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Research Article

Prescribed Fire Influences Habitat Selection of Female Eastern Wild Turkeys

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ABSTRACT Prescribed fire is widely used in southeastern pine (*Pinus* spp.) forests to maintain desirable forest conditions and provide early successional vegetation. However, it is unclear how fires applied just prior to and during the reproductive cycle of ground nesting Galliformes influence resource selection. We examined the short-term influence of prescribed fire on habitat selection of female eastern wild turkeys (*Meleagris gallopavo silvestris*) throughout their reproductive cycle (Feb–Aug) at Kisatchie National Forest in west-central Louisiana, USA during 2014 and 2015. Kisatchie was dominated (>60%) by pine stands managed with prescribed fire at a frequent (i.e., 1–3 yr) return interval. We captured 46 females and equipped them with backpack-style global positioning system (GPS) transmitters programmed to collect relocation data hourly from 0600 to 2000 each day. We used distance-based analysis to estimate selection or avoidance of vegetation communities relative to reproductive phenology of individual females. Hardwood and mixed-pine hardwood vegetation communities were selected for before and after reproductive efforts; hardwood stands were avoided during brooding. While laying their first clutch of the reproductive period, females selected mature pines burned 0–5 months prior. Females avoided mature pine stands 2 growing seasons post-burn prior to initiating their first nests. Females avoided mature pine stands 3 growing seasons post-burn when brooding. Turkeys did not select for pine stands that had experienced ≥3 growing seasons post-burn during any reproductive period, and may avoid these stands during pre-nesting and brooding. Frequent fire return intervals maintain vegetation communities that females select at some point during the reproductive season in pine-dominated landscapes.

KEY WORDS brownian bridge movement model, distance-based habitat selection, Louisiana, *Meleagris gallopavo*, nesting, prescribed fire, reproduction, resource selection, space use.

The management of longleaf pine (*Pinus palustris*) forests in the southeastern United States employs frequent (i.e., 1–3 yr) fire return intervals to maintain a sparse canopy and limit midstory encroachment by impeding hardwood species (Brockway and Lewis 1997). These repeated, low-intensity fires can occur before substantial fuel accumulation, resulting in top-killing of ground-cover forbs, shrubs, and sapling hardwood stems that resprout from underground storage organs the following growing season (Drewa et al. 2002). Understory interactions with fire are highly dynamic; variation in timing of fire and fuel load can alter fire intensity and influence understory plant survival, germination of herbaceous plants, and future vegetation communities (Thaxton and Platt 2006, Ellair and Platt 2013, Wiggers et al. 2013). Reducing midstory plants and variations in fire intensity promote diversity in understory plant growth, woody plant stem density, germination of legumes and grasses, and vertical and horizontal structure (Brockway and Lewis 1997, Thaxton and Platt 2006, Grady and Hoffmann 2012). However, these changes are short-lived; reduction in fire frequency allows hardwood stems to increase in the midstory and overstory (Provencher et al. 2001, Beckage et al. 2009, Haywood 2012), decreasing the prominence of herbs and grasses and reducing structural heterogeneity in the understory (Kush et al. 2000, Varner et al. 2000).

Prescribed fire in pine forests is most often applied prior to and during the reproductive period of eastern wild turkeys (*Meleagris gallopavo silvestris*; turkeys), and may immediately affect habitat availability (Streich et al. 2015, Little et al. 2016, Yeldell et al. 2017). Under the optimality theory, turkeys should select vegetation communities that maximize

