FINAL PERFORMANCE REPORT

WILDLIFE RESTORATION PROGRAM

GRANT NUMBER W-35
Segment 65

AL-W-F17AF01211

SUPPLEMENTAL PROJECT REPORT

STUDY 29

THESIS: RESOURCE SELECTION AND BAIT RESPONSE BY FEMALE EASTERN WILD TURKEY IN ALABAMA

PERFORMANCE PERIOD

OCTOBER 1, 2017 - SEPTEMBER 30, 2019

ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
DIVISION OF WILDLIFE AND FRESHWATER FISHERIES

Prepared by: Lee A. Margadant
School of Forestry and Wildlife, Auburn University

Resource Selection and Bait Response by Female Eastern Wild Turkey in Alabama

by

Lee Aaker Margadant

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
December 14, 2019

Keywords: eastern wild turkey, resource selection

Approved by

James B. Grand, Chair, Professor of Wildlife Science
Robert A. Gitzen, Associate Professor of Wildlife Science
William D. Gulsby, Assistant Professor of Wildlife
Science

Acknowledgments

I have to thank my advisor Dr. Barry Grand for taking a chance on me and helping to guide me through unfamiliar territory. I have to thank my lab mates; Briana Stewart, Sky Keller, Steve Zenas, Matt Gonnerman, and Laura Bell for the comradery going through this project. I also have to recognize people who are far smarter than me, whose assistance was crucial in me getting through all the stages of my research, Anna Tucker, Kylee Dunham, and Shoayang Yang. Each of you was a tremendous teacher and an inspiration and I am forever grateful for your guidance. Thank you to Jeff Makemson, Amy Silvano, Steve Barnett, and Frank Allen for all the support and guidance in the field. My mom and dad, who raised me to be an outdoorsman and encouraged me with regular care packages of coffee beans from home. My inspirational nephews, Lucas and Jordan, and my niece Avery, I had no idea how important being a good uncle would be to me until I met you guys. I hope I have made you all proud.

Table of Contents

List of Tables

List of Illustrations

Chapter I: Introduction

In the southeastern United States, there is a perception that eastern wild turkey (*Meleagris gallopavo silvestris*; hereafter turkey) populations have declined steadily over the last decade. An important component of effectively addressing this issue is to develop an understanding of the size and structure of turkey populations. Furthermore, understanding the composition of what types of resources are available to turkeys on the landscape could provide information about the role they play in these declines.

My first chapter tests hypotheses regarding the selection of land cover types between important periods in a female turkey's life history. This is essential because a key aspect of successful management for wildlife species is understanding how individuals use the resources present on the landscape. Individuals select resources in order to obtain food, avoid predation and ensure successful reproduction (Mannan and Steidl 2013). Time of year, the amount of disturbance on the landscape, and forage availability can all influence selection of resources by turkeys (Brown 2006, Lehman et al. 2008, Yeldell et al. 2017). Understanding differences in resource selection among time periods by turkeys can provide managers with important information for actions that may lead to more abundant turkey populations.

The turkey location data we collected allowed me to examine turkey selection for different land cover types within and among seasons. To assess turkey resource selection, I characterized resource use versus availability to estimate selection indices, with availability defined within a radius of each turkey's capture location (Manly et al. 2002). I tested the hypothesis that selectivity varied among cover types but in a constant way across seasons.

To address the need for estimates of size and structure of the population, we selected camera trap surveys as a means of generating population estimates for turkeys throughout Alabama. However, an important aspect of many techniques that generate demographic estimates from camera data is that they typically require the use of bait or another lure to increase the probability of detection of an individual (Mccoy et al. 2011, Mills et al. 2019). Consequently, we placed corn at each camera trap as a means of increasing the probability of detection of turkeys on the camera trap surveys we initiated across state-managed lands in Alabama.

The presence of bait may affect home range and movement by attracting individuals to easy food resources (Reinecke and Shaiffer 1988, Balme et al. 2014). However, there is little information available regarding the effect bait can have on turkeys movements. Baited camera traps may induce bias in estimates of population size or sex ratio through changes in detectability and occupancy (Gerber et al. 2012, Balme et al. 2014, Du Preez et al. 2014). We marked adult female turkeys with GPS data loggers allowing us to examine their movements in response to the availability of resources including bait.

In the third chapter, I further examined turkey movements in response to bait during camera trapping surveys and experimental bait deployments across seven study areas in Alabama from 2015 – 2018. I estimated turkey utilization distributions and examined the change in probability of use for each individual at each bait site each week. My hypothesis was that turkeys would respond to bait by increasing their use of baited sites, but that bait would not cause turkeys to use previously unused areas.

These two chapters provide information that will allow biologists charged with managing turkey populations to understand the important seasonal shifts in resource selection that occur in a female turkey’s life history and inform population-monitoring techniques by assessing biases that may be present due to the utilization of bait. Additionally, this research will inform managers of the selection of topographic resources by individuals, creating a more accurate picture for scientific management. Finally, through examining the spatial biases of traditional demographic monitoring techniques, managers can take steps to decrease bias and increase the precision of methods used for monitoring populations.

Literature Cited

Balme, G., L. Hunter, and H. Robinson. 2014. Baited camera-trap surveys – marginally more Precise but at what cost? A response to Du Preez et al. (2014). Biological Conservation 179:144–145. Elsevier Ltd.

Brown, J. S. 1990. Habitat selection as an evolutionary game. Evolution 44:732-746.

Gerber, B. D., S. M. Karpanty, and M. J. Kelly. 2012. Evaluating the potential biases in carnivore capture-recapture studies associated with the use of lure and varying density estimation techniques using photographic-sampling data of the Malagasy civet. Population Ecology 54:43–54.

Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United State-representing a decade of land cover change Information. Photogrammetric Engineering and Remote Sensing 81:345–354.

Lehman, C. P., M. A. Rumble, and L. D. Flake. 2008. Winter habitat Selection patterns of Merriam's turkeys in the southern Black Hills, South Dakota. Western North American Naturalist 67:278–291.

Manly, B. F. J., L. L. Mcdonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource Selection by animals : statistical design and analysis of field studies. Second edition. Springer..

Mannan, R., and R. Steidl. 2013. Habitat. Pages 229–243 *in* P. R. Krausman and J. W. I. Cain, editors. Wildlife management & conservation: contemporary principles & practices. Johns Hopkins University Press, Baltimore, MD.

Mccoy, J. C., S. S. Ditchkoff, and T. D. Steury. 2011. Bias associated with baited camera sites for assessing population characteristics of deer. Journal of Wildlife Management 75:472–477.

McKerrow, A., and S. Williams. 2012. Southeast GAP analysis project.

Mills, D., J. Fattebert, L. Hunter, and R. Slotow. 2019. Maximizing camera trap data: using attractants to improve detection of elusive species in multi-species surveys. PLoS ONe 14:e0216447..

Du Preez, B. D., A. J. Loveridge, and D. W. Macdonald. 2014. To bait or not to bait: a comparison of camera-trapping methods for estimating leopard Panthera pardus density. Biological Conservation 176:153–161.

Reinecke, K., and C. Shaiffer. 1988. A field test for differences in condition among trapped and shot mallards. The Journal of Wildlife Management 52:227–232.

Yeldell, N. A., B. S. Cohen, T. J. Prebyl, B. A. Collier, and M. J. Chamberlain. 2017. Prescribed fire influences habitat selection of female eastern wild turkeys. Journal of Wildlife Management 81:1287–1297.

Chapter 2: Habitat Selection by Female Eastern Wild Turkeys

Abstract

A key element for the successful management of a wildlife species is understanding the specific resources an animal is using and at what time of the year. Resource selection by animals is typically addressed in the terms of use versus availability. I defined availability for individual female eastern wild turkeys as a circular buffer with a radius equal to the largest distance an individual moved from its capture site. I outfitted 38 female eastern wild turkeys with GPS loggers from 2015 – 2019 on seven study areas. My objectives were to describe the use of land cover and landform types during the reproductive period, hunting season, and non-reproductive periods. During the non-reproductive period I found that hardwood forest were 1.29 times more likely to be selected compared to their availability on the landscape (95%; CL = 1.04 – 1.41). Mixed and pine forests were both 1.36 times more likely to be selected in the non-reproductive period, however the confidence limits for both estimates overlapped zero indicating that selection occurred in proportion to its availability (95%; CL = 0.89 – 2.09) (95%; CL = 0.92 – 2.02). Further, turkeys selected south-facing forested slopes 1.73 times more than their availability in the non-reproductive period (95%; CL = 1.17 – 2.56). During the reproductive period, I hypothesized that open areas would be important to turkeys for nesting and brood-rearing habitat. However, I found that the use of open areas was much lower than its availability on the landscape for most of the year. Selection for all land covers was in proportion to availability throughout most of the reproductive period including bottomland cover types. During the turkey-hunting season, I hypothesized that turkeys gathered in mixed-sex flocks for mating would use open areas. However, I found that open areas continued to be avoided during this period.

Introduction

The population of eastern wild turkey (*Meleagris gallopavo silvestris;* hereafter turkey) in Alabama may have dropped dramatically over the last decade (Barnett and Barnett 2010, S. Barnett, ADCNR, pers. comm.). This decline is important because turkeys are one of the most culturally and economically important game species in the Southeast (Grado et al. 1997). For example, 43,769 licenses were purchased to harvest turkeys in Alabama in 2016 (Bryant 2016). Therefore, reversing this population decline has become a focal issue for wildlife managers throughout the state.

Habitat loss and fragmentation could be contributing to potential declines in turkeys. The loss of nesting and brood-rearing habitat could be an important contributor to a decline in the population (Norman et al. 2007). Further, habitats that do not provide sufficient forage during some seasons could also be affecting survival rates (Kiss 2014). Disproportionate use of land cover types by turkeys for nesting and foraging could indicate that essential habitat is limiting. Consequently, understanding turkey selection of habitat throughout the year is important to the management of turkey populations. Additionally, understanding selection in terms of its availability on the landscape will allow managers to examine the role of land cover availability in population declines.

Habitats are often characterized by a combination of fine-scale metrics like vegetation community, canopy cover, and successional category, many of these components can be characterized by land cover and landform. For example, one measure of landform, elevation, can be related to vegetation community, soil productivity and hydrology (Chamberlain 1999, Knick et al. 2008). Land cover can be described in broad categories such as water, forest, agriculture, impervious surfaces, and other land and water types. In combination, land cover and landform are often examined as resources that are selected by animals (Danks and Klein 2002, Boyce et al. 2003, Kelly and Holub 2008, Zuckerberg et al. 2016).

Determining which resources animals select provides fundamental information about how an animal meets its requirements for survival on the landscape (Manly et al. 2002). Habitat selection, or more appropriately resource selection, is often measured by comparisons of use and availability, where use is defined as the quantity of a resource that an individual utilizes, and availability is defined as the access an individual has to multiple resources. Preference for a resource is contingent on both of these samples and inferences resulting from their comparison allow us to identify resources which are used disproportionately to their availability (Beyer et al. 2010). Resource selection is inferred from use of resources in greater proportion than their availability.

Resources exist on the landscape in a dynamic state that causes their availability to be spatiotemporally variable (Paolini et al. 2018). Seasonal changes in abiotic and biotic environmental conditions affect the availability of resources for survival, which results in changes in animal space use (Rice et al. 2017). Turkeys are able to persist in this environment due to their generalist nature, displaying variable use throughout the year. However, during certain periods of the year selection is driven by specific life history requirements.

For example, nesting and brood-rearing are important life-history events for reproduction by female turkeys; thus, it is important to understand resource selection during the period when these events take place. This period has unique life history requirements that are not present throughout the rest of the year. During this time, most females will breed, attempt to nest, and rear a brood. Turkeys have been observed using open areas, savannas, and planted pines to nest (Martin et al. 2012). Additionally, in Alabama turkey nested in an ecotone between grassy pasture-like areas and denser shrub/scrub areas and reared their broods in grassy permanent opens (Blackburn et al. 1975, Speake 1975). In addition to reproduction, the early spring also coincides with the spring turkey-hunting season in Alabama. The male-only hunting season opens in mid-March and extends through April. However, the season is thought to be a source of pressure for females as it coincides with breeding, nest initiation, and incubation. As such, resource requirements of female turkeys during the turkey-hunting season may be influenced by hunting pressure.

The fall and winter also coincide with important shifts in forage availability across the range of turkeys. Plants and insects become dormant in the fall and winter and fewer sources of forage remain on the landscape (Parker et al. 2008, Klebesadel and Helm 2010). During this period, female turkeys in South Carolina and Louisiana move to deciduous forests and exploit seasonally available hard mast crops (Zwank et al. 1988, Moore 2006). Similarly, during this period turkeys in Alabama have previously been shown to prefer forest which had been disturbed, with cattle or fire keeping the forest floor and understory open (Speake 1975).

In addition to the seasonal shifts I described, landforms can also be related to the selection of certain land cover types during fall and winter. For example, topography and elevation of the landscape can influence seasonal exposure and temperature for an area, thus affecting resource selection (Kosicki and Chylarecki 2012, Gaüzère et al. 2017). For example, in the winter months resource selection can be focused on areas with less exposure to the weather and frequent and early sunlight for thermoregulation (Storch 1993, Lehman et al. 2008).

Additionally, abiotic variables like temperature may also drive selection during the spring and summer. Turkeys avoid exposure during the hottest times of the day by seeking areas which offer thermal cover. Often times these areas of refuge can be quantified by landform characteristics of the landscape. For example, female turkeys in Mississippi and Georgia selected hardwood drains and bottoms during the reproductive period. These hardwood bottoms were thought to provide travel corridors, diverse forage, and reduce thermal exposure during the summer months (Everett 1982, Miller 1997, Miller et al. 2000, Martin et al. 2012).

My objectives were to describe the use of land cover and landform types during the reproductive period, non-reproductive period, and hunting season. I developed hypotheses based on literature review and field observations regarding the use and selection of land cover types and landforms during each season. I hypothesized that open areas would be of importance to nesting and brood-rearing birds during the reproductive period. I also hypothesized that bottomland topography would be important in the reproductive period for turkeys as travel corridors and thermal cover. During the non-reproductive period, I hypothesized that turkeys would select deciduous hardwood forests. I assumed that this would be driven by mast crops from hardwood trees as the primary source of forage during this time. Further, I hypothesized that forested stands on north-facing slopes would be selected, under the assumption that they would have more mast-producing potential. Finally, I hypothesized that open space would be selected during the turkey-hunting season, as birds would be gathered in open areas to mate.

My aim was to provide biologists and managers with a better understanding of how land cover and landform types are related to the distribution of turkeys in Alabama and to identify types that may be limiting. As most of the southeastern United States is experiencing a decline in wild turkey populations, this type of research can help inform managers which land cover is important to turkeys. Examining selection for land cover that occurs in the extremes relative to its availability, can indicate those land covers that may be lacking on the landscape.

Study Area

Data from seven study sites were included in my analysis, James D. Martin-Skyline Wildlife Management Area (WMA), Oakmulgee WMA, and Barbour WMA, Scotch WMA, Uchee Creek Special Opportunity Area (SOA), Cedar Creek SOA, and Drummond private land. All of these sites are currently operated by the Alabama Department of conservation and natural resources (ADCNR) except for Scotch WMA and Drummond private land. The sites were selected to represent the diversity of habitats across the state and offer insight as to how turkey populations differ among areas including private lands and areas with low hunting pressure.

At 24,577 hectares, northern Alabama's James D. Martin-Skyline Wildlife Management Area (hereafter, Skyline) is the largest management area in the state. Skyline lies on the Cumberland Plateau, which offers mountainous topography characterized by steep slopes and numerous coves and hollows. It is composed of a patchwork of forests managed in a partnership between the ADCNR and the Alabama Power Company. The area represents a varied collection of cover types including hardwood forests, upland pine stands, and agricultural fields. Skyline is managed to benefit wildlife through prescribed burning, maintenance of 285 food plots and wildlife openings, and warm-season grass re-establishment.

Oakmulgee Wildlife Management Area is managed under a cooperative agreement between the United States Forest Service and the ADCNR. It lies in west-central Alabama, just south of Tuscaloosa. Oakmulgee stretches over the 18,211 hectares in Bibb, Hale, Perry, and Tuscaloosa counties and much of Oakmulgee Ranger District of the Talladega National Forest. Land cover includes a mix of longleaf pine stands and mixed hardwoods bottoms. The management area is treated with a 3-5 year prescribed burning regimen and thinning of longleaf stands. There are 100 maintained wildlife openings on the WMA as well offering multiple sources of year-round forage for turkey.

