Evaluation of Reproductive Phenology and Ecology of Wild Turkey (Meleagris gallopavo) Across the Southeastern United States

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EVALUATION OF REPRODUCTIVE PHENOLOGY AND ECOLOGY OF WILD TURKEY  
(MELEAGRIS GALLOPAVO) ACROSS THE SOUTHEASTERN UNITED STATES

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Science

in

The School of Renewable Natural Resources

by

Landon Robert Schofield
B.S., The University of Idaho, 2015
December 2019
To the person who held the house down and kept the kids alive in my absence during long field seasons and late nights in the office. Emily Ann, this is as much your achievement and you deserve every bit of the credit. I couldn’t have done it without you by my side and without your endless support and encouragement. You have followed me all across the country in support of my passions and dreams. To you, “Thank You” is not adequate to express my deep appreciation to you. Love you. I would also like to dedicate this thesis to my Boy Scouts Scoutmaster and dear friend, Jerald Karel. You were the first to ignite my passion for wildlife management and that passion is what has continued to carry me on this career path.
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ABSTRACT

The primary driver of population growth and sustainability of gallinaceous birds is annual recruitment. Habitat selection by wild turkeys (*Meleagris gallopavo* spp.) during reproductive activities could influence production at multiple temporal and spatial scales. Vegetation conditions at nest sites that could drive nest success have not been clearly identified, which suggests that other factors may drive reproductive success.

Female wild turkeys maintain dominance hierarchies, which could influence how reproductively active females distribute themselves across the landscape during reproductive periods. Using high-frequency GPS data collected from reproductively active females, I analyzed nesting attempts for Eastern (*n* = 381), Gould’s (*n* = 17), and Rio Grande wild turkeys (*n* = 67) at 10 study sites during 2014 – 2017. I evaluated average daily distance traveled, size of utilization distributions, overlap of utilization distributions, and habitat selection during the pre-egg laying and egg-laying periods. I found that larger ranges during laying and less distance traveled daily during laying contributed to greater nest success. Overlap of 50% utilization distributions occurred in 59.6% of all nesting attempts (*n* = 465) and negatively impacted nest success for Eastern wild turkeys. These results suggest that movement behaviors and the spatial distribution of nesting females may be an additional component of wild turkey reproductive success.

Identifying nest sites should govern all other components of habitat selection as female wild turkeys will be tied to these locations for the duration of the reproductive period. My objective was to evaluate vegetation conditions immediately before the selection of nest sites to determine if conditions at nests were different than those available. I evaluated vegetation conditions at nest sites and presumed travel paths used by 131 nesting female wild turkeys.
used 164 nesting attempts and measured vegetation at 37,976 locations along 492 movement paths. Average vegetation height at the nest site was met or exceeded at 61–71% of random points, whereas visual obstruction was met or exceeded at 22-25%. These results indicate that vegetative conditions used by wild turkeys for nesting were not limited. This work illustrates that adequate nesting habitat may not be as limited across the landscape as previously thought, and that the process of nest site selection is time limited and likely occurs immediately prior to nest initiation.
CHAPTER 1. INTRODUCTION

The wild turkey (Meleagris gallopavo spp.) is the largest galliform in North America encompassing a vast range across the continent. In the 1900s, due to unregulated hunting and lack of sustainable habitat management, the wild turkey was almost extirpated from the United States across its range. Following extensive restoration efforts, state, federal, and non-profit organizations were able to bring the wild turkey back to sustainable population levels making it one of the most successful conservation stories in the United States. Wild turkey hunting is a popular sport and form of economic revenue. Wild turkey is the second most hunted species in the United States with approximately 2.6 million hunters pursuing wild turkeys (Harris 2006).

Ensuring a sustainable population is important to retain hunter numbers which provides a contribution of approximately $1.6 billion to the nation’s economy (Harris 2006). However, across the United States there has been a decline in wild turkey populations. Managers and researchers alike are challenged with identifying potential drivers of population decline in order to maintain sustainable populations and gain the economic benefits from the resource to invest back into conservation.

The wild turkey is a non-migratory game bird that is indigenous to North America and has a historical range that includes the continental United States, parts of southeastern Canada and northern Mexico (Mock et al. 2002). There are 6 subspecies of wild turkey including the Eastern wild turkey (Meleagris gallopavo silvestris), Gould’s wild turkey (M. g. mexicana), Merriam’s wild turkey (M. g. merriami), Rio Grande wild turkey (M. g. intermedia), and Oceola wild turkey (M. g. osceola).

Wild turkeys are generalists (Klasing 2005, Greene et al. 2010) with significant plasticity in habitat use (Porter 1992). Vegetative conditions used by turkeys during the reproductive
period (Thogmartin 1999, Chamberlain and Leopold 2000, Conley et al. 2016) and at nest sites (Chamberlain and Leopold 1998, Miller et al. 1999, Streich et al. 2015, Yeldell et al. 2017a) have been considered drivers of reproductive success, as suitable conditions were thought to be limited on the landscape. Despite the focus of understanding nest site vegetative characteristics, specific characteristics that could potentially drive reproductive success have not been clearly identified and suggest another aspect of wild turkey biology may underlie production.

Understanding the scale of habitat selection is critical to further management strategies and provide focus on how to maintain turkey populations (Collier and Chamberlain 2011). During the reproductive period of wild turkeys, habitat selection, vegetative conditions, and behavioral factors all have probability to influence nest fate. Identifying nest sites should dominate all other components of habitat selection for female wild turkeys, as individuals will be tied to these locations for the duration of the reproductive period. Contemporary research has found that habitat sampling by wild turkeys does not occur and the likelihood of visiting a nest site before nest site selection was low across all subspecies (Byrne et al. 2014, Conley et al. 2015, 2016). Thus, the sampling window for habitat conducive to nest sites may be driven by what is available during the time period immediately before the first egg is laid.

Schaap et al. (2005) suggested that the driving force behind dispersion of female Rio Grande wild turkeys during the breeding season was not availability of suitable nest sites, which were readily available in that landscape (Locke et al. 2013, Dreibelbis et al. 2015), but rather the act of buffering to separate from other breeding females. Spatial buffering may be an adaptive variation of territoriality to reduce nest or brood predation and/or avoid potential competition for resources (Brown 1964, Schaap et al. 2005), and limits on the ability to spatially buffer may lead to predator satiation or brood parasitism (Sullivan et al. 2020) within the local landscape.
Using GPS transmitters, I evaluated the selection process of wild turkeys immediately prior to the selection of nest sites and initiation of egg laying to evaluate if the characteristics found at the nest site are different from previously visited random sites. Additionally, the data allowed us to evaluate the potential relationships between space use during the reproductive period and reproductive success. In this thesis I present data from 10 study sites extending from Coronado National Forest in Arizona to the Webb Wildlife Management Area Complex in South Carolina including data from wild turkey subspecies including Eastern wild turkeys, Rio Grande wild turkeys, and Gould’s wild turkeys. Chapter 2 describes movement behaviors prior to and during egg laying and the demographic response. Chapter 3 evaluates the habitat traveled through by female wild turkeys immediately prior to nest initiation to see if availability of selected habitat was limited and to see if what was traveled through from roost to first egg being layed was different. Chapter 4 provides overall conclusions of the thesis and provides management implications and suggestions for future research.
CHAPTER 2. DEMOGRAPHIC IMPACT OF RANGE OVERLAP BY REPRODUCTIVELY ACTIVE WILD TURKEYS ACROSS THE SOUTHERN UNITED STATES.

2.1 Introduction

Social dominance and the development of social hierarchies have potential to influence aspects of avian life history (Noble 1939). Constraints resulting from social hierarchies are known to alter foraging opportunities and space use (Baker et al. 1981, Ekman and Askenmo 1984), and social hierarchies can serve as mediating factors relative to spacing and reproductive success efforts in various avian species (Ryder et al. 2009, Oh and Badyaev 2010). Birds that use mating systems centered around leks exhibit notable social hierarchies both by breeding males on leks, and reproductively active females visiting leks (Robel and Ballard Jr 1974, Foster 1983, Widemo 1997). Earlier previous works have demonstrated the importance of social hierarchies in the distribution and maintenance of female reproductive effort in various lekking species of birds (West 1967, Fretwell 1969). Ultimately, social hierarchies can influence the distribution and aggregation of breeding females on the landscape in ways that mimic nesting territories (Brown 1964, Broughton et al. 2012), descriptions of which have appeared in historical literature on numerous birds (Nice 1941, Hinde 1956).

Territoriality is an individual behavior used to regulate space use in avian populations (Howard 1920, Brown 1969). Territories are areas defended temporally, and can be characterized by both presence of an individual and patterns of individual behavior (Noble 1939). Thus, territoriality is widely recognized as a defended area, with equivalency to a range, utilized area, or activity space (Maher and Lott 1995). However, territory structure or defense may only hold during specific phenological periods (Emlen 1957) as the primary function of territoriality is to provide an assured supply of resources (Kaufmann 1983).
Territoriality is the primary population-level mechanism thought to restrict space use, in that areas with resources are defended, forcing subservient individuals into regions of lower resource quality or limited availability (Carpenter 1987, Ostfeld 1990, Yosef and Grubb 1992, Wolff 1997, Martínez-Padilla et al. 2014). Under the density-limitation hypothesis, the adaptive function of territoriality is to keep the population within carrying capacity of the habitat by limiting resource availability and reproduction (Wyrme-Edwards 1962). However, territoriality can alternatively be defined as requisite space where reproduction occurs (i.e., sexual territory, Wagner and Hill 1994) as opposed to an area defended because of critical resources (Kaufmann 1983). Therefore, territoriality could have both fitness and demographic consequences on individuals, and ultimately contribute to population regulation, but be unrelated to resource availability within the territory.