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individual fitness by balancing acquisition of resources (e.g., forage, nesting cover) while minimizing predation risk for themselves and potentially their brood (Reiss 1987). Herbaceous vegetation comprises a substantial component of turkey diets (Glover and Bailey 1949, Schemnitz 1956, Exum et al. 1987) and improved access to food remaining after fire disturbance may increase attractiveness of burned stands to turkeys (Martin et al. 2012). Likewise, increases in ground cover vegetation (Wiggers et al. 2013), herbaceous plants (Ellair and Platt 2013), and invertebrates (New 2014) after low-intensity fire may increase concealment and forage for broods (Campo et al. 1989, Burk et al. 1990, Sisson et al. 1990, Still and Bauman 1990). Non-forested areas (e.g., pastures, wildlife food plots, recently clearcut forests) can also provide green vegetation, grass, forbs, soft mast, and insects, which are important in the wild turkey's spring and summer diet (Dalke et al. 1942, Kennamer et al. 1980). In pine-dominated landscapes, hardwood stands are important for providing hard mast during fall and winter months (Hurst 1992, Steffen et al. 2002, Little et al. 2016).

Turkeys rely on their visual system to interpret their surroundings (Hart et al. 1999, Werner et al. 2014). Similar to open areas (e.g., fields), the sparse understory immediately after prescribed fire but before plant regrowth (Lavoie et al. 2010) may aid turkeys in detecting and avoiding predators (Tisdale and Fernandez-Juricic 2009, Javůrková et al. 2012). However, increases in understory vegetation after several growing seasons decrease sight distances and may increase predator foraging efficiency (e.g., bobcat [*Lynx rufus*], Rolley and Ward 1985, Kolowski and Woolf 2002; raccoons [*Procyon lotor*], Bowman and Harris 1980; raptors, Andersson et al. 2009). Because responses to forage availability and predation may be based on physiological demands throughout a female turkey's reproductive cycle (Dickson 1992), turkeys may use fire-influenced vegetation communities differently between their reproductive phases. For example, female turkeys in a frequently burned pine savanna used burned areas immediately after fire application but avoided areas burned $\geq$2 years prior throughout the entire reproductive period (Mar–Oct; Martin et al. 2012).

The recent development of global positioning system (GPS)-equipped transmitters for use with wild turkeys has enhanced our ability to describe behavior, particularly space use and movement ecology (Collier and Chamberlain 2010, Guthrie et al. 2011, Cohen et al. 2015, Gross et al. 2015). Because refinements in estimates of space use incorporate temporal information to create utilization distributions, researchers can now calculate more accurate estimates (Walter et al. 2015). Specifically, estimators such as dynamic Brownian bridge movement models (Kranstauber et al. 2012) and movement-based kernel density estimators (Benhamou and Cornélis 2010) provide more reliable estimates of area used by individual animals, allowing researchers to better assess preference and avoidance of different vegetation communities. However, previous studies of resource selection by turkeys have often used minimum convex polygons or kernel density methods (Holbrook et al. 1987, Palmer et al. 1996, Thogmartin 2001, Little et al. 2016, Niedzielski and Bowman 2016). These estimates of space use tend to overflow into never-visited areas and possibly bias estimates of selection (Benhamou and Cornélis 2010). Furthermore, past studies have analyzed use across relatively coarse temporal seasons relative to the reproductive phenology of individuals (Holbrook et al. 1987, Stys et al. 1992, Miller and Conner 2007). In contrast, high temporal resolution GPS data allows researchers to more accurately describe reproductive behaviors of individual turkeys. Because nest initiation dates and reproductive effort can vary significantly within turkey populations (Oetgen et al. 2015, Yeldell et al. 2017), incorporating individual variation in reproductive phenology into an assessment of space and resource use can improve our understanding of selection and the potential influences of fire disturbance on wild turkey behavior.

Prescribed fire may immediately affect habitat availability. Understanding if prescribed fire results in vegetation communities that are selected or avoided, and the duration of these effects, is important for managing turkeys in pine-dominated landscapes. Our objective was to examine selection and avoidance of vegetation communities by female wild turkeys on a landscape managed with prescribed fire. Because responses may be based on physiological demands throughout a female turkey's reproductive cycle (Dickson 1992), we hypothesized selection of vegetation communities would differ during specific phases of each individual's reproductive cycle. We were most interested in how prescribed fire may affect turkey selection of mature pine stands and hypothesized females would select for mature pine stands $\leq$2 growing seasons post-burn during pre-nesting, laying, and brooding. We also hypothesized that stands with more growing seasons post-burn would be less selected across all reproductive phases.

