SURVIVAL, HABITAT USE, AND NEST-SITE CHARACTERISTICS OF WILD TURKEYS IN CENTRAL MISSISSIPPI

By

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Wild Turkey (*Meleagris gallopavo*) survival, habitat use, and nest-site characteristics were studied on Malmaison Wildlife Management Area, Mississippi, 2003-2004. Survival rates were 0.55, 0.0004, 0.26, and 0.30 for jakes, adult gobblers, juvenile hens, and adult hens, respectively for the entire study. Spring survival for all groups was 0.51 (95% CI 0.36, 0.65) and was least among seasons. Predation (65%) and harvest (21%) were major causes of mortality. Brood hens used bottomland hardwood stands, pine plantations, and old fields more than expected during the post-nesting period. Non-brood hens used bottomland hardwood stands more than expected during the pre- and post-nesting periods. Forbs were the predominant vegetation type at nests. Vegetation height was 0.3-0.6 m for all nest sites. Vertical screening cover for all nests was in the 21-40% obscurity category at 1 m and 41-60% category at 3 and 5 meters. Vine composition differed between successful (2%) and unsuccessful (20%) nests (P = 0.03).

DEDICATION

This thesis is dedicated to my grandfather, John Holder. His character was beyond reproach, like that of the men in the Louis L'Amour books he used to read.

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Where do I begin? So many have been influential, helpful, willing, and generous. I believe it appropriate to start with Dr. Stephen Dinsmore who offered me the chance to fulfill my desire to work with a magnificent animal and helped me become a more well-rounded wildlife biologist during the process. To Mark Sczypinski and Byron Buckley, I extend one more sincere thank you for your help in the field and for the valuable information you brought to this project's table during the data collection phase. Thank you Dale Adams for putting up with a graduate student for two years. I hope those atv ruts weren't too hard to smooth out. Your dedication is an inspiration. I'd like to take the time to thank Ron Seiss and Dave Godwin with MDWFP. The volumes of information and advice both of you shared helped to steer this project in the right direction. Thanks Dr. Burger and Dr. Vilella for your guidance and insights as committee members. Your help with analysis and advice concerning career choices was invaluable. To Mark Smith, thank you. Your help was invaluable and timely. Special thanks go to Dr. Kaminski. Your advice and our conversations never fell on deaf ears. I will miss especially our post-game analyses concerning Dawg football. I sincerely appreciate everything you did for me and am indebted. Thanks to my fellow graduate students for different perspectives and helping hands. Last but certainly not least, thanks Mom and Dad, for your encouragement.

B.D.H.

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CHAPTER I

INTRODUCTION

The Eastern Wild Turkey (*Meleagris gallopavo silvestris*) occurs primarily in the eastern United States from Florida northward to Ontario, Manitoba, and Saskatchewan and west to Texas. The present distribution of this subspecies is similar to that observed during pre-colonial times (Kennamer et al. 1992).

In 1817 the French ornithologist L.J.P. Vieillot named the Eastern subspecies *silvestris*, meaning “forest” turkey, due to the close association observed between the bird and what was at the time a vastly forested landscape (Kennamer et al. 1992). Mature hardwood and mixed forests interspersed with openings characterized Wild Turkey habitat throughout its range (Mosby and Handley 1943). Mature forests provided hard mast during winter and softmast for much of the spring and summer. Habitat for brood-rearing and nesting occurred in and along edges of openings and in the forest interior where light penetration during early spring encouraged understory growth before accretion of the canopy occured. Grasses and herbaceous vegetation provided cover to nesting hens and poults and attracted insects to meet nutritional needs.

Wild Turkey populations declined dramatically across the eastern United States during the 1800s and early 1900s. As early pioneers and settlers began moving inland from the East Coast, market hunting of Wild Turkeys increased. Year-round harvest remained largely unchecked and continued into the early 1900s (Commer 1986). Increased deforestation followed on the heels of increased settlement. Vast forests were felled for agricultural purposes and to supply much needed timber products. By 1920, the Wild Turkey was absent from 18 of the 39 states it historically occupied (Mosby and Handley 1943).

No state's Wild Turkey population remained unaffected by human encroachment, including Mississippi's. The early 1900s saw much of Mississippi's forests cleared, and the Wild Turkey was nearly extirpated (Leopold 1929). Small numbers of birds remained in a few large tracts of timber such as the Leaf River Wildlife Management Area in southern Mississippi and a few other areas throughout the state. By the early 1940s, an estimated 4,500 Wild Turkeys remained in Mississippi (Hurst 1988).

Regulatory laws such as the Lacey Act of 1905 addressed and restricted the harvest and sale of wild game and helped arrest declines in Wild Turkey populations (Kennamer et al. 1992). Reclamation of former ranges was due to a large extent on successful relocation efforts (Davis and Widder 1985). In Mississippi, 290 birds were successfully relocated from the Leaf River Wildlife Management Area to other parts of the state between 1954 and 1958 (Commer 1986). More importantly, small farms and previously harvested forests began to reach a successional stage characterized by shrubs and small trees that provided habitat for relocated and naturally emigrating Wild Turkeys

(Kennamer et al. 1992). Relocations continue within Mississippi today on a smaller scale and to newly acquired public land areas where habitat has been restored. Black Prairie and Hamer Wildlife Management Areas in north and central Mississippi have been the sites of recent relocations.

The Wild Turkey is an ecologically and economically important bird species in Mississippi (Hurst 1988). Wild Turkeys are part of the natural assemblage of wildlife in the Southeast and help disperse plant and tree seeds (McKnight 1965, Brendemuehl 1990, Miller and Miller 1999). Just as Native Americans and early settlers pursued Wild Turkeys for year-around sustenance, many people today pursue Wild Turkeys for recreational opportunity (Flather et al. 1989). Hunters spend millions of dollars in the pursuit of Wild Turkeys each year in Mississippi (Grado et al. 1997, Southwick 2003).

Mississippi has an estimated statewide population of approximately 400,000 Wild Turkeys (MDWFP Annual Gobbler Survey 2003) which benefit from continued habitat enhancement on public and private lands. The state of Mississippi has placed a priority on Wild Turkey research, and important information collected during the past two decades has helped to sustain and enhance Wild Turkey populations. Investigations into Wild Turkey survival rates and habitat use have helped to direct and improve management in Mississippi (Miller 1997).

Determining survival rates is vital to understanding population age structure, recruitment into different age classes, future population growth, and population management strategies (Vangilder 1992). Individual fitness influences lifetime reproductive success. Theoretically, an individual that lives longer contributes more to the population, so survival is a critical component of population change (Smith and Smith 2003). Furthermore, it is important to understand the factors that influence survival. Studies in multiple states where Wild Turkeys occur have recorded seasonal, annual, age- and gender-specific survival rates, and mortality agents (Godwin 1991, Miller 1997, Hubbard et al.1999).

Survival of male and female Wild Turkeys differs, and is affected by habitat and seasonal sources of mortality (Vangilder 1992, Thogmartin and Schaeffer 2000). In polygamous bird species, female survival is more important than male survival because of their reproductive contribution (i.e., egg laying, incubation, brood rearing). However, gobbler survival has become increasingly important because of greater hunter demands and changes in hunting regulations to meet those demands (Godwin 1991, Wieme 2001). Current and representative survival information allows managers to model and predict population change more accurately and make well informed management decisions.

Ensuring increased survival of nesting hens, nest success, and poult survival is equally important because of their influences on population growth. Habitat plays an important role in determining reproductive success (i.e., nest success and brood survival). Hewitt (1967) identified poor habitat as a major factor limiting Wild Turkey population growth. Availability and quality of nesting and brood habitat has been identified as factors affecting Wild Turkey reproduction and populations (Badyaev 1995, Godfrey and Norman 1999). Recent studies in Mississippi have investigated and identified factors affecting nesting success and brood survival (Phalen 1986, Lowery 1999), population biology (Miller 1997) and habitat use (Palmer 1990, Godwin 1991). Information from these studies provides insights into how habitat may influence factors affecting population growth.

Ideal habitat features that satisfy nesting and brood rearing requirements consistently include a relatively open overstory canopy with a more developed understory (Lazarus and Porter 1985, Seiss 1989, Lowery 1999). Small openings, right-of-ways, and road edges also are favorable to nesting hens and feeding poults due to vegetation characteristics similar those previously mentioned (Porter 1992).

Information-based habitat management practices have been developed to provide suitable nest and brood habitat for Wild Turkeys. Creating, maintaining (i.e., mowing, disking) and planting [i.e., clover (*Trifolium* spp.) and sorghum (*Sorghum* spp.)] wildlife openings are techniques used to provide nesting and brood habitat.

Openings are managed to provide foraging areas and cover for broods by being maintained at an early successional vegetative stage dominated by grasses and herbaceous vegetation (Hillestad and Speake 1970, Martin and McGinnes 1975, Hurst 1992, Porter 1992). These vegetation types and characteristics allow movement, provide cover, and attract insects for brood consumption. Clovers and grain crops may be planted in openings to provide additional forage and attract insects.

Vegetation along edges between openings and non-openings (i.e., mature forests) is thought to provide suitable nesting habitat due to composition and concealment qualities. Nests in edges may avoid detection by predators and proximity to brood habitat (i.e., managed openings) may be beneficial (Seiss 1989, Lowery 1999).

Additional information is needed regarding current habitat management and its influence on population biology. Investigating when, and how frequently wildlife openings are used in comparison to other available habitats, may clarify Wild Turkey preference of managed openings and their ability to provide a needed resource in a predominantly forested landscape. Information gathered from this study should help to improve existing habitat management practices.

The primary objectives of my study were to 1) estimate gender-, age-, and period-specific survival rates of Wild Turkeys, 2) determine habitat use by Wild Turkey hens with and without broods with a focus on the use of wildlife openings, and 3) quantify and compare microhabitat characteristics of successful and unsuccessful nests.

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CHAPTER II

SURVIVAL OF WILD TURKEYS IN CENTRAL MISSISSIPPI

ABSTRACT

The Eastern Wild Turkey (*Meleagris gallopavo silvestris*) is an important game bird in Mississippi. Unbiased and precise estimates of survival and an understanding of those factors that influence survival are needed for science-based management. Seasonal and annual survival and cause-specific mortality of Wild Turkeys were estimated from a radio-marked sample of 31 hens and 15 gobblers on Malmaison Wildlife Management Area in central Mississippi during 2003-2004. Survival was modeled as a function of age, gender, season, year, and reproductive status using the Program MARK nest survival model. AIC model selection was used to evaluate competing models (n = 10). Survival for the entire study period was estimated using the best approximating model which included 4 gender*age combinations. Adult gobblers had lesser survival than adult hens. Jake and juvenile hen survival did not differ from that of adult hens. Survival rates for jakes, adult gobblers, juvenile hens, and adult hens were 0.55 (95% CI 0.21, 0.80), 0.0004 (95% CI 4.41E-7, 0.02), 0.26 (95% CI 0.06, 0.53), and 0.30 (95% CI 0.12, 0.51), respectively, for the study period.

Reproductive status had no effect on survival and there was little evidence supporting a year effect on survival. Seasonal survival was best estimated using a three season (spring, summer and fall/winter) model. Spring survival for all groups was 0.51 (95% CI 0.36, 0.65). Summer survival was 0.75 (95% CI 0.55, 0.87) and fall/winter survival was 0.80 (95% CI 0.56, 0.92) for all groups. Low spring survival was most likely from hunting and nesting activity when Wild Turkeys are most vulnerable to depredation. Predation and harvest were major causes of mortality accounting for 65% and 21% of losses, respectively. These results are similar to general patterns of survival seen for Wild Turkeys range-wide. Jake survival remains high because of restricted harvest. Additional survival information is needed to determine population changes due to increased jake survival.

INTRODUCTION

The Eastern Wild Turkey (*Meleagris gallopavo silvestris*) is important to many who enjoy the outdoors (Southwick 2003) and are ecologically important as part of the Southeast's native wildlife assemblage and seed dispersers (McKnight 1965, Brendemuehl 1990, Miller and Miller 1999). Wild Turkey numbers have increased due to habitat restoration, re-introduction programs, and protection.

Investigations into components driving population change are important. Survival rates influence population change (Miller 1997). Studies on Wild Turkey survival have identified factors limiting population growth. This information has been used to develop management strategies and techniques to address limiting factors. As a result, Wild Turkey populations continue to thrive in all of their former range (Kennamer et al. 1992). Unbiased and precise estimates of survival remain important in detecting population trends and directing science-based management.

Determining variation in Wild Turkey survival is critical in directing harvest and habitat management to increase survival. Past studies indicate differential survival between ages, gender, seasons, and years. Everett et al. (1980) indicated a 19% hen loss during 3 nesting seasons and a 35% loss of gobblers during a 10-day spring hunt in Alabama. Burk (1989) recorded average mortality rates of 0.35 and 0.67 for hens and gobblers across a 3-year study in Mississippi. Vander Haegen et al. (1988) recorded greater average mortality for juvenile hens (43%) than adult (25%) hens across a 2-year study in Massachusetts. Lowery (1999) reported that survival rates differed among years for hens in southern Mississippi, presumably because of increased nesting activity and associated mortality. In Mississippi, Godwin (1991) found strong seasonal differences in gobbler survival, with 93% of all gobbler mortalities occurring during the spring. Jones (2001) reported a hen survival rate of 0.82 (SE = ± 0.04) during spring in Mississippi which was the least among seasons.

Miller (1997) estimated survival of hens that nested and tended broods and those that did not to quantify survival costs of reproduction. Estimates of survival may be somewhat misleading if reproductive activity is not taken into account.

Hen survival has been well documented in Mississippi and in many other states. Less is known about differential survival between adult and juvenile gobblers (jake). In Mississippi, jake harvest is greatly restricted in an effort to increase numbers of mature gobblers in the population. Potential population effects have not been investigated. The need for current Wild Turkey survival information continues to be of importance to monitor and predict population changes and to guide harvest regulations.

I studied Wild Turkeys on a predominantly forested, public wildlife management area in central Mississippi in 2003 and 2004. My objectives were to 1) estimate age-, gender-, and season-specific survival rates of juvenile hens, adult hens, juvenile gobblers, and adult gobblers, and 2) to understand the influence of reproductive status on hen survival.

STUDY AREA

My study was conducted at Malmaison Wildlife Management Area (MWMA) and surrounding lands. This 3,600-ha public use area was owned by the Mississippi Department of Wildlife, Fisheries and Parks and was located in Grenada, Carroll and

Leflore counties (Figure 2.1). Much of the management area fell within the alluvial floodplain of the Yalobusha River. The eastern portion of the study area was predominantly loess hills. Habitats occurring on the MWMA included mature bottomland hardwood, upland hardwood, and pine-hardwood forests, wetlands, old fields, and managed wildlife openings. Dominant bottomland tree species included sycamore (*Platanu, occidentalis*), elm (*Ulmus* spp.), sugarberry (*Celtis laevigata*), water oak (*Quercus nigra*), willow oak (*Q. phellos*), overcup oak (*Q. lyrata*), swamp chestnut oak (*Q. michauxii*), cherrybark oak (*Q. pagoda*) and pecan (*Carya illinoensis*). Sedges (*Carex* spp.), switch cane (*Arundinaria gigantea*), greenbriar (*Smilax* spp.), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), pepper vine (*Ampelopsis arborea*), may apple (*Passiflora incarnate*), poison ivy (*Toxicodendron radicans*), muscadine grape (*Vitis rotundifolia*) broomsedge (*Andropogon virginicus*), clover (*Trifolium* spp.), foxtail (*Setaria* spp.) and several grasses (*Andropogon* spp. and *Paspalum* spp.) were the dominate ground cover. White oak (*Q. alba*), loblolly pine (*Pinus taeda*), beech (*Fagus grandifolia*), and elm (*Ulmus* spp.) were the dominate tree species in the upland habitats whereas much of the understory vegetation is similar to that of bottomland habitats except for more blackberry (*Rubus spp*.), kudzu (*Pueraria montana*) and honeysuckle (*Lonicera japonica*).