Wild turkeys (*Meleagris gallopavo* spp.) are a ground nesting uniparental galliform that use a mating system similar to exploded lekking (Emlen and Oring 1977, Kotrschal and Taborsky 2010). Wild turkeys are generalists (Klasing 2005, Greene et al. 2010) with significant plasticity in habitat use (Porter 1992). Vegetative conditions used by turkeys during the reproductive period (Thogmartin 1999, Chamberlain and Leopold 2000, Conley et al. 2016) and vegetation associations at nest sites (Chamberlain and Leopold 1998, Miller et al. 1999, Streich et al. 2015, Yeldell et al. 2017a) have long been considered drivers of reproductive success under the assumption that certain vegetation conditions are limited on the landscape. Generally, turkey nest sites are found in areas with understory vegetation (Badyaev 1995, Lehman et al. 2003, Byrne and Chamberlain 2013, Streich et al. 2015, Collier et al. 2019) and moderate canopy closure (Hillestad and Speake 1970, Streich et al. 2015, Yeldell et al. 2017a), but consensus on vegetation conditions that drive nest success is lacking (Pollentier et al. 2017, Wood et al. 2018).
Turkeys are gregarious outside of reproductive periods, during which females disband winter flocks and move into areas for nesting while generally avoiding interactions with other females during egg laying (Healy 1992, W. Healy, personal communication). Movements and range size of wild turkeys during the reproductive period are highly variable (Conley et al. 2016, Bakner et al. 2019) and how social behaviors drive spatial distribution is unknown (Miller et al. 1999, Schaap et al. 2005). Schaap et al. (2005) suggested that the driving force behind dispersion of female Rio Grande wild turkeys during the breeding season was not availability of suitable nest sites, which were readily available in that landscape (Locke et al. 2013, Dreibelbis et al. 2015), but rather the act of buffering to separate from other breeding females. Spatial buffering may be an adaptive variation of territoriality to reduce nest or brood predation and/or avoid potential competition for resources (Brown 1964, Schaap et al. 2005), and limits on the ability to spatially buffer may lead to predator satiation or brood parasitism (Sullivan et al. 2020) within the local landscape. Thus, how reproductively active female wild turkeys distribute themselves across the landscape may underlie population fitness via a density-specific response on reproductive success.

To evaluate potential relationships between space use during the reproductive period and reproductive success, I used spatio-temporal data collected on GPS tagged female wild turkeys across the southern United States to evaluate how movement behaviors prior to and during egg laying influenced nest success. My objective was to examine demographic responses to movements and space use prior to and during egg laying.

2.2 Study Area

My research was conducted at 10 study sites across the southern United States (Figure 2.1). I studied Eastern wild turkeys on the Webb Wildlife Management Area (WMA) Complex

Figure 2.1. Map of study sites and number of unique female wild turkey nesting attempts across the southern United States during 2014-2017.

The Webb WMA Complex was comprised of 3 contiguous Wildlife Management Areas (Webb, Palachacola, and Hamilton Ridge) located on the James W. Webb Wildlife Center and Management Area. The Webb WMA Complex is in Hampton and Jasper counties of South Carolina and is owned and managed by the South Carolina Department of Natural Resources. The Webb WMA Complex was 10,483 ha and consisted of mostly bottomland hardwood typical of the Savannah River and 4,673 ha of upland hardwood stands along drainages (Wightman et al. 2018). Planted and managed upland pines accounted for 3,346 ha and was composed of loblolly (Pinus taeda) and longleaf pine (Pinus palustris). Mixed-pine hardwood, wildlife openings, and wetlands comprised the remaining 2,464 ha (Wightman et al. 2018).
B. F. Grant Wildlife Management Area (BFGWMA) was owned by the Warnell School of Forestry and Natural Resources at the University of Georgia and was managed jointly by the Georgia Department of Natural Resources-Wildlife Resources Division (GADNR) and the Warnell School. B. F. Grant was dominated by loblolly pine stands, agricultural lands, mixed hardwood and pine forests, and hardwood lowlands containing mostly oaks, sweet gum, and hickory. Agricultural lands were mostly grazed mixed fescue (Festuca sp.) fields and hay fields planted for rye grass (Lolium sp.). Cedar Creek Wildlife Management Area (CCWMA) was owned by the U. S. Forest Service (USFS) and managed in partnership with GADNR. Cedar Creek was composed primarily of loblolly pine uplands, mixed hardwood and pine forests, and hardwood lowlands of similar species composition as B. F. Grant. Prescribed fire was applied on an approximately 3-5-year return interval.

The Silver Lake Wildlife Management Area (SLWMA) was owned and managed by GADNR and the adjacent Lake Seminole Wildlife Management Area was owned by the U.S. Army Corps of Engineers (USACE) and managed by GADNR in southwest Georgia. Both sites were dominated by mature pine forests and forested wetlands. Overstory species were predominately longleaf pine, loblolly pine, slash pine (P. elliottii), oaks (Quercus spp.), and sweetgum (Liquidambar styraciflua). Prescribed fire was applied on an approximately 2-3-year return interval. For a detailed description of site conditions on SLWMA, see Wood et al. (2018).

Kisatchie National Forest (KNF) was located in western Louisiana, was owned and managed by the USFS, and was divided into 5 Ranger Districts. My research was conducted on the Kisatchie Ranger District, Winn Ranger District, and the Vernon Unit of the Calcasieu Ranger District located in Natchitoches, Winn, and Vernon parishes, respectively. Collectively, the Kisatchie Ranger District, Winn Ranger District, and the Vernon Unit area were
approximately 41,453 ha, 67,408 ha, and 61,202 ha, respectively (Yeldell et al. 2017b). The KNF was composed of pine-dominated forests, hardwood riparian areas, and forested wetlands, with forest openings and forest roads distributed throughout. Overstory trees included loblolly pine, longleaf pine, shortleaf pine, slash pine, sweetgum, oaks, and hickories (Carya spp.) (Yeldell et al. 2017b).

Peason Ridge Wildlife Management Area (PRWMA) consisted of 30,070 ha located in Sabine, Natchitoches, and Vernon parishes of west-central Louisiana. The PRWMA was part of a noncontiguous U.S. Army training area located north of Fort Polk and consisted of U.S. Army and USFS lands. Over 80% of PRWMA area was unmanaged pine plantation that consist primarily of loblolly pine.

My Caddo Parish research site was in northwest Louisiana north of Greenwood, Louisiana. Between 2014 and 2016, 32 turkeys (5 males, 27 females) were re-introduced on private property as part of a Louisiana Department of Wildlife and Fisheries restocking project. No turkeys were present within the parish prior to these restockings (C. Cedotal, personal communication). Private properties accessed at Caddo were primarily managed for timber and hunting/private recreational purposes. Dominant tree species included loblolly pine and slash pine with interspersed hardwood-pine stands in bottomland areas.

The Angelina National Forest (ANF) was in south eastern Texas and was owned and managed by the USFS. During 2016 and 2017, 101 turkeys (23 males, 78 females) from Iowa, West Virginia, and Missouri were re-introduced as part of a Texas Parks and Wildlife restocking project. The ANF was comprised of 62,423 ha covering San Augustine, Angelina, Jasper, and Nacogdoches counties. The area was pine dominated with hardwood riparian zones. Overstory stands in the ANF included loblolly pine, shortleaf pine, longleaf pine, sweetgum, and oaks.
My research in south central Texas (District 7) was conducted on a suite of (>200ha) private lands widely distributed across multiple ecoregions that were broadly interspersed across Caldwell, DeWitt, Fayette, Gonzales, Jackson, and Lavaca counties. Ecoregions included the post-oak savannah, blackland prairie, and the South Texas plains. Dominant overstory of the post-oak savannah consisted of post oak (*Quercus stellata*) and live oak (*Quercus virginiana*). The blackland prairie consisted of grasslands and parks consisting of live oak, sugarberry (*Celtis laevigata*), mesquite (*Prosopis glandulosa*) and huisache (*Acacia farnesiana*). The South Texas plains consisted of mesquite, Texas persimmon (*Diospyros texana*), algerita (*Mahonia trifoliolata*), lotebush (*Ziziphus obtusifolia*), pricklypear (*Opuntia engelmannii*) and tasajillo (*Opuntia leptocaulis*).

