

SEASONAL AREA OF USE AND HABITAT SELECTION BY FEMALE WILD  
TURKEYS IN RESPONSE TO PRESCRIBED FIRE IN A MANAGED LONGLEAF  
PINE SAVANNA IN SOUTHWESTERN GEORGIA

by

CHRISTINA MICHELLE PEREZ

(Under the Direction of Robert J. Warren and Michael J. Chamberlain)

ABSTRACT

I examined seasonal space use and habitat selection by female wild turkeys on 2 study areas in southwestern Georgia and related them to prescribed fire. Females selected mature pine and pine-hardwood stands burned 1 year earlier or not burned  $\geq 4$  years when they established seasonal areas of use. Within seasonal areas of use, females used pine plantations and mature pine stands more than were available, and stands burned during the current year or 2 years earlier were used more than expected. Additionally, I used a distance analysis to evaluate the immediate effect of prescribed fires on habitat use by comparing turkey locations 10 days before a fire to 10 days after a fire and found that females were significantly farther from burned stands post-fire. My results can assist land managers in implementing fire return intervals to create habitats required by female turkeys within the longleaf pine-wiregrass ecosystem.

INDEX WORDS: eastern wild turkey, *Meleagris gallopavo silvestris*, longleaf pine, prescribed fire, female habitat selection, compositional analysis

SEASONAL AREA OF USE AND HABITAT SELECTION BY FEMALE WILD  
TURKEYS IN RESPONSE TO PRESCRIBED FIRE IN A MANAGED LONGLEAF  
PINE SAVANNA IN SOUTHWESTERN GEORGIA

by

CHRISTINA MICHELLE PEREZ

B.S., Louisiana State University, 2010

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial

Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2013

© 2013

Christina Michelle Perez

All Rights Reserved

SEASONAL AREA OF USE AND HABITAT SELECTION BY FEMALE WILD  
TURKEYS IN RESPONSE TO PRESCRIBED FIRE IN A MANAGED LONGLEAF  
PINE SAVANNA IN SOUTHWESTERN GEORGIA

by

CHRISTINA MICHELLE PEREZ

Major Professor: Robert J. Warren  
Michael J. Chamberlain  
Committee: L. Mike Conner  
Steven B. Castleberry

Electronic Version Approved:

Maureen Grasso  
Dean of the Graduate School  
The University of Georgia  
August 2013

## DEDICATION

I dedicate this thesis to my whole family. Thanks especially to my parents and grandparents for the constant love and support, and for teaching me the values of hard work and dedication in achieving one's dreams.

## ACKNOWLEDGEMENTS

I thank everyone who worked so hard to make this project possible. Thank you to my wonderful advisors, Drs. Michael Chamberlain, Mike Conner, and Robert Warren, for the support, encouragement, advisement, and assistance throughout my work. I also appreciate Dr. Castleberry's assistance on our project and for serving on my committee. These four people deserve great thanks for being so patient with me throughout the journey.

I owe many thanks to the Georgia Department of Natural Resources and the Joseph W. Jones Ecological Research Center for funding and support. Many great people from both organizations assisted the turkey team in trapping, tracking, repairing the roof, retrieving stuck vehicles, and many other joyful field duties. I also thank them for allowing me to assist and pester with as many questions as I wanted while they did their daily duties. These opportunities were invaluable.

So much of my success in ArcGIS, I owe to a great mentor and friend Jean Brock. Joey Hinton, thank you for all of your help, time, sarcasm, and friendship during the past two years. For that matter, I would also like to thank all of the new friends I made in Georgia and the old friends who supported me all the way through this project. It means so much to me.

## TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS .....	v
LIST OF TABLES .....	viii
CHAPTER	
1 INTRODUCTION AND LITERATURE REVIEW.....	1
Wild Turkey Ecology.....	1
Longleaf Pine-wiregrass Ecology.....	4
Justification and Thesis Format.....	6
Literature Cited.....	7
2 SEASONAL AREA OF USE AND HABITAT SELECTION BY FEMALE WILD TURKEYS IN RESPONSE TO PRESCRIBED FIRE.....	11
Abstract.....	12
Introduction.....	12
Study Areas.....	15
Methods.....	17
Results.....	20
Discussion.....	22
Management Implications.....	26
Literature Cited.....	26

3 SUMMARY AND CONCLUSIONS.....	39
Literature Cited.....	41

LIST OF TABLES

	Page
<b>Table 2.1:</b> Seasonal selection and ranks (0 = lowest, 5 = highest) of 3rd order (habitat selection within the home range) selection during pre-incubation ( $P < 0.001$ ), summer ( $P = 0.006$ ), and fall/winter ( $P = 0.04$ ) using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.....	31
<b>Table 2.2:</b> Selection and ranks (0 = lowest, 4 = highest) of 2 <sup>nd</sup> order (time-since-fire selection in home ranges vs. availability across study area) selection ( $P = < 0.001$ ) and 3 <sup>rd</sup> order (time-since-fire selection within the home range) selection ( $P = 0.0005$ ) using compositional analysis of female wild turkeys on Silver Lake Wildlife Management Area and the Joseph W. Jones Center during 2011 and 2012.....	32
<b>Table 2.3:</b> Seasonal ranks (0 = lowest, 4 = highest) of 2 <sup>nd</sup> order (habitat selection in seasonal areas of use vs. availability across study area) and 3 <sup>rd</sup> order (habitat used based on locations vs. availability within seasonal areas of use) fire return interval habitat selection using compositional analysis of female wild turkeys on Silver Lake Wildlife Management Area during 2011 and 2012.....	33
<b>Table 2.4:</b> Ranking matrix of 2 <sup>nd</sup> order and 3 <sup>rd</sup> order fire return interval habitat selection during pre-incubation using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012. ....	34

**Table 2.5:** Ranking matrix of 2<sup>nd</sup> order fire return interval habitat selection during nesting season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012. ....35

**Table 2.6:** Ranking matrix of 2<sup>nd</sup> order and 3<sup>rd</sup> order fire return interval habitat selection during the summer season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012..... 36

**Table 2.7:** Ranking matrix of 2<sup>nd</sup> order and 3<sup>rd</sup> order fire return interval habitat selection during fall/winter season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.....37

**Table 2.8:** Selection and ranks (0 = lowest, 5 = highest) of 3<sup>rd</sup> order (habitat selection within the home range) selection ( $P = 0.014$ ) using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.....38

## CHAPTER 1

### INTRODUCTION AND LITERATURE REVIEW

Prescribed fire is an important management tool used to restore and maintain longleaf pine (*Pinus palustris*) within the southeastern United States (Landers et al. 1995), but some biologists believe that seasonal fire may play a role in recent declines in eastern wild turkey (*Meleagris gallopavo silvestris*) populations throughout the Southeast. Specifically, concerns exist that prescribed fire during the growing season may negatively affect nesting and brood-rearing females, resulting in decreased recruitment. I examined seasonal space and habitat use of female wild turkeys and related these parameters to growing season prescribed fires. The information gained from this study can assist land managers in decision-making and implementing prescribed fires where wild turkeys are present.

#### **Wild Turkey Ecology**

The eastern wild turkey is one of 5 subspecies of wild turkeys found in the United States. During the early 1900's, eastern wild turkey abundance declined severely because of habitat loss and over hunting. During the mid-1900's, state and federal agencies began to protect and restore public lands. In the process, turkey habitat was restored and turkey hunting regulations were revised. During the 1950's, after years of failed attempts at releasing farm-raised turkeys into the wild, state and federal agencies began relocating

groups of wild-captured turkeys to successfully repopulate restored forests. Today, turkeys are a valuable and popular recreational game species throughout their range.