STUDY AREA

We conducted research on Kisatchie National Forest (KNF) and Fort Polk Wildlife Management Area (WMA) in west-central Louisiana, USA. Kisatchie National Forest and Fort Polk WMA experienced subtropical climates, with mean daily temperatures ranging from a low of 9.4 °C in January to 28.3 °C in July, and mean annual rainfall of approximately 114 cm. Kistachie National Forest was owned and managed by the United States Forest Service (USFS) and is divided into 5 Ranger Districts. We conducted research 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. Fort Polk WMA was jointly owned by the USFS and the United States Army. The northern portion of Fort Polk WMA owned by the United States Army was within the Fort Polk Joint Readiness Training Center, whereas the southern portion was within the Vernon Unit of KNF. Environmental conditions and forest management practices were similar on the Vernon Unit and Fort Polk WMA; hence, we considered these areas as a single study site. The spatial extents of Kisatchie Ranger District, Winn Ranger District, and the

Vernon-Fort Polk area were approximately 41,453 ha, 67,408 ha, and 61,202 ha, respectively. The area was composed of pine-dominated forests, hardwood riparian zones, and forested wetlands, with forest openings, utility right-of-ways, and forest roads distributed throughout. Overstory trees included longleaf pine, loblolly pine (*P. taeda*), shortleaf pine (*P. echinata*), slash pine (*P. elliottii*), sweetgum (*Liquidambar styraciflua*), oaks (*Quercus* spp.), hickories (*Carya* spp.), and red maple (*Acer rubrum*). Understory plants included yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), blackberry (*Rubus* spp.), greenbrier (*Smilax* spp.), wild grape (*Vitis* spp.), broomsedge (*Andropogon virginicus*), woodoats (*Chasmanthium* spp.), and panic grasses (*Panicum* spp. and *Dichanthelium* spp.). Forest stands on private lands typically had lower diversity of overstory tree species, greater canopy cover, and less dense understory growth than KNF. Other private lands in the area consisted of small rural settlements, agricultural fields, pastures, and hardwood-dominated forested wetlands. Common predators of turkeys and turkey nests at KNF and surrounding areas included coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat, Virginia opossum (*Didelphis virginiana*), raccoon, Cooper's hawk (*Accipiter cooperii*), and barred owl (*Strix varia*).

Land managers on KNF used prescribed fire to promote the growth of longleaf pine, inhibit the growth of undesirable hardwood species, and reduce fuel loads (Haywood 2012). Prescribed fire was primarily applied to upland sites containing pine-dominated and mixed pine-hardwood stands. Prescribed fire was applied in dormant seasons (Dec–Mar) and growing seasons (Apr–Jul), with most fires (71.3% of area burned) applied in dormant seasons (Yeldell et al. 2017). The average size of burn patches on KNF was 484.9 ± 295.3 (SD) ha (Yeldell et al. 2017) but ranged from 7.2 ha to 1,567.4 ha. The proportion of public land within the study area burned each year was 23.2% and 19.2% in 2014 and 2015, respectively (Yeldell et al. 2017). Most upland pine stands were burned on a 3–4-year rotation, although some areas had no recent burn history at the time of this study. Prescribed burning was uncommon on private lands within the boundary of and surrounding KNF.