Barbour Wildlife Management Area encompasses 11,417-hectare in the Southeastern region of the state. Barbour mainly consists of longleaf and loblolly pine (*Pinus taeda*) with stream bottoms dominated by hardwoods. The northern portion of Barbour has been converted to longleaf pine forest, and the remaining WMA is under a long-term timber management plan with the goal of converting remaining loblolly pine stands to longleaf pine while maintaining a hardwood component in the stream bottoms and slopes. Barbour is managed with a 2-3 year prescribed fire regimen and 210 year-round food plots and wildlife openings.

Scotch Wildlife Management Area represented a landscape intensively managed for short rotation loblolly pine forest. The site is in Clarke County in Southwestern Alabama and covers 7,883 hectares of commercial forestland that is owned and managed by the Scotch Paper Company. The site was managed in a long-standing cooperative partnership between Scotch Land Management LLC and Alabama Wildlife and Freshwater Fisheries (WFF) to provide hunting access for the public in Southwestern Alabama. The site had a flat terrain comprised largely of varying aged loblolly pine plantations that are subject to regular disturbance due to ongoing timber management on site.

Cedar Creek SOA (Cedar Creek) lies in Dallas County in south-central Alabama. At 2,590 hectares, Cedar Creek lies in an area known for its highly productive, rich black topsoil known as the Black Belt (Webster and Samson 1992). It is bordered to the west by the Alabama River and Cedar Creek to the south. The landscape of Cedar Creek is characterized by glades of cedar trees as well as mixed hardwood and pine stands on rolling hills and hollows with hardwood bottoms. The pine and cedar stands are managed for turkeys and other wildlife annually with prescribed fire on a three-to-five-year rotation. The special opportunity area (SOA) system was instituted in 2018 and was designed to offer a different format for hunters in Alabama. The SOA sites are typically smaller than the average wildlife management area and cannot sustain the hunting pressure that those WMA's are often subjected to. These SOA's are subject to a limited permit hunting system with the goal to reduce the hunting pressure and to increase the quality of the hunt.

Uchee Creek SOA lies near the eastern border of Alabama in Russell County Alabama and covers 1,916 hectares. Uchee Creek bisects the property and the landscape is composed of bottomland hardwoods, mixed uplands, and pine forests. The area is managed to provide wildlife openings planted with cool-season crops and is subjected to annual prescribed burns to promote native vegetation regeneration.

The Drummond study area is privately owned and lies in Dallas County Alabama with the eastern border delineated by the Black Warrior River. The property is intensively managed for the benefit of the turkey population and recreational harvest. Planted wildlife openings are maintained and regular habitat maintenance such as mowing and burning promote native vegetation regeneration.

Methods

Field Methods

We captured female turkeys on each study area using walk-in traps and cannon nets on wildlife openings that occurred on study areas throughout Alabama from August – October, and February – March of 2015 - 2018. Each captured bird was fitted with a riveted aluminum leg band (National Band and Tag, Newport, Kentucky) and a transmitter was attached with a backpack harness of shock cord secured around the base of each wing (Kenward 2001). Each adult female received a 100-gram backpack containing a very high frequency transmitter and a remotely downloadable Global Positioning System (GPS) logger (Model # W510, Advanced Telemetry Systems (ATS), Isanti, MN USA) or a 109-gram GPS logger unit equipped with PinPoint Argos satellite communication capabilities (Lotek Wireless, Wareham, UK). Only adult females (> 1-year-old) were fitted to ensure marked birds could support the weight of the transmitters.

Transmitters were programmed to log estimated locations in a stratified manner to accommodate the life history of turkeys (Table 2.1). Location sampling by the downloadable loggers was less frequent during winter months to increase the battery life of the transmitters for up to two years. The Lotek units were deployed in early 2018 and were not programmed for a winter decrease in sampling.

Spatial Data

I combined relevant land cover and landform into discreet categories I used land cover from the National Land Cover Database (NLCD), which uses satellite imagery to classify land cover of the United States at 30-meter resolution (Homer et al. 2015). Although, NLCD uses 16 broad categories that provided little thematic resolution in forested areas (Table 2.2). The landform component was obtained from the Southeastern landforms raster layer which was generated from digital elevation models (DEM) and hydrography and modeled the slope, aspect, and elevation of the into 14 discrete categories (Table 2.3)(McKerrow and Williams 2012). When combined with NLCD this resulted in 225 categories of land cover categories (Table 2.4) land cover.

To examine hypotheses dealing broadly with forested cover, I combined three types of forests based on NLCD land cover - hardwood forest (Deciduous forest, woody wetland), mixed forest (mixed forest), and pine forest (evergreen forest), into a single forest category. Conversely, in hypotheses which examined stand type, I reclassified forests into three individual types based on NLCD land cover - hardwood forest, mixed forest, and pine forest. I also tested hypotheses, which examined the selection of topographic forest metrics between seasons. I created north-facing forested slope (north-facing slopes) and south-facing forested slope (south-facing slopes) categories based on the landform values from the land cover categories dataset. north-facing slopes and south-facing slopes included any NLCD forest category value that occurred in steep slopes, side slopes and coves and ravine landforms in either a north - northeast or south-southwest aspect. I created a forest category, which included the remaining non-slope forest landforms regardless of aspect. I also examined the selection of bottomland topography between seasons. I created a bottom category that included any NLCD forest category value that occurred in drainages, streambeds, flats, and coves. I created a forest category, which included the remaining non-bottomland forest landforms. (Table 2.5).

I performed an analysis of selection for land cover categories by combining categories and by using subsets of observations collected in each season specific to test each hypothesis. I created an open space category by combining the NLCD categories for developed-open space, developed-low intensity, developed-medium intensity, barren land, grassland/herbaceous, pasture/hay, and cultivated crops. I also created a shrub cover category that was represented by the NLCD category shrub/scrub. For the various a priori hypotheses, I reclassified forest land cover and landform to test specific hypotheses.

Use and availability data

To define availability, I created a 6.9-km circular buffer around each turkey's individual capture location using ArcGIS ArcMap 10.6 (ESRI, Redlands, CA). I determined this distance from the largest movement observed for a marked female on our project. I then generated one random (not used) location within the buffer for every GPS location for every bird. I assigned each random location date and time that corresponded with an estimated bird location (used). I then tessellated the land cover categories of each used and available location.

I estimated use and selection within and among seasons that were defined based on literature review and field observations. The non-reproductive period extended from 30 September – 14 March. This period corresponded to the reduced sampling rate for the transmitters. The reproductive period extended from 15 March to 30 September and spanned the period from when turkeys in Alabama breed until brood rearing is completed. I also examined resource selection during the period from incubation through the brood-rearing period, 31 March until 30 September. These were determined from observation of females marked in this study. Lastly, I examined resource selection during the spring turkey-hunting season, 15 March through 30 April.

Estimating resource selection

I estimated use and availability as the proportion of estimated animal locations and the proportion of non-used (random) locations in each land cover category in each season on each study area, respectively (Lele et al. 2013). I defined selectivity as the ratio of use to availability and estimated the odds of selection for each land cover category in each season using Resource Selection Functions (RSF) (Manly et al. 2002). The odds of selection were estimated using generalized linear mixed-effects models (GLMM) which were fit to the binomial use, with land cover category and season as the fixed effects, and individual, study site, and year as random effects (Bates et al. 2015). I estimated the odds of selection as the exponentiated coefficients (β) of the fixed effects. When $e^{\beta} = 1.0$ (β=0.5), use of the resource type is in proportion to availability (i.e. no selection). When $e^{\beta} < 1.0$ (β<0.5), use of the resource type is less than availability (i.e., avoided). When $e^{\beta} > 1.0$ (β > 0.5), use of the resource is greater than availability (i.e., selected). For each hypothesis described above, I compared two statistical models, a null model, where selectivity varied among resource types but not seasons, and an interaction model, where selectivity varied among resource types and seasons. I compared the strength of evidence for models using model weights (*w*) calculated using Akaike information criterion (AIC_c) corrected for small sample size in the (MuMIn) package in R (Kamil 2016). I performed all analyses using software R (Rubba 2016)(R core team 2018).

Results

I used 25,811 locations from 38 adult females for this analysis. The number of locations that occurred in each season was 1,184 in fall (31-Sept – 1-Nov), 8,410 in the incubation season(31-Mar – 8-June), 8,484 in post-nest (9-June – 30-Sept), 1,881 in pre-breeding (1-Feb – 14-Mar), 2,865 in pre-nest (15-Mar – 30-Mar) , and 2,987 in the winter (2-Nov – 31-Jan) season. The distribution of marked female turkeys and the number of locations they provided at each study area was as follows: 6,855 locations from 9 females marked at Barbour WMA, 347 locations from 1 female at Cedar Creek SOA, 1,431 locations from 1 female at Drummond property, 3,809 locations from 5 females at Oakmulgee WMA, 2,519 locations from 4 females at Scotch WMA, 10,196 locations from 13 females at Skyline WMA, and 654 locations from 2 females at Uchee Creek SOA (Table 2.6). I used subsets of this data to examine specific hypotheses regarding the selection of groups of land cover categories that were relevant to each hypothesis.

Nonbreeding period

During this period, the majority (>50%) of available land cover was in hardwood forest, while open areas and shrub cover were approximately one-fifth as available (Table 2.7). Concordantly, the largest number of turkey locations also occurred in hardwood forest during the non-reproductive period and the rest of the year. When I compared the selection for each of the three forest categories, open areas, and shrub during the non-reproductive period and the rest of the year the interaction model fit best (w = 1.00, Figure 2.1). There was no support for the model without seasonal differences in selection (w = 0). Hardwood forest were 1.29 more likely to be selected in the non-reproductive period (95%; CL = 1.04 – 1.41). Mixed and pine forests were both 1.36 times more likely to be selected in the non-reproductive period, however the confidence limits for both estimates overlapped zero indicating that selection occurred in proportion to its availability (95%; CL = 0.89 – 2.09) (95%; CL = 0.92 – 2.02). The remaining land cover categories were used in proportion to their availability.

When I reclassified forests based on aspect and slope, use and availability of non-slope forest were highest and nearly identical in nonbreeding and the rest of the year, but north-facing slopes and south-facing slopes were used about half as frequently as non-slope forests and they were less available (Table 2.8). Selectivity for the reclassified land cover categories varied between the non-reproductive period and the rest of the year (w = 1.00) (Figure 2.2). South facing forested slopes were 1.73 times more likely to be used by female turkeys than their availability would suggest in the non-reproductive period (95%; CL = 1.17 – 2.56) but were used in proportion to their availability in the rest of the year. Female turkeys selected for non-slope forest and north-facing slopes during the rest of the year, but not in the non-reproductive period. Females avoided open space in both periods.

Reproductive period

During the reproductive period, 15 March – 30 September, and the rest of the year, the majority of turkey locations and land cover categories were in hardwood forest (Table 2.9). Selectivity indices varied among land cover categories and seasons (w = 1.00). However, females used open space in proportion to availability during the reproductive period and avoided it during the rest of the year (Figure 2.3). They used the remaining land cover categories in proportion to availability. When I shortened the season of interest to 31 March until 30 September, females avoided open areas during the incubation and brood-rearing period and the rest of the year (Table 2.10, Figure 2.4).

When I reclassified forest cover categories to compare the use of bottoms to all other forests, non-bottom forests were more available than the all remaining land cover categories (Table 2.11). Selection varied between seasons and among land cover categories (w = 1.00). Females selected bottomlands during the reproductive period and used them in proportion to their availability on the landscape during rest of the year. Although selection varied between the reproductive period and in the rest of the year, females used non-bottom forests in proportion to their availability, and again avoided open areas in both seasons (Figure 2.5).

Hunting season

During this period, forests constituted approximately 80% of the used and available land cover categories in each season. The majority (>50%) of available locations were in forested land cover, while open areas and shrub cover were less available (Table 2.12). Selection indices did not vary between the turkey hunting season and the rest of the year (w = 1.00). Although selection indices varied, forests were selected and open areas were avoided in both seasons. Use of shrub areas was similar to their availability each season (Figure 2.6).

Discussion

I set out to provide biologists and managers with a better understanding of how land cover and landform types are related to the distribution of turkeys in Alabama and to identify types that may be limiting during different parts of the year. Similar to the findings of others (Blackburn et al. 1975, Speake 1975, Everett et al. 1980, Holbrook et al. 1987, Moore 2006), my results suggest that resource selection by turkeys varies by season and during some portions of the year turkeys select cover types that may have limited availability on my study areas. While testing each of my hypotheses, I found differences in selection by female turkeys among land cover categories within and among seasons under each hypothesis. However, my predictions under each hypothesis were not always correct, and in most cases, the most available or frequently used habitat was not selected.

Nonbreeding period

I expected female turkeys to be more selective for hardwood forests in the non-reproductive period than during the rest of the year. Hardwood forests are the predominant cover on the landscape for our study, and they were the most commonly used land cover categories. Interestingly, hardwood forests were selected during the non-reproductive period and the rest of the year and the difference in selectivity between the seasons was not great indicating similar selection year-round. Turkeys were expected to be more selective for hardwoods in the non-reproductive period because they typically contain a wide variety of mast-producing species, specifically oaks (*Quercus spp*.).

The winter season may exert a moderate degree of directional selection and promote a more specialized resource selection strategy by turkeys. This seasonal effect is caused by a reduction in insect and herbaceous vegetation availability on the landscape leaving only those hard mast crops that persist throughout the winter months (Brown 2006). Therefore, selection of hardwood forest during this period may be in response to the availability of hard mast (Vander Haegen et al. 1988, Kane et al. 2007). Hardwoods provide a variety of hard mast including; American Beech (*Fagus grandifolia*), Pecan (*Carya illinoinensis*), Pine (*Pinus spp*.), and several varieties of oak (Meanley 1956, Edwards et al. 1993). Although other species contribute, oaks and hickories are commonly thought to be the most important winter mast providers in the southeast; however, they are also incredibly variable in their seasonal yields (Fralish 2004). Edwards (1993) found that pines, dogwoods, elm, and yellow poplar species serve in a compensatory role to the more prominent hard mast crops in this region during low yield years. Moreover, Huntley (1989) found that a combination of other mast-producing crops was of equal or greater value than oak and hickory during the winter. However, the effect of the scale must be acknowledged in my examination of selection for forested land cover types. We did not measure important factors such as species composition, age, and canopy cover within each forest type. Each of these factors may contribute to the value of a land cover in terms of vegetative cover and forage availability (Fralish 2004, Yarrow and Yarrow 2005).

As a surrogate, I sought to test the role landform played in non-reproductive period resource selection by turkeys. I expected north-facing slopes to be selected by female turkeys during the non-reproductive period, and I thought north-facing slopes would have greater mast production potential than other stand types (Bidwell et al. 1989). However, north-facing slopes were use in proportion to their availability and instead, south-facing slopes were preferred in the non-reproductive period. Contrary to what I believed, many of the key mast-producing hardwood tree species, specifically oaks, more frequently occur on more xeric slopes, which are typically more south-facing (Golden 1979, Shankman and Wills 1995). North facing slopes are more mesic and species like sweetgum (*Liquidambar styraciflua*), beech (*Fagus grandifolia*), and silver maple (*Acer saccarinum*) are more likely to occur there (Runkle 1982). Although my predictions were not correct, my results suggest that slope and aspect may affect resource selection by turkeys on our study areas in winter. This preference for slope seems to illustrate an important response during the most forage-limited period of a turkey's life history and maybe related to foraging availability and thermal refuge during the winter months.

Similarly to my results, in southeastern Oklahoma female turkeys selected pine-hardwood stands facing south or occurring on a slope less than or equal to 10% (Bidwell et al. 1989). This was also observed in more northern populations where Merriam's wild turkeys (*Meleagris gallopavo merriami*) have been shown to overwinter on south-facing slopes in the Black Hills of South Dakota (Rumble and Anderson 1996, Lehman et al. 2008). In these landscapes, snow cover is a limiting factor and solar radiation first reaches the south-facing slopes, melting snow cover there first. This solar radiation can reduce the cost of thermoregulation for turkeys during the winter. Turkeys in this region were observed to persist on Ponderosa pine (*Pinus ponderosa*) seeds and utilize the topography of the area to maximize thermoregulatory efficiency and to avoid snow cover (Lehman et al. 2008). Though winter on our study areas is much milder than in northern regions, it is plausible that a similar thermoregulatory effect could be driving south-facing slopes selection during the winter on our research sites.

