ASSESSING MOVEMENTS AND ECOLOGY OF MALE WILD TURKEYS DURING SPRING REPRODUCTIVE AND HUNTING SEASONS USING MICRO-GPS TECHNOLOGY

by

JOHN THOMAS GROSS

(Under the Direction of Michael J Chamberlain)

ABSTRACT

Because wild turkeys are an important game species and turkey hunter numbers are increasing, there is a need to understand how hunting affects turkey spatial ecology. With the recent advent of micro-GPS technology suitable for use on wild turkeys, researchers can now collect data at a resolution and scale not previously possible. Therefore, I used micro-GPS units to detail spatial ecology of male eastern (*Meleagris gallopavo silvestris*) and Rio Grande (*M. g. intermedia*) wild turkeys in Louisiana and Texas. I found that mean home range size was 383 ha in Louisiana and 270 ha in Texas, and average daily distance traveled was 3725 m and 4608 m, respectively. I found little evidence that hunting pressure affected movements in the spring. Individuals showed a high degree of variability in response to hunting pressure, suggesting that spring movements may be linked to previous experience or variables I did not study.

INDEX WORDS: daily movements, home range, hunting pressure, Louisiana, *Meleagris gallopavo*, micro-GPS, roosting characteristics, Texas
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JOHN THOMAS GROSS

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JOHN THOMAS GROSS

Major Professor: Michael J. Chamberlain
Committee: Karl V. Miller
Robert J. Warren

Electronic Version Approved:
Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 2014
DEDICATION

I dedicate this thesis to my mother, Debbie, and the rest of my family who have helped me along the way. Without your love and support none of this would have been possible.
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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

Wild turkeys are an important game species in North America, and as the number of spring turkey hunters continues to rise across most of the country, it will become increasingly important to refine the knowledge base we use to make important management decisions. According to the National Wild Turkey Federation (National Wild Turkey Federation [NWTF] 2003), there has been over $2 billion in economic impact directly related to the management and pursuit of wild turkeys in the United States. Wild turkeys are a valuable economic and aesthetic asset, and their continued popularity as a game species mandates sound management driven by scientific research.

Borrowing from Hunter (1989), Collier and Chamberlain (2010) suggested that wild turkey research has stagnated in the recent past. One way to break through a plateau of information acquisition is by the advent of technological advancements. In the case of the wild turkey, this technological advancement was the development of a micro-GPS unit capable of collecting large amounts of data at a spatial and temporal scale that was previously impossible. Although a wealth of knowledge on the ecology and management of wild turkeys exists, most of that knowledge base was acquired using methods that are becoming outdated, specifically very-high-frequency (VHF) radiotelemetry. While the data generated by studies using these methods has been important to our current understanding of wild turkeys, there are many sources of error associated with ground based telemetry and triangulation.
Advancements in micro-GPS technology allow researchers to collect data with increased spatial accuracy, increased collection interval intensity, decreased bias, and reduced costs (Guthrie et al. 2011). The ability to collect data over long-durations at high and low intensities allows researchers to tailor collection schedules to answer questions focused at specific time intervals as well as long-term trends. Micro-GPS systems allow improved standardization of data, as well as collection protocols that can be used for better future collaboration between researchers and management agencies.

The goal of this project was to outfit male wild turkeys with micro-GPS units to evaluate fine scale movements during breeding and hunting season, with special emphasis on wild turkey behavior relative to hunting pressure. Several secondary objectives and descriptive analyses were conducted using data acquired through micro-GPS telemetry, including home range and core area estimates, daily roost site selection, distances between consecutive roosts, and daily distances traveled. In addition to outfitting wild turkeys with micro-GPS units, I also collected data on hunters outfitted with handheld Garmin GPS units to assess how wild turkeys behave in direct relationship to the presence of hunters. This research has the potential to alter how we view wild turkey movements, space use, habitat use, and interactions with human disturbance because of the opportunity to collect data with refined detail. Clearly, biologists, researchers, managers and hunters will be interested in the data we collected because it has given us insights to turkey interactions with hunters previously not available. Turkey hunters certainly will be interested in descriptions of turkey behavior prior to and during the spring hunting season.
LITERATURE REVIEW

Wild turkey populations have increased in North America since the 1940’s, such that they can now be found and hunted in every state except Alaska (Kennamer 2000). Despite this overall growth, some local populations have declined recently (Tapley et al. 2010) although wild turkeys remain an important game species throughout most of the United States. The eastern wild turkey (*Meleagris gallopavo silvestris*) is the most hunted, abundant, and widely dispersed of the 5 subspecies (Kennamer 2002). The Rio Grande turkey (*M. g. intermedia*) is also a popular game species throughout much of its range. According to the National Wild Turkey Federation (National Wild Turkey Federation [NWTF] 2003), there has been over $2 billion in economic impact directly related to the management and pursuit of wild turkeys in the United States.

Managing wild turkey populations effectively requires an adequate understanding of how they use their environment, especially during times of the year when turkeys are hunted. Home ranges and core areas of individual turkeys are highly variable, and many studies have detailed annual home range size of male eastern wild turkeys (Brown 1980, Wigley et al. 1986, Kelley et al. 1988, Godwin et al. 1995, Miller et al. 1997) with results ranging from 140 ha in Alabama (Brown 1980) to 3,514 ha in Arkansas (Wigley et al. 1986). In bottomland forests of Louisiana, Grisham et al. (2008) estimated the mean annual home range size of males to be 880 ha with a spring home range of 768 ha. Brown (1980) reported spring home range sizes ranging from 95 ha in South Carolina to 204 ha in Alabama. In addition, Rauch et al. (2010) found that spring home ranges for adult males in West Virginia were $410 \pm 28$ ha and juvenile home ranges were $164 \pm 22$ ha. Published home range and core area estimates for male Rio Grande turkeys are sparse, with most research being conducted on females. However, Philips (2004) noted that
annual home ranges for males in the Texas Panhandle averaged 974 ha and spring home ranges for male Rio Grande turkeys in south-central Texas can vary from 200-1500 ha (B.A. Collier, Louisiana State University, personal communication).

Core areas are areas of concentrated use within home ranges and presumably contain critical resources important for reproduction and survival (Asensio et al. 2012). Grisham et al. (2008) estimated that mean core area size during spring was 116 ha for adults in a bottomland hardwood forest in Louisiana. They found that core areas were larger during the fall and winter than in the spring and summer, and juveniles maintained larger home ranges than adults.

Although spatial fidelity (pattern of space use) of males is poorly understood, Miller et al. (2001) observed a lack of a consistent pattern among individuals, which points to some factor, most likely habitat, as influencing individual decisions. Although they could not identify a pattern of spatial fidelity, they did find that some individuals changed their space use patterns to meet their habitat requirements. Likewise, males did not display differences in dispersional patterns across seasons, although one would expect males to alter movement patterns during the spring breeding season (Miller et al. 2001).

Average daily movements and roost site selection of male turkeys can provide valuable information to managers. Many studies have shown that wild turkeys increase movements during the spring (Kelley et al. 1988, Godwin et al. 1990, Godwin et al. 1994). Godwin et al. (1994) reported that adult males moved an average of 2,492 m during a morning observation period, and that the mean distances moved during spring (when hunting occurred) were greater than in fall and winter. Likewise, Holdstock et al. (2006) reported the average distance of known locations in spring for male Rio Grande turkeys from the nearest roost was 710 m, giving a minimum linear distance traveled for that day.
Dispersal from managed areas is an important factor in wild turkey management on many public lands (Brown 1980, Godwin et al. 1990). Godwin et al. (1990) found that a higher percentage of males captured on Tallahala Wildlife management area were found outside of management area boundaries during spring than any other season. This indicates an increase in movements and a possible correlation to reproductive and hunting seasons. From a management perspective, daily movements, and especially extensive movements that take individuals beyond management area boundaries, are important for managers on public and private lands.

Selection of quality roost sites is key to wild turkey survival because roost sites provide protection from inclement weather and predation (Porter 1978, Kilpatrick et al. 1988). Roosting behavior in turkeys is poorly understood relative to other facets of their ecology. Although roost availability is critical to all subspecies of turkey, it is critical for Rio Grande turkeys because roost sites become more limited in these open environments compared to the typical habitat occupied by eastern wild turkeys. Roost sites are thought to be a limiting factor to turkey distributions in otherwise suitable habitats (Kilpatrick et al. 1988, Rumble 1992, Swearingin et al. 2010) and Kothmann and Litton (1975) noted that the westward expansion of Rio Grande turkeys in Texas was in part due to the increase in use of power line poles as roosts. Many studies have detailed the landscape and microhabitat characteristics of individual roost sites for Easterns and Rios, but few have detailed movement characteristics associated with the selection of roost sites. Chamberlain et al. (2000) found that females in Mississippi did not alter movement patterns just prior to roosting. They concluded that female movements throughout the day may be influenced by known roosting locations or that they simply roosted in the nearest suitable location at the end of the day. In Colorado, Hoffman (1991) found that Merriam (M. g. merriami) males used consecutive roosts that averaged over 1000 m apart and only used a
previous roost site 19% of the time, with back to back occurrences being rare. They also found that no roost site was used more than 4 times. In contrast, Easterns may use the same roost sites for multiple nights (Kilpatrick et al. 1988) but typically not consecutively (Healy 1992).

Harvest of wild turkeys in the spring is the primary cause of mortality in adult males (Hughes et al. 2007, Chamberlain et al. 2012), yet we lack a basic understanding of how wild turkeys respond to hunting activity. The number of hunters involved in hunting wild turkeys has increased from about 1.69 million in 1984-1985 to 2.66 million in 1998-1999 and again to 2.80 million in 2009 (Tapley et al. 2001, Tapley et al. 2010). This increase can be attributed to the increase in spring hunting participation. Nationally, rates of spring hunting have increased by 22-35% in each 5 year interval since 1985 (Tapley 2001). In the past, hunter attitudes, success rates and demographics have been studied extensively through the use of surveys (Palmer et al. 1990, Backs 1995, Thackston and Holbrook 1996, Little et. al 2001, Casalena et al. 2010), but the effect of increasing hunter numbers on turkey ecology is not understood.