Eastern wild turkeys use a variety of habitats including managed pine forests (Davis et al. 1995, Morgan et al. 2006), older aged forests (Porter 1992), hardwoods, farms fields, and forest openings. Preference for different forest types varies seasonally throughout the year, and managing for the variety of habitats that females require throughout their different biological seasons is important to ensure recruitment and population sustainability. Female wild turkeys in the Southeast typically use hardwoods during the fall and winter, and move into upland pine or pine-hardwood forests during spring when flocks disperse and prior to nesting season (Williams et al. 1973; Speake et al. 1975; Kennamer et al. 1980, 1981; Miller and Conner 2007). During early spring, females disperse in search of suitable nesting habitat characterized by relatively dense ground cover and woody vegetation (Hillestad 1970, Speake et al. 1975). Although females will nest in stands burned during the previous 1-3 years, they prefer to nest in stands burned either 2 (Sisson et al. 1990, Davis et al. 1995) or 3 years (Exum et al. 1987) prior to nesting.

Understanding the motivations for movements within the biological seasons (e.g., ground roosting with pre-flight poults, seeking brood-foraging habitats, selecting trees for roosting with broods) aids in understanding how female wild turkey habitat requirements change with time. In fire-maintained longleaf pine landscapes, understanding the role that prescribed fire plays in shaping understory characteristics is important to more thoroughly predict its impacts on wild turkeys. Brooding habitats provide vegetative cover and host many invertebrates as food for poults. Adequate brooding cover for young

poults is a critical habitat component for turkey management (Hurst 1981, Peoples et al. 1996). Hurst and Stringer (1975) found poult diets changed with age from primarily animals and insects to plants. Distances traveled by broods during the summer brooding season vary and increase as broods get older. Williams et al. (1973) observed the average distance traveled on the first day of brooding was 193.85 m, with the longest distance from nest to first ground roost being 548.64 m. Average home range size during the summer brooding seasons have been estimated at 149 ha (Hillestad 1970), 111 ha (Speake et al. 1975), and 415 ha (Chamberlain et al. 2000). As a comparison among seasons, Chamberlain et al. (2000) estimated home ranges at 607 ha during the fall-winter season, 307 ha during pre-incubation, and 273 ha during the nesting season in a managed pine plantation.

Poults begin to fly as early as 7 days (Hillestad 1970), but they are unable to fly to roost until 10 to 14 days of age (Williams et al. 1973, Spears et al. 2007). This pre-flight period is marked with low poult survival; therefore, the amount of habitat available for ground roosting is related to survival (Spears et al. 2007). In a concurrent study on the same study sites as my project, ground roosts were found to be farther from mature pine stands than expected (Williams 2012) and, therefore, were also associated with areas of higher ground level cover such as agricultural fields and shrubby edges. Once all poults are capable of flying, the brood will begin to roost in trees (Spears et al. 2007). During this critical period for a brooding female, she is challenged with finding a diversity of habitats to support poults by providing food, cover, and roost sites that change daily as poults mature.

Initial tree roosts for broods are usually on large horizontal trunks or branches 3-5 m high, increasing to 9-12 m as the poult reaches 5 weeks old (Williams et al. 1973, Spears et al. 2007). During the first 4 weeks of tree roosting, poults may roost under the female's wings or on the same branch (Williams et al. 1973). After 6 weeks of tree roosting, females and poults may roost in adjacent trees and different broods may begin to intermingle (Williams and Austin 1988). Chamberlain et al. (2000) observed that brooding females selected bottomland hardwood stands for roosts and used mature pine (>30 years old) and pine-hardwood stands for the remainder of the year. Within mature longleaf pine forests managed with prescribed fire, a goal is often to remove hardwood stems from longleaf pine-wiregrass stands; therefore, it is important for researchers to consider how habitat selection also might be affected by unburned habitat types and hardwood hammocks during these critical brooding periods and the other biological seasons for the female (Fall/Winter, Pre-incubation, Nesting, Summer/Brooding).

### **Longleaf Pine-wiregrass Ecology**

Longleaf pine forests once existed from southern North Carolina south to Florida and west to parts of eastern Texas, covering more than 37 million ha (Croker 1979, Brockway and Lewis 1997). Native understories consist of predominantly grasses and herbaceous forbs and shrubs. Today, less than 1.2 million ha of these forests remain as a result of conversion to agriculture, commercial harvest, and fire exclusion by early European settlers (Brockway and Lewis 1997). Longleaf pine forests historically required and adapted to frequent fire disturbances caused initially by lightning strikes and later maintained by anthropogenic sources (Croker 1979, Landers et al. 1995, Fill et al. 2012). Without fire disturbance, longleaf pines are outcompeted and replaced by hardwoods and

other pine species (Landers et al. 1995). Equally as important as the longleaf pine is the early successional herbaceous understory that exists as a result of fire. Species such as the gopher tortoise (*Gopherus polyphemus*), eastern indigo snake (*Drymarchon corais couperi*), and red-cockaded woodpecker (*Picoides borealis*) have adapted to longleaf pine ecosystems and are currently listed on state or federal threatened and endangered species list. State, federal, and private landowners recognize the importance of longleaf pine ecosystems and there is interest in restoring longleaf pine forests throughout the Southeast, yet many people are concerned about the compatibility of prescribed fire used for longleaf pine restoration and survival of wild turkeys.

Today, prescribed fire is an important management tool for landowners, but discrepancies exist over the timing and frequency of application. Some managers use only dormant season fire (i.e., October to March), while others advocate that growing season fire (i.e., April to September) is more advantageous to longleaf pine maintenance and restoration. Where wiregrass (*Aristida* spp.) is the predominant species in the understory, such as on my study sites, research indicates that growing season fire is necessary to induce wiregrass flowering (Mulligan and Kirkman 2002, Fill et al. 2012).

Length of time between fire application, or fire return interval, coupled with season of fire creates a diversity of available habitats across a landscape. Dormant season prescribed fires are usually lower intensity fires that serve to decrease fuel loads and remove ground cover while decreasing hardwoods and promoting new growth (Brockway and Lewis 1997). Growing season prescribed fires are also used to reduce hardwood stems and decrease competition for the longleaf pine while also promoting wiregrass reproduction. Burn rotations are determined by forest and wildlife management

objectives. Many quail managers have adopted 2-year burn rotations to provide constant early successional nesting and brooding cover. Timber managers may only require 3- to 5-year or longer burn rotations, and certainly there can be many properties with multi-use land management objectives. Mulligan and Kirkman (2002) recommend growing season fire to induce wiregrass reproduction followed by 1 to 2 years without a growing season fire to prevent grass seedling mortality. Heirs et al. (2000) recommends varying season of fires to promote legume species within the longleaf pine ecosystem, which is a principle practiced on my study sites. Clearly, there can be a number of objectives; therefore, a variety of burn seasons and rotations becomes necessary to accommodate diverse goals. Examining female turkey locations immediately before and after fire applications, in addition to long-term fire histories in preferred habitats will provide a better understanding of how turkeys respond to fire within the southeastern U. S. longleaf pine forests.

### **Justification and Thesis Format**

My study was designed to evaluate habitat selection of female wild turkeys and the effects of prescribed fire on seasonal habitat selection between 2 study areas in southwestern Georgia (i.e., Joseph W. Jones Ecological Research Center and Silver Lake Wildlife Management Area). Chapter 2 is a manuscript that describes the seasonal movements and habitat use of female wild turkeys in response to prescribed fires. Specifically, my research focused on identifying the immediate effects of prescribed fire on movements and the effects of prescribed fire return intervals on female wild turkey habitat selection with the goal of recommending prescribed fire management guidelines that accommodate the needs of female turkeys throughout their annual cycle. First, I

conducted habitat use analyses to identify seasonal habitat preferences. Next, I examined 10-day periods of time immediately before and immediately after fire events to determine short-term effects of prescribed fire on habitat use. Finally, I examined the effects of fire return interval by evaluating habitat selection of female wild turkeys relative to prescribed fire during differing time periods (i.e., not-burned, 0-years since fire, 1-year since fire, 2- years since fire, 3-years since fire) within 95% minimum convex polygon (MCP) seasonal areas of use. Chapter 3 presents a summary of my research findings, guidelines for prescribed fire management designed to minimize effects on wild turkeys, and suggestions for future research.