The Coronado National Forest (CNF) in southeastern Arizona was owned and managed by the USFS and included an area of 720,340 ha. My study sites were within the sky islands connecting the Sierra Madre Occidental to the Rocky Mountains, and included the Pinaleño, Chiricahua, Huachuca, and Patagonia Mountains located in Graham, Cochise, and Santa Cruz counties. Landscapes included semidesert grasslands, madrean evergreen woodlands, petran montane conifer forests, and petran subalpine conifer forests. Semidesert grasslands consisted of catclaw acacia (*Acacia greggii*), Parry's agave (*Agave parryi*), and Soaptree yucca (*Yucca elata*). Madrean evergreen woodland consisted of Emory oak (*Quercus emoryi*), Arizona White Oak (*Q. arizonica*), and Alligator Juniper (*Juniperus deppeana*). Petran montane conifer forest consisted of Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and New Mexico locust (*Robinia neomexicana*). Petran subalpine conifer forest consisted of Engelmann spruce (*Picea engelmannii*) and Douglas fir (*P. menziesii*). Riparian corridors were also found along steep slopes and ravines often consisting of Arizona sycamore (*Platanus wrightii*) and Fremont
2.3 Methods

Female Eastern wild turkeys were captured using rocket nets (Wunz 1984), Gould’s wild turkeys using walk in traps (Davis 1994, Peterson et al. 2003) and Rio Grande wild turkeys using walk in traps and drop nets (Glazener et al. 1964) during January–March, 2014–2017. I classified individuals as juvenile or adult based on the presence of barring on the ninth and tenth primary feathers (Pelham and Dickson 1992). Eastern wild turkeys and Rio Grande wild turkeys were fitted with a numbered, riveted aluminum tarsal band, whereas Gould’s wild turkeys were given an alphanumeric color-coded patagial tag. All individuals were fitted with a backpack-style GPS transmitter (Guthrie et al. 2011) equipped with a very high frequency (VHF) signal and mortality sensor. Each unit weighed approximately 88 g (Lotek Minitrack Backpack L or Lotek Pinpoint Backpack; Lotek Wireless, Newmarket, Ontario, Canada). Transmitters were programmed to collect data at 1-hr. intervals (Cohen et al. 2018) between 0500 to 2000 daily with one location at 23:58:58 to identify roost sites. All birds were released at the capture site immediately after processing. Capture myopathy within 3 weeks post-release was < 4%. The Institutional Animal Care and Use Committee at Louisiana State University (Protocol #A2015-07) and University of Georgia (Protocol #A2014 06-008-Y1-A0 and A3437-01) approved capture and handling protocols.

Daily live-dead status was monitored daily during the reproductive season using handheld Yagi antennas and R4000 (Advanced Telemetry Systems, Inc., Isanti, MN) or Biotracker (Biotrack Ltd., Wareham, Dorset, UK) receivers. GPS locations were downloaded ≥ 1 time per week via a VHF/UHF handheld command unit receiver (Biotrack Ltd., Wareham,
Dorset, UK). I viewed GPS locations and determined incubation when female locations became concentrated around a single point for several days (Collier and Chamberlain 2011, Conley et al. 2015, Yeldell et al. 2017a, Wood et al. 2018). Nesting females were not disturbed or flushed from nest sites during monitoring, but instead were live–dead checked daily via VHF from a distance of > 20 m.

To determine date of nest initiation (i.e. initiation of egg laying) and date of incubation initiation I mapped the spatial-temporal data using ArcGIS 10.3.1 (Environment Systems Research Institute, Redlands, California, USA). Locations were evaluated hourly until incubation start date was determined (Byrne et al. 2014, Conley et al. 2015, 2016). Once the incubation start date was determined, I evaluated hourly locations for the previous 20 days and determined when a female initially visited the nest site (defined as location being <20m from the known nest site, Conley et al. (2016). Date of first visit was recorded as the date of nest initiation and used as the beginning of the laying period as wild turkeys rarely visit nest sites before laying the first egg (Conley et al. 2016, Collier et al. 2019). Wild turkeys require approximately 27 days of continuous incubation to complete nesting (Williams et al. 1971), but incubation can vary from 25 to 29 days (Healy 1985). Therefore, I considered a nest to have been depredated or abandoned if the female left the nest ≤ 25 days into incubation, or if only intact eggs, no eggs, or egg fragments were found at the nest bowl. Following Yeldell et al. (2017a), after nest termination, nest sites were located to determine nest fate (Yeldell et al. 2017a, Wood et al. 2018).

Previous research has defined the pre-laying period as 45 days before initiation of nest incubation (Chamberlain and Leopold 2000, Conley et al. 2016). However, recent studies correlating male gobbling chronology and female reproductive phenology have shown limited
evidence of reproductive activity prior to 15 March (Chamberlain et al. 2018, Wightman et al. 2018). As such, I limited my estimates of the pre-laying period to the number of days from 15 March to nest initiation (onset of laying). I acknowledge that I generalized timing from Eastern wild turkeys to Rio Grande wild turkeys which have similar reproductive phenology (Melton et al. 2011, Conley et al. 2015), and Gould’s which have a poorly understood reproductive phenology (Collier et al. 2019). I excluded nesting attempts initiated prior to 15 March \( (n = 3) \) from my analysis. For all renesting attempts, I defined the pre-laying period as beginning on the day following the prior attempt’s date of termination but limited the pre-laying period for any renesting attempt to \( \leq 45 \) days.

For each female, I estimated average daily distance traveled for both the pre-laying and laying periods for each nesting attempt. I estimated average daily distance traveled by summing the total distance traveled for each day within the respective period (number of days pre-laying or laying) and divided by the length (in days) of the respective period. Next, I estimated range size for pre-laying and laying periods for each female using a dynamic Brownian Bridge movement model (dBBMM) to build utilization distributions (UD) at 50% and 99% (Byrne et al. 2014, Cohen et al. 2018). I calculated all UDs in program R version 3.5.2 (R Core Team 2018) using package move (Kranstauber and Smolla 2013). The dBBMM requires a time indexed series of animal locations, an estimate of mean telemetry error for each location, and an estimate of Brownian motion variance \( (\sigma^2) \) which is a measure of irregularity in movements. I used a constant window and margin size equal to 21 and 9 respectively, and a location error of 20m (Byrne et al. 2014). Window and margin size were kept constant rather than varying to account for changes in GPS sampling frequency because I found no measurable effects of altering these values when I began my analysis (Cohen et al. 2018). Range overlap is an effective measure of
shared space use and can be used to evaluate the degree of interaction among individuals (Kernohan et al. 2001), so I used logistic regression to estimate the probability of nest success as a function of range overlap by nesting attempt and site, categorizing overlap as a 1 if overlap occurred and 0 if not.

For analysis, I used an independent 2-group t-test with an \( \alpha = 0.05 \) in R version 3.5.2 (R Core Team 2018) to evaluate differences between movement distances during pre-laying and laying. Next, I used generalized linear models within R (R Core Team 2018) to estimate the impact of pre-laying period UD size, average daily distance traveled during pre-laying, laying period UD size, average daily distance traveled during laying, laying period UD overlap, and length of laying period, on the probability of nest success.

I used Landsat 8 satellite data from the USGS Earth Explorer to estimate the proportion of habitat types within each pre-laying and laying range for reproductively active females. I used images from Landsat Operational Land Imager (OLI) 30 m resolution during the month of May to classify habitat types during the nesting season. Only images with less than 10% cloud cover were used. As I was working across multiple ecotypes, I used an unsupervised classification in ERDAS Image software (Hexagon Geospatial, Norcross, GA) with 30 classes to better define pixels. Based on 2 years of ground truthing data at a suite of study sites, I recoded and combined classes to create 6 unique habitat classes (water, coniferous, deciduous, mixed coniferous-deciduous, open/road and infrastructure). Landcover proportions were calculated by overlaying individual utilization distributions on the classified landcover image and calculating the pixels of each habitat class within the UD divided by the overall number of pixels. For my analysis, I used generalized linear models within R version 3.5.2 (R Core Team 2018) to predict the impact of 50% UD vegetation characteristics of both pre-laying & laying periods, pre-laying period UD
size, pre-laying period average daily distance traveled (ADD), laying-period UD size, laying-period ADD, laying-period UD overlap, and length of laying-period on probability of nest success.

2.4 Results

I used 465 nesting attempts (Table 2.1) by 331 females (293 adults, 38 juveniles) from 2014–2017 (Table 2.2).

Table 2.1. Nesting attempts (n) by female wild turkeys separated by subspecies, study site and attempt number during 2014-2017 on Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex).

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>n</th>
<th>Subspecies</th>
<th>Attempt 1</th>
<th>Attempt 2</th>
<th>Attempt 3</th>
<th>Attempt 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>2016-2017</td>
<td>46</td>
<td>Eastern</td>
<td>32</td>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>BFGWMA</td>
<td>2017</td>
<td>15</td>
<td>Eastern</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Caddo</td>
<td>2016</td>
<td>7</td>
<td>Eastern</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CCWMA</td>
<td>2017</td>
<td>41</td>
<td>Eastern</td>
<td>28</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>CNF</td>
<td>2017</td>
<td>17</td>
<td>Gould</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>District 7</td>
<td>2016-2017</td>
<td>67</td>
<td>Rio Grande</td>
<td>49</td>
<td>15</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>KNF</td>
<td>2014-2015, 2017</td>
<td>101</td>
<td>Eastern</td>
<td>63</td>
<td>29</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>PRWMA</td>
<td>2016-2017</td>
<td>43</td>
<td>Eastern</td>
<td>32</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>SL</td>
<td>2015-2016</td>
<td>67</td>
<td>Eastern</td>
<td>45</td>
<td>20</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>2014-2017</td>
<td>61</td>
<td>Eastern</td>
<td>52</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2.2. Number of nesting attempts by female wild turkeys across study areas and states during 2014–2017.

