild turkey, *Meleagris gallopavo*, Northern bobwhite, *Colinus virginianus*, quail plantation, forest structure, habitat use, nest video camera

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DEDICATION

I dedicate this thesis to my two best friends, my fiancée and my father. Nicole, thanks for enduring the two long years apart and for being patient with me during the stress-filled months of analysis and writing. Dad, thanks for instilling in me the love and respect of the outdoors and this great game bird.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

The wild turkey (*Meleagris gallopavo*) is a species of great interest to many wildlife managers and private landowners because of its popularity as a game species and its widespread distribution. Although the wild turkey is one of the most studied wildlife species, it is important that wildlife managers and researchers continue to fill the knowledge gaps that exist within the ecology of this bird.

The wild turkey was once nearly extirpated from North America by the pressures of extensive habitat loss and relentless market hunting (Dickson 1992). Wild turkey populations throughout the United States reached their lowest numbers during the early part of the twentieth century (Mosby 1975). Fortunately, dedication and ingenuity prevailed, and wild turkey restoration programs have been producing successful results since the early 1950's. These restoration programs coupled with improved harvest regulations have seen wild turkey populations grow to pre-colonial levels and even expand beyond the historical range (Kennamer and Kennamer 1990). Because it is now prevalent in 49 of the 50 US states, and in parts of Canada and Mexico, the wild turkey utilizes a wide range of habitat types. The adaptability of the wild turkey to a wide range of ecological conditions was noted many years ago by influential researchers, such as Henry Mosby, Herbert Stoddard, Wayne Bailey, and others (Mosby and Handley 1943, Stoddard 1963, Bailey and Rinell 1967).

Adequate research has been conducted on many aspects of wild turkey (*Meleagris gallopavo*) habitat use and in most ecological regions. Much of this research has concentrated on habitat use of areas classified by general vegetative cover types, such as short-rotation industrial pine forests (Kennamer et al. 1980, Hurst et al. 1991), agricultural areas (Paisley et al. 1995, Vander Haegen et al. 1989), bottomland hardwood forests or streamside management zones (Palmer and Hurst 1995), mixed pine-hardwood forests (Godwin et al. 1992), or a combination of these (Holbrook et al. 1987). Researchers agree that turkeys need access to a wide diversity of habitat types reflecting the fact that different habitats are required at different times of the year and for different behaviors (Wigley et al. 1985, Dickson 1992, Godwin et al. 1992).

In the southeastern U.S., habitat use in the fall and winter for both sexes of wild turkey usually involves movement out of pine forests and openings to hardwood forests and creek bottoms where hard mast forage is present (Everett et al. 1985). Conversely, areas used more in the spring and summer by both gobblers and hens include fields, clearings, and pine forests, with less use of hardwood stands (Speak et al. 1975). Hurst et al. (1991) believed that gobbler habitat use in the spring was driven by the pursuit of hens for breeding. Thus, spring gobbler habitat use is likely to be similar to that of the hens.

Studies have found that the most successful turkey nests were those located in stands with relatively open overstory canopies, herbaceous or shrubby understories, greater visual obstruction at ground level, and in close proximity to feeding areas, travel corridors, and a water source (Lazarus and Porter 1980, Badyaev 1995, and Chamberlin and Leopold 1998).

Brood-rearing habitat that produces the highest poult survival is characterized by an abundance of clearings or openings that generate greater amounts of herbaceous vegetation and invertebrates for food (Dickson 1992). Godfrey and Norman (1999) found a positive correlation between the amount of dense, herbaceous understory and poult survival. In forested areas broods used stands that had lower stocking, less midstory density, and abundant herbaceous ground story (Campo et al. 1989).

The preferred roost sites for hens are mature trees in pure pine or mixed pine-hardwood stands (Chamberlin et al. 2000). It is thought that turkeys choose roost sites that are over or within a short distance to water and in close proximity to feeding grounds (Dickson 1992).

Despite all the research on wild turkey habitat use, few studies have involved detailed analysis of forest structure as a component of hen and gobbler habitat use. Rather, most studies have concentrated on more general, coarse habitat classifications such as major forest cover types. Research that has concentrated on microhabitat analyses has been confined to either nesting or brood-rearing behaviors. Although important, these behaviors represent only a portion of a turkey's life cycle, and it is important that other aspects of habitat use be evaluated to a similar degree. It is possible that turkeys choose habitats based on specific details of vegetative structure, in addition to many of the general habitat classifications previously studied. It may be important to evaluate forest structure at a smaller scale or in greater detail, since vegetative composition of smaller patches within macro-habitat categories can be highly variable. Furthermore, details of forest structure such as timber density and basal area may be more important to wildlife managers than general habitat classifications for proper management of wild turkey habitat.

While previous wild turkey research has been conducted on landscapes managed for northern bobwhite (*Colinus virginianus*), it did not specifically address the effects of that management on wild turkey behaviors, movements, or habitat use patterns. Northern bobwhite plantations are often dominated by forested uplands of mature pines (*Pinus spp.*) at low basal areas with little to no midstory present. Hardwood encroachment is often controlled by the use of frequent prescribed fire at a 1-2-year frequency (Stoddard, 1931), as well as by chemical and mechanical means. Although a few mature hardwood stems may remain in the upland, hardwood stands are usually relegated to lowland areas or narrow "finger" drainages.

This type of bobwhite management differs from traditional wild turkey habitat management in several ways. Common wild turkey management practices suggest using prescribed fire at a longer frequency of 3-5 years (Stoddard 1963), and placing a greater importance on maintaining larger, open hardwood bottomland areas (Bidwell et al. 1989). In the uplands, mature forests are managed for a higher timber density, usually with a semi-open to nearly closed canopy of mixed pine-hardwood species and a reduced understory. Well-dispersed openings that produce grasses, forbs, and insects are recommended for adults, as well as for the young (Speak 1975).

Despite these differences, northern bobwhite and turkey management are generally similar for both nesting and brood-rearing habitats. For turkeys, nesting habitat is managed to include a nearly open overstory with a thick, brushy understory of both woody and herbaceous species providing visual obscurity near ground level (Lazarus and Porter 1980). Groundstory conditions suitable for nesting habitat can be improved using prescribed burning in a short, 3-year rotation, and avoiding burn rotations of 6 years or longer (Palmer et al. 1996). For northern bobwhite, good nesting habitat is found in fallow fields, field borders, openings, lightly stocked forests, and grasslands. These areas should provide a dense mixture of grasses and herbaceous weeds growing in clumped arrangements to allow ground travel (Yarrow and Yarrow 1999). Brood-rearing habitat for both birds should be developed to include open areas with a mostly herbaceous ground layer with minimal amounts of young, woody growth. These areas contain high amounts of legumes and forbs that attract greater quantities of invertebrates which are important for poult/chick growth and development (Dickson 1992, Yarrow and Yarrow 1999). Northern bobwhites may require more bare ground than turkeys for chick motility and turkeys may need slightly more vertical structure than bobwhite chicks for visual obscurity of poults.

Although wild turkeys persist on northern bobwhite-managed landscapes, little is known about how the unique forest structure aspect of this management affects turkey habitat use and movement. The objective of this research was to investigate how the forest characteristics, common to northern bobwhite management influence the daily and seasonal habitat use patterns of eastern wild turkeys (*M. g. silvestris)*. I evaluated habitat use by hens and gobblers at different times of the year to examine shifts in use as a response to cover type and its associated seasonal fluctuation in resource availability. In addition, I examined how forest structure and related ground cover conditions influenced daily habitat use and movement rates of turkeys, and how those differed among seasons.

As an additional objective, this research also evaluated the use of miniature infrared-illuminated video monitoring systems to record wild turkey nest predators and nesting behaviors. This technique has been shown to be useful in northern bobwhite research (Staller 2001), but has yet to be published as a technique used in wild turkey research. Video footage was reviewed to gain more knowledge about wild turkey nest predator species, hen reaction to nest predators, and nest predator evidence at predated or abandoned nest sites. In addition, many other interesting aspects of nesting ecology can be gleaned from nest video footage, such as timing and frequency of hen recess and other on-nest behaviors.

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CHAPTER 2

SEASONAL HOME RANGE AND HABITAT USE OF WILD TURKEYS IN SOUTHERN GEORGIA

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CHAPTER 2

SEASONAL HOME RANGE AND HABITAT USE OF WILD TURKEYS IN SOUTHERN GEORGIA

INTRODUCTION

Numerous home range and habitat use studies have been conducted for the wild turkey (*Meleagris gallopavo*) in almost every part of its range. These works have discussed varied results reflecting the fact that turkeys use habitats differently based on specific landscape components present in particular geographic regions. While a large portion of these studies have involved the eastern subspecies (*M. g. silvestris*) in the Southeast, few have dealt with eastern turkeys residing in low-basal area, fire-maintained upland pine forests of the coastal plain.

Contrary to earlier schools of thought, turkeys have been found to tolerate many different habitat types and land use patterns (Dickson et al. 1978, Porter 1992). However, areas that encompass a high diversity of habitats have often been touted as those where turkeys thrive (Speak et al. 1975, Pack et al 1988, Godwin et al 1992). These areas provide different habitat types in close proximity to one another and allow turkeys to fulfill their life history requirements without the burden of traveling long distances (Williams and Austin 1988). Countless studies have documented the importance of thinning and burning of forested areas to increase production of more desirable food sources, as well as ground-level cover (Stoddard 1963, Zwank et al. 1988, Smith et al. 1990). Therefore, it would stand to reason that wild turkeys should flourish in an area where habitat diversity is high, burning is frequent, and forest canopies are maintained in a low-density state. To test this theory, I used radio telemetry to evaluate the home range and habitat use patterns of turkeys inhabiting these types of forests, which are managed to benefit northern bobwhite (*Colinus virginianus*) (hereafter, bobwhite) hunting.

METHODS

Study Area

This study was conducted on 3 contiguous plantation properties located in Grady and Thomas counties, Georgia: Pebble Hill Plantation, Springwood Plantation, and Willow Oak Plantation, totaling approximately 2,770 ha. This area is situated in the Red Hills region of the Gulf Coastal Plain in southern Georgia (Figure 2.1). All three properties are managed at differing intensities for bobwhite hunting. Pebble Hill manages for bobwhite most intensively and encompasses 1,146 ha or 41% of the main research area. It consists of mostly low-density, mature longleaf, shortleaf , and loblolly pine (*Pinus palustris, Pinus echinata, Pinus taeda*, respectively) stands with an interspersion of young planted pine stands, bottomland hardwood drains, cypress (*Taxodium spp.*) swamps, and a few fallow fields. Springwood's management is of intermediate intensity and contains areas of low-density, mature pine stands, but has a higher percentage of planted pines and hardwood stands than Pebble Hill. In addition to swamps and fallow fields, Springwood also maintains several large pastures used for horse grazing. Springwood comprises approximately 1,057 ha or 38% of the main study area. Willow Oak's bobwhite management is of low to intermediate intensity and is a 566-ha area (20% of main study area) that contains planted pine stands, bottomland hardwoods, and mixed pine-hardwood stands. A large portion of Willow Oak is maintained in pastures, cultivated grassland and hayfields, fallow fields, and small, seasonal wildlife food plots. Numerous forest roads, trails, and logging roads traverse each of these properties providing ready access for research in these areas.

Although the majority of the research was conducted on these 3 plantations, transmitter equipped turkeys were occasionally located on 4 other adjacent plantations throughout the study. Since these additional properties also managed intensively for bobwhite, I included those locations in the data set as well. The entire area defined as the study site totaled nearly 6,100 ha (Table 2.1).

Capture and Radio Telemetry

I captured wild turkeys during January, February, and December 2003; January, November and December 2004; and January and February 2005 using 3- and 4-projectile rocket nets (Bailey et al. 1980). The rocket net sites were baited with cracked corn, wheat, oats, sorghum, sunflower, or a mixture of these. Upon capture, turkeys were physically restrained for processing at which time they were sexed, aged, banded, and fitted with radio transmitters. Sexing and aging was completed by evaluating physical and morphometric characteristics using procedures outlined in Pelham and Dickson (1992). All turkeys were banded with both aluminum identification tags (National Band and Tag Co., Newport, KY) and Darvic™ colored leg bands (Haggie Engraving, Crumpton, MD) affixed to the right and left tarsus, respectively. Aluminum identification bands provided a unique identifier for each turkey. The colored leg bands were placed in unique combinations and allowed identification of individual turkeys from a distance (as required for a joint collaborative study). Backpack-style radio transmitters (Advanced Telemetry Systems, Isanti, MN) operating in the 150 - 151 MHz range with an 8-hour mortality delay and 1,000-day battery life were fitted to each turkey using elastic bungee harnesses. The tarsus length to the nearest 0.1 cm and body weight to the nearest 0.1 kg were measured and recorded. On male turkeys, spur length to the nearest 0.1 cm and beard length to the nearest 0.1 cm were measured and recorded. Additional information recorded at the time of capture included air temperature, capture time, release time, physical condition, and release behavior.

Turkeys were located using triangulation telemetry techniques (White and Garrott 1990) and direct observation. Hen turkeys known to be incubating a nest were located by homing techniques (White and Garrott 1990). Triangulation telemetry was accomplished from both fixed and roving stations where at least 3 bearings were taken and recorded. The fixed stations were made up of 138 points set up at various locations across the study area. Roving stations were located anywhere convenient and were recorded using coordinates given by a hand-held Global Positioning System (GPS). Telemetry was accomplished using a hand-held, 3-element yagi antenna and Telonics TR-2, Advanced Telemetry Systems R2000, and Wildlife Materials International TRX-2000S telemetry receivers. Additionally, a null-peak system with dual, 7-element yagi antennas mounted on an all-terrain utility vehicle was used in 2004 and 2005 to improve telemetry accuracy. Estimations of locations were calculated by using the triangulation program DogTrack™ (Foresters Inc., Blacksburg, VA).

Telemetry Accuracy

A telemetry accuracy test was performed to determine telemetry accuracy and to test for differences in accuracy between observers and antenna types. Tests were conducted on 4 observers who located test transmitters using the same techniques outlined for actual telemetry. Each observer located 20 test transmitters, 10 for each antenna type, for a total of 80 test locations. Each transmitter was placed at random locations on the study site by a person other than the one completing the test. Transmitters were placed at a height of 0.5 m above the ground in various habitat types. All tests were performed during the leaf-on period since the majority of actual telemetry locations (>75%) were to be recorded during this time. Estimated locations of the test transmitters were calculated using DogTrack.

The telemetry program LOAS v.3.0.4 (Ecological Software Solutions 1999) was used to calculate bearing errors for each test bearing. I used analysis of variance (ANOVA) procedures in SAS (SAS Institute Inc. 2004) to calculate mean bearing errors for all observers and antenna types, and to test for differences between these. Telemetry accuracy was also evaluated by using ArcView® v.3.2 to calculate distances between the actual location of test transmitters and their estimated location. These "error distances" were then used in SAS to compute mean error distances for each observer and antenna type and to test for differences within each of these. Mean error distances were used to extrapolate to a mean error area by using the mean error distance as the radius in the $A=\pi r^2$ formula. This allowed visualization of telemetry error in terms of land area.

Additionally, I assessed cover type classification accuracy by using the test transmitters and comparing the cover type at the actual transmitter location to the cover type at the estimated transmitter location. This comparison was accomplished using a cover type map in ArcView® v.3.2, and the end result was the percentage of test telemetry locations that were correctly classified.

Data Analysis

Overstory cover types on the study area were delineated from high resolution satellite imagery using ArcView® v3.2 (Environmental Systems Research Institute 1999). Habitat polygons were manually digitized on screen at a scale of 1:2,500 in the following categories: swamp, hardwood drain, low-density pine, high-density pine, low-density mixed hardwood-pine, high-density mixed hardwood-pine, field or opening, and road. Infrared reflectance in the imagery allowed for distinguishing between coniferous and deciduous vegetation as well as bare ground, grass, and water. The imagery's high resolution enabled differentiation of overstory (trees) from understory (shrubs) vegetation, which allowed me to categorize forest stands as high-density or low-density. The minimum size for habitat polygons was 0.1 ha. Habitats delineated as swamps were those that held water for the majority of the year and had vegetation indicative of this habitat type (*Taxodium distichum*, *Nyssa sylvatica*, *Nyssa aquatica*, *Cephalanthus occidentalis*, etc.). Since open water habitats made up such a small portion of the study site, these areas were grouped into the swamp habitat. The hardwood drain habitats were those that had approximately 75% or more of the overstory in deciduous trees. The majority of these areas were bottomland hardwood type stands, although a very small amount of pure upland hardwood stands were included in this habitat type. Likewise, the low-density pine, and the high-density pine habitat types each had at least 75% of their overstory vegetation in coniferous trees. Habitats categorized as low-density mixed hardwood-pine and high-density mixed hardwood-pine were those forested areas that had a mixture of both pine and hardwood trees, and did not fit into the previous hardwood or pine categories. Low-density stands were differentiated from high-density stands on a subjective basis by comparing the percentage of overstory canopy to the percentage of bare ground or understory that could be seen in the image. If the overstory canopy made up more than 65% of the area then it was deemed to be high-density. If the area had between 10 and 65% overstory canopy then it was considered low-density. Stands that had less than 10% overstory canopy were treated as openings. Other areas that were classified as fields or openings were pastures, agricultural fields, wildlife food plots, and fallow fields.

Locations for turkeys were recorded and stored in a database, and were assigned to seasons to facilitate construction of seasonal home ranges. Seasons were determined for female locations based on whether the individual nested or not. Breeding season for nesting females ran from 1 March until the date of the last nesting activity. If females renested after an unsuccessful attempt, then they were still considered to be in the nesting season until the date of the last nesting activity of the subsequent nest. Postbreeding season for females that nested ran from the date of last nesting activity until 14 October. No radio-monitored hens in this study were known to have a brood that survived more than 14 days post-hatch. Therefore, all postbreeding season locations for hens should be considered locations of the individual hen and not a hen with her brood. Breeding season for males and females that showed no sign of a nesting attempt included 1 March to 31 May. Postbreeding season for males and females that showed no sign of a nesting attempt included 1 June to 14 October. Fall and winter locations were combined into one season which ran during 15 October – 28/29 February for all turkeys.

I constructed 95% fixed kernel home ranges using Hawth's tools (Beyer 2004) in ArcGIS® v9.1 (Environmental Systems Research Institute 2004) from turkey locations within each season described above. The minimum number of locations required to build a seasonal home range was set at 10. This was based on a scatter plot of the number of locations versus home range area. The scatter plot showed that seasonal home range area did not significantly increase after 10 locations. For turkeys that were located at least 9 months out of a year and had at least 5 locations in each season, annual home ranges were constructed using the same methods.

I used PROC MIXED in SAS (SAS Institute Inc. 2004) to investigate differences in home range sizes between seasons, years, and sexes at the α=0.05 level. The program Bycomp

(Ott and Hovey 1997) in SAS was used to perform compositional analysis according to Aebischer et al. (1993). This program performs a simultaneous analyses of habitats to determine if habitat use is nonrandom at the α=0.05 level. Compositional analysis was performed to investigate habitat selection at Johnson's 2^{nd} and 3^{rd} orders (Johnson 1980). In order to determine the "available" habitat area for the 2^{nd} order selection, ArcView® v3.2 was used to create a 100% minimum convex polygon (MCP) around all turkey locations. This "available" MCP was then buffered by 750 m to encompass the largest area allowed by the land cover imagery. Animal movements extension (Hooge and Eichenlaub 1997) and XTools (DeLaune 2003) were used within ArcView® v3.2 to calculate the percentage of each habitat type within the study area and within each home range. The percentage of each habitat type within each home range was used for the "use" habitat in the 2^{nd} order selection analysis. The 2^{nd} order "use" habitat for each home range was used as the "available" habitat to examine the 3^{rd} order selection. The "use" habitat for each home range in the 3^{rd} order selection was defined as the percentage of turkey locations within each habitat type in that home range.

RESULTS

Telemetry Accuracy

Analysis of variance procedures indicated that mean bearing error differed between observers ($F_{3,304}$=8.17, P<0.001) but not antenna types ($F_{1,304}$=0.20, P=0.65), and the interaction between the 2 was not significant ($F_{3,304}$=1.16, P=0.32). Among the 4 tested observers, only one had a mean bearing error that was different than all other observers in pairwise comparisons. Since this observer accounted for only 17% of the telemetry locations in the project it was decided that telemetry locations recorded by this person would be pooled with all others and not analyzed separately. With that in consideration, mean bearing error for all observers and antenna types combined was 14.1° (SE=0.97). Mean error distance did not differ between observers ($F_{3,72}$=1.79, P=0.16), antenna types ($F_{3,72}$=1.09, P=0.30), or in the interaction between the 2 ($F_{3,72}$=1.31, P=0.28). Mean error distance for all observers and antenna type combined was 109.2 m (SE=12.00) and extrapolates to a mean error area of 3.75 ha.