Wildlife management agencies would benefit tremendously from an improved understanding as to how hunters’ behavior in space and time affects animal movements. Few studies have detailed space use of hunters. In the past, studies such as Johnson (1943) and Thomas et al. (1976) asked hunters to field-report their hunting activities on maps. However, Stedman et al. (2004) found that hunters who field-reported their activities overestimated their total distances traveled as well as their distances from roads, signifying a need for improved methods of data collection. Gaining this knowledge requires a new approach to detailing hunter movements. Recently Stedman et al. (2004) used handheld GPS to describe habitat use of white-tailed deer (Odocoileus virginianus) hunters in Pennsylvania, and reported that hunters consistently overestimated the total distances they traveled and the distance they hunted from
public roads. Lebel et al. (2012) used handheld GPS to describe characteristics of successful white-tailed deer hunter behavior in Quebec, Canada. They found that hunters experienced greater levels of success when they hunted in areas where vegetation was sparse and visibility was greatest. They also reported that hunters had a greater chance of harvesting a white-tailed deer when they hunted areas that had a lower density of access routes when compared to areas of higher hunter use. Lyon and Burcham (1998) used GPS to examine elk (Cervus canadensis) hunters over 3 seasons in Montana, and found that hunters spent most of their time on slopes that were less steep than the study area average. They also reported an average distance of hunters from the nearest road to be 267m. Broseth and Pedersen (2000) used GPS technology to track and describe ptarmigan (Lagopus lagopus) hunter success and landscape use in Norway. They found that hunting pressure was not consistent across their study site; instead the amount hunting pressure a given area received was shown to be strongly dependent on the starting point of the hunters, meaning that areas closer to access points received higher amounts of hunting pressure. They also reported that hunting pressure and vulnerability of willow ptarmigan were linked, as birds were more likely to be killed if they were located near access points and areas that received higher hunting pressure.

Movements of wild turkeys, related to hunting pressure and perceived predation risk are not well known. Everett et al. (1978) used weekly telemetry locations of males in Alabama to demonstrate that hunting pressure did not cause shifts in movement patterns during a spring hunting season. Williams et al. (1978) reported a similar finding in Florida during fall hunting seasons, noting that most turkeys maintained their pre-season ranges and roosting sites, with some turkeys actually decreasing movements.
Although little research has quantified how hunting activity affects wild turkey movements, there have been similar studies conducted on other game species. Kilgo et al. (1998) found that hunting pressure on the Osceola National Forest of Florida caused white-tailed deer to change movement patterns. During hunting seasons, deer avoided clearcuts, young pine plantations and other open habitats and deer preferred swamps and mature pine forests that provided cover. Deer also increased nocturnal activity and increased their distance from roads (Kilgo et al. 1998). Root et al. (1988) and Karns et al. (2012) found that intensive hunting caused deer to travel greater distances than at other times. However, mean home range or core area sizes did not shift in response to hunting (Karns et al. 2012). Hodges et al. (2000) found similar results for raccoons (*Procyon lotor*) hunted during summer seasons in Mississippi.

Radio-telemetry has been widely used to monitor and study aspects of wild turkey populations throughout their range. Although VHF radio-telemetry has provided important data for the management of wild turkey populations, these data may be biased by several factors including distance between observer and the transmitter, intersection angle of the triangulated bearings, and animal movement between readings (Saltz 1994, Withey et al. 2001). Advances in technology, such as the development of global positioning system (GPS) transmitters have allowed researchers to obtain more accurate and useful animal movement data. Specific to wild turkeys, advancements in micro-GPS technology are allowing researchers to gain a better understanding of wild turkey habitat selection and spatial ecology (Guthrie et al. 2011).

When assessing the validity of past home-range estimation studies, Laver and Kelly (2008) found that most used radiotelemetry to collect location estimates. The precision of estimated locations can be affected by errors in triangulation angle definition, animal movements between bearings, signal strength, and tracking frequency (White and Garrott 1986). According
to Montgomery et al. (2011) the differences between estimated and real locations can be as great as tens of thousands of meters for VHF (very high frequency) and are typically less than 100m for GPS telemetry. Using 59 VHF test transmitters, Thogmartin (2001) found that 80% of estimated turkey locations were only accurate to within 250 m of actual locations and 90% were only accurate to within 450 m. Guthrie et al. (2011) found that mean error for static tests across 3 varying landscapes for micro-GPS units was 15.5m. Advancements in GPS telemetry have provided researchers with a cost-effective means for more accurately monitoring wildlife (Guthrie et al. 2010). Additionally, Guthrie et al. (2011) found that using micro-GPS to collect locations was cheaper than the cost of VHF telemetry after just 180 recorded locations. This was due to the mitigated costs of researchers not having to be in the field to collect data via GPS. Likewise, Guthrie et al. (2011) found that spatial accuracy of data collected via micro-GPS provided a substantial improvement in assessing habitat use and movement patterns of wild turkeys over traditional VHF telemetry techniques.

In particular, a working knowledge of how male turkeys behave during the breeding season is relevant, since males are hunted during this period. Wild turkeys typically breed from late February through the end of April in their southern ranges (Kennamer et al. 2002). Hunting pressure has been shown to alter animal behaviors over space and time (Root et al. 1988, Kilgo et al. 1998). Harvest of wild turkeys in the spring is the primary causes of mortality (Hughes 2007, Chamberlain et al. 2012), but this harvest and the effects that hunters have on male movement and ecology is not well known. My objective was to examine the movement ecology of male wild turkeys in response to human disturbance, in particular hunting pressure. This research took advantage of newly developed micro-GPS technologies and increased accuracy of spatial analysis tools. I expected to generate large amounts of data that was spatially and
temporally precise enough to detail fine-scale movements and how they related to hunter activity. The data collected are important to biologists who want to understand how turkeys interact with and use their environments. This research will also interest hunters who are concerned with how male turkeys behave just before, during, and after hunting seasons.

**OBJECTIVES**

The goals of this project were to: 1) detail the home range and core area sizes, daily movement distances, and roosting characteristics of male wild turkeys during spring reproductive and hunting seasons using micro-GPS technology, and 2) detail the effects of hunting pressure on weekly core area sizes, weekly core area shifts, daily movement distances, and roosting behavior of male wild turkeys.

**THESIS FORMAT**

My thesis is presented in manuscript format. Chapter 1 is an introduction and a literature review of prior studies addressing similar aspects of wild turkey ecology and hunter behaviors. Chapter 2 presents a descriptive study of eastern wild turkey (*Meleagris gallopavo silvestris*) and Rio Grande wild turkey (*M. g. intermedia*) home ranges, core areas, daily movements and roosting characteristics. Chapter 3 presents an analysis of the effects of hunting pressure on the movement ecology of eastern wild turkeys. Chapters 2 and 3 will be submitted to peer-reviewed scientific journals for publication. Chapter 4 discusses conclusions and management implications that my study addresses.
Literature Cited


CHAPTER 2

SPACE USE, DAILY MOVEMENTS, AND ROOSTING BEHAVIOR OF MALE WILD TURKEYS DURING SPRING HUNTING SEASONS IN LOUISIANA AND TEXAS


1
ABSTRACT

Because wild turkeys are an important game species and turkey hunter numbers are increasing, the need for better information on how they use their environment is critical. With the recent advent of micro-GPS technology suitable for use on wild turkeys, we are now able to collect data on a scale not previously possible. Therefore, we used micro-GPS units to detail the home range and core area sizes, daily movement distances, and roosting characteristics of male eastern (*Meleagris gallopavo silvestris*) and Rio Grande (*M. g. intermedia*) wild turkeys in Louisiana and Texas. Mean home range size was 383 ha in Louisiana and 270 ha in Texas and average daily distance traveled was 3725 m and 4608 m, respectively. The mean distance between consecutive roost sites was 803m in Louisiana and 211m in Texas.

INDEX WORDS: daily movements, home range, Louisiana, *Meleagris gallopavo*, micro-GPS, roosting characteristics, Texas

INTRODUCTION

Wild turkey populations have increased in North America since the 1940’s and huntable populations exist in every state except Alaska (Kennamer 2000). Despite this overall population growth, some local populations have recently declined (Tapley et al. 2010). However, wild turkeys remain an important game species throughout most of the United States. The eastern wild turkey (*M. g. silvestris*) is the most hunted, abundant, and widely dispersed of the 5 subspecies (Kennamer 2002). The Rio Grande turkey (*M. g. intermedia*) is also a popular game species throughout much of its range. According to the National Wild Turkey Federation (National Wild Turkey Federation [NWTF] 2003), there has been over $2 billion in economic impact directly related to the management and pursuit of wild turkeys in the United States.
Because turkeys are valuable both economically and aesthetically, it is critical that we thoroughly understand their ecology to ensure management for sustainable populations.

Effective management of wild turkey populations requires an understanding of how they use their environment, particularly during times of the year when turkeys are hunted. Home ranges and core areas of individual turkeys are highly variable, and many studies have detailed annual home range size of male eastern wild turkeys (Brown 1980, Wigley et al. 1986, Kelley et al. 1988, Godwin et al. 1995, Miller et al. 1997) with results ranging from 140 ha in Alabama (Brown 1980) to 3,514 ha in Arkansas (Wigley et al. 1986). Published home range estimates for male Rio Grande turkeys are sparse, with most research being conducted on females, although Philips (2004) noted that annual home ranges for males in the Texas Panhandle averaged 974 ha.

In bottomland forests of Louisiana, Grisham et al. (2008) estimated the mean annual home range size of males to be 880 ha with a spring home range of 768 ha. Core area size during spring averaged 116 ha for adults. Home range size did not differ by season, but core areas were larger during the fall and winter than in the spring and summer, and juvenile males maintained larger home ranges than adults (Grisham et al. 2008). Brown (1980) reported spring home range sizes ranging from 95 ha in South Carolina to 204 ha in Alabama. In addition, Rauch et al. (2010) found that spring home ranges for males in West Virginia were 410 ±28 ha and juvenile home ranges were 164 ± 22 ha. Estimates for spring home ranges for male Rio Grande turkeys vary from 200-1500 ha (B.A. Collier, Louisiana State University, personal communication).

Little data exists on daily movements of wild turkeys, as most research has focused on seasonal dispersal and space use (McMahon and Johnson 1980, Kelley et al. 1988, Holdstock et al. 2006). Godwin et al. (1994) reported that adult males moved an average of 2,492 m during a
morning observation period, and that the mean distances moved during spring (when hunting occurred) were greater than that for fall and winter. Likewise, Holdstock et al. (2006) reported the average distance of known locations in spring for male Rio Grande turkeys from the nearest roost was 710 m, giving a minimum linear distance traveled for that day. From a management perspective, daily movements, and especially extensive movements that take individuals beyond management area boundaries, are important for managers on public and private lands.

Selection of quality roost sites is key to wild turkey survival because roosts provide protection from inclement weather and predation (Porter 1978, Kilpatrick et al. 1988). Roosting behavior in turkeys is poorly understood relative to other facets of their ecology. Although roost availability is critical to all subspecies of turkey, it is critical for Rio Grande turkeys because suitable roost sites often are limited in areas of their range. Among all subspecies of wild turkey, roost sites may be a limiting factor to turkey distributions in otherwise suitable habitats (Kilpatrick et al. 1988, Rumble 1992, Swearingin et al. 2010). For example, Kothmann and Litton (1975) noted that the westward expansion of Rio Grande turkeys in Texas was in part due to the increase in use of power line poles as roosts. Although the landscape and microhabitat characteristics of individual roost sites for Eastern and Rio Grande turkeys have been investigated, the daily movement characteristics dealing with the selection of roost sites has been inadequately researched. Chamberlain et al. (2000) found that females in Mississippi did not alter movements just prior to roosting and concluded that female movements throughout the day may be influenced by known roosting locations or that they simply roosted in the nearest suitable location at the end of the day. In Colorado, Hoffman (1991) found that males used consecutive roosts that averaged over 1000 m apart and only used a previous roost site 19% of the time. They also found that no single roost site was used more than 4 times. Eastern wild turkey are
known to use the same roost sites for multiple nights (Kilpatrick et al. 1988), but they typically do not use the same roost site consecutively (Healy 1992).