METHODS

Animal Capture and Monitoring

We captured female turkeys using rocket nets during January–March of 2014 and 2015. We classified each turkey as adult or subadult based on presence of barring on the ninth and tenth primary feathers (Pelham and Dickson 1992). We fitted all turkeys with a serially numbered, butt-end style or riveted aluminum tarsal band. We also fitted each turkey with a backpack-style GPS transmitter equipped with a very high frequency (VHF) beacon and mortality sensor weighing approximately 88 g (Lotek Minitrack Backpack L, Lotek Wireless, Newmarket, Ontario, Canada). We programmed GPS transmitters to record hourly locations from 0600 to 2000 each day and 1 nightly roost location at midnight, with the exception that in 2014 we collected roost locations only prior to 15 February. We released all birds on site immediately after processing. We used a hand-held, 3-element Yagi antenna and R2000 receiver (Advanced Telemetry Systems, Isanti, MN, USA) to locate and monitor status of radio-marked individuals ≥1 time per week from mid-February to -August. Turkey capture, handling, and marking procedures were approved by the Institutional Animal Care and Use Committee at the University of Georgia (AUP #A3437-01).

We used VHF telemetry and examined GPS locations of each female to monitor reproductive behavior. If location data indicated a female restricted movement to an area ≤30 m in radius, we assumed the female was incubating a nest based on typical behavior and movement patterns associated with incubation (Conley et al. 2015). Once we determined a female was laying or incubating a nest, we monitored its location via VHF telemetry and GPS data interpretation until nest termination. Wild turkey nests require approximately 27 days of continuous incubation before hatching (Williams et al. 1971), but incubation time in pen-raised turkeys has ranged from 25 to 29 days (Healy and Nenno 1985). Therefore, we closely monitored females we suspected to be incubating for up to 30 days. After nest termination, we used GPS data to locate nest sites and confirm nest attempts based on presence of eggs, eggshell remains, or a shallow ground depression with turkey feathers present (Williams et al. 1971). If a nest was incubated for ≥25 days, we located the female after nest termination via VHF signal homing and performed a flush count to determine the presence of poults. We considered a brood to be present if ≥1 poult was seen or heard with the female. Poults 0–18 days old are unlikely to be seen flushing with the adult female (Glidden and Austin 1975, Healy 1992); therefore, we also considered a brood present if the adult female displayed brood protective behavior, whereby the female does not fly away, feigns a broken wing, or repeatedly emits a putt call while circling the observer. After 18 days post-hatch, we relied on visual and auditory detection of poults to confirm brood presence. We performed brood surveys 2 times a week up to 56 days post-hatch or until we failed to detect poults during 2 consecutive brood surveys.

We delineated up to 8 reproductive phases for each reproductively active female based on individual phenology. We defined nest initiation as the first day a female began laying eggs in a nest and considered females that initiated ≥1 nest as reproductively active, whereas females that did not appear to initiate a nest were reproductively inactive. The pre-nest 1 phase began on the date of capture (range = 16 Jan–3 Mar) and ended upon initiation of the first nest, pre-nest 2 phase began upon failure of the first nest or loss of brood and ended upon initiation of the second attempted nest, and pre-nest 3 phase began upon failure of the second attempted nest or loss of brood and ended upon initiation of a third attempted nest. The lay 1, lay 2, and lay 3 phases referred to females laying eggs in the first, second, and third attempted nest, respectively. Because turkeys lay approximately 1 egg/day (Williams et al. 1971) and the eastern wild turkey lays an average clutch size of 12 eggs (Vangilder

1992), we estimated that the laying sequence began 12 days prior to the onset of nest incubation. Thus, the laying period for each attempted nest was 12 days long. The incubation phase began the day following the onset of nest incubation and lasted until nest termination. For any female that hatched a brood, we defined the brood-rearing phase as day of hatch to the last day we detected ≥1 surviving poult or up to 56 days post-hatch if poults were present during all brood surveys. We stopped monitoring broods and constrained the brood-rearing phase to within 56 days post-hatch because at approximately this time, turkey poults' physical development, energetic demands, and diet begin to shift closer to that of adult turkeys. For example, plant matter becomes an important component in a turkey poult's diet at approximately 42–56 days post-hatch (Healy et al. 1975) and secondary sexual characteristics become apparent as juveniles develop into adult forms around 56 days post-hatch (Healy and Nenno 1980). The post-nesting phase began following the last day of nest incubation or brood-rearing. Following a nest failure, a female either entered the post-nesting phase or another pre-nesting phase if a subsequent nest was attempted.