When the cover type at actual test transmitter locations was compared to that of estimated test transmitter locations, the 2 were in agreement in 59 out of 80 test locations for a cover type classification accuracy rate of 74%.

Home Range

Forty-one individual turkeys were used in home range calculations. Three extremely large, outlying home ranges were removed from analysis. Inadequate sample size precluded calculation of home ranges for the fall/winter seasons for males. Several turkeys survived longer than a year and had more than one home range within a season in subsequent years. Low sample size within seasons necessitated use of multiple home ranges per individual (different years) within seasons. When home range sizes were pooled irrespective of seasons they did not differ by sex ($F_{1,103}$=0.20, P=0.66) or by year ($F_{2,102}$=1.85, P=0.16). Home range size did not differ between years in any season: annual female ($F_{2,14}$=3.36, P=0.06), annual male ($F_{1,2}$=0.18, P=0.71), breeding male ($F_{2,7}$=0.66, P=0.55), breeding-nonnesting female ($F_{2,12}$=0.77, P=0.48), breeding-nesting female ($F_{2,16}$=0.50, P=0.62), fall/winter female ($F_{1,3}$=4.93, P=0.11), postbreeding male ($F_{1,5}$=4.80, P=0.08), postbreeding-nonnesting female ($F_{1,11}$=0.57, P=0.47), and postbreeding-nesting female ($F_{2,12}$=1.06, P=0.38).

Mean annual home range size was 318.1 ha (SD=132.8) for females and 296.4 ha (SD=85.9) for males and were not different (t=0.28, P=0.78). Comparisons of home range size by season found overall differences ($F_{8,96}$=2.09, P=0.04; Tables 2.2, 2.3). Mean home range size for male turkeys in the breeding season was the largest of any season at 365.5 ha (SD= 195.6), and was significantly larger than mean home ranges in postbreeding male (t=2.13, P=0.04), postbreeding-nonnesting female (t=2.47, P=0.02), postbreeding-nesting female (t=2.53, P=0.01), and fall/winter female seasons (t=2.13, P=0.04). Mean home range size for males during the postbreeding season was the smallest of all seasons at 173.2 ha (SD= 51.2) and was significantly different in comparison to annual female (t=2.34, P=0.02) and breeding-nonnesting female (t=2.25, P=0.03) seasons. Mean home range size did not differ between females that nested and those that did not nest in either the nesting (t=0.53, P=0.60) or postnesting (t=-0.02, P=0.99) seasons.

Habitat Use

At the 2nd order of habitat selection, a simultaneous analysis of all habitats indicated that annual habitat use did not differ between males and females (Wilks' λ=0.542, $F_{6,14}$=1.97, P=0.14). Therefore, male and female habitat compositions were pooled for analysis of annual selection. This analysis also suggested nonrandom habitat use (Wilks' λ=0.070, $F_{5,15}$=33.28, P<0.001). At the 2nd order, the postbreeding male season exhibited random habitat use (Wilks' λ=0.099, $F_{6,1}$=1.51, P=0.55). All other seasons in the 2nd order analysis were significant for nonrandom use: breeding-nonnesting female (Wilks' λ=0.076, $F_{6,9}$=18.19, P<0.001), breeding-nesting female (Wilks' λ=0.147, $F_{6,13}$=12.61, P<0.001), breeding male (Wilks' λ=0.091, $F_{6,4}$=6.66, P=0.04), postbreeding-nonnesting female (Wilks' λ=0.047, $F_{6,7}$=23.75, P<0.001), and postbreeding-nesting female (Wilks' λ=0.051, $F_{6,9}$=28.1, P<0.001).

In 2nd order compositional analysis, hardwood drain was ranked at the top in the annual home range category (Table 2.4) as well as breeding-nonnesting female (Table 2.5), breeding-nesting female (Table 2.6), and postbreeding-nonnesting female (Table 2.7) seasons. Hardwood drain ranked 2^{nd}, 2^{nd}, and 3^{rd} in postbreeding-nesting female (Table 2.8), postbreeding male, and breeding male (Table 2.9) seasons, respectively. Low-density mixed hardwood-pine was the top-ranked habitat in the postbreeding-nesting female season and 2^{nd} in all other seasons where habitat use was found to be nonrandom; including the annual home range category. Low-density pine habitat ranked in the middle or bottom in all seasons, except for breeding and postbreeding male seasons where it was the top-ranked habitat. In the annual category as well as in every season, the swamp habitat was ranked last (Table 2.10).

At the 3^{rd} order selection level, simultaneous analysis of all habitats demonstrated that habitat use on the annual scale differed between male and female turkeys (Wilks' λ=0.258, $F_{5,15}$=8.63, P<0.001). Therefore, male and female habitat compositions were not pooled for the 3^{rd} order annual compositional analysis. Only female compositions were used on the annual scale since the sample size for male compositions was not adequate for separate analysis. There were several instances where the swamp habitat type was not available to turkeys, so this habitat type was removed from all 3^{rd} order analyses, as suggested by Aebischer et al. (1993). At the 3^{rd} order selection level, breeding male and postbreeding male seasons were found to exhibit random habitat use (Wilks' λ=0.266, $F_{5,5}$=2.76, P=0.15 and Wilks' λ=0.233, $F_{5,1}$=0.66, P=0.72, respectively). Third order compositional analysis revealed that habitat use was nonrandom for breeding-nesting female (Wilks' λ=0.380, $F_{5,14}$=4.57, P=0.01), postbreeding-nesting female (Wilks' λ=0.282, $F_{5,9}$=4.58, P=0.02), breeding-nonnesting female (Wilks' λ=0.381, $F_{5,10}$=3.24, P=0.05) and postbreeding-nonnesting female (Wilks' λ=0.303, $F_{5,8}$=3.68, P=0.05) seasons. Third order, annual habitat use for females was found to be nonrandom (Wilks' λ=0.369, $F_{5,12}$=4.10, P=0.02). Third order compositional analysis rankings placed the hardwood drain habitat first for the annual compositions (Table 2.11) and all of the seasons except the breeding male, postbreeding-nonnesting female (Table 2.12), and postbreeding male seasons, which all ranked hardwood drain second (Tables 2.13, 2.14, 2.15). Although rankings varied slightly between the seasons a general trend existed where field, low-density mixed, and high-density mixed habitats were usually ranked low, whereas high-density pine and low-density pine habitats were usually ranked in the middle to upper part of the ranking scale (Table 2.16).

DISCUSSION

Home Range

As previously discussed by Miller (1997), comparisons of home range size are complicated by the differing methods of home range delineation in use, and are further convoluted by the differences in season designations. Nonetheless, home range comparisons between studies can still be made by considering generalities, gross differences, and seasonal changes. Overall, seasonal home ranges in this study are similar to or smaller than those reported in most other studies (Bidwell et al. 1989, Hurst et al. 1991, Miller 1997). Assuming that smaller home range suggests better habitat conditions (Porter 1977, Exum et al. 1987), habitat in this area seems to be excellent for meeting the seasonal needs and requirements of wild turkeys.

Mean home range size for nesting hens in this study was approximately 290 ha and is just slightly larger than the 273 ha kernel home range reported by Chamberlin et al. (2000) for nesting hens in Mississippi, but much smaller than hens in eastern Oklahoma (Bidwell et al. 1989) and Arkansas (Thogmartin, 2001). The abundance of low-density stands in this study should create easy access to adequate nesting cover without hens having to travel far to find suitable nest sites. However, dispersing hens that are unfamiliar with an area or hens that travel farther to find suitable breeding partners may inflate the mean home range size for this season.

Since the home range seasons were designated according to nesting activity, or lack thereof, hens that failed on the first nesting attempt and attempted to renest could have inflated the mean by moving a large distance between the area of the first attempt to the area of the second attempt. Home range size in this study varied the most during the breeding season, which is similar to turkeys in northwestern Arkansas (Badyaev et al.1996) and east-central Mississippi (Smith et al. 1990). Large variation in breeding season home range could be a result of low sample size. However, after witnessing movements of breeding season turkeys in this study, I believe that large variations were a result of the inherent variability between individuals.

Nesting hens, nonnesting hens, and gobblers all showed a decrease in home range size from their respective breeding to their respective postbreeding seasons. Turkeys on this study site seemed to move much more during the breeding season. During the early- to mid-summer months movement activity declined substantially as breeding activity ceased, possibly causing the aforementioned decrease in home range size. It is unclear why nonnesting hens also followed this trend. Perhaps an increase in soft mast or other food items from spring to summer also played a roll.

Mean home range size of hens during the fall and winter was small relative to all other hen seasons (204.8 ha, SD=72.6), contrary to studies of hens in Mississippi, Missouri, and Louisiana (Smith and Teitelbaum 1986, Kurzejeski and Lewis 1990, Chamberlin et al. 2000). This may attest to excellent fall and winter range in this area and would indicate that hens may not have to move far to find necessary resources during this time of year.

Turkey home ranges varied widely in all seasons, although not as much as turkeys studied in other areas (Cobb et al. 1993, Miller 1997). Again, high variability could be an indicator of small sample size

Habitat Use

Both 2nd order and 3rd order analysis illustrate the importance of the hardwood drain habitat on this study area. At the 2nd order, hardwood drain was the highest ranking habitat type in 4 out of 7 seasons with 2 of the 3 remaining seasons ranking it second. At the 3rd order, hardwood drain was also ranked first in 4 out of 7 seasons, with the remaining seasons ranking it second. Clearly, the hardwood drain habitat on this study site is valuable to both hens and gobblers during a large portion of the year. Studies in Mississippi have also shown the importance of hardwood drainage areas, especially in locations where this habitat type is reduced or the surrounding habitat is poor (Burk et al. 1990, Palmer and Hurst 1995). The hardwood drains in this study seemed to be of the greatest importance to the females. Although this habitat was also high-ranking for all the male seasons, males most preferred the low-density pine stands.

At both the 2nd and 3rd orders the field or opening habitat was ranked last or next-to-last in all seasons except for one. Although many studies have emphasized the value of well dispersed openings (Speak et al. 1975, Healy 1985), turkeys on this study site may have had their need for open areas met in the abundance of low-density pine or low-density mixed pine-hardwood stands. It is also possible that the small size of some fields on this study site made it more difficult to correctly categorize turkey locations within these small openings. Within many of the stands bobwhite management activities such as frequent prescribed fire, roller-drum chopping, mowing, and herbicide use allow grasses, forbs, and young shrubs to dominate the understory. This, perhaps, emulates vegetative conditions found in 2- or 3-year fallow fields or openings. Swanson et al. (1995) discussed the advantages of understory conditions in thinned stands versus dense stands. Zwank et al. (1988) reported that hens in Louisiana used fallow fields and wheat fields less following a 47% basal area reduction of timber in surrounding forests, citing increases in diversity and cover of understory vegetation as a major factor. In Florida, cypress woods of variable age and density were thought to provide similar ground-level vegetation as true openings, circumventing the need for providing turkeys with large openings (Williams and Austin 1988). Based on these studies, desirable foods and adequate protective cover could have been found in many of the low-density stands without turkeys having to venture greater distances to find true fields, pastures or openings.

At the 2^{nd} order selection level, both low- and high-density mixed habitat appeared to be of moderately high importance in that they were ranked second or third in nearly every season. While stand density was not characterized, Bidwell's et al. (1989) study in eastern Oklahoma also found that hens preferred mixed pine-hardwood stands and hens in Mississippi were found to prefer mixed stands for roosting habitat (Chamberlin et al. 2000). In that same location in Mississippi, burned mixed stands were preferred by gobblers at the 1^{st} order, but not at the 2^{nd} or 3^{rd} order. In this study, I believe mixed habitats were ranked moderately because these stands are well-dispersed on the study site, and are in close proximity of the highly preferred hardwood drain and low-density pine stands. While mixed areas may not provide all of the desired benefits of the hardwood drain and low-density pine habitats, they do contain some attributes of each and may serve as a transition zone between the 2 habitats.

A few differences were noted when comparing 2^{nd} order with 3^{rd} order rankings. The low-density mixed habitat was ranked high in all 2^{nd} order seasons except postbreeding male, yet it was ranked at or near the bottom in each of the 3^{rd} order seasons. If one were to assume that turkeys purposefully arrange their home range around preferred habitats (2^{nd} order), then it would be logical that turkeys would also be observed within those habitats (3^{rd} order). This was not the case for the low-density mixed habitat type. Low 3^{rd} order preference for the low-density mixed habitat may be due to its juxtaposition with 2 other habitats that were highly preferred in the 2nd or 3rd order analysis. On this study site, stands of low-density mixed forest were always contiguous with hardwood drain or low-density pine stands. Therefore, if turkeys were positioning their home ranges to encompass low-density pine and hardwood drain stands, then the low-density mixed stands may have been ranked high in the 2nd order but not the 3rd order simply due to its adjacency to the other two types, regardless of whether it was a preferred type or not. This relationship of turkey habitat use to habitat associations and juxtaposition has been presented previously (Speake et al. 1975, Smith and Teitelbaum 1986).

At both selection orders, males seemed to show a higher use of low-density pine stands while females tended to show the highest use of the hardwood drain habitat during both the breeding and postbreeding seasons. The only 2 exceptions to this were 2nd order postbreeding nesting females who used low-density mixed stands much higher than its availability, and 3rd order postbreeding nonnesting females who used high-density pine frequently, allowing it the top ranking for that season. On this study site, the majority of high-density pine stands were ones that contained mid-rotation to mature-aged row-planted pines, similar to many industrial even-aged pine plantations throughout the Southeast. Turkey habitat use in these areas has been adequately studied and most report variable use of planted pine stands (Kennamer et al. 1980[a], Exum et al. 1987, Hurst et al. 1991, Stys 1992). However, it seems that turkey use of pine plantations are a factor of season, year, and other available surrounding habitat types. It is unclear why nonnesting hens in this study used high-density pine stands in the post breeding season enough to result in it being top-ranked. Likewise, most other seasons in the 3rd order selection had this stand type ranked third with the annual female category ranking it second. Perhaps use of this stand type is a result of the stand categorization methods. While many of the stands characterized as high-density were truly that, a fair amount were in varying stages of conversion to low-density stands as recommended for bobwhite management (Moser et al. 2002). While these stands may not have met my requirement for low-density status (10-65% overstory canopy coverage), many were in varying degrees of progression towards this and may have began to develop understory conditions similar to the low-density category. Additionally, many of the high-density stands were adjacent to low-density stands and may have been desirable to turkeys due to understory conditions created by an edge effect.

Turkeys on this study site exhibited the highest use of hardwood drains relative to its availability, moderately high use of low-density pine relative to its availability, and moderate use of high-density pine, low-density mixed, and high-density mixed habitats (roughly proportional to their availability). Habitats on this study area that were used less than their available proportions were the field or opening and swamp habitats. Nevertheless, low use of field or openings should not be construed as insignificance of these habitats. No hens tracked during this study were known to be rearing broods. Peoples et al. (1995) and Sisson (1991) have previously documented the importance of fields and openings for brood rearing purposes in this area.

Although, no assessment of fall or winter habitat use was made, it may be possible to speculate what habitats turkeys on this study site might prefer based on previous studies. In forested areas of eastern Oklahoma wintering hens chose stands with open understories (Bidwell et al. 1989). Turkeys in piedmont Virginia were associated with habitat edges during the winter (Holbrook et al. 1987). Hens in Mississippi most preferred hardwood sawtimber in fall and winter, while males most preferred pine sawtimber in fall and winter (Miller et al 1999). On my study site it is apparent that fall and winter habitat use is likely to be variable by year and by sex, and is probably controlled by hard mast production. This was witnessed via winter trapping efforts as a poor hardwood mast crop was experienced in the fall of 2003 followed by a significantly better one in 2004. Although turkeys were observed in all habitats during the fall and winters of both years, turkeys in 2003 were seen more frequently in low and high-density pine stands as well as openings. In the fall and winter of 2004, turkeys were rarely observed in these areas and were most often found in hardwood drain, and to a lesser degree in both low-density and high-density mixed habitats. Many previous studies have documented fall and winter preference for bottomland hardwood areas (Kennamer et al. 1980[b], Everett et al. 1985), and the variability of habitat use in relation to mast production (Speake et al. 1975, Dickson 1990)

RECOMMENDATIONS

Numerous studies have reported the importance of thinning and burning of forested areas to increase production of more desirable food sources as well as ground-level cover for the wild turkey (Smith et al. 1990, Godfrey and Norman 1999). On my study site, these practices regularly occur as required for bobwhite management. From my research, it is evident that these activities do not restrict wild turkeys' use of this area. These practices should continue, since it is likely that bobwhite management improves conditions for turkeys, especially for nesting and brood-rearing behaviors. However, as in other studies, my data have shown the importance of the hardwood drainage areas. In this study the hardwood drain habitat compromised about 25% of the total study area. On other areas where bobwhite management is a priority, I would recommend that at least 15-20% of that area contain mature hardwood forests, if it is expected to receive year-round use by a modest population of turkeys. It is unclear how wild turkey use of this area might change in the absence of the hardwood drain habitat type. It is likely that locales absent of hardwood drainage areas may only see limited and variable use by low numbers of turkeys. An increasing trend among some bobwhite plantations is to manage for the removal of nearly all hardwood stems. It seems that additional research is necessary to assess the trade offs between bobwhite and wild turkey management.

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Table 2.1 Study site land area (ha), turkey telemetry locations, and observed turkey nests by overstory cover type, Grady and Thomas Counties, Georgia, 2003-2005.

	Land Area		Telemetry Locations		Nests	
Habitat	**Hectares**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Hardwood drain	1,509.7	24.8	1,350	38.8	0	0.0
High-density pine	839.5	13.8	470	13.5	7	31.8
Low-density pine	2,389.7	39.2	847	24.3	10	45.5
High-density mixed	316.3	5.2	196	5.6	0	0.0
Low-density mixed	179.8	2.9	181	5.2	2	9.1
Field/opening	647.4	10.6	353	10.1	3	13.6
Swamp	143.5	2.4	76	2.2	0	0.0
Road	69.1	1.1	9	0.3	0	0.0
Total	6,095.0	100	3,482	100	22	100

Table 2.2 Mean home range size (ha) of wild turkeys by season, pooled for 2003-2005, Grady and Thomas Counties, Georgia.

Season	Mean	SE	Min-Max	N
Annual Female	318.1	32.2	96.8 – 590.7	17
Annual Male	296.4	43.0	241.4 – 424.7	4
Breeding Male	365.5	61.8	185.2 – 830.5	10
Breeding-Nonnesting Female	315.1	47.1	53.9 – 630.2	15
Breeding-Nesting Female	289.8	31.4	84.4 – 656.2	19
Fall/Winter Female	204.8	32.5	102.4 – 269.5	5
Postbreeding Male	173.2	19.4	82.3 – 232.0	7
Postbreeding-Nonnesting Female	222.4	25.9	66.3 – 479.9	13
Postbreeding-Nesting Female	223.4	32.7	89.1 – 588.2	15

Note: home ranges could not be calculated for males in fall/winter of any year due to low sample sizes.

Table 2.3 Pairwise comparisons of turkey home range size between seasons, pooled for 2003-2005, Grady and Thomas Counties, Georgia. *P*-values marked with an asterisk (*) indicate home range size of row season differs significantly from home range size of column season.

Season[a]	**ANM**	**BRM**	**BOF**	**BNF**	**FWF**	**PBM**	**POF**	**PNF**
ANF	0.28[b]	-0.86	0.06	0.61	1.62	2.34	1.89	1.94
	0.777[c]	0.390	0.951	0.540	0.109	0.021*	0.062	0.055
ANM		-0.85	-0.24	0.09	0.99	1.43	0.94	0.94
		0.398	0.810	0.931	0.324	0.157	0.349	0.348
BRM			0.90	1.41	2.13	2.83	2.47	2.53
			0.372	0.163	0.036*	0.006*	0.015*	0.013*
BOF				0.53	1.55	2.25	1.78	1.83
				0.597	0.124	0.027*	0.079	0.071
BNF					1.23	1.92	1.36	1.40
					0.222	0.058	0.176	0.165
FWF						0.39	-0.24	-0.26
						0.696	0.809	0.795
PBM							-0.76	-0.80
							0.448	0.428
POF								-0.02
								0.985

[a]Season codes: ANF=annual female, ANM=annual male, BRM=breeding male, BOF=breeding-nonnesting female, BNF=breeding-nesting female, FWF=fall/winter female, PBM=postbreeding male, POF=postbreeding-nonnesting female, PNF=postbreeding-nesting female.
[b]Top number is the *t*-value.
[c]Bottom number is the *P*-value. Significance was set at the α=0.05 level.