<table>
<thead>
<tr>
<th>Site</th>
<th>State</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angelina National Forest</td>
<td>Texas</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>B.F. Grant WMA</td>
<td>Georgia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Caddo Parish</td>
<td>Louisiana</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Cedar Creek WMA</td>
<td>Georgia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Coronado National Forest</td>
<td>Arizona</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>District 7</td>
<td>Texas</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>39</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>South Carolina</td>
<td>3</td>
<td>15</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Kisatchie national Forest</td>
<td>Louisiana</td>
<td>37</td>
<td>27</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>Peason Ridge WMA</td>
<td>Louisiana</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>Silver Lake WMA</td>
<td>Georgia</td>
<td>0</td>
<td>38</td>
<td>29</td>
<td>0</td>
</tr>
</tbody>
</table>
Average pre-laying period length across all sites and years was 24.5 days (SD = 12.9 days, range = 2–45) and average laying period length was 11.7 days (SD = 2.9 days, range 3–22; Figure 2.2).

Figure 2.2. Length of egg-laying days across all study sites: Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFG), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CC), Coronado National Forest (CNF), South Central Texas (D7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PR), and Webb Wildlife Management Area Complex (Webb).

Average daily distance traveled by females during the laying period ($\bar{x} = 2907$, SD = 678 m) was greater than during the pre-laying period ($\bar{x} = 2596$, SD = 656 m, $t = 7.10$, df = 927, $P<0.01$) for all sites except in Caddo Parish (translocated females, Figure 2.3).
Figure 2.3. Average daily distance traveled (m) and mean utilization distribution size during the pre-laying and laying periods for female wild turkeys on Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex) during 2014-2017.

For females in translocated populations, pre-laying 50 and 99% UDs averaged 70 ha (SD = 96, range = 1–590) and 1,460 ha (SD = 1,762, range = 79–10,491), whereas in established populations the pre-laying 50 and 99% UDs averaged 35 ha (SD = 25, range = 0.12–174 ha) and 490 ha (SD = 377, range = 51–3,976) respectively. The 50 and 99% UDs during laying for translocated populations averaged 29 ha (SD = 20, range = 4–92) and 324 ha (SD = 252, range = 44–1,408), whereas for established populations they averaged 28 ha (SD = 16, range = 1–133) and 239 ha (SD = 165, range = 1–2,123) respectively. Core use UDs of translocated females pre-laying rangers were 43% larger than established populations ($t = 2.52$, df = 70, $P = 0.007$)
and laying periods were 8% larger than established populations ($t = 0.77$, df = 76, $P = 0.221$).

Ninety-nine percent UD of translocated females pre-laying rangers were 62% larger than established populations ($t = 4.12$, df = 69, $P = 0.00005$) and ranges during laying periods were 35% larger than established populations ($t = 2.99$, df = 71, $P = 0.002$) (Table 2.3).

Table 2.3. Mean area (ha) of ranges and associated standard deviations (SD) for both the 99% and 50% utilization distribution (UD) during the pre-laying and laying periods of female wild turkeys on Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex) during 2014-2017.

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Pre-laying 99 UD</th>
<th>Laying Period 99 UD</th>
<th>Pre-laying 50 UD</th>
<th>Laying Period 50 UD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>46</td>
<td>1408 (1826)</td>
<td>286 (199)</td>
<td>58 (88)</td>
<td>25 (17)</td>
</tr>
<tr>
<td>BFGWMA</td>
<td>15</td>
<td>480 (511)</td>
<td>222 (106)</td>
<td>34 (14)</td>
<td>27 (13)</td>
</tr>
<tr>
<td>Caddo</td>
<td>7</td>
<td>1760 (1118)</td>
<td>561 (410)</td>
<td>147 (102)</td>
<td>50 (19)</td>
</tr>
<tr>
<td>CCWMA</td>
<td>41</td>
<td>381 (137)</td>
<td>238 (103)</td>
<td>30 (16)</td>
<td>29 (14)</td>
</tr>
<tr>
<td>CNF</td>
<td>17</td>
<td>699 (594)</td>
<td>444 (525)</td>
<td>36 (34)</td>
<td>33 (38)</td>
</tr>
<tr>
<td>District 7</td>
<td>67</td>
<td>453 (297)</td>
<td>192 (98)</td>
<td>30 (23)</td>
<td>19 (10)</td>
</tr>
<tr>
<td>KNF</td>
<td>101</td>
<td>596 (501)</td>
<td>277 (137)</td>
<td>38 (27)</td>
<td>35 (15)</td>
</tr>
<tr>
<td>PRWMA</td>
<td>43</td>
<td>596 (421)</td>
<td>239 (137)</td>
<td>48 (36)</td>
<td>27 (12)</td>
</tr>
<tr>
<td>SL</td>
<td>67</td>
<td>375 (210)</td>
<td>192 (77)</td>
<td>27 (17)</td>
<td>24 (10)</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>61</td>
<td>424 (215)</td>
<td>223 (139)</td>
<td>38 (16)</td>
<td>26 (15)</td>
</tr>
</tbody>
</table>

Across all 3 subspecies, females who traveled less distance daily during the pre-laying period had a higher probability of nest success (Figure 2.4).
Figure 2.4. Probability of nest success relative to average daily distance traveled during the pre-laying period for female wild turkey of subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GOULD).
Likewise, female Eastern and Gould’s who traveled less distance daily during the laying period had higher nest success, whereas Rio Grande females did not (Figure 2.5).
Figure 2.5. Probability of nest success relative to average daily distance traveled during the laying-period for female wild turkey of subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GOULD).
Probability of nest success increased as 50% UD area increased for Eastern and Rio Grande females and decreased as 50% UD area increased for Gould’s (Figure 2.6).
Figure 2.6. Probability of nest success relative to area of 99% utilization distribution for female wild turkey during the laying period for subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GOULD).
Probability of nest success for Eastern wild turkeys was not influenced by estimated 99% UD area, but it increased for Rio Grande and decreased for Gould’s as the 99% UD area increased (Figure 2.7).
Figure 2.7. Probability of nest success relative to area of 50% utilization distribution for female wild turkey during the laying period for subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GOULD).
For 50% laying range UDs, the percentage of females who had overlapping ranges during temporally synchronous nesting attempts was 59.6% (Table 2.4) with an average proportional area of overlap of 12.4%. The percentage of overlapping ranges increased for the 99% laying period UD to 84.5% across sites and years (Table 2.4).

Table 2.4. Percentage of overlap between laying period 50% and 99% utilization distributions (UD) of female wild turkeys including the proportion of overlapping ranges (% of Site Total) per study site on Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex) during 2014-2017.

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>n</th>
<th>50% UD (% of Site Total)</th>
<th>99% UD (% of Site Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>2016-2017</td>
<td>46</td>
<td>29 (63%)</td>
<td>39 (84.8%)</td>
</tr>
<tr>
<td>BFGWMA</td>
<td>2017</td>
<td>15</td>
<td>9 (60%)</td>
<td>11 (73.3%)</td>
</tr>
<tr>
<td>Caddo</td>
<td>2016</td>
<td>7</td>
<td>3 (42.8%)</td>
<td>3 (42.9%)</td>
</tr>
<tr>
<td>CCWMA</td>
<td>2017</td>
<td>41</td>
<td>33 (80.4%)</td>
<td>40 (97.6%)</td>
</tr>
<tr>
<td>CNF</td>
<td>2017</td>
<td>17</td>
<td>10 (58.8%)</td>
<td>11 (64.7%)</td>
</tr>
<tr>
<td>District 7</td>
<td>2016-2017</td>
<td>67</td>
<td>45 (67.2%)</td>
<td>52 (77.6%)</td>
</tr>
<tr>
<td>KNF</td>
<td>2014-2015, 2017</td>
<td>101</td>
<td>73 (72.2%)</td>
<td>91 (90.1%)</td>
</tr>
<tr>
<td>PRWMA</td>
<td>2016-2017</td>
<td>43</td>
<td>21 (28%)</td>
<td>28 (65.1%)</td>
</tr>
<tr>
<td>SL</td>
<td>2015-2016</td>
<td>67</td>
<td>65 (97%)</td>
<td>67 (100%)</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>2014-2017</td>
<td>61</td>
<td>43 (70.4%)</td>
<td>51 (83.6%)</td>
</tr>
</tbody>
</table>

Predicted nest success for Eastern wild turkeys did not differ for either the 50 or 99% UDs between overlapping or non-overlapping ranges (Table 2.5). Conversely, predicted nest success for Gould’s females was approximately 20% higher for individuals whose 50 and 99% UDs overlapped other females, but my estimates had considerable uncertainty. For Rio Grande wild turkeys at both UD areas, nest success was predicted to be 5-10% higher when no overlap of 50 or 99% UDs occurred (Table 2.5).
Table 2.5. Probability of nest success relative to overlap of laying period utilization distributions (UD) for female Eastern (EWT), Gould’s (Gould) and Rio Grande (RGWT) wild turkeys on 10 study sites during 2014-2017.