Reproductive period

This may be the most important period in the life history of female turkeys and includes breeding, nesting, and brood rearing. This is important in my research due to the fact that my sample of the population is entirely female, and based on movement data, at least 39.5% of my study animals may have attempted to nest. Studies of Rio Grande wild turkeys in Texas indicated that turkeys exhibited a similar rate of nesting attempts (35%) (Conley et al. 2016). Nonetheless, the turkeys I monitored should have selected nest sites whether we detected nesting or not, thus their movements would likely indicate if open land cover were selected in early reproduction, but not brood-rearing.

Therefore, I tested two hypotheses to examine the importance of open land cover for female turkeys during different portions of the reproductive period. In both of these analyses, I expected selection for open land cover. I examined selection during the late reproductive period when open land cover was expected to be of greatest importance to a female turkey (Porter 1980, Dickson 1992), and the entire reproductive period. My estimates of the odds ratios for both periods did not appear to indicate that female turkey's selected open areas (CIs included 1.0). The two seasonal periods I examined overlapped except for a single short period at the beginning of the reproductive period, 15 March – 30 March. Since this was the only difference between the periods, we can attribute that increase in the odds of selection to the short period prior to nest initiation. This suggests that, while the estimates odds of selection indicate avoidance throughout the year; there is a brief period prior to nest initiation during which open areas become more important to turkeys.

Although life history events like nesting and brood-rearing are biologically critical, the effect of selection was not detectable in broad land cover categories. Multiple studies indicate that nesting and brood-rearing selection criteria are defined by fine-scale vegetative ground cover metrics (Badyaev 1995, Fuller et al. 2013). Fine-scale metrics that are shown to be important in nest-site selection are canopy closure, understory vegetation, and successional stage influenced by prescribed fire (Yeldell et al. 2017, Streich et al. 2015). These characteristics can be present in any land cover type and may be the reason why my analyses did not indicate any selection during this period. Thus, the scale we assessed selection at is not appropriate to make inference about the nesting as it is governed by habitat metrics which we were not able to quantify at the landscape scale.

The availability of land cover types across our study areas may also contribute to the selection that was observed. Forested land cover dominated our use and availability data while open land cover only made up 9% of the used and 11% of the available resources. This suggests that while open land cover may not make up a large proportion of the landscape, it may exist in large enough quantity to exceed the requirements of turkeys and may be why it appears as selected well below its availability throughout my analysis.

Conversely, strong selection for a resource may indicate that there is not enough of that resource on the landscape or indicate a period when a resource is limiting. Paradoxically, providing more of that resource on the landscape may decrease selection if use becomes more similar to availability. Consequently, we should not interpret selection of a resource as being the only important component in our analysis and we should not interpret resources with use lower than availability as being unimportant to a turkey.

Additionally, small openings within multiple coarse land cover categories may provide the fine-scale vegetative characteristics that nesting may require. Further, examining land cover at broad scales only allows us to make assumptions as to what kind of actual vegetative cover is there based on the raster layers. My findings could be due to a lack of open areas that contained suitable nesting and brood-rearing vegetation or perhaps forested area contained that suitable vegetation for nesting. Thus, use of either forested or open cover classes is entirely dependent on current vegetation conditions at ground level, and whether they represent suitable nesting or brood-rearing cover. Those conditions are entirely dependent on how the forest or open area is managed.

As hypothesized, river and stream bottoms would be preferred by turkeys in the summer months, potentially as a means of thermal cover and as movement corridors. Upland and slope forests and shrub land covers were used in proportion to their availability and open cover continued to be avoided during this season. This result is not surprising given that when I examined my previous hypothesis regarding selection in the reproductive period, hardwood and mixed forests were selected and on most areas hardwood and mixed forests predominate river and stream bottoms.

Selection of bottoms may be attributable to the dense overstory and thermal refuge these areas provide during the reproductive period, the warmest period of the year. Thermal refuge is thought to be important because previous research observed that wild turkeys experienced heat stress at 35° C in laboratory testing (Buchholz 2019). Further, domestic turkey breeds exhibited signs of hyperthermia at temperatures of 32° C (Wilson and Woodward 1955). This becomes problematic because temperatures in the southeast can reach over 39° C with regularity in the summer. Additionally, it became evident throughout our research project that turkeys are very sensitive to heat stress. Capture-related stress during these periods resulted in increased mortality rates (Zenas 2018). As a result, turkeys are known to select riparian and herbaceous sites during the day (Collier et al. 2017). Rio Grande turkeys (*Meleagris gallopavo intermedia*) alter space use and movements with temperature variations in Oklahoma (Rakowski et al. 2019). Rakowski found that vegetation type could strongly influence temperature throughout space, with taller vegetation types such as forests averaging nearly 9°C cooler. Thus, it is likely that the selection for bottoms during the reproductive period was the result of turkeys seeking thermal refugia.

My results indicate that turkeys use open land cover at a lower frequency than would be expected based on availability during every part of the year. Avoidance during the reproductive period and the incubation and brood-rearing period suggest that coarse land cover types like the ones I used may not be suitable to define characteristics of ideal nesting and brood-rearing habitats, and it is likely that the vegetation species and structure I hypothesized would be associated with open areas were not present. Vegetative cover in open cover classes can range from bare mineral soil to agronomic crops, mowed grass, or early successional vegetation. Accordingly, turkey preference will vary widely depending on management of open areas. We did not quantify these characteristics in this study. Therefore, we cannot definitively say that open areas are unimportant to turkeys. However, my classification of open areas included the NLCD land cover categories developed-open space, developed-low intensity, and developed-medium intensity. While these types include roadsides and rights-of-way that may be suitable for turkey nesting, they also include large mowed fields and parks (Homer et al. 2015) where regular disturbance occurs.

I expected the turkey-hunting season to represent a source of disturbance to female turkeys despite the fact that there is no hunting season for hens in the state of Alabama. Turkey hunting season is a potential source of disturbance to turkeys on the landscape (Dickson 1992, Gross et al. 2016, Collier et al. 2017*b*). In Alabama, a male-only turkey-hunting season occurs in the early spring and corresponds with the period of nest initiation and incubation. As such, I expected that open areas would be selected during the hunting season as turkeys were expected to be congregating in mixed-sex flocks in open areas in which males could display for potential mates. However, when I compared selection of forest, open areas, and shrub cover during hunting season to selection during the rest of the year I found that female turkeys continued to select forested land and avoid open areas. Thus, if open areas are preferred during this time period, hunting disturbance may be preventing their use by females, which would confound our results relative to use of open areas. Comparison of selection by females on hunted and un-hunted areas could yield different results.

An important aspect of selection to consider is the fact that in my analysis and in the literature, turkeys frequently exhibit resource use in proportion to or below its availability on the landscape. Speake (1975) identified similar trends of selection in proportion to availability by turkeys in Alabama. Further, turkeys in Virginia also used resources in proportion to their availability and while some preference occurred, no two individuals showed the same preferences (Holbrook et al. 1987). This is likely due to the fact that turkeys are a generalist species and use a broad suite of resources to survive in a temporally varying environment (Wilson and Yoshimura 1994).

When use versus availability data is employed to examine resource selection by animals, there is an assumption that the amount of time an animal spends in a land cover type is an indication of use. Additionally, preference or avoidance for a given land cover type implies that it was used more or less frequently than expected by chance and is conditional on the definition of our sample of availability (Beyer et al. 2010). I defined availability for each individual turkey based on greatest distance moved from its capture location and I considered selection at the home range or landscape scale. Home range is the area in which an animal lives and moves (Burt

1943) and even though I did not delineate home ranges, I assume that the animal locations I analyzed are representative of its home range, and distribution of those locations across land cover types represent how that individual allocated its time with respect to the cover types available within the home range. However, availability depends strongly on the type of land cover and how it interacts with the distribution and availability of other land covers (Aarts et al. 2013).

RSF is used to measure use relative to availability and indicate selection in cases where use exceeds availability. This is sufficient for guiding management where the focal species is persistent on a landscape over time and land cover types with low availability and high usage are most limiting (Aarts et al. 2013). The persistence of our focal populations of turkeys on the landscape may make them seem like an ideal species for this type of analysis, however, the propensity to select resources in proportion to their availability can make it hard to interpret which resources are limited or important. Further, the usefulness of RSF depends on the scale at which resources are measured and measures of availability. Therefore it is important to consider that this method may be inappropriate when trying to generalize for other populations or when making predictions on a reintroduced species in a novel environment.

Further, it is important to consider that a land cover type that is avoided may not always be unimportant to turkeys. Selection in proportion to availability does not inform us of the proportion of locations occurring in specific cover types or the relative availability of cover types. However, by estimating the proportion of locations, used and available, and their distribution in each study site, land cover type, and season, we get a more accurate impression of use and availability to accompany our RSF analysis. For example, RSF may indicate that hardwood forests are not selected for strongly by turkeys throughout the year despite the fact that they are the most frequently used and most available land cover type. Conversely, RSF indicates that open areas are avoided, but they play a critical role during some parts of the year.

Management Implications

My results suggest that on the areas used by the turkeys in my research, turkeys mostly used, and in some periods selected forestlands. Further, shrub cover types were used in proportion to their availability in every season. These two results suggest that forest cover and shrub habitats that were present in my study areas are available in quantities that meet the needs of female turkeys. By contrast, the land cover types I used to define open areas were avoided in every season suggesting that they were disturbed too frequently for use by female turkeys, that fewer open areas are necessary to meet female turkey resource needs, or that the open areas did not contain the appropriate vegetation or resources needed by hens during the time periods we analyzed due to their management history.

Literature Cited

Aarts, G., J. Fieberg, S. Brasseur, and J. Matthiopoulos. 2013. Quantifying the effect of habitat availability on species distributions. Journal of Animal Ecology 82:1135–1145.

Badyaev, A. V. 1995. Nesting habitat and nesting success of eastern wild turkeys in the Arkansas Ozark Highlands. The Condor 97:221–232.

Badyaev, V., and J. D. Faust. 1996. Nest site fidelity in female wild turkey : potential causes and reproductive consequences. The Condor 98: 589–594.

Barnett, S. W., and V. S. Barnett. 2010. The wild turkey in Alabama. Alabama Department of COnservation and Natural Resources, Montgomery.

Bates, D., M. Maechler, B. Bolker, and S. Walker. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software 67:1–48.

Beyer, H., Haydon, D, Morales, J., Frair, J, Hebblewhite, M., Mitchell, M, and Matthiopoulos, J. 2010. The interpretation of habitat preference metrics under use-availability designs. Philosophical Transactions of the Royal Society B: Biological Sciences 365:2245–2254.

Bidwell, T., S. Shalaway, O. Maughan, and L. Talent. 1989. Habitat use by female eastern wild turkeys in southeastern Oklahoma. Journal of Wildlife Management 53:34–39.

Blackburn, W. E., J. P. Kirk, and J. E. Kennamer. 1975. Availability and utilization of summer foods by eastern wild turkeys in Lee County, Alabama. Pages 86–96 *in* The Third National Wild Turkey Symposium.

Boyce, M. S., J. S. Mao, E. H. Merrill, D. Fortin, M. G. Turner, J. Fryxell, and P. Turchin. 2003. Scale and heterogeneity in habitat selection by elk in Yellowstone National Park.

Ecoscience 10:421–431.

Brown, J. S. 2006. Habitat selection as an evolutionary game. Evolution 44:732-746.

Bryant, S. 2016. Alabama hunting survey: 2015 - 2016 season. Montgomery, Alabama.

Buchholz, R. 2019. Thermoregulatory role of the unfeathered head and neck in male wild turkeys. The Auk 113:310-318.

Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. Journal of Mammalogy 24:346–352.

Chamberlain, M. J. 1999. Ecological relationships among bobcats, coyotes, gray fox, and raccoons and their interactions with wild turkey hens. Dissertation.Mississippi State University.Starkville.

Collier, B. A., J. D. Guthrie, J. B. Hardin, and K. L. Skow. 2017*a*. Movements and habitat selection of male Rio Grande wild turkeys during drought in south Texas. Journal of the Southeastern Association of Fish and Wildlife Agencies 4:94–99.

Collier, B. A., P. Wightman, M. J. Chamberlain, J. Cantrell, and C. Ruth. 2017*b*. Hunting activity and male wild turkey movements in South Carolina. Journal of the Southeastern Association of Fish and Wildlife Agencies 4:85–93.

Conley, M. D., N. A. Yeldell, M. J. Chamberlain, and B. A. Collier. 2016. Do movement behaviors identify reproductive habitat sampling for wild turkeys? Ecology and Evolution 6: 7103-7112..

Damm, P. E. 2010. Using automated cameras to estimate wildlife populations. M.S. Thesis. Auburn University. AL..

Danks, F. S., and D. R. Klein. 2002. Using GIS to predict potential wildlife habitat: a case study of muskoxen in northern Alaska. International Journal of Remote Sensing 23:4611–4632.

Dickson, J. G. 1992. The wild turkey: biology & management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Edwards, J., D. Guynn, and S. Loeb. 1993. Seasonal mast availability for wildlife in the Piedmont Region of Georgia. USDA Forest Service Research Paper SE-287.

Everett, D. 1982. Factors limiting populations of wild turkeys on state wildlife management areas in north Alabama. Dissertation. Auburn University, AL

Everett, D., D. Speake, and W. Maddox. 1980. Natality and mortality of a north Alabama wild turkey population. Pages 117–126 *in* J. M. Sweeney, editor. Fourth National Wild Turkey Symposium. Little Rock, AR.

Fralish, J. S. 2004. The keystone role of oak and hickory in the central hardwood forest. Upland Oak Ecology Symposium: History, Current Conditions, and Sustainability. USDA Forest Service Gen. Tech. Rep. SRS-73 78–87.

Fuller, A. K., S. M. Spohr, D. J. Harrison, and F. A. Servello. 2013. Nest survival of wild turkeys Meleagris gallopavo silvestris in a mixed-use landscape: influences at nest-site and patch scales. Wildlife Biology 19:138–146.

Gaüzère, P., K. Princé, and V. Devictor. 2017. Where do they go? The effects of topography and habitat diversity on reducing climatic debt in birds. Global Change Biology 23:2218–2229.

Golden, M. S. 1979. Forest vegetation of the lower Alabama Piedmont. Ecology 60:770–782.

Grado, S., G. Hurst, and K. Godwin. 1997. Economic impact and associated values of the wild turkey in Mississippi. Pages 438–448 *in*. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51.

Gross, J. T., B. S. Cohen, B. A. Collier, and M. J. Chamberlain. 2016. Influences of hunting on movements of male wild turkeys during spring. Proceedings of the 11th National Wild Turkey Symposium 2000:259–268.

Vander Haegen, M. W., W. E. Dodge, and M. W. Sayre. 1988. Factors affecting productivity in a northern wild turkey population. Journal of Wildlife Management 52:127–133.

Holbrook, T., M. Vaughan, and P. Bromley. 1987. Wild turkey habitat preferences and recruitment in intensively managed piedmont forests. Journal of Wildlife Management 51:182–187.

Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United State-representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing 81:345–354.

Huntley, J. 1989. Importance and management of mast species other than oaks. Pages 74–82 *in* C. McGee, editor. Southern Appalachian Mast Management. Knoxville, Tennessee.

Kamil, B. 2016. MuMIn: Multi-Model Infernece.

Kane, D. F., R. O. Kimmel, and W. E. Faber. 2007. Winter survival of wild turkey females in central Minnesota. Journal of Wildlife Management 71:1800–1807.

Kelly, M. J., and E. L. Holub. 2008. Camera trapping of carnivores: trap success among camera types and across species, and habitat selection by species, on Salt Pond Mountain, Giles

County, Virginia. Northeastern Naturalist 15:249–262.

Kenward, R. E. 2001. A manual for wildlife radio tagging. The Auk 118:812–815.

Kiss, B. W. 2014. Survival, reproduction, movement, and habitat use of female eastern wild turkeys (Meleagris gallopavo silvestris) in Manitoba's Pembina Valley. M.S. Thesis. University of Manitoba.

Klebesadel, L. J., and D. Helm. 2010. Food reserve storage, low-temperate injury, winter survival, and forage yields of timothy in subarctic Alaska as related to latitude-of-origin. Crop Science 26:325.

Knick, S. T., J. T. Rotenberry, and M. Leu. 2008. Habitat, topographical, and geographical components structuring shrubsteppe bird communities. Ecography 31:389–400.

Kosicki, J. Z., and P. Chylarecki. 2012. Effect of climate, topography, and habitat on species-richness of breeding birds in Poland. Basic and Applied Ecology 13:475–483.