There were approximately 60 small (1-3 ha), managed openings interspersed throughout the management area. These openings were specifically managed to benefit Wild Turkeys and other wildlife including White-tailed Deer (*Odocoileus virginianus*) and Northern Bobwhites (*Colinus virginianus*).

METHODS

Trapping and Processing

Field work occurred from 21 January through 4 August 2003 and 21 January through 18 August 2004. Trapping began 21 January and ended the second week of March. Approximately 20 trap sites were prepared and baited twice daily with wheat (*Triticum aestivum*) at a rate of approximately 27.2 kg/day. Rocket and cannon nets were used to trap Wild Turkeys, typically during early morning (Eriksen et al. 1996). Trap sites were checked at noon and dusk to determine time of use (morning or afternoon) and flock composition (male/female) by waste droppings (Eaton 1992).

Upon capture, birds were placed in cardboard holding boxes before being processed. The age and gender of each individual was determined using standard techniques (Brenneman 1996). Ninety-gram "back-pack" style transmitters (Advanced Telemetry Systems, Isanti, Minnesota) were secured to the bird's back using nylon coated rubber tubing (Norman and Hurst 1996). The transmitters included a mortality switch capable of emitting a rapid signal pulse after 3 (± 2) hours of inactivity. Transmitters were powered to last approximately 3 years. Additionally, juvenile gobblers (jakes) were fitted with No. 8 United States Geological Survey aluminum leg bands for further identification purposes.

Captured Wild Turkeys were processed on site as quickly as possible and immediately released (typically ≤1 hour post-capture). To minimize biases associated with capture and handling induced mortality, I chose to use a two week "censor" period for each marked bird (Seiss 1989, Godwin 1991). If the bird died within that period of time, it was attributed to capture and handling stress and excluded from the sample and analysis (Spraker et al. 1987). Turkey handling and marking procedures were approved by the Institutional Animal Care and Use Committee (IACUC), Mississippi State University (IACUC Protocol No. 02-016).

The status of marked birds was monitored ≥3 times a week from January through July and once every two weeks for the remainder of the year. TRX-2000s and 1000s receivers (Wildlife Materials, Carbondale, IL) and 3-element hand-held Yagi antennas (Advanced Telemetry Systems, Isanti, MN) were used to monitor radioed birds. An Advanced Telemetry Systems (Advanced Telemetry Systems, Isanti, MN) receiver also was used during late spring, 2004. An attempt to determine status of birds was made immediately after detection of the mortality signal except for females during nesting season (15 March-30 June). During this period, a mortality signal was presumed to indicate incubation. Inspection was usually delayed for 28 days (average incubation period; Dickson 2001) to prohibit disturbance of a possible nesting attempt. However, if the direction and distance of the hen's mortality signal changed significantly from the predetermined nest area, an immediate attempt was made to determine hen fate.

Statistical Analyses

I used the nest survival model within program MARK (White and Burnham 1999, Dinsmore et al. 2002) to model effects of selected factors on daily survival rates. The nest survival model differs from the more familiar known fate model in that it allows the time of a loss to occur during an interval, rather than on a known (or making assumptions about) the exact date of a loss. Exact dates of mortality (failure) for radio marked turkeys were not always known during my study period so I chose to use the nest survival model over more traditional failure time models. The range of interval lengths during which mortality was known to have occurred was 2 days to 2 weeks.

To construct individual encounter histories for the nest survival model, five values are needed: the day the turkey was initially marked (*i*), the last day the turkey was known to be present (alive) (*j*), the last day the turkey was observed (*k*), the fate of the turkey (1 for a mortality and 0 for a surviving bird), and number of turkeys with the same encounter history. An example of an encounter history in my study is:

/* Frequency # 0.383 */ 135 280 282 1 1;

Independent variables used in model construction were determined *a priori* based on their presumptive relationships with natural history, annual cycles, and survival of Wild Turkeys. The variables I chose to include in my model set were age group (adult versus juvenile) (Hubbard et al. 1999, Wieme 2001), sex (Everett et al. 1980, Little et al. 1990), season (Kurzejeski et al. 1987, Seiss 1989), and year (Wright et al. 1996, Inglis 2001).

Marked birds were placed into one of four groups for analysis (jakes, adult gobblers, juvenile hens, and adult hens). For Wild Turkeys captured as juveniles, I set the date of transition from juvenile to adult at 1 March of the second year post capture because the bird would have entered into its second year of sexual maturity. Three different seasonal intervals (Table 2.1) were created to investigate variation in survival based on seasonal behavior and opening of hunting seasons. A 3-season grouping included spring, summer, and a fall/winter combination. I chose to combine fall and winter into one interval due to lack of differential survival recorded in previous studies (Godwin 1991, Lowery 1999). The 2-season grouping included spring and all other seasons combined. I separated the spring season from all others due to decreased survival during this interval associated with nesting activity and the spring gobbler hunting season. I also wanted to determine if the spring season had the greatest effect on survival for all groups. The last seasonal group consisted of a spring/summer and fall/winter combination which essentially separated reproductive and non-reproductive seasons. The study period was partitioned into two years for analysis of differential survival between the 2003 and 2004 field seasons.

Reproduction can impose physiological and survival costs associated with parental care (Burger et al. 1995, Dickson 2001). A covariate of reproductive status was used to account for differential survival between those hens that were and those that were not nesting (Miller 1997). Failure to account for this difference may produce misleading estimates of survival by violating the assumption in survival analysis that all individuals are pulled from the same distribution (Heisey and Fuller 1985). The encounter history contained the covariate values of reproductive status. A 0 (non-nesting) or 1 (nesting) was assigned to each day during the study period for all marked hens. This was then modeled as a single reproductive status effect.

An information-theoretic approach was used in Program MARK to select between competing models (Burnham and Anderson 1999). Akaike's information criterion (AIC: Akaike 1973) was used to determine which model fit the data best by assigning a value to each (Anderson et al. 2000). The model with the smallest AIC value was selected as the best approximating model and was used to calculate parameter estimates (i.e., survival rates).

The relative distances between the best approximating model and each competing model were calculated. The resulting values assigned to each model represented strength of evidence (model weight, w_i). Models which explain more variation are ranked greater and weighted more greatly (Burnham and Anderson 1998). If the weights of competing models are similar, model averaging is generally recommended.

Daily group survival rates were converted so that comparisons could be made between observed rates from my study and annual and period specific rates from previous studies. Conversion was achieved by simply raising the daily survival rate to the appropriate number of days (n) in each period [(daily nest survival)^n] (Table 2.1) (Mayfield 1961).

RESULTS

I obtained survival data from 36 Wild Turkeys (14 jakes, 16 adult hens, 6 juvenile hens) in 2003 and from 38 Wild Turkeys (11 adult gobblers, 18 adult hens, 9 juvenile hens) in 2004. Survival was estimated for a 700-day period from 19 September 2002 to 18 August 2004.

Model Selection Results

A reduced model with four age/gender groups (juvenile males, adult males, juvenile females, and adult females) was the best model (Table 2.2). Reduced 3-season (ΔAIC = 3.99) and 2-season (ΔAIC = 4.45) models were the next best, but had low weights ($w_i < 0.10$). Reduced additive models of gender and 2-seasons (ΔAIC = 5.23) and 3-seasons (ΔAIC = 6.82), a spring/summer+fall/winter model (ΔAIC = 5.52), a year model (ΔAIC = 8.56), a constant survival model (ΔAIC = 14.23), a gender-only model (ΔAIC = 15.65), and a model with reproductive status (ΔAIC = 16.17) received little support in my study.

There was evidence for a strong group effect on survival. Adult gobblers had lesser daily survival ($\beta_{AM} = -1.86$, 95% CI -2.73, -0.99) than adult hens. Jake ($\beta_{JM} = 0.70$, 95% CI -0.43, 1.83) and juvenile hen ($\beta_{JF} = -0.12$, 95% CI -1.05, 0.81) daily survival did not differ than that of adult hens.

Daily survival was less during spring ($\beta_{spring} = -1.73$, 95% CI -2.80, -0.66) compared to fall/winter daily survival. Daily survival during the summer season ($\beta_{summer} = 0.77$, 95% CI -0.08, 1.63) did not differ from daily survival during the fall/winter season. Very little evidence existed for effects of year, gender only, and reproductive status ($\beta_{Repro} = -0.25$, 95% CI -2.24, 1.75).

Survival Rates

Survival rates for each group were derived from the "best" approximating model (Fig. 2.2). Model averaging was not used because of the overwhelming evidence for the "best" model effect and because of computational limitations associated with the numerous covariates in the reproductive model. Survival rates for jakes, adult gobblers, juvenile hens, and adult hens were 0.55 (95% CI 0.21, 0.80), 0.0004 (95% CI 4.41E-7, 0.02), 0.26 (95% CI 0.06, 0.53), and 0.30 (95% CI 0.12, 0.51), respectively, for the entire study.

Survival estimates from a 3 season (spring, summer, and fall/winter) model indicated spring survival for all groups was 0.51 (95% CI 0.36, 0.65). Summer survival was 0.75 (95% CI 0.55, 0.87) and fall/winter survival was 0.80 (95% CI 0.56, 0.92) for all groups.

An annual+group model was constructed post hoc to determine group-specific survival rates for 2003 and 2004 (Table 2.3). Survival was less during the second year for juvenile and adult hens. Jake survival was greatest among groups. An additional group+3 season model was constructed post hoc to determine survival rates during the spring, summer, and fall/winter periods for each group (Table 2.4). Jake survival was 0.86 (95% CI 0.66, 0.95), 0.92 (95% CI 0.78, 0.98), and 0.93 (95% CI 0.78, 0.98) for spring, summer, and fall/winter, respectively, during 2003. Adult gobbler survival was 0.31 (95% CI 0.10, 0.55) and 0.54 (95% CI 0.20, 0.79) for spring and summer, respectively, during 2004. Juvenile hen survival was 0.74 (95% CI 0.52, 0.88) for spring, 2003 and 2004, respectively. Adult hen survival was 0.77 (95% CI 0.61, 0.87) for spring and greater than juvenile survival.

Causes of Mortality

Of the 29 mortalities that occurred during the study, 19 (65%) were attributed to predation (16 hens and 3 gobblers). Seven (21%) adult gobblers were harvested, 2 (7%) hens were harvested illegally, and 2 (7%) suffered an unknown fate. For the latter, transmitters were found with bite marks present, but no Wild Turkey carcasses were recovered. The 7 adult gobblers harvested during 2004 had been marked as jakes in 2003.

DISCUSSION

Survival Rates

Gender-specific survival was similar to those found in other studies in Mississippi and Iowa (Burk 1989, Little et al. 1990). Survival of hens in my study was greater than gobblers. Godwin (1991) reported annual gobbler survival rates between 0.39 and 0.54 for three years in Mississippi. Chamberlain (1999) reported a mean annual survival rate of 0.63 for hens on a study area in the Mississippi delta. Survival differences between age groups were similar to those reported by Vander Haegen et al. (1988) in Massachusetts where adult hen survival was slightly greater than juvenile survival. In Iowa, adult hen survival (0.68 ± 0.05 [SE]) was slightly less than juvenile survival (0.71 ± 0.13 [SE]) though they did not differ significantly ($P = 0.49$) (Hubbard et al. 1999). Godwin (1991) reported no difference in survival rates between jakes and adult gobblers in Mississippi. However, his survival rates were determined before jake harvest was restricted in 1998. My analysis indicated jakes had a much greater annual survival rate than adult gobblers and had the greatest survival among all groups.

Adult hens experienced slightly greater survival than juvenile hens during my study. The effect of age on survival may be attributed to reproductive investment (i.e., nesting, brood rearing) in the spring and offset by maturity and experience to avoid predators and find food during other times of the year (Vander Haegen et al. 1988, Miller 1997). Juvenile hens may experience greater mortality rates during the reproductive season due to the selection of nest sites that do not offer as much cover making them more vulnerable to predation (Badyaev et al. 1996). Juvenile hens also may increase their vulnerability to predation by moving greater distances alone in search of nest sites (Miller and Leopold 1992, Hubbard et al. 1999).

A high survival rate for adult gobblers during most of the year may be partially offset by increased mortality during the spring hunting season due to hunter demand for a mature bird (Godwin 1991, Lint et al. 1993). The restricted harvest of jakes also may serve to directly increase the risk for adult gobbler spring mortality by making them virtually the only harvestable segment of the population. In Mississippi, restricted harvest of jakes may have increased their survival by reducing probably the greatest source of annual mortality for gobblers in the Southeast.

Seasonal differences in survival for each group were similar to studies conducted elsewhere in the Southeast (Palmer 1990, Godwin 1991) and in Wisconsin (Wright et al. 1996) with the least survival during spring (hunting, nesting) and summer (brooding) for adult and juvenile hens and gobblers. Increased mortality due to limited food resources (i.e., poor hard mast crop) may occur seasonally, particularly in late winter (Vangilder 1996). Miller (1997) suggested the synergetic effects of a dry growing season and subsequent mast crop failure may deleteriously impact fall/winter Wild Turkey survival. Fall/winter hen survival was greater during my study than reported by Seiss (1989) and Chamberlain (1995) who both noted the opening of other hunting seasons (deer, squirrel, etc.) around the times of increased mortality, particularly during the fall period. Seasonal hen survival rates reported by Roberts et al. (1995) were 0.80, 0.85, 0.83 and 0.87 for spring, summer, fall, and winter, respectively, in New York. My rates were similar, except for fall where I reported greater survival.

Cause-specific Mortality

Most Wild Turkey hen mortalities at Malmaison WMA were believed to be caused by predation based on carcass condition. In Mississippi, Jones (2001) reported that 79% of hen mortalities were attributed to predation and 76% occurred during the reproductive period. Ancillary observations indicated most hen deaths occurred during reproductive periods during my study. Two hens (7%) were harvested illegally during the 2004 spring hunting season. Palmer et al. (1993) reported one illegal harvest (3%) during a 4-year period in Mississippi. Illegal harvest was less than that reported in Arkansas (10%) during a 6-year study (Thogmartin and Schaeffer 2000). Two study areas in Missouri experienced illegal harvest of 13.2% and 31.2% (Vangilder 1996). Illegal harvest does not seem to be a large cause of mortality on Malmaison WMA. Legal, spring season adult gobbler harvest on my study area was slightly less than reports from Godwin (1991) (78%) in Mississippi during a four year study. However, Godwin (1991) pooled jakes and adult gobblers for analysis and harvest rates for each are unknown. Everett et al. (1980) reported 44% of adult gobblers were harvested during a ten-day spring hunting season in Alabama. Seven of 11 (64%) adult gobblers were harvested legally during my study. This percentage may be inflated because of a record harvest at Malmaison WMA during the 2004 spring season (Dale Adams, Mississippi Department of Wildlife, Fisheries and Parks, pers. comm. 2004). No known jake mortality was attributed to harvest during my study.