<table>
<thead>
<tr>
<th>Subspecies</th>
<th>UD</th>
<th>No Overlap</th>
<th>Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWT</td>
<td>50%</td>
<td>0.19 (0.12-0.27)</td>
<td>0.22 (0.17-0.27)</td>
</tr>
<tr>
<td></td>
<td>99%</td>
<td>0.25 (0.14-0.37)</td>
<td>0.21 (0.16-0.25)</td>
</tr>
<tr>
<td>Gould</td>
<td>50%</td>
<td>0.57 (0.20-0.94)</td>
<td>0.70 (0.42-0.98)</td>
</tr>
<tr>
<td></td>
<td>99%</td>
<td>0.50 (0.10-0.90)</td>
<td>0.73 (0.46-0.99)</td>
</tr>
<tr>
<td>RGWT</td>
<td>50%</td>
<td>0.14 (0.01-0.28)</td>
<td>0.09 (0.01-0.17)</td>
</tr>
<tr>
<td></td>
<td>99%</td>
<td>0.20 (0.01-0.40)</td>
<td>0.08 (0.01-0.15)</td>
</tr>
</tbody>
</table>

The coniferous habitat class was the dominant vegetation class across all sites except for District 7 and Webb WMA Complex. District 7 consisted more of open/road classification class ($\bar{x}=0.73$, SD=0.42, Range = 0‒0.96), and Webb WMA Complex consisted primarily of mixed coniferous-deciduous ($\bar{x}=0.55$, SD=0.24, Range = 0‒0.9) (Table 2.6 and 2.7).

Table 2.6. Average landcover class proportions for the 99% UD for the pre-laying period. Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex).

<table>
<thead>
<tr>
<th>Site</th>
<th>Water (SD)</th>
<th>Deciduous (SD)</th>
<th>Coniferous (SD)</th>
<th>Mixed (SD)</th>
<th>Open/Road (SD)</th>
<th>Infrastructure (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>0.04 (0.03)</td>
<td>0.10 (0.04)</td>
<td>0.49 (0.16)</td>
<td>0.32 (0.14)</td>
<td>0.04 (0.02)</td>
<td>0.01 (0.00)</td>
</tr>
<tr>
<td>BFGWMA</td>
<td>0.03 (0.02)</td>
<td>0.04 (0.02)</td>
<td>0.66 (0.08)</td>
<td>0.17 (0.05)</td>
<td>0.10 (0.05)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>Caddo</td>
<td>0.02 (0.00)</td>
<td>0.09 (0.02)</td>
<td>0.53 (0.06)</td>
<td>0.15 (0.02)</td>
<td>0.20 (0.07)</td>
<td>0.01 (0.00)</td>
</tr>
<tr>
<td>CCWMA</td>
<td>0.01 (0.01)</td>
<td>0.01 (0.01)</td>
<td>0.77 (0.08)</td>
<td>0.15 (0.05)</td>
<td>0.06 (0.04)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>CNF</td>
<td>0.26 (0.05)</td>
<td>0.00 (0.00)</td>
<td>0.70 (0.04)</td>
<td>0.04 (0.03)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>District 7</td>
<td>0.09 (0.06)</td>
<td>0.21 (0.12)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.68 (0.42)</td>
<td>0.02 (0.03)</td>
</tr>
<tr>
<td>KNF</td>
<td>0.02 (0.02)</td>
<td>0.05 (0.05)</td>
<td>0.72 (0.14)</td>
<td>0.13 (0.10)</td>
<td>0.06 (0.07)</td>
<td>0.02 (0.03)</td>
</tr>
<tr>
<td>PRWMA</td>
<td>0.02 (0.04)</td>
<td>0.15 (0.11)</td>
<td>0.40 (0.13)</td>
<td>0.31 (0.10)</td>
<td>0.07 (0.05)</td>
<td>0.05 (0.03)</td>
</tr>
<tr>
<td>SL</td>
<td>0.03 (0.02)</td>
<td>0.17 (0.13)</td>
<td>0.60 (0.10)</td>
<td>0.07 (0.10)</td>
<td>0.10 (0.09)</td>
<td>0.03 (0.02)</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>0.04 (0.03)</td>
<td>0.12 (0.09)</td>
<td>0.24 (0.19)</td>
<td>0.50 (0.24)</td>
<td>0.07 (0.05)</td>
<td>0.03 (0.01)</td>
</tr>
</tbody>
</table>
Table 2.7. Average landcover class proportions for the 99% UD for the laying-period. Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PRWMA), and Webb Wildlife Management Area Complex (Webb WMA Complex).

<table>
<thead>
<tr>
<th>Site</th>
<th>Water</th>
<th>Deciduous</th>
<th>Coniferous</th>
<th>Mixed</th>
<th>Open/Road</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>0.06 (0.07)</td>
<td>0.12 (0.06)</td>
<td>0.42 (0.21)</td>
<td>0.34 (0.18)</td>
<td>0.06 (0.06)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>BFGWMA</td>
<td>0.03 (0.02)</td>
<td>0.04 (0.03)</td>
<td>0.67 (0.11)</td>
<td>0.17 (0.05)</td>
<td>0.09 (0.06)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>Caddo</td>
<td>0.02 (0.01)</td>
<td>0.12 (0.04)</td>
<td>0.48 (0.14)</td>
<td>0.13 (0.06)</td>
<td>0.24 (0.12)</td>
<td>0.01 (0.00)</td>
</tr>
<tr>
<td>CCWMA</td>
<td>0.01 (0.02)</td>
<td>0.01 (0.01)</td>
<td>0.77 (0.09)</td>
<td>0.14 (0.04)</td>
<td>0.06 (0.05)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>CNF</td>
<td>0.27 (0.06)</td>
<td>0.00 (0.00)</td>
<td>0.70 (0.04)</td>
<td>0.03 (0.03)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>District 7</td>
<td>0.05 (0.07)</td>
<td>0.20 (0.11)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.39 (0.43)</td>
<td>0.02 (0.03)</td>
</tr>
<tr>
<td>KNF</td>
<td>0.02 (0.03)</td>
<td>0.05 (0.06)</td>
<td>0.72 (0.16)</td>
<td>0.13 (0.11)</td>
<td>0.07 (0.08)</td>
<td>0.02 (0.03)</td>
</tr>
<tr>
<td>PRWMA</td>
<td>0.02 (0.04)</td>
<td>0.12 (0.09)</td>
<td>0.43 (0.15)</td>
<td>0.30 (0.11)</td>
<td>0.07 (0.05)</td>
<td>0.05 (0.05)</td>
</tr>
<tr>
<td>SL</td>
<td>0.04 (0.04)</td>
<td>0.17 (0.13)</td>
<td>0.61 (0.11)</td>
<td>0.07 (0.11)</td>
<td>0.09 (0.09)</td>
<td>0.01 (0.01)</td>
</tr>
<tr>
<td>Webb WMA Complex</td>
<td>0.06 (0.06)</td>
<td>0.11 (0.08)</td>
<td>0.28 (0.23)</td>
<td>0.50 (0.27)</td>
<td>0.04 (0.06)</td>
<td>0.01 (0.01)</td>
</tr>
</tbody>
</table>

Proportion of use of the analyzed habitat classes during both the pre-laying and laying periods influenced probability of nesting success equally with the exception of water. For Eastern wild turkeys and Gould’s wild turkeys, the use of water between the pre-laying and laying periods influenced nest success inversely (Figure 2.8 and 2.9).
Figure 2.8. Probability of nest success relative to the dominant habitat classes (water, deciduous, coniferous, mixed coniferous-deciduous, open/road, and infrastructure) found within 50% utilization distribution for female wild turkey during the pre-laying period for subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GWT).
Figure 2.9. Probability of nest success relative to the dominant habitat classes (water, deciduous, coniferous, mixed coniferous-deciduous, open/road, and infrastructure) found within 50% utilization distribution for female wild turkey during the laying period for subspecies Eastern wild turkey (EWT), Rio Grande wild turkey (RGWT), and Gould wild turkey (GWT)
2.5 Discussion

Demographic consequences of movements to reproductively active wild turkeys are poorly understood (Conley et al. 2015, 2016), although contemporary studies have begun detailing relationships between individual movements and reproductive fitness (Bakner et al. 2019). Increasing evidence suggests that vegetative associations at nest sites have limited utility in predicting nest success (Conley et al. 2015, Pollentier et al. 2017, Wood et al. 2018), so improving our collective understanding of how female behaviors during the reproductive period may influence nest success is necessary. Conley et al. (2015, 2016) suggested that reproductively active wild turkeys and other ground-nesting species show considerable plasticity in habitat selection. However, once egg laying begins, female movements are restricted to a range that includes the nest site until the clutch is completed, at which point females are constrained to even smaller incubation ranges (Bakner et al. 2019). My results show that during the pre-laying period, females move relatively less per day within larger ranges, whereas during laying, movements increase within smaller ranges. Under the theory of adaptive site familiarity, behavioral decisions driving movement should be influenced by familiarity with local conditions (Matthiopoulos et al. 2005). However, (Conley et al. 2016) reported that female wild turkeys were typically not familiar with areas surrounding nest sites, as they did not visit these sites prior to nest initiation. Hence, my findings that females increased movements during laying could be associated with females prospecting areas within their ranges to find, assess, and use resources around nest sites. Plausibly, these movements would have fitness consequences, but that is unclear for wild turkeys (Burkhalter et al. 2015, Davis et al. 2016, Fasciolo et al. 2016). Regardless, I offer that increased movements during laying are a behavioral response consistent
with findings detailed in Conley et al. (2016), as females begin to increase prospecting of available resources within close proximity to nests once laying has begun.