Previous studies assessing space use, movements, and roosting behavior of male wild turkeys have used locations collected via very high frequency (VHF) transmitters and often contained high levels of locational error (White and Garrot 1986, Thogmartin 2001, Laver and Kelly 2008, Montgomery et al. 2011). However, the advent of micro-GPS transmitters designed for wild turkeys has allowed acquisition of more spatially and temporally accurate data. Guthrie et al. (2011) found that mean error for static tests across 3 landscapes for micro-GPS units was 15.5 m and that spatial accuracy provided a substantial improvement to assess habitat use and movement patterns of wild turkeys over traditional VHF telemetry.

We used micro-GPS technology to describe space use and varying aspects of male roosting behavior of eastern and Rio Grande wild turkeys. Our objectives were to describe home range and core area sizes for male eastern and Rio Grande wild turkeys during the spring hunting and reproductive season. We also detailed daily movements, distances between consecutive roost sites, and frequency of roost sites reused.

**STUDY AREA**

We conducted research on 4 study sites during 2012-2013. The primary study area was the 2390 ha Tunica Hills Wildlife Management Area (WMA) located in West Feliciana parish, Louisiana. Tunica Hills was divided into 2 tracts, the North Tract (949 ha) and the South Tract (1440 ha). The South Tract was the site of most trapping and monitoring activity along with several adjacent tracts of private land. Tunica Hills was owned and operated by the Louisiana Department of Wildlife and Fisheries, and was located at the southernmost edge of the loess
blufflands. Tunica Hills and surrounding private lands were composed of dissected uplands characterized by steep bluffs, ravines and rugged hills. Forest types were primarily upland hardwoods. Common overstory species included American beech (Fagus grandifolia), various oaks (Quercus spp.), hickories (Carya spp.), eastern hophornbeam (Ostrya virginiana), yellow-poplar (Liriodendron tulipifera), red maple (Acer rubrum var. rubrum), loblolly pine (Pinus taeda), and eastern redcedar (Juniperus virginiana). Understory plants included oak leaf hydrangea (Hydrangea quercifolia), two-wing silverbell (Halesia diptera), pawpaw (Asimina triloba), muscadine grape (Vitis rotundifolia), flowering dogwood (Cornus florida), sweetleaf (Symlocos tinctoria), blackberry (Rubus sp.) and switchcane (Arundinaria gigantea).

Tunica Hills was open to recreational activities, including hunting, trapping, hiking and sightseeing, biking, and horseback riding. Hunting was allowed during specified seasons for white-tailed deer (Odocoileus virginianus), wild turkey, and small game animals. Turkey hunting was regulated with a season structure that allowed for a lottery system and a one-week hunt open to the public. The turkey season included a one-day youth hunt, followed by 3 weekends (Saturday and Sunday only) of lottery hunting limited to 15 hunters. After the last Sunday of lottery hunting, the WMA was open to the public for 7 days.

Mosher Hill Hunting Club (hereafter Mosher) was a 2500 ha property owned by Weyerhaeuser Company and was leased to a private hunting club. Located in Washington Parish, Louisiana, the property was located east of HWY 25 and south of Franklinton. Mosher bordered the Bogue Chitto River to the east and the Bogue Chitto State park to the north. Mosher was located in the Lower Coastal Plain region, and consisted mostly of well drained, sandy soils. Forest cover was primarily loblolly pine (Pinus taeda) managed intensively for fiber production. The area also contained small drainages and low areas with hardwood forests.
consisting of water oak (*Q. nigra*), green ash (*Fraxinus pennsylvanica*), sweet bay (*Magnolia virginiana*), southern magnolia (*M. grandiflora*), wild azalea (*Rhododendron canescens*), baldcypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and red bay (*Persea borbonia*).

Located in West Baton Rouge Parish LA, Double D hunting club (hereafter Double D), was a 688 ha privately owned hunting club. Double D was approximately 5 km north of Interstate 10 in the floodplains between the Mississippi and Atchafalaya rivers. The property was classified as bottomland hardwoods, and contained a mix of roadways, gas pipelines and food plots. Due to a closed canopy and prolonged seasonal flooding, much of the mid and understory was sparse. Overstory species included water oak, nuttall oak (*Q. nuttallii*), overcup oak (*Q. lyrata*), eastern cottonwood (*Populus deltoides*), American sycamore (*Platanus occidentalis*), bitter pecan (*Carya x lecontei*), water hickory (*C. aquatica*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), and ash (*Fraxinus sp.*). Midstory and understory species included red mulberry (*Morus rubra*), boxelder (*Acer negundo*), red maple (*A. rubrum*), roughleaf dogwood (*Cornus drumondii*), trumpet creeper (*Bignonia capreolata*), dewberry (*Rubus sp.*), and poison ivy (*Toxicodendron radicans*).

Located northwest of San Diego, Texas, Temple Ranch (hereafter, Temple) was located in the eastern portion of the Central Rio Grande Plains eco-region in southern Texas. Temple consisted of 5,261 ha, and was intensively managed for hunting white-tailed deer and northern bobwhite (*Colinus virginianus*) with limited amounts of hunting for wild turkey (Byrne et al. 2014). Temple consisted of thornscrub parklands with a well-defined mosaic of shrub clusters scattered throughout low-succession grasslands (Northrup et al. 2005, Guthrie et al. 2011, Byrne et al. 2014). Closed-canopy woodlands were limited to riparian zones and were intermittently
present in the clay loam drainages along San Diego Creek. These woodlands consisted of honey mesquite (*Prosopis glandulosa*), hackberry (*Celtis occidentalis*), and Texas persimmon (*Diospyros texana*; Archer 1990). Grassland herbaceous species included coastal sandbur (*Cenchrus incertus*; Archer 1990), thin paspalum (*Paspalum setaceum*), red gramma (*Bouteloua trifida*), and fringed signal grass (*Urochloa ciliatissima*) (Guthrie et al. 2011, Byrne et al. 2014).

**METHODS AND MATERIALS**

We captured male eastern wild turkeys using rocket nets during January-March 2012 on Tunica Hills and adjacent private lands. In 2013, trapping expanded to Mosher and Double D hunting clubs. Once captured, birds were fit with micro-GPS units. All micro-GPS units were attached to birds using 3-mm shock cord backpack style according to the recommendations of Wilson and Norman (1995). Birds were also fit with aluminum rivet bands on their right tarsus between the foot and spur. We estimated age (adult or juvenile) based on development and barring of 9th and 10th primary feathers (Pelham and Dickson 1992). In Texas, we trapped male Rio Grande wild turkeys in March 2009 using drop nets as part of ongoing research being conducted by Texas A&M University in cooperation with Texas Parks and Wildlife Department. Once captured, each male was similarly fit with an aluminum leg band and a micro-GPS unit, and released at the capture site. Capture and handling protocols were approved by the University of Georgia Institutional Animal Care and Use Committee (Permit A2011 07-003-R1).

All micro-GPS units were either produced by Sirtrack Wildlife Tracking Solutions (Sirtrack Wildlife Tracking Solutions, Havelock North, New Zealand) or MiniTrack Backpack GPS units (Biotrack Ltd Wareham, Dorset, United Kingdom). Sirtrack units were approximately 10cm × 4cm and data were recovered after unit retrieval. Biotrack units measured
approximately 7.5cm × 2.5cm and data could be remotely downloaded. We monitored survival via weekly VHF triangulation. We recorded one location at 1200 hours and one at 2400 hours daily until March 10 when the schedule switched to one location every 15 minutes during daylight hours and one location 2400 hours. This schedule continued until April 30 and coincided with peak breeding dates and all hunting. Beginning May 1, the units recorded one location at 1200 hours weekly to provide coarse location data until the following March when the data acquisition schedule was repeated.

We evaluated home-range and core area sizes, linear distance traveled per day, and roosting activities during the breeding season (1 March through 31 May). This time period also coincided with all hunting activity on each field site. We used a dynamic Brownian bridge movement model (dBBM; Kranstauber et al. 2012) to calculate seasonal utilization distributions (UD’s) for all males. This model created UDs based on the animal’s estimated movement path instead of individual locations, which accounted for temporal autocorrelation and is appropriate when estimating home range sizes using large quantities of spatial data. The dBBM is an improved version of the Brownian Bridge Movement Model (Horne et al. 2007) because it allows the Brownian motion to change along the movement path as movements change, resulting in a more accurate UD (Kranstauber et al. 2012). Using the program R version 3.1.0 (R Development Core Team, 2013) and the package “move” (Kranstauber and Smolla 2013), we derived 95% and 50% contours from the calculated UDs to represent home ranges and core areas, respectively. We used a margin size of 11 and a window size of 31 based on the recommendations of Kranstauber et al. (2012). Based on GPS testing conducted by Guthrie et al. (2011), we used a GPS location error of 18m for all birds.
To determine daily distance traveled and distance between consecutive roost sites, we used the “XY to Line” tool in ArcGIS 10.0 (ESRI 2011). For daily distance traveled, we used each recorded location to create a total daily movement path and then calculated total linear distance. To assess distances between consecutive roosts, we extracted all roost sites and measured the linear distance between roost locations for consecutive days. We considered a roost site to be reused if an individual roosted within 40m of a previous roost site (approximately 2x the estimated GPS error).

**RESULTS**

We captured 19 males across the 3 field sites from 2012 to 2013 in Louisiana and 8 males in 2009 in Texas. Of the 27 birds captured, 26 were fit with micro-GPS units. In Louisiana, 13 units were recovered through hunter harvest or researcher efforts. In Texas, 5 units were successfully recovered using walk-in traps. We calculated spring home range and core area sizes for 18 male wild turkeys (13 in Louisiana; 5 in Texas; Table 2.1). Mean home range size in Louisiana (eastern wild turkey) was 383 ± 55 ha (mean ± SE; range 141-740) with a mean core area of 56 ± 8 ha (range 19-102). Mean home range size of males in Texas (Rio Grande wild turkey) was 270 ± 15 ha (range 226-319) with a mean core area of 26 ± 7 ha (range 15-52).