It should be noted that some Wild Turkey mortalities attributed to predation may have actually resulted from some other source of trauma. Losses caused by crippling from being shot and other sources of trauma, old age, and diseases are difficult to determine (Seiss 1989, Godwin 1991, Wieme 2001). Death may have occurred directly or made the bird more vulnerable to predation. The carcasses of Wild Turkeys are often reduced to a few bone fragments overnight by scavengers, obscuring the true cause of death. However, mis-identifying cause of death was thought to be somewhat minimized because of frequent status checks of marked Wild Turkeys during my study.

Wild Turkey survival on MWMA appears to be influenced by age, gender, and season, and follows trends similar to past studies in Mississippi and other states (Vander Haegen 1988, Seiss 1989, Palmer 1990, Wright et al. 1996). Adult hen survival was slightly greater than that of juvenile hens. Hen survival was greater than that of adult gobblers. Spring survival was the least for all groups (Little et al. 1990, Godwin 1991). Jake survival was greatest and was consistant with rates reported by Wieme (2001). Predation and harvest were the greatest sources of mortality (Miller 1997, Inglis 2001, Jones 2001). Adult gobbler harvest on MWMA during 2004 fell between rates reported by Godwin (1991) and Chamberlain (1995).

Interpretation of Results

Sample sizes were small for all groups during my study, particularly for adult gobblers (n = 11). Caution should be observed when using survival rates presented in this study to make inferences about survival rates of Wild Turkeys in Mississippi, particularly gobblers. Survival and harvest rates for jakes and adult gobblers were determined from one year of data during my study.

Future Research

Further study of jake survival in Mississippi is needed. Jake survival was greatest among groups and adult gobbler survival was least. Two year-old adult gobblers may still be vulnerable to harvest. Increased and disproportionate harvest of adult gobblers may significantly alter age distributions, decrease adult gobbler abundance, and cause population declines if jake recruitment into a mature cohort does not adequately replace adult gobbler loss due to consecutive poor hatch years. Additionally, density dependent effects (i.e., increased competition for food) associated with increased gobbler abundance may affect Wild Turkey populations in Mississippi. Thus, the long-term effects of the "no jake" regulation on turkey populations in Mississippi are largely unknown, and should be the focus of future study.

Ideally, jake survival should be studied in the context of the current no jake harvest regulation, although to do this properly will require a large-scale experiment where harvest regulations are manipulated over a period of several years. Similarly, a better understanding of jake survival will be useful for understanding turkey population trends in Mississippi, perhaps with the use of simulations and a sufficient sample size in Program MARK.

Given adequate samples of marked turkeys, detailed habitat covariates (i.e., stand type, vegetation characteristics, proximity to other habitat types, predator density, and food resources) can be included in models to better explain variation in annual or seasonal survival (Hubbard et al. 1999). Little information exists regarding effects of body condition (i.e., body mass) on survival in the Southeast, so including this as a covariate in models of turkey survival and reproduction might provide additional insight into turkey-habitat relationships (Dinsmore and Collazo 2003, Dinsmore et al. 2003).

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Table 2.1. Year and seasonal intervals used to estimate survival of Wild Turkeys at Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Interval	Date
2003	Jan. 1 - Dec. 31
2004	Jan. 1 – Aug. 18
Spring	Mar. 1 - May 31
Summer	Jun. 1 - Aug. 31
Fall/Winter	Sep. 1 - Feb. 29

Table 2.2. Model selection results for Wild Turkey daily survival at Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Model	AICc	ΔAICc	AICc wt.	*k*	Deviance
Age*Gender	383.09	0.00	0.71	4	375.09
3 season	387.08	3.99	0.09	3	381.08
2 season (spr+all else)	387.54	4.45	0.08	2	383.53
Gender+2 season	388.32	5.23	0.05	4	380.31
Spr/sum+fall/winter	388.60	5.52	0.04	2	384.60
Gender+3 season	389.91	6.82	0.02	5	379.91
Year	391.65	8.56	0.01	2	387.64
Constant survival	397.31	14.23	0.00	1	395.31
Gender	398.74	15.65	0.00	2	394.74
Reproductive status (hens only)	399.26	16.17	0.00	2	395.26

Table 2.3. Annual survival rates for Wild Turkeys at Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Group	Year	Survival Rate (95% CI)
Jakes*	2003	0.72 (0.40, 0.94)
	2004	N/A
Adult gobblers*	2003	N/A
	2004	0.42 (0.02, 0.43)
Juvenile hens	2003	0.72 (0.38, 0.89)
	2004	0.31 (0.19, 0.70)
Adult hens	2003	0.74 (0.47, 0.89)
	2004	0.50 (0.27, 0.69)

* Survival data were available for one year.

Table 2.4. Seasonal survival rates (95% CI) for Wild Turkeys at Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Group	Season			Year
	Spring	Summer	Fall/Winter	
Jakes	0.86 (0.66, 0.95)	0.92 (0.78, 0.98)	0.93 (0.78, 0.98)	2003
Adult gobblers*	0.31 (0.10, 0.55)	0.54 (0.20, 0.79)	N/A	2004
Juvenile hens	0.74 (0.52, 0.88)	0.85 (0.66, 0.94)	0.88 (0.65, 0.96)	2003-04
Adult hens	0.77 (0.61, 0.87)	0.87 (0.72, 0.94)	0.89 (0.71, 0.96)	2003-04

* No survival data were available for this interval.

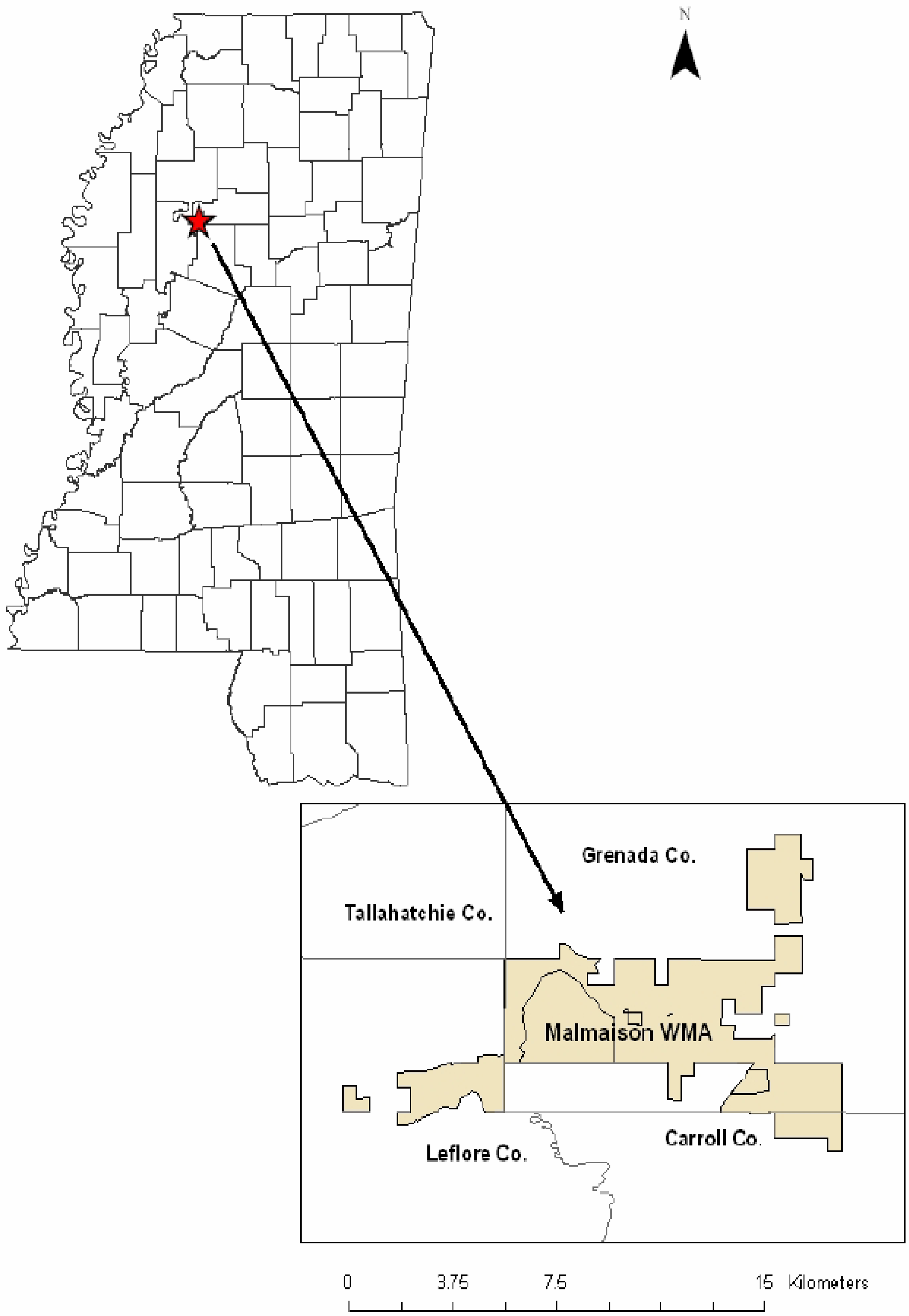

Figure 2.1. Location and configuration of Malmaison Wildlife Management Area, Mississippi, 2003-2004.

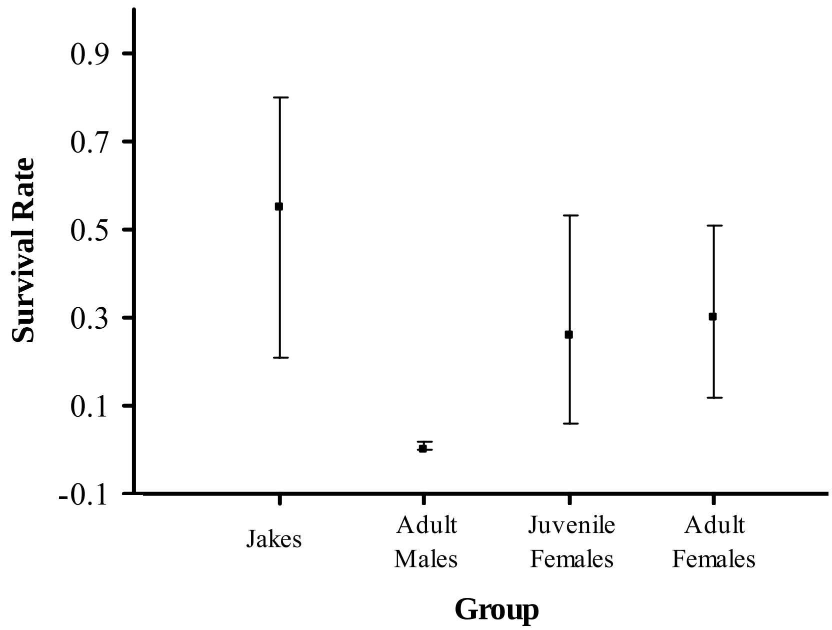

Figure 2.2. Study long survival rates and 95% confidence intervals for each age-gender combination of Wild Turkeys at Malmaison WMA, Mississippi, 2003-2004.

CHAPTER III

WILD TURKEY HABITAT USE IN CENTRAL MISSISSIPPI

ABSTRACT

Research into seasonal habitat use of wildlife is important to determine preferable habitats during an annual cycle and to determine how wildlife respond to habitat management practices implemented to provide optimum environments. Pre- and post-nesting Wild Turkey (*Meleagris gallopavo*) hen habitat use was studied on Malmaison Wildlife Management Area and on surrounding lands in central Mississippi during 2004. Location data were collected from 6 brood hens and 18 non-brood hens. Hens used bottomland hardwood stands, managed openings, pine plantations on adjacent lands, some edges and old fields (i.e., 2-10 year old fallow fields and hardwood regeneration areas) more than expected ($P < 0.05$) across the study period (15 March-13 August). Information for 4 brood hens indicated random habitat use during the pre-nesting period (15 March-15 May). Brood hens used bottomland hardwood stands, pine plantations, and old fields more than expected during the post-nesting period (16 May-13 August). Non-brood hens used bottomland hardwood stands more than expected during the pre- and post-nesting periods. Pine plantations also were used more than expected by non-brood hens during the post-nesting period. Upland hardwood stands were avoided by brood hens and used as expected by non-brood hens during the post-nesting period.

Seasonal habitat use was similar to what has been reported. Additional information regarding spatial relationships among habitats and use should be investigated. Maintaining a mix of seral types is recommended to provide habitat for Wild Turkeys.

INTRODUCTION

Availability and quality of nesting and brood habitat have been identified as key factors affecting Wild Turkey reproduction and populations (Badyeav 1995, Godfrey and Norman 1999). Ideal nesting habitat consistently include an open canopy with a well developed understory in contrast to other, less productive habitats used by nesting turkeys (Seiss 1989, Porter 1992, Inglis 2001, Jones 2001). Successful nests often occur in areas with open overstory canopy, well developed understory, and structural complexity in vegetation (Hurst and Dickson 1992). This complexity is important for concealment against predators (Bowman and Harris 1980). Nest proximity to brood habitat seems to be an important factor (Lazarus and Porter 1985, Hurst and Dickson 1992).

Brood habitat can be characterized by abundant, low, grassy and herbaceous ground cover that allows movement, provides cover, attracts insects for developing poults, and a lack of midstory canopy coverage (Hillestad and Speake 1970, Healy 1985, Miller 1997). Godfrey and Norman (1999) found poult survival was correlated with the percentage of brood habitat composed of herbaceous understory vegetation in Virginia. During the first 2 weeks post hatch, poults may forage in areas (e.g., old fields, forest edges, forest interiors) where vegetation is dense enough to protect them from predators, but move into open pastures and fields later in development (Hurst and Dickson 1992). Small openings, right-of-ways, and road edges are used by nesting hens and feeding poults due to vegetation composition and concealment (Porter 1992).

Creating and maintaining (i.e., mowing, disking, planting) wildlife openings are techniques currently used to develop and enhance nesting and brood habitat (Martin and

McGinnes 1975, Healy 1981, Godfrey and Norman 1999, Lafton et al. 2001). Everett et al. (1985) noted importance of interspersing grassy openings for broods within nesting habitat in Alabama. Importance of openings, containing such species as clover (*Trifolium* spp.) or blackberries (*Rubus* spp.), for turkeys existing in mid-rotation pine plantations in Virginia was described by Holbrook (1973). Sisson et al. (1991) recommended providing old fields or lightly grazed woodlands in addition to winter-burned pine forests for broods in southern Georgia.

Vegetation found in edges between openings and non-openings (i.e., mature forests) is thought to provide suitable nesting habitat for Wild Turkeys (Williams et al. 1973, Holbrook et al. 1987, Seiss 1989, Lowery 1999, Jones 2001). Nests in edges may avoid detection by predators and broods may not have to travel as far to find adequate cover and forage. Openings are maintained at an early successional stage to provide Wild Turkey brood habitat by encouraging growth of favorable vegetation types (i.e., grasses, forbs). These vegetation types facilitate movement, attract insects (important nutritional requirement for poults) and offer poults cover to avoid detection by predators (Hillestad and Speake 1970, Everett et al. 1980, Healy 1985, Porter 1992). Clovers and heavily seeded grain crops may be planted in openings to provide additional forage and attract insects (Lafton et al. 2001).