Analysis of UD overlap is useful for assessing the degree of interaction among individuals (Fieberg and Kochanny 2005). Overlap of 50% UDs during the laying period occurred in 59.6% of the total nesting attempts and increased to 84.5% when I evaluated the 99% laying period Uds. The overlap of the laying period areas could provide insight into the role of space use behaviors by reproductively active females (Schaap et al. 2005). My results indicated positive benefits of utilization distribution size on nest success, but no positive benefit of utilization overlap on nest success.

Wild turkeys are thought to avoid interactions with conspecifics during the nesting period (W. Healy, personal Communication). However, perhaps there is a threshold in preferred space between other reproductively active individuals. A preference to nest within an unspecified proximity to other individuals may include benefits of queueing off of others behavior (Nicol 2006, Thornton and Raihani 2008). However, reducing nest predation via increased vigilance (Picman 1988, Quinn and Ueta 2008) or spatial location within a nesting group (Brunton 1997) could benefit individuals nesting in rough associations. Additionally, it is plausible that there are benefits of relatedness between neighboring individuals (Krakauer 2008) and nest parasitism (Rohwer and Freeman 1989, Sullivan et al. 2020) on reproductively active wild turkeys. Finally, it is plausible that wild turkey sibling/breeding groups show prior rights, or the specific utilization of areas for nesting, similar to land tenure in felids (Diefenbach et al. 2006).

My results support the contention outlined by Schaap et al. (2005), in that dispersion of female wild turkeys during the breeding season may be related to spatial buffering and resource identification in reproductive areas. Individuals should select vegetative conditions that
maximize reproductive success (Conley et al. 2016, Yeldell et al. 2017b, Wood et al. 2018), but demographic benefits to wild turkeys may not be driven by vegetative associations on the landscape. I recognize that other un-marked individuals were present on the landscape and were engaged in the same reproductive activities. However, as I observed similar response of high overlap of reproductively active females (>50% of marked individuals) I suggest that any limitations based on available nesting habitat is not likely the most important driver of demographic response. Rather, density-specific drivers related to reduced exposure to predators, preference for isolation, individual queueing, or selection of nesting areas by breeding groups may be driving spatial selection and subsequent demographic response by reproductively active wild turkeys.
CHAPTER 3. MEASURING CONGRUENCE BETWEEN WILD TURKEY NEST SITES AND AVAILABLE VEGETATION.

3.1 Introduction

The process of habitat selection influences species demography at multiple spatial scales. Habitat selection differs from use or association, as it implies informed choice and is commonly measured relative to availability of certain conditions or as use versus non-use (Mayor et al. 2009, Cunningham and Johnson 2012). Habitat selectivity is assumed to be adaptive in that preferred habitats will yield higher fitness. By definition, selection is required to have positive benefits to species demography (Jones 2001), thus variation in habitat quality should favor individuals that choose habitats that yield the greatest reproductive success and survival (Martin 2004).

It is widely recognized that habitat selection is an inherently scale-sensitive process (Mayor et al. 2009) ranging from organizational (Hutto 1985, Morris 1987), environmental or geographic (Kotler and Brown 1988, Danell et al. 1991), behavioral (Johnson et al. 2002, Revilla et al. 2004), to spatial (Holland et al. 2004) and temporal selection (Fortin et al. 2002).

Reproductive success and individual fitness may be greatly influenced by the scales at which individuals select habitat (Schmutz et al. 1989, Mayor et al. 2009). Thus, habitat selection is regularly presented as a hierarchical process where an individual first selects a location to live (i.e. range) and then searches and selects locations within its range specific to demographic needs over time (Orians and Wittenberger 1991). For birds, habitat selection is typically measured as where the individual is located compared to what is available within some restricted spatial area (Jones 2001) and selection is assumed to be driven by some type of search behavior wherein individuals are able to distinguish good from poor habitat (Orians and Wittenberger 1991).
Wild turkeys (Meleagris gallopavo spp.) are a ground nesting uniparental galliform that exhibits substantial plasticity in habitat selection (Porter 1992). Wild turkeys experience relatively low nest success compared to other species with similar reproductive strategies (Holloran et al. 2005), but also exhibit significant temporal variation in nest success (Seiss et al. 1990, Collier et al. 2009, Yeldell et al. 2017a, Wood et al. 2018). Annual productivity, primarily through nest success, is the primary driver of wild turkey population trajectories (McGhee et al. 2008, Pollentier et al. 2014). Therefore, identifying nest sites affording greater reproductive success and reduced predation risk should govern all other components of habitat selection for reproductively active females. Contemporary research has noted that the likelihood of a wild turkey evaluating a nest site before selection occurs was low across all subspecies (Byrne et al. 2014, Conley et al. 2015, 2016, Collier et al. 2019). Thus, female wild turkeys likely have a narrow window within which to evaluate habitat conditions around potential nest sites, and selection may be driven by what conditions are available immediately before the first egg is laid. Therefore, if sampling for nest sites based on vegetation characteristics is restricted to a narrow temporal window, are reproductively active female wild turkeys actually identifying vegetative characteristics that have fitness consequences?

The literature on wild turkey nest site characteristics has routinely identified vegetation height and screening cover as the 2 primary vegetative metrics that influence nest success (Lutz and Crawford 1987, Schmutz et al. 1989, Badyaev 1995, Randel et al. 2005). However, throughout the published literature, there are numerous contradictory conclusions relative to what vegetative metrics influence nest success, with some authors noting no such influences (Lehman et al. 2003, Yeldell et al. 2017a, Wood et al. 2018), and others reporting positive influences of various metrics (Badyaev 1995, Fuller et al. 2013). Thus, my objective was to
evaluate vegetation conditions immediately before the selection of nest sites to determine if conditions at the nest site were different than those available to females immediately before nest initiation. Thus, I evaluated vegetation conditions at nest sites and along presumed travel paths used by female wild turkeys prior to nest initiation. I evaluated if 1) availability of vegetation conditions were limited where females traveled immediately prior to laying the first egg, and 2) if there were consequences of vegetation conditions to nest success.

3.2 Study area

I conducted research at 7 study sites (Figure 3.1) across the southern United States, including B.F. Grant Wildlife Management Area, Cedar Creek Wildlife Management Area, Kisatchie National Forest, Peason Ridge Wildlife Management Area, Angelina National Forest, private lands in south-central Texas, and Coronado National Forest.

Figure 3.1. Distribution and number of unique female wild turkey nesting attempts across the southern United States used within our analysis.

The B. F. Grant Wildlife Management Area (BFG) was owned by the Warnell School of Forestry and Natural Resources at the University of Georgia and was managed jointly by the
Georgia Department of Natural Resources-Wildlife Resources Division (GADNR) and the Warnell School. The BFG was dominated by loblolly pine stands, agricultural lands, mixed hardwood and pine forests, and hardwood lowlands containing mostly oaks, sweet gum, and hickory. Agricultural lands were mostly grazed mixed fescue (*Festuca sp.*) fields and hay fields planted for rye grass (*Lolium sp.*). Cedar Creek Wildlife Management Area (CC) was owned by the U. S. Forest Service (USFS) and managed in partnership with GADNR. The CC was composed primarily of loblolly pine uplands, mixed hardwood and pine forests, and hardwood lowlands of similar species composition as BFG. Prescribed fire was applied on an approximately 3-5-year rotation.

Kisatchie National Forest (KNF) was located in western Louisiana and was owned and managed by the USFS. Research was conducted on the Kisatchie Ranger District, Winn Ranger District, and the Vernon Unit of the Calcasieu Range District located in Natchitoches, Winn, and Vernon parishes, respectively. Collectively, the Kisatchie Ranger District, Winn Ranger District, and the Vernon Unit area were approximately 41,453 ha, 67,408 ha, and 61,202 ha, respectively (Yeldell et al. 2017a). The KNF was composed of pine-dominated forests, hardwood riparian areas, and forested wetlands, with forest openings and forest roads distributed throughout. Overstory trees included loblolly pine, longleaf pine, shortleaf pine, slash pine, sweetgum, oaks, and hickories (*Carya spp.*; Yeldell et al. 2017a).

Peason Ridge Wildlife Management Area (PR) consisted of 30,070 ha located in Sabine, Natchitoches, and Vernon parishes of west-central Louisiana. The PR was part of a noncontiguous U.S. Army training area located north of Fort Polk and consisted of 13,360 ha of U.S. Army lands and 190 ha of USFS lands. The PR was approximately 80% pine plantation that consisted primarily of loblolly pine.
The Angelina National Forest (ANF) in southeastern Texas was owned and managed by the USFS. The ANF is comprised of 62,423 ha covering San Augustine, Angelina, Jasper and, Nacogdoches counties. The area is pine dominated with hardwood riparian zones. Overstory stands in the ANF included loblolly pine, shortleaf pine, longleaf pine, sweetgum, post oak, and white oak.