Lehman, C. P., M. A. Rumble, and L. D. Flake. 2008. Winter habitat selection patterns of Merriam's turkeys in the southern Black Hills, South Dakota. Western North American Naturalist 67:278–291.

Lele, S. R., E. H. Merrill, J. Keim, and M. S. Boyce. 2013. Selection, use, choice, and occupancy: clarifying concepts in resource selection studies. Journal of Animal Ecology 82:1183–1191.

Manly, B. F. J., L. L. Mcdonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource selection by animals : statistical design and analysis of field studies. Second Edition. Springer.

Martin, J. A., W. E. Palmer, S. Michael Juhan, and J. P. Carroll. 2012. Wild turkey habitat use in frequently-burned pine savanna. Forest Ecology and Management 285:179–186.

McKerrow, A., and S. Williams. 2012. Southeast GAP analysis project. <http://www.basic.ncsu.edu/segap/>.

Meanley, B. 1956. Foods of the wild turkey in the White River bottomlands of southeastern Arkansas. The Wilson Bulletin 68:305–311.

Miller, D. A. 1997. Habitat relationships and demographic parameters of an eastern wild turkey population in central Mississippi. Mississippi State University.

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., B. Leopold, G. Hurst, and P. Gerard. 2000. Habitat selection models for eastern wild turkeys in central Mississippi. Journal of Wildlife Management 64:765–776.

Moore, W. F. 2006. Survival, nesting success, and habitat selection of wild turkey populations in the upper coastal plain of South Carolina. Dissertation. Clemson University.

Norman, G. W., J. C. Pack, C. I. Taylor, D. E. Steffen, and K. H. Pollock. 2007. Reproduction of eastern wild turkeys in Virginia and West Virginia. Journal of Wildlife Management 65:1.

Paolini, K. E., B. K. Strickland, J. L. Tegt, K. C. VerCauteren, and G. M. Street. 2018. Seasonal variation in preference dictates space use in an invasive generalist. PLoS ONE 13:1–18.

Parker, K. L., M. P. Gillingham, T. A. Hanley, and C. T. Robbins. 2008. Foraging efficiency: energy expenditure versus energy gain in free-ranging black-tailed deer. Canadian Journal of Zoology 74:442–450.

Porter, W. 1980. An evaluation of wild turkey brood habitat in southeastern Minnesota. Pages 203–212 *in* J. Sweeney, editor. Proceedings of the fourth National Wild Turkey Symposium. National Wild Turkey Federation, Little Rock, AR.

R Core Team. 2018. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rakowski, A. E., R. D. Elmore, C. A. Davis, S. D. Fuhlendorf, and J. M. Carroll. 2019. Thermal refuge affects space use and movement of a large-bodied galliform. Journal of Thermal Biology 80:37–44.

Runkle, J.R. 1982. Patterns of disturbance in some old-growth mesic forests of eastern North America. Ecology 64:1533–1546.

Rice, M. B., A. D. Apa, and L. A. Wiechman. 2017. The importance of seasonal resource selection when managing a threatened species: targeting conservation actions within critical habitat designations for the Gunnison sage-grouse. Wildlife Research 44:407.

Rubba, C. 2016. htmltab: Assemble data frames from HTML tables.

Rumble, M. A., and S. H. Anderson. 1996. Feeding ecology of Merriam's turkeys (Meleagris gallopavo merriami) in the Black Hills, South Dakota. American Midland Naturalist 136:157–171.

Shankman, D., and K. M. Wills. 1995. Pre-European settlement forest communities of the Talladega Mountains, Alabama. Southeastern Geographer 35:118–131.

Speake, D. W. 1975. Habitat use and seasonal movements of wild turkeys in the southeast. 122–130 *in* L. K. Halls, editor. The Third National Wild Turkey Symposium. The Texas Chapter of the Wildlife Society, San Antonio, Texas.

Storch, I. 1993. Patterns and strategies of winter habitat selection in alpine capercaillie. Ecography 16:351–359.

Webster, G. R., and S. A. Samson. 1992. On defining the Alabama Black Belt: historical changes and variations. Southeastern Geographer 32:163–172.

Wickham, H. 2017. tidyverse: Easily install and load the “tidyverse” R package version 1.2.1.

Wilson, D. S., and J. Yoshimura. 1994. On the coexistence of specialists and generalists. The American Naturalist 144:692–707.

Wilson, W., and A. Woodward. 1955. Some factors affecting body temperatures of turkeys. Poultry Science 369–371.

Zenas, S. J. 2018. Factors influencing post-capture survival and survival of eastern wild turkeys in Alabama. M.S. Thesis. Auburn University. AL.

Zuckerberg, B., D. Fink, F. A. La Sorte, W. M. Hochachka, and S. Kelling. 2016. Novel seasonal land cover associations for eastern North American forest birds identified through dynamic species distribution modeling. Diversity and Distributions 22:717–730.

Zwank, P., T. White, and F. Kimmel. 1988. Female turkey habitat use in Mississippi River Batture. Journal of Wildlife Management 52:253–260.

Table 2.1. The GPS and satellite logger sampling rates and the seasonal shift in the programming that occurred annually. The sampling rate was reduced in the non-reproductive period (1-October - 14-March) to extend battery life of loggers as long as two years.

		Sampling Rate (hour)	
Season	Dates	ATS GPS transmitter	Lotek Satellite Transmitter (2018)
Reproductive period[1]	15 March - 30 Sept	0700, 0900, 1100,1300, 1700, 1900	0600, 1200, 1400, 1600, 1800, 2000, 2200
Non-reproductive period[2]	1 Oct - 14 March	1500, 0100	0600, 1200, 1400, 1600, 1800, 2000, 2200
Hunting Season[3]	15 March - 30 April	0700, 0900, 1100,1300, 1700, 1900	0600, 1200, 1400, 1600, 1800, 2000, 2200

[1]Reproductive period - 15 March – 30-Sept.
[2]Non-reproductive period -1-Oct – 14-March.
[3]Hunting season - Turkey hunting season, 15 March – 30 April in 2015 - 2017, except at Barbour WMA in 2016 where the season ran from 22 March to 30 April. In 2018, the statewide turkey season was changed to 24 March - 30 April. The SOA properties offered reduced hunting pressure with hunts occurring on alternating weekends 22-24 March, 5-7 April, 16-18 April, and 26-28 April in 2018.

Table 2.2. National land cover database values that correlate to the vegetative characteristics of the landscape determined from aerial photography (Homer et al. 2015).

Value	Classification
11	Open Water
12	Perennial Ice/Snow
21	Developed, Open Space
22	Developed, Low Intensity
23	Developed, Medium Intensity
24	Developed, High Intensity
31	Barren Land (Rock/Sand/Clay)
41	Deciduous Forest
42	Evergreen Forest
43	Mixed Forest
51	Dwarf Scrub
52	Shrub/Scrub
71	Grassland/Herbaceous
72	Sedge/Herbaceous
73	Lichens
74	Moss
81	Pasture/Hay
82	Cultivated Crops
90	Woody Wetlands
95	Emergent Herbaceous Wetlands

Table 2.3. Southeast Landform classifications generated from digital elevation models (DEM) and hydrography, which model the slope, aspect, and elevation of the region. These topographic details of the landscape yield 14 discrete categories based on slope and slope position (McKerrow and Williams 2012)

Value	Classification
10	Steep slope - N/NE
11	Steep slope - S/SW
12	Slope crest
13	Upper slope
14	Flat summit/ridge
20	Side slope -N/NE
21	Cove/ravine - N/NE
22	Side slope -S/SW
23	Cove/ravine - S/SW
30	Dry Flat
31	Moist Flat
33	Slope bottom
40	Stream
42	Lake/river

Table 2.4. The land cover and landform categories (land cover categories), which are a product of the NLCD and the southeastern landform dataset, provided 225 categories of land cover offering broad and fine-scale land cover classification.

[1]Value[2]	Classification
1122	Open Water, Side slope - S/SW
1130	Open Water, Dry Flat
1131	Open Water, Moist Flat
2112	Developed Open Space, Slope Crest
2114	Developed Open Space, Flat Summit/Ridge
2120	Developed Open Space, Side slope - N/NE
2121	Developed Open Space, Cove/Ravine - N/NE
2122	Developed Open Space, Side slope - S/SW
2130	Developed Open Space, Dry Flat
2131	Developed Open Space, Moist Flat
2133	Developed Open Space, Slope Bottom
2140	Developed Open Space, Stream
2142	Developed Open Space, Lake/River
2214	Developed Low Intensity, Flat Summit/Ridge
2230	Developed Low Intensity, Dry Flat
3122	Barren Land, Side slope - S/SW
3131	Barren Land, Moist Flat
4110	Deciduous Forest, Steep Slope - N/NE
4111	Deciduous Forest, Steep Slope - S/SW
4112	Deciduous Forest, Slope Crest
4114	Deciduous Forest, Flat Summit/Ridge
4120	Deciduous Forest, Side slope - N/NE
4121	Deciduous Forest, Cove/Ravine - N/NE
4122	Deciduous Forest, Side slope - S/SW
4123	Deciduous Forest, Cove/Ravine - S/SW
4130	Deciduous Forest, Dry Flat
4131	Deciduous Forest, Moist Flat
4133	Deciduous Forest, Slope Bottom
4140	Deciduous Forest, Stream
4142	Deciduous Forest, Lake/River
4212	Evergreen Forest, Slope Crest
4214	Evergreen Forest, Flat Summit/Ridge
4220	Evergreen Forest, Side slope - N/NE
4221	Evergreen Forest, Cove/ Ravine - N/NE
4222	Evergreen Forest, Side slope - S/SW
4223	Evergreen Forest, Cove/Ravine - S/SW
4230	Evergreen Forest, Dry Flat

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

Table 2.4. The land cover and landform categories (land cover categories), which are a product of the NLCD and the southeastern landform dataset, provided 225 categories of land cover offering broad and fine-scale land cover classification.

[1]Value[2]	Classification
4231	Evergreen Forest, Moist Flat
4233	Evergreen Forest, Slope Bottom
4240	Evergreen Forest, Stream
4310	Mixed Forest, Steep Slope - N/NE
4311	Mixed Forest, Steep Slope - S/SW
4312	Mixed Forest, Slope Crest
4314	Mixed Forest, Flat Summit/Ridge
4320	Mixed Forest, Side slope - N/NE
4321	Mixed Forest, Cove/Ravine - N/NE
4322	Mixed Forest, Side slope - S/SW
4323	Mixed Forest, Cove/Ravine - S/SW
4330	Mixed Forest, Dry Flat
4331	Mixed Forest, Moist Flat
4333	Mixed Forest, Slope Bottom
4340	Mixed Forest, Stream
4342	Mixed Forest, Lake/River
5210	Shrub/Scrub, Steep Slope - N/NE
5212	Shrub/Scrub, Slope Crest
5214	Shrub/Scrub, Flat Summit/Ridge
5220	Shrub/Scrub, Side slope - N/NE
5221	Shrub/Scrub, Cove/Ravine - N/NE
5222	Shrub/Scrub, Side slope - S/SW
5223	Shrub/Scrub, Cove/Ravine - S/SW
5230	Shrub/Scrub, Dry Flat
5231	Shrub/Scrub, Moist Flat
5233	Shrub/Scrub, Slope Bottom
5240	Shrub/Scrub, Stream
5242	Shrub/Scrub, Lake/River
7112	Grassland/Herbaceous, Slope Crest
7114	Grassland/Herbaceous, Flat Summit/Ridge
7120	Grassland/Herbaceous, Side slope - N/NE
7121	Grassland/Herbaceous, Cove/Ravine - N/NE
7122	Grassland/Herbaceous, Side slope - S/SW
7123	Grassland/Herbaceous, Cove/Ravine - S/SW
7130	Grassland/Herbaceous, Dry Flat
7131	Grassland/Herbaceous, Moist Flat
7133	Grassland/Herbaceous, Slope Bottom

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

Table 2.4. The land cover and landform categories (land cover categories), which are a product of the NLCD and the southeastern landform dataset, provided 225 categories of land cover offering broad and fine-scale land cover classification.

[1]Value[2]	Classification
7140	Grassland/Herbaceous, Stream
8112	Pasture/Hay, Slope Crest
8114	Pasture/Hay, Flat Summit/Ridge
8120	Pasture/Hay, Side slope - N/NE
8121	Pasture/Hay, Cove/Ravine - N/NE
8122	Pasture/Hay, Side slope - S/SW
8123	Pasture/Hay, Cove/Ravine - S/SW
8130	Pasture/Hay, Dry Flat
8131	Pasture/Hay, Moist Flat
8133	Pasture/Hay, Slope Bottom
8140	Pasture/Hay, Stream
8214	Cultivated Grass, Flat Summit/Ridge
8220	Cultivated Grass, Side slope - N/NE
8230	Cultivated Grass, Dry Flat
8231	Cultivated Grass, Moist Flat
8233	Cultivated Grass, Slope Bottom
8240	Cultivated Grass, Stream
9012	Woody Wetlands, Slope Crest
9014	Woody Wetlands, Flat Summit/Ridge
9020	Woody Wetlands, Side slope - N/NE
9021	Woody Wetlands, Cove/Ravine - N/NE
9022	Woody Wetlands, Side slope - S/SW
9023	Woody Wetlands, Cove/Ravine - S/SW
9030	Woody Wetlands, Dry Flat
9031	Woody Wetlands, Moist Flat
9033	Woody Wetlands, Slope Bottom
9040	Woody Wetlands, Steam
9042	Woody Wetlands, Lake/River
9540	Emergent Herbaceous Wetlands, Stream

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

Table 2.5. Turkey hunting seasons occurred on state-managed study areas in Alabama in 2015 - 2018. Season dates were variable from study area to study and year to year. Special Opportunity Areas (SOA) study areas were used only in 2018 and offered a reduced season. Scotch WMA was not active after the 2015 field season.

Study Site[1]	Hunting Season	2015		2016		2017		2018	
Barbour	Turkey	15-Mar	30-Apr	22-Mar	30-Apr	22-Mar	30-Apr	24-Mar	30-Apr
Oakmulgee	Turkey	15-Mar	30-Apr	15-Mar	30-Apr	15-Mar	30-Apr	24-Mar	30-Apr
Scotch	Turkey	15-Mar	30-Apr	*	*	*	*	*	*
Skyline	Turkey	15-Mar	30-Apr	15-Mar	30-Apr	15-Mar	30-Apr	24-Mar	30-Apr
2018 - turkey season only									
Uchee Creek	22-Mar	24-Mar	5-Apr	7-Apr	16-Apr	18-Apr	26-Apr	28-Apr	
Cedar Creek	22-Mar	24-Mar	5-Apr	7-Apr	16-Apr	18-Apr	26-Apr	28-Apr	
Drummond (PVT)	15-Mar	*	*	*	*	*	*	30-Apr	

[1]Barbour – Barbour Wildlife Management Area (WMA), Cedar Creek – Cedar Creek Special Opportunity Area (SOA), Drummond (PVT) – Drummond Private Property, Oakmulgee – Oakmulgee WMA, Scotch - Scotch WMA, Skyline – Skyline WMA, Uchee Creek – Uchee Creek SOA.

Table 2.6. The number (n) and distribution (%) of locations used by female turkeys by season and study site in Alabama 2015-2018.

Season	Bar		Ced		Dru		Oak		Sco		Sky		Uch	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Reproduction	5471	0.80	247	0.71	1286	0.90	2566	0.67	2461	0.98	7211	0.71	517	0.79
Non-reproduction	1384	0.20	100	0.29	145	0.10	1243	0.33	58	0.02	2985	0.29	137	0.21

[1]Bar – Barbour WMA, Ced – Cedar Creek Special Opportunity Area (SOA), Dru – Drummond Private Property, Oak – Oakmulgee WMA, Sco - Scotch WMA, Sky – Skyline WMA, Uch – Uchee Creek SOA.
[2]Fall – 31-Sept – 1-Nov, Incubation – 31-Mar – 8-June, Post-nest – 9-Jun – 30-Sept, Winter – 2-Nov – 31-Jan, Pre-breeding – 1-Feb – 14-March.