### **Literature Cited**

- Brockway, D.G., and C.E. Lewis. 1997. Long-term effects of dormant-season prescribed fire on community diversity, structure and productivity in a longleaf-pine wiregrass ecosystem. *Forest Ecology and Management* 96:167-183.
- Chamberlain, M.J., B.D. Leopold, and L.W. Burger. 2000. Characteristics of roost sites of adult wild turkey females. *Journal of Wildlife Management* 64:1025-1032.
- Crocker, T.C., Jr. 1979. Longleaf pine: the longleaf pine story. *Journal of Forest History* 23:32-43.
- Davis, J.R., H.R. Barnhill, D.C. Guynn, Jr., R.E. Larkin, and W.M. Baughman. 1995. Wild turkey nesting ecology in the Lower Coastal Plain of South Carolina. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 49:454-465.
- Exum, J.H., J.A. McGlincy, D.W. Speake, J.L. Buckner, and F.M. Stanley. 1987. Ecology of the eastern wild turkey in an intensively managed pine forest in

southern Alabama. Tall Timbers Research Station Bulletin 23, Tallahassee, Florida, USA.

- Fill, J.M., S.M. Welch, J.L. Waldron, and T.A. Mousseau. 2012. The reproductive response of an endemic bunchgrass indicates historical timing of a keystone process. *Ecosphere* 3: art61. <http://dx.doi.org/10.1890/ES12-00044.1>
- Heirs, J.K., R. Wyatt, and R.J. Mitchell. 2000. The effects of fire regime on legume reproduction in longleaf pine savannahs: is a season selective? *Oecologia* 125:521-530.
- Hillestad, H.O. 1970. Movements, behavior, and nesting ecology of the wild turkey in eastern Alabama. Pages 109-124 *in* G.C. Sanderson and H.C. Schultz, editors. Wild turkey management: current problems and programs. University of Missouri Press, Columbia, USA.
- Hurst, G. A., and B. D. Stringer. 1975. Food habits of wild turkey poults in Mississippi. *Proceedings of the National Wild Turkey Symposium* 3:76-84.
- Hurst, G.A. 1981. Habitat requirements of the wild turkey on the Southeast Coastal Plain. Pages 2-13 *in* P.T. Bromley and R.L. Carlton, editors. *Proceedings of the Symposium: Habitat requirements and habitat management for the wild turkey in the Southeast*. Richmond, Virginia, USA.
- Kennamer, J.E., J.R. Gwaltney, and K.R. Sims. 1980. Habitat preferences of eastern wild turkey on an area intensively managed for pine in Alabama. *Proceedings of the National Wild Turkey Symposium* 4:240-245.
- Kennamer, J.E., J.R. Gwaltney, K.R. Sims, and A. Hosey, Jr. 1981. Effects of forest management on wild turkey in the Coastal Plains Regions. Pages 240-245 *in* P.T.

- Bromley and R.L. Carlton, editors. Proceedings of the Symposium: Habitat requirements and habitat management for the wild turkey in the Southeast. Richmond, Virginia, USA.
- Landers, J.L., D.H. Van Lear, and W.D. Boyer. 1995. The longleaf pine forests of the Southeast: requiem or renaissance? *Journal of Forestry* 93:39-44.
- Miller, D.A., and L.M. Conner. 2007. Habitat selection within seasonal use areas of female eastern wild turkeys in a managed pine landscape in Mississippi. *Journal of Wildlife Management* 71:744-751.
- Morgan, J.J., S.H. Schweitzer, J.P. Carroll. 2006. Summer *Meleagris gallopavo silvestris* use of a landscape dominated by agriculture and *Pinus* spp. plantations. *Southeastern Naturalist* 5:637-648.
- Mulligan, M.E., and L.K. Kirkman. 2002. Burning influences on wiregrass (*Aristida beyrichiana*) restoration plantings: natural seedling recruitment and survival. *Restoration Ecology* 10:334-339.
- Peoples, J.C., D.C. Sisson, and D.W. Speake. 1996. Wild turkey brood habitat use and characteristics in Coastal Plain pine forests. *Proceedings of the National Wild Turkey Symposium* 7:89-96.
- Porter, W.F. 1992. Habitat requirements. Pages 202-213 in J. Dickinson, editor. *The wild turkey: biology and management*. Stackpole, Harrisburg, Pennsylvania, USA.
- Sisson, D.C., D.W. Speake, J.L. Landers, and J.L. Buckner. 1990. Effects of prescribed burning on wild turkey habitat preference and nest site selection in south Georgia. *Proceedings of the National Wild Turkey Symposium* 6:44-50.

- Speake, D.W., T.E. Lynch, W. J. Fleming, G.A. Hurst, and W. J. Hamrick. 1975. Habitat use and seasonal movements of wild turkeys in the Southeast. Proceedings of the National Wild Turkey Symposium 3:122-130.
- Spears, B.L., M.C. Wallace, W.B. Ballard, R.S. Phillips, D.P. Holdstock, J. H. Brunjes, R. Applegate, M.S. Miller, and P.S. Gipson. 2007. Habitat use and survival of preflight wild turkey broods. Journal of Wildlife Management 71:69-81.
- Williams, L.E., Jr., and D.H. Austin. 1988. Studies of the wild turkey in Florida. Florida Game and Freshwater Fish Commission, Technical Bulletin 10, Gainesville, USA.
- Williams, Jr., L.E., D.H. Austin, T.E. Peoples, and R.W. Phillips. 1973. Observations on movement, behavior, and development of turkey broods. Pages 79-99 in G.C. Sanderson and H.C. Schultz, editors. Wild turkey management: current problems and programs. University of Missouri Press, Columbia, USA.
- Williams, M.M. 2012. Effects of growing season prescribed fire on Eastern wild turkey (*Meleagris gallopavo silvestris*) nest success and poult survival in southwestern Georgia. Thesis. University of Georgia, Athens, USA.

CHAPTER 2

SEASONAL AREA OF USE AND HABITAT SELECTION BY FEMALE WILD  
TURKEYS IN RESPONSE TO PRESCRIBED FIRE

---

Perez, C. M. To be submitted to the Journal of Wildlife Management.

## **Abstract**

Prescribed fire is an important management tool used to restore and maintain longleaf pine (*Pinus palustris*) forests within the southeastern United States, but concerns exist that prescribed fire during the growing season may negatively affect nesting and brood-rearing female wild turkeys (*Meleagris gallopavo silvestris*). Using compositional analysis, I examined seasonal space use and habitat selection by female wild turkeys on 2 similar study areas in southwestern Georgia and related these parameters to growing season prescribed fires. Females selected mature pine and pine-hardwood stands burned 1 year earlier or not burned within 4 or more years when they established seasonal areas of use. Within seasonal areas of use, females used pine plantations and mature pine stands more than were available, and stands burned during the current year or 2 years earlier were most selected. Additionally, I used a distance analysis to evaluate the immediate effect of prescribed fires on habitat use by comparing turkey locations 10 days before a fire to 10 days after a fire and found that females were 114-m farther from a burned stand post-fire. This study can assist land managers in implementing fire return intervals to create and maintain seasonal habitats required by female turkeys within the longleaf pine-wiregrass ecosystem.

## **Introduction**

The eastern wild turkey (*Meleagris gallopavo silvestris*) is one of 5 subspecies of wild turkeys found in the United States. This subspecies uses a wide variety of habitats including managed pine forests (Davis et al. 1995, Morgan et al. 2006), older aged forests (Porter 1992), hardwoods, farms fields, and forest openings. Wild turkeys may use habitats differently depending upon season (Williams et al. 1973; Speake et al. 1975;

Kenamer et al. 1980, 1981; Miller and Conner 2007), and females in particular have highly variable habitat requirements because of nesting and brood-rearing (Hillestad 1970, Speake et al. 1975, Badyaev 1995). In pine-dominated forests of the Southeast, female wild turkeys typically use hardwood forests during the fall and winter, and move into upland pine or pine-hardwood forests prior to nesting season (Williams et al. 1973; Speake et al. 1975; Kenamer et al. 1980, 1981; Miller and Conner 2007). During early spring, females disperse in search of suitable nesting habitat characterized by relatively dense ground cover and woody vegetation (Hillestad 1970, Speake et al. 1975). In forests where prescribed fire is used to manage understory plant communities, females generally nest in stands burned 2 (Sisson et al. 1990, Davis et al. 1995) or 3 years (Exum et al. 1987) prior to nesting.