My research in south central Texas (District 7) was conducted on a suite of (>200ha) private lands widely distributed across multiple ecoregions within 6 counties: Caldwell, DeWitt, Fayette, Gonzales, Jackson, and Lavaca. Ecoregions included the post-oak savannah, blackland prairie and South Texas plains. Dominant overstory of the post-oak savannah consisted of post oak (Quercus stellata) and live oak (Quercus virginiana). The blackland prairie consisted of grasslands and parks dominated by live oak, sugarberry (Celtis laevigata), mesquite (Prosopis glandulosa) and huisache (Acacia farnesiana). The South Texas plains consisted of mesquite, Texas persimmon (Diospyros texana), algerita (Mahonia trifoliolata), lotebush (Ziziphus obtusifolia), pricklypear (Opuntia engelmannii) and tasajillo (Opuntia leptocaulis).

My Arizona study sites were within the sky islands connecting the Sierra Madre Occidental to the Rocky Mountains, and included the Pinaleño, Chiricahua, Huachuca, and Patagonia Mountains located in Graham, Cochise, and Santa Cruz Counties. The Coronado National Forest (CNF) in southeastern Arizona was owned and managed by the USFS and included an area of 720,340 ha. Landscapes included semidesert grasslands, madrean evergreen woodlands, petran montane conifer forests, and petran subalpine conifer forests. For a detailed description of site conditions in the CNF, see Collier et al. (2019).
3.3 Methods

Female Eastern wild turkeys were captured using rocket nets, Gould’s wild turkeys using walk-in traps, and Rio Grande wild turkeys using walk-in traps and drop nets baited with cracked corn, peanuts or milo during January–March 2017. Additionally, during 2016 and 2017, 101 turkeys (23 males, 78 females) from Iowa, West Virginia, and Missouri were re-introduced as part of a Texas Parks and Wildlife restocking project. I classified individuals as juvenile or adult based on the presence of barring on the ninth and tenth primary feathers (Pelham and Dickson 1992). Eastern wild turkeys and Rio Grande wild turkeys were fitted with a numbered, riveted aluminum tarsal band whereas Gould’s were given an alphanumeric color-coded patagial tag. All individuals were fitted with a backpack-style GPS transmitter weighing approximately 88 g (Guthrie et al. 2011) equipped with a very high frequency (VHF) signal (Lotek Minitrack Backpack L, Lotek Pinpoint Backpack; Lotek Wireless, Newmarket, Ontario, Canada). Transmitters were programmed to collect data at 1 hr intervals (Cohen et al. 2018) from 0500 to 2000 daily with one location at 23:58:58 to identify roost site locations. All birds were released at the capture site immediately after processing. Capture myopathy within 3 weeks post-release was < 4%. The Institutional Animal Care and Use Committee at Louisiana State University (Protocol #A2015-07) and the University of Georgia (Protocol #A2014 06-008-Y1-A0) approved capture and handling protocols. Individuals were monitored >4 times per week and downloaded GPS information ≥1 time per week via a VHF/UHF handheld command unit receiver (Biotrack Ltd., Wareham, Dorset, UK) during the nesting period (March–July) to monitor nesting activity. I determined first date of egg laying and nest site locations from VHF tracking and spatio-temporal GPS locational data (Collier and Chamberlain 2011, Yeldell et al. 2017a). Nesting
females were not disturbed or flushed from nest sites during monitoring, but instead were live-dead checked daily via VHF from >20m (Byrne et al. 2014, Yeldell et al. 2017a).

Following Yeldell et al. (2017a), I considered incubation to have started when a female did not significantly deviate from a central location for several days. Once it was determined a female was laying or incubating a nest, the nest was monitored using VHF telemetry and GPS locations until nest termination. After nest termination, nests were visually inspected to estimate clutch size, determine hatching rate of eggs, and collect measurements of vegetative characteristics at nest sites. Following Melton et al. (2011), I classified nest fate as successful if $\geq 1$ egg hatched and unsuccessful if the nest was depredated (nest or eggs showed signs of disturbance) or abandoned (female left nest area and eggs remained unhatched).

To determine date of nest initiation (i.e. initiation of egg laying period) and date of incubation, I mapped the spatial-temporal data using ArcGIS 10.3.1 (Environment Systems Research Institute, Redlands, California, USA). Locations were evaluated hourly until incubation start date was determined (Byrne et al. 2014, Yeldell et al. 2017a, Bakner et al. 2019). Once the incubation start date was determined, I evaluated the locations for the previous 20 days and determined when a female initially visited the nest site (defined as a location being within a 20m radius; Conley et al. 2016). I then placed a buffer of 20 m around the nest site and considered the first GPS fix within the 50m buffer as the time of first nest visit and used this date as the beginning of the egg laying period (Conley et al. 2016). I manually connected GPS fixes with straight lines to create a general movement path for the 3 hr period before the first nest visit. I then generated 2 random points along each hourly movement path, which resulted in a maximum of 6 randomly assigned points along the 3 hr path (Figure 3.2).
At each random point, I established a 10 m transect on each side of the estimated movement path, perpendicular to the path (Figure 3.3). I uniquely identified transects with 1 being farthest from the nest site and 6 being closest. Every 1 m along each 10 m transect, I measured visual obstruction (decimeter) using a Robel pole (Robel et al. 1970) following Yeldell et al. (2017a) at a distance of 15m from the transect (Figure 3.3).
I conducted readings in 2 directions towards the transect line. I defined visual obstruction as the lowest point on the Robel pole at which I could see the pole when viewing from 1 m above the ground and estimated average height of understory vegetation along my line of sight between the transect and each respective 1 m location along the transect. I recorded 40 measurements (20 on each side of movement path segment) along each perpendicular transect. At each nest location, I collected the same measurements in each cardinal direction (Yeldell et al. 2017a, Wood et al. 2018). I averaged Robel pole reading from the 4 nest site measurements to estimate mean vegetation height and visual obstruction at the nest site. Robel pole readings were conducted >7 days post nest hatch or fail.

For each nest site, I compared the estimated visual obstruction and average vegetation height to the same metrics collected along movement paths that the female presumably used.
before selecting their nest site. For analysis, I assigned each cross-transect measurement a 1 if vegetation conditions met or exceeded the same measurement collected at the nest site, and a 0 if measurements failed to meet the conditions. I then calculated the proportion that contained vegetation metrics that met or exceeded what the female selected for nesting.

3.4 Results

I used 164 nesting attempts during 2017 (Table 3.1) by 131 individuals (118 adults, 13 juveniles) for analysis.

Table 3.1. Number of wild turkey (*Meleagris gallopavo* spp.) nesting attempts by site (Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFG), Cedar Creek Wildlife Management Area (CC), Coronado National Forest (CNF), South Central Texas (District 7), Kisatchie National Forest (KNF), and Peason Ridge Wildlife Management Area (PR)) and species that were used to sample 492 pre-nest initiation sampling paths during 2017.

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Subspecies</th>
<th>Attempt</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANF</td>
<td>13</td>
<td>Eastern</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>BFG</td>
<td>2</td>
<td>Eastern</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CC</td>
<td>40</td>
<td>Eastern</td>
<td>27</td>
</tr>
<tr>
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I measured vegetation at 37,976 locations along 492 movement paths. I found little evidence that available vegetation conditions changed as one approached (from cross transect 1 to 6) the
nest site (Table 3.2). Across all subspecies and nesting attempts, the proportion of vegetation structure met was reduced as attempts increased (Figure 3.4).

![Image of bar graphs showing proportion of vegetation height measurements that met or exceeded nest site vegetation height measurements. Analysis included data from all subspecies (Goulds, Rio Grande, and Eastern wild turkey) across all study sites.](image)

**Figure 3.4.** Proportion of vegetation height measurements that either met or exceeded nest site vegetation height measurements. Analysis included data from all subspecies (Goulds, Rio Grande, and Eastern wild turkey) across all study sites.

Average vegetation height at the nest site was met or exceeded at 61–71% of random points, whereas visual obstruction was met or exceeded 22-25% of the time. Average vegetation height and visual obstruction at random locations met or exceeded comparable measurements at nest sites 66% and 24% of the time for unsuccessful nests, and 67% and 17% of the time for successful nests, respectively. The proportion of random points where average vegetation height and visual obstruction met or exceeded that at nest sites was at minimum 53% and 10%, respectively (Table 3.2).
Table 3.2. Predicted probability, by cross transect, that vegetation characteristics (vegetation height or visual obstruction) measurements at random locations met or exceeded vegetation measurement at the nest site for 492 pre-nest initiation sampling paths collected during 2017. Cross transects are labeled 1-6 with 6 being the measurements closer to the nest site and 1 being the measurement farthest from the nest.

<table>
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<th>Cross Transect</th>
<th>Vegetation height</th>
<th>Visual obstruction</th>
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<tr>
<td>1</td>
<td>0.62 (0.006)</td>
<td>0.22 (0.005)</td>
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<tr>
<td>2</td>
<td>0.67 (0.006)</td>
<td>0.22 (0.005)</td>
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<td>3</td>
<td>0.67 (0.006)</td>
<td>0.23 (0.005)</td>
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<td>4</td>
<td>0.63 (0.006)</td>
<td>0.22 (0.005)</td>
</tr>
<tr>
<td>5</td>
<td>0.68 (0.006)</td>
<td>0.25 (0.005)</td>
</tr>
<tr>
<td>6</td>
<td>0.71 (0.005)</td>
<td>0.23 (0.005)</td>
</tr>
</tbody>
</table>

The proportion of average vegetation height at random locations that met or exceeded values at the nest site was 72% and 66% for juvenile and adult females, respectively, whereas visual obstruction was 18 and 23% for juveniles and adults, respectively.