Mean daily distance traveled (Table 2.2) and mean distance between consecutive roost sites (Table 2.3) for males in Louisiana was 3725 ± 199 m (range: 131-7751 m) and 803 ±83 m (range 3-4350 m), respectively. In Texas, the mean daily distance traveled was 4608 ± 516 m (range: 484-11,581 m), whereas the mean distance between consecutive roost sites was 211 ± 40 m (range: 1-3,261 m). The frequency at which males were found at previously-used roost sites (Table 2.4) averaged 28.2% ± 2.5% in Louisiana and 87.6% ± 3.0% in Texas.
DISCUSSION

Male wild turkeys in Louisiana had an average spring home range size of 383 ha, ranging from 740 to 141 ha, with a core area of 56 ha ranging from 102-19 ha. Our estimates of breeding season home ranges were smaller than those reported by Grisham et al. (2008), who reported a spring home range size of 768 ha and a core area of 116 ha, but larger than the spring home range estimates from Brown (1980). However, our estimates are similar to Rauch et al. (2010) who reported home ranges of 410 ha during spring hunting seasons in West Virginia. Notably, we used a technique for estimating home range sizes in wild turkeys that has not previously been used (but see Byrne et al. 2014), so comparisons of our results to other studies should be made with this forethought. Nevertheless, the larger ranges in birds monitored in Louisiana (141 to 740ha; n=13) indicates a high degree of variability among turkeys. Likewise, we estimated spring home ranges for male Rio Grandes in Texas to be 270 ha, with core areas averaging 26 ha. Not surprisingly, these estimates were smaller than the 974 ha annual home range reported by Phillips (2004), because our estimates accounted for a shorter time period and did not include seasonal changes or dispersal.

Daily distance traveled for birds in Louisiana was 3,725 m and in Texas was 4,498 m. Similarly, Godwin et al. (1994) reported morning and afternoon movement distances of 2,492 m and 2,457 m respectively for males in Mississippi based on hourly telemetry locations during the half-day observation periods. Godwin et al (1994) also noted 2 previous studies, Martin (1984) and Smith et al. (1989), who reported considerably shorter daily distances traveled in Texas and Louisiana. However, Martin (1984) and Smith et al. (1989) estimated distances traveled by using considerably fewer telemetry locations than Godwin et al. (1994) and our study. Therefore, the findings of Godwin et al. (1994) are most comparable to our work, and collectively, these studies
suggest that males have fairly consistent distances that they move daily. The 17% larger distances moved by Rio Grande males was likely due to the more open, grassland habitats they inhabited, as well as the distribution of resources within those habitats.

We reported an average distance of 803 m and 211 m between consecutive roost locations for Easterns in Louisiana and Rio Grande males in Texas, respectively. Our findings for Easterns in Louisiana are similar to Hoffman (1991) who reported distances between consecutive roosts to be 1,074 m for male Merriam’s wild turkey (Meleagris gallopavo merriami) in Colorado. However, our estimate for Rio Grandes in Texas is much lower. Holdstock et al. (2006) reported that the distance between successive roost sites was 1,342 m for male Rio Grandes in Texas and Kansas, but they did not calculate distances between each consecutive roost event. Rather, they measured distances between successive roosting areas where an individual would leave a known roosting area and relocate to another roosting area, not the distance between each morning and afternoon roost.

Easterns and Rio Grandes clearly behave differently in regard to roosting habits as shown by our marked differences in distance between consecutive roosts. Furthermore, eastern wild turkeys reused previous roost sites 28% of the time with consecutive occurrences being rare (7%). However, Rio Grandes in Texas showed a much greater degree of roost site fidelity using previous roost sites almost 88% of the time, with consecutive occurrences exceeding 72%. These results are not surprising due to the limited availability of roosts on our study site and the necessity of using roosts in the same location night after night.

Information detailing daily movements of males is sparse in the published literature, with most work focusing on seasonal movements. Our findings, coupled with previous reports on daily movements (Godwin et al. 1994, Healy et al. 1992, Holdstock et al. 2006) indicate that wild
turkeys may move considerable distances in a single day. These movements should be considered when developing management strategies, especially on smaller lands where daily movements may take individuals well beyond artificial boundaries. For example, Godwin et al. (1990) found that 34% of male wild turkeys on Tallahala Wildlife Management Area in Mississippi had ≥ 50% of their telemetry locations off of the area during 4 spring hunting seasons. In addition long distance movements may reduce survival because of an increased susceptibility to predation (Stenseth and Lidicker 1992, Holdstock et al. 2006) and increased energy demands (Sheilds 1987). However, our findings indicate that males are intensively using their home ranges and core areas during spring and that these large daily movements may not increase their spring ranges. Male daily movements during spring are related to breeding behavior (Davis 1973, Godwin 1990, Hurst et al. 1991) and Kelley et al. (1988) suggested that males will travel greater distances during the spring in search of females. The smaller spring home ranges for Rios compared to Easterns is likely due to their dependence on fewer roost sites. However, our data indicate that the Rio Grande turkeys traveled longer distances per day, but within smaller home ranges than their Eastern counterparts. We hypothesize that these individuals were required to move more to find necessary resources, but were also constrained to a relatively smaller home range because of their dependence on available roost sites.

Brown (1980) described variation in previous home range studies and cited differences in data collection and analysis, as well as habitat and individual characteristics as reasons for this variability. Recent developments in GPS technology (Guthrie et al. 2011), as well as creation of methods to analyze this data, such as the dynamic Brownian bridge movement model (Kranstauber et al. 2012), have helped reduce bias associated with the collection and analysis of home range data. Most previous studies used data collected via VHF telemetry or field
observations of turkey locations and were analyzed with methods such as Minimum Convex Polygons (MCP’s) or Kernel Density estimators. While these studies and methods have provided the framework for wild turkey research, the progression of technology has allowed us to capture and detail data on space use and movements unlike before. We offer that the estimates of space use, daily movements, and roosting behavior reported herein represent the most spatially and temporally accurate estimates available under the current technology.

LITERATURE CITED


Table 2.1. Breeding season home Ranges (95%) and Core Areas (50%) in hectares created using a dynamic Brownian Bridge Movement Model (dBBMM) of male wild turkeys in Louisiana (2012-2013) and Texas (2009).

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<tr>
<td>Mean</td>
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Table 2.2. Mean daily distance traveled (m) with associated standard error for individual male wild turkeys in Louisiana (LA) and Texas (Tx), USA from 2009-2013.

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\(^1\) n= Number of days analyzed for daily distance estimates.
\(^2\) Max= The maximum linear distance traveled (m) for individual turkeys on a single day. Min = The minimum linear distance traveled (m) for individual turkeys on a single day.
Table 2.3. Mean distance between consecutive roost sites (m) with associated standard errors for male wild turkeys in Louisiana (2012-2013) and Texas (2009).

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<td>2509</td>
<td>4</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>803±83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx</td>
<td>1</td>
<td>68</td>
<td>288</td>
<td>63.06</td>
<td>2527</td>
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<td>79</td>
<td>235</td>
<td>68.20</td>
<td>2967</td>
<td>2</td>
</tr>
<tr>
<td>Tx</td>
<td>3</td>
<td>61</td>
<td>87</td>
<td>33.09</td>
<td>1452</td>
<td>3</td>
</tr>
<tr>
<td>Tx</td>
<td>4</td>
<td>68</td>
<td>292</td>
<td>62.10</td>
<td>2528</td>
<td>2</td>
</tr>
<tr>
<td>Tx</td>
<td>5</td>
<td>80</td>
<td>215</td>
<td>71.94</td>
<td>3261</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>211±40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹n = Number of days analyzed for distance between consecutive roost estimates.
²Max = Maximum distance between consecutive roost sites (m) for individual turkeys on a single day. Min = Minimum distance between consecutive roost sites (m) for individual turkeys on a single day.
Table 2.4. Number and percentage of reused and consecutively used roost sites for individual male wild turkeys in Louisiana (2012-2013) and Texas (2009).

<table>
<thead>
<tr>
<th>State</th>
<th>ID</th>
<th>n</th>
<th>Re-used</th>
<th>Consecutive</th>
<th>% Re-used</th>
<th>% Consecutive</th>
</tr>
</thead>
<tbody>
<tr>
<td>La 1</td>
<td>31</td>
<td>5</td>
<td>1</td>
<td></td>
<td>16.1%</td>
<td>3.2%</td>
</tr>
<tr>
<td>La 2</td>
<td>56</td>
<td>20</td>
<td>3</td>
<td></td>
<td>35.7%</td>
<td>5.4%</td>
</tr>
<tr>
<td>La 3</td>
<td>70</td>
<td>20</td>
<td>5</td>
<td></td>
<td>28.6%</td>
<td>7.1%</td>
</tr>
<tr>
<td>La 4</td>
<td>76</td>
<td>19</td>
<td>1</td>
<td></td>
<td>25.0%</td>
<td>1.3%</td>
</tr>
<tr>
<td>La 5</td>
<td>39</td>
<td>4</td>
<td>1</td>
<td></td>
<td>10.3%</td>
<td>2.6%</td>
</tr>
<tr>
<td>La 6</td>
<td>52</td>
<td>16</td>
<td>7</td>
<td></td>
<td>30.8%</td>
<td>13.5%</td>
</tr>
<tr>
<td>La 7</td>
<td>35</td>
<td>8</td>
<td>0</td>
<td></td>
<td>22.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>La 8</td>
<td>49</td>
<td>19</td>
<td>5</td>
<td></td>
<td>38.8%</td>
<td>10.2%</td>
</tr>
<tr>
<td>La 9</td>
<td>53</td>
<td>15</td>
<td>1</td>
<td></td>
<td>28.3%</td>
<td>1.9%</td>
</tr>
<tr>
<td>La 10</td>
<td>47</td>
<td>21</td>
<td>10</td>
<td></td>
<td>44.7%</td>
<td>21.3%</td>
</tr>
<tr>
<td>La 11</td>
<td>45</td>
<td>11</td>
<td>1</td>
<td></td>
<td>24.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>La 12</td>
<td>62</td>
<td>20</td>
<td>7</td>
<td></td>
<td>32.3%</td>
<td>11.3%</td>
</tr>
<tr>
<td>La 13</td>
<td>41</td>
<td>12</td>
<td>4</td>
<td></td>
<td>29.3%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>50.4</td>
<td>14.6</td>
<td>3.5</td>
<td>28.2%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Tx 1</td>
<td>68</td>
<td>59</td>
<td>42</td>
<td></td>
<td>86.8%</td>
<td>61.8%</td>
</tr>
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<td>Tx 2</td>
<td>79</td>
<td>72</td>
<td>63</td>
<td></td>
<td>91.1%</td>
<td>79.7%</td>
</tr>
<tr>
<td>Tx 3</td>
<td>61</td>
<td>57</td>
<td>48</td>
<td></td>
<td>93.4%</td>
<td>78.7%</td>
</tr>
<tr>
<td>Tx 4</td>
<td>68</td>
<td>52</td>
<td>40</td>
<td></td>
<td>76.5%</td>
<td>58.8%</td>
</tr>
<tr>
<td>Tx 5</td>
<td>80</td>
<td>72</td>
<td>65</td>
<td></td>
<td>90.0%</td>
<td>81.3%</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>71.2</td>
<td>62.4</td>
<td>51.6</td>
<td>87.6%</td>
<td>72.1%</td>
</tr>
</tbody>
</table>