Longleaf pine (*Pinus palustris*) forests once covered 37 million ha in the Southeast (Croker 1979), but today less than 1.2 million ha remain as a result of conversion to agriculture, commercial harvest, and fire exclusion beginning with the immigration of early European settlers (Brockway and Lewis 1997). These forests were historically maintained by frequent fire disturbances caused initially by lightning strikes and later maintained by anthropogenic sources (Croker 1979, Landers et al. 1995, Fill et al. 2012). Without fire disturbance, longleaf pines are replaced by hardwoods and other pine species (Landers et al. 1995). The early successional herbaceous understory that exists as a result of fire is equally as important as the longleaf pine overstory to maintenance of this forest ecosystem. Today, prescribed fire is an important management tool for landowners, but little is known about how fire season or the fire-return interval used for longleaf pine restoration affects wild turkeys. Some managers use only dormant-

season fire (i.e., October to March), whereas others advocate that growing-season fire (i.e., April to September) is more advantageous to longleaf pine maintenance and restoration. Where wiregrass (*Aristida* spp.) is the predominant species in the understory, growing season fire is necessary to induce wiregrass flowering (Mulligan and Kirkman 2002, Fill et al. 2012).

Jones et al. (2005) compared brood habitat use between a site managed with growing season fire to a site managed without growing season fire and found that broods used stands burned less than 3 years earlier and avoided mature pine stands that were managed with prescribed fire. However, females selected habitats burned during the growing season for nesting. Notably, earlier research recommended dormant season fire to create openings for brooding habitats and to minimize nest loss to prescribed fire (Stoddard 1935). Logically, growing season fire has the potential to disrupt females during nesting or brooding and also affect movements of females, but little research has directly addressed this topic.

From a long-term perspective on land and wildlife management, prescribed fire intervals have the potential to destroy, create, or improve the landscape for wild turkeys over a period of years, gradually affecting how turkeys use landscapes through time. In the short term, a single prescribed fire, or many within a season, has the potential to temporarily displace birds from stands where fire occurs or negatively alter stands so that they no longer provide suitable nesting or brooding habitats. Conversely, fires could positively alter stands so that they attract nesting and brooding females. Regardless, short-term responses of female turkeys to prescribed fire could influence habitat selection at larger spatial and temporal scales. My objectives were to identify immediate effects of

prescribed fire on wild turkey space use and evaluate the effects of prescribed fire return intervals on female wild turkeys, with the goal of recommending prescribed fire management guidelines that accommodate the needs of female turkeys throughout their annual cycle.

## **Study Areas**

### *Silver Lake Wildlife Management Area (Silver Lake WMA)*

Silver Lake WMA was a 3,901-ha property located in Decatur County, Georgia. The property was bordered on 3 sides by water and included numerous lakes, ponds, and depressional wetlands scattered throughout the property. Forest stands were composed of longleaf pine-wiregrass communities, slash pine (*P. elliotii*), loblolly pine (*P. taeda*), mixed pine hardwood, hardwood, and gum (*Nyssa* sp.)–cypress (*Taxodium* sp.) stands.

The Georgia Department of Natural Resources (GADNR) purchased Silver Lake WMA in 2009. The site was inhabited by several federally or state threatened or endangered species including active resident clusters of red-cockaded woodpeckers (*Picoides borealis*), gopher tortoises (*Gopherus polyphemus*), and bald eagles (*Haliaeetus leucocephalus*). The GADNR's management objectives were primarily to conserve and restore biodiversity on the site while providing diverse recreational activities for the public through forest management designed to provide better quality wildlife habitat.

Historically, prescribed fires were conducted throughout the property during the dormant season (September – March), but emphasis on growing season (April – October) fires has grown within GADNR for controlling hardwoods and restoring the native grassland understory vegetation that supports red-cockaded woodpeckers, gopher

tortoises, and game birds. From 2009 to 2012, burns were conducted in consecutive days 4 -5 times per year over an average of 129 ha during consecutive days. The largest area burned at one time was approximately 1300 ha in February 2010. During 2012, slash and loblolly stands were thinned, wildlife openings were created, and new fire breaks were installed to decrease the size of the burn units and increase stand diversity. There is no female turkey hunting season on Silver Lake WMA, but hunting is allowed for males during regulated spring quota hunts.

*The Joseph W. Jones Ecological Research Center (The Jones Center)*

The Jones Center at Ichauway was a 12,000-ha private research facility located in Baker County, Georgia. Previously the hunting plantation of Robert W. Woodruff, quail hunting and diversity within the longleaf pine ecosystem were primary management goals. The property was bisected by Ichauwaynochaway Creek and bordered to the east by the Flint River. Riparian hardwood hammocks and mixed pine hardwood stands were associated with these water bodies. The property was predominantly composed of longleaf pine-wiregrass stands, but other stands included slash pine flatwoods, natural loblolly pine stands, oak barrens, grassy limesink ponds, creek swamps, cypress-gum ponds, agricultural fields, and food plots planted for either deer or quail.

Prescribed fire was the primary management tool on the Jones Center for maintaining the traditional wiregrass understory and preventing hardwood encroachment. Approximately half of the property was burned annually under a 2-year burn rotation cycle. Burning primarily occurred March through August within half of the site's 144 burn units which averaged approximately 70 ha in size.

The turkey population on the Jones Center was reestablished through cooperative efforts by Jones Center biologists, GADNR, and Tall Timbers Research Station during the late 1970s (Smith et al. 2006). The population is not hunted and has remained stable in the past, but is believed to have increased during the last decade. With the restoration of longleaf pine-wiregrass, Jones Center land managers used growing-season fire to restore and promote the historically native understory composition.

## **Methods**

### *Capture and Monitoring*

We captured wild turkeys during the winter (December through February) of 2011 and 2012, and during summer (June - July) of 2011 using rocket nets. After capture, turkeys were temporarily held in appropriately sized cardboard boxes, banded, aged as adult or juvenile (Williams and Austin 1988), and equipped with 60-g backpack-style VHF-radio transmitters (Sirtrack, Havelock North, New Zealand; and Telenax, Playa del Carmen, Mexico). Capture and handling protocols were approved by the University of Georgia Institutional Animal Care and Use Committee (Permit A2013 05-034-Y1-A0).

We estimated locations of radio-tagged females at least twice weekly throughout the year using triangulation. Telemetry data were recorded into a cellular phone equipped with Location of a Signal-SD (LOAS-SD) software (Ecological Software Solutions, LLC) and connected to a Bluetooth GPS unit. At least 2 locations were obtained within a 15-minute time period to reduce error caused by animal movement. Beginning on 15 March, we monitored females 2 or more times daily to assess pre-incubation movements and to determine nest initiation dates. This monitoring regime was maintained until 14 days post hatch or until it was determined that nest loss or abandonment occurred. After

14 days post-hatch, we located females once per day until Day 28 of brooding and then twice weekly for the remainder of the year.

### *Data analysis*

We evaluated habitat use and the effects of fire return intervals on female habitat selection during 4 biological seasons (i.e., Pre-incubation, Nesting, Summer, Fall/Winter). Mean nest initiation on the Jones Center was 13 April 2011 and 19 April 2012, compared to 22 April 2011 and 21 April 2012 on Silver Lake WMA (Williams 2012), so we defined the nesting season as a 28-day incubation period centered on the mean nest initiation for each site during each year. We defined the pre-incubation season as from 1 February until the start of nesting season. Summer began at the end of the nesting season and ended 30 September of each year. Winter was defined as October 2011 through January 2012.

We estimated turkey locations from field triangulation data using LOAS-SD. To minimize telemetry error, locations were only used if observer distances were determined to be less than 800 m from the estimated turkey locations by LOAS-SD. Locations were separated into the appropriate season and used to create a 95% minimum convex polygon (MCP) seasonal area of use (Miller and Conner 2007) for each female using Home Range Tools for ArcGIS (HRT; Rogers et al. 2007). All locations for a female were used to estimate the size of seasonal areas of use, but only females with  $\geq 20$  on-site locations during a season were used for habitat selection and fire return interval analyses because fire histories outside of the study areas were unknown.