Although much is known about Wild Turkey habitat use, more information is needed regarding the influences of habitat management on population biology. Seasonal use and frequency of use of wildlife openings compared to other available habitat types should indicate some degree of preference during different time periods.

My objective was to determine habitat use, specifically of managed wildlife openings, by Wild Turkey brood and non-brood hens. I investigated habitat use during two ecologically important times of the year (spring and summer) to see which habitats hens and brood hens used.

STUDY AREA

My study was conducted at Malmaison Wildlife Management Area (MWMA) and surrounding lands. This 3,600-ha public use area was owned by the Mississippi Department of Wildlife, Fisheries and Parks and was located in Grenada, Carroll and Leflore counties (Figure 3.1). Much of the management area fell within the alluvial floodplain of the Yalobusha River, although the eastern portion of the study area was predominantly loess hills. Habitats occurring on the MWMA included mature bottomland hardwood, upland hardwood, and pine-hardwood forests, wetlands, old fields, and managed wildlife openings. Dominant bottomland tree species included sycamore (*Platanus occidentalis*), elm (*Ulmus* spp.), sugarberry (*Celtis laevigata*), water oak (*Quercus nigra*), willow oak (*Q. phellos*), overcup oak (*Q. lyrata*), swamp chestnut oak (*Q. michauxii*), cherrybark oak (*Q. pagoda*) and pecan (*Carya illinoensis*). Sedges (*Carex* spp.), switch cane (*Arundinaria gigantea*), greenbriar (*Smilax* spp.), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), pepper vine (*Ampelopsis arborea*), may apple (*Passiflora incarnate*), poison ivy (*Toxicodendron radicans*), muscadine grape (*Vitis rotundifolia*) broomsedge (*Andropogon virginicus*), clover (*Trifolium* spp.), foxtail (*Setaria spp.*) and several grasses (*Andropogon* spp. and *Paspalum* spp.) were the dominate ground cover. White oak (*Q. alba*), loblolly pine

(*Pinus taeda*), beech (*Fagus grandifolia*), and elm (*Ulmus* spp.) were the dominate tree species in the upland habitats while much of the understory vegetation was similar to that of bottomland habitats except for more blackberry (*Rubus* spp.), kudzu (*Pueraria montana*) and honeysuckle (*Lonicera japonica*).

There were approximately 60 small (1-3 ha), managed openings interspersed throughout the management area. These openings were specifically managed to benefit Wild Turkeys and other wildlife including White-tailed Deer (*Odocoileus virginianus*) and Northern Bobwhites (*Colinus virginianus*). During spring and summer of 2003 and 2004, many managed openings found on MWMA and surrounding lands were dominated by white clover (*Trifolium repens*), annual grasses, and vetch (*Vicia* spp.). Grain crops (*Sorghum* spp.) and winter wildlife blends of oats, peas, and grasses were planted during spring and summer in a few selected openings to provide winter food sources wildlife. Most openings were mowed once during the growing season to maintain an early successional stage. Despite their intended wildlife benefits, there have been no rigorous assessments of managed opening use by Wild Turkeys.

METHODS

Trapping and Processing

Field work occurred from 21 January through 13 August 2004. Trapping efforts began on 21 January and ended the second week of March. Approximately 20 trap sites were prepared and baited twice daily with wheat (*Triticum aestivum*) at a rate of approximately 27.2 kg/day. Trap sites were spaced throughout the management area and their number varied in response to weather and site use. Rocket and cannon nets were used to trap Wild Turkey hens; their use depended on specific site conditions (Eriksen et al. 1996). Trap sites were checked at mid-day and dusk to determine time of use (morning or afternoon). Flock composition (male/female) was determined by waste droppings (Eaton 1992). On the basis of flock size and composition, an observer and net were stationed at a site in an attempt to capture Wild Turkey hens.

Upon capture, hens were placed in cardboard holding boxes before being processed. The age and gender of each individual was determined using standard techniques (Brenneman 1996). I secured 90 g “back-pack” style transmitters (Advanced Telemetry Systems) to the bird’s back using nylon coated rubber tubing (Norman and Hurst 1996). The transmitters included a mortality switch capable of emitting a signal distinctly different from an active signal after 3 (± 2) hours of inactivity. Transmitters were powered to last approximately 3 years.

Captured hens were processed on site as quickly as possible and immediately released (typically ≤1 hour post-capture). To minimize biases associated with capture and handling induced mortality, I chose to use a two week “censor” period for each marked bird (Seiss 1989, Godwin 1991). If the bird died within that period of time, it was attributed to capture and handling stress and excluded from the sample and analysis (Spraker et al. 1987). Turkey handling and marking procedures were approved by the Institutional Animal Care and Use Committee (IACUC), Mississippi State University (IACUC Protocol No. 02-016).

Telemetry Procedures

Telemetry was conducted using a 3-element Yagi antenna (Advanced Telemetry Systems, Isanti, MN) and a multi-frequency receiver (Wildlife Materials, Carbondale, IL). An Advanced Telemetry Systems (Advanced Telemetry Systems, Isanti, MN) receiver also was used during late spring of 2004.

Radioed hens were located ≥3 days per week throughout spring and summer (15 March to 13 August). Hen locations were taken at all daytime hours during the data collection period. Daily telemetry schedules were purposely altered for each hen. A random drawing of hen frequencies and start times were used so that individual hens would not be located at the same time each day. This ensured representative and random sample of diurnal habitat use. Three bearings were taken from fixed roadside telemetry stations towards the direction of the strongest signal to triangulate a hen's position (Cochran and Lord 1963). Bearings between 60 and 120 degrees were preferred (Heezen and Tester 1967) and compass declination was set for increased accuracy of triangulation. I attempted to maintain a 12 minute threshold between the first and third bearing to decrease location error caused by hen movement (Chamberlain 1995). Bearing data were entered into Program Locate III (Version 3.10; Nams 2005) to generate UTM coordinates of hen locations. I conducted telemetry tests to measure mean angular bearing error using "dummy" transmitters (beacon tests) during leaf on and leaf off conditions (Godwin 1991, Chamberlain 1995). Transmitters were tied to small saplings 0.8 m above ground or attached to 3.79 L plastic containers filled with a sugar water solution to simulate a hen turkey.

Estimating Available Habitat

Habitat was assumed to be available to Wild Turkeys at the stand level based on natural and life history characteristics (Wiens 1976, Jones 2001). Major habitat types of MWMA were delineated at the stand level and digitized into a habitat coverage map in ArcMap 8.3 (ESRI 2001) using aerial photo-interpretation and ground-truthing measures. Aerial photographs were 1 m ground sample distance (GSD) images rectified to a horizontal accuracy of ± 3 m of reference digital ortho quarter quadrangles. Habitat types included agricultural fields (AG), mature bottomland hardwood forests (BLHD), mature upland hardwood forests (ULHD), old fields (OF), managed openings (MGDO), and 10-15 year old pine plantations (PNPL). Because edge habitats have been identified as important Wild Turkey habitat, a 7 m buffer was created around roads, agricultural fields, managed openings, and early successional fields to create an edge habitat type (Holbrook et al. 1987). Small fields (1-3 ha), right-of-ways, and narrow lanes that were mowed at least once per year or planted were classified as MGDO's. Hardwood regeneration areas, clear cuts, and fallow fields 2-8 years old were classified as OF habitat. Habitat classification error was reduced by selecting growing season images which clearly exhibited differences between hardwood canopies, monoculture pine plantations, early successional fields, and old fields.

Home ranges for each hen were generated using the 95% adaptive kernel estimator within the Movement Extension in ArcView 3.2 (ESRI 2002). The adaptive kernel method (Worton 1989) is a nonparametric technique that is less affected by small numbers of observations. Hens with ≥19 locations (n = 24) were included in home range calculations (Chamberlain 1999, Jones 2001, Welch 2003). Habitats within each hen's home range were considered available [Johnson's (1980) 3rd order landscape level] and used to define the area to be digitized for habitat use analysis (Conner et al. 2003, Welch 2003).

Statistical Analyses

Potential differences in understory development and species composition between upland and bottomland forest stands warranted separating hens into two populations for analysis (Figures 3.2 and 3.3; Seiss 1989, Miller 1997, A. Ezell, College of Forest Resources, Mississippi State University, pers. comm.). Additionaly, habitat use results from the chosen distance-based analysis would be misleading due to inflated distance averages between bottomland bird locations and upland hardwood sites if the study area remained undivided. During my study, hens captured in the delta section of the study area remained within this section (Figure 3.4). The same was true for hens capture in the hills section. My sample population of hens was divided into delta and hills sub-populations for additional analyses. Delta and hills groups were further subdivided into pre- (15 March-15 May) and post-nest (16 May-13 August) habitat use periods between brood and non-brood hens. Location data gathered after 15 May were considered post-nesting movements. This date was chosen based on approximate termination of nesting attempts by radio-tagged hens and by what has been considered the end of the nesting season in Mississippi (Hurst 1988).

I used Euclidean distances (Conner and Plowman 2001) to investigate habitat use of radio-marked Wild Turkey hens. This is a distribution-free procedure that uses the animal as the sampling unit, is not bound by unit sum constraints, and is more robust to telemetry error because it does not require the individual to be "assigned" to a particular habitat as is the case with other methods (Neu et al. 1974, Aebischer et al. 1993). By definition, animal locations represent habitat use and each home range represents available habitat. Two assumptions were considered essential for habitat use versus availability analyses: 1) hen locations were independent, and 2) habitats were available. Independence of hen locations may be questionable because one hen's location may influence another hen's location if one follows the other. Violation of this assumption was thought to be minimal because of the time of year most of the locations were taken (spring and summer) when flocking behavior would not be as evident (Chamberlain 1995). Violation of the availability assumption was dampened because habitats within the home range were considered available if the individual was located in those habitats (Johnson 1980).

The Euclidean distance method measures and averages distances between an individual's (i) estimated locations and all habitat types (u_i). Similarly, distances between randomly generated points within 95% home range polygons and habitat types are measured and averaged (r_i). The distance from the animal's location to the habitat type where it was found will be smaller than the distance from that same location to other habitat types. If average distances between an individual's locations and random locations to associated habitats are similar, then available habitats are used randomly. If the ratio u_i:r_i >1, habitats are used less than expected. Alternatively, if the ratio u_i:r_i <1, then available habitats are used more than expected. A vector of ratios (d_i) for each hen to each habitat was calculated by dividing u_i by r_i and all d_is were averaged to yield a mean vector (ρ). Differences between ρ and a vector of 1s were tested using multivariate analysis of variance (MANOVA) to determine nonrandom habitat use. If nonrandom habitat use occurred, each ρ was tested to determine a difference from 1 using a t-test ($P \leq 0.05$). A significant difference indicated the habitat was used disproportionately (least P-value = greatest ranking of use).

Because of insufficient sample sizes in the resulting subgroups, Euclidean distance analysis could not be performed because associated MANOVA's could not be computed to determine random or nonrandom habitat use. The chi-square goodness-of-fit procedure was used instead because it counts each individual location as the sampling unit rather than each animal (Neu et al. 1974). Determination of habitat use was based on Bonferroni confidence intervals constructed at $P = 0.05$ (Byers and Steinhorst 1984).

RESULTS

I monitored 28 Wild Turkey hens between 15 March and 13 August, 2004. Four hens were excluded from analysis due to an insufficient number of location estimates. Location data from 24 hens ($n = 11$ for delta and $n = 13$ for hills section) was used for habitat selection analysis. From these sub-populations, 2 delta brood hens and 4 upland brood hens were used for pre- and post-nesting period habitat use analysis.

Telemetry accuracy tests were performed for the 2 observers who collected hen habitat use data. A mean angular error of $8° \pm 2.5°$ was recorded for a total of 45 test locations during leaf on and leaf off periods.

Home Range

Mean 95% hen home range estimates were 426.56 ha (SD 236.67) (n = 19) and 283.75 ha (SD 213.21) (n = 13) for pre and post-nesting periods. An equal variance t-test detected no significant difference between the two periods ($t_{0.05(2),30} = 2.04$, P = 0.09). Mean home ranges of brood (n = 6) and non-brood hens (n = 7) during the post-nesting season were 315.51 ha (SD 267.37) and 256.53 ha (SD 171.68). No significant difference was detected between the two groups ($t_{0.05(2),11} = 2.20$, P = 0.64).

Habitat Use

Most (n = 23) of Wild Turkey hens captured in each distinct area (delta or hills section) remained in their respective sections throughout the study period. One hen, captured in the hills section of MWMA, moved to the delta section. Percentage area for each habitat type for combined delta hen home ranges were 4% AG, 77% BLHD, 4% MGDO, 11% OF, 0.01% PNPL, and 4% Buffer. Euclidean distance analysis detected nonrandom patterns in habitat use for delta hens (Wilk's Lambda = 0.11, $F_{6,5} = 6.95$, P = 0.03). Examination of distances to habitat types indicated delta hens were found closer to BLHD ($\rho_{BLHD} = 0.59 \pm 0.08$ ($x \pm SD$), $t_{ll} = -5.00$, P < 0.01), MGDO ($\rho_{MGDO} = 0.81 \pm 0.05$, $t_{ll} = -3.92$, P < 0.01), and Buffer ($\rho_{Buffer} = 0.86 \pm 0.05$, $t_{ll} = -2.98$, P = 0.01) habitat types than expected (Table 3.1). There were no differences between hen locations and random points for AG ($\rho_{AG} = 0.92 \pm 0.05$, $t_{ll} = -1.57$, P = 0.15), OF ($\rho_{OF} = 0.98 \pm 0.04$, $t_{ll} = -0.32$, P = 0.76), and PNPL ($\rho_{PNPL} = 0.99 \pm 0.02$, $t_{ll} = -0.41$, P = 0.69) habitats.

A ranking of proportional habitat use based on ρ indicated that BLHD was used most by hens, followed by MGDO, Buffer, AG, PNPL, and OF. Pair-wise comparisons of distance ratios associated with habitat types indicated that hens were found significantly closer to BLHD than to all other habitat types (Table 3.2). Hens were found significantly closer to MGDO than to AG, OF, and PNPL, and were closer to Buffer than to OF.

Only 2 hens in the delta section were successful in hatching a brood. One hen had at least one poult at the end of the study period. The other hen lost her brood about two weeks after hatch. Due to insufficient pre-nesting locations (n = 32), no formal habitat analysis could be performed. Subsequent analysis of post-nesting movements between the two brood hens indicated nonrandom habitat use (χ^2_5 = 9.98, P < 0.05). BLHD was used greater than expected (Table 3.3). AG and OF were used less than expected.

Non-brood hens (n = 9) exhibited random habitat use (χ^2_4 = 3.43, P > 0.05) during the pre-nesting period in the delta region of MWMA. Habitats were used non-randomly (χ^2_4 = 31.50, P < 0.05) by non-brood hens during the post nesting period. BLHD and MGDO were used more than expected (Table 3.4). OF was used less than expected.