Table 2.7. The number (n) and distribution (%) of locations used by and available to female turkeys during the non-reproductive period versus the rest of the year on seven study areas in Alabama 2015-2018

	Land cover type[1]										
Rest of the year[2]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	9256	0.47	1961	0.10	2097	0.11	4360	0.22	2085	0.11	19759
Used	10134	0.51	1785	0.09	1289	0.07	4614	0.23	1937	0.10	19759
Non-reproductive[3]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	3464	0.57	591	0.10	623	0.10	852	0.14	522	0.09	6052
Used	3962	0.65	704	0.12	108	0.02	967	0.16	311	0.05	6052

[1]hwood – Deciduous hardwood forest, mix – Mixed forest, open – open land cover, pine – Coniferous forests, success – shrub/scrub land cover.
[2]Rest of the year -15-March – 30-Sept.
[3]Non-reproductive period -1-Oct – 14-March.

Table 2.8. The number (n) and distribution (%) of locations used by and available to female turkeys during the non-reproductive period versus the rest of the year on seven study areas in Alabama 2015-2018

	Land cover type[1]										
Rest of the year[2]	forest		north-facing slopes		open		sfs		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	9293	0.47	3265	0.17	2097	0.11	3019	0.15	2085	0.11	19759
Used	10209	0.52	3826	0.19	1289	0.07	2498	0.13	1937	0.10	19759
Non-reproductive[3]	forest		north-facing slopes		open		sfs		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	2724	0.45	1084	0.18	623	0.10	1099	0.18	522	0.09	6052
Used	2749	0.45	1239	0.20	108	0.02	1645	0.27	311	0.05	6052

[1]forest – non-slope forest types, north-facing slopes – north-facing forested slopes, open – open land cover, sfs – south-facing forested slopes, shrub – shrub/scrub land cover.
[2]Rest of the year –15-March – 30-Sept.
[3]Non-reproductive –1-Oct – 14-March.

Table 2.9. The number (n) and distribution (%) of locations used by and available to female turkeys during the reproductive period versus the rest of the year on seven study areas in Alabama 2015-2018

	Land cover type[1]										
Rest of the year[2]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	3464	0.57	591	0.10	623	0.10	852	0.14	522	0.09	6052
Used	3962	0.65	704	0.12	108	0.02	967	0.16	311	0.05	6052
Reproductive[3]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	9256	0.47	1961	0.10	2097	0.11	4360	0.22	2085	0.11	19759
Used	10134	0.51	1785	0.09	1289	0.07	4614	0.23	1937	0.10	19759

[1]hwood – Deciduous hardwood forest, mix – Mixed forest, open – open land cover, pine – Coniferous forests, shrub – Shrub/scrub land cover.
[2]Rest of the year –15-March – 30-Sept.
[3]Reproductive – Reproductive season, 15-March-30-Sept.

Table 2.10. The number (n) and distribution (%) of locations used by and available to female eastern wild turkeys during incubation and brood-rearing period versus the rest of the year on seven study areas in Alabama 2015-2018.

	Land cover type[1]										
Incubation brood-rearing[2]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	7750	0.46	1712	0.10	1726	0.10	3887	0.23	1819	0.11	16894
Used	8331	0.49	1510	0.09	1183	0.07	4112	0.24	1758	0.10	16894
Rest of the year[3]	hwood		mix		open		pine		shrub		
	n	%	n	%	n	%	n	%	n	%	Total
Available	4970	0.56	840	0.09	994	0.11	1325	0.15	788	0.09	8917
Used	5765	0.65	979	0.11	214	0.02	1469	0.16	490	0.05	8917

[1]hwood – Deciduous hardwood forest, mix – Mixed forest, open – open land cover, pine – Coniferous forests, Shrub – shrub/scrub cover.
[2]Incubation brood-rearing – Incubation and brood-rearing period, 31-March-30-Sept.
[3]Rest of the year - 1-Oct – 30-Mar

Table 2.11. The number (n) and distribution (%) of locations used by and available to female eastern wild turkeys during the reproductive period versus the rest of the year on seven study areas in Alabama 2015-2018.

	Land cover type[1]								
Reproductive [2]	bottom		forest		open		shrub		
	n	%	n	%	n	%	n	%	Total
Available	7934	0.40	10028	0.51	789	0.04	1008	0.05	19759
Used	8572	0.43	9822	0.50	442	0.02	923	0.05	19759
Rest of the year[3]	bottom		forest		open		shrub		
	n	%	n	%	n	%	n	%	Total
Available	2019	0.33	3570	0.59	202	0.03	261	0.04	6052
Used	1759	0.29	4053	0.66	58	0.01	182	0.03	6052

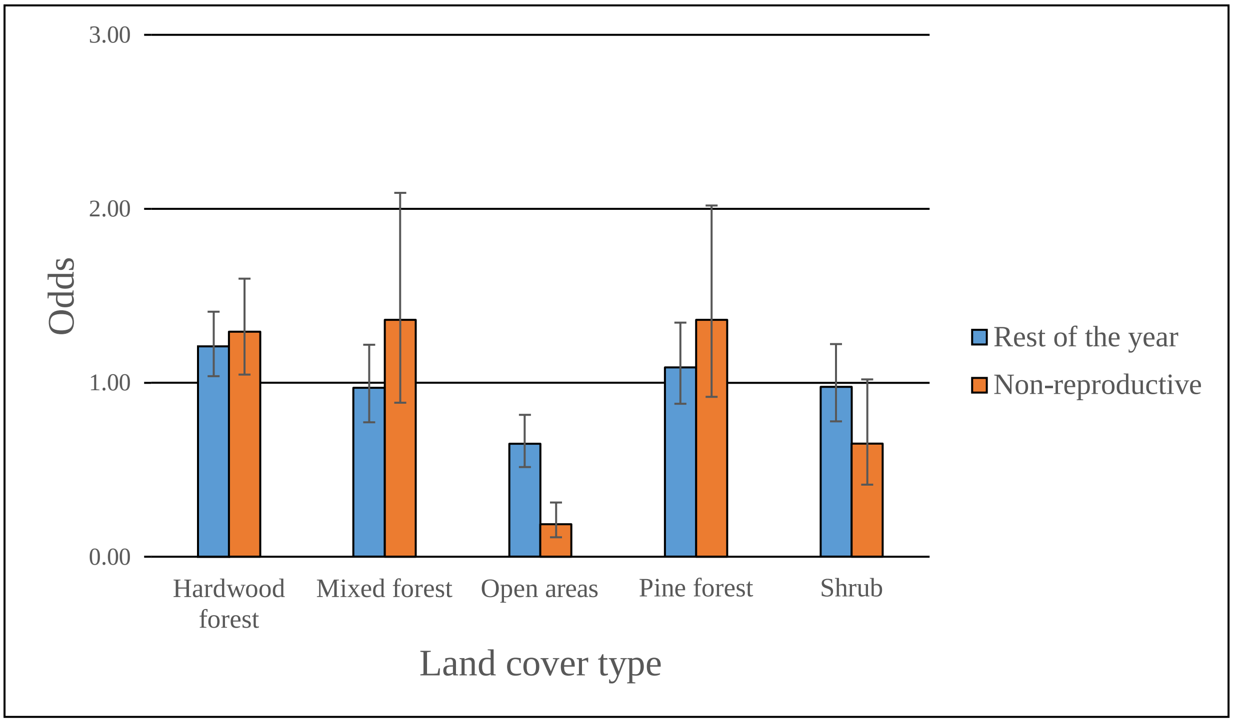
[1]bottom – forest land cover that occurs in bottoms, river, and stream landforms, forest – remaining forest land cover that does not occur in bottomland, open – open land cover, shrub – shrub/scrub land cover.
[2]Reproductive – Reproductive period, 15-March-30-Sept.
[3]Rest of the year –15-March – 30-Sept.

Table 2.12. The number (n) and distribution (%) of locations used by and available to female eastern wild turkeys during turkey hunting season versus the rest of the year on seven study areas in Alabama 2015-2018.

	Land cover type[1]						
Rest of the year[2]	forest		open		shrub		
	n	%	n	%	n	%	Total
Available	15503	0.79	2015	0.11	1990	0.10	19509
Used	16735	0.86	1121	0.06	1652	0.08	19509
Hunting season[3]	forest		open		shrub		
	n	%	n	%	n	%	Total
Available	4981	0.79	705	0.11	617	0.10	6304
Used	5431	0.86	276	0.05	596	0.09	6304

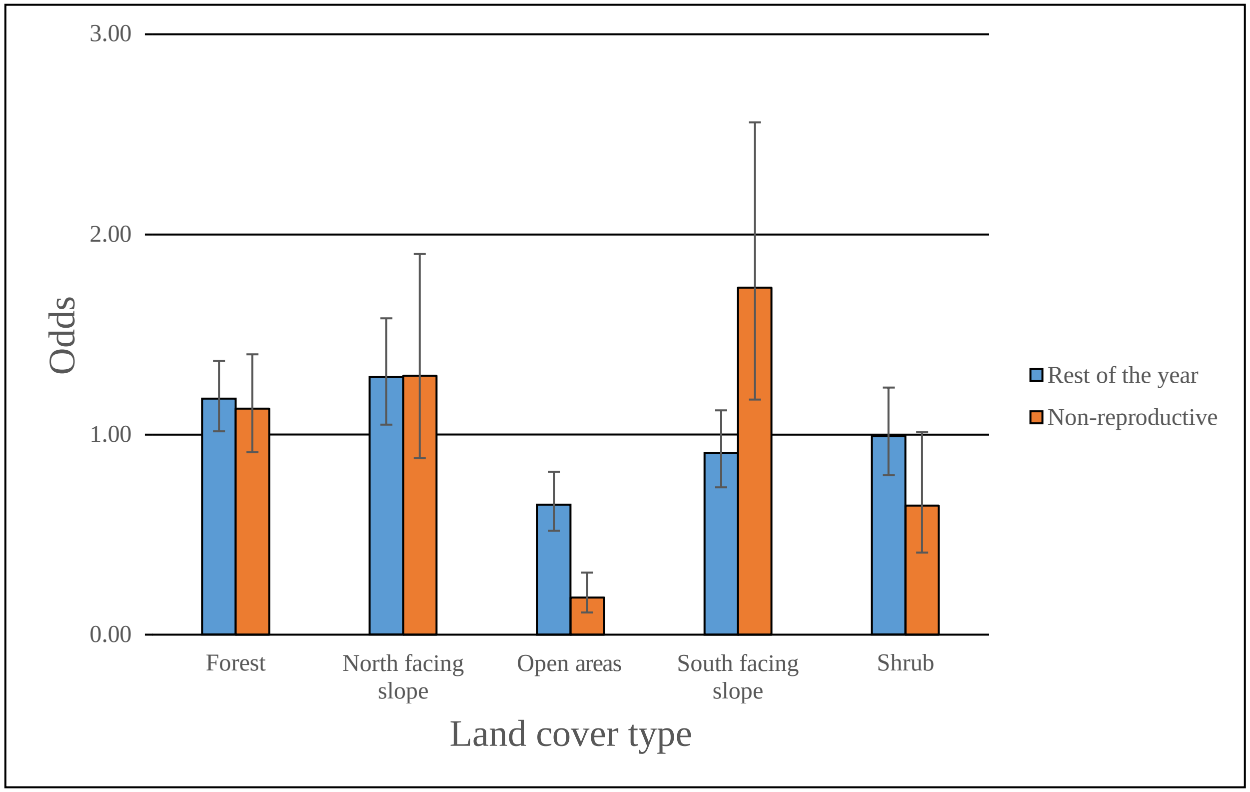
[1]forest – All forested land cover, open – open land cover, shrub – shrub/scrub land cover.
[2]Rest of the year – Rest of the year, 15-March – 30-Sept.
[3]Hunting season– Turkey hunting season, 15 March – 30 April in 2015 - 2017, except at Barbour WMA in 2016 where the season ran from 22 March to 30 April. In 2018, the statewide turkey season was changed to 24 March - 30 April. The SOA properties offered reduced hunting pressure with hunts occurring on alternating weekends 22-24 March, 5-7 April, 16-18 April, and 26-28 April in 2018.

Figure 2.1. The odds of selection of land cover types by radio- marked female turkeys on seven study areas in Alabama during the non-reproductive season compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



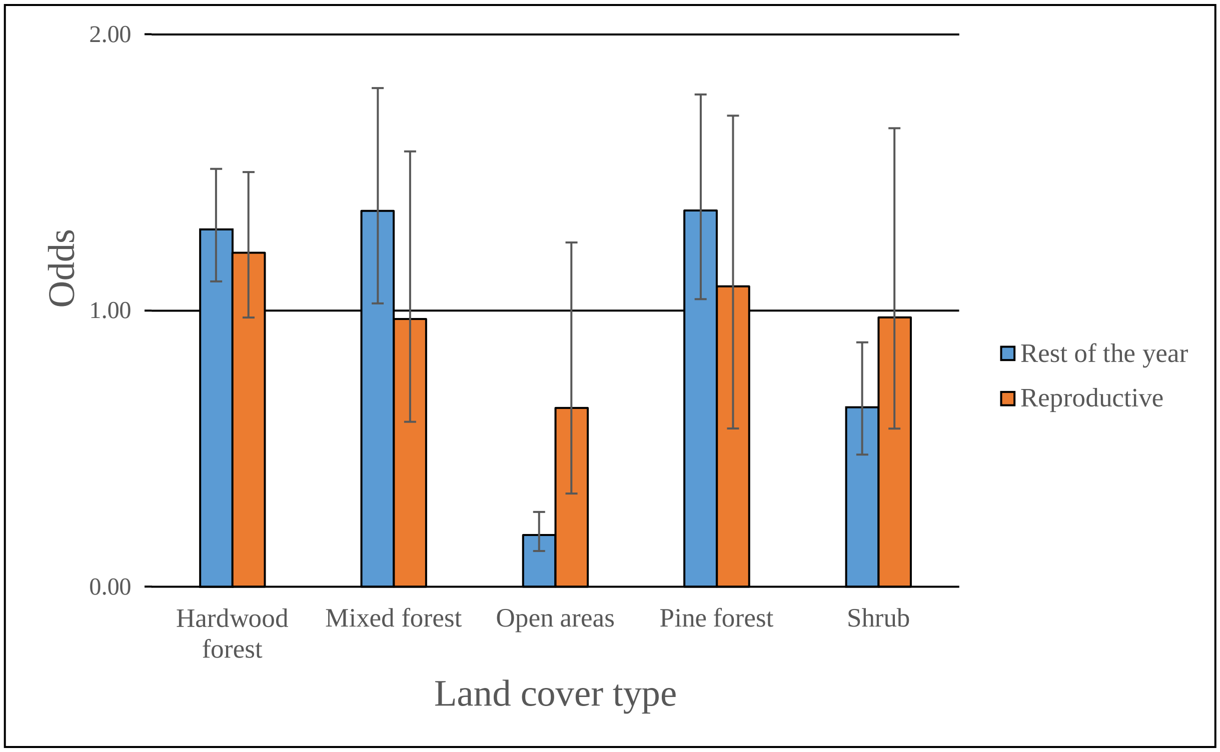
[1]Rest of the year – 15-March – 30-Sept.
[2]Non-reproductive period - 1-Oct – 14-March.