Using an existing landcover map created for a concurrent study (Williams 2012) on the same study areas, we delineated 6 habitat types for analysis of habitat selection in

ArcGIS 9.3 (ESRI 2008). Habitat types included mature pine, mature pine-hardwood, forest opening, forested/herbaceous wetlands, mature hardwood, and pine plantation. Habitat types and fire histories were gathered from detailed records maintained by the Jones Center and GADNR on the study sites. To determine the effects of fire return interval on female habitat selection, we created a different landcover map to reflect time-since-fire. Time-since-fire was considered as the number of growing seasons since the last fire application and was determined at the mid-point of each of the 4 biological seasons. A detailed burn history from January 2009 to December 2012 for both study sites was compiled in ArcGIS 9.3 (ESRI 2008), and 5 categories of time-since-fire were created (0-years since fire, 1-year since fire, 2-years since fire, 3-years since fire, and not-burned for > 4 years). Only 1 landcover database for fire analyses was created, but time-since-fire during each season from 2011 and 2012 was calculated within the attribute table.

We used compositional analysis (Aebischer et al. 1993) to examine turkey habitat selection and the effects of fire return interval on habitat use at 2 of Johnson's (1980) spatial scales—selection of the 95% seasonal area of use within the study area (2<sup>nd</sup> order) and selection of locations within the 95% seasonal area of use (3<sup>rd</sup> order). Seasonal areas of use and seasonal point locations were intersected with the habitat and time-since-fire landcovers using ArcGIS 9.3 (ESRI 2008). Composition of habitats within each study area was calculated by estimating the sum of the area of habitats within the study area and dividing by the total size of the study area to estimate availability within the study area. The same technique was used to estimate availability within seasonal areas of use. Habitats used by females were calculated by dividing the total number of locations within

each habitat by the total number of locations for that animal within the seasonal area of use. We used similar techniques to evaluate use and availability for fire return interval analysis. All compositional analysis data were evaluated using the 'compana' script from the adehabitat (Calenge 2013) package for Project R (R Core Team 2013).

To evaluate effects of prescribed fire on turkey movements immediately following a burn, we used a distance-based analysis to determine if distances to a burned stand changed females' movements within their areas of use. Rather than using seasonal areas of use, composite 100% MCP use areas for each turkey were created to represent the entire area a female used during the study. Composite areas of use were intersected with the burn history landcover and tables of distance from turkey locations to each burn event were generated using the Generate Near Tables tool in ArcGIS 9.3. Distances were averaged from female locations to each burn event within her area of use during the 10-day intervals pre- and post-fire. Burns conducted within 5 consecutive days were combined into a single burn event and turkey locations prior to the starting date and after the last date of that burn event were used for calculating averages. We compared the mean distance of each individual's locations to each burn event for the 10-day period immediately before a fire to the mean distance to each burn event for the 10-day period following a fire using a paired t-test to evaluate whether the prescribed burn had an immediate influence on female movements during the 10-day interval following a fire.

## **Results**

During 2011 and 2012, 64 female wild turkeys were monitored yielding 139 seasonal areas of use. The average number of locations used to create seasonal areas of use was  $47.7 \pm 20$ . Estimated mean seasonal areas of use were  $142 \pm 29$  ha ( $n = 57$ )

during pre-incubation,  $87 \pm 16$  ha ( $n = 45$ ) during nesting,  $197 \pm 26$  ha ( $n = 52$ ) during summer, and  $386 \pm 85$  ha ( $n = 12$ ) during winter.

Turkeys selected habitats within their seasonal areas of use ( $3^{\text{rd}}$  order,  $\Lambda = 0.764$ ,  $P = 0.014$ ), but the composition of habitats within seasonal areas of use was similar to the composition of habitats across the study areas ( $2^{\text{nd}}$  order selection,  $\Lambda = 0.897$ ,  $P = 0.33$ ). During pre-incubation, females consistently used pine plantations over all other habitat types. Furthermore, mature pine was used more than forest openings and hardwoods which were avoided in favor of all other forest types (Table 2.1). No habitat was used more than expected during nesting season, but during the summer, female turkeys used pine plantations, mature pine, and mature pine-hardwoods ( $\Lambda = 0.66$ ,  $P = 0.006$ ) more than were available. In the winter, females used all pine habitats and preferred mature pine to riparian/forested wetland habitats ( $\Lambda = 0.356$ ,  $P = 0.044$ ).

Prescribed fire return intervals influenced habitat use at both the  $2^{\text{nd}}$  and  $3^{\text{rd}}$  orders (Table 2.2) during all seasons except within the nesting season area of use ( $3^{\text{rd}}$  order). Within study areas, turkeys selected stands burned 1-year earlier more than other stands when selecting areas of use. Additionally, stands not burned for  $\geq 4$  years were selected over stands burned 3-years earlier. Within their seasonal areas of use, turkeys used stands burned during the current growing season (0-years since fire) and avoided stands burned 3-years earlier.

In evaluating turkey movements immediately following a fire, we identified 48 burn events (36 on the Jones Center and 12 on Silver Lake WMA) during 2011 and 2012. The average area of burn events within an individual's composite area of use was 62.8 ha accounting for 7.64% of females' composite areas of use. During the 10-day interval

following a burn event, females were found approximately  $114 \pm 50$ -m farther from burned stands than before the fire ( $t = -2.25$ ,  $df = 193$ ,  $P = 0.03$ ).

## **Discussion**

Mean seasonal areas of use were generally smaller in this study than home ranges estimated in previous studies with the exception of summer areas of use. In this study, the estimated mean summer area of use was 197-ha, whereas average home range size during the summer brooding seasons have generally been estimated at <150-ha (Hillestad 1970, Speake et al. 1975, but see Chamberlain et al. 2000 and Miller and Conner 2005). Sizes of pre-incubation, nesting, and fall/winter mean areas of use were estimated at 142-ha, 87-ha, 386-ha, respectively, which were considerably smaller than home ranges estimated for the same seasons within managed pine forests in Mississippi (pre-incubation: 307-ha, nesting: 273-ha, and fall/winter: 607-ha by Chamberlain et al. 2000; and pre-incubation: 326-ha, fall/winter: 524-ha by Miller and Conner 2005). Our study differs because we estimated seasonal areas of use using a minimum of 20 locations (average  $47.7 \pm 20$ ) within a season for an animal instead of 200 locations in a season used in earlier studies; however, the majority of seasonal areas of use were composed of  $\geq 30$  locations making them equivalent to home ranges. Difference in seasonal area of use and home range sizes between studies may be a result of differences between forest type compositions. Our study took place in a predominantly longleaf pine wiregrass ecosystem managed for historic longleaf diversity, whereas the studies conducted in Mississippi pine ecosystems included more commercially managed pine forests. Miller and Conner (2005) suggested that while the habitat was sufficient to support wild turkeys, their study sites lacked habitat diversity at the landscape level, which yield larger home ranges. Additionally,

Miller and Conner (2005) noted that turkeys were more likely to use areas containing burned or thinned stands during pre-incubation; however, the fire return interval was 3-5 years in Mississippi compared to 1-2 years on our study areas. Within a managed pine landscape in a Mississippi national forest, prescribed fires occurred an average of every 6.3 years, and findings were inconclusive as to whether turkeys preferred recently burned areas (Miller et al. 1999). They recommended that mature forests be maintained with interspersed regenerating areas supplying nesting habitats near wintering habitats to maximize opportunity to sample nest sites during pre-incubation. Studies conducted in frequently burned landscapes in southern Georgia and Florida showed that turkeys select stands burned less than 2 years earlier (Main and Richardson 2002, Martin et al. 2012). Given the frequent fire return intervals on our study areas, it is possible that females did not travel as far for required habitats and recently burned areas.