1 n= Number of roost events analyzed for estimates of roost site selection.
2 Reused= Number of times an individual returned to the same roost site.
3 Consecutive= Number of times an individual returned to the same roost site on consecutive nights.
Figure 2.1. Seasonal utilization distribution (UD) created using a dynamic Brownian Bridge Movement Model (dBBMM) for a male wild turkey on Tunica Hills WMA, Louisiana in 2012. Home range (95%) is shown in pale yellow and core area (50%) area in dark yellow. Red dots indicate nightly roosting locations.
Figure 2.2. A movement path of an adult male eastern wild turkey on Tunica Hills WMA, Louisiana in 2013. Yellow arrows depict each of 44 locations collected on 13 April, 2013. Red stars indicate the location of morning and afternoon roosts.
Figure 2.3. Nightly roost locations buffered to 20m for an adult male eastern wild turkey during spring on Tunica Hills WMA, Louisiana in 2013. Buffers that overlap were considered reused roost sites.
CHAPTER 3

INFLUENCES OF HUNTING ON MOVEMENTS OF MALE WILD TURKEYS DURING SPRING

\[\text{\footnotesize J.T. Gross, B.S. Cohen and M.J. Chamberlain. To be submitted to Proceedings of the National Wild Turkey Symposium.}\]
ABSTRACT

Wild turkeys are an important game species throughout North America, and interest in turkey hunting continues to increase. Harvest during spring is the primary source of mortality for males, but little research has addressed how hunting during spring affects movements and space use of wild turkeys. We used micro-GPS transmitters coupled with hunter movement data collected with handheld GPS units to detail the spatial ecology of male eastern wild turkeys (Meleagris gallopavo silvestris) in Louisiana relative to hunting pressure. We evaluated the effects of hunter presence on daily movement distances and distances between consecutive roost sites. We also used hunter track logs to create high and low risk gradients across the hunted landscape to evaluate how hunting pressure affected weekly core area size and shifts in weekly core area centers. We found that hunter presence had little effect on male movements; males increased distances moved by 6% on hunted days (3976 ± 98 m; mean ± SE; range 1422-7751 m, n=156 days) compared to non-hunted days (3741 ± 62; range 882-7416, n=331 days). We found that low risk encounters tended to result in decreased weekly core area sizes and increased the proximity of weekly core area centers to one another. High risk encounters increased both core area size and the distance between weekly core area centers, but parameter estimates from these analyses suggested that the strength of the observed relationship was weak. We noted that responses to hunting pressure were highly variable among individuals. For weekly core area size, 4 individuals showed a decrease in core area size, 1 did not change, and 7 increased (β = -1.40 - +1.05). For weekly core area shift, 5 individuals constricted the proximity of weekly core area centers to one another, whereas 7 individuals increased the distance between core area centers (β = -1.19 - +1.4). We suggest that the lack of a consistent pattern among individuals suggests that other factors such as breeding behavior, female movements, previous experience,
dominance status, and habitat characteristics were more influential on male movements than was hunting pressure.

INDEX WORDS: core area, daily movements, hunting pressure, Meleagris gallopavo, micro-GPS, roosting characteristics

INTRODUCTION

Wild turkey populations have increased in North America since the 1940’s, and huntable populations now occur in every state except Alaska (Kennamer 2000, Tapley et al. 2001). Although some local populations have declined in recent years (Tapley et al. 2010), wild turkeys remain an important game species throughout most of the United States. The eastern wild turkey (M. g. silvestris) is an important game species throughout much of the United States. It is the most hunted, abundant, and widely dispersed of the 5 subspecies (Kennamer 2002) and According to the National Wild Turkey Federation (National Wild Turkey Federation [NWTF] 2003), there has been over $2 billion in economic impact directly related to the management and pursuit of wild turkeys in the United States. Within the last 3 decades, wild turkey management has shifted its focus from protection and reintroduction to sustainability of harvest (Tapley 2001). Although the ecology of some of the most common predators to the wild turkey has been studied extensively, we know little about how sport hunting activities influence turkey behavior.

Hodges et al. (2005) suggested that adult male turkeys were less susceptible to predation than females and juvenile males because of their larger size and lack of the requirement to nest, although. Males are generally large enough to make them difficult prey items for most predators, although bobcats (Everett et al. 1980, Wright and Vangilder 2001), coyotes (Paisley et al. 1996, Hodges et al. 2005), and great horned owls (Vangilder 1996) are known to depredate
male turkeys. Males may be more susceptible to predation during the breeding season than at other times perhaps because breeding behaviors may make them less aware of predators (Paisley et al. 1996). Although adult males are generally less susceptible to predation than females and juvenile males, they are more susceptible to hunter harvest in the spring than any other group (Wright 1998, Hubbard and Vangilder 2005, Chamberlain et al. 2012).

Harvest of wild turkeys in the spring is the primary cause of mortality in adult males (Hughes et al. 2005, Chamberlain et al. 2012), yet we lack a basic understanding of how wild turkeys respond to hunting activity. The number of turkey hunters has increased from about 1.69 million in 1984-1985 to 2.66 million in 1998-1999 to 2.80 million in 2009 (Tapley et al. 2001, Tapley et al. 2010). Nationally, rates of spring hunting have increased by 22-35% in each 5 year interval since 1985 (Tapley 2001). Although hunter attitudes, success rates and demographics have been studied (Palmer et al. 1990, Backs et al. 1995, Thackston et al. 1996, Little et. al 2001, Casalena et al. 2010) the effect that increasing hunter numbers has on turkey ecology has not been well documented.

Wildlife management agencies would benefit tremendously from an improved understanding of how hunter behavior affects animal movements. Prior studies have asked hunters to field-report their hunting activities on maps (Johnson 1943, Thomas et al. 1976). However, Stedman et al. (2004) found that hunters who field-reported their activities overestimated their total distances traveled as well as their distances from roads. Recently, several studies have used improved GPS technologies to detail the space use of hunters.

Stedman et al. (2004) used handheld GPS to describe habitat use of white-tailed deer (*Odocoileus virginianus*) hunters in Pennsylvania, and reported that hunters consistently
overestimated the total distances they traveled and the distance they hunted from public roads. Lebel et al. (2012) used handheld GPS to describe characteristics of successful white-tailed deer hunter behavior in Quebec, Canada. They found that hunters experienced greater levels of success when they hunted in areas where vegetation was sparse and visibility was greatest. They also reported that hunters had a greater chance of harvesting a white-tailed deer when they hunted areas that had a lower density of access routes when compared to areas of higher hunter use. Lyon and Burcham (1998) used GPS to examine elk (*Cervus canadensis*) hunters over 3 seasons in Montana, and found that hunters spent most of their time on slopes that were less steep than the study area average. They also reported an average distance of hunters from the nearest road to be 267m. Broseth and Pedersen (2000) used GPS technology to track and describe ptarmigan hunter success and landscape use in Norway. They found that hunting pressure was not consistent across their study site; instead the amount of hunting pressure a given area received was shown to be strongly dependent on the starting point of the hunters, meaning that areas closer to access points received higher amounts of hunting pressure. They also reported that hunting pressure and vulnerability of willow ptarmigan (*Lagopus lagopus*) were linked, as birds were more likely to be killed if they were located near access points and areas that received higher hunting pressure.

Movements of wild turkeys as they relate to hunting pressure and perceived predation risk are not well known. Everett et al. (1978) used weekly telemetry locations in Alabama to report that hunting pressure did not cause shifts in male movement patterns during a spring hunting season. Similarly, in response to a fall hunting season in Florida, Williams et al. (1978) reported that most turkeys maintained their pre-season ranges and roosting sites, with some turkeys actually decreasing movements.
Although little research has quantified how hunting activity affects wild turkey movements, there have been similar studies conducted on other game species. Kilgo et al. (1998) found that hunting pressure on the Osceola National Forest caused white-tailed deer to change movement patterns, both spatially and temporally. During hunting seasons, deer avoided clearcuts, young pine plantations, and other open habitats. Deer preferred to use swamp and mature pine forests that provided more cover during hunting season, and also were found to increase nocturnal activity and increase their distance from roads (Kilgo et al. 1998). Root et al. (1988) found that intensive hunting caused deer to travel greater distances than at other times. Karns et al. (2012) also found that deer decreased overall movement distances during hunting periods when compared to non-hunted periods. Additionally, they observed 9 instances of deer displaying change of direction or flight characteristics when <100m from a known hunter. However, Karns et al. (2012) were not able to show a significant shift in mean home range or core area sizes in response to hunting. Hodges et al. (2000) found similar results for raccoons (*Procyon lotor*) hunted during summer seasons in Mississippi.

Selection of quality roost sites is key to wild turkey survival because roost sites provide protection from inclement weather and predation (Porter 1978, Kilpatrick et al. 1988). Roosting behavior in turkeys is poorly understood relative to other facets of their ecology. Because turkey hunters often enter areas where turkeys may be roosted, turkey hunting could influence roost site selection. However, information detailing influences of hunting on roosting behavior of wild turkeys is unavailable. However, among non-breeding shorebirds, roost-site selection was not related to the amount of boating disturbance (Peters and Otis 2006), although red knots (*Calidris canutus*) and dowitchers (*Limnodromus* spp.) avoided roost sites that had high levels of boating activity within 1000 m and 100 m of prospective roost sites, respectively.
Previous studies assessing space use and movements of male wild turkeys have used locations collected via very high frequency (VHF) transmitters and often contained high levels of locational error (White and Garrott 1986, Thogmartin 2001, Laver and Kelly 2008, Montgomery et al. 2011). However, the advent of micro-GPS transmitters designed specifically for wild turkeys has increased our capability to gather data that are more spatially and temporally accurate, and free of researcher biases. Guthrie et al. (2011) found that mean error for static tests across 3 varying landscapes for micro-GPS units was 15.5m and found that spatial accuracy of data collected via micro-GPS provided a substantial improvement in assessing habitat use and movement patterns of wild turkeys over traditional VHF telemetry techniques. The advent of micro-GPS units for turkeys now allows researchers to evaluate how hunting activity influences wild turkey movement ecology. In a bottomland hardwood forest in Louisiana, Collier and Chamberlain (2010) found that a male turkey fitted with a micro-GPS moved ~1,000 m and shifted its roost location on the opening day of the youth hunting season. This male then exhibited short-distance linear movements for several days, until moving ~2,000 m on the opening day of a 50 hunter lottery hunt. This preliminary study suggests the need to further evaluate the effect of hunter behavior on wild turkey movements in the spring. Therefore, we used micro-GPS technology to describe male wild turkey responses to hunting pressure. By monitoring hunter and turkey behavior simultaneously with GPS technology, we describe how hunting affected daily movements, core areas, and roost site selection of male turkey during spring hunting seasons. Likewise, because core areas presumably provide the most critical requirements for maintenance of space by wild turkeys (Burt 1943, Samuel et al. 1985, Asensio et al. 2012), we evaluated how hunting pressure influences the location and size of core areas through time while turkeys are exposed to hunting.
STUDY AREAS

We conducted research on 3 study sites during 2012-2013. The primary study area was the 2390 ha Tunica Hills Wildlife Management Area (WMA) located in West Feliciana parish, Louisiana. Tunica Hills was divided into 2 tracts, the North Tract (949ha) and the South Tract (1440ha). The South Tract was the site of most trapping and monitoring activity along with several adjacent tracts of private land. Tunica Hills was owned and operated by the Louisiana Department of Wildlife and Fisheries, and was located at the southernmost edge of the loess blufflands. Tunica Hills and surrounding private lands were composed of dissected uplands characterized by steep bluffs, ravines and rugged hills. Forest types of Tunica Hills were characterized as upland hardwoods with the major soil type being wind-deposited silt loams from the Mississippi River. Common overstory species included American beech (*Fagus grandifolia*), various oaks (*Quercus* spp.), hickory (*Carya* sp.), eastern hop hornbeam (*Ostrya virginiana*), yellow-poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum var. rubrum*), loblolly pine (*Pinus taeda*), and eastern redcedar (*Juniperus virginiana*). Understory shrubs and plants included oak leaf hydrangea (*Hydrangea quercifolia*), two-wing silverbell (*Halesia diptera*), pawpaw (*Asimina triloba*), muscadine grape (*Vitis rotundifolia*), flowering dogwood (*Cornus florida*), sweetleaf (*Symlocos tinctoria*), blackberry (*Rubus sp.*), and switchcane (*Arundinaria gigantea*).