The hills section was 4% AG, 4% BLHD, 9%MGDO, 10% OF, 22% PNPL, 7% Buffer, and 45% ULHD. Euclidean distance analysis detected nonrandom habitat use for hills section hens (n = 13) (Wilk's Lambda = 0.16, $F_{7,6}$ = 4.43, P = 0.04). Examination of distances to habitat types indicated upland hens were found closer to PNPL (ρ_{PNPL} = 0.83 ± 0.05, t_{13} = -3.57, P < 0.01), MGDO (ρ_{MGDO} = 0.89 ± 0.04, t_{13} = -2.65, P = 0.02), and OF (ρ_{OF} = 0.89 ± 0.04, t_{13} = -2.57, P = 0.02) habitat types than expected (Table 3.5). No differences were detected between hen locations and random points for AG (ρ_{AG} = 1.04 ± 0.03, t_{13} = 1.67, P = 0.12), ULHD (ρ_{ULHD} = 1.00 ± 0.13, t_{13} = 0.02, P = 0.98), BLHD

(ρ_{BLHD} = 0.92 ± 0.05, t_{13} = -1.84, P = 0.09), and Buffer (ρ_{Buffer} = 0.94 ± 0.03, t_{13} = -2.00, P = 0.07) habitats.

A ranking of proportional habitat use based on ρ indicated PNPL was most preferred by hens followed by MGDO, OF, Buffer, BLHD, ULHD, and AG. Pair-wise comparisons of distance ratios associated with habitat types indicated that hens were found significantly closer to all other habitat types when compared to AG (Table 3.6). No other significant differences between habitat types were detected.

Chi-square analysis for hills section brood hens (n = 4) during the pre-nesting period indicated random habitat use (χ^2_5 = 6.83, P > 0.05). Nonrandom habitat use was detected for post-nesting movements of hills section brood hens (χ^2_7 = 102.96, P < 0.05). AG and ULHD habitats were used less than expected (Table 3.7). BLHD, PNPL, and OF types were used more than expected by hills section brood hens.

Nonrandom habitat use was detected for pre (χ^2_7 = 20.85, P < 0.05) and post (χ^2_7 = 12.00, P < 0.05) nest locations of hills section non-brood hens. BLHD was used more than expected during pre-nesting movements and AG was used less than expected (Table 3.8). Non-brood hens used BLHD less than expected and PNPL greater than expected during the post-nesting period (Table 3.9).

DISCUSSION

Pre-nesting Habitat Use

Non-brood hens in the hills section used bottomland hardwoods on my study area more than expected during the pre-nesting period. Use of bottomland hardwoods by non-brood hens during the pre-nesting period could be contributed to hard mast availability and early ground-story development (Miller 1997). However, hens that remained in this area may have experienced decreased nest success because time was not spent searching for better nesting sites in other habitats (Orians and Wittenberger 1991). Random habitat use by brood hens in the hills section of my study area supports this.

Post-nesting Habitat Use

Use of loblolly pine plantations (≤15 years of age) by hills section hens was greater than expected at Malmaison WMA. Brood and non-brood hens used pine plantations on adjacent lands greater than expected during the post-nesting period. Lambert et al. (1990) reported that old pine plantation and hardwood stands received the greatest overall use by hens in southeastern Louisiana. Thinning of these privately owned pine plantations adjacent to MWMA was conducted in late spring of 2003, and was soon followed by a resurgence of grasses and some herbaceous vegetation. Logging roads, lanes, and a few managed openings, all dominated by grasses and herbaceous vegetation, were present and probably provided additional foraging areas and cover for hens with and without broods. Hens used pine plantations in Kemper County in spring and summer for nesting and brood-rearing and presence of spur roads appeared to be the most important variable in selection of pine plantations by turkeys (Smith et al. 1990). Palmer (1990) reported the presence of grasses and forbs on hen use plots in an area dominated by pine forests. Palmer (1990) also reported pine sapling (5 – 15 years old) stands were selected by hens during pre-nesting periods within other years, but noted this may have been attributed to their close juxtaposition to bottomland hardwoods and attraction to edge. Small creek drainages with limited hardwoods existed in these pine stands, and hen use of these habitats may not have been detected due to patch size.

Delta hens in my study used mature bottomland hardwood stands greater than expected, and this was supported by analysis of post-nesting brood and non-brood hen habitat use. Brood hens in the hills section of my study area used bottomland hardwoods greater than expected during the post-nesting period. Turkeys in Alabama used pastures, creek bottoms, and right-of-ways during summer; and openings, pastures, and creek bottoms during spring (Everett 1982). In Louisiana batture land forests, hens used thinned hardwood stands during all periods, which Zwank et al. (1988) attributed to reduced canopy cover that stimulated growth of herbaceous plants providing food and cover. Similar conditions existed in certain parts of the delta section of MWMA and surrounding lands where reduced canopy cover was primarily caused by the death of old trees and uneven-aged stands. In the Mississippi delta, Chamberlain (1995) reported spring and summer habitat use of immature poletimber stands of sweetgum (*Liquidambar styraciflua*), Nuttall oak (*Quercus texana*), and willow (*Salix nigra*), immature sawtimber size elm, ash (*Fraxinus* spp.), and sugarberry, and privately forested lands were used more than expected based on habitat availability. Immature pole and sawtimber stands and privately forested lands probably had a more developed understory due to smaller canopy size providing better foraging and cover for hens and broods, particularly young broods (Williams et al. 1973, Campo et al. 1989). Williams et al. (1973) reported older broods (4-6 weeks of age) preferred bottomland hardwood and open habitats in that order over other habitats. Chamberlain (1995) noted that used stands were generally located at higher topographic elevations. The delta section of MWMA and surrounding lands has numerous ridges that remain unflooded for long periods of time. Burk (1989) indicated that hens used stream-side management zones of all sizes greater than expected in an area dominated by pine plantations. Phalen (1986) and Seiss (1989) concluded that bottomland hardwood forests were preferred brood habitat because herbaceous plants which attract food and provide additional cover for young poults, dominated in the understory. Some forested areas on MWMA, particularly in the delta section, could be characterized as park-like (Porter 1992), and contained a grass and forb dominated understory desirable for young broods.

Managed openings were used more than expected and ranked second behind mature bottomland hardwood stands in preference by all delta hens on my study area based on results from Euclidean distance analysis. Chi-square analysis supported this regarding post-nesting habitat use of non-brood hens in the delta section. In the hills section, managed openings were used more than expected and ranked second behind pine plantations in preference. Many studies have demonstrated the importance of open habitats to Wild Turkeys in the Southeast in providing foraging areas and brood habitat (Pack et al.1980, Hurst and Dickson 1992, Peoples et al. 1996). Managed openings on MWMA vary in shape and size and are maintained at a stage dominated by grasses with forbs present or planted with white clover (Hurst and Dickson 1992) to attract insects and provide cover for broods. Many are found juxtaposed to multiple habitat types potentially providing easier access to other forage items and cover in the interior and along the edge of other habitats (i.e., regeneration areas). Also, many of MWMA's openings are relatively free from human intrusion during most of the year. Nevertheless, use of these openings, particularly by brood hens, may have been offset by the availability of surrounding bottomland hardwood forests and the favorable conditions these areas may provide (Williams and Austin 1988, Ross and Wunz 1990, William et al. 1997). Use of managed openings in and around the hills section of MWMA may have been offset during spring and summer because of the habitat recently thinned pine plantations provided and to grass and forb dominated understories beneath some stands of upland hardwoods.

Most of the larger (5-10 ha) managed openings are located in the hills section of MWMA and surrounding lands. I assumed habitat use of these larger openings would be more readily detected if in fact they were used (White and Garrott 1990). Hens, particularly with broods, may prefer smaller, non-symmetrical openings as mentioned before and therefore large areas of these expansive openings go unused (William and Austin 1988, Wunz 1990).

Brood hens in the hills section of MWMA used old field habitats more than expected during the post-nesting period. Delta hens on MWMA and surrounding areas used old field habitats less than expected. Palmer (1990) reported regeneration areas were used as available all years by all hens during a 2-year study in the Mississippi delta. Chamberlain (1995) reported non-use of regeneration areas by hens during a 2-year study in Mississippi. Several old fields in the hills section had immature poletimber and saplings stands with more favorable understories that seemed to provide cover and insects for young poults (1-4 weeks old). The rest of the old fields in the hills and delta sections of MWMA were composed mainly of extremely dense vegetation (i.e., *Rubus* spp. thickets) that would have impeded movement and use particularly by poults. However, old fields and road sides dominated by blackberry were used by nesting hens (n = 7) during my study. Phalen (1986) reported hens preferred to nest in densely vegetated regeneration areas during a 2-year study in Mississippi.

Upland hardwood stands were used less than and as expected during the post-nesting period by brood and non-brood hens as determined using both forms of analysis. In Mississippi, Miller (1997) reported unsuccessful pre-incubators significantly preferred hardwood sawtimber over all other habitat types. In Tennessee, Williams et al. 1997 reported older broods (4-6 weeks) selected upland hardwood stands. In the Ouachita Mountains of Arkansas, Wigley et al. (1986) reported upland sawtimber stands were preferred during all seasons by juvenile hens except during spring when all DBH classes were used as available. Upland hardwoods represent the dominant habitat type in the hills section on MWMA. The lack of use suggests upland hardwood stands provide inadequate spring and summer turkey habitat particularly for young broods (Everett et al. 1985, Williams et al. 1997). The only hen that nested in upland hardwoods and was successful, moved her brood to more open forest near a pine plantation and road edge. Areas of sparse groundstory existed in parts of upland hardwood forest stands in and around MWMA. This may have contributed to lack of use by brood and non-brood hens. Topographic relief may have been too great in many areas for use, particularly by young broods (Pack et al.1980). Upland hardwoods on MWMA probably provide better fall and winter habitat because of hard mast production.

Delta section hens did not move into the hills section of the study area at any point during my study. The same was true for all hills section hens except one. This suggests that these different physiographic regions may contain unique environmental conditions which could cause local adaptations within the Wild Turkey population thereby giving rise to individuals more suitably adapted to each region (Smith and Smith 2003).

Habitat quality and abundance may be another explanation for lack of dispersal particularly for delta section hens. Multiple studies in Mississippi have indicated the importance of stream and creek hardwood bottoms (Seiss 1989, Phalen 1986, Porter 1992, Miller 1997) for brood and foraging habitat in upland landscapes. I detected use of a major creek bottom by some hills section hens. Stands of mature hardwoods were present throughout the delta section and appeared to be adequate brood and foraging habitat. Nesting habitat appeared to be in abundance as well in the form of old fields and clear cuts.

Given my observations, future Wild Turkey relocation efforts may be more successful if birds are moved to regions with environmental conditions similar to those from which they came. Assuming the two subpopulations in my study represented two ecotypes (Smith and Smith 2003); Wild Turkeys would be better suited to the local climate and able to recognize desirable habitat characteristics more rapidly.

Interpretation of Results

Further analysis of pre- and post-nesting brood and non-brood hen habitat use could not be accomplished using the Euclidean distance method due to inadequate sample sizes. Because Euclidean distance analysis incorporates use of a MANOVA to determine nonrandom habitat use, parametric sample size assumptions were violated and subsequent analysis of the subgroups was not possible. Consequently, switching to a less robust method (chi-square goodness of fit) for habitat use analysis was necessary.

The chi-square method of analysis suffers from telemetry error more than the distance based approach because location estimates must fall in the habitat patch to determine disproportionate use. The distance based approach calculates average distances between location estimates and habitat patches to determine disproportionate use. Location estimates do not have to repeatedly fall within a habitat type to determine its use and preference by Wild Turkeys, thereby reducing telemetry error and patch size effects in the Euclidean distance analysis. Consequently, use of edge and small or narrow habitat patches can be detected by Euclidean distance analysis. Because location estimates may never fall in these areas, the chi-square method may have failed to detect disproportionate use of these habitats. Random use of habitats, as determined using the chi-square method, may have been partly due to microhabitat overlap or location misplacement as a result of telemetry error and patch size (White and Garrott 1990). Unequal location estimates for individuals may bias habitat use results when using the chi-square method (Conner and Plowman 2001).

The hills (n = 13) and delta (n = 11) section hen sample sizes were small and risked violating sample size assumptions (i.e., normal distribution, increased variance) needed to draw statistically and biologically meaningful conclusions. Therefore, caution should be used when drawing conclusions from the habitat use results of this study to guide management recommendations (Seiss 1989, Miller 1997). This is particularly true due to the inadequacies (telemetry error, detection failure, unequal locations among hens) mentioned earlier for the Neu et al. (1974) method.

Future Research

Future research should focus on acquiring larger sample sizes of hens and using Euclidean distances to determine habitat use among hens with broods and those without during pre- and post-nesting periods. Dividing brood periods into early, mid, and late season (Phalen 1986) would help in determining when specific habitats (i.e., managed openings) are used most as poults develop. Further classification and analysis of managed openings based on management practice, location of each in relation to other habitat types, and size and shape may help determine which openings receive the most use (Wunz and Pack 1992, Miller 1997). This information may give wildlife managers some indication of the ability of adjacent habitat to meet Wild Turkey resource requirements and how to better manage openings.

MANAGEMENT RECOMMENDATIONS

Wild Turkey hens used open habitats on MWMA and adjacent lands that appeared to have greater amounts of groundstory vegetation. These included mature bottomland hardwood stands, managed openings, recently thinned pine plantations, edges, and old fields dominated by hardwood saplings. On the basis of this study and other literature on the Wild Turkey, I can make two broad management recommendations:

1) Brood and nesting habitat may not currently be a limiting factor on MWMA based on presence of certain desirable vegetation characteristics, identified in past studies (Phalen 1986, Seiss 1989, Miller 1997, Lowery 1999) and mine, found within several habitat types. Wild Turkeys are opportunistic and use a variety of habitats to meet requirements (Hurst and Dickson 1992, Miller 1997). My results supported this with hens using a variety of habitats. A mixture of stand seral stages (i.e., 2-5 year successional stages, poletimber, and sawtimber) exists on MWMA. Maintaining this mixture of early successional (i.e., managed openings, 2nd or 3rd year fallow fields) and mature hardwood stand habitats may be key to continue providing adequate amounts of quality brood and nesting habitat on MWMA (Miller 1997). Overstory and midstory thinning in selected saw and poletimber stands in the delta and hills sections should help to ensure uneven age stands of timber and promote understory development critical for brood and nesting habitat (Zwank et al. 1988). Efforts should be made to remove only those trees that have little wildlife value.

2) Managed openings were used more than expected by non-brood hens on MWMA and were the second most preferred habitats among all hens based on Euclidean distance analysis. Openings should continue to be managed as foraging habitat for Wild Turkeys and their broods. Although my analysis did not detect brood hen use of managed openings, I visually observed marked and unmarked hens with broods, particularly ≥4 weeks old, in and very near managed openings. I recommend continued annual mowing of managed openings to maintain an early successional stage which will facilitate movement and promote growth of grasses. Grain crops (i.e., *Sorghum* spp.) and

clovers should continue to be planted along lane edges and in openings to provide forage for Wild Turkeys from spring through winter (Yarrow and Yarrow 1999). Grain crops will provide seeds during fall and winter and clovers attract insects which poults require and can be eaten directly by Wild Turkeys. Developing poults will benefit from these plantings as their diets shift from insects to plant matter (Hurst 1992).

Some openings on MWMA were dominated by less desirable vegetation which did not appear to readily attract insects (pers. obs.). Strip-disking existing managed openings (particularly lane openings) every 2 years is recommended to promote growth of herbaceous vegetation and seed producing plants that attract insects and provide forage for Wild Turkeys (Lafton et al. 2001, Greenfield et al. 2003). In addition, existing openings planted in white clover (*Trifolium repens*) may become too dense and robust over time. This may prohibit poult movement and reduce palatability of actual stems. Mowing may be necessary throughout the growing season to reduce height and thickness of stands and allow broods access.