The composition of habitats within the seasonal area of use did not differ from the composition of habitats within the study area, but use of the habitats within the seasonal area of use differed from availability. During pre-incubation and summer, selection was greatest for pine plantations, mature pine, and mature pine hardwood. We did not detect significant habitat selection during the nesting season; however, in a concurrent study Williams (2012) found that turkeys on both study areas selected nest sites with greater woody ground cover and less canopy closure than expected. Williams (2012) also determined that ground roosts for brooding hens were characterized by greater ground level cover and were farther from mature pine stands than expected. Brooding habitats provide vegetative cover and host many invertebrates as food for poults. Adequate brooding cover for young poults is a critical habitat component for turkey management

(Hurst 1981, Peoples et al. 1996). Young pine plantations and mixed pine hardwood forests on our study sites likely provided higher ground level cover for ground roosting and concealment of poults. During the winter, mature pine was selected over wetland/riparian areas and used more than all other forest types. Previous studies have demonstrated a selection of hardwoods during the winter (Williams et al. 1973; Speake et al. 1975; Kennamer et al. 1980, 1981; Miller and Conner 2007) presumably for access to hard mast. Miller et al. (1999) noted that pine regeneration habitats, especially those either burned or thinned associated with mature pine (>30yrs), were generally preferred by males and females throughout all seasons agreeing with Godwin et al. (1992) that these areas most likely provided increased forage and insect production in the spring and summer and offered many legume seeds during the fall/winter. Given the frequent fire-maintained longleaf pine savannas and associated legume abundance on our study areas (Edwards et al. 2013), it is not surprising that mature pine habitats serve as sufficient wild turkey habitat throughout the winter.

Fire return intervals affected female habitat selection within the study area and within the seasonal area of use. Stands burned 1-year earlier were used more than all other stands throughout the pre-incubation, summer, and winter seasons. Within their seasonal areas of use, females used stands burned during the current growing season greater than availability. Similarly, other studies found that both females and males used stands burned during the previous 18 months (Martin et al. 2012) and avoided stands not burned during the past 2 years within pine ecosystems (Palmer et al. 1996, Martin et al. 2012). During pre-incubation, females established areas of use including stands burned 1-year earlier more than were expected and appeared to avoid stands burned during the

current growing season. However, within the pre-incubation areas of use, females used stands burned during the current growing season more than expected and avoided using stands that were not burned for  $\geq 4$  years or burned 3-years earlier. A 0-years since fire stand indicates a fire conducted during the current growing season and the beginning of the growing season falls within the pre-incubation period for wild turkeys. Therefore, 0-year old burned stands were not available when females initially established seasonal area of use. Selection for 0-year old burned stands within the seasonal area of use once they became available during pre-incubation demonstrates the importance of including growing season fire for wild turkey management. Additionally, during the nesting season stands burned 1-year earlier were favored, and stands that were not burned for  $\geq 4$  years or burned 3-years prior were avoided when establishing nesting areas of use.

During the 10-day period following a fire, females moved farther away from the stand than before the fire, although females selected recently burned stands within their areas of use when location data were assessed across biological seasons. These data demonstrate that prescribed fire initially repels females but later results in desired habitat. The 10-day interval examined here most likely includes a time period when sufficient vegetation has not begun to regenerate for forage or cover. Martin et al. (2012) found that use of areas recently burned declined approximately 500 days post-fire when ground story vegetation became too dense to forage. Ancillary observations of turkeys near and in recent burn units were common on our study sites, and more studies should focus on the initial effects of prescribed fire on wild turkey movements during shorter (1 day, 2 day, etc.) and longer (weeks, months) time intervals within seasons.

## **Management Implications**

Selection of 0-year since fire stands within seasonal areas of use is important to consider when deciding on land management. These 0-year since fire stands are burned during the current growing season and this study provides evidence to maintain these recently burned habitats throughout the pre-incubation, summer, and winter seasons. Williams (2012) found that prescribed fire during nesting had minimal effects on nest survival rates for the Jones Center and Silver Lake WMA. This study presents direct evidence that frequent fire necessary for longleaf pine-wiregrass restoration is beneficial and compatible with management for preferred wild turkey habitats throughout all seasons. Keeping in mind that 1- and 2-year burn rotations are also preferred within different seasons, it is best to maintain a diversity of different aged stands within the landscape. This study evaluated habitat and fire return interval within seasonal home ranges, however as suggested in other studies, more focus on patch diversity created by forest type and fire return interval would yield better insight to the effects of prescribed fire on wild turkeys.

## **Literature Cited**

- Aebischer, N.J., P.A. Robertson, and R.E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. *Ecology* 74: 1313-1325.
- Badyaev, A.V. 1995. Nesting habitat and nesting success of eastern wild turkeys in the Arkansas Ozark Highlands. *The Condor* 97:221-232.
- Brockway, D.G., and C.E. Lewis. 1997. Long-term effects of dormant-season prescribed fire on community diversity, structure and productivity in a longleaf-pine wiregrass ecosystem. *Forest Ecology and Management* 96:167-183.

- Calenge, C., M. Basille, S. Dray, and S. Fortmann-Roe. 2013. Adehabitat : Analysis of habitat selection by animals. Version 1.8.12.
- Crocker, T.C., Jr. 1979. Longleaf pine: the longleaf pine story. *Journal of Forest History* 23:32-43.
- Davis, J.R., H.R. Barnhill, D.C. Guynn, Jr., R.E. Larkin, and W.M. Baughman. 1995. Wild turkey nesting ecology in the Lower Coastal Plain of South Carolina. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 49:454-465.
- Edwards, L., J. Ambrose, and L.K. Kirkman. 2013. *The natural communities of Georgia*. The University of Georgia Press, Athens, Georgia, USA.
- Environmental Systems Resource Institute (ESRI). 2008. ArcMap 9.3. ESRI, Redlands, California, USA.
- Exum, J.H., J.A. McGlincy, D.W. Speake, J.L. Buckner, and F.M. Stanley. 1987. Ecology of the eastern wild turkey in an intensively managed pine forest in southern Alabama. *Tall Timbers Research Station Bulletin* 23, Tallahassee, Florida, USA.
- Fill, J.M., S.M. Welch, J.L. Waldron, and T.A. Mousseau. 2012. The reproductive response of an endemic bunchgrass indicates historical timing of a keystone process. *Ecosphere* 3: art61. <http://dx.doi.org/10.1890/ES12-00044.1>
- Glitzenstein, J.S., D.R. Streng, R.E. Masters, K.M. Robertson, and S.M. Hermann. 2012. Fire frequency effects on vegetation in north Florida pinelands: Another look at the long-term Stoddard Fire Research Plots at Tall Timbers Research Station. *Forest Ecology and Management* 264: 197-209.

- Godwin, K.D., G.A. Hurst, B.D. Leopold, and R.L. Kelley. 1992. Habitat use of wild turkey gobblers on Tallahala Wildlife Management Area, Mississippi. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 46:249-259.
- Hillestad, H.O. 1970. Movements, behavior, and nesting ecology of the wild turkey in eastern Alabama. Pages 109-124 *in* G.C. Sanderson and H.C. Schultz, editors. Wild turkey management: current problems and programs. University of Missouri Press, Columbia, USA.
- Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.
- Jones, B.C., J.E. Inglis, and G.A. Hurst. 2005. Wild turkey brood habitat use in relation to prescribed burning and red-cockaded woodpecker management. Proceedings of the National Wild Turkey Symposium 9:209-215.
- Kenamer, J.E., J.R. Gwaltney, and K.R. Sims. 1980. Habitat preferences of eastern wild turkey on an area intensively managed for pine in Alabama. Proceedings of the National Wild Turkey Symposium 4:240-245.
- Landers, J.L., D.H. Van Lear, and W.D. Boyer. 1995. The longleaf pine forests of the Southeast: requiem or renaissance? Journal of Forestry 93:39-44.
- LOAS 4.0. 2010. Ecological Software Solutions LLC. Hegymagas, Hungary. Version 4.0.3.7
- Main, M.B. and L.W. Richardson. 2002. Response of wildlife to prescribed fire in Southwest Florida pine flatwoods. Wildlife Society Bulletin 30:213-221.