Tunica Hills was open to numerous recreational activities, including hunting, trapping, hiking and sightseeing, biking, and horseback riding. Hunting was allowed during specified seasons for white-tailed deer, wild turkey, and small game animals. Turkey hunting was regulated with a season structure that allowed for a lottery system and a one-week hunt open to the public. The turkey season began with a one-day youth hunt on the 3rd Saturday in March of
every year, followed by 3 weekends (Saturday and Sunday only) of lottery hunting where only 15 participants were allowed to hunt. After the last Sunday of lottery hunting, the WMA was open to the public for 7 days.

Mosher Hill Hunting Club (hereafter Mosher) was a 1700 ha property owned by Weyerhaeuser Company and was leased to a private hunting club. Located in Washington Parish, Louisiana, the property was located east of HWY 25 and south of Franklinton. Mosher bordered the Bogue Chitto River to the east and the Bogue Chitto State park to the north. Mosher was located in the Lower Coastal plain region, and consisted mostly of well drained, sandy soils. The area had 100 club members, of which 10 were spring turkey hunters. The turkey season began with a 2 day youth hunt opening on 16 March 2013, followed by a 4 week open season which began the following weekend and concluded on 14 April. Most hunting activity was concentrated on the weekends, although hunting during the week did occur. The area was comprised mostly of loblolly pine (*Pinus taeda*) and was intensively managed for wood fiber production. The area also contained small river drainages and low areas that consisted mostly of hardwood species including water oak (*Quercus nigra*), green ash (*Fraxinus pennsylvanica*), sweet bay (*Magnolia virginiana*), southern magnolia (*Magnolia grandiflora*), wild azalea (*Rhododendron canescens*), baldcypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and red bay (*Persea borbonia*).

Located in West Baton Rouge Parish LA, Double D hunting club (hereafter Double D), was a 688 ha privately owned hunting club. Double D was approximately 5 km north of Interstate 10 in the floodplains between the Mississippi and Atchafalaya rivers. The area had 13 club members, of which 4 were turkey hunters. The turkey season began with a 2 day youth hunt opening on 16 March 2013, followed by a 5 week open season which began the following
weekend and concluded on 21 April. Most hunting activity was concentrated on the weekends, although hunting during the week did occur. The property was classified as bottomland hardwoods, and contained a mix of roadways, gas pipelines and food plots. Due to a closed canopy and prolonged seasonal flooding, much of the mid and understory was sparse. Overstory species included water oak, nuttall oak (*Quercus nuttallii*), overcup oak (*Quercus lyrata*), eastern cottonwood (*Populus deltoides*), American sycamore (*Platanus occidentalis*), bitter pecan (*Carya x lecontei*), water hickory (*Carya aquatica*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), ash (*Fraxinus sp.*). Midstory and understory species included red mulberry (*Morus rubra*), boxelder (*Acer negundo*), red maple (*Acer rubrum*), roughleaf dogwood (*Cornus drumondii*), trumpet creeper (*Bignonia capreolata*), dewberry (*Rubus sp.*), and poison ivy (*Toxicodendron radicans*).

**METHODS**

Male eastern wild turkeys were captured using cannon nets during January-March 2012 on Tunica Hills and adjacent private lands. Due to a lack of trapping success on Tunica Hills in 2013, trapping effort expanded to Mosher and Double D hunting clubs. Once captured, birds were fitted with micro-GPS units. All micro-GPS units were attached to birds using 3-mm shock cord backpack style according to the recommendations of Wilson and Norman (1995). Birds were also fitted with aluminum rivet bands on their right tarsus. All bands were provided by the Louisiana Department of Wildlife and Fisheries and were placed between the foot and spur of each bird. We estimated age (adult or juvenile) based on development and barring of 9th and 10th primary feathers (Pelham and Dickson 1992). Capture and handling protocols were approved by
the University of Georgia Institutional Animal Care and Use Committee (Permit A2011 07-003-R1).

All turkeys were fitted with micro-GPS units designed and produced by Sirtrack Wildlife Tracking Solutions (Sirtrack Wildlife Tracking Solutions, Havelock North, New Zealand) or MiniTrack Backpack GPS units designed by Biotrack Ltd (Biotrack Limited, Wareham, Dorset, United Kingdom). Sirtrack units were approximately 10cm × 4cm, were programmed before deployment, and had to be recovered to retrieve data. Units produced by Biotrack measured approximately 7.5cm × 2.5cm and were capable of being remotely downloaded. All units housed a GPS and VHF component, allowing us to triangulate birds once per week to monitor survival. Units were programmed to record one location at noon and one location at midnight each day from time of capture through March 10 of the same year. On March 10, the units were programmed to switch to a higher intensity schedule to collect one location every 15 minutes during daylight hours and one location at midnight each day. This schedule continued for 50 days, which coincided with peak breeding dates and all hunting activity. After the 50 days was complete, the unit began recording one location at noon once per week to provide coarse location data and to ensure that battery life was maintained so that units could collect data in 2 consecutive springs. The unit was programmed to repeat this schedule beginning on March 10 of the following year if the bird was still being monitored.

All hunters on Tunica Hills WMA were required to stop at designated check-in stations upon entry into the study area. We briefly discussed our study objectives with each hunter, before providing them with a handheld Garmin eTrex GPS unit. Each unit was pre-programmed to collect one location every 30 seconds for the duration of the hunt. We turned each unit on before giving it to the hunter and asked them to carry it throughout the duration of the hunt.
Each GPS unit was equipped with a belt clip, but most hunters chose to place the units in an extra pocket or a backpack. We collected units from hunters upon exiting the WMA where we downloaded data and cleared the units for re-deployment. During the 2012 hunting season it was not mandatory for hunters to carry GPS units, but only 3 hunters refused to participate in the study. During the 2013 hunting season, the Louisiana Department of Wildlife and Fisheries made participation mandatory.

On the adjacent Mosher Hill and Double D hunting clubs, we asked hunters to voluntarily pick up a GPS unit from designated check-in stations before every hunt. We programmed these GPS units similarly to those deployed on Tunica Hills. We believe that we captured most (> 90%) of the hunting events on both private lands. We then retrieved the units twice weekly, downloaded data from them, and cleared them for re-deployment.

We evaluated how hunting influenced linear distance traveled per day, distance between consecutive roost sites, shifts in weekly core areas, and weekly core area size. We limited our analysis period from 1 March-31 April during 2012 and 2013 to coincide with peak hunting and breeding activity on all sites. We constructed weekly core areas to coincide with the unique hunting season structure of Tunica Hills WMA which consisted of 4, weekend lottery hunts followed by a 7 day open hunting period. This allowed us to assess how the hunting activity of the weekend affected turkey movements during the hunted period and the following week. We quantified the effect of hunter presence by designating each day as hunted or not and used hunter track logs from hunted days to create risk gradients across the landscape.

Daily movements of wild turkeys have not been well studied, and most research has focused on seasonal movements, dispersal and space use (McMahon and Johnson 1980, Kelley
et al. 1988, Holdstock et al. 2006). Daily distances moved by males are larger in spring than other seasons (Godwin et al. 1994) and long distance daily movements could influence individual survival and management goals. Therefore we evaluated how daily linear distances were affected by hunter presence. We calculated linear distance traveled per day using the “XY to Line” tool in ArcGIS 10.0 (ESRI 2011). Each recorded location from that day was used to create a total daily movement path and the total linear distance was measured.

Roost site selection is important for wild turkey survival as roosts provide protection from inclement weather and predation (Porter 1978, Kilpatrick et al. 1988). Roosting behavior in turkeys is poorly understood relative to other facets of their ecology, and could be affected by hunter disturbance. Hunting wild turkeys often puts hunters in close proximity to roost sites well before turkeys leave the roost, and this disturbance could influence roost site selection. Hence, we calculated distances between nightly roost locations as a measure of roost site fidelity during the spring hunting season. The micro-GPS units were programmed to collect locations every night at midnight when birds were on a roost. These locations were extracted and distance between consecutive roost locations was measured in ArcGIS 10.0 (ESRI 2011). We applied a Welch Two Sample T-test to compare the differences in daily movements and distances between consecutive roost sites between hunted and non-hunted days.

Core areas are areas of concentrated use within home ranges and presumably contain critical resources important for reproduction and survival (Asensio et al. 2012). It is plausible to assume that turkeys could alter the size of their core areas and the potentially shift their core areas in response to hunting and disturbance. To determine weekly core use areas, we grouped turkey locations into weeks corresponding to the Tunica Hills hunting season. We used program R version 3.1.0 (R Development Core Team, 2013), and package “adehabitatHR” (Calenge
to calculate the kernel density core-use areas (50%) for each bird for each week. Once the 50% core areas were calculated, we calculated the centroids for each week and measured the shift in location of the centroid over consecutive weeks (Figure 3.1).

We used hunter track logs to create daily risk gradients of hunting activity. These risk zones were used to determine encounter rates for each bird for each day of the hunting season. We designated risk zones as high risk and low risk. We defined the high risk zone as any area within 100 m of a recorded hunter location for that day and low risk as anything between 100 m and 300 m. To calculate the risk zones, all hunter data from one day were combined into a single shape file and we created a raster layer for each day using the Euclidean Distance tool in ArcMap (ArcGIS 10). We then reclassified this raster layer into high and low risk zones based on the 100 m and 300 m definitions. To calculate encounter rates, all recorded turkey locations were separated by day and projected onto the calculated risk maps. Once the daily risk zones and associated turkey locations were displayed, we used the Extract Values to Points tool in ArcMap (ArcGIS 10) to assign a risk value for each turkey location (Figure 3.2). Each turkey location generated a value of 1 for low risk or 2 for high risk. We grouped data so that total number of encounters was calculated for each week and compared to the corresponding shift in core area and core area size.