Table 2.4 Habitat ranking matrix of 7 major overstory cover types based on 2^{nd} order compositional analysis of annual 95% kernel home ranges for male and female turkeys (combined), Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain	.	+++	+++	+	+++	+++	+++	6
Field	---	.	-	---	+	-	+	2
HD-Pine	---	+	.	-	+	-	+++	3
LD-Mix	-	+++	+	.	+++	+	+++	5
LD-Pine	---	-	-	---	.	---	+++	1
HD-Mix	---	+	+	-	+++	.	+++	4
Swamp	---	-	---	---	---	---	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.5 Habitat ranking matrix of 7 major overstory cover types based on 2nd order compositional analysis of 95% kernel home ranges during the breeding-nesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain		+++	+++	+	+++	+++	+++	6
Field	---	.	+	-	-	-	+++	2
HD-Pine	---	-	.	---	-	-	+++	1
LD-Mix	-	+	+++	.	+	+	+++	5
LD-Pine	---	+	+	-	.	-	+++	3
HD-Mix	---	+	+	-	+	.	+++	4
Swamp	---	---	---	---	---	---	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.6 Habitat ranking matrix of 7 major overstory cover types based on 2nd order compositional analysis of 95% kernel home ranges during the breeding-nonnesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain	.	+++	+++	+	+++	+++	+++	6
Field	---	.	-	-	-	-	+	1
HD-Pine	---	+	.	-	+++	-	+	3
LD-Mix	-	+	+	.	+++	+	+++	5
LD-Pine	---	+	---	---	.	---	+	2
HD-Mix	---	+	+	-	+++	.	+++	4
Swamp	---	-	-	---	-	---	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.7 Habitat ranking matrix of 7 major overstory cover types based on 2^{nd} order compositional analysis of 95% kernel home ranges during the postbreeding-nonnesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD[b]-Pine**	**LD[c]-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain	.	+	+++	+	+++	+++	+++	6
Field	-	.	-	-	+	-	+	2
HD-Pine	---	+	.	-	+	-	+++	3
LD-Mix	-	+	+	.	+++	+	+++	5
LD-Pine	---	-	-	---	.	-	+	1
HD-Mix	---	+	+	-	+	.	+++	4
Swamp	---	-	---	---	-	---	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.8 Habitat ranking matrix of 7 major overstory cover types based on 2nd order compositional analysis of 95% kernel home ranges during the postbreeding-nesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain	.	+++	+++	-	+++	+	+++	5
Field	---	.	+	-	+	-	+++	3
HD-Pine	---	-	.	---	-	-	+	1
LD-Mix	+	+	+++	.	+++	+	+++	6
LD-Pine	---	-	+	---	.	-	+++	2
HD-Mix	-	+	+	-	+	.	+++	4
Swamp	---	---	-	---	---	---	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.9 Habitat ranking matrix of 7 major overstory cover types based on 2nd order compositional analysis of 95% kernel home ranges during the breeding male season, for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD[b]-Pine**	**LD[c]-Mix**	**LD-Pine**	**HD-Mix**	**Swamp**	**Rank**
Drain	.	+++	+++	-	-	+	+	4
Field	---	.	-	---	---	-	+	1
HD-Pine	---	+	.	-	---	-	+	2
LD-Mix	+	+++	+	.	-	+	+	5
LD-Pine	+	+++	+++	+	.	+	+	6
HD-Mix	-	+	+	-	-	.	+	3
Swamp	-	-	-	-	-	-	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.10 Compositional analysis rankings of 2nd order habitat use, for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates more preferred habitat.

	Season						
Habitat	**AMF**[a]	**BOF**[b]	**BNF**[c]	**BRM**[d]	**POF**[e]	**PNF**[f]	**PBM**[g,h]
Hardwood drain	6	6	6	4	6	5	5
High-density pine	3	3	1	2	3	1	4
Low-density pine	1	2	3	6	1	2	6
High-density mixed	4	4	4	3	4	4	2
Low-density mixed	5	5	5	5	5	6	1
Swamp	0	0	0	0	0	0	0
Field/opening	2	1	2	1	2	3	3

[a]annual male and female

[b]breeding-nonnesting female

[c]breeding-nesting female

[d]breeding male

[e]postbreeding-nonnesting female

[f]postbreeding-nesting female

[g]postbreeding male.

[h]This season was not significant for nonrandom habitat use. It is assumed that habitats were used in proportion with their occurrence on the landscape and were ranked as such.

Table 2.11 Habitat ranking matrix of 6 major overstory cover types based on 3rd order compositional analysis of annual 95% kernel home ranges for female turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Rank**
Drain	.	+++	+	+	+++	+	5
Field	---	.	-	+	-	-	1
HD-Pine	-	+	.	+	+	+	4
LD-Mix	-	-	-	.	-	-	0
LD-Pine	---	+	-	+	.	+	3
HD-Mix	-	+	-	+	-	.	2

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.12 Habitat ranking matrix of 6 major overstory cover types based on 3rd order compositional analysis of 95% kernel home ranges during the postbreeding-nonnesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	Field	HD[b]-Pine	LD[c]-Mix	LD-Pine	HD-Mix	Rank
Drain	.	+	-	+++	+	+	4
Field	-	.	---	+	-	+	2
HD-Pine	+	+++	.	+++	+++	+++	5
LD-Mix	---	-	---	.	-	-	0
LD-Pine	-	+	---	+	.	+	3
HD-Mix	-	-	---	+	-	.	1

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.13 Habitat ranking matrix of 6 major overstory cover types based on 3rd order compositional analysis of 95% kernel home ranges during the postbreeding-nesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD[b]-Pine**	**LD[c]-Mix**	**LD-Pine**	**HD-Mix**	**Rank**
Drain	.	+	+	+++	+++	+	5
Field	-	.	-	+	-	-	1
HD-Pine	-	+	.	+	-	+	3
LD-Mix	---	-	-	.	-	-	0
LD-Pine	---	+	+	+	.	+	4
HD-Mix	-	+	-	+	-	.	2

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.14 Habitat ranking matrix of 6 major overstory cover types based on 3rd order compositional analysis of 95% kernel home ranges during the breeding-nonnesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD[b]-Pine**	**LD[c]-Mix**	**LD-Pine**	**HD-Mix**	**Rank**
Drain	.	+++	+	+++	+	+	5
Field	---	.	-	-	---	-	0
HD-Pine	-	+	.	+	-	+	3
LD-Mix	---	+	-	.	-	-	1
LD-Pine	-	+++	+	+	.	+	4
HD-Mix	-	+	-	+	-	.	2

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.15 Habitat ranking matrix of 6 major overstory cover types based on 3rd order compositional analysis of 95% kernel home ranges during the breeding-nesting female season for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates greater preference for that type. In the matrix, (+) indicates that row habitats were used more than the column habitats and (-) indicates the opposite. When (+++) or (---) are shown it indicates that the difference was significant at ($P \leq 0.05$).

	Drain[a]	**Field**	**HD**[b]**-Pine**	**LD**[c]**-Mix**	**LD-Pine**	**HD-Mix**	**Rank**
Drain	.	+++	+++	+++	+	+++	5
Field	---	.	-	-	-	+	1
HD-Pine	---	+	.	+	-	+	3
LD-Mix	---	+	-	.	-	+	2
LD-Pine	-	+	+	+	.	+	4
HD-Mix	---	-	-	-	-	.	0

[a]Drain=hardwood drain.

[b]HD prefixes indicate that the cover type was defined as a high stem density stand.

[c]LD prefixes indicate that the cover type was defined as a low stem density stand.

Table 2.16 Compositional analysis rankings of 3rd order habitat use, for turkeys in Grady and Thomas counties, Georgia, 2003-2005. Higher ranking indicates more preferred habitat.

	Season[a]						
Habitat	**ANF[a]**	**BOF[b]**	**BNF[c]**	**BRM[d,h]**	**POF[e]**	**PNF[f]**	**PBM[g,h]**
Hardwood drain	5	5	5	4	4	5	4
High-density pine	4	3	3	3	5	1	3
Low-density pine	3	4	4	5	3	4	5
High-density mixed	2	2	0	0	1	2	0
Low-density mixed	0	1	2	1	0	0	1
Field/opening	1	0	1	2	2	3	2

[a]annual female

[b]breeding-nonnesting female

[c]breeding-nesting female

[d]breeding male

[e]postbreeding-nonnesting female

[f]postbreeding-nesting female

[g]postbreeding male

[h]Seasons that were not significant for nonrandom habitat use. It is assumed that habitats were used in proportion with their occurrence on the landscape and were ranked as such.

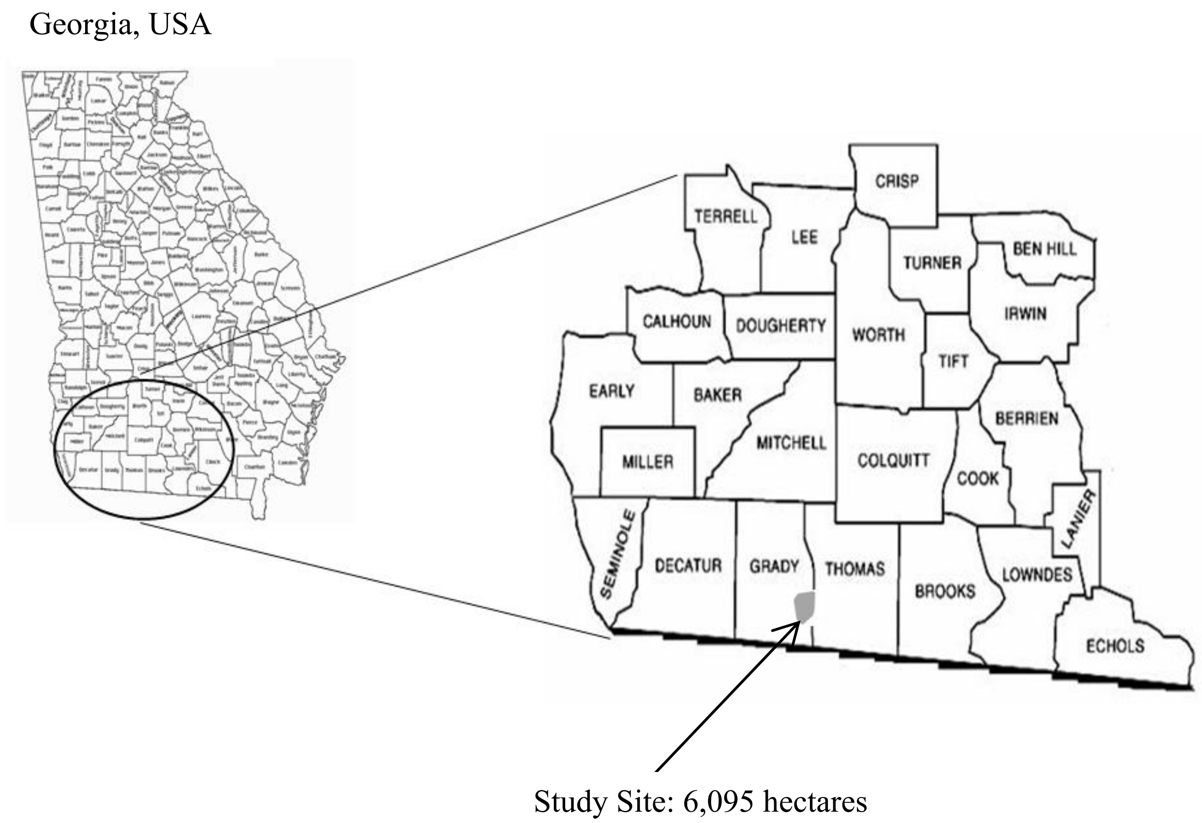

Figure 2.1 Study site location, Grady and Thomas counties, Georgia.

CHAPTER 3

INFLUENCE OF FOREST STRUCTURE ON SEASONAL AND DAILY HABITAT USE OF WILD TURKEYS IN SOUTHERN GEORGIA

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CHAPTER 3

INFLUENCE OF FOREST STRUCTURE ON SEASONAL AND DAILY HABITAT USE OF WILD TURKEYS IN SOUTHERN GEORGIA

INTRODUCTION

Scores of radio telemetry-based studies have been conducted to investigate wild turkey (*Meleagris gallopavo*) habitat use in a wide range of ecosystems. While all of these studies were informative, most yielded limited results useful to wildlife managers, because habitat preference was often based on coarsely defined habitat types. In many parts of the wild turkey's distribution, forest structure features such as timber density, basal area, and groundcover conditions may differ among patches that are within the more broader-scale overstory cover types. It is possible that turkeys choose habitats based on specific details of forest structure, in addition to many of the coarse, general habitat classifications more generally studied. Because of this, it may be important to evaluate forest structure and other habitat features at smaller scales or in greater detail, as previously discussed by Pack et al. (1980).

Within most studies, habitat use and most commonly, habitat preference, is determined based on a set of point-in-time telemetry locations that are usually separated by a day or more. Even though this can produce acceptable results, it may be possible to more accurately assess habitat use if telemetry locations are taken in series throughout the portion of a day. This method could allow telemetry to be conducted with less error and may provide a better assessment of habitats truly preferred as opposed to point-in-time locations that may be subject to a turkey's momentary use of a random or less than preferred habitat type. Additionally, recording multiple telemetry locations in sequence throughout the portion of a day will afford analysis of habitat use and movements relative to diurnal patterns. Turkey managers and researchers have anecdotally reported differences in behaviors (feeding, loafing, breeding, etc.) and movements of wild turkeys in response to the time of day. However, studies of this, especially ones relating time of day to forest structure, are scant in the literature.

In this study, I addressed these issues by conducting intensive radio telemetry (also known as focal telemetry) on wild turkeys residing on northern bobwhite (*Colinus virginianus*) plantations in southern Georgia. The goal of the study was to investigate differences between sex, seasons, and the time of day with respect to specific forest structure characteristics present at turkey locations. I also wanted to assess daily movement rates of wild turkeys and how these rates related to time-of-day, season, sex, and cover type.

Although previous studies have examined wild turkey habitat use in relation to forest structure, none have investigated this on sites where low-basal area, fire-maintained upland pine forests are managed specifically for quail hunting. This type of area is common in southern Georgia and northern Florida and this research may serve those who wish to manage for both bobwhites and wild turkeys.

METHODS

Study Area

This study was conducted on three contiguous plantation properties located in Grady and Thomas counties, Georgia. Pebble Hill Plantation, Springwood Plantation, and Willow Oak Plantation total approximately 2,770 ha and are situated in the Red Hills region of the Gulf Coastal Plain in southern Georgia (Fig. 3.1). All three properties are managed at differing intensities for bobwhite hunting. Pebble Hill manages for bobwhite most intensively and encompasses 1,146 ha or 41% of the total research area. It consists of mostly low-basal area, mature longleaf *(Pinus palustris*), shortleaf (*Pinus echinata*), and loblolly pine (*Pinus taeda*) stands with an interspersion of young planted pine stands, bottomland hardwood drains, cypress (*Taxodium spp*.) swamps, and a few fallow fields. Springwood's management is of intermediate intensity and contains areas of low-basal area, mature pine stands, but has a higher percentage of planted pines and hardwood stands than Pebble Hill. In addition to swamps and fallow fields, Springwood also maintains several large pastures used for horse grazing. Springwood comprises approximately 1,057 ha or 38% of the study area. Willow Oak's bobwhite management is of low to intermediate intensity and is a 566 ha area (20% of study area) that contains planted pine stands, bottomland hardwoods, and mixed pine-hardwood stands. A large portion of Willow Oak is maintained in pastures, cultivated grassland and hayfields, fallow fields, and small, seasonal wildlife food plots. Numerous forest roads, trails, and logging roads traverse each of these properties providing ready access for research in these areas.

Capture and Radio Telemetry

I captured wild turkeys during January, February, and December 2003; January, November and December 2004; and January and February 2005 using 3- and 4-projectile rocket nets (Bailey et al. 1980). The rocket net sites were baited with cracked corn, wheat, oats, sorghum, sunflower, or a mixture of these. Upon capture, turkeys were physically restrained for processing at which time they were sexed, aged, banded, and fitted with radio transmitters. Sexing and aging was completed using procedures outlined in Pelham and Dickson (1992). All turkeys were banded with both aluminum identification tags (National Band and Tag Co., Newport, KY) and Darvic™ colored leg bands (Haggie Engraving, Crumpton, Maryland) affixed to the right and left tarsus, respectively. Aluminum identification bands provided a unique identifier for each turkey. The colored leg bands were attached in unique combinations and allowed identification of individual turkeys from a distance (as required for a joint collaborative study). Backpack-style radio transmitters (Advanced Telemetry Systems, Isanti, MN) operating in the 150 - 151 MHz range with an 8-hour mortality delay and 1,000-day battery life were fitted to each turkey using elastic bungee harnesses. The tarsus length to the nearest 0.1 cm and the body weight to the nearest 0.1 kg were measured and recorded. On male turkeys, spur length to the nearest 0.1 cm and beard length to the nearest 0.1 cm were measured and recorded. Additional information recorded at the time of capture included air temperature, capture time, release time, physical condition, and release behavior.

Turkeys were located using an intensive telemetry technique, also referred to in the literature as focal telemetry (Palmer and Hurst 1995, Chamberlin et al. 2000). To accomplish this I chose individual turkeys as subjects of the intensive telemetry sessions for a period of 6-7 hours during the day. Using triangulation telemetry techniques (White and Garrott 1990) and direct observation, I located the subject every 30 minutes until 12 locations were recorded or 7 hours had passed (it was not always possible to record a location every 30 minutes due to erratic movements of the subjects and poor global positioning system (GPS) reception). The telemetry was accomplished on foot and $\geq$3 bearings were recorded from both fixed and roving stations. The majority of the telemetry bearings were recorded at roving stations using coordinates given by a hand-held GPS unit. Telemetry was accomplished using a hand-held 3-element yagi antenna and a Telonics TR-2, Advanced Telemetry Systems R2000, or Wildlife Materials International TRX-2000S telemetry receiver. I conducted all telemetry in full camouflage attire to avoid being detected by the subject turkey or other turkeys in its presence. The intensive telemetry sessions were categorized as either morning or afternoon sessions and efforts were made to assure that both categories contained a similar number of sessions. I typically began each morning session with the first location of the subject being one soon after the turkey left its overnight roost (approximately sunrise). Afternoon sessions began between 13:00 and 14:00 hours and continued until the requisite number of locations was recorded or the turkey flew up to its overnight roost (approximately sunset). Estimations of locations were calculated by using the triangulation program DogTrack™ (Foresters Inc., Blacksburg, VA).

Telemetry Accuracy

I tested telemetry accuracy for myself and another field technician to determine telemetry error and cover type classification accuracy. Test transmitters were placed in the field by someone other than the person performing the test and exact locations were recorded using a GPS unit. Transmitters were placed in various habitats at a height of 0.5 m to simulate a transmitter on an actual turkey. All tests were performed during the "leaf-on" period since this is when nearly all of the actual telemetry would occur. Test telemetry was accomplished following the same techniques described above for intensive telemetry and locations were estimated using the DogTack telemetry program.

The telemetry program LOAS v.3.0.4 (Ecological Software Solutions 1999) was used to calculate bearing errors for each test bearing. I used t-test procedures in SAS (SAS Institute Inc. 2004) to calculate mean bearing errors for each observer and to test for differences between the two. Telemetry accuracy was also evaluated by using ArcView® v.3.2 (Environmental Systems Research Institute 1999) to calculate distances between the actual location of test transmitters and their estimated location. These "error distances" were used to compute mean error distances and were tested for differences between observers using a t-test in SAS. The mean error distances were used to extrapolate to a mean error area by using the mean error distance as the radius in the $A=\pi r^2$ formula. This allowed visualization of telemetry error in terms of land area.

Additionally, I assessed cover type classification accuracy by using the test transmitters and comparing the cover type at the actual transmitter location to the cover type at the estimated transmitter location. This comparison was accomplished using a cover type map in ArcView® v.3.2 and the end result was the percentage of test telemetry locations that were correctly classified.