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Table 3.1. Mean vector (ρ)[a] and 95% confidence intervals for 3rd order selection of habitats by delta section hens at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	95% LCL	Mean (ρ)	95% UCL
AG	0.8145	0.9234	1.032
BLHD	0.4038	0.5876	0.7714
MGDO	0.7006	0.8091	0.9175
OF	0.8846	0.9855	1.086
PNPL	0.9559	0.9932	1.03
Buffer	0.7473	0.8554	0.9634

[a] Mean ratio (mean animal location distance to habitat A/mean random point Distance to habitat A) across all hens for each habitat type.

Table 3.2. Pair-wise comparison of habitat use by delta section hens at Malmaison WMA, Mississippi and surrounding lands, 2004.

	AG	BLHD	MGDO	OF	PNPL	Buffer
AG		[a]5.46 (0.001)	2.64 (0.025)	-1.02 (0.331)	-1.13 (0.283)	1.17 (0.112)
BLHD	-5.46 (0.001)		-3.17 (0.010)	-3.85 (0.003)	-4.42 (0.001)	-4.03 (0.002)
MGDO	-2.64 (0.025)	3.17 (0.010)		-3.01 (0.013)	-3.15 (0.010)	-2.16 (0.056)
OF	1.02 (0.331)	3.85 (0.003)	3.01 (0.013)		-0.14 (0.891)	2.64 (0.025)
PNPL	1.13 (0.283)	4.42 (0.001)	3.15 (0.010)	0.14 (0.891)		2.25 (0.048)
Buffer	-1.74 (0.112)	4.03 (0.002)	2.16 (0.056)	-2.64 (0.025)	-2.25 (0.048)	

[a] Numbers are t-statistics (P-values) associated with pair-wise comparisons of corrected distances to habitats.

Table 3.3. Analysis of post-nest habitat use for brood hens in the delta section at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	% Observed Locations	% Expected Locations	95% Bonferroni Intervals	
AG	0.015	0.041	-0.006-0.035*	(-)
BLHD	0.851	0.774	0.790-0.911*	(+)
MGDO	0.060	0.037	0.020-0.100	(0)
OF	0.060	0.113	0.020-0.100*	(-)
Buffer	0.015	0.035	-0.006-0.035	(0)

* Probability of disproportional use ≤ 0.05. (+) = used more than expected, (0) = used as expected, and (-) = used less than expected.

Table 3.4. Analysis of post-nest habitat use for non-brood hens in the delta section at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	% Observed Locations	% Expected Locations	95% Bonferroni Intervals	
BLHD	0.797	0.697	0.742-0.851*	(+)
MGDO	0.096	0.046	0.056-0.136*	(+)
OF	0.064	0.203	0.031-0.097*	(-)
Buffer	0.043	0.055	0.015-0.07	(0)

* Probability of disproportional use ≤ 0.05. (+) = used more than expected, (0) = used as expected, and (-) = used less than expected.

Table 3.5. Mean vector (ρ)[a] and 95% confidence intervals for 3rd order selection of habitats by hills section hens at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	95% LCL	Mean (ρ)	95% UCL
AG	[a]0.9862	1.045	1.105
BLHD	0.8166	0.9130	1.015
MGDO	0.7927	0.8862	0.9798
OF	0.7965	0.8898	0.9832
PNPL	0.7225	0.8276	0.9327
Buffer	0.8809	0.9430	1.005
ULHD	0.7138	1.003	1.292

[a] Mean ratio (mean animal location distance to habitat A/mean random point distance to habitat A) across all hens for each habitat type.

Table 3.6. Pair-wise comparison of habitat use by hills section hens at Malmaison WMA, Mississippi and surrounding lands, 2004.

	AG	BLHD	MGDO	OF	PNPL	Buffer	ULHD
AG		[a]3.39 (0.005)	3.24 (0.007)	3.13 (0.009)	3.30 (0.006)	2.37 (0.036)	0.28 (0.784)
BLHD	-3.39 (0.005)		0.59 (0.563)	0.53 (0.603)	1.14 (0.276)	-0.58 (0.570)	-0.54 (0.600)
MGDO	3.24 (0.007)	-0.59 (0.563)		-0.06 (0.954)	0.79 (0.442)	-1.97 (0.073)	-0.74 (0.473)
OF	-3.13 (0.009)	-0.53 (0.603)	0.06 (0.954)		0.90 (0.388)	-1.18 (0.260)	-0.75 (0.466)
PNPL	-3.30 (0.006)	-1.14 (0.276)	-0.79 (0.442)	-0.90 (0.388)		-1.75 (0.105)	-1.39 (0.191)
Buffer	-2.37 (0.036)	0.58 (0.570)	1.97 (0.073)	1.18 (0.260)	1.75 (0.105)		-0.42 (0.680)
ULHD	-0.28 (0.784)	0.54 (0.600)	0.74 (0.473)	0.75 (0.466)	1.39 (0.191)	0.42 (0.680)	

[a] Numbers are t-statistics (P-values) associated with pair-wise comparisons of corrected distances to habitats.

Table 3.7. Analysis of post-nest habitat use for brood hens in the hills section at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	% Observed Locations	% Expected Locations	95% Bonferroni Intervals	
AG	0.017	0.036	0.004-0.029*	(-)
BLHD	0.108	0.038	0.078-0.137*	(+)
MGDO	0.081	0.086	0.055-0.108	(0)
OF	0.136	0.099	0.103-0.169*	(+)
PNPL	0.309	0.223	0.264-0.353*	(+)
Buffer	0.062	0.068	0.039-0.085	(0)
ULHD	0.287	0.450	0.244-0.330*	(-)

* Probability of disproportional use ≤ 0.05. (+) = used more than expected, (0) = used as expected, and (-) = used less than expected.

Table 3.8. Analysis of pre-nest habitat use for non-brood hens in the hills section at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	% Observed Locations	% Expected Locations	95% Bonferroni Intervals	
AG	0.015	0.031	0-0.030*	(-)
BLHD	0.126	0.068	0.086-0.166*	(+)
MGDO	0.130	0.099	0.089-0.170	(0)
OF	0.126	0.121	0.086-0.166	(0)
PNPL	0.111	0.149	0.073-0.149	(0)
Buffer	0.061	0.071	0.032-0.090	(0)
ULHD	0.431	0.461	0.371-0.491	(0)

* Probability of disproportional use ≤ 0.05. (+) = used more than expected, (0) = used as expected, and (-) = used less than expected.

Table 3.9. Analysis of post-nest habitat use for non-brood hens in the hills section at Malmaison WMA, Mississippi and surrounding lands, 2004.

Habitat Type	% Observed Locations	% Expected Locations	95% Bonferroni Intervals	
BLHD	0.029	0.070	0.003-0.061*	(-)
MGDO	0.115	0.102	0.054-0.177	(+)
OF	0.087	0.125	0.033-0.141	(-)
PNPL	0.260	0.153	0.175-0.344*	(+)
Buffer	0.077	0.074	0.026-0.128	(0)
ULHD	0.433	0.476	0.337-0.528	(0)

* Probability of disproportional use ≤ 0.05. (+) = used more than expected, (0) = used as expected, and (-) = used less than expected.

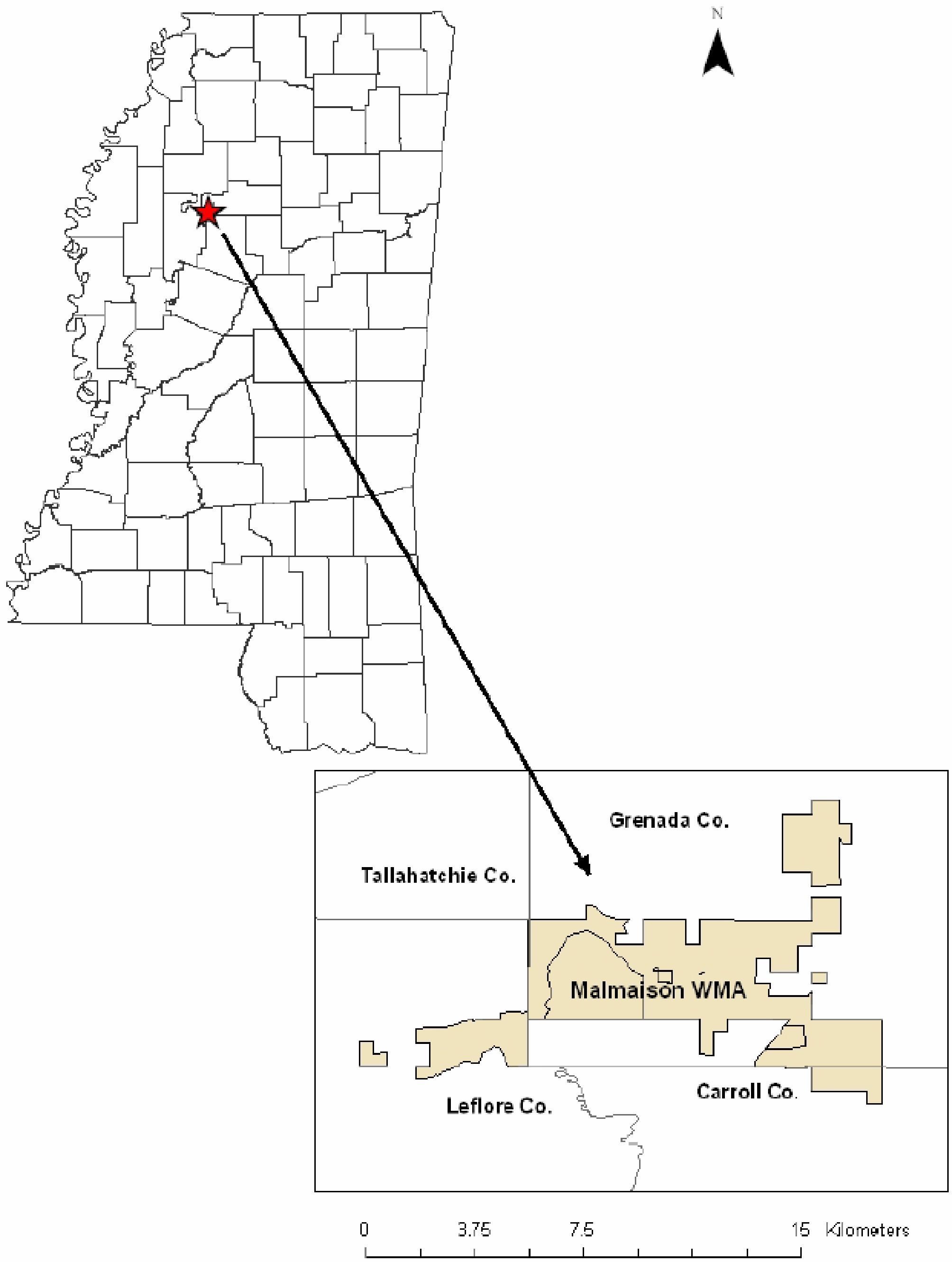

Figure 3.1. Location and configuration of Malmaison Wildlife Management Area, Mississippi, 2003-2004

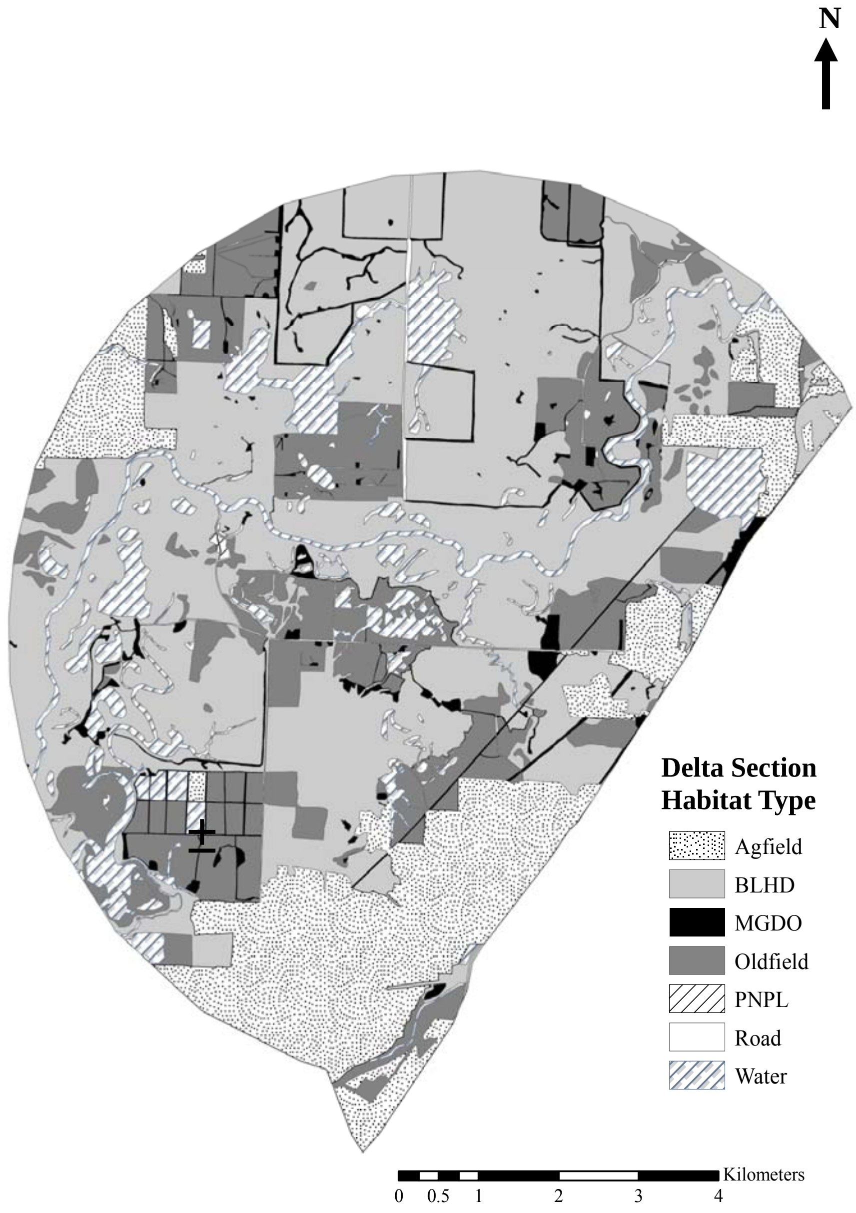

Figure 3.2. Habitat coverage of the delta section of Malmaison, WMA, Mississippi and surrounding lands, 2004.