Eastern wild turkeys had the highest proportion of random points where average vegetation height met or exceeded vegetation measurements at the nest site (75%) followed by Goulds (59%) and Rio Grande wild turkeys (46%). I noted similar results for visual obstruction (27, 17, and 15%, for Eastern, Gould’s, and Rio Grande wild turkeys, respectively, Table 3.2). Across my Eastern wild turkey study sites, locations in the western region (Texas, PR, KNF) had higher (80%, 86% and 87%, respectively) probability of average vegetation height meeting or exceeding that selected for nesting, whereas locations in the eastern region (CC, BFG) were lower (57 and 58%, respectively). The same trend held for visual obstruction, where locations in the western region had higher (40%, 49% and 34%, respectively) probability of visual...
obstruction meeting or exceeding that selected for nesting, whereas locations in the eastern region (CC, BFG) had lower (4% and 1%, respectively).

3.5 Discussion

Establishment of quality nesting habitat is regularly identified as a manageable action for wild turkey population sustainability (Bailey and Rinell 1967, Dickson et al. 1978, Healy and Nenno 1983, Bidwell et al. 1989, Moore et al. 2010, Little et al. 2014) under the assumption that vegetation conditions conducive to nest success are limited on the landscape and impact demographic response (Badyaev 1995, Thogmartin 1999, Streich et al. 2015, Isabelle et al. 2016). My results indicate that vegetation conditions at nest sites selected by wild turkeys, as quantified using the predominant metrics thought to drive nest success, are readily available within areas that females use immediately before onset of laying. Likewise, my findings indicate that these same metrics had little influence on nest success, suggesting that sampling methods commonly used to quantify vegetation characteristics selected by wild turkeys may lack sufficient scope and resolution to be of practical use when attempting to relate vegetation to potential demographic outcomes.

Previous works assessing vegetation conditions at nest sites of wild turkeys have typically included measurements collected at the nest site and random points around the nest, and the results have failed to illustrate consistent conclusions as to vegetative characteristics that drive nest success (Schmutz et al. 1989, Badyaev 1995, Nguyen et al. 2004, Randel et al. 2005, Yeldell et al. 2017a, Wood et al. 2018). Conley et al. (2016) and Collier et al. (2019) found little evidence to support the concept of habitat sampling proposed by earlier authors (Badyaev et al. 1996, Chamberlain and Leopold 2000), instead noting that wild turkeys showed considerable plasticity in habitat selection. Based on my results, I suggest that the process of nest site
selection within local populations of wild turkeys, relative to vegetative conditions, may be better defined as stereotypy, or a persistent repetitive act with no obvious purpose or benefit (Martin 1993). Understanding behaviors of female wild turkeys prior to nest initiation has largely been ignored until recently due to technological limitations (Collier and Chamberlain 2011). However, I posit that my results support the idea that vegetation selected for nesting is time-dependent and not spatially limited on the landscape. Rather, females may be attempting to satisfy a general threshold for vegetative cover that provides a location where they perceive they can hide themselves and the nest during incubation. If so, female wild turkeys may indeed be selecting nest sites with a threshold of cover the day the first egg is laid, with no apparent consideration of the fitness consequences of the vegetation selected.

Selection of vegetation conditions and the relative difference between what is used and what is available has provided the foundation for evaluating fitness consequences of habitat selectivity (Jones 2001). In order to be adaptive, habitat selection is required to have positive benefits to species demography. Absent links to fitness, I suggest that vegetation characteristics, as quantified using common techniques replete in extant literature, may be irrelevant to nest success in the wild turkey. Moreover, I posit that these measurements and other similar metrics commonly used and reported by researchers (Yeldell et al. 2017a, Wood et al. 2018, Collier et al. 2019) may be unrelated to the process of nest loss via predation. Techniques for assessing vegetation characteristics at nest sites such as screening cover (Robel et al. 1970) or canopy cover (Lemmon 1956) have not changed significantly even as alternative methods for quantifying vegetation structure and landscape conditions have evolved greatly to include NDVI (Pettorelli et al. 2005), LANDSAT (Short 1982) and LiDAR (Hill and Thomson 2005) among others. Perhaps we have fallen into a scientific paradigm (Morrison et al. 2012), where the
majority of people follow a common set of rules on what is to be observed, how it is to be observed, and how it is to be interpreted. However, when paradigms are perpetuated without challenge, resource management may suffer, and thus based on my results, I am concerned with the metrics and approaches used for vegetation evaluation relative to fitness consequences in wild turkey nesting studies.
CHAPTER 4. CONCLUSIONS

I found that the average pre-laying period length of reproductively active female wild turkeys was 24.5 days and the average laying period length was 11.7 days. My results show that during the pre-laying period, females move relatively less per day within larger ranges, whereas during laying movements increase within smaller ranges. Under the theory of adaptive site familiarity, behavioral decisions driving movement should be influenced by familiarity with local conditions. My findings suggest that females increased movements during the laying period could be associated with females prospecting areas within their ranges to find, assess, and use resources around nest sites. Females who traveled less distance daily during the pre-laying period attributed to higher probabilities of nest success. I offer that increased movements during laying are a behavioral response and shows that females begin to increase prospecting of available resources within close proximity to nests once laying has begun. Overlap of 50% utilization distributions during the laying period occurred in 59.6% of the total nesting attempts and increased to 84.5% when I evaluated the 99% laying period utilization distributions. My results indicated positive benefits of utilization distribution size on nest success, but no positive benefit of utilization overlap on nest success. Further research is needed to understand the density-specific drivers related to reduced exposure to predators, preference for isolation, individual queueing, and selection of nesting areas by breeding groups and how those factors may be driving spatial selection and subsequent demographic responses.

I found little evidence that available vegetation conditions changed as female wild turkeys approached the nest site. My results indicate that vegetation conditions at nest sites selected by wild turkeys, as quantified using the predominant metrics thought to drive nest success, are readily available within areas females use immediately before onset of laying.
Likewise, my findings indicate that these same metrics had little influence on nest success, suggesting that sampling methods commonly used to quantify vegetation characteristics selected by wild turkeys may lack sufficient scope and resolution to be of practical use when attempting to relate vegetation to potential demographic outcomes. I conclude that measurements commonly used to describe vegetation characteristics at nest sites of wild turkeys are inadequate to appropriately link vegetation conditions to demographic outcomes.
REFERENCES


Short, N. M. 1982. Landsat tutorial workbook.


APPENDIX A. SUPPLEMENTARY MATERIAL FOR CHAPTER 1

Figure A.1: Length of egg-laying days across all study sites: Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFG), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CC), Coronado National Forest (CNF), South Central Texas (D7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PR), and Webb Wildlife Management Area Complex (Webb).
Figure A.2. Proportion of 50% Utilization distribution overlap during the egg-laying period for wild turkey across study sites: Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFG), Caddo Parish (Caddo), Cedar Creek Wildlife Management Area (CC), Coronado National Forest (CNF), South Central Texas (D7), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PR), and Webb Wildlife Management Area Complex (Webb).
Figure A.3: Probability of nest success by length of egg-laying period for female wild turkeys (*Meleagris gallopavo*) across multiple study sites in the southern United States.
Table A.1. Acquired Landsat 8 images from United States Geological Survey (USGS) used for unsupervised landcover classification.

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APPENDIX B. SUPPLEMENTARY MATERIAL FOR CHAPTER 2

Figure A.4. Proportion of vegetation height measurements that either met or exceeded nest site vegetation height measurements by nesting attempt across all study sites: Angelina National Forest (ANF), B.F. Grant Wildlife Management Area (BFGWMA), Cedar Creek Wildlife Management Area (CCWMA), Coronado National Forest (CNF), Kisatchie National Forest (KNF), Peason Ridge Wildlife Management Area (PR), and South Central Texas (TXD7).
VITA

Landon Robert Scofield, born in Boise, Idaho in 1988, grew up in a sportsman’s paradise in South Central Idaho. After graduating high school, from Buhl High School, he served a two-year mission for the Church of Jesus Christ of Latter-Day Saints in the country of Peru.

Upon returning from Peru, he attended the College of Southern Idaho, later transferring to the University of Idaho and majored in Wildlife Resources and Geographic Information Systems. During his time as an undergraduate, Landon participated in a variety of research opportunities including fisheries ecology, prescribed fire, avian ecology, and ungulate ecology. He worked for the Idaho Department of Fish and Game, the University of Idaho, and the Idaho Cooperative Fish and Wildlife Research Unit. He soon discovered his passion for upland game bird ecology and desired to further his education in this area. He jumped at the opportunity to research Wild turkeys in the School of Renewable Natural Resources at Louisiana State University. Upon completion of his master’s degree, he will begin to work for the East Foundation in San Antonio, Texas, as their Range and Wildlife Biologist.