Figure 2.2. The odds of selection of land cover types by radio-marked female turkeys on seven study areas in Alabama during the non-reproductive period compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



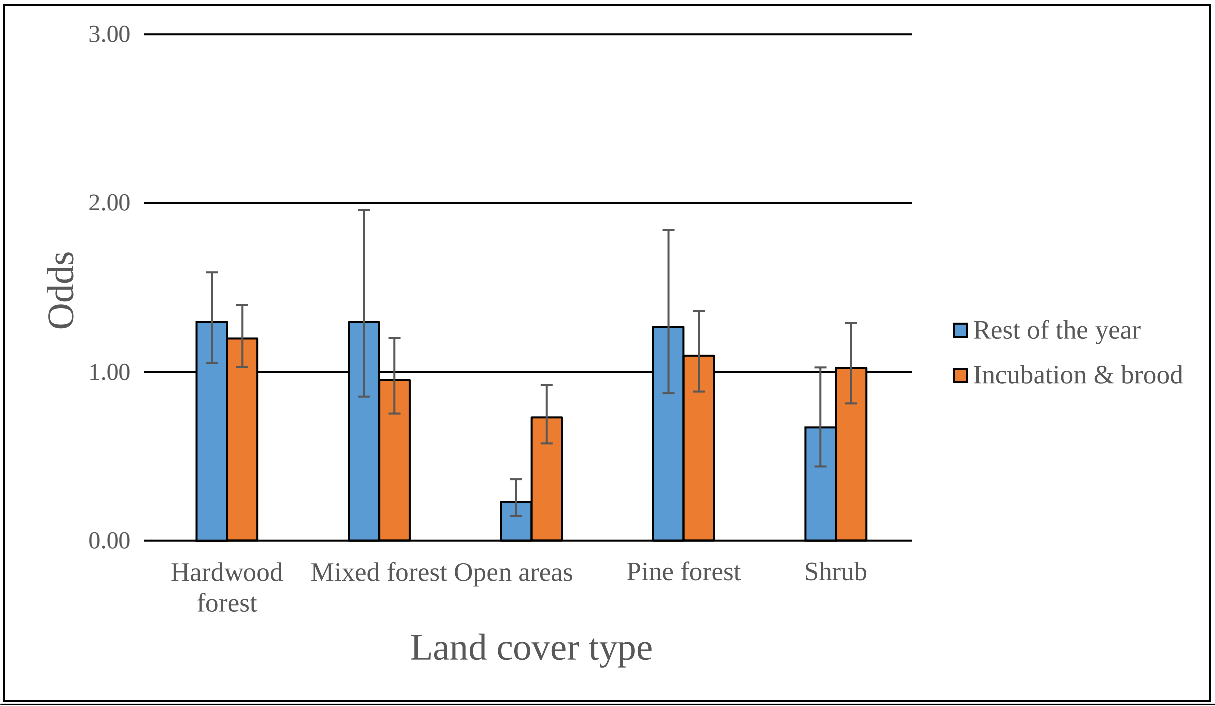
[1]Forest – non-slope forest types, north-facing slopes – north-facing forested slopes, open – open land cover, sfs – south-facing forested slopes, shrub – shrub/scrub land cover.
[2]Rest of the year – Rest of the year, 15-March – 30-Sept.
[3]Non-reproductive – 1-Oct – 14-March.

Figure 2.3. Odds of selection of land cover types by radio-marked female turkeys on seven study areas in Alabama during the reproductive period, 15 March – 30 September, compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



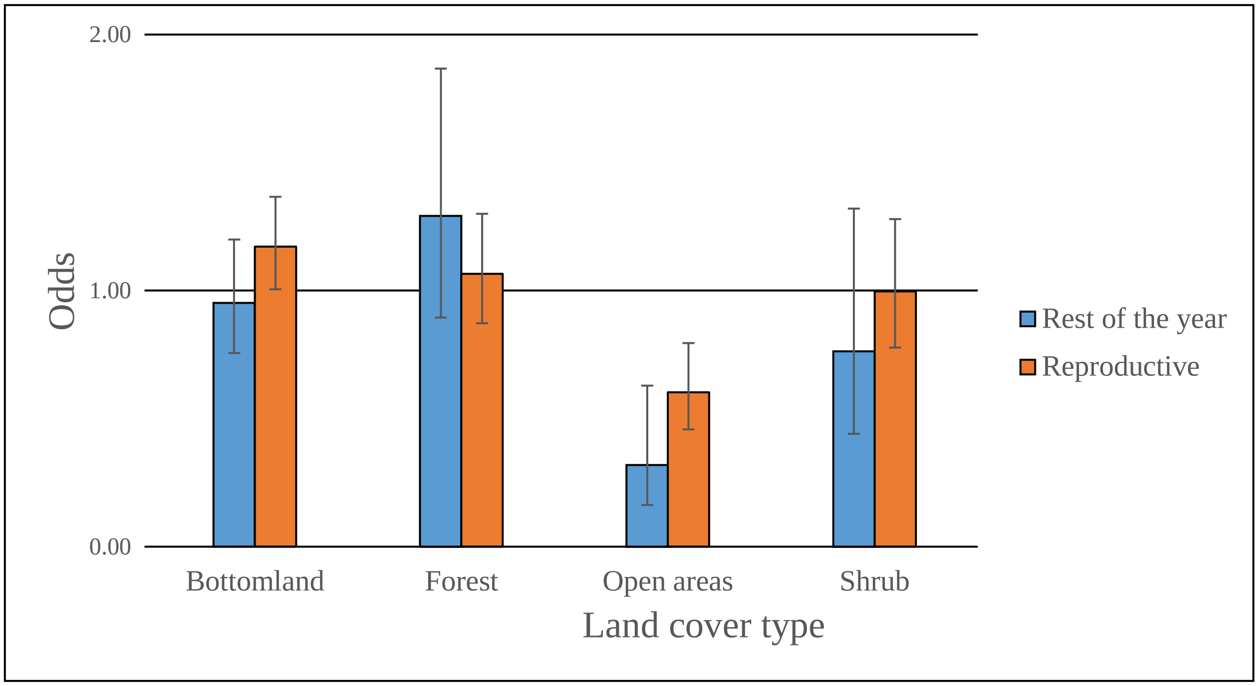
[2]Reproductive – 15-March-30-Sept.
[1]Rest of the year – 15-March – 30-Sept.

Figure 2.4. Odds of selection of land cover types by radio-marked female turkeys on seven study areas in Alabama during the incubation and brood-rearing period, 31 March-30 September, compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



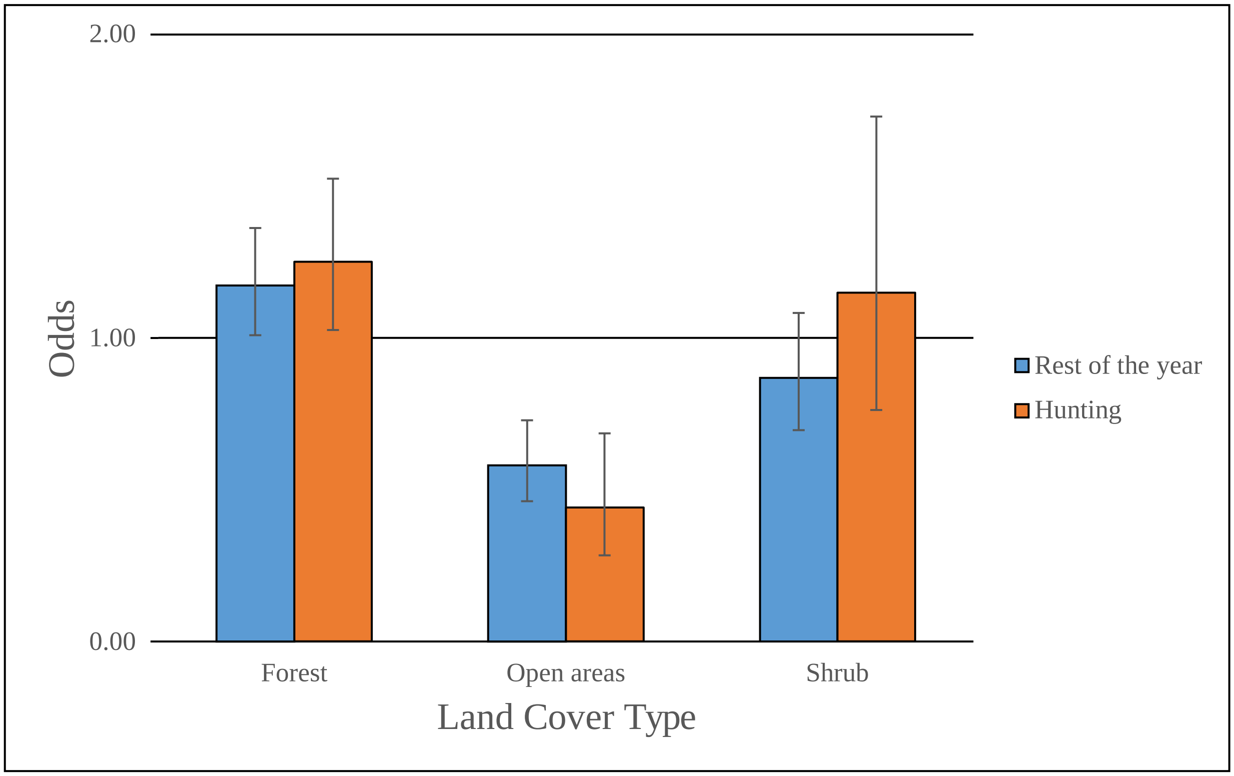
[1]Incubation & brood - Incubation and brood-rearing period, 31-March-30-Sept.
[2]Rest of the year - 1-Oct – 30-Mar

Figure 2.5. Odds of selection of land cover types by radio-marked female turkeys on seven study areas in Alabama during the reproductive period compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



[1]Reproductive– Reproductive period, 15-March-30-Sept.
[2]Rest of the year - 15-March – 30-Sept.

Figure 2.6. Odds of selection of each land cover types by radio-marked female turkeys on seven study areas in Alabama during the turkey-hunting season compared to the rest of the year 2015-2018. (Odds = 1.0, indicate land cover selection equivalent to availability on the landscape, Odds <1.0, indicate land cover selection less than its availability on the landscape (avoidance), Odds >1.0, indicate land cover selection greater than its availability on the landscape (preference)).



[2]Rest of the year – 5 May – 14 March

[1]Hunting – Turkey hunting season, 15 March – 30 April in 2015 - 2017, except at Barbour WMA in 2016 where the season ran from 22 March to 30 April. In 2018, the statewide turkey season was changed to 24 March - 30 April. The SOA properties offered reduced hunting pressure with hunts occurring on alternating weekends 22-24 March, 5-7 April, 16-18 April, and 26-28 April in 2018

Chapter 3: The Effect of Bait on Female Eastern Wild Turkey Movements.

Abstract

Decisions about species management should be informed by accurate estimates of population size and structure. Baited camera surveys are a valuable tool for estimating population size and structure; however, sources of error need to be understood for appropriate survey design. There is little published information about whether the use of bait could alter the movements and home range of Eastern Wild Turkeys (*Meleagris gallopavo silvestris*, hereafter turkey), or lead to biased estimates of occupancy and density. I marked thirteen adult female turkeys on five study areas in Alabama using transmitters with onboard GPS loggers to monitor movements. I examined turkey response to bait by calculating weekly probabilities of use using a Kernel Density Estimator and location data. I estimated the probability of use $P(use_{ijw})$ of each individual (*i*) at each camera site (*j*) during each week (*w*). I used the sign of the difference between $P(use_{ijw})$ and $P(use_{ijw+1})$ as a binomial indicator of an increase in probability of use and estimated the probability of an increase in $P(use_{ijw})$ using generalized linear mixed models. $P(use_{ijw})$ was 1.78 (0.87-3.62; 95% C.L.) times more likely to increase when bait was present versus when bait was absent, but confidence limits included 1.0 indicating that bait did not have a conclusive effect. My results indicate that the use of bait on cameras trapping surveys will not bias our demographic estimates and does not violate the assumptions of our analytic techniques. Further analysis should examine whether use in response to bait differs between sites inside and outside of a turkey's home range.

Introduction

Automated camera traps are a useful tool in wildlife populations studies, allowing biologists to estimate multiple parameters related to species presence, abundance, and resource use (Koerth et al. 1997, Curtis et al. 2009, Keever et al. 2017). Using cameras is cost-effective and much less labor-intensive than monitoring by human observers, and can be used to sample in difficult places and situations. Additionally, statistical techniques have evolved to allow biologists to accurately estimate population sizes and sex ratios from automated camera data (Koerth et al. 1997, Trolle and Kéry 2003, Burton et al. 2015, Keiter et al. 2017). However, an important aspect of this technique is that it typically employs the use of bait or another lure placed in front of the camera to increase the probability of detection of an individual in the wild (Damm 2010, McCoy et al. 2011, Mills et al. 2019). Thus, the effects of bait should be assessed.

Understanding effects of bait in surveys can build on studies of bait and supplemental feeding for a variety of uses such as vaccinating populations against disease, poisoning problem wildlife species, and aiding in the capture of wildlife for management and research purposes (Dunkley and Cattet 2003). By attracting individuals, bait may affect home ranges and movement (Reinecke and Shaiffer 1988, Balme et al. 2014). Effects noted include increased density and decreased the fitness of white-tailed deer (Odocoileus virginianus) (Grenier et al. 1999, Tarr and Pekins 2010) and altered movement and trap habituation of black bears (*Ursus americanus*) (Fersterer et al. 2001, Brongo et al. 2006). In game bird populations, the negative effects of bait are of equal importance. Baiting roadways with grain to improve the harvest of Northern Bobwhites (*Colinus virginianus*) has become a common practice in many states, and several studies have sought to determine the effects of this practice on survival, home range size, and predator abundance (Sisson et al. 2000, Doerr and Silvy 2002). During drier years, road baiting decreased bobwhite survival by concentrating them on areas of little cover, exposing them to higher predation and harvest rates (Haines, Hernandez, Henke, and Bingham, 2004). Northern Bobwhite home range size also declined in response to the baiting of roadways. This effect was not observed in wetter years when other food sources were more abundant. A similar effect has not been observed in turkeys, and we remain uncertain as to how they respond in terms of home range establishment in the presence of bait.

Another area of concern is that baiting camera traps may induce bias in estimates of population size, occurrence, or sex ratio through changes in detectability and presence (Gerber et al. 2012, Balme et al. 2014, Du Preez et al. 2014). In white-tailed deer, individuals may not respond to bait similarly. Heterogeneous detectability among individuals can bias estimates and lead to poor management decisions (McCoy et al., 2009). Further research on white-tailed deer in Connecticut examined the effect of bait sites on movement. Researchers found that when a bait site was established within a pre-existing core area, deer maintained their original core area. If a bait site was established outside of original core use areas but within the boundaries of its pre-existing home range, deer either shifted existing core area closer to the bait site or established new core use areas near the bait site (Kilpatrick and Stober, 2002). However, when a bait site was outside of a deer's home range it was not used and did not influence movement.

Further, when occupancy analysis is used to estimate the distribution and density of wildlife populations, data must meet certain assumed criteria (MacKenzie et al. 2006). Occupancy estimation can be used to estimate the percentage of an area that is used by a population of animals when populations are closed with respect to site use for the duration of the sampling season. Standard analyses assume use is independent; that is, detection of an individual at one site is independent of detection at another site. If bait causes shifts in established home ranges it could affect the use of sites, thus altering occupancy. Violating these assumptions could lead to biased estimates of occupancy (MacKenzie et al. 2006, Otto et al. 2013, Neilson et al. 2018).

It is very important to be aware of these potential risks when using bait on surveys to estimate demographic parameters. The perception that turkey populations have declined in the Southeastern United States induced Alabama Department of Conservation and Natural Resources (ADCNR) to initiate a statewide turkey-monitoring program in 2015. Their goal is to monitor the population to inform harvest management within the state. The monitoring program uses a camera trap survey on baited sites. This survey will be repeated periodically to generate a multi-season occupancy model to estimate demographic rates. The survey assumes that bait will not affect the probability of use of survey sites or percent area occupied.

However, the lack of research regarding the effect baited camera stations has on the home ranges and movements of turkeys left questions regarding the introduction of bias into the survey results. I examined the potential for bias in estimates of occupancy by using a camera trap survey to test the spatial response of female turkeys during the period of the summer survey. My objectives were to test the assumption that bait would not influence turkey movement by testing the effect of bait on weekly utilization distributions of individual birds with controlled bait deployment at locations within and outside of a turkey's home range. I sought to examine the effect of baited camera stations on the use and movement of female turkeys, and estimate the probability of a change in utilization caused by bait by comparing utilization distributions with and without baited survey stations present.

Study Areas and Methods

The research took place on the James D. Martin-Skyline Wildlife Management Area (WMA), Oakmulgee WMA, Barbour WMA, and the Scotch WMA. For a description of capture methods, marking techniques, and study areas where the bait tests occurred, see Chapter II of this thesis.

I used two methods to determine the effect of bait on home ranges and bait response of turkeys in the field. The initial sampling method made use of targeted bait tests. In these tests, bait sites were deployed within areas previously occupied by female turkeys prior to the initiation of the summer camera survey. The test timeframe was the same across all study areas and the initial download of locations determined using the Global Positioning System (GPS) occurred during the week of 18-June – 22-June. From this download, a 100% minimum convex polygon (MCP) and a kernel density estimator (KDE) were used to estimate occupied areas that represented use of space by turkeys and movement prior to bait presence. The occupied areas were overlaid on map layers in ArcGIS ArcMap 10.6 (ESRI, Redlands, CA) with the MCP representing the absolute range occupied by a bird during a given time. A location on the outside of the MCP was selected, avoiding the non-used areas that tend to be captured within the MCP. At this location, a baited camera survey site was established for two weeks beginning 25 June 2017-2018. The bait station included an automated camera with chicken scratch or corn bait placed in an open area likely to be used by turkeys. The cameras were set to capture images on a one-minute time interval and motion-activation to provide an opportunity to observe use by marked turkeys occurring at the site that may not have been captured within the GPS logger. A second download from the GPS logger occurred beginning 7-July and this data was examined for the response to bait examined. These tests typically occurred in the instance when a turkey had left the study area on which it was captured and occupied other properties removed from the summer camera survey effort. However, this method did not yield an appropriate sample size after two seasons.