Forest Measurements

Following each focal period, I navigated to the locations determined from the intensive telemetry via GPS and recorded various forest measurements. Based on the mean size of the test telemetry error polygons, I used a 0.5-ha area around each location as the sample plot for tree stem density, basal area, and ground-level (understory) vegetation condition. Since 0.5 ha was too large of an area to do complete measurements, I used 4, 0.01-ha subplots within each main plot, and used the mean of the 4 subplots in the analyses. Of the 4 subplots, one was centered on the estimated telemetry location and the remaining 3 were 18 m away in 120° increments from the center (Figure 3.2). I recorded the following measurements at each subplot:

- basal area by deciduous (HBA), and coniferous (PBA)
- stem density count by deciduous (HSD) and coniferous (PSD)
- percent ground cover for grasses (GRS), forbs (FRB), shrubs (SHB), and bare ground or leaf litter (BRG) estimated using the modified Daubenmire classes (Daubenmire 1959) as follows:
    - class 1: 0-5%
    - class 2:5-25%

- class 3: 25-50%
- class 4:50-75%
- class 5:75-95%
- class 6:95-100%

All basal area measurements were made with a 10 baf prism, recorded in ft^2/acre and later converted to m^2/ha. Only trees that measured greater than 2.54 cm diameter-at-breast-height (dbh) were tallied in the stem density counts. Likewise, only trees that measured greater than 11.43 cm dbh were tallied in the basal area measurement since trees smaller than this have been shown to produce highly variable and unreliable measurements (Sparks et al. 2002). A key for all forestry measurement abbreviations and units of measurement are given in Table 3.1.

Data Analysis

Overstory cover types on the study area were delineated from high resolution satellite imagery using ArcView® v3.2. Cover type polygons were manually digitized on screen at a scale of 1:2,500 in the following categories: swamp, hardwood drain, low-density pine, high-density pine, low-density mixed hardwood-pine, high-density mixed hardwood-pine, field or opening, and road. Infrared reflectance in the imagery allowed for distinguishing between coniferous and deciduous vegetation as well as bare ground, grass, and water. The imagery's high resolution enabled differentiation of overstory from understory vegetation, which allowed me to categorize forest stands as high-density or low-density. The minimum size of cover type polygons was 0.1 ha. Cover types delineated as swamps were those that held water for the majority of the year and had vegetation indicative of this cover type (*Taxodium distichum*, *Nyssa sylvatica*, *Nyssa aquatica*, *Cephalanthus occidentalis*, and etc.). Since open water habitats made up such a small portion of the study site, these areas were included in the swamp habitat.

Hardwood drain cover types were those that had approximately 75% or more of the overstory in deciduous trees. The majority of these areas were bottomland hardwood type stands, although a very small amount of upland hardwood stands were included in this cover type. Likewise, low-density pine, and high-density pine cover types each had at least 75% of their overstory vegetation in coniferous trees. Habitats categorized as low-density mixed hardwood-pine and high-density mixed hardwood-pine were those forested areas that had a mixture of both pine and hardwood trees and did not fit into the previous hardwood or pine categories. Low-density stands were differentiated from high-density stands on a subjective basis by comparing the percentage of overstory canopy to the percentage of bare ground or understory that could be seen in the image. If the overstory canopy made up more than 65% of the area then it was deemed to be high-density. If the area had between 10 and 65% overstory canopy then it was considered low-density. Stands that had <10% overstory canopy were treated as openings. Other areas that were classified as fields or openings were pastures, agricultural fields, wildlife food plots, and fallow fields.

I used Xtools (DeLaune 2003) in ArcView® v3.2 to assign overstory cover type to each intensive telemetry location by intersecting the habitat map with the locations. Although subplots at intensive locations were often in different cover types, I chose to use the cover type at the center plot (estimated location) as the type for that location. To justify this I found the telemetry error distance (straight line distance between actual and estimated test transmitter locations) to be normally distributed, which indicated that it was more likely for the actual location to be closer to the center subplot than any of the 3 outlying subplots.

Times for all telemetry locations were standardized to day length by calculating the time's fractional portion of the sunlit day. This was necessary since turkey behaviors are likely tied to day length and using actual times may distort comparisons between data from different times of the year. After standardizing time, the telemetry data were grouped into one of 14 time-of-day levels. While each level accounts for 7.5% of the day, the true amount of time occupied by each level depends on the time of year. Level 1 is the period prior to sunrise, level 8 is the period that surrounds midday, and level 14 is the period just prior to sunset (Figure 3.3).

Telemetry data were assigned to seasons based on my knowledge of wild turkey breeding ecology in this area. Seasons were determined for female locations based on whether the hen nested or not. Breeding season for nesting females (BNF) ran from 1 March until the date of the last nesting activity. If females renested after an unsuccessful attempt, then they were still considered to be in the nesting season until the date of the last nesting activity of the subsequent nest. Postbreeding season for females (PNF) that nested ran from the date of last nesting activity until 14 October. No radio-monitored hens in this study were known to have a brood that survived more than 14 days post-hatch. Therefore, all postbreeding season telemetry sessions for hens should be considered as ones without poults. Breeding season for males (BRM) and females that showed no sign of a nesting attempt (BOF) included 1 March to 31 May. Postbreeding season for males (PBM) and females that showed no sign of a nesting attempt (POF) included 1 June to 14 October.

Forest structure measurements at intensive turkey locations were analyzed using repeated measures analysis of variance. This was accomplished through the PROC MIXED procedure in SAS (SAS Institute Inc. 2004). This procedure utilizes maximum likelihood estimation, handles missing data points, and applies multiple comparison procedures to both between and within subject factors. It also provides for many covariance structures for the repeated measures and allows use of random effects within a repeated measures analysis.

All stem density, basal area, and understory vegetation data were square-root transformed prior to analyses to achieve normality. Following analyses the results were back-transformed (squared) for ease of interpretation. Therefore, all means presented for these categories are estimations and 95% confidence intervals are given in place of standard errors.

To asses the forest structure at turkey locations with respect to sex (SEX), season (SEA), and time-of-day (TOD), a combination of information-theoretic approach, and traditional hypothesis testing was used. I used Akaike's Information Criterion (AIC) to aid in the selection of the best covariance structures within the repeated measures design. Program Compmix (SAS Institute Inc. 1997) in SAS was used to test various covariance structures and rank them according to AICc values (AIC for small sample sizes). Covariance structures were tested using restricted maximum likelihood estimation (REML) and the most complex model as suggested by Ngo and Brand (1997). All covariance structures considered are found in Table 3.2.

Once appropriate covariance structures were determined a set of candidate models were considered to test the hypotheses that turkeys use areas with particular stem densities, basal areas, and groundcover conditions dependent upon the effects of season, sex of the individual, and time-of-day. In this manner all forest structure measurements were considered to be dependent (response) variables and season, sex, and time-of-day were considered to be independent (explanatory) variables. Overstory cover type (TYP) was also included in the models as an independent variable, but only to serve as a means of controlling its potential confounding effects with the other independent variables. This was based upon the *a priori* assumption that forest stem densities, basal areas, and ground cover conditions are correlated with the overstory cover type as well as the fact that the frequency of use within each cover type would likely differ by SEA, SEX and TOD. This justifies the use of both information theoretic approach and traditional hypothesis testing. Information theoretic approach allowed for identification of the most appropriate models while the F-values and *P*-values produced by the repeated measures analysis of variance allowed for better interpretation of the model effects, most notably, the potentially confounding TYP effect.

Pine stem density, hardwood stem density, total stem density (TSD), pine basal area, hardwood basal area, and total basal area (TBA) were all evaluated with respect to the model that was indicated as best by the compmix program. I also considered models that were within 4 AIC_c values of the best model as suggested by Burnham and Anderson (1998). The percentage of understory cover in grass (GRS), shrubs (SHB), forbs (FRB), and bare ground (BRG) were modeled using the same approach. Analysis of the interactions between SEA and SEX were not possible since the SEA factor already accounts for sex. As previously stated, TYP was considered in some of the models to investigate and control for its confounding effects on the other independent variables (Table 3.3).

Time specific movement rates of turkeys were calculated and assessed with respect to SEX, SEA, TOD, and TYP. These rates were intended to allow for the detection of TOD as an effect within the daily movements of turkeys and were calculated by dividing the distance between each successive telemetry location by the elapsed time. In addition, overall movement rates were modeled with respect to SEX and SEAS. This type of movement rate was calculated by dividing the sum of all successive distances by the elapsed time for the entire focal telemetry session. The distances for both types of movement rates were measured in meters by ArcView® v.3.2 and the rates are reported as meters per hour. A key for all season and independent variable abbreviations used is in Table 3.4

RESULTS

During 2004 and 2005, a total of 88 intensive telemetry sessions was conducted and each recorded between 4 and 14 individual turkey locations for a total of 659 turkey locations. Seven individual male and 20 individual female turkeys were subjects of the intensive telemetry. One male and 6 female turkeys were juveniles. Six turkeys were tracked in both years of the study.

Telemetry Error

Bearing error did not differ between the 2 observers (t=1.35, P=0.17) and the pooled mean bearing error was 13.4° (SE=0.85). Mean error distance did not differ between the 2 observers (t=0.99, P=0.32) and the pooled mean error distance was 40.5m (SE=5.00). This error distance extrapolates to a mean error area of 0.51 ha. When the cover type at actual test transmitter locations was compared to that of estimated test transmitter locations, the 2 were in agreement in 56 out of 70 test locations for a cover type classification accuracy rate of 80%.

Forest Structure – Stem Density

The model that was indicated as best for predicting hardwood stem density was the SEA+TYP model. No other models were within 4 ΔAICc values. Within this model HSD differed by SEA ($F_{5,521}$=3.81, P=0.002). Hardwood stem density was highest during the BOF and POF seasons with means of 486.3 (CI=379.2-606.7) and 551.7 (CI=411.0-713.0) stems per ha, respectively. While these 2 seasons did not differ from each other in HSD (t=-0.74, P=0.46) they did differ from most other seasons in pairwise comparisons (Table 3.5). Means for other seasons are shown in Table 3.6

Three models ranked closely together when pine stem density was considered. The top ranking model was SEX+TYP, while the TOD+TYP and SEA+TYP models were within 3.29 and 3.68 ΔAICc values, respectively. Within the TOD+TYP model PSD differed by TOD level

($F_{13,511}$= 1.76, *P*=0.05). However, PSD did not differ by SEX ($F_{1,524}$=0.19, *P*=0.66) or SEA ($F_{5,521}$=1.01, *P*=0.41) in their respective models indicating that most of the variation in the data was attributed to the TYP effect. In pairwise comparisons of pine stem density between TOD levels (Table 3.7), TOD levels 8, 13, and 14 were consistently present in significant comparisons with other levels. Pine stem density at these times were much lower than most other times with means of 78.3 (CI=35.8-137.4), 56.0 (CI=19.7-110.9), and 58.0 (CI=16.2-125.6) stems per ha, respectively. Means for other TOD levels can be found in Table 3.8.

Total stem density had SEA+TYP chosen as its best model. The SEA+TOD+TYP model was ranked second with a ΔAICc value of 3.26. In the SEA+TYP model TSD differed by SEA ($F_{5,521}$=2.56, *P*=0.03). In the SEA+TOD+TYP model TSD differed by both TOD ($F_{13,508}$=1.96, *P*=0.02) and SEA ($F_{5,508}$=2.42, *P*=0.04). Total stem density was highest at locations during the POF season with a mean of 856.7 (CI=645.4-1097.9) and lowest during the PBM season with a mean of 495.1 (CI=343.6-674.1). Results of all pairwise comparisons of TSD between seasons are shown in Table 3.9 and the remainder of seasonal means for TSD are shown in Table 3.6 (mean estimates were obtained from the SEA+TYP model to remain consistent with HSD and PSD means). Significant comparisons of TSD between TOD levels most often involved TOD levels 12, 13, and 14. Total stem density was consistent through the course of the TOD scale and dropped off significantly at levels 12, 13, and 14. These 3 levels had TSD means of 474.8 (CI=329.6-646.5), 456.4 (CI=313.3-626.5), and 398.0 (CI=244.6-588.7) stems per ha, respectively. Means of total stem density by TOD are shown in table 3.10 and significant pairwise comparisons between TOD levels in Table 3.11. All mean stem densities by stem class and sex are given in Table 3.12.

Forest Structure – Basal Area

The SEX+TYP model was ranked as the best model to estimate hardwood basal area and the SEA+TYP model was ranked second with a ΔAICc value of 3.29. In these 2 models mean HBA at turkey locations differed by SEX ($F_{1,524}$=4.17, *P*<0.04) but did not differ by SEA ($F_{5,521}$=1.88, *P*=0.10). Mean HBA was 9.1 (CI=8.1-10.2) at female locations and 7.6 (CI=6.2-9.1) m^2/ha at male locations.

For the pine basal area category the best model was SEA+TYP, although the SEX+TYP model was only 0.17 ΔAICc values different. Within these two models PBA at turkey locations did not differ by SEA ($F_{5,521}$=1.80, *P*=0.11) or SEX ($F_{1,521}$=0.19, *P*=0.66). In both of the models TYP was highly significant indicating that most of the variation in the PBA data could be attributed to the confounding TYP effect.

Total basal area was best approximated by the SEA+TYP model. No other models were within 4 ΔAICc values of this top-ranked model. Total basal area at turkey locations differed by SEA ($F_{5,521}$=5.06, *P*<0.001). Trends in pairwise comparisons of TBA between seasons were not apparent, although more than half of the comparisons were significant (Table 3.13). Total basal area at telemetry locations was lowest during the BRM season and highest during the POF season. Mean TBA was 17.0 (CI=14.8-19.4) in BRM and 23.3 (CI=20.6-26.2) m^2/ha in the POF season. The mean basal area at turkey locations in each basal area class, by season and sex are given in Tables 3.14 and 3.15, respectively.

Forest Structure – Understory

The SEA+TYP model was chosen as the top model for BRG percentage. No other models were within 4 ΔAICc values. The percentage of BRG at telemetry locations differed by SEA ($F_{5,521}$=5.86, *P*<0.001). The BRM and BNF seasons were noted as being part of most significant pairwise comparisons between seasons (Table 3.16). The BRM and BNF seasons both had the highest mean percentage of BRG with means of 40.4 (CI=33.8-47.5) and 36.7 (CI=31.6-42.2), respectively. These 2 seasons differed from all other seasons, but did not differ from each other (t=0.90, P=0.37).

The model chosen as best to predict percentage of groundcover in forbs was the SEA+TYP model. In this model percent forbs differed between seasons ($F_{5,521}$=7.16, P<0.001). The BRM and BNF seasons had the lowest mean percentages of FRB cover (8.6, CI=6.7-10.6; 9.0, CI=7.4-10.7) and were different from all other seasons, although they were not different from each other (t=-0.36, P=0.72). Table 3.17 gives results of all other seasonal comparisons. Forb ground cover averaged 11.3 (9.5-13.1), 12.1 (CI=9.9-14.6), 14.6 (CI=12.2-17.2), and 13.2 (CI=11.8-14.7) percent during BOF, POF, PBM, and PNF seasons, respectively.

The SEA+TYPE model was chosen as the best model for percentage of grass groundcover. No other models were within 4 ΔAICc units of this model. The percentage of groundcover in grasses at turkey locations differed by SEA ($F_{5,521}$=24.81, P<0.001). In pairwise comparisons of seasons (Table 3.18), GRS differed between all SEA pairs involving BNF except BRM-BNF (t=-0.79, P=0.43), and BNF-BOF (t=-0.41, P=0.68). Grass ground cover was lowest during the BRM and BNF seasons with means of 15.4 (CI=12.2-19.1) and 17.1 (CI=14.3-20.3) percent, respectively. Grass cover was greatest at locations during the PBM season with a mean of 25.6 (CI=21.4-30.2). All GRS cover means by season are given in Table 3.19.

The best approximating model for the shrub groundcover data was SEA+TYP. The SEA model was ranked next with a ΔAIC_c value of 2.61. The mean percentage of SHB cover at turkey locations differed by SEA ($F_{5,521}$=3.99, P=0.002) in the SEA+TYP model as well as the SEA model ($F_{5,527}$=4.71, P<0.001). Again, this indicates that TYP may be a small confounding effect and should be accounted for in analysis of SHB cover. In the SEA+TYP model mean percentage of SHB cover at turkey locations was lowest during the BRM season (19.8, CI=15.8-24.2) and highest during the PBM season (30.1, CI=25.2-35.5) (Table 3.19). Results of pairwise comparisons between seasons are given in table 3.20

Although no models including the SEX effect were used, Table 3.21 displays means for all groundcover categories by sex and is provided for informational purposes.

Daily Movements

When time specific movement rates were considered, the model chosen as best was the TYP model. The TYP+SEX model was ranked second and was within 1.34 AIC_c values and the TYP+SEA model was third with a ΔAIC_c of 2.95.

In the TYP model time specific movement rates differed by TYP ($F_{5,536}$=3.27, P=0.004). Movement rates were greatest when turkeys were in swamp habitat which had a mean of 393.0 (CI=215.3-570.7) meters per hour. Movement rates were least when turkeys were in fields (202.1, CI=140.0-264.2), hardwood drains (202.1, CI=172.8-231.5), high-density mixed (147.9, CI=80.6-215.3), and low-density mixed (146.4, CI=60.6-232.2) cover types. Mean time-specific movement rates are given in Table 3.22 and significant pairwise comparisons between seasons in Table 3.23.

In the TYP+SEX model time specific movement rates did not differ between the sexes ($F_{1,537}$=0.73, P=0.39), but did differ within TYP ($F_{6,537}$=2.84, P=0.01). When using the TYP+SEA model, time specific movement rates did not differ within SEA ($F_{5,534}$=1.54, P=0.18) but, again differed within TYP ($F_{6,534}$=3.03, P=0.006).

The SEX model was top-ranked when overall movement rates were modeled. No other models were within 4 AIC_c values. In this model overall movement rates differed by SEX

($F_{1,61}$=2.90, *P*=0.05). Males moved at faster overall rates with a mean of 241.4 (CI=195.6-287.3) meters per hour while females averaged 190.3 (CI=166.3-214.4) (Table 3.24).

This study concentrated on wild turkey habitat use as it relates to forest structure rather than major cover types. Nonetheless, it was deemed appropriate to include data on how turkeys used major cover types throughout the course of a day and how each of the forest structure variables differed at turkey locations within each cover type. These data are presented in graphical form in Figures 3.4-3.8 and in tabular form in Table 3.25, respectively.

DISCUSSION

The somewhat unique data collection and analysis methodologies in this study made comparisons to previous studies difficult. In the results of all analyses, estimations of means in each forest structure category were taken from models that included the Type effect. Therefore, the confounding effect of cover type has been accounted for or "partialed out" (Hopkins 2000) within each model and results should be interpreted without considering the correlation between cover type and each forest structure category.

All forest structure categories with the exception of pine stem density, hardwood basal area, and pine basal area included the season effect within its best model. Although the seasons in this study only concentrated on roughly half of the year, this period includes one of the most important times in wild turkey ecology—the reproductive season. My results suggest that turkeys in this area utilize areas of different forest structure based on their reproductive status and the time of year.

In the stem density categories, hardwood stem density was higher at locations used by nonnesting hens in both the breeding and postbreeding periods and was lowest at locations used by males and nesting hens, during the postbreeding season. On this study site, areas of high hardwood stem density were almost always in parts of hardwood drains that were thick and appeared to have escaped prescribed fire for many years. These areas often contained little understory vegetation, and young midstory hardwood trees comprised the largest part of the stem tallies. Approximately half of the hens in the nonnesting categories were juvenile. Juvenile hens that have not been alive for one complete annual cycle may have been using areas of high stem density because they may not yet be experienced enough to utilize areas of lower stem density that are thought to provide better foraging habitat. Since breeding-nonnesting and postbreeding-nonnesting female seasons also contained adult hens that did not nest, these results may suggest that hens, juvenile and adult alike, which are not in reproductive condition, may not be compelled to move into areas of lower hardwood stem density where gobblers often reside, in search of breeding opportunities. In addition, these hens may have felt lower predation risks in areas where hardwood stem densities were higher.

Time of day had an effect on the locations turkeys used with respect to pine stem density. Pine stem density was relatively stable through the course of the day, but dropped off during the final 2 time-of-day levels. Areas of lower pine stem density were often locations that contained greater forb and grass cover. Turkeys may have been moving to areas where pine stem density was lower in order to feed prior to roosting. Hillstead and Speake (1971) reported that hens in east-central Alabama exhibited peaks in feeding activity in the morning and then again in the evening. A decrease in pine stem density at the end of the day could also be caused by turkeys choosing to roost in areas where pine stem density was low. Other studies have documented preferred roost sites that are composed of large, mature trees (Rumble 1992, Chamberlin et al. 2000, Wakeling et al. 2001). While these 2 measures are not directly comparable, stands on this study site with a larger component of younger trees tended to have higher stem densities and stands of large mature trees often had low stem density counts.