- Martin, J.A., W.E. Palmer, S.M. Juhan, Jr., and J.P. Carroll. 2012. Wild turkey habitat use in frequently-burned pine savanna. *Forest Ecology and Management* 285: 179-186.
- Miller, D.A., G.A. Hurst, and B.D. Leopold. 1999. Habitat use of eastern wild turkeys in central Mississippi. *Journal of Wildlife Management* 63: 210-222.
- Miller, D.A., and L.M. Conner. 2005. Seasonal and annual home ranges of female eastern wild turkeys in a managed pine landscape in Mississippi. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 59:89-99.
- Miller, D.A., and L.M. Conner. 2007. Habitat selection within seasonal use areas of female eastern wild turkeys in a managed pine landscape in Mississippi. *Journal of Wildlife Management* 71:744-751.
- Morgan, J.J., S.H. Schweitzer, and J.P. Carroll. 2006. Summer *Meleagris gallopavo silvestris* use of a landscape dominated by agriculture and *Pinus* spp. plantations. *Southeastern Naturalist* 5:637-648.
- Mulligan, M.E., and L.K. Kirkman. 2002. Burning influences on wiregrass (*Aristida beyrichiana*) restoration plantings: natural seedling recruitment and survival. *Restoration Ecology* 10:334-339.
- Palmer, W.E., G.A. Hurst, B.D. Leopold. 1996. Preincubation and habitat use by wild turkey hens in central Mississippi. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 50:417-427.
- Porter, W.F. 1992. Habitat requirements. Pages 202-213 in J. Dickinson, editor. *The wild turkey: biology and management*. Stackpole, Harrisburg, Pennsylvania, USA.

- R Core Team (2013). R: A language and environment for statistical computing. R Foundations for Statistical Computing. Vienna, Austria. URL <http://www.R-project.org/>.
- Rodgers, A.R., A.P. Carr, H.L. Beyer, L. Smith, and J.G. Kie. 2007. HRT: Home Range Tools for ArcGIS. Version 1.1. Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada.
- Sisson, D.C., D.W. Speake, J.L. Landers, and J.L. Buckner. 1990. Effects of prescribed burning on wild turkey habitat preference and nest site selection in south Georgia. *Proceedings of the National Wild Turkey Symposium* 6:44-50.
- Speake, D.W., T.E. Lynch, W. J. Fleming, G.A. Hurst, and W. J. Hamrick. 1975. Habitat use and seasonal movements of wild turkeys in the Southeast. *Proceeding of the National Wild Turkey Symposium* 3:122-130.
- Williams, Jr., L.E., D.H. Austin, T.E. Peoples, and R.W. Phillips. 1973. Observations on movement, behavior, and development of turkey broods. Pages 79-99 in G.C. Sanderson and H.C. Schultz, editors. *Wild turkey management: current problems and programs*. University of Missouri Press, Columbia, USA.
- Williams, L.E., Jr., and D.H. Austin. 1988. *Studies of the wild turkey in Florida*. Florida Game and Freshwater Fish Commission, Technical Bulletin 10, Gainesville, USA.
- Williams, M.M. 2012. Effects of growing season prescribed fire on Eastern wild turkey (*Meleagris gallopavo silvestris*) nest success and poult survival in southwestern Georgia. Thesis. University of Georgia, Athens, USA.

**Table 2.1:** Seasonal selection and ranks (0 = lowest, 5 = highest) of 3<sup>rd</sup> order (habitat selection within the home range) selection during pre-incubation ( $P<0.001$ ), summer ( $P=0.006$ ), and fall/winter ( $P=0.04$ ) using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

3 <sup>rd</sup> Order							
Pre-Incubation							
	Pine	Pine-HW	Open	Wetland	Hardwood	Pine Plant	Rank
Pine	0	+	+++	+	+++	---	4
Pine-HW	-	0	+	+	+++	---	3
Open	---	-	0	-	+	---	1
Wetland	-	-	+	0	+	---	2
Hardwood	---	---	-	-	0	---	0
Pine Plant	+++	+++	+++	+++	+++	0	5
Summer							
	Pine	Pine-HW	Open	Wetland	Hardwood	Pine Plant	Rank
Pine	0	+	+++	+	+	-	4
Pine-HW	-	0	+	+	+	-	3
Open	---	-	0	-	---	---	0
Wetland	-	-	+	0	-	---	1
Hardwood	-	-	+++	+	0	-	2
Pine Plant	+	+	+++	+++	+	0	5
Fall/Winter							
	Pine	Pine-HW	Open	Wetland	Hardwood	Pine Plant	Rank
Pine	0	+	+	+++	+	+	5
Pine-HW	-	0	+	+	+	-	3
Open	-	-	0	+	-	-	1
Wetland	---	-	-	0	-	-	0
Hardwood	-	-	+	+	0	-	2
Pine Plant	-	+	+	+	+	0	4

\* Ranking (0 = lowest, 5 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.2:** Selection and ranks (0 = lowest, 4 = highest) of 2<sup>nd</sup> order (time-since-fire selection in home ranges vs. availability across study area) selection ( $P = <0.001$ ) and 3<sup>rd</sup> order (time-since-fire selection within the home range) selection ( $P = 0.0005$ ) using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

2 <sup>nd</sup> Order						
Time-since-fire						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank*
0-Year	0	---	+	+	-	2
1-Year	+++	0	+++	+++	+++	4
2-Year	-	---	0	+	-	1
3-Year	-	---	-	0	---	0
≥4 Years	+	---	+	+++	0	3

  

3 <sup>rd</sup> Order						
Time-since-fire						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	+	+	+++	+++	4
1-Year	-	0	-	+++	+	2
2-Year	-	+	0	+++	+	3
3-Year	---	---	---	0	---	0
≥4 Years	---	-	-	+++	0	1

\* Ranking (0 = lowest, 4 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.3:** Seasonal ranks (0 = lowest, 4 = highest) of 2<sup>nd</sup> order ( $P < 0.001$ ; habitat selection in seasonal areas of use vs. availability across study area) and 3<sup>rd</sup> order ( $P < 0.001$ ; habitat used based on locations vs. availability within seasonal areas of use) fire return interval habitat selection using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

2 <sup>nd</sup> Order						
Habitat						
Season	0-Year	1-Year	2-Year	3-Year	>4 Years	<i>P</i> -value <sup>a</sup>
Pre-incubation	0	4	2	1	3	<0.001
Nesting	3	4	2	1	0	0.048
Summer	2	4	1	3	0	0.009
Fall/Winter	0	4	3	1	2	<0.001
<i>Mean</i>	1.25	4	2	1.5	1.25	
3 <sup>rd</sup> Order						
Habitat						
Season	0-Year	1-Year	2-Year	3-Year	>4 Years	<i>P</i> -value
Pre-incubation	4	2	3	0	1	<0.001
Nesting	4	2	3	1	0	0.509
Summer	3	4	1	0	2	<0.001
Fall/Winter	3	2	4	1	0	0.025
<i>Mean</i>	3.5	2.5	2.75	0.5	0.75	

a. *P*-values indicate selection within a season.

**Table 2.4:** Ranking matrix of 2<sup>nd</sup> order and 3<sup>rd</sup> order fire return interval habitat selection during pre-incubation using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

Pre-Incubation						
2 <sup>nd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	---	---	---	---	0
1-Year	+++	0	+++	+++	+++	4
2-Year	+++	---	0	+	-	2
3-Year	+++	---	-	0	-	1
>4 Years	+++	---	+	+	0	3
3 <sup>rd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	+++	+	+++	+++	4
1-Year	---	0	-	+++	+++	2
2-Year	-	+	0	+++	+++	3
3-Year	---	---	---	0	-	0
>4 Years	---	---	---	+	0	1

\* Ranking (0 = lowest, 4 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.5:** Ranking matrix of 2<sup>nd</sup> order fire return interval habitat selection during nesting season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

Nesting						
2 <sup>nd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	-	+	+	+	3
1-Year	+	0	+	+++	+++	4
2-Year	-	-	0	+	+	2
3-Year	-	---	-	0	+	1
>4 Years	-	---	-	-	0	0

\* Ranking (0 = lowest, 4 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.6:** Ranking matrix of 2<sup>nd</sup> order and 3<sup>rd</sup> order fire return interval habitat selection during the summer season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