This resulted in a second study design, in which I made use of the annual camera trap surveys that occurred on each study site during the summer. The camera trap study was designed to estimate turkey density and occupancy through camera monitoring and controlled, systematic bait deployments across four of our study areas. Cameras were deployed at each site for 5 days after it was cleared of vegetation. The camera was removed, and 7 – 8 L of corn bait was distributed at each site. Five days later, the bait was replenished and a camera was deployed for five more days. This design allowed me to opportunistically test marked turkeys that were occupying these study areas to determine changes in their probability of use of sites with and without bait. Space utilization by marked turkeys was assessed weekly beginning with the week prior to bait deployment at each site.

The results of both study methods were pooled and space utilization by each turkey was assessed using KDE methods (Silverman 1986) in MATLAB (Mathworks, Inc. 2012). A 50 m x 50 m grid was generated that extended 2000 meters around the outermost turkey locations on each study area. The grid established the area over which the KDE surfaces for each bird was calculated. The KDE estimated probability density value at each grid point for each bird during each week, which is proportional to local probability of use. The KDE was fit using smoothed univariate cross-validation to select a bandwidth (*h*) (Hall et al. 1992). $P(use_{ijw})$ was interpolated from the KDE for each bird (*i*) at each camera trap site (*j*) for each week (*w*) (Kernohan et al. 2001) of the camera survey or targeted test.

However, the estimated values of $P(use_{ijw})$ were infinitesimal, the magnitude of the differences between them was often large (e.g., 10^{200}) making direct comparisons of $P(use_{ijw})$ using parametric methods problematic. Therefore, I used the sign of each $P(use_{ijw+1})$ - $P(use_{ijw})$ as the response variable. The result was a binomial variable that indicated whether $P(use_{ijw})$ increased (1) or decreased (0) over from the previous week. The resulting estimates of the effects of bait were based on the frequency and sign of differences in $P(use_{ijw})$ and $P(use_{ijw+1})$. When

P(use) was zero during every week, the site was considered unavailable to that individual and eliminated from further consideration.

I estimated the effect of bait on use with a Generalized Linear Mixed Model (GLMM) which is a generalized extension of the contingency table that uses the frequencies of observations in multiple categories rather than the explicit contingency table (Conover 1980). GLMM allows many factors to be tested and allows for random effects. I used a GLMM with increased use as a function of bait with individual, week, study area, and year as random effects. All analysis was performed using R open sources software (Bates et. al. 2015, R Core Team 2018).

Results

I used 2,195 GPS locations from 13 birds, at seven study areas during 42 weeks in 2015 – 2018 in my analysis. P(use_{ijw}) was estimated for 328 camera sites across all the study areas included in the analysis (Table 3.1, Figure 3.1). The coefficients (β) resulting from the GLMM are log(odds) of the effect on the odds of an increase in P(use_{ijw}) when bait is present or absent (Appendix 3.1). The random effect of study site and year parameters but both converged on zero and were not included in the final analysis. Sites with bait were 1.78 (0.87-3.62; 95% C.L.) times as likely to be used by female turkeys as sites that were not baited, but confidence limits included 1.0. While the odds of an increase in P(use_{ijw}) when bait was absent was 0.90 (0.55-01.45; 95% C.L.), confidence limits again included 1.0 (Table 3.2).

Discussion

My hypothesis that P(use_{ijw}) would not increase when bait was present on the landscape was correct. I expected that corn bait would not be sufficiently detectable by turkeys to consistently cause shifts in use that would measurably increase P(use_{ijw}) at camera sites. My analysis indicated that bait did not increase P(use_{ijw}) of camera sites. Additionally, baited and non-baited camera sites were observed to have a similar probability of increased P(use_{ijw}). Although these findings indicate no related problems with occupancy estimates for female turkeys on this project, male occupancy was indicated to have a higher occupancy rate when bait was present on the survey site (Keller 2019).

It was necessary to use KDE and GLMM to examine the effects of bait because I could only sample the locations of turkeys; thus, it was possible that turkeys used camera sites even when I never recorded the GPS location of a turkey at a camera site observed only one marked female in approximately 1,200,000 images reviewed during the camera survey. Further, cameras were sometimes not deployed the week before bait was deployed making it impossible to detect turkeys in images. Moreover, when cameras were deployed, images were only collected at 1- or 4-minute intervals making it possible to miss use by a radio-marked female or for the transmitter to be obscured in an image. Additionally, even though the values of P(use_{ijw}) were infinitesimal, the magnitude of the differences between them was often large (e.g., 10^{200}) making direct comparisons of P(use_{ijw}) and P(use_{ijw+1}) using parametric methods problematic. Therefore, it was necessary to base estimates of the effects of bait on the frequency and sign of differences between P(use_{ijw}) and P(use_{ijw+1}).

Bait and other attractants used to maximize encounter rates and could come with a potential cost. All attractants are designed to increase the probability of an encounter between the target species and a sampling device. There are a variety of attractants that are used in research projects, bait which is typically composed of food, scent lures, visual lures, sound lures, and natural attractants like tree species or posts (Schlexer 2008). For an attractant to elicit a detectable change in home range, it would have to be detectable from outside of an individual's home range or area it is occupying. This would seem more likely to occur in species with a strong sense of smell or when a sound lure was in place. Turkeys, like most bird species, have a very limited sense of smell. Odors are interpreted by the olfactory lobes of the forebrain, in turkeys these lobes are considerably reduced (Dickson 1992). Although turkeys possess excellent vision, an individual is unlikely to visually detect a bait attractant outside of its home range. Further, in instances where a target species is equipped with long-range olfaction abilities, the effect of bait on their movements may not be dramatic. Research on Pacific Fisher (*Pekania pennanti*) in British Columbia revealed that site location and landscape heterogeneity explained a fisher's movement tortuosity, the departure of an animal's path from a straight line, more than bait proximity (Stewart et al. 2019).

Moreover, the importance of bait or other artificial food sources is often influenced by season. Turkeys in the northern extremes of their range are constrained more by winter food availability than by winter temperatures (Haroldson et al. 1998). Lower food availability makes turkeys much more responsive to artificial food sources, a fact that has regularly been exploited in trapping efforts on research projects in northern climates (Porter et al. 1983, Vander Haegen et al. 1988, Haroldson et al. 1998, Kiss 2014). However, turkeys in Alabama are not as food-limited in winter and often do not respond to bait. The Southeast offers a multitude of plant species which supply some soft or hard mast crop that persists through the fall and winter. To survive the winter, turkeys favor these lipid and carbohydrate-rich mast species over corn-based baits (Harlow et al. 1975).

Additionally, the two trapping periods on our research project were informed by turkeys response to bait. From February to the start of turkey hunting season, 24 March, turkeys are more visible in open spaces after wintering on forested slopes where they consisted on hard mast crops. From late August to mid-October, we experienced our most productive trapping period in which bigger flocks were more responsive to bait. This period represents the beginning of a season where seeds and herbaceous growth begin to diminish and insects become dormant on the landscape. This period ends with the first availability of hard mast crops in the forest after which, turkeys no longer respond to bait.

However, we conducted camera trap surveys to estimate occupancy for the study population during July and early August. During this time there are no limitations in terms of forage and turkeys are unlikely to exhibit a disproportionate response to bait on the landscape (Dickson 1992, Yarrow and Yarrow 2005). My results in Chapter 2 indicates that resource selection during this time occurs broadly in proportion to resource availability, suggesting turkeys can meet their survival requirements across the entire landscape.

My results indicate that female turkeys were just as likely to use sites with or without bait during the summer camera survey period, 25 June – 15 August 2015-2018. Therefore, camera trap surveys conducted with bait during this time period should yield unbiased the estimates of occupancy by female turkeys. However, this conclusion may not apply to estimates of abundance or estimates of occupancy by male turkeys (Keller, 2019). Additionally, these results may be confounded by whether a site occurs within or outside of an area previously occupied by turkeys. Exploring these factors would further clarify whether bait affects detection rates or occupancy by turkeys.

Literature Cited

Balme, G., L. Hunter, and H. Robinson. 2014. Baited camera-trap surveys – marginally more precise but at what cost? A response to du Preez et al. (2014). Biological Conservation 179:144–145.

Bates, D., M. Maechler, B. Bolker, S. Walker. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software 67:1-48.

Brongo, L. L., M. S. Mitchell, and J. B. Grand. 2006. Effects of trapping with bait on bait-station indices to black bear abundance. Wildlife Society Bulletin 33:1357–1361.

Burton, A. C., E. Neilson, D. Moreira, A. Ladle, R. Steenweg, J. T. Fisher, E. Bayne, and S. Boutin. 2015. Wildlife camera trapping: A review and recommendations for linking surveys to ecological processes. Journal of Applied Ecology 52:675–685.

Conover, W. 1980. Practical nonparametric statistics. Wiley, New York, NY.

Curtis, P. D., B. Boldgiv, P. M. Mattison, and J. R. Boulanger. 2009. Estimating deer abundance in suburban areas with infrared-triggered cameras. Human-Wildlife Interactions 3:116–128.

Damm, P. E. 2010. Using automated cameras to estimate wildlife populations. M.S. Thesis. Auburn University, AL.

Dickson, J. G. 1992. The wild turkey: biology & management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Doerr, T. B., and N. J. Silvy. 2002. Effects of supplemental feeding on northern bobwhite populations in south Texas. Pp. 223-240 in Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX.

Dunkley, L., and M. R. L. Cattet. 2003. A comprehensive review of the ecological and human social effects of artificial feeding and baiting of wildlife. Canadian Cooperative Wildlife Health Centre: Newsletter & Publications 21:1–70.

Fersterer, P., D. L. Nolte, and G. J. Ziegltrum. 2001. Effect of feeding stations on the home ranges of American black bears in western Washington. Ursus 12:51–54.

Gerber, B. D., S. M. Karpanty, and M. J. Kelly. 2012. Evaluating the potential biases in carnivore capture-recapture studies associated with the use of lure and varying density estimation techniques using photographic-sampling data of the Malagasy civet. Population Ecology 54:43–54.

Grenier, D., C. Barrette, and M. Crête. 1999. Food access by white-tailed deer (*Odocoileus virginianus*) at winter feeding sites in eastern Quebec. Applied Animal Behaviour Science 63:323–337.

Hall, P., J. Marron, and B. Park. 1992. Smoothed cross-validation. Probability Theory and Related Fields 92:1–20.

Harlow, R., J. Whelan, H. Crawford, and J. Skeen. 1975. Deer foods during years of oak mast abundance and scarcity. Journal of Wildlife Management 39:330–336.

Haroldson, K., M. Svihel, R. Kimmel, and M. Riggs. 1998. Effect of winter temperature on wild turkey metabolism. Journal of Wildlife Management 62:299–305.

Mathworks, Inc. 2012. MATLAB 9.2. Natick, Massachusetts.

Keever, A. C., C. P. McGowan, S. S. Ditchkoff, P. K. Acker, J. B. Grand, and C. H. Newbolt. 2017. Efficacy of N-mixture models for surveying and monitoring white-tailed deer populations. Mammal Research 62:413–422.

Keiter, D. A., A. J. Davis, O. E. Rhodes, F. L. Cunningham, J. C. Kilgo, K. M. Pepin, and J. C. Beasley. 2017. Effects of scale of movement, detection probability, and true population density on common methods of estimating population density. Scientific Reports 7:1–12.

Kernohan, B. J., R.A Gitzen, and J.J. Millspaugh. 2001. Analysis of animal space use and movements. Pp. 125-166 in J.J. Millspaugh and J.M. Marzluff (eds). Radio tracking and animal populations.Academic Press. San Diego, California.

Kiss, B. W. 2014. Survival, reproduction, movement, and habitat use of female eastern wild turkeys (Meleagris gallopavo silvestris) in Manitoba's Pembina Valley. M.S. Thesis. University of Manitoba, Winnipeg.

Koerth, B. H., C. D. Mckown, J. C. Kroll, B. H. Koerth, C. D. Mckown, and J. C. Kroll. 1997. Infrared-triggered camera versus helicopter counts of white-tailed deer. Wildlife Society Bulletin 25:557–562.

MacKenzie, D., J. Nichols, J. Royle, K. Pollock, L. Bailey, and J. Hines. 2006. Occupancy estimation and modeling. First edition. Academic Press, Burlington, MA.

McCoy, J. C., S. S. Ditchkoff, and T. D. Steury. 2011. Bias associated with baited camera sites for assessing population characteristics of deer. Journal of Wildlife Management 75:472–477.

Mills, D., J. Fattebert, L. Hunter, and R. Slotow. 2019. Maximizing camera trap data: using attractants to improve detection of elusive species in multi-species surveys. PLoS ONe 14: 1-16.

Neilson, E. W., T. Avgar, A. Cole Burton, K. Broadley, and S. Boutin. 2018. Animal movement affects interpretation of occupancy models from camera-trap surveys of unmarked animals. Ecosphere 9:e2092.

Otto, C. R. V, L. L. Bailey, and G. J. Roloff. 2013. Improving species occupancy estimation when sampling violates the closure assumption. Ecography 36:1299–1309.

Porter, W. F., G. C. Nelson, and K. Mattson. 1983. Effects of winter conditions on reproduction in a northern wild turkey population. The Journal of Wildlife Management 47:281–290.

Du Preez, B. D., A. J. Loveridge, and D. W. Macdonald. 2014. To bait or not to bait: a comparison of camera-trapping methods for estimating leopard *Panthera pardus* density. Biological Conservation 176:153–161.

Reinecke, K., and C. Shaiffer. 1988. A field test for differences in condition among trapped and shot mallards. The Journal of Wildlife Management 52:227–232.

Schlexer, F. V. 2008. Attracting animals to detection devices. Pages 263–292 *in* R. Long, P. MacKay, W. Zielinski, and J. Ray, editors. Noninvasive survey methods for carnivores. Island Press, Washington, D.C.

Silverman, B. 1986. Density estimation for statistical and data analysis. Chapman and Hall, New York, NY.

Sisson, D. C., H. L. Stribling, D. W. Speake, L. A. Brennan, W. E. Palmer, L. W. Burger, and T. L. Pruden. 2000. Effects of supplemental feeding on home range size and survival of northern bobwhites in south Georgia. Pages 128-131 *in* L.A. Brennan, W.E. Palmer, L.W. Burger, Jr., and T.L. Pruden (eds.). Quail IV: Proceedings of the Fourth National Quail

Symposium. Tall Timbers Research Station, Tallahassee, FL.

Stewart, F. E. C., J. P. Volpe, and J. T. Fisher. 2019. The debate about bait: a red herring in wildlife research. Journal of Wildlife Management 00:1–8. <http://dx.doi.org/10.1002/jwmg.21657>.

Tarr, M. D., and P. J. Pekins. 2010. Influences of winter supplemental feeding on the energy balance of white-tailed deer fawns in New Hampshire, U.S.A. Canadian Journal of Zoology 80:6–15.

Trolle, M., and M. Kéry. 2003. Estimation of ocelot density in the Pantanal using capture-recapture analysis of camera-trapping data. Journal of Mammalogy 84:607–614.

Vander Haegen, M. W., W. E. Dodge, and M. W. Sayre. 1988. Factors affecting productivity in a northern wild turkey population. Journal of Wildlife Management 52:127–133.

Yarrow, G. K., and D. T. Yarrow. 2005. Managing wildlife: on private lands and the southeast. Sweet Water Press, Birmingham, AL.

Table 3.1. The number of observations of Eastern Wild Turkeys at camera sites where they displayed an increase or decrease in probability of use (P(use)) with the presence and absence of bait.

P(use)	No Bait	Bait
Increase	905	200
Decrease	818	272

Table 3.2. Odds (OR) of an increase in P(use) when bait is present and absent and the 95% confidence limits for each eastern wild turkey (*i*) for each camera site (*j*) for each week (*w*) during 2015 - 2018 surveys and targeted tests.

		Confidence Limits	
Baited	Odds	Lower	Upper
Bait	1.77	0.87	3.62
No bait	0.90	0.55	1.45

Figure 3.1. The probability of an increase or decrease in use at camera trap sites (P(use)) by radio-marked female turkeys in response to bait on three study areas in Alabama, 2015-2018.