Turkeys in this study commonly moved to the area where they would ultimately roost several hours before sunset and remained there before flying up to roost in the hour surrounding sunset. The literature is nearly void of studies reporting wild turkey habitat use in relation to time-of -day. In South Carolina it was reported that gobblers were located in pastures with the highest frequency in the early morning and late afternoon and the use of mixed hardwood-pine stands steadily increased from early morning to late afternoon. Gobblers also increased their use of pine and hardwood stands following early morning, but decreased use in these types after midday (Fleming and Webb 1974).

In all seasons, mean hardwood stem density at turkey locations was considerably greater than pine stem density. Since the confounding cover type effect is accounted for, I believe this to be caused by the composition of different forest structures resulting from bobwhite management that are present on the study site. Most forested areas on the site that contain pine species are those upland areas managed for the bobwhite. These areas contain low pine stem densities and are often in stark contrast to the drainages and other odd areas that escape intensive management and usually contain high hardwood stem densities. This is not to say that areas of high pine stem density do not exist, just that these types of areas are far less common on this study site.

Within the total stem density category, season and time-of-day were again shown to have an effect. Differences between seasons were nearly the same as those in the hardwood stem density category, therefore the effect of season on total stem density is likely a result of the hardwood component that makes up this category. Likewise, time-of-day was noted as being a factor influencing total stem density, but since the same trend between time-of-day levels was found in total stem density as in pine stem density, then it is probable that this is a result of the pine component of total stem density.

Hardwood basal area, on average, was higher at female locations than at male locations. Areas with higher hardwood basal area often had more canopy closure and less ground level vegetation. Hens may have been using areas of higher hardwood basal area because these areas have more open understories that allow them to feel safer due to less visual obstruction at ground level. To the contrary, low basal area stands were often very open and contained abundant understory vegetation. Therefore, gobbler use of low-basal area stands could be a result of the desire of males to utilize forested areas that are more open and provide unobstructed, long-distance vision, as suggested by Stoddard (1963).

Total basal area was lowest during the breeding male and breeding-nesting female seasons (17.0 and 17.2 m^2/ha, respectively). Hens in Arkansas preferred stands with basal areas of 20-24 m^2/ha and avoided stands >24 m^2/ha in the spring (Wigley et al. 1985). In males the low mean total basal area could be explained by gobblers seeking out more open areas for display or seeking out females for breeding who were using low basal area sites. Mean low basal area at breeding-nesting female locations can most likely be explained by their search for suitable nest sites. Numerous studies have demonstrated low basal areas at nest sites, or understory conditions that are a product of low basal areas (Still and Baumann 1990, Badyaev 1995, Lazurus and Porter 1980). Total basal area at male locations during the postbreeding season remained low with a mean of 18.1 m^2/ha, which is comparable to what was found of gobblers in Arkansas who preferred stands with 15-20 m^2/ha and avoided stands >24 m^2/ha in the summer. However, locations of nesting hens in the postbreeding season showed an increase in total basal area from their breeding season locations with mean of 20.8 m^2/ha, suggesting the transition from low-basal area nesting sites to a higher basal area summer range. Hens in Okalahoma used pine plantations with mean basal areas of < 14.5 m^2/ha more in the summer than any other season (Bidwell et al. 1989).

In the ground cover categories mean percentage of ground cover in shrubs, grasses, and forbs were all lowest at locations during the breeding male and breeding-nesting female seasons. Additionally, these 2 seasons had the 2 highest mean bare ground percentages among all the seasons. These results, with respect to the breeding-nesting hen season, are somewhat perplexing given that one would expect hens during this season to spend some amount of time in areas that are representative of preferred nesting habitat. Chamberlain and Leopold (1998) discuss the importance of understory with abundant herbaceous and grass cover for hens during prenesting periods. Nesting hens in Arkansas selected cover types that had greater understory cover with more complex and variable structure (Badyaev 1995) and hens in Minnesota chose nest sites with open forest canopies that allowed dense woody and herbaceous ground cover (Lazarus and Porter 1980). It may be that breeding hens during the nesting season are in these areas of prime nesting habitat for only a short amount of time, perhaps just long enough to lay an egg, and then return to areas with less ground cover. Hens tracked during this season routinely moved along or within short distances of the ecotone that separated two stand types that had vastly different amounts of groundcover. However, Palmer et al. (1996) did report that preincubation hens in Mississippi were located closer to creeks than what would be expected at random. On this study site nearly all of the creeks were in sections of hardwood drains where understory was lacking.

The postbreeding male season was always opposite of the breeding-nesting female and breeding male seasons by having the greatest shrub, forb, and grass ground cover percentages and the least amount of bare ground. Since breeding activities had ceased by this season, gobblers were no longer seeking hens for breeding and were less likely to be in those stands where ground cover was low, these being preferred by hens.

For time-specific movement rates the swamp type habitat had too few observations for proper analysis. Time-specific movement rates were least in fields, hardwood drains, high-density mixed, and low-density mixed stands. This implies that these habitats are more preferred as feeding, loafing, or escape cover than other types since lower movement rates mean the birds are spending more time in these cover types. Perhaps turkeys moved at faster rates through low-density pine and high-density pine stands because they either did not feel as safe in these types or did not prefer these areas for feeding or loafing. Williams and Austin (1988) have previously discussed the correlation between habitat quality and both daily and seasonal movements, stating that poor habitat quality causes turkeys to move farther distances and at faster rates.

There are few instances of daily or hourly movement rates reported in the literature. Thogmartin (2001) reported that during the reproductive period, adult hens in Arkansas moved an average of 438 meters per day and subadult hens moved 552 meters per day. Movement rates in that study were greatest during April and June. In Louisiana, hens moved an average of 373 meters per day in spring and 230 meters per day in summer (Smith and Teitelbaum 1986). Daily movements of nonnesting hens in Alabama averaged 0.4 miles (642 m) during the reproductive season and daily feeding and general movements were usually linearly aligned. Laying hens often roosted, fed, and loafed within 500 yards (450 m) of their nests (Hillstead and Speak 1971). Overall movement rates in this study would produce daily movements of over 2 km if extrapolated to a daily distance (assuming an average day length of 13 hours). However, each of the previous studies calculated distances moved by using the Euclidian distance between locations at the beginning and end of the day or between locations on successive days. Since movement rates in this study were calculated between successive locations that were often less than 45 minutes apart, a better estimate of actual distances traveled by turkeys was obtained. I believe that movement distances would have been similar to the other studies had they been calculated in the same manner, considering that turkeys in this study rarely traversed areas in a straight line. Movement vectors of turkeys often zigzagged across the landscape in a seemingly random manner and frequently intersecting paths traveled just hours earlier. This alone, may suggest that turkeys on this study site during these seasons had near-optimum habitat conditions and did not have to travel far or to specific areas to meet their daily needs.

RECOMMENDATIONS

This study strengthens the argument for the importance of maintaining high diversity for optimal wild turkey habitat. It has shown that turkeys on this study site utilized areas of differing forest structures based mostly on season, but also on sex and time-of-day. This was the case even within the same forest cover type. If land and wildlife managers wish to have a site that is conjointly managed for bobwhite and wild turkey habitat, then I recommend a management plan that encourages a diversity of cover types and forest structures. While low-basal area stands created for bobwhite management are certainly suitable for wild turkeys, these stands should not be expected to meet all of their needs in every season and every part of their life cycle. Well dispersed among these upland, low-basal area stands should be large patches or even entire stands of both pine and hardwood species at higher stem densities. Most importantly, I believe in the importance of retaining hardwood drainage areas and promoting the diversity within them.

This could be accomplished by periodically allowing prescribed fires to creep into these areas as well as through selection thinnings or by selective herbicide use.

More research is needed on the effects of forest structure and bobwhite management on wild turkey habitat use. In particular, other seasons and other aspects of life history such as brood-rearing need to be addressed within this topic. Since an increasing trend among some bobwhite plantations it to manage for the removal of nearly all hardwood stems, the effects of this, too, should be investigated with respect to the wild turkey.

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Table 3.1 Key for forestry measurement abbreviations used in the text of chapter 3.

Abbreviation	Meaning	Units of Measurement
Stem Density		
HSD	Hardwood Stem Density	stems/ha
PSD	Pine Stem Density	stems/ha
TSD	Total Stem Density	stems/ha
Basal Area		
HBA	Hardwood Basal Area	m^2 /ha
PBA	Pine Basal Area	m^2 /ha
TBA	Total Basal Area	m^2 /ha
Understory Groundcover		
BRG	Bare Ground or leaf litter	%
FRB	Forbs	%
GRS	Grasses	%
SHB	Shrubs or woody vines	%

Table 3.2 Candidate covariance structures for repeated measures analysis of forest structure at turkey locations in Grady and Thomas counties, Georgia, 2004-2005.

	Covariance Structures[a]	
Model Number	**Random Effect[b]**	**Repeated Effect[c]**
1	VC	VC
2	VC	AR(1)
3	VC	CS
4	AR(1)	AR(1)
5	AR(1)	VC
6	AR(1)	CS

[a]Covariance structures are: AR(1)-first order autoregressive, CS-compound symmetry, VC-variance components

[b]In all cases the subject identification number (bird id) was used as the random effect.

[c]In all cases the intensive telemetry session (session id) was the effect that contained repeated measurements

Table 3.3 Candidate models for analysis of forest structure at turkey locations, Grady and Thomas counties, Georgia, 2004-2005.

Model Number	**Model Effects**	**Model Number**	**Model Effects**
1	SEA[a]	7	TOD*SEA
2	SEX	8	TOD*SEX
3	TOD[b]	9	TOD*SEA+TYP
4	SEA+TYP[c]	10	TOD*SEX+TYP
5	SEX+TYP	11	SEA+TYP+TOD
6	TOD+TYP	12	SEX+TYP+TOD

[a]Season

[b]Time-of-Day

[c]Cover Type

*Indicates interaction between the two effects.

Table 3.4 Key for season and independent variable abbreviations used in the text of chapter 3.

Abbreviation	Meaning
Seasons	
BRM	Breeding Male
BNF	Breeding-nesting Female
BOF	Breeding-nonnesting Female
PBM	Postbreeding Male
PNF	Postbreeding-nesting Female
POF	Postbreeding-nonnesting Female
Independent Variables	
SEA	Sex
SEX	Season
TOD	Time-of-day
TYP	Overstory Cover Type

Table 3.5 Pairwise comparisons of hardwood stem density at turkey locations between seasons, Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		***t*-value**	***P*-value**
BRM	BNF	-0.81	0.42
BRM	BOF	-1.52	0.13
BRM	**POF**	**-2.01**	**0.05**
BRM	PBM	1.41	0.16
BRM	PNF	0.54	0.59
BNF	BOF	-0.81	0.42
BNF	POF	-1.43	0.15
BNF	**PBM**	**2.26**	**0.02**
BNF	PNF	1.72	0.09
BOF	POF	-0.74	0.46
BOF	**PBM**	**3.00**	**0.003**
BOF	**PNF**	**2.64**	**0.01**
POF	**PBM**	**3.28**	**0.001**
POF	**PNF**	**3.04**	**0.002**
PBM	PNF	-1.13	0.26

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.6 Means and 95% CIs of stem density (stems/ha) at turkey locations by stem class and season, Grady and Thomas counties, Georgia, 2004-2005.

	Hardwood Stem Density		Pine Stem Density		Total Stem Density	
Season[a]	**Mean[b]**	**95% CI**	**Mean[c]**	**95% CI**	**Mean[d]**	**95% CI**
BRM	368.5	258.1 - 498.5	122.3	65.4 - 196.8	599.1	430.1 - 796.0
BNF	428.8	326.7 - 544.7	97.6	55.5 - 151.6	689.4	538.2 - 859.2
BOF	486.3	379.2 - 606.7	177.1	118.6 - 247.3	788.7	626.9 - 969.0
PBM	268.4	175.4 - 381.3	117.3	62.3 - 189.5	495.1	343.6 - 674.1
PNF	334.7	268.2 - 408.5	126.2	89.9 - 168.8	586.7	485.5 - 697.4
POF	551.7	411.0 - 713.0	137.0	75.0 - 217.4	856.7	645.4 - 1097.9

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, PBM – postbreeding male, PNF – postbreeding-nesting female, and POF – postbreeding-nonnesting female.

[b]Means differ between some seasons ($F_{5,521}$=3.81, P=0.002)

[c]Means do not differ between seasons ($F_{5,521}$=1.01, P=0.41)

[d]Means differ between some seasons ($F_{5,521}$=2.56, P=0.03).

Table 3.7 Significant pairwise comparisons of pine stem density at turkey locations between time-of-day levels, Grady and Thomas counties, Georgia, 2004-2005.

Time-of-day[a] Pair		***t*-value**	***P*-value**	**Time-of-day Pair**		***t*-value**	***P*-value**
1	13	2.10	0.04	6	13	2.62	0.01
2	8	2.25	0.02	6	14	2.27	0.02
2	13	2.82	0.005	7	13	2.27	0.02
2	14	2.46	0.01	7	14	1.96	0.05
3	8	2.33	0.02	8	9	-2.54	0.01
3	13	2.92	0.004	9	10	1.97	0.05
3	14	2.51	0.01	9	12	2.10	0.04
4	8	2.03	0.04	9	13	3.19	0.002
4	13	2.65	0.01	9	14	2.75	0.01
4	14	2.27	0.02	11	13	2.40	0.02
5	13	2.18	0.03	11	14	2.03	0.04
6	8	2.04	0.04				

[a]Time-of-day levels (1-14) are categories for fractional portions of the sunlit day and are used to standardize time across different months of the year. While each level accounts for 7.5% of the day, the true amount of time occupied by each level depends on the time of year. Level 1 is prior to sunrise, level 8 encompasses midday, and level 14 approximates sunset.

Table 3.8 Mean and 95% confidence intervals of pine stem density at turkey locations by time-of-day, Grady and Thomas counties, Georgia, 2004-2005. Stem densities are recorded in stems/ha.

Time-of-day Level[a]	Mean	95% Confidence Interval
1	143.5	76.6 - 231.3
2	163.0	106.5 - 231.5
3	160.0	109.3 - 220.4
4	149.6	98.6 - 211.1
5	129.8	83.1 - 186.7
6	149.8	98.5 - 211.8
7	137.7	85.3 - 202.6
8	78.3	35.8 - 137.4
9	170.1	111.6 - 240.9
10	102.3	59.0 - 157.5
11	135.6	84.1 - 199.4
12	88.6	40.8 - 154.7
13	56.0	19.7 - 110.9
14	58.0	16.2 - 125.6

[a]Time-of-day levels (1-14) are categories for fractional portions of the sunlit day and are used to standardize time across different months of the year. While each level accounts for 7.5% of the day, the true amount of time occupied by each level depends on the time of year. Level 1 is prior to sunrise, level 8 encompasses midday, and level 14 approximates sunset.

Table 3.9 Pairwise comparisons of total stem density at turkey locations between seasons, Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		***t*-value**	***P*-value**
BRM	BNF	-0.78	0.44
BRM	BOF	-1.57	0.12
BRM	POF	-1.82	0.07
BRM	PBM	0.90	0.37
BRM	PNF	0.13	0.90
BNF	BOF	-0.91	0.36
BNF	POF	-1.27	0.21
BNF	PBM	1.74	0.08
BNF	PNF	1.19	0.23
BOF	POF	-0.50	0.62
BOF	**PBM**	**2.55**	**0.01**
BOF	**PNF**	**2.23**	**0.03**
POF	**PBM**	**2.67**	**0.01**
POF	**PNF**	**2.40**	**0.02**
PBM	PNF	-0.96	0.34

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.10 Mean and 95% confidence intervals of total stem density at turkey locations by time-of-day, Grady and Thomas counties, Georgia, 2004-2005. Stem densities are recorded in stems/ha.

Time-of-day Level[a]	Mean	95% Confidence Interval
1	576.8	404.3 - 779.8
2	719.6	567.1 - 890.3
3	691.0	555.6 - 841.2
4	657.8	521.8 - 809.4
5	727.2	585.5 - 884.3
6	771.7	622.0 - 937.6
7	673.3	524.5 - 840.5
8	682.1	513.1 - 875.1
9	712.7	560.0 - 883.8
10	687.4	539.9 - 852.6
11	727.8	574.4 - 899.3
12	474.8	329.6 - 646.5
13	456.4	313.3 - 626.5
14	398.0	244.6 - 588.7

[a]Time-of-day levels (1-14) are categories for fractional portions of the sunlit day and are used to standardize time across different months of the year. While each level accounts for 7.5% of the day, the true amount of time occupied by each level depends on the time of year. Level 1 is prior to sunrise, level 8 encompasses midday, and level 14 approximates sunset.

Table 3.11 Significant pairwise comparisons of total stem density at turkey locations between time-of-day levels, Grady and Thomas counties, Georgia, 2004-2005.

Time-of-day[a] Pair		***t*-value**	***P*-value**	**Time-of-day Pair**		***t*-value**	***P*-value**
2	12	2.26	0.02	7	13	2.05	0.04
2	13	2.44	0.02	7	14	2.38	0.02
2	14	2.75	0.01	8	13	2.09	0.04
3	12	2.14	0.03	8	14	2.43	0.02
3	13	2.33	0.02	9	12	2.38	0.02
3	14	2.64	0.01	9	13	2.57	0.01
4	13	2.00	0.05	9	14	2.86	0.004
4	14	2.35	0.02	10	12	2.14	0.03
5	12	2.43	0.02	10	13	2.34	0.02
5	13	2.62	0.01	10	14	2.64	0.01
5	14	2.90	0.004	11	12	2.57	0.01
6	12	2.78	0.01	11	13	2.73	0.01
6	13	2.96	0.003	11	14	2.98	0.003
6	14	3.21	0.001				

[a]Time-of-day levels (1-14) are categories for fractional portions of the sunlit day and are used to standardize time across different months of the year. While each level accounts for 7.5% of the day, the true amount of time occupied by each level depends on the time of year. Level 1 is prior to sunrise, level 8 encompasses midday, and level 14 approximates sunset.

Table 3.12 Means and 95% CIs of stem density at turkey locations by hardwood, pine, and total for each sex, Grady and Thomas counties, Georgia, 2004-2005. All stem densities are reported as stems/ha.

Basal Area Class	Mean	95% Confidence Interval
Hardwood[a]		
Female	409.2	335.6 - 490.0
Male	320.8	222.1 - 437.6
Pine[b]		
Female	131.5	101.0 - 166.0
Male	119.8	74.6 - 175.6
Total[c]		
Female	678.8	577.7 - 788.0
Male	553.5	409.7 - 718.7

[a]Means do not differ between sexes (t=2.08, P=0.14).

[b]Means do not differ between sexes (t=0.19, P=0.66).

[b]Means do not differ between sexes (t=2.01, P=0.16).

Table 3.13 Pairwise comparisons total basal area at turkey locations between seasons in Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		***t*-value**	***P*-value**
BRM	BNF	-0.09	0.93
BRM	**BOF**	**-1.82**	**0.07**
BRM	**POF**	**-3.68**	**<0.001**
BRM	PBM	-0.73	0.47
BRM	**PNF**	**-2.89**	**0.004**
BNF	**BOF**	**-1.97**	**0.05**
BNF	**POF**	**-3.99**	**<0.001**
BNF	PBM	-0.68	0.50
BNF	**PNF**	**-3.33**	**0.001**
BOF	**POF**	**-2.29**	**0.02**
BOF	PBM	1.04	0.30
BOF	PNF	-0.98	0.33
POF	**PBM**	**2.93**	**0.004**
POF	PNF	1.79	0.07
PBM	**PNF**	**-1.98**	**0.05**

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.14 Means and 95% confidence intervals of basal area at turkey locations by season and basal area class, Grady and Thomas Counties, Georgia, 2004-2005. Basal areas are recorded as m^2/hectare.

	Hardwood Basal Area		Pine Basal Area		Total Basal Area	
Season[a]	**Mean[b]**	**95% CI**	**Mean[c]**	**95% CI**	**Mean[d]**	**95% CI**
BRM	6.9	5.3 - 8.7	7.2	5.3 - 9.5	17.0	14.8 - 19.4
BNF	8.1	6.6 - 9.7	4.9	3.6 - 6.5	17.2	15.3 - 19.2
BOF	8.8	7.2 - 10.4	7.2	5.5 - 9.0	19.6	17.6 - 21.8
PBM	8.1	6.4 - 10.1	6.9	4.9 - 9.2	18.1	15.8 - 20.6
PNF	9.2	8.0 - 10.5	7.0	5.6 - 8.6	20.8	19.2 - 22.4
POF	10.3	8.3 - 12.5	7.4	5.4 - 9.8	23.3	20.6 - 26.2

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female, POF – postbreeding-nonnesting female.