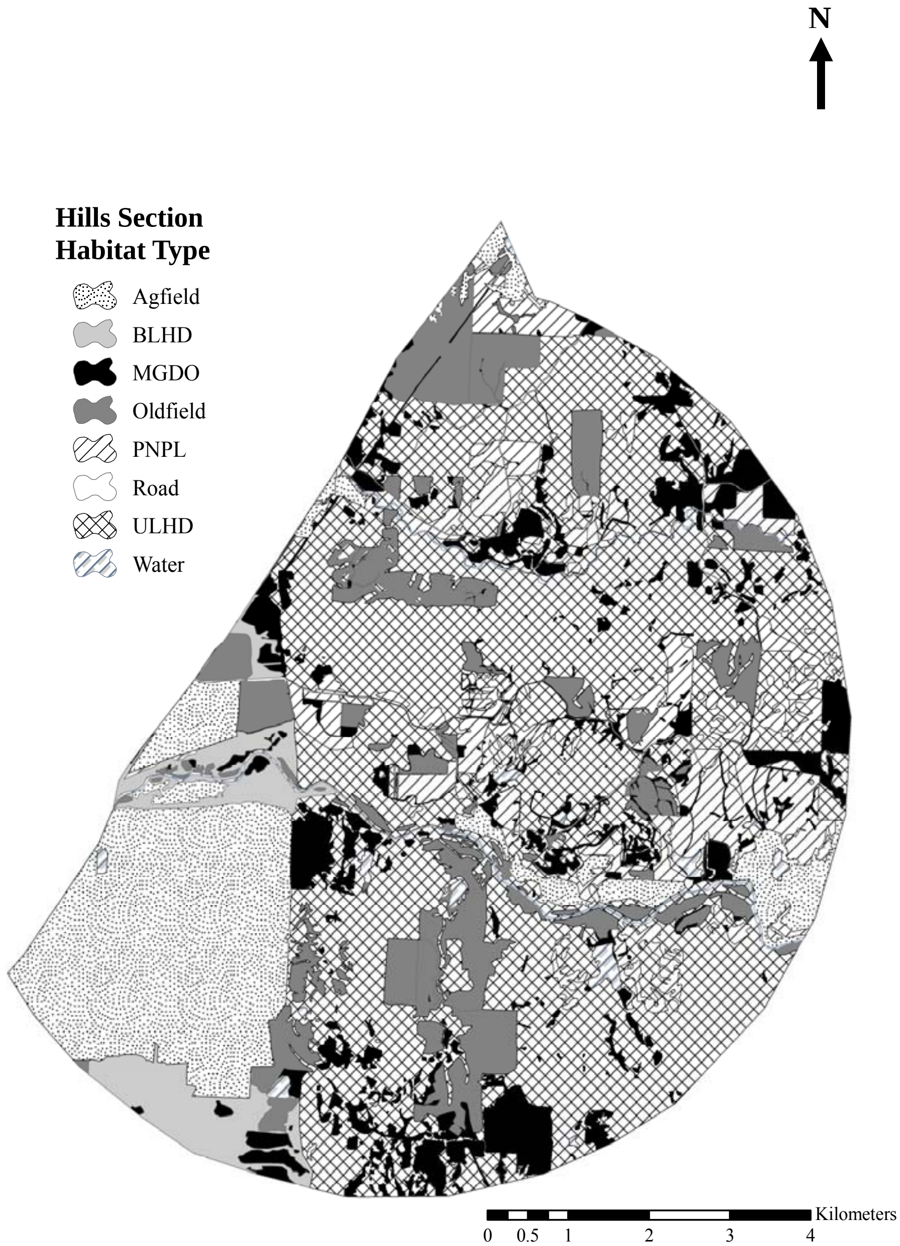

Figure 3.3. Habitat coverage of the hills section of Malmaison, WMA, Mississippi and surrounding lands, 2004.

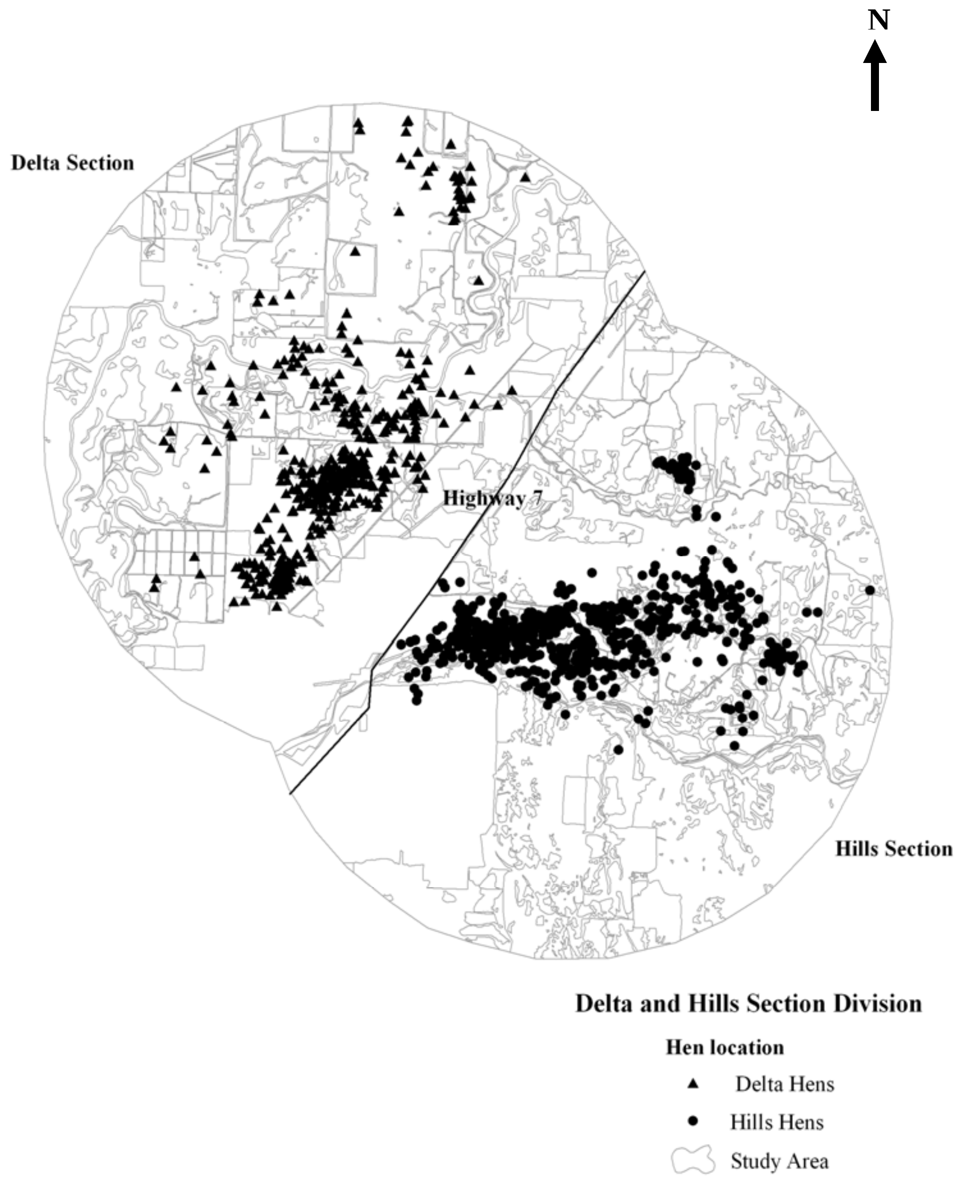

Figure 3.4. Map of Malmaison WMA showing the clear division along Highway 7 between the delta and hills sections. Hens remained in the physiographic region they were captured in as indicated by location estimates.

CHAPTER IV

CHARACTERISTICS OF WILD TURKEY NEST SITES IN CENTRAL MISSISSIPPI

ABSTRACT

Micro-habitat characteristics were quantified for 18 Eastern Wild Turkey (*Meleagris gallopavo silvestris*) nests at Malmaison Wildlife Management Area in Central Mississippi in 2003-2004. Measurements at each nest site included distance to nearest edge, edge type (natural or man-made), elevation, vegetation composition and height, and obscurity of the nest by vegetation. Each of these variables was compared between 6 successful and 12 unsuccessful nests. Mean distance to edge was 21.82 ± 17.49 m and 24.99 ± 27.51 m for successful and unsuccessful nests, respectively. Sixteen of 18 nests were located ≤50 m from a managed opening. Forbs were the predominant vegetation type surrounding turkey nests and comprised 49% and 61% of the vegetation at successful and unsuccessful nest sites. Vegetation height was 0.3-0.6 m for successful and unsuccessful nest sites. Vertical screening cover for all nests was in the 21-40% obscurity category at 1 m and 41-60% category at 3 and 5 meters and did not differ between successful and unsuccessful nests. Percentage overhead cover was 41-60% and vegetation height was 0.6-0.9 m at all nest cups. Vine coverage differed between successful (2%) and unsuccessful (20%) nests sites ($P = 0.03$). No other

significant differences were observed between characteristics of successful and unsuccessful nests. Nesting hens appeared to select micro-habitats that provided relatively dense visual cover, usually in the form of forbs, out to 5 m from the nest and were located near managed openings and mowed roadsides. Dense patches of cover may impede nest searches by aerial and terrestrial predators. Additional information regarding relationships between patch size, effects of nesting habitat distribution among adjacent habitat types, and nest success is needed.

INTRODUCTION

Nest success is one of the more important factors limiting Wild Turkey (*Meleagris gallopavo*) populations (Miller 1997, Rolley et al. 1998, Thogmartin 1999, Thogmartin and Schaeffer 2000). Nest success is influenced by nesting habitat in many ground-nesting species, including the Wild Turkey. Habitat characteristics of successful and unsuccessful Wild Turkey nests have been well documented in the Southeast (Williams and Austin 1988, Badyaev 1995, Chamberlain and Leopold 1998, Inglis 2001).

Ideal habitat features which satisfy Wild Turkey nesting requirements in forested ecosystems consistently include a more open canopy, greater overhead cover directly above the nesting hen, and a well-developed understory (Campo et al. 1989, Seiss 1989, Palmer 1990). Small openings, right-of-ways, and road edges are also used by nesting hens because of favorable vegetative characteristics (Still and Baumann 1990, Porter 1992). Creating, maintaining (i.e., mowing, disking) and planting [i.e., clover (*Trifolium* spp.) and sorghum (*Sorghum* spp.)] wildlife openings on public and private lands are techniques used to create and enhance habitat for turkey broods but also provide additional nesting habitat in some cases (Martin and McGinnes 1975, Yarrow and Yarrow 1999, Dickson 2001). Nesting habitat often occurs in edges between one habitat type and another (i.e., a maintained opening and a forest stand). Vegetation found in these transitional zones is thought to provide suitable Wild Turkey nesting habitat due to composition and concealment qualities, and proximity to brood habitat (Williams et al. 1973, Holbrook et al. 1987, Seiss 1989, Lowery 1999).

Further investigation of factors affecting nest success is needed as landscapes change due to human demands and uses. Updated information will help resource managers provide optimum nesting habitats as agencies continue pursuit of improved management strategies. My objective was to quantify nest site characteristics and compare them between successful and unsuccessful nests in central Mississippi.

STUDY AREA

My study was conducted at Malmaison Wildlife Management Area (MWMA) and surrounding lands in west-central Mississippi. This 3,600-ha public use area was owned by the Mississippi Department of Wildlife, Fisheries and Parks and was located in Grenada, Carroll and Leflore counties (Figure 4.1). Much of the management area fell within the alluvial floodplain of the Yalobusha River. The eastern portion of the study area was predominantly loess hills. Habitats occurring on the MWMA included mature bottomland hardwood, upland hardwood, and pine-hardwood forests, wetlands, old fields, and managed wildlife openings. Dominant bottomland tree species included sycamore (*Platanus occidentalis*), elm (*Ulmus* spp.), sugarberry (*Celtis laevigata*), water oak (*Quercus nigra*), willow oak (*Q. phellos*), overcup oak (*Q. lyrata*), swamp chestnut oak (*Q. michauxii*), cherrybark oak (*Q. pagoda*) and pecan (*Carya illinoensis*). Sedges (*Carex* spp.), switch cane (*Arundinaria gigantea*), greenbriar (*Smilax* spp.), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), pepper vine (*Ampelopsis arborea*), may apple (*Passiflora incarnate*), poison ivy (*Toxicodendron radicans*),muscadine grape (*Vitis rotundifolia*) broomsedge (*Andropogon virginicus*), clover (*Trifolium* spp.), foxtail (*Setaria* spp.) and several grasses (*Andropogon* spp. and

Paspalum spp.) were the dominate ground cover. White oak (*Q. alba*), loblolly pine (*Pinus taeda*), beech (*Fagus grandifolia*), and elm (*Ulmus* spp.) were the dominate tree species in the upland habitats whereas much of the understory vegetation was similar to that of bottomland habitats except for more blackberry (*Rubus* spp.), kudzu (*Pueraria montana*) and honeysuckle (*Lonicera japonica*).

There were approximately 60 small (1-3 ha), managed openings interspersed throughout the management area. These openings were specifically managed to benefit Wild Turkeys and other wildlife including White-tailed Deer (*Odocoileus virginianus*) and Northern Bobwhites (*Colinus virginianus*). During spring and summer of 2003 and 2004, many managed openings found on MWMA and surrounding lands were dominated by white clover (*Trifolium repens*), annual grasses, and vetch (*Vicia* spp.). Grain crops (i.e., *Sorghum* spp.) and winter wildlife blends of oats, peas, and grasses were planted during the spring and summer in a few selected openings to provide winter food sources for turkeys, deer, and other non-game wildlife. Most openings were maintained at an early successional stage by mowing at least once during the growing season. Despite their intended wildlife benefits, there have been no rigorous assessments of managed opening use by Wild Turkeys.

METHODS

Trapping and Processing

Wild Turkey hens were trapped during February and early March of 2003 and 2004. Approximately 20 trap sites were prepared and baited twice daily with wheat

(*Triticum aestivum*) at a rate of approximately 27.2 kg/day. Hens were captured using rocket and cannon nets (Eriksen et al. 1996). Upon capture, 90 g transmitters (Advanced Telemetry Systems, Isanti, MN) were secured “backpack” style to hens (Norman and Hurst 1996).

Captured hens were processed on site as quickly as possible and immediately released (typically ≤1 hour post-capture). To minimize biases associated with capture and handling induced mortality, I chose to use a two week “censor” period for each marked bird (Seiss 1989). If the bird died within that period of time, it was attributed to capture and handling stress and excluded from the sample and analysis (Spraker et al. 1987). Turkey handling and marking procedures were approved by the Institutional Animal Care and Use Committee (IACUC), Mississippi State University (IACUC Protocol No. 02-016).

Telemetry Procedures

Telemetry was conducted using a 3-element Yagi antenna (Advanced Telemetry Systems, Isanti, MN) and a multi-frequency receiver (Wildlife Materials, Carbondale, IL). An Advanced Telemetry Systems (Advanced Telemetry Systems, Isanti, MN) receiver also was used during late spring of 2004.

Hens were triangulated using 3 bearings from fixed telemetry stations at least 5 times a week during the nesting season (March to May) and locations were plotted on 1:24,000 scale maps to determine localization and nest initiation (Cochran and Lord 1963, White and Garrott 1990). Hens were considered to be nesting when 2-3 consecutive, daily locations were close during the spring nesting season. To pinpoint the nest location, I took ≥3 bearings towards the nesting hen within 50 m of the nest, flagged the bearings, and returned after nesting was complete to locate the nest (Lowery 1999, Inglis 2001). Location and status of nesting hens were checked daily using respective bearings and checkpoints for each nest which were established post flagging. A nesting attempt was assumed to be over after 28 days had elapsed (the mean incubation period; Dickson 2001) or if the hen's position had changed. At the end of a nesting attempt the nest was located and nest fate (successful or unsuccessful) determined by examining eggshell remnants (Doumitt et al. 1995, Davis 1959, Miller et al. 1998). A nest attempt was successful if ≥1 egg hatched. I also attempted to identify the specific cause of each nest failure (i.e., nest predator, flooding, etc.).