Summer						
2 <sup>nd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	-	+	-	+	2
1-Year	+	0	+++	+	+++	4
2-Year	-	---	0	---	+	1
3-Year	+	-	+++	0	+	3
>4 Years	-	---	-	-	0	0
3 <sup>rd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	-	+	+++	+	3
1-Year	+	0	+++	+++	+	4
2-Year	-	---	0	+	-	1
3-Year	---	---	-	0	---	0
>4 Years	-	-	+	+++	0	2

\* Ranking (0 = lowest, 4 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.7:** Ranking matrix of 2<sup>nd</sup> order and 3<sup>rd</sup> order fire return interval habitat selection during fall/winter season using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

Fall/Winter						
2 <sup>nd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	---	---	-	---	0
1-Year	+++	0	+	+++	+	4
2-Year	+++	-	0	+++	+	3
3-Year	+	---	---	0	-	1
>4 Years	+++	-	-	+	0	2
3 <sup>rd</sup> Order						
	0-Year	1-Year	2-Year	3-Year	>4 Years	Rank
0-Year	0	+	-	+	+++	3
1-Year	-	0	-	+	+	2
2-Year	+	+	0	+	+++	4
3-Year	-	-	-	0	+	1
>4 Years	---	-	---	-	0	0

\* Ranking (0 = lowest, 4 = highest) indicates preference for that type.

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

**Table 2.8:** Selection and ranks (0 = lowest, 5 = highest) of 3<sup>rd</sup> order (habitat selection within the home range) selection ( $P=0.014$ ) using compositional analysis of female wild turkeys on Silver Lake WMA and the Jones Center during 2011 and 2012.

	Pine	Pine-HW	Open	Wetland	Hardwood	Pine Plant	Rank
Pine	0	+	+	+	+++	---	4
Pine-HW	-	0	+	+	+	-	3
Open	-	-	0	-	+	---	1
Wetland	-	-	+	0	+	---	2
Hardwood	---	-	-	-	0	---	0
Pine Plant	+++	+	+++	+++	+++	0	5

\*\*In the ranking matrix, row habitats with a “+” are ranked above column habitats, and row habitats with a “+++” are significantly ranked above column habitats. The opposite is true for “-“ and “---“ respectively.

## CHAPTER 3

### SUMMARY AND CONCLUSIONS

I examined seasonal space use and habitat selection by female wild turkeys on 2 study areas comprised primarily of longleaf pine-wiregrass savannas in southwestern Georgia and related them to prescribed fire. Selection by females for habitat and fire return interval was evaluated using compositional analysis, and a distance analysis was used to evaluate the effects of fire on turkey space use 10-days after a burn. Prior to this research, recommendations of 3-7 year fire return intervals for wild turkeys were based on studies of female habitat selection on commercially and on federally managed pine forests in Mississippi (Stys et al. 1992, Miller et al. 1999 and Miller and Conner 2007). Other research has contradicted these findings, demonstrating that frequent fire is beneficial to wild turkeys and other wildlife (Main and Richardson 2002, Martin et al. 2012). Additionally, some research suggests that dormant season prescribed fire is most beneficial to female wild turkeys; whereas other studies demonstrated that growing season prescribed fires are necessary for restoring and maintaining longleaf pine-wiregrass savannas (Mulligan and Kirkman 2002, Fill et al. 2012) and compatible with female wild turkey habitat management (Palmer et al. 1996, Martin et al. 2012). Evidence supporting growing season prescribed fire for wild turkey management is provided by turkey habitat and time since fire selection on our study sites.

Based on the results of this study, prescribed fire for longleaf pine savanna restoration is compatible with female wild turkey habitat management. Females selected

mature pine and pine-hardwood stands burned 1 year earlier or not burned for  $\geq 4$  years when they established seasonal areas of use. Within seasonal areas of use, females used pine plantations and mature pine stands and stands burned during the current year or 2 years earlier more than were available. During the 10-day period following a prescribed fire, females moved farther away from the stand than before the fire; however, the results of my seasonal habitat selection analysis revealed that females preferred burns conducted during the current year throughout all seasons. Martin et al. (2012) found that use of recent fires declined approximately 500 days post-fire when ground story vegetation became too dense for foraging. It is likely that the 10-day period that I evaluated demonstrated a time when vegetation has not regenerated and the stands are not useful, but over the course of a female's biological season growing season prescribed fires are beneficial and preferred. Therefore, within the size of a given seasonal area of use across the landscape, a diversity of habitats with varying fire rotation intervals should be maintained.

Specifically, I recommend a 2-year fire rotation interval be used to maintain a diverse distribution of times-since-fire throughout the landscape during turkey nesting and summer seasons. Growing season fires are compatible with management for female wild turkeys and should be incorporated to maintain and restore the longleaf pine savanna, which in this study equated to mature pine, a habitat preferred by wild turkeys. Scale of fire was not specifically evaluated in this study, and in addition to continued research, I recommend burn units be created such that rotations provide patches of adjacent 0-, 1-, and 2-year old burned pine stands within the size of seasonal areas of use. For example in this study, rotations should be such that 0-, 1-, and 2- year old burned

pine stands each occur within the following areas: 142 ha during pre-incubation, 87 ha during nesting, 197 ha during summer, and 386 ha during winter.

Ancillary observations of turkeys near and in recent burn units were common on my study sites, and I believe that focus on the initial effects of prescribed fire on wild turkey movements during shorter (1 day, 2 day, etc.) and longer (weeks, months) time intervals within seasons in future studies will lead to better recommendations for timing prescribed fire application within biological seasons. Stands age daily after fire and when the fire occurs during the year has a dramatic effect on stand regeneration rates, quality, and benefits at a given time for wild turkeys. If only 1 habitat or fire return interval provided for turkeys throughout all seasons, then a homogenous forest would provide all necessities throughout all seasons, but this not the case. I suspect there may be a combination of habitat types and fire return intervals associated with locations that are important but unrepresented because of VHF telemetry error and low frequencies of locations. With increased capabilities of GPS location data, I believe focus on habitat and the fire return interval in days associated with many female GPS locations throughout a season will yield insight into how habitat requirements evolve throughout a season and transition from season to season offering better understanding on the effects of prescribed fire on wild turkey habitat selection.

### **Literature Cited**

Fill, J.M., S.M.Welch, J.L. Waldron, and T.A. Mousseau. 2012. The reproductive response of an endemic bunchgrass indicates historical timing of a keystone process. *Ecosphere* 3: art61. <http://dx.doi.org/10.1890/ES12-00044.1>

- Main, M.B. and L.W. Richardson. 2002. Response of wildlife to prescribed fire in Southwest Florida pine flatwoods. *Wildlife Society Bulletin* 30:213-221.
- Martin, J.A., W.E. Palmer, S.M. Juhan, Jr., and J.P. Carroll. 2012. Wild turkey habitat use in frequently-burned pine savanna. *Forest Ecology and Management* 285: 179-186.
- Miller, D.A., G.A. Hurst, and B.D. Leopold. 1999. Habitat use of eastern wild turkeys in central Mississippi. *Journal of Wildlife Management* 63:210-222.
- Miller, D.A., and L.M. Conner. 2007. Habitat selection within seasonal use areas of female eastern wild turkeys in a managed pine landscape in Mississippi. *Journal of Wildlife Management* 71:744-751.
- Mulligan, M.E., and L.K. Kirkman. 2002. Burning influences on wiregrass (*Aristida beyrichiana*) restoration plantings: natural seedling recruitment and survival. *Restoration Ecology* 10:334-339.
- Palmer, W.E., G.A. Hurst, and B.D. Leopold. 1996. Preincubation and habitat use by wild turkey hens in central Mississippi. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 50:417-427.
- Stys, J.E., G.A. Hurst, B.D. Leopold, and M.A. Melchoirs. 1992. Wild turkey use of control-burned loblolly pine plantations. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 46:37-45.
- Williams, M.M. 2012. Effects of growing season prescribed fire on Eastern wild turkey (*Meleagris gallopavo silvestris*) nest success and poult survival in southwestern Georgia. Thesis. University of Georgia, Athens, USA.