[b]Means do not differ between seasons ($F_{5,521}$=1.88, P<0.10).

[c]Means do not differ between seasons ($F_{5,521}$=1.80, P=0.11).

[d]Means differ between some seasons ($F_{5,521}$=5.06, P<0.001).

Table 3.15 Means and 95% confidence intervals of basal area at turkey locations by pine, hardwood and total for each sex, Grady and Thomas counties, Georgia, 2004-2005. Basal areas are reported as m^2/hectare.

Basal Area Class	Mean	95% Confidence Interval
Hardwood[a]		
Female	9.1	8.1 - 10.2
Male	7.6	6.2 - 9.1
Pine[b]		
Female	6.7	5.6 - 7.9
Male	7.1	5.4 - 9.2
Total[c]		
Female	20.0	18.6 - 21.5
Male	17.7	15.6 - 20.0

[a]Means differ between sexes (t=2.04, P<0.04).

[b]Means do not differ between sexes (t=0.44, P=0.66).

[c]Means differ between sexes (t=3.71, P=0.05).

Table 3.16 Pairwise comparisons of the percentage of bare ground at turkey locations between seasons, Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		***t*-value**	***P*-value**
BRM	BNF	0.90	0.37
BRM	**BOF**	**2.62**	**0.01**
BRM	**POF**	**2.50**	**0.01**
BRM	**PBM**	**3.88**	**<0.001**
BRM	**PNF**	**4.01**	**<0.001**
BNF	**BOF**	**1.99**	**0.05**
BNF	**PBM**	**3.30**	**0.001**
BNF	**PNF**	**3.62**	**<0.001**
BOF	POF	0.22	0.83
BOF	PBM	1.54	0.12
BOF	PNF	1.24	0.21
POF	PBM	1.14	0.26
POF	PNF	0.78	0.43
PBM	PNF	-0.66	0.51

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.17 Pairwise comparisons of the percentage of forb ground cover at turkey locations between seasons, Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		***t*-value**	***P*-value**
BRM	BNF	-0.36	0.72
BRM	**BOF**	**-2.12**	**0.03**
BRM	**POF**	**-2.43**	**0.02**
BRM	**PBM**	**-4.13**	**<0.001**
BRM	**PNF**	**-3.93**	**<0.001**
BNF	**BOF**	**-2.02**	**0.04**
BNF	**POF**	**-2.35**	**0.02**
BNF	**PBM**	**-4.06**	**<0.001**
BNF	**PNF**	**-4.24**	**<0.001**
BOF	POF	-0.63	0.53
BOF	**PBM**	**-2.28**	**0.02**
BOF	PNF	-1.82	0.07
POF	PBM	-1.42	0.16
POF	PNF	-0.80	0.42
PBM	PNF	1.02	0.31

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.18 Pairwise comparisons of percentage of grass ground cover at turkey locations between seasons in Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		*t*-value	*P*-value
BRM	BNF	-0.79	0.43
BRM	BOF	-1.14	0.25
BRM	**POF**	**-3.48**	**0.001**
BRM	**PBM**	**-3.93**	**<0.001**
BRM	**PNF**	**-3.75**	**<0.001**
BNF	BOF	-0.41	0.68
BNF	**POF**	**-3.11**	**0.002**
BNF	**PBM**	**-3.44**	**0.001**
BNF	**PNF**	**-3.45**	**0.001**
BOF	**POF**	**-2.73**	**0.01**
BOF	**PBM**	**-3.07**	**0.002**
BOF	**PNF**	**-2.90**	**0.004**
POF	PBM	-0.20	0.84
POF	PNF	0.69	0.49
PBM	PNF	0.97	0.33

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.19 Mean percentage of ground at turkey locations covered by bare ground, forbs, grasses, and shrubs, by season, Grady and Thomas counties, Georgia, 2004-2005.

	Bare Ground		Forbs		Grasses		Shrubs	
Season[a]	**Mean**[b]	**95% CI**	**Mean**[c]	**95% CI**	**Mean**[d]	**95% CI**	**Mean**[e]	**95% CI**
BRM	40.4	33.8 - 47.5	8.6	6.7 - 10.6	15.4	12.2 - 19.1	19.8	15.8 - 24.2
BNF	36.7	31.6 - 42.2	9.0	7.4 - 10.7	17.1	14.3 - 20.3	20.7	17.3 - 24.4
BOF	30.0	25.4 - 35.0	11.3	9.5 - 13.1	18.0	15.0 - 21.1	23.3	19.8 - 27.2
POF	29.2	23.5 - 35.5	12.1	9.9 - 14.6	25.0	20.7 - 29.7	26.5	21.7 - 31.7
PBM	24.7	19.7 - 30.3	14.6	12.2 - 17.2	25.6	21.4 - 30.2	30.1	25.1 - 35.5
PNF	26.7	23.5 - 30.0	13.2	11.8 - 14.7	23.3	20.9 - 25.9	25.6	22.7 - 28.7

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

[b]Means differ between some seasons ($F_{5,521}$=5.86, P<0.001).

[c]Means differ between some seasons ($F_{5,521}$=7.16, P<0.001).

[d]Means differ between some seasons ($F_{5,521}$=24.81, P<0.001).

[e]Means differ between some seasons ($F_{5,521}$=3.99, P=0.002).

Table 3.20 Pairwise comparisons of percentage of shrub ground cover at turkey locations between seasons in Grady and Thomas counties, Georgia, 2004-2005.

Season[a] Comparison Pair		*t*-value	*P*-value
BRM	BNF	-0.35	0.72
BRM	BOF	-1.31	0.19
BRM	**POF**	**-2.11**	**0.04**
BRM	**PBM**	**-3.52**	**0.001**
BRM	**PNF**	**-2.31**	**0.02**
BNF	BOF	-1.09	0.28
BNF	**POF**	**-1.99**	**0.05**
BNF	**PBM**	**-3.19**	**0.002**
BNF	**PNF**	**-2.46**	**0.01**
BOF	POF	-1.11	0.27
BOF	**PBM**	**-2.24**	**0.03**
BOF	PNF	-1.00	0.32
POF	PBM	-1.00	0.32
POF	PNF	0.33	0.74
PBM	PNF	1.60	0.11

[a]Season codes are: BRM – breeding male, BNF – breeding-nesting female, BOF – breeding-nonnesting female, POF – postbreeding-nonnesting female, PBM – postbreeding male, and PNF – postbreeding-nesting female.

Table 3.21 Mean and 95% CIs of percent groundcover at turkey locations by groundcover class and sex, Grady and Thomas counties, Georgia, 2004-2005.

Groundcover Class	Mean	95% Confidence Interval
Bare Ground[a]		
Female	29.4	26.6 - 32.4
Male	31.6	26.7 - 36.9
Forbs[b]		
Female	11.9	10.7 - 13.1
Male	11.5	9.7 - 13.6
Grasses[c]		
Female	21.1	19.1 - 23.3
Male	20.4	17.1 - 24.0
Shrubs[d]		
Female	24.3	22.2 - 26.5
Male	25.1	21.5 - 28.9

[a]Means do not differ between sexes (t=-0.80, P=0.42)

[b]Means do not differ between sexes (t=0.30, P=0.77)

[c]Means do not differ between sexes (t=0.41, P=0.68)

[d]Means do not differ between sexes (t=-0.30, P=0.70)

Table 3.22 Mean and 95% CIs of time-specific movement rates (m/h) of turkeys by overstory cover type, Grady and Thomas counties, Georgia, 2004-2005. Movement rates are termed time-specific since they were calculated between each successive telemetry location.

Cover Type[a]	**Mean**[b]	**95% Confidence Interval**
Field	202.1	140.0 - 264.2
Hardwood Drain	202.1	172.8 - 231.5
HD Mixed	147.9	80.6 - 215.3
HD-Pine	231.0	177.0 - 285.1
LD-Mixed	146.4	60.6 - 232.2
LD-Pine	270.0	228.9 - 311.2
Swamp	393.0	215.3 - 570.7

[a]HD and LD labels indicate cover types that are high stem density and low stem density stand types, subjectively defined by assessing tree canopy coverage in an infrared satellite image.

[b]Means differ between some cover types ($F_{5,536}$=3.27, P=0.004)

Table 3.23 Significant pairwise comparisons of time specific movement rates of turkeys between cover types, Grady and Thomas counties, Georgia, 2004-2005.

Cover Type[a] Comparison Pair		***t*-value**	***P*-value**
Drain	LD-Pine	-2.80	0.01
Drain	Swamp	-2.10	0.04
Field	Swamp	-2.00	0.05
HD-Pine	HD-Mixed	1.95	0.05
LD-Mixed	LD-Pine	-2.60	0.01
LD-Mixed	Swamp	-2.46	0.01
LD-Pine	HD-Mixed	3.10	0.002
HD-Mixed	Swamp	-2.55	0.01

[a]HD and LD labels indicate cover types that are high stem density and low stem density stand types, subjectively defined by assessing tree canopy coverage in an infrared satellite image.

Table 3.24 Means and 95% confidence intervals of overall movement rates of turkeys by sex, Grady and Thomas counties, Georgia, 2004-2005. Overall movement rates are reported as m/h.

Sex	Mean[a]	95% CI
Female	190.3	166.3 - 214.4
Male	241.4	195.6 - 287.3

[a]Means differ between sexes (t=1.97, P=0.05)

* Overall movement rates are the sum of all distances between each telemetry location within an intensive telemetry session, divided by the total elapsed time.

Table 3.25 Means and standard errors for all forest structure variables by cover type, based on all telemetry locations, Grady and Thomas counties, Georgia, 2004-2005. The number of telemetry locations used for analysis is shown in parenthesis with each cover type.

	HW-Drain (295)		**Field (55)**		**HD[b]-Mixed (46)**		**HD-Pine (75)**		**LD[c]-Mixed (30)**		**LD-Pine (152)**	
Variable[a]	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
PSD	144.6	14.33	277.3	41.22	197.8	27.84	542.7	56.62	192.5	36.71	223.5	19.73
HSD	1081.7	36.03	206.8	38.05	718.5	70.43	330.3	43.26	403.3	125.70	131.3	13.05
TSD	1226.3	38.83	484.1	57.96	916.3	74.85	873.0	81.80	595.8	130.21	354.8	24.00
PBA	4.2	0.23	8.0	1.01	12.0	0.81	14.8	0.83	8.5	0.84	10.5	0.40
HBA	19.5	0.51	2.0	0.37	11.3	0.78	3.2	0.43	5.3	0.47	2.7	0.23
TBA	23.7	0.44	10.1	1.03	23.3	0.81	18.0	0.87	13.8	0.81	13.2	0.40
GRS	16.5	0.55	34.0	2.22	23.3	1.66	25.1	1.14	23.8	2.08	29.7	0.94
SHB	24.5	0.73	22.8	1.37	28.0	1.30	28.8	1.36	27.5	1.75	32.0	0.89
FRB	9.3	0.34	17.8	0.86	14.1	1.31	15.6	0.63	16.5	1.23	16.0	0.50
BRG	42.0	1.15	18.7	0.87	30.7	2.42	22.5	1.72	23.0	2.76	21.2	0.95

[a]Variable codes and (units of measurement) are: PSD-pine stem density (stems/ha), HSD-hardwood stem density (stems/ha), TSD-total stem density (stems/ha), PBA-pine basal area (m^2/ha), HBA-hardwood basal area (m^2/ha), TBA-total basal area (m^2/ha), GRS-grass (%), SHB-shrub (%), FRB-forb (%), BRG-bare ground (%)

[b]HD-high density

[c]LD-low density

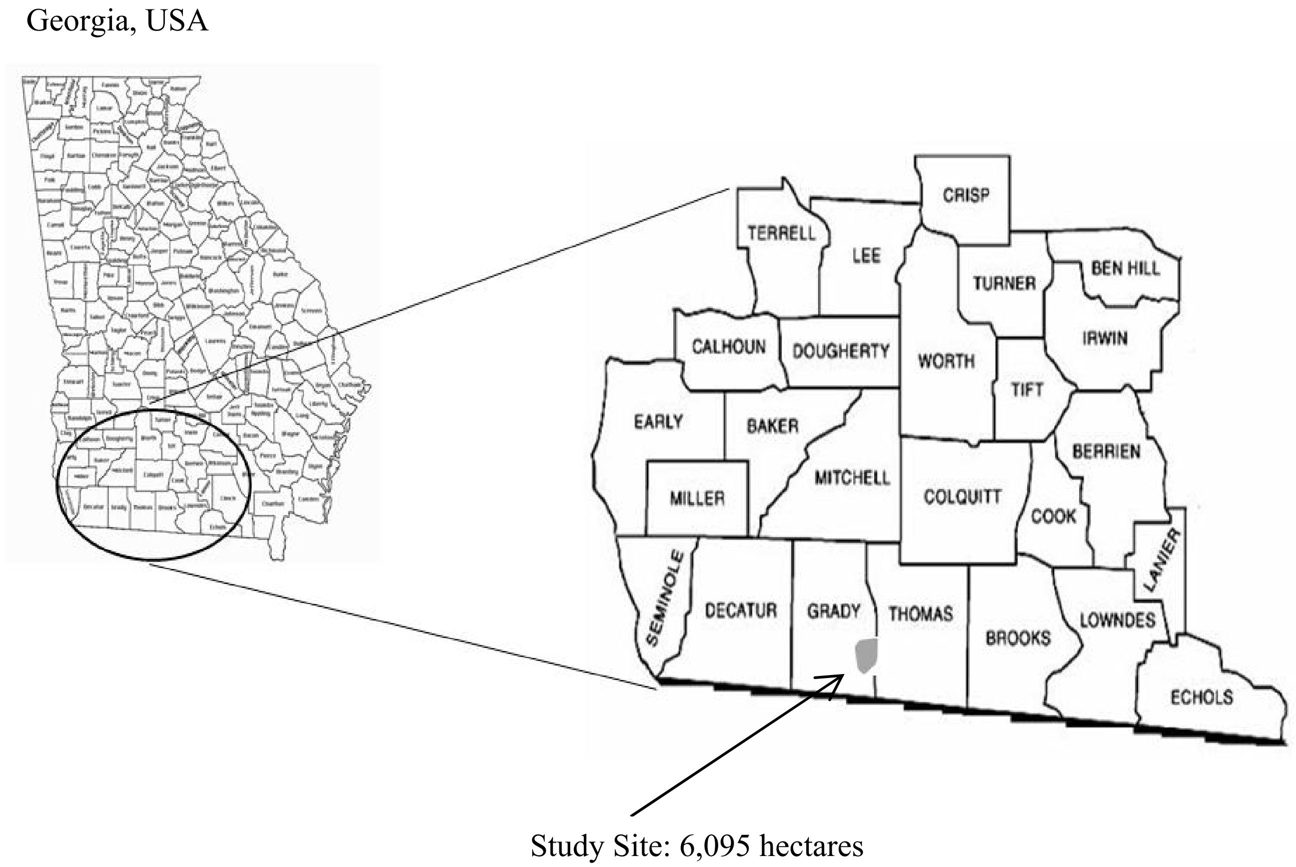


Figure 3.1 Study site location, Grady and Thomas counties, Georgia.

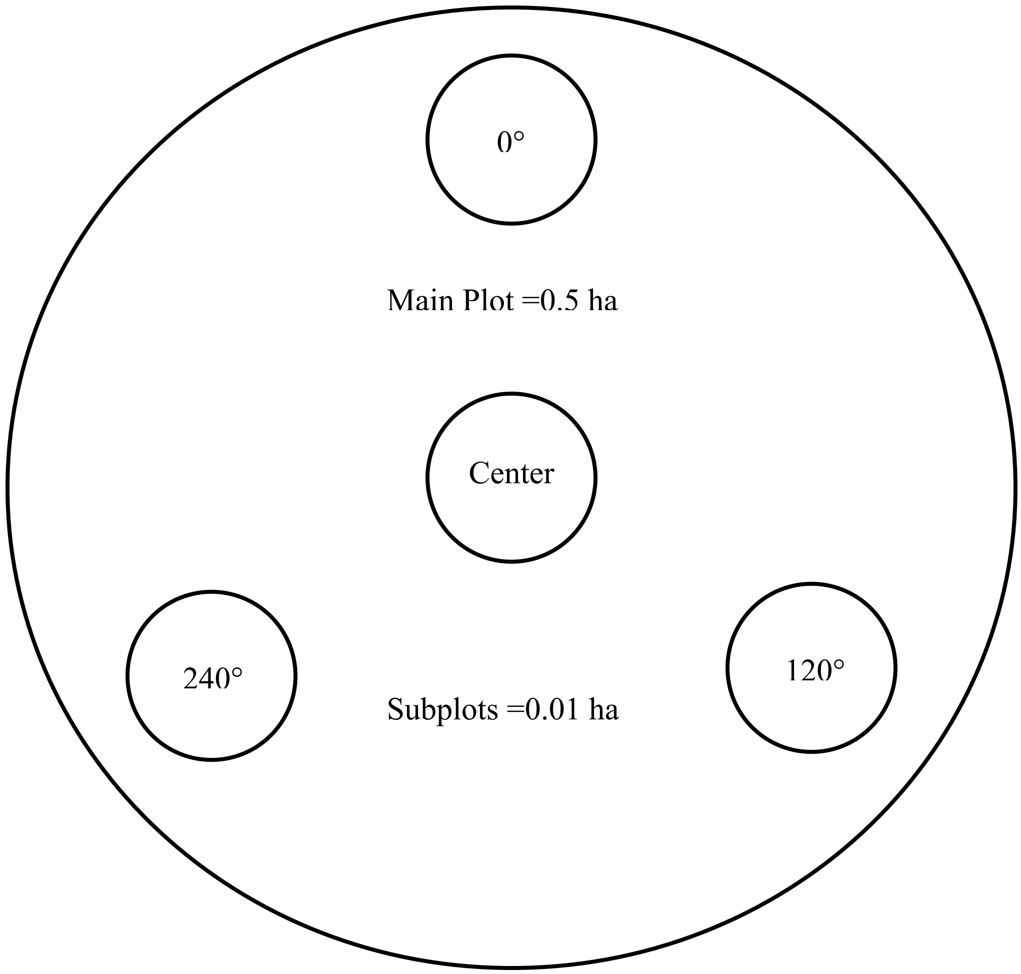


Figure 3.2. Layout of main plot and subplots for forestry vegetation measurements at turkey locations, Grady and Thomas counties, Georgia, 2004-2005.