We conducted generalized linear mixed modeling (GLMM) analyses using the lme4 (Bates et al. 2011) and LMER Convenience Functions (Tremblay 2011) to investigate if high and low risk encounters affected turkey core area size and shifts. The GLMMs allowed incorporation of a flexible covariance structure into the modeling framework, resulting in better estimates of variability than standard generalized linear models (Clayton and Kaldor 1987, Breslow and Clayton 1993). We used a log link with Poisson error term in these analyses, and
fitted models using Laplace approximation. The dependent variable was a count measure, with hunter activity being quantified as the number of times each turkey was presented with a high or low risk event. Fixed response variables were the weekly count of high and low risk events. To account for the assumed individual behavioral characteristics of each turkey, we treated each turkey as a random effect. Although our samples were from 3 study sites, we ignored this factor as a random effect because of insufficient replication. We conducted all analyses using program R version 2.11.1 (R Development Core Team 2010).

RESULTS

We captured 17 adult males and 2 juvenile males during 2012-2013 and examined the influences of hunting on the movements of 11 adult and 1 juvenile wild turkey. We obtained an average of 1,964 locations per bird during our study period. We observed an 8% increase ($t_{11} = -2.162, P=0.05$) in daily distances traveled for hunted days ($4,033 \pm 98$ m; mean $\pm$ SE; range 1,422-7,751 m, n=156 days) compared to non-hunted days ($3,730 \pm 62$; range 882-7,416, n=331 days). Alternatively, we only found that 2 males exhibited a significant increase in daily movement distances and we observed a 19% decrease in daily distance traveled on hunted days for male 12 (Table 3.1).

The mean distance between consecutive roost sites increased ($t_{11} = -1.488, P=0.165$) 18% on hunted days (947 $\pm$ 69m; range 7-4350; n =151 roost events) compared to non-hunted days (798 $\pm$ 36m; range 3-3548; n=363 roost events). Although this is a small increase in distance between consecutive roosts on hunted days, it may indicate that birds were less likely to return to the same areas where hunters were present. However, we only noted one individual case of a significant increase in consecutive roosting distances on hunted days, and we observed a 54%
decreased distance between consecutive roosts on hunted days compared to non-hunted days for another male (Table 3.2).

We found that low risk encounters tended to result in decreased weekly core area sizes ($\beta = -0.01$) and increased the proximity of weekly core area centers to one another ($\beta = -0.01$). High risk encounters increased both core area size ($\beta = 0.01$) and the distance between weekly core area centers ($\beta = 0.01$; Tables 3.3 and 3.4); however, parameter estimates from these analyses suggest that the strength of the observed relationship is weak. Average weekly core area sizes ranged from 454 ha (week 4) to 120 ha (week 5; Table 3.5), and average shift in weekly core area ranged from 437 m (week 4) to 1234 m (week 1; Table 3.6). Individual turkey behavior was variable with regards to core area size and shift in weekly core area centers. For weekly core area size, 4 individuals showed a decrease in core area size, 1 did not change, and 7 increased (parameter estimates of -1.40 to 1.05; Figure 3.3). For weekly core area shift, 5 individuals constricted the proximity of weekly core area centers to one another, whereas 7 individuals increased the distance between core area centers (parameter estimates of -1.19 to 1.4; Figure 3.4). To illustrate the degree of variability, one male moved beyond the Tunica Hills WMA boundary on opening day of hunting season and never returned (Figure 3.5) whereas another male showed no signs of shifting his movement activities in the presence of hunting risk (Figure 3.6).
DISCUSSION

We found that daily distances moved by wild turkeys in Louisiana were greater on hunted days (3,977 ± 98 m) than on non-hunted days (3,741 ± 62 m). Although daily distances moved were statistically greater on hunted vs non-hunted days, these differences were minor and likely did not reflect biological relevance. We suspect that this finding is simply a consequence of the resolution and volume of data we collected; as such our results seems to support the findings of Everett et al. (1978) and Williams et al. (1978) who reported no changes in male movements due to hunting pressure. Karns et al. (2012) found that white-tailed deer significantly reduced their daily movements during a hunting season when compared to other seasons. Our approach provided greater resolution data relative to how hunting affected animal movements, because we evaluated differences in movements when hunters were actually present, not just during an entire hunting period. We offer that this distinction is important because many variables can cause movement patterns to shift from season to season, including breeding chronology and resource availability. Karns et al. (2012) noted that although they saw a decrease in movements during periods when deer were hunted, this period also coincided with the post-breeding period which may have caused the decrease in movement.

Consecutive roost sites were 17% farther away from one another on hunted days when compared to non-hunted days. In Colorado, Hoffman (1991) found that males used consecutive roosts that averaged over 1000 m apart and only used a previous roost site 19% of the time. Our reported estimates of 909 m and 766 m for hunted and non-hunted days are similar to the findings of Hoffman (1991). Although it appears that hunting only modestly affects roost site selection by males, males may be more likely to increase their distance between consecutive
roosts if hunters were present when they left their morning roost sites, or they were disturbed in areas surrounding the morning roost.

We observed that low risk encounters decreased core area size and tightened the proximity of weekly core areas to one another, whereas high pressure encounters increased core area size and increased distances between weekly core areas. While the observed effect sizes were small, we speculate that perhaps low or indirect pressure may cause turkeys to reduce their core areas, but not shift these areas as the perceived risk from hunting does not warrant such a response. Conversely, when hunting pressure increases (high risk), turkeys may be more likely to increase their core area size and shift these areas. Regardless, it is important to note that responses to hunting pressure varied widely among individual turkeys, suggesting that responses may have been based on previous experiences with predation risk or influenced by variables we did not measure.

Our findings generally parallel those published from studies designed to assess interactions between predators and their prey. Ydenberg and Dill (1986) noted that prey made optimal fleeing decisions that balanced the chance of capture with the trade-offs of the increased energy demand. Likewise, the probability of fleeing or shifting movements may be related to the severity of the approach by a predator, in that an approach that is more direct and in closer proximity to an animal is more likely to cause it to flee (Burger and Gochfeld 1990, Cooper 1998, Frid 2002). Dill (1974) hypothesized that flight initiation distances, or fleeing probability, would increase when predators were larger or increased the speed in which they approached their prey. Similarly, flight initiation distances should increase when the distance to the nearest refuge increases because the risk of capture would also increase, and flight initiation distances would increase when resources are low (Frid 2002). Our results concur with these predictions, and
male turkeys appeared more likely to change their movement patterns when faced with a high risk encounter.

Male wild turkeys move more in spring than in other seasons (Kelley et al. 1988, Godwin et al. 1994), primarily a result of breeding behaviors. Female movements, courtship and mating behaviors, and social pressure between dominant and subordinate males can influence movements of males in spring (Shields 1987, Hurst 1991, Holdstock 2006). Our results show that hunting had minor effects on male turkey movements in the spring. The timing of the hunting season, coinciding with the peak in breeding behavior, may have mitigated the effects of hunting pressure because males were more concerned with pursuing breeding opportunities than avoiding predators.

We report a wide variation in response to hunting among individual birds. While some males were killed by hunters (Figure 3.7), some males seemed to avoid hunter interaction by fleeing (Figure 3.8). Miller et al. (2001) and Grisham et al. (2008) reported a high degree of variability in male spatial fidelity during spring. Grisham et al. (2008) reported that half of the males in their study shifted their space use, but they were unable to detect a pattern at the population level. We suggest that the lack of a consistent pattern among individuals in our study signals that other factors such as breeding behavior, female movements, dominance status, and habitat characteristics were more influential on male movements than was hunting pressure.

**LITERATURE CITED**


forestland characteristics on spatial-distribution of hunters. Journal of Wildlife
Management 40:500-506.

Vangilder, L. D. 1996. Survival and cause-specific mortality of wild turkeys in the Missouri

White, G. C., and R. A. Garrott. 1986. Effects of biotelemetry triangulation error on detecting

Williams, L. E. Jr., D. H. Austin, and T. E. Peoples. 1978. Turkey harvest patterns on a heavily
hunted area. Proceedings of the Southeastern Association of Fish and Wildlife Agencies
32:303-308.

Wilson, T.S., and G.W. Norman. 1995. Techniques and materials used in attaching radio
transmitters to wild turkeys. Proceedings of the National Wild Turkey Symposium.
7:115-121.


Ydenberg, R. C., and L. M. Dill. 1986. The economics of fleeing from predators. Advances in
the Study of Behavior 16:229-249.
Table 3.1. Daily distance traveled (m) and associated $P$-values estimates for individual male wild turkeys on hunted and non-hunted days in Louisiana in 2012 and 2013.

<table>
<thead>
<tr>
<th>Turkey #</th>
<th>Hunted Days</th>
<th>Non-hunted Days</th>
<th>$P$-value$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4745</td>
<td>4416</td>
<td>0.37</td>
</tr>
<tr>
<td>2</td>
<td>4915</td>
<td>4481</td>
<td>0.20</td>
</tr>
<tr>
<td>3</td>
<td>4390</td>
<td>4085</td>
<td>0.42</td>
</tr>
<tr>
<td>4</td>
<td>4321</td>
<td>4070</td>
<td>0.38</td>
</tr>
<tr>
<td>5</td>
<td>4187</td>
<td>3204</td>
<td>0.03</td>
</tr>
<tr>
<td>6</td>
<td>3823</td>
<td>3009</td>
<td>0.02</td>
</tr>
<tr>
<td>7</td>
<td>3969</td>
<td>3787</td>
<td>0.44</td>
</tr>
<tr>
<td>8</td>
<td>5051</td>
<td>4051</td>
<td>0.10</td>
</tr>
<tr>
<td>9</td>
<td>3699</td>
<td>3667</td>
<td>0.87</td>
</tr>
<tr>
<td>10</td>
<td>2995</td>
<td>3065</td>
<td>0.82</td>
</tr>
<tr>
<td>11</td>
<td>2877</td>
<td>3009</td>
<td>0.46</td>
</tr>
<tr>
<td>12</td>
<td>3288</td>
<td>4041</td>
<td>0.02</td>
</tr>
<tr>
<td>Mean</td>
<td>3976</td>
<td>3741</td>
<td>0.04</td>
</tr>
</tbody>
</table>

$^1P$-value = $P$-value estimate comparing daily distance traveled on hunted and non-hunted days.

Table 3.2. Distance between consecutive roost sites (m) and associated $P$-values estimates for individual male wild turkeys on hunted and non-hunted days in Louisiana in 2012 and 2013.