Vegetation Community Delineation

To delineate major vegetation communities within our study area, we obtained forest inventory data from the USFS, the United States Army Environmental and Natural Resources Division, and local forest product companies. We then developed a 30-m resolution land cover map of major plant communities throughout our study area similar to Little et al. (2016). We classified forest stands as pine if they consisted of ≥70% loblolly, longleaf, slash, or shortleaf pine in the overstory. We classified pine stands as mature if they were ≥20 years old and consisted primarily of trees in the pulpwood and sawtimber classes (≥20.4 cm diameter at breast height [DBH]). We classified pine stands as immature if they were <20 years old and consisted of trees in the seedling, sapling, and pulpwood classes (range = 0–20.3 cm DBH). Although there are a number of successional phases (Haywood 2009, 2012) associated within our immature pine classification, this vegetation community comprised a relatively small (6.2%) proportion of our study area. Separation of these stands based on their successional phases would have created vegetation community types that were a very small component of the landscape.

Mixed pine-hardwood stands consisted of a variety of tree species, including loblolly pine, longleaf pine, slash pine, sweetgum, white oak (*Quercus alba*), swamp chestnut oak (*Q. michauxii*), sassafras (*Sassafras albidum*), hickories, and Southern magnolia (*Magnolia grandiflora*). We classified stands as mixed pine-hardwood if they were 50–70% pine or hardwood. Within mixed-pine hardwood stands, trees ranged in size from seedling and sapling to mature sawtimber. Hardwood stands were confined to streamside management zones (SMZs), river bottoms, and forested wetlands. Hardwood stands on our study site were characterized by closed canopies, a prominent midstory, and a lack of understory vegetation. Hardwood stands were comprised of oaks, cypress (*Taxodium distichum*), and river birch (*Betula nigra*). We classified wildlife food plots, pastures, and agricultural fields, and recent clearcuts (≤4 yr old) as open areas. Although clearcuts 2–4 years old share similar characteristics to younger clearcuts, they also tend to be thicker with briars and hardwood saplings (Miller et al. 1995). Clearcuts this age could have been considered a unique vegetation community, but these stands represented <0.1% of our study area. Therefore, we included them with clearcuts ≤2 years old as open areas. Wetland areas were herbaceous or non-forested. Developed areas included human structures and settlements or barren land that were not considered to be a component of turkey habitat.

We obtained spatial data displaying history of prescribed fire application throughout our study area from public land management agencies and private timber companies. We used these data to create a map of fire events that occurred during the study period and 4 years prior to the beginning of each year of our study. We combined fire history data with our land cover map to distinguish between areas that had and had not been burned in recent years. Because prescribed fire in our study area was predominately applied to mature pine stands (Haywood 2012), we categorized mature pine stands as burned within 0–5 months prior to the first laying event (MP0; had experienced 0 growing seasons), burned approximately 1 year prior (MP1; had experienced 1 growing season post-burn), and burned 2 years prior (MP2; had experienced 2 growing seasons post-burn). Vegetation communities that had experienced ≥3 growing seasons post-burn tend to converge on our study site (Haywood 2009, 2010, 2012). In particular, ground cover vegetation decreases, midstory hardwoods encroach, and canopy closure tends to occur on our study site ≥3 growing seasons post-burn (Haywood 2010, 2012; Glitzenstein et al. 2012). Some mature pine stands on our site did not have any history of prescribed fire application during 2001–2014, which was the date range of our prescribed fire history. These stands share similar characteristics with stands ≥3 growing seasons post-burn (i.e., low understory vegetation, canopy closure). Given these shared characteristics, we felt it best to combine any mature pine stands burned ≥3 years prior or having no known history of fire application and classify these stands together (MP3; had experienced ≥3 growing seasons post-burn).

Habitat Selection

We examined third-order habitat selection (Johnson 1980) in a use versus availability framework similar to Manly et al. (2002) study design III. Because fire disturbance immediately alters vegetation structure and may affect habitat availability, we estimated daily selection by calculating daily utilization distributions (UDs) and comparing them to each individual turkey's home range. We estimated UDs using a third-generation estimator, the dynamic Brownian bridge movement model (dBBMM; Kranstauber et al. 2012). The dBMMM is a mechanistic model that accounts for changes in animal behaviors (e.g., foraging, resting) and helps remove unused areas from range estimates, thereby reducing commission errors that may affect selection estimates (Horne et al. 2007). The dBBMM requires several parameters to estimate a Brownian bridge UD: a time index series of animal locations, an estimate of mean telemetry error for each location, and an estimate of Brownian motion variance (σ^2_m), which is a measure of the irregularity of an animal's movement path between 2 locations and is a function of the animal's behavior. The dBMMM accounts for changes in animal behaviors over time by estimating a unique σ^2_m value for each time step between GPS locations (Gurarie et al. 2009). For the dBBMM parameters, we chose to use a constant window and margin size equal to 7 and 3, respectively, and a location error of 20 m (Kranstauber et al. 2012, Byrne et al. 2014). Because availability relies on quantifying the area known by an animal, we defined available vegetation communities for individuals as those within each turkey's home range. We calculated each home range as the 95% dBBMM UD built around locations collected from the time of capture throughout the lifetime of the transmitter. We defined used vegetation communities as those within each daily core area. We calculated daily core area as the 50% dBBMM UD built around locations collected from 0000 to 2359 each day. We used a window size of 15 and a margin of 5 as input parameters for the dBBMM (Byrne et al. 2014). We chose the window size and margin based on the temporal resolution of our data (Kranstauber et al. 2012, Byrne et al. 2014). To provide an estimate of how much space individuals were using daily, we calculated size of core areas during each reproductive phase. Because we did not expect space use to vary significantly by nest attempt (Conley et al. 2015), we pooled all nest attempts to estimate space use during the incubation phases.

To calculate selection ratios, we first used Euclidean distance analysis with a systematic sampling within each area of use as described by Benson (2013) to produce raster grids of distances to each vegetation community with a pixel size of 10 m. For each day of the study period, we updated the fire history within our study area according to application of prescribed fires. For estimates of daily use and daily availability, for each day of data collection we calculated distance to each vegetation community of every pixel within an individual's daily core area and home range. We then summarized pixel distances to calculate a mean distance to each vegetation community for used (i.e., daily core area) and available (i.e., what was available that day in an individual's home range) for each individual for every day of data collection. For each individual, we then calculated daily selection ratios for each vegetation community by dividing mean distance to a vegetation community for the daily core area by the mean distance to a vegetation community for the individual's home range.

To draw inference about selection at the population level, we then pooled daily selection ratios of each turkey during each reproductive phase, calculated a mean selection ratio for each individual for each of their reproductive phases, and then calculated a mean selection ratio for our sample respective to each phase. We set our alpha level, α, equal to 0.05 and estimated 95% confidence intervals around population-level selection ratios. We considered ratios with 95% confidence intervals excluding 1.0 to be statistically informative (Conner et al. 2003). We chose not to analyze selection of incubating females because we had previously examined the influence of vegetation community, landscape features, and vegetation characteristics on nest site selection (Yeldell et al. 2017).

Within this framework, a selection ratio approximately equal to 1.0 indicated use proportional to availability (i.e., random use), whereas a ratio <1.0 indicated selection of vegetation communities and a ratio >1.0 indicated avoidance of vegetation communities (Conner et al. 2003). In the event that a female raised 2 broods from 2 separate nest attempts within the same year, we pooled data from the 2 brood-rearing periods and calculated a temporally weighted average estimate of core area space use and a mean selection ratio during the brood-rearing phases. We conducted all analyses in program R v.3.1.1 (R Core Team 2013).

RESULTS

We collected data from 46 female turkeys captured and radio-marked in the winters of 2014 and 2015. We observed

Table 1. Mean size of core areas for reproductively active female eastern wild turkeys during reproductive phases at Kisatchie National Forest, west-central Louisiana, USA, 2014 and 2015.

Reproductive phase	n[a]	Date range[b]	Temporal extent ($\bar{x}$ days)[c]	Temporal extent (SE)	Area ($\bar{x}$ ha)[d]	Area (SE)
Pre-nest 1	40	15 Feb–22 May	55.8	3.0	62.9	5.3
Lay 1	40	25 Mar–3 Jun	12	NA	31.5	2.3
Pre-nest 2	21	12 Apr–12 Jun	10.5	1.4	54.1	6.2
Lay 2	21	18 Apr–24 Jun	12	NA	34.0	3.2
Pre-nest 3	7	17 May–30 Jun	15.9	2.1	78.0	6.1
Lay 3	7	25 May–12 Jul	12	NA	45.2	6.7
Incubation	61	6 Apr–19 Jul	11.4	1.2	0.25	0.03
Brood	9[e]	1 May–1 Aug	23.1	8.4	11.6	3.7
Post-nesting	31	1 May–13 Aug	36.2	4.5	52.4	5.2

[a] Sample size of dynamic Brownian bridge 50% utilization distributions from which we estimated core area space use.
[b] Date range from first date of earliest phase initiation to last date of latest phase termination.
[c] Temporal extent (days) of turkey location data used to estimate space use. We did not calculate temporal extent of egg-laying phases, but estimated it from previous literature.
[d] Size (ha) of core area of use.
[e] Brood-rearing core area of use pooled for 1 female turkey that raised 2 broods in 1 year.

87% ($n = 40$; 35 adults and 5 juveniles) of females initiate ≥1 nest, whereas 13% ($n = 6$; 3 adult and 3 juvenile) did not initiate a nest. We observed 40 initial nesting attempts, 21 second nest attempts, 7 third nest attempts, and 1 fourth nest attempt (Yeldell et al. 2017). In 2015, we observed 1 female initiate a second nest and successfully hatch a second brood following the loss of her first brood.

Core area sizes ($\bar{x} \pm$ SE) during pre-nesting phases were 62.9 ± 5.3 ha, 54.1 ± 6.2 ha, and 78.0 ± 6.1 ha for pre-nest 1, pre-nest 2, and pre-nest 3 phases, respectively (Table 1). Core area sizes during laying phases were 31.5 ± 2.3 ha, 34.0 ± 3.2 ha, and 45.2 ± 6.7 ha for lay 1, lay 2, and lay 3 phases, respectively (Table 1). Mean core area size during incubation was 0.25 ± 0.03 ha. Size of core areas used during brood-rearing periods was 11.6 ± 3.7 ha, whereas size of core areas used by reproductively active females after cessation of reproductive activity was 52.4 ± 5.2 ha ($n = 31$; Table 1).

During pre-nest 1 (date range = 15 Feb–22 May), females selected hardwood stands and avoided mature pines burned 2 years prior (Fig. 1 and Table 2). We did not detect selection during the pre-nest 2 (12 Apr–12 Jun) or pre-nest 3 (17 May–30 Jun) phases. During lay 1 (25 Mar–3 Jun), females selected mature pines burned the previous winter (Fig. 2). While laying eggs of a second nest attempt (lay 2; 18 Apr–24 Jun), females selected mixed pine-hardwood stands and open areas (Fig. 2). We did not detect significant selection or avoidance during lay 3 (25 May–12 Jul) phase. During brood-rearing (1 May–1 Aug), females avoided hardwood stands and mature pine stands burned ≥3 years prior (Fig. 3). Following the cessation of all reproductive activity (1 May–13 Aug), females selected mixed pine-hardwood stands and open areas (Fig. 4).