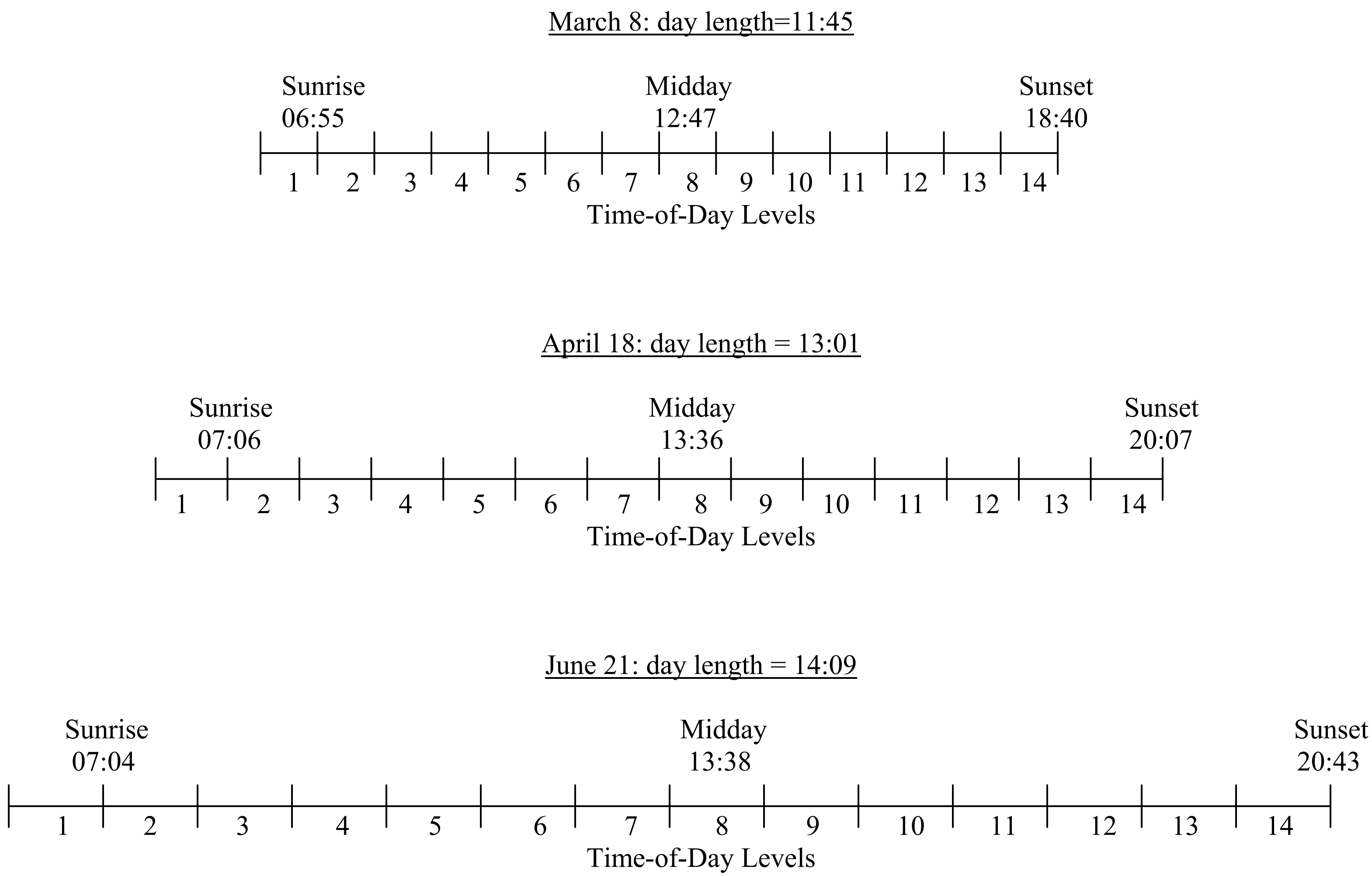
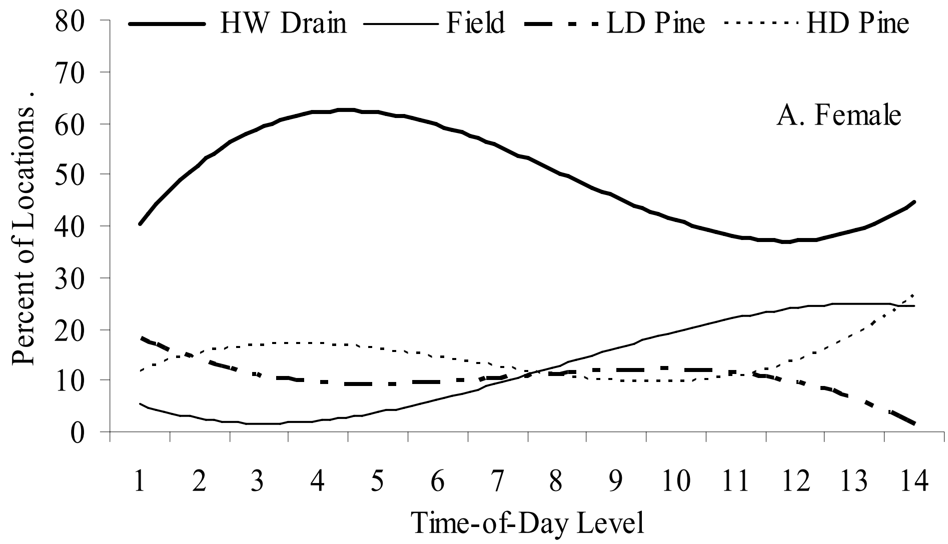


Figure 3.3. Illustration of time-of-day levels used in the data analysis and how day length differs at different times of the year, Grady and Thomas Counties, Georgia.



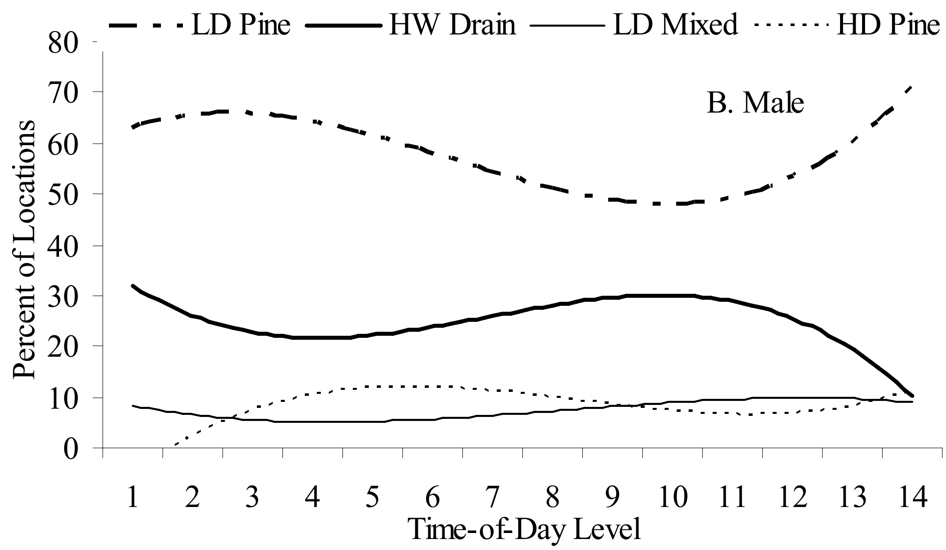


Figure 3.4. Trend lines of percent of telemetry locations in the four most used cover types by time-of-day by, A) female and B) male turkeys, Grady and Thomas counties, Georgia, 2004-2005. Cover type abbreviations are: HW Drain- hardwood drain, LD Pine- low-density pine, HD Pine- high-density pine, and LD Mixed- low-density mixed.

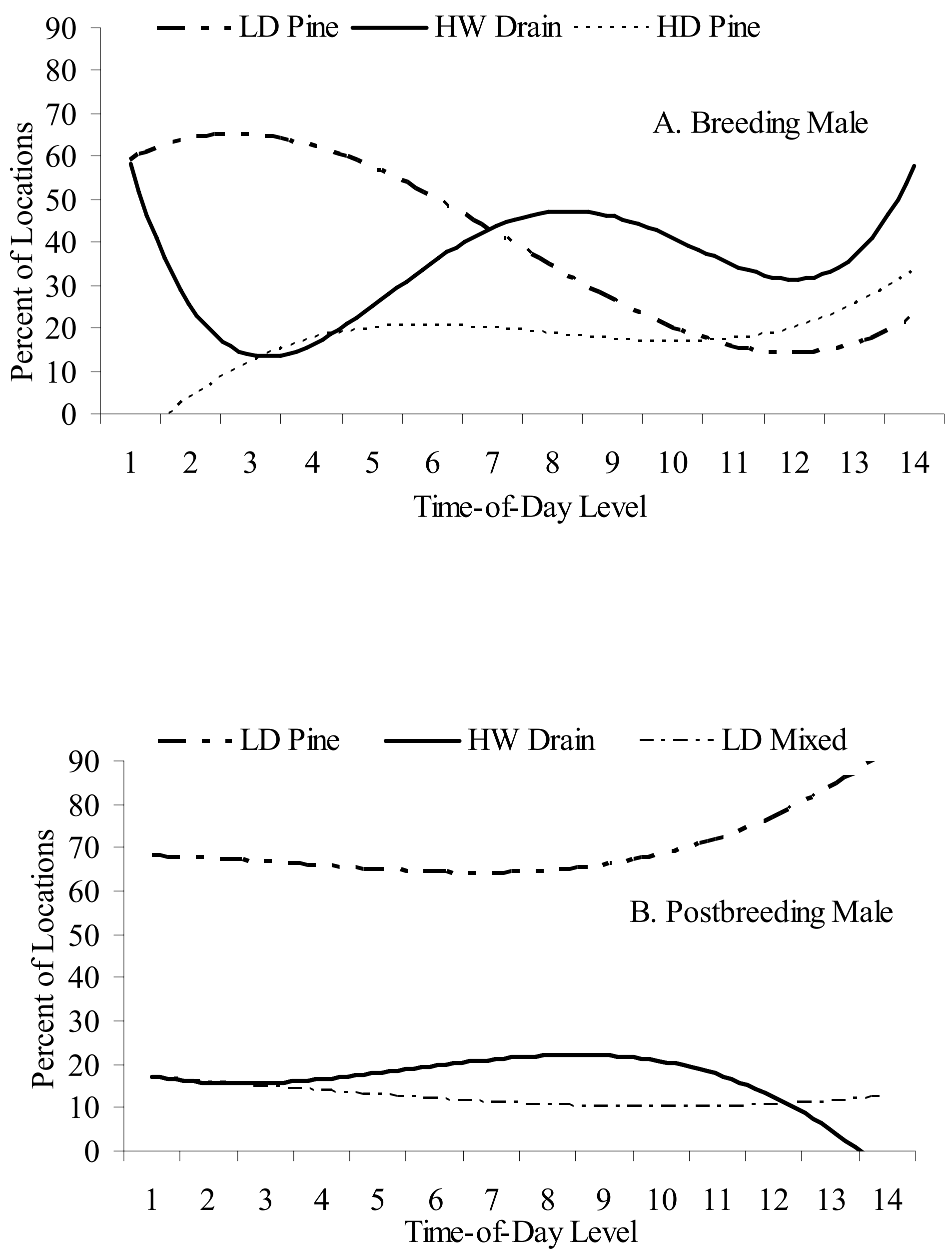


Figure 3.5. Trend lines of percent of telemetry locations in the three most used cover types by time-of-day within A) breeding male and B) postbreeding male seasons, Grady and Thomas counties, Georgia, 2004-2005. Cover type abbreviations are: LD Pine- low-density pine, HW Drain- hardwood drain, HD Pine- high-density pine, and LD Mixed- low-density mixed.

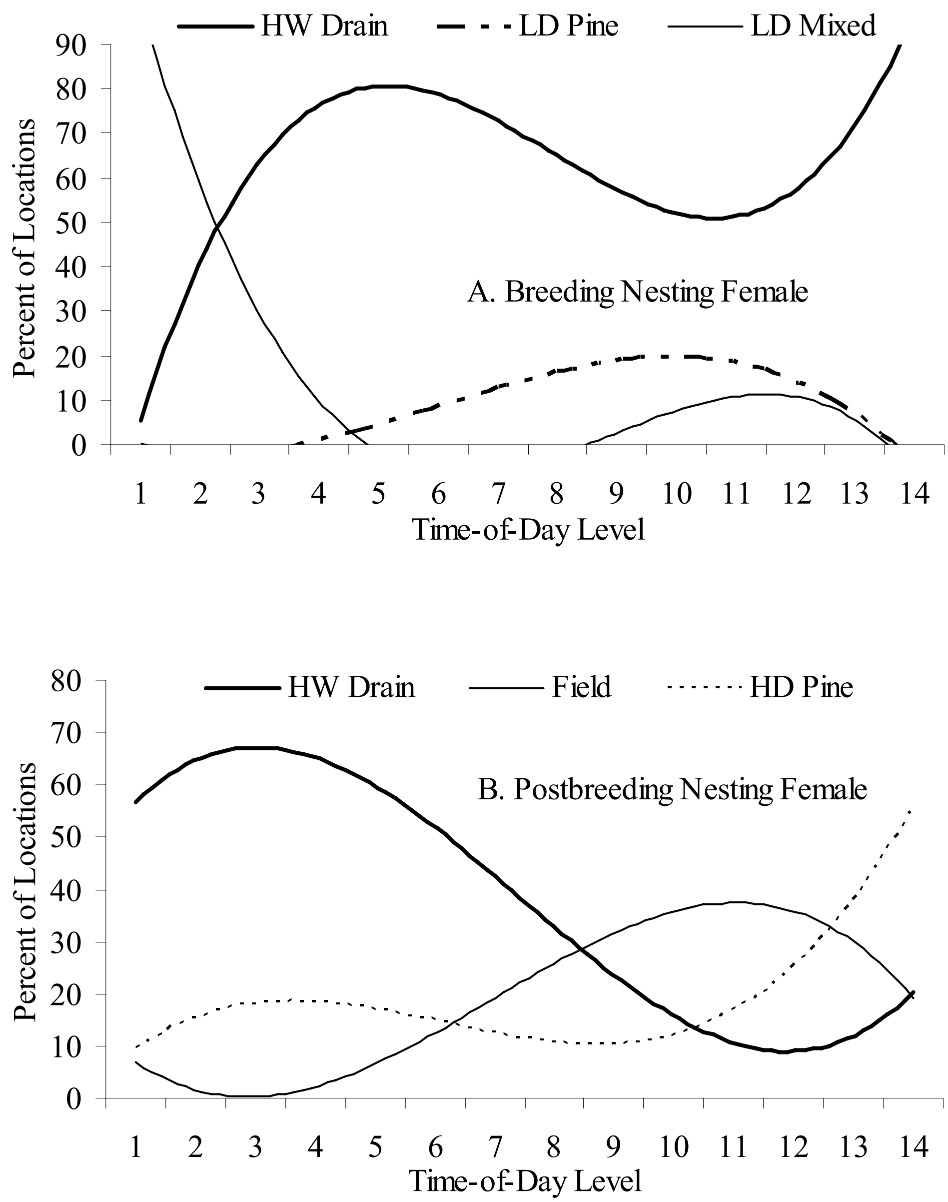


Figure 3.6. Trend lines of percent of telemetry locations in the three most used cover types by time-of-day of A) breeding-nesting and B) postbreeding nesting female seasons, Grady and Thomas counties, Georgia, 2004-2005. Cover type abbreviations are: HW Drain- hardwood drain, LD Pine- low-density pine, LD Mixed- low-density mixed, and HD Pine- high-density pine.

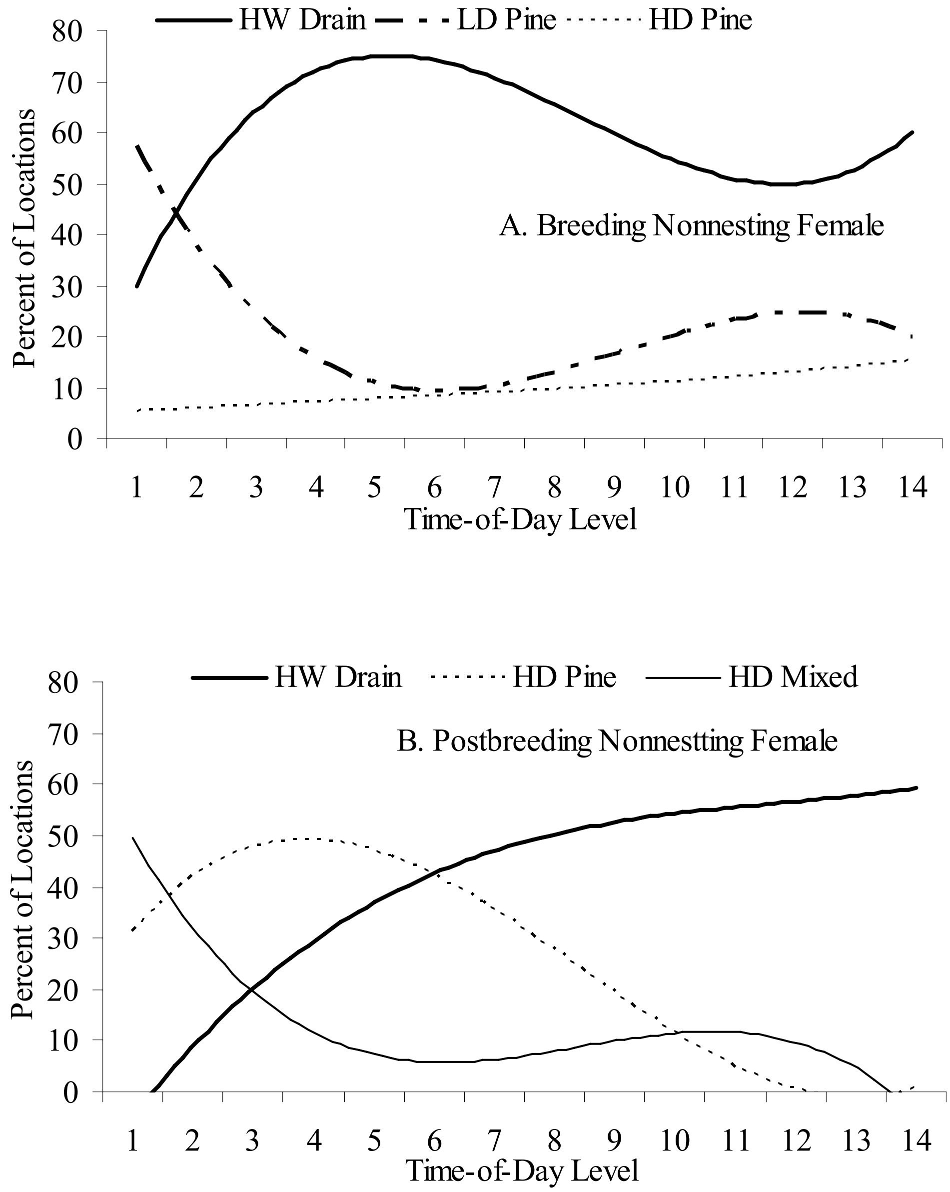


Figure 3.7. Trend lines of percent of telemetry locations in the three most used cover types by time-of-day of A) breeding-nonnesting and B) postbreeding nonnesting female seasons in Grady and Thomas counties, Georgia, 2004-2005. Cover type abbreviations are: HW Drain- hardwood drain, LD Pine- low-density pine, HD Pine- high-density pine, and HD Mixed- high-density mixed.

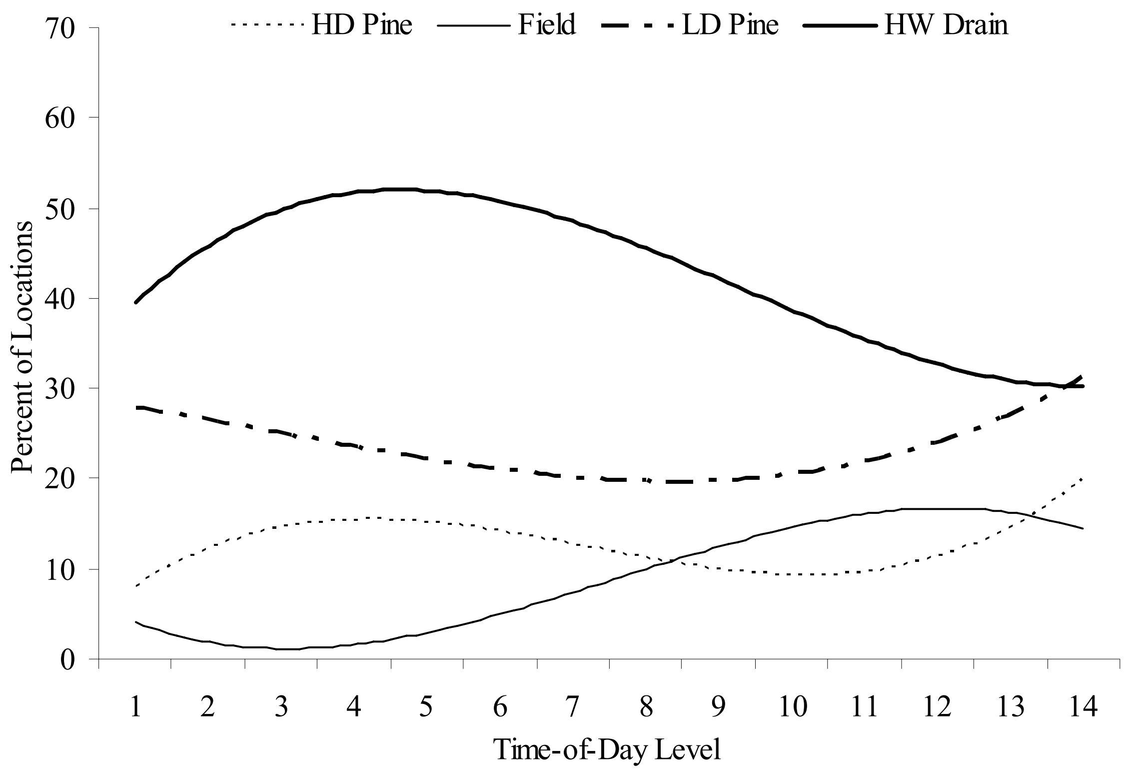


Figure 3.8. Trend lines of percent of telemetry locations in the four most used cover types by time-of-day for all wild turkey telemetry locations, Grady and Thomas counties, Georgia, during 2004-2005. Cover type abbreviations are: HD Pine- high-density pine, LD Pine- low-density pine, HW Drain- hardwood drain.