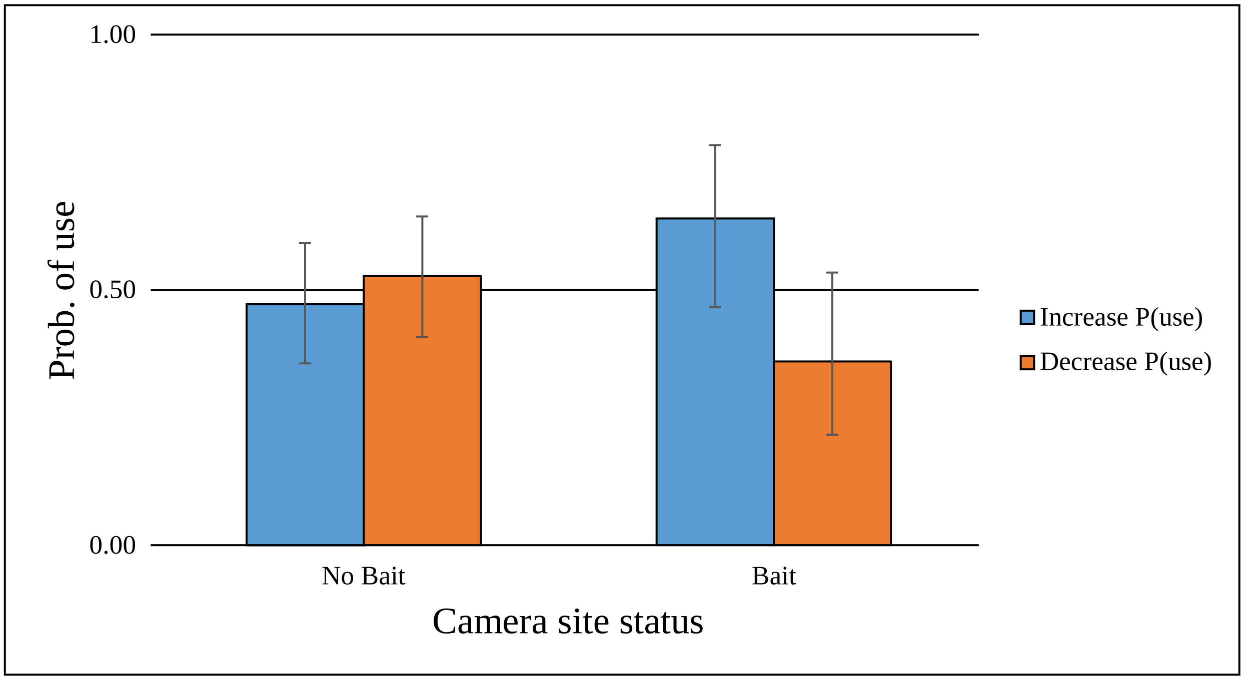
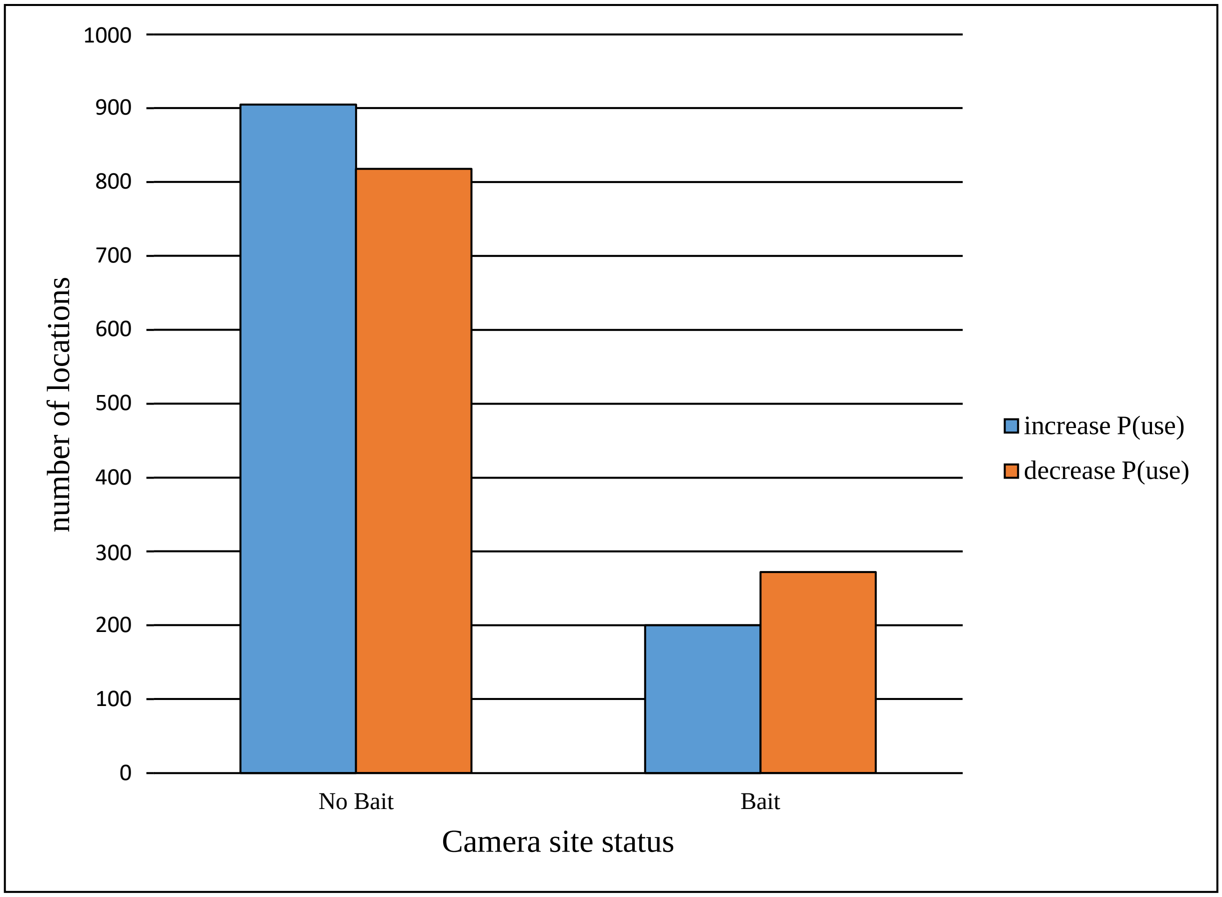


Figure 3.2. The number of observations of radio-marked female turkeys occurring at baited and unbaited camera trap sites where probability of use (P(use) by radio-marked female turkeys increased or decreased in Alabama, 2015-2018.



Appendix 2.1

During the initial analysis of my data, I was confronted with use locations that occurred within open water based on land cover categories raster data. Though these were frequent, we assumed that this was the result of errors in animal locations due to GPS error. However, most of our data were collected using from the ATS transmitter units which returned a value for horizontal dilution of precision (HDOP) with each location captured. This refers to horizontal position errors that result from the configuration of the satellite array at the time of position capture (Langley 1999). If there is a sufficient number of satellites above the transmitter at the time of capture, the HDOP value will typically register below 2.0, values larger than this will have significant errors associated with the satellite fixes. Upon examination, there were no HDOP values above 2.0 in the data set with the majority of the dataset registering far below this value. Additionally, the Lotek satellite units that were deployed returned values for the number of satellites used to generate the fix. A fix is 3D when it was generated with the signal from at least four satellites and 2D with at least three satellites (Bolis 2013). The satellite units only provided about 12.9% of our overall dataset but a majority of the fixes they provided were 3D with few 2D locations. Those locations that represented obvious error were censored from the dataset.

I isolated these suspect points, tested them in ArcMap, and found that the error points occurred in two categories within the land cover categories raster layer; values indicating water use from NLCD land cover and those values indicating water use in landform values. The errors in the NLCD values were due to raster misclassification. When raster layers are generated from aerial photography, they are digitized into pixels. Those pixels oftentimes do not correspond perfectly with the boundaries of physical ground cover (i.e., bodies of water). The locations that were classified incorrectly due to this pixel error were manually corrected to the correct adjacent land cover. The second category of suspected error points occurred from classification in the Landform layer. When isolated onto the map these locations all occurred in streambeds, drainages, and bottomlands. These areas are often seeps or are seasonally dry and rarely contain water that would prohibit movement or access by turkeys. Further, field observations of marked females at Barbour WMA in 2018 indicated the consistent use of specific drainages as a means of travel between private lands to the southeast of the management area. These observations further suggested that these drainages were of importance to turkeys.

These points along with field observations indicated underlying selection by turkeys that were occurring during the spring and summer. This proved to be of significance as my analyses during this time of the year indicated that turkey selection of broad land cover was typically in proportion to availability. This selection of river and stream bottomland disclosed resources selection occurring as a means of satisfying an unforeseen life history requirement.

Appendix 2.2

The number (n) of locations used by female turkeys and the land cover categories category (Table 2.4) in which they occurred at our seven study areas in Alabama in 2015-2018.

[1]land cover category[2]	Study area[1]						
	Bar	Ced	Dru	Oak	Sco	Sky	Uch
2112	11	0	0	10	2	1	0
2114	33	0	0	8	19	3	0
2120	3	1	0	1	0	3	0
2121	1	0	0	0	0	3	0
2122	4	1	0	7	1	1	0
2123	0	0	0	0	0	0	0
2130	47	2	3	7	19	0	4
2131	11	4	6	1	2	0	3
2133	0	0	0	0	0	2	0
2140	0	0	0	0	0	1	0
2142	0	0	1	0	0	0	0
2211	0	0	0	0	0	0	0
2214	1	0	0	0	0	0	0
2220	0	0	0	0	0	0	0
2230	2	0	0	0	1	0	0
2231	0	0	0	0	0	0	0
2330	0	0	0	0	0	0	0
2331	0	0	0	0	0	0	0
3120	0	0	0	0	0	0	0
3122	0	0	0	0	0	1	0
3123	0	0	0	0	0	0	0
3130	0	0	0	0	0	0	0
3131	0	0	0	0	0	2	0
4110	0	0	0	0	0	117	0
4111	0	0	0	0	0	124	0
4112	187	1	12	171	1	1679	13
4114	79	0	20	46	0	614	2
4120	780	45	8	201	13	723	18
4121	146	15	1	134	4	1414	2
4122	340	14	20	186	7	722	4
4123	73	7	2	57	0	1260	1
4130	412	10	110	88	6	409	22
4131	989	51	68	59	19	363	23

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

The number (n) of locations used by female turkeys and the land cover categories category (Table 2.4) in which they occurred at our seven study areas in Alabama in 2015-2018.

[1]land cover category[2]	Study area[1]						
	Bar	Ced	Dru	Oak	Sco	Sky	Uch
4133	147	32	4	66	1	386	3
4140	143	15	5	50	2	532	15
4142	20	0	0	0	0	1	0
4210	0	0	0	0	0	0	0
4211	0	0	0	0	0	0	0
4212	69	0	5	477	120	41	70
4214	114	17	8	192	206	21	29
4220	220	21	1	243	272	36	30
4221	17	0	0	78	18	13	4
4222	126	7	5	270	228	15	36
4223	11	0	0	70	14	29	5
4230	365	9	87	81	428	17	42
4231	198	8	363	118	260	124	58
4233	40	3	0	146	33	8	7
4240	9	0	4	18	12	4	1
4310	0	0	0	0	0	2	0
4311	0	0	0	0	0	5	0
4312	93	0	0	116	2	49	7
4314	51	0	5	92	1	46	2
4320	151	4	0	109	2	22	17
4321	46	1	0	72	1	34	4
4322	117	2	19	116	9	40	11
4323	7	2	0	74	1	89	1
4330	217	2	65	46	6	11	7
4331	225	3	128	33	39	22	7
4333	46	1	1	81	3	22	6
4340	14	5	3	44	14	13	1
4342	0	0	1	1	0	0	0
5210	0	0	0	0	0	2	0
5211	0	0	0	0	0	0	0
5212	71	5	0	49	50	60	8
5214	212	22	11	28	129	56	18
5220	46	8	0	11	47	24	2
5221	6	0	0	0	5	26	0
5222	63	5	0	9	100	17	0

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

The number (n) of locations used by female turkeys and the land cover categories category (Table 2.4) in which they occurred at our seven study areas in Alabama in 2015-2018.

[1]land cover category[2]	Study area[1]						
	Bar	Ced	Dru	Oak	Sco	Sky	Uch
5223	0	0	0	3	4	8	0
5230	203	4	20	36	280	52	132
5231	111	5	50	16	60	41	12
5233	5	1	0	3	26	26	1
5240	20	0	8	0	4	24	0
5242	0	0	2	0	0	0	0
7112	7	0	0	0	5	27	0
7114	13	1	0	0	18	29	1
7120	4	0	0	0	1	10	0
7121	0	0	0	0	0	6	0
7122	0	0	0	1	3	26	4
7123	0	0	0	0	1	16	0
7130	29	0	0	0	11	14	1
7131	5	0	11	0	6	8	2
7133	3	0	0	0	3	21	0
7140	1	0	0	0	0	7	0
8111	0	0	0	0	0	0	0
8112	1	0	0	0	0	14	1
8114	19	0	0	0	0	71	1
8120	0	0	0	0	0	62	0
8121	0	0	0	0	0	12	0
8122	11	0	0	0	0	9	0
8123	0	0	0	0	0	5	0
8130	26	1	10	0	0	143	0
8131	10	0	13	0	0	139	5
8133	0	0	0	0	0	84	0
8140	0	0	0	0	0	6	0
8212	0	0	0	0	0	0	0
8214	4	0	0	0	0	0	0
8220	0	0	0	0	0	2	0
8221	0	0	0	0	0	0	0
8222	0	0	0	0	0	0	0
8230	33	0	23	1	0	2	0
8231	40	0	20	0	0	87	0
8233	0	0	0	0	0	3	0

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

The number (n) of locations used by female turkeys and the land cover categories category (Table 2.4) in which they occurred at our seven study areas in Alabama in 2015-2018.

[1]land cover category[2]	Study area[1]						
	Bar	Ced	Dru	Oak	Sco	Sky	Uch
8240	3	0	0	0	0	8	0
9012	0	0	0	4	0	0	0
9014	4	0	0	1	0	0	0
9020	16	0	0	1	0	0	0
9021	0	0	0	9	0	0	0
9022	4	0	0	7	0	0	0
9023	0	0	0	6	0	0	0
9030	18	0	27	11	0	0	0
9031	251	8	241	21	0	0	7
9033	2	3	0	9	0	0	0
9040	40	1	40	13	0	25	4
9042	8	0	0	1	0	0	0
9522	0	0	0	0	0	0	0
9530	0	0	0	0	0	0	0
9531	0	0	0	0	0	0	0
9533	0	0	0	0	0	0	0
9540	1	0	0	0	0	0	0

[1]The First two digits of land cover categories class correspond to NLCD cover classes (Tale 2.2)
[2]The Third and fourth digits correspond to the Southeastern landform classification (Table 2.3)

Appendix 3.1 - Generalized linear mixed-effects model

R: A language and environment for statistical computing. Version 3.6.1. 2018.

Tidyverse package. Version 1.21. 2017.

lme4: Linear Mixed-Effects Models using 'Eigen' and S4. Version 1.1-2.1. 2019.

Generalized linear mixed model fit by maximum likelihood (Laplace

Approximation) [glmerMod]

Family: binomial (logit)

Formula: use ~ bait + (1 | Bird_ID) + (1 | Wk)

Data: datum

AIC	BIC	logLik	deviance	df.resid
2861.3	2884.1	-1426.7	2853.3	2191

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.4522	-0.8593	-0.3994	0.8940	2.5036

Random effects:

Groups	Name	Variance	Std.Dev.
Bird_ID	(Intercept)	0.1344	0.3665
Wk	(Intercept)	0.5323	0.7296

Number of obs: 2195, groups: Bird_ID, 13; Wk, 12

Fixed effects:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-0.1103	0.2459	-0.449	0.654	
baitTRUE	0.6853	0.1169	5.864	4.51e-09	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:

(Intr)

baitTRUE -0.087

bait_lc = tidy(baittest,conf.int=TRUE,effects="fixed")

effect	term	estimate	std.error	statistic	p.value	conf.low	conf.high
fixed	(Intercept)	-0.1102954	0.2458764	-0.4485805	0.6537343	-0.5922042	0.3716135
fixed	baitTRUE	0.6852786	0.1168582	5.8641903	4.51E-09	0.4562407	0.9143164