Nest-site Measurements

I quantified micro-habitat characteristics at each nest site in an attempt to relate habitat to success. I took all habitat measures 28 days post nest initiation to avoid biasing results of vegetation characteristics due to temporal differences in the development of early and late nests. Micro-habitat measurements included distance from nest to nearest edge, edge type (natural or man-made), nest elevation, vegetation composition, vegetation height, and obscurity of nest by vegetation. This suite of characteristics was selected based on their relationship with nest fate in previous studies of the Wild Turkey (Phalen 1986, Seiss 1989, Palmer 1990, Chamberlain 1995, Miller 1997, Lowery 1999, Inglis 2001).

Distance to edge was recorded in meters using a 50 m survey tape. Edges were classified as 1) managed opening (i.e., mowed or planted opening or roadside), 2) natural opening (i.e., opening created by a fallen tree), and 3) water. Natural openings existed were trees had fallen in the forest interior creating small grassy openings.

Vegetation composition and density at nest sites were measured using a derivative of the line intercept method (Canfield 1941). Measurements were taken along 5.4 m lines (delineated using a 50 m survey tape) radiating from the nest in 8 cardinal directions (N, NE, E, SE, S, SW, W and NW). Distances where vegetation types intersected the line were recorded and a percentage for each type was determined for each nest. Vegetation was classified using 1 of 6 categories (forbs, grass, vines, woody vegetation, woody debris, and bare ground). Vegetation height was placed into 1 of 5 height classes (0.0-0.3 m; 0.3-0.6 m; 0.6-0.9 m; 1.2-1.5 m; ≥1.5 m) and measured using a 2 m metal pole with height classes marked accordingly. Height measurements were taken every 0.5 m along each of the 8 lines.

Nest obscurity (e.g., dense vegetation surrounding the nest) may increase nesting success by impeding searches of potential nest predators (Bowman and Harris 1980, Crabtree et al. 1989) due to disrupted visual and olfactory reception. Nest obscurity was measured at 3 different distances (1 m, 3 m, and 5 m) from each nest along the 8 previously established lines. A Nudds board (Nudds 1977) divided into 6 0.3 m vertical sections was placed at the nest and a percent obscurity class (5 equal intervals, in 20% increments) was determined along each of the 8 lines at each distance interval. Percentage obscurity was based on the estimated coverage of each 0.3 m section. Measurements were taken from an “outside looking in” manner from a height of 0.6 m to simulate a potential nest predator’s perception of the nest-site.

Vegetation height, composition, and percentage overhead cover were quantified within a 1 m^2 hoop (Seiss 1989) centered on the actual nest. This was done to examine potential associations between vegetation characteristics at the nest and nest fate. Nest obscurity classes mentioned earlier were used to quantify overhead cover. An elevation reading also was taken at the nest and these measurements were partitioned into their respective physiographic regions (delta or loess hills) because of the consistent difference in elevation between these sites.

I developed a set of general hypotheses to explain possible habitat differences between successful and unsuccessful nests. These included: 1) successful nests will be closer to edge than unsuccessful nests (Seiss 1989), 2) greater amounts of herbaceous vegetation (forbs) will occur at successful nest sites (Holbrook et al. 1987), 3) vegetation height will be greater throughout the measured area of successful nest sites than at unsuccessful sites (Inglis 2001), and 4) obscurity of successful nests will be greater at different distances than unsuccessful nests (Crabtree et al. 1989).

Summary statistics were calculated for successful and unsuccessful nest sites across all habitat variables. Characteristics of successful and unsuccessful nest sites were compared using simple t-tests ($\alpha = 0.05$ for all tests) because of the small sample of nests.

RESULTS

Micro-habitat characteristics were measured at 8 and 10 nests sites for 2003 and 2004, respectively. Simple equal-variance t-tests revealed only one significant difference of percentage vine composition between successful and unsuccessful ($t_{12} = 2.43$, $P = 0.03$)

nests; successful nests had fewer (2%) vines than unsuccessful nest sites (20%). All other nest site characteristics did not differ between successful and unsuccessful nests.

Nest-site Measurements

Micro-habitat variables were recorded for each of the 18 nest sites. All nests were located ≤50 m from an edge with a mean of 25.38 m. No difference was detected between distances of successful and unsuccessful nests to an edge or maintained opening (Table 4.1). All nests were ≤100 m from at least one managed opening edge with a mean of 28.77 m. Five of 6 (83%) successful nests were located ≤50 m from a managed opening. Forbs were the most prominent vegetation type inside the 10 m circle around the nest, accounting for 57% of all cover (Table 4.2).

Vegetation height was similar between successful and unsuccessful nest sites and was found to be in the 0.3-0.6 m height class. Vegetation generally occurred in this height class throughout the 10 m nest patch.

Percentage obscurity of all nests by vertical cover occurred in the 20-41% class at 1 m from the nest cup. Percentage obscurity of all nests at 3 and 5 meters increased to the 41-60% obscurity class. No difference in nest obscurity was detected between successful and unsuccessful nests (Table 4.3).

Elevation at the nest did not differ between successful and unsuccessful nests in the delta or hills sections of MWMA (Table 4.4). Only one nest attempt failed due to flooding in the delta portion of MWMA. No differences in vegetation height or percentage overhead cover between successful and unsuccessful nests were detected (Table 4.4). Percentage overhead cover at the nest occurred in the 41-60% category.

Vegetation height was 0.6-0.9 meters at the nest. Four of 6 (67%) successful nests included a major forb component at the nest cup.

DISCUSSION

Nesting rates were low during both years of my study with just 12 nesting attempts each year by 8 and 11 hens, respectively. I assume that several nesting attempts that I failed to detect were interrupted by predators during egg-laying. Several nests which were “flagged” during incubation were never found (4 in 2003 and 2 in 2004). Despite these limitations, the nesting rate was less than that generally reported for the Southeast (Hurst 1988, Inglis 2001) and hampered my ability to make firm conclusions about the nesting success of Wild Turkeys at MWMA.

Past studies indicate that successful nests where often closer to an edge than unsuccessful nests were (Phalen 1986, Holbrook et al. 1987, Seiss 1989, Lowery 1999). Type of edge (man-made or natural) was an important predictor of nest success in multiple studies with successful nests being closer to roads, trails, and fire lanes (Exum et al. 1987, Seiss 1989). Seiss (1989) reported that successful and unsuccessful nests were located 12.1 and 7.8 m from an edge, respectively, a pattern that is similar to what I found in my study. Some studies suggest that nest depredation may increase when closer to edge habitat due to predator search patterns along these areas (Gates and Gysel 1978, Hon et al. 1978), although other studies fail to support this hypothesis (Yahner and Wright 1985, Ratti and Reese 1978). Nest depredation on MWMA may have been attributed to scent trails left by hens during movements to and from the nest during incubation. Occasional movements into nearby openings or around the nest site may attract predators searching edges to the nest site.

Most (89%) nests on MWMA were located near a man-made edge such as maintained openings or roads, which is similar to what Seiss (1989) and Lowery (1999) reported elsewhere in Mississippi. My findings lend support to the idea that nesting hens attempt to find nest sites near adequate brood habitat (i.e., openings) (Lazarus and Porter 1985).

Elevation at the nest site is thought to be important, particularly in areas prone to flooding (i.e., alluvial floodplains). Nest attempts may be adversely affected by rising water, which will cause nest abandonment (Zwank et al. 1988) or outright nest loss. Much of MWMA lies in alluvial floodplain with certain areas inundated annually, and this may be a major cause of nest loss during years with above normal spring precipitation. However, only one nest was inundated by flooding during this study.

Past studies indicate nests where found in areas of dense vegetation like pine/hardwood regeneration stands and cutovers (Speake et al. 1975, Phalen 1986, Holbrook et al. 1987, Seiss 1989). Nests were found in similar areas on MWMA and these areas were dominated by dense patches of forbs. Nest sites on MWMA included a large percentage of forbs (herbaceous vegetation) at both successful (49%) and unsuccessful (61%) nests sites, and smaller percentages of woody vegetation and debris. Forbs such as *Rubus* spp. and other leafy vegetation may provide ideal concealment with the added benefit that they also may provide food for the nesting hen in the form of soft mast and insects.

Certain vegetation heights at nest sites, particularly those in the 0.3 m to 0.9 m range, have been correlated with successful nesting (Healy 1981, Palmer 1990, Lowery 1999, Inglis 2001). Vegetation heights for successful and unsuccessful nest sites on MWMA fell within the 0.3 to 0.6 m category. Height of vegetation at nest sites on MWMA also contributed to screening nests from searching predators. It may be increasingly difficult for a predator to detect a nesting hen within larger patches of greater spatial heterogeneity in vegetation characteristics (Bowman and Harris 1980, Crabtree et al. 1989). Several hens were found in homogenous patches of vegetation such as tall Johnson grass (*Sorghum halepense*) and blackberry (*Rubus* spp.) where stem density may have been great enough to thwart searches by nest predators. Several unsuccessful nests on MWMA were found in patches with similar vegetation composition and structure to that of successful nests. However, nest predation during my study usually occurred after a rain event. Scent produced by a wet hen may aid in the success of nest predator searches and negate benefits of nesting in a heavily vegetated area (Roberts and Porter 1998, Lowery 1999).

Future Research

Similar microhabitat characteristics found between nesting hens during my study and past studies continue to support patterns (i.e., adequate lateral cover, proximity to brood habitat) that define adequate nesting habitat for Wild Turkey hens. Little is known regarding how landscape fragmentation and habitat patch size affects nesting success in Mississippi. Some habitats used by nesting hens may be ecological sinks due to features such as patch size and arrangement within a landscape (Brown and Litvaitis 1995, Schmitz and Clark 1999, Thogmartin 1999, Thogmartin and Schaeffer 2000).

Future research should concentrate on how nests are arranged spatially and their distances to habitats which potential nest predators may find attractive due to some other ultimate factor during the spring nesting season (i.e., soft mast, insects, or cover). Linking these variables to nest fate may help to guide future placement and size of wildlife openings, or suggest how nesting habitat should be distributed within a specified area.

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Table 4.1. Mean distance from nests to edge on Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

	Successful (n = 5)	SD	Unsuccessful (n = 12)	SD	P-value
Distance (m)	21.82	± 17.49	24.99	± 27.51	0.81
Distance (m) to managed openings	21.82	± 17.49	27.03	± 28.86	0.71

Table 4.2. Percentage vegetation composition of nest sites on Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Vegetation Type	Total	Successful	Unsuccessful	P-value
Forbs	57%	49%	61%	0.41
Graminoid	13%	21%	9%	0.26
Vines	14%	2%	20%	0.03*
Woody vegetation	4%	11%	1%	0.07
Woody debris	1%	1%	1%	0.82
Bare ground	10%	16%	8%	0.26

* Significant if < alpha = 0.05.

Table 4.3. Percentage obscurity of nests from predators on Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

Distance from nest	Successful	Unsuccessful	P-value
1m	21-40%	21-40%	0.62
3m	41-60%	41-60%	0.61
5m	41-60%	41-60%	0.99

Table 4.4. Percentage overhead cover, mean elevation, and mean vegetation height at nests found on Malmaison WMA, Mississippi and surrounding lands, 2003-2004.

		Successful	SD	Unsuccessful	SD	P-value
Elevation (m)	Delta	45	± 2.89	42	4.79	0.33
	Hills	94	± 1.73	96	3.21	0.41
Percent overhead cover		41-60%		41-60%		0.89
Vegetation height (m)		0.6-0.9 m		0.6-0.9 m		0.38

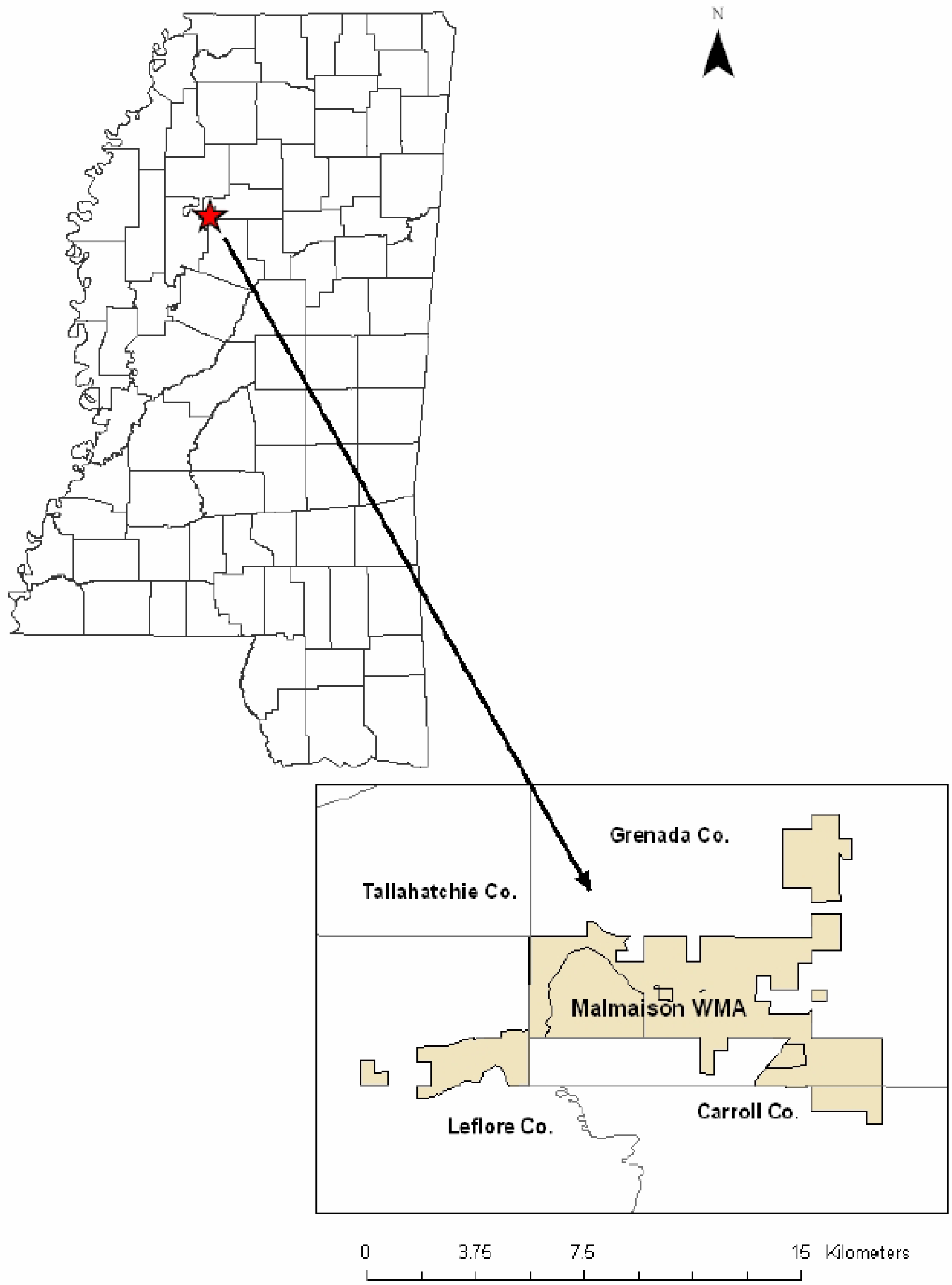

Figure 4.1. Location and configuration of Malmaison Wildlife Management Area, Mississippi, 2003-2004.