CHAPTER 4

USE OF MINIATURE VIDEO CAMERAS TO MONITOR WILD TURKEY NESTS IN SOUTHERN GEORGIA

Juhan, S. M., Jr., J. P. Carroll, and W. E. Palmer. To be submitted to the Journal of Wildlife Mangement

CHAPTER 4

USE OF MINIATURE VIDEO CAMERAS TO MONITOR WILD TURKEY NESTS IN SOUTHERN GEORGIA

INTRODUCTION

Within the population dynamics of any ground-nesting bird, losses due to nest predation and hen predation are always a concern. Most wild turkey survival studies indicate that mortality rates of hens are usually highest during the reproductive season, and a high percentage of mortality during the nesting season is attributed to predation of the hen while on the nest (Everett et al. 1980, Seiss et al 1990, Palmer et al. 1993). The most common method for identifying culprit species of nest predation and hen predation events is *ex post facto* examination of clues at the nest site such as scat, hair, egg shell fragments, hen carcass condition, and so forth (Hernandez et al. 1997). However, some have questioned the validity and accuracy of this technique (Lariviere 1999, Martin 1987, Major ad Kendal 1996). Accurate identification of wild turkey nest predator species may be important to wildlife managers, especially in areas where nest predation is thought to be limiting turkey populations.

In the context of the following chapter *nest predation* is defined as any event whereby an egg or eggs are removed from the nest, eaten, or otherwise destroyed, regardless of whether or not the hen abandons the nest. The term *hen predation* is used to refer to the depredation of a hen by a predator while on the nest, and *nest abandonment* is used to refer to the desertion of the nest by the hen regardless of the action that caused the abandonment.

Use of video monitoring equipment to identify nest predator species has been shown to be useful in northern bobwhite (*Colinus virginianus*) (Staller 2001) and grassland passerine (Pietz and Granfors 2000) research. Although the use of still photography has been used to successfully document wild turkey nest predators (Pharris and Goetz 1980, Lehman 2005), the use of video monitoring equipment for this purpose has yet to be reported as a technique used in wild turkey research. In addition to nest predation, other interesting information can be gleaned from nest video data such as hen reaction to predators, timing and frequency of hen recess, and other behaviors. This study used miniature, infrared-illuminated video camera systems to record nest predation and hen predation events, as well as on-nest behaviors of hens. While predation events, predator species and on-nest behaviors are reported here, the main goal was to evaluate the efficacy of using this technology in wild turkey research.

METHODS

Study Area

This study was conducted on 3 contiguous plantation properties located in Grady and Thomas Counties, Georgia (Figure 4.1). Pebble Hill Plantation, Springwood Plantation, and Willow Oak Plantation total approximately 2,770 ha. This area is situated in the Red Hills region of the Gulf Coastal Plain in southern Georgia. Springwood and Willow Oak are owned and managed by private individuals, while Pebble Hill is owned by the Pebble Hill Plantation Foundation and is managed by Tall Timbers Research Station and Land Conservancy of Tallahassee, FL. All 3 properties are managed for northern bobwhite hunting.

Capture and Radio Telemetry

I captured wild turkey hens during January, February, and December 2003; January, November and December 2004; and January and February 2005 using 3- and 4-projectile rocket nets (Bailey et al. 1980). Backpack-style radio transmitters (Advanced Telemetry Systems, Isanti, MN) operating in the 150-151 MHz range with an 8-hour mortality delay and 1,000-day battery life were fitted to each turkey using elastic bungee harnesses.

During the months of March through July, hens were located using triangulation telemetry techniques (White and Garrott 1990) and direct observation, 4-5 days per week. Triangulation telemetry was accomplished from both fixed and roving stations where at least 3 bearings were recorded. The fixed stations were made up of 138 points set up at various locations across the study area. Roving stations were located anywhere convenient and were recorded using coordinates given by a hand-held Global Positioning System (GPS). Telemetry was accomplished using a hand-held, 3-element yagi antenna and a Telonics TR-2, Advanced Telemetry Systems R2000, or Wildlife Materials International TRX-2000S telemetry receiver. Estimations of locations were calculated by using the triangulation program DogTrack™ (Foresters Inc., Blacksburg, VA). Hens that were found to be in the same location on 2 consecutive days were assumed to be nesting. I confirmed nesting status by using homing techniques (White and Garrott 1990) and approached the suspected nest site no closer than 20 m. Once I had an idea of the potential nest site I returned to the area at another time when I was able to confirm that the hen was away during a recess. At this time I verified nesting status, counted all eggs present, and installed the video monitoring equipment.

Video Monitoring

The video monitoring equipment used in this study consisted of a miniature, infrared-illuminated camera, 12-volt, deep-cycle marine battery, video cassette recorder (vcr) housed in a weatherproof box, and a vcr-to-camera connection cable. Only the camera system was located in the immediate vicinity of the nest with the connection cable connecting it to the vcr and battery located approximately 25 m away. Cameras were installed on stakes or suitable saplings at a distance of 1-1.5 m from the nest and a height of 0.75-1.25 m. All equipment was camouflaged using natural vegetation and small amounts of camouflage netting.

Hens were allowed to incubate nests for at least 5 days before the equipment was installed to decrease the chance of nest abandonment caused by the presence of the equipment. Monitoring continued until the eggs hatched, were depredated, or were abandoned by the hen. In cases were the hen abandoned the nest, and the eggs were still intact, I continued to monitor the nest by video to record potential egg predator species. I reviewed all video footage in its entirety and recorded all important events such as predator species, hen reaction to predators, and times the hen left for and returned from recess. For the footage recorded at abandoned nests I recorded egg predator species and times of the depredation events.

RESULTS

Preliminary results indicated that a straight-line distance from the camera lens to the nesting hen that was greater than 1.5 m substantially decreased the ability to capture quality footage at night. Additionally, it was noted that cameras placed closer than 0.75 m restricted the field of vision to the point that predator species could potentially attack hens on the nest without being seen on tape.

In the course of the 3-year study, I recorded footage of 8 incubating hens totaling more than 2,000 hours of video. Frequency of nest recess for these 8 hens was highly variable. The frequency of nest recess was 0.71 (SD = 0.27) recesses per day or roughly 3 recesses in every 4 days. The mean time hens left the nest for recess was 14:48 (SD = 3:00). The mean time they returned from recess was 15:51 (SD = 2:53) yielding a mean duration of recess of 1 hour and 3 minutes (SD = 53 min).

From the 8 active nests videoed, I captured 2 hen depredations, 1 nest depredation, 3 events that caused nest abandonment, and 3 nest hatches. One hen was depredated by a bobcat (*Lynx rufus*) and the other a coyote (*Canis latrans*) (Table 4.1). One nest was partially depredated by a nine-banded armadillo while the hen was on recess. Two hens were forced to abandon their nests by bobcats and one other by a coyote.

In addition, I recorded >1,600 hours of footage on 9 nests that had previously been abandoned by hens. Nest predation on these abandoned nests occurred on 24 separate occasions (Table 4.2). Since the majority of the events featured predators returning to the nest within a few minutes or hours of the first appearance, I only considered depredations by the same species on the same nest separate events if they were separated by more than 24 hours. Opossum (*Didelphis virginiana*) (Figure 4.2a) and nine-banded armadillo (*Dasypus novemcinctus*) were the 2 most common nest predators with 10 and 6 depredation events, respectively. American crow (*Corvus brachyrhynchos*), bobcat (Figure 4.3), gray rat snake (*Elaphe obsolete spiloides*) (Figure 4.2b), and coyote (Figure 4.4a) were also captured on film eating eggs with 3, 2, 2, and 1 nest predation events, respectively.

I recorded 1 instance of an unbanded hen dumping an egg into an abandoned nest that was not hers. This hen did not return on future occasions to dump additional eggs.

DISCUSSION AND RECCOMMENDATIONS

Williams and Austin (1988) are one of the few studies in the literature that calculate and report frequency and duration of hen nest recess in the same manner as this study. Frequency of recess was lower for Florida hens in that study with a mean of 0.55, or roughly one recess every 2 days. Mean duration of recess reported by Williams and Austin (1988) was greater than this study at more than 1.5 hours. Hillstead and Speak (1971) reported recess duration in the range of

20-60 minutes for hens in Alabama. Although Williams and Austin (1988) report that the majority of hen recesses were in the afternoon, they do say that some 37% of recesses occurred in the morning hours. This is contrary to my findings in that only 20% of hens in this study recessed in the morning. However, differences between these studies may not be biologically nor statistically significant due to their low sample sizes.

Results of nest and hen predation events recorded via video are both interesting and informative. Predator species recorded are common and concur with what has previously been reported in the literature (Davis 1959, Stoddard 1963, Williams et al. 1980). Even with the aid of video, assigning predator species to egg depredation by inspecting nest evidence and egg shell remnants was difficult. In this study, indicators at nests and characteristics of egg shell remnants often varied within predator species. Egg shell fragments were frequently subjected to rapid alteration by fire ants (*Solenopsis invicta*). In addition, many of the eggs were carried out of view of the camera. While the species that removed the egg could be determined, there was not always 100% certainty that other species did not alter the egg shell remains prior to being assessed by researchers. Multiple predator species were frequently recorded visiting nest sites in the same 24-hour period.

In this study, results were limited by frequent equipment malfunction and hen abandonment caused by the presence of the camera equipment. In 2004, 2 abandonments were attributed to the camera equipment, compared to 4 in 2005. It could not be determined what aspects of the camera set-up caused hens to abandon their nests. Cameras and associated equipment were always camouflaged to the greatest extent possible with precautions being taken to not disturb the nest bowl, eggs, or surrounding vegetation.

Use of video surveillance equipment to monitor wild turkey nests certainly has utility in wild turkey research, but still needs further study. Due to the high rates of nest abandonment caused by the equipment I would recommend that this methodology only be employed in studies where turkey populations are healthy and a large number ($\geq$30) of hens are radio-tagged.

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Table 4.1 Five instances of nesting hen turkey depredation attempts that were recorded on video, Grady and Thomas counties, Georgia, 2004-2005.

Predator Species	**Time of Day for Attempt**	**Successful?**
Bobcat[a]	19:26	No
Bobcat	0:09	No
Bobcat	18:25	Yes*
Coyote[b]	6:09	Yes*
Coyote	night[c]	No

[a]*Lynx rufus*

[b]*Canis latrans*

[c]No time available due to equipment malfunction.

*Dead hen located within 24 hours.

Table 4.2 Number of turkey nest depredation events and median time of depredation by predator species, Grady and Thomas counties, Georgia, 2004-2005. All depredations with the exception of one were on nests that had previously been abandoned by the hen.

Species[a]	**Number of Events**[b]	**Median Time**	**Range**
Nine-banded Armadillo	6	19:45	15:47-06:09*
Bobcat	2	23:09	20:02-02:16*
Coyote	1	21:24	n/a
American Crow	3	16:36	15:17-17:56
Gray Rat Snake	2	14:54	13:46-16:02
Virginia Opossum	10	01:45	22:06-04:51*

[a]Scientific names ordered from top to bottom: *Dasypus novemcinctus*, *Lynx rufus, Canis latrans, Corvus brachyrhynchos*, *Elaphe obsoleta spiloides*, *Didelphis virginiana.*

[b]Depredations by the same species on the same nest were not considered separate events unless they were separated by more than 24 hours.

*Time ranges for predators that are primarily nocturnal begin in the afternoon or evening and extend into the morning hours of the next day, thus these ranges appear reversed.

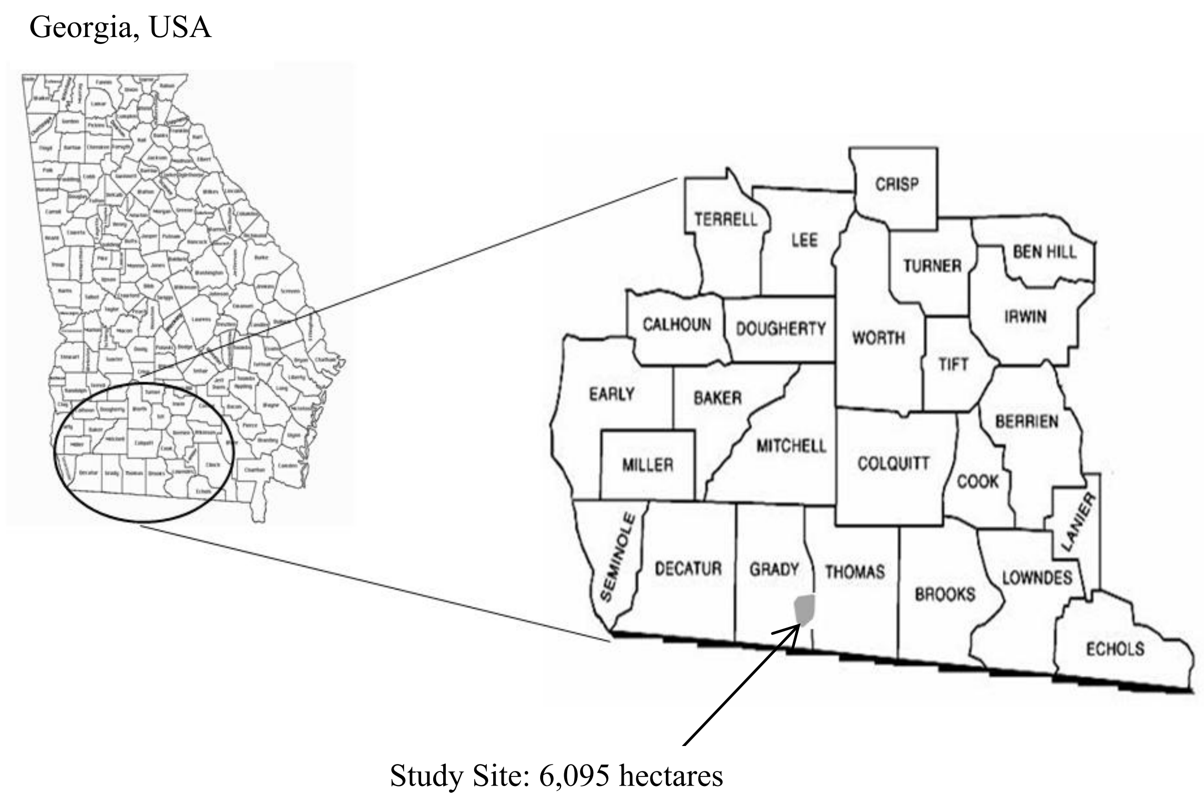

Figure 4.1 Study site location, Grady and Thomas counties, Georgia.

A.

B.

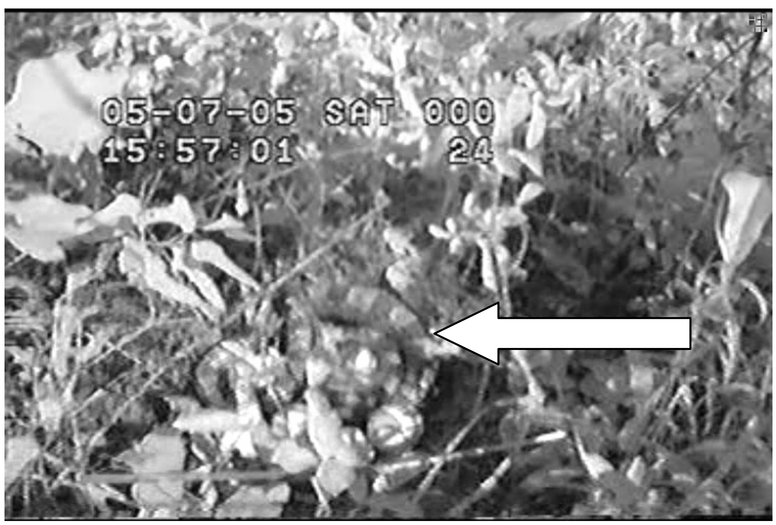

Figure 4.2 Still-frame images of a A.) Virginia opossum (*Didelphis virginiana*) and B.) gray rat snake (*Elaphe obsoleta spiloides*) (center of image) taken from wild turkey nest videos in Grady and Thomas counties, Georgia, 2004-2005.

A.

B.

Figure 4.3 Still-frame images of bobcats (*Lynx rufus*) taken from turkey nest videos after unsuccessful hen depredation attempts in Grady and Thomas counties, Georgia, 2004. The bobcat in A.) never returned to consume the eggs, but the bobcat in B.) returned in 2 hours to consume several eggs (note partially opened egg near center of image).

A.

B.

Figure 4.4 Still-frame images of A.) coyote (*Canis latrans*) (head, top left under time and date) and B.) wild turkey (*Meleagris gallopavo*) hen turning her eggs, taken from turkey nest videos in Grady and Thomas counties, Georgia, 2004-2005.

CHAPTER 5

CONCLUSION

HABITAT USE

This research used two methods to address the habitat use of wild turkeys on southern Georgia bobwhite plantations. First, I used general overstory cover types and radio telemetry to assess seasonal habitat use of both male and female turkeys using compositional analysis (Aebischer et al.1993). Secondly, a more detailed evaluation of habitat use in relation to forest structure was accomplished using intensive radio telemetry. This method allowed the recording of sequential locations of individual turkeys throughout the span of a day. These locations were revisited and various forest structure attributes were recorded and ultimately compared between seasons, sexes, and times of the day. Within this analysis I also examined the daily movement rates of turkeys.

The analysis of general habitat use indicated the importance of the hardwood drain habitat for turkeys on this study site. At both the 2nd and 3rd orders of analysis (Johnson 1980) the hardwood drain habitat was preferred by hens in most seasons. In the seasons where this type was not top-ranked, it was second- or third-ranked. Male turkeys in this study preferred the low-density pine stands most. In most seasons the second-ranked habitat for males was the hardwood drain. In most sexes and seasons, the swamp and field habitats were the least preferred types. Preference for the high-density pine, low-density mixed, and high-density mixed cover types was variable and depended upon sex, season, and scale of use (order).

With the analyses of the forest structure data, I was able to show how wild turkeys require a diversity of stem densities, basal areas, and ground cover conditions based on sex, reproductive status, and time of year. Areas that hens preferred had higher tree stem density and basal area than those preferred by gobblers. Within the hens, locations of nonnesting hens had higher stem densities and basal areas than did locations of nesting hens. While time-of-day was found to be a factor in two forest structure categories, it was not thought to have much of an overall effect in relation to the forest structure at turkey locations. Turkey locations during the breeding-nesting female and breeding male seasons were lower in shrub, forb, and grass cover than all other seasons.

Daily time-specific movement rates differed according to the cover type traversed and were least in fields, hardwood drains, high-density mixed, and low-density mixed stands. Overall daily movement rates of turkeys were greater for males than females. Daily movement rates were similar to the other studies that have reported this measure.

The results derived from these two habitat use methods indicate a chief commonality. Wild turkeys residing on bobwhite plantations in this area utilize a diversity of cover types and forest structures in their seasonal movements. The unique forest cover type and structures that result from bobwhite management are not considered to be a detriment to wild turkeys, especially when these areas are well juxtaposed to hardwood cover types and stands with differing basal areas and stem densities. If conjoint management of wild turkeys and bobwhites are a goal, any management activities that decrease cover type and structural diversity should be based on calculated decisions that evaluate the costs and benefits of those activities.

VIDEO SURVEILLANCE OF NESTS

I monitored wild turkey nests using miniature infrared-illuminated camera systems. These camera systems have been found to be useful in identifying nest predators and observing nesting behaviors of several other ground nesting birds. Thus, I wanted to test their efficacy in wild turkey research.

Video footage was recorded on 8 nests that were being incubated and 9 previously abandoned nests. Various nest predator species were recorded and were similar to what has previously been reported. One incubating hen was depredated by a bobcat (*Lynx rufus*) and another, a coyote (*Canis latrans*). Recorded egg predators included: opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), American crow (*Corvus brachyrhynchos*), gray rat snake (*Elaphe obsolete spiloides*), bobcat, and coyote. I also recorded various behaviors of incubating hens which included timing, duration, and frequency of nest recess.

Use of video surveillance equipment to monitor wild turkey nests certainly has utility in wild turkey research, but still needs further study. Even with this technology I found if difficult to assign predator species to egg depredation by inspecting nest evidence and egg shell remnants due to various uncontrollable factors. Since a high percentage of nest abandonments were caused by the equipment, I recommended that this methodology only be employed in studies where wild turkey populations are healthy and a large number ($\geq$30) of hens are radio-tagged.

LITERATURE CITED

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74:1313–1325.

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