<table>
<thead>
<tr>
<th>Turkey #</th>
<th>Hunted Days</th>
<th>Non-hunted Days</th>
<th>$P$-value$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1247</td>
<td>830</td>
<td>0.23</td>
</tr>
<tr>
<td>2</td>
<td>1196</td>
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<td>3</td>
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<td>822</td>
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</tr>
<tr>
<td>4</td>
<td>804</td>
<td>810</td>
<td>0.97</td>
</tr>
<tr>
<td>5</td>
<td>1239</td>
<td>548</td>
<td>0.36</td>
</tr>
<tr>
<td>6</td>
<td>1678</td>
<td>1109</td>
<td>0.03</td>
</tr>
<tr>
<td>7</td>
<td>880</td>
<td>547</td>
<td>0.27</td>
</tr>
<tr>
<td>8</td>
<td>1376</td>
<td>1408</td>
<td>0.94</td>
</tr>
<tr>
<td>9</td>
<td>673</td>
<td>530</td>
<td>0.19</td>
</tr>
<tr>
<td>10</td>
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<td>0.14</td>
</tr>
<tr>
<td>12</td>
<td>490</td>
<td>1058</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>943</td>
<td>790</td>
<td>0.059</td>
</tr>
</tbody>
</table>

$^1P$-value = $P$-value estimate comparing distance between consecutive roost sites on hunted and non-hunted days.
Table 3.3. Parameter estimates (log scale) of hunting pressure on weekly core area size of 12 male wild turkeys in Louisiana in 2012 and 2013. Standard errors (SE), z values, and probabilities that a coefficient differs from 0 are also presented.

| Covariate    | Estimate | Coefficient (SE) | z value | Pr(>|z|) |
|--------------|----------|------------------|---------|----------|
| Intercept    | 6.58     | 0.20             | 33.74   | <0.01    |
| High Pressure| 0.01     | 0.00             | -12.71  | <0.01    |
| Low Pressure | -0.01    | 0.00             | -0.41   | 0.68     |
| Turkey       | 0.46*a   | N/A              | N/A     | N/A      |

*aTurkey was considered a random effect in the model. Thus, it is a variance estimate.

Table 3.4. Parameter estimates (log scale) of hunter pressure on weekly core area shifts of 12 male wild turkeys in Louisiana in 2012 and 2013. Standard errors (SE), z values, and probabilities that a coefficient differs from 0 are also presented.

| Covariate    | Estimate | Coefficient (SE) | z value | Pr(>|z|) |
|--------------|----------|------------------|---------|----------|
| Intercept    | 6.76     | 0.19             | 25.91   | <0.01    |
| High Pressure| 0.01     | 0.00             | 1.77    | 0.07     |
| Low Pressure | -0.01    | 0.00             | -38.86  | <0.01    |
| Turkey       | 0.32*a   | N/A              | N/A     | N/A      |

*aTurkey was considered a random effect in the model. Thus, it is a variance estimate.
Table 3.5. Weekly core area sizes (ha) for individual male wild turkeys in Louisiana from 2012 to 2013.

<table>
<thead>
<tr>
<th>Bird #</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>22</td>
<td>130</td>
<td>119</td>
<td>130</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>24</td>
<td>132</td>
<td>127</td>
<td>113</td>
<td>46</td>
</tr>
<tr>
<td>3</td>
<td>122</td>
<td>74</td>
<td>132</td>
<td>24</td>
<td>92</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>49</td>
<td>195</td>
<td>41</td>
<td>47</td>
<td>102</td>
<td>51</td>
</tr>
<tr>
<td>5</td>
<td>78</td>
<td>44</td>
<td>53</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>211</td>
<td>368</td>
<td>131</td>
<td>387</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>27</td>
<td>35</td>
<td>49</td>
<td>235</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>124</td>
<td>158</td>
<td>137</td>
<td>54</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>27</td>
<td>34</td>
<td>40</td>
<td>29</td>
<td>46</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>105</td>
<td>56</td>
<td>176</td>
<td>33</td>
<td>105</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>23</td>
<td>30</td>
<td>31</td>
<td>46</td>
<td>–</td>
</tr>
<tr>
<td>12</td>
<td>102</td>
<td>141</td>
<td>11</td>
<td>18</td>
<td>19</td>
<td>–</td>
</tr>
<tr>
<td>Mean</td>
<td>54</td>
<td>88</td>
<td>97</td>
<td>73</td>
<td>120</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 3.6. Distance between weekly core area centers (m) for male wild turkeys in Louisiana in 2012 and 2013.

<table>
<thead>
<tr>
<th>Bird #</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2663</td>
<td>718</td>
<td>403</td>
<td>335</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>2613</td>
<td>661</td>
<td>379</td>
<td>394</td>
<td>1080</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>217</td>
<td>542</td>
<td>279</td>
<td>666</td>
<td>176</td>
</tr>
<tr>
<td>4</td>
<td>–</td>
<td>269</td>
<td>481</td>
<td>184</td>
<td>45</td>
<td>650</td>
</tr>
<tr>
<td>5</td>
<td>–</td>
<td>723</td>
<td>1758</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>–</td>
<td>1789</td>
<td>2041</td>
<td>377</td>
<td>4096</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>–</td>
<td>2054</td>
<td>430</td>
<td>277</td>
<td>760</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>–</td>
<td>651</td>
<td>1764</td>
<td>982</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>–</td>
<td>133</td>
<td>73</td>
<td>95</td>
<td>528</td>
<td>–</td>
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<td>10</td>
<td>–</td>
<td>2203</td>
<td>600</td>
<td>1280</td>
<td>2095</td>
<td>814</td>
</tr>
<tr>
<td>11</td>
<td>–</td>
<td>129</td>
<td>284</td>
<td>480</td>
<td>275</td>
<td>–</td>
</tr>
<tr>
<td>12</td>
<td>–</td>
<td>1369</td>
<td>1601</td>
<td>73</td>
<td>87</td>
<td>–</td>
</tr>
<tr>
<td>Mean</td>
<td>–</td>
<td>1234</td>
<td>913</td>
<td>437</td>
<td>928</td>
<td>680</td>
</tr>
</tbody>
</table>
Figure 3.1. Weekly kernel density core-use areas (50%) and associated centroids for a male wild turkey on Tunica Hills WMA, Louisiana in 2013. Colored polygons represent 5 weekly core areas. A centroid was calculated for each core area and the distance (m) between consecutive centroids was calculated as the shift in weekly core area center.
Figure 3.2. Euclidean distance calculated from hunter track logs and associated turkey locations at Tunica Hills WMA, Louisiana from 2013. Hunter track logs (red dots) were used to create Euclidean distance calculations of high risk zones (100 m; orange buffer) and low risk zones (300 m; yellow buffer) to calculate encounter rates. Blue dots represent turkey locations for the same day as hunter track logs. Turkey locations within the orange buffer were classified as high risk encounters and locations in the yellow buffers were classified as low risk encounters.
Figure 3.3. Variability of individual males in response to hunting risk (as assessed through plotting of $\beta$ values obtained through inspection of random effects in the model) on the increase in weekly core area size for male wild turkeys in Louisiana from 2012 and 2013.

Figure 3.4. Variability of individual males in response to hunting risk (as assessed through plotting of $\beta$ values obtained through inspection of random effects in the model) on shift in weekly core area (50%) centers for male wild turkeys in Louisiana from 2012 and 2013.
Figure 3.5. A depiction of a male eastern wild turkey avoiding hunter activity by leaving the management area on opening day of hunting season at Tunica Hills WMA, Louisiana in 2012. Yellow points indicate the bird’s locations from 15 Feb to 16 March 2012, the red line with arrows shows the bird’s movement path on 17 March 2012 (opening day of hunting season), and blue points indicate the birds locations from 18 March to 7 April when the bird was killed. Black lines are the hunter track logs recorded with handheld GPS units on opening day.
Figure 3.6. Seasonal utilization distribution (UD) created using a dynamic Brownian Bridge Movement Model (dBBMM) for a male wild turkey on Tunica Hills WMA, Louisiana in 2013. Home range (95%) is shown in yellow and core area (50%) area in yellow. Red lines indicate primary hunting trails on Tunica Hills WMA and coincide with high levels of hunting pressure. In contrast to Figure 3.5, this individual maintained his home range and core use area in the presence of hunting pressure.
Figure 3.7. Recorded movement paths of 1 hunter and 1 male wild turkey in West Feliciana Parish, Louisiana in 2013. The yellow line depicts the movement path of a male wild turkey leaving his roost (first red arrow) and moving ~1,200 m in 1 hour where he is killed by a stationary turkey hunter (red star). The hunter path is depicted by the red locations.
Figure 3.8. Movement paths recorded via GPS for 1 hunter and 1 male wild turkey in West Feliciana Parish, Louisiana in 2013. The yellow line depicts the movement path of a male wild turkey; the blue points are a hunter track log. The red star indicates where the hunter and turkey meet. After the turkey interacts with the hunter he moves > 3,000m.
CHAPTER 4

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Wild turkey populations have increased dramatically across North America in the recent past. Despite these large increases, some local populations have stabilized or even declined. In addition to this, hunter participation in spring wild turkey hunting continues to increase, and spring harvest is the leading cause of mortality in adult males. Coupled with this, the advent of micro-GPS technology has greatly improved our ability to gather fine scale data on the behavior of wild turkeys, and has allowed us to address questions that were previously not possible. Therefore, I detailed the movement ecology of male wild turkeys in the spring and examined the effects of hunting pressure on male wild turkeys.

I measured the home ranges and core area sizes, daily distances traveled, and consecutive roost site distances for 19 male wild turkeys in Louisiana and Texas. Spring home range size was variable among individual turkeys, but as a population I report rather small spring home ranges. Males moved large distances, and moved intensively throughout their spring home ranges. These large daily movements were generally tortuous, and thus did not take individuals outside of their respective home ranges. I report larger distances traveled on a daily basis and smaller spring home range sizes for birds in Texas than in Louisiana. This increase in daily movements may be a function of the patchy distribution of resources across their range. Rio Grande turkeys in Texas are more dependent on fewer roost sites, and therefore are not able to occupy as much space. Although we report intensive movements within a small area, wild
turkeys are highly mobile and are capable of covering large distances in a single day. This degree of mobility should be considered when making management decisions, especially on small areas.

I found that birds in Louisiana used consecutive roost sites that were over 800 m apart, and that they reused roost sites less than 30% of the time. Birds in Texas used consecutive roost sites that averaged just over 200 m apart and reused roost sites almost 90% of the time. This difference in consecutive roost site distance and frequency may be related to availability of quality roost sites. In parts of the Rios home range, roost site availability has been shown to be a limiting factor to range expansion. Concurrently, we noted that Rios have a high dependence on few adequate roost locations, suggesting that these earlier findings are accurate.

Micro-GPS technology has recently evolved to be applicable for wild turkey research and has given us the ability to study new facets of wild turkey ecology. Therefore, we analyzed the effects of hunting pressure on the movements of male wild turkeys in Louisiana. I investigated the effects that hunter presence had on daily movement distances and distances between consecutive roost sites by comparing data from hunted and non-hunted days. We also evaluated the effects that hunting pressure had on the sizes of weekly core areas and the shifts in weekly core area centers. We found that there was little or no difference in daily movement distances or distances between consecutive roosts on hunted and non-hunted days. Our analysis of the effects of hunting pressure on the movement behaviors of male wild turkeys suggests that individual turkeys apparently display a high level of variability in movement decisions. Some males shifted weekly core area center and increased weekly core area sizes, whereas others decreased weekly core area sizes and did not shift weekly core area centers. Wild turkey movements in the spring
are highly influenced by breeding behavior and males may ignore levels of predation risk to maximize their chances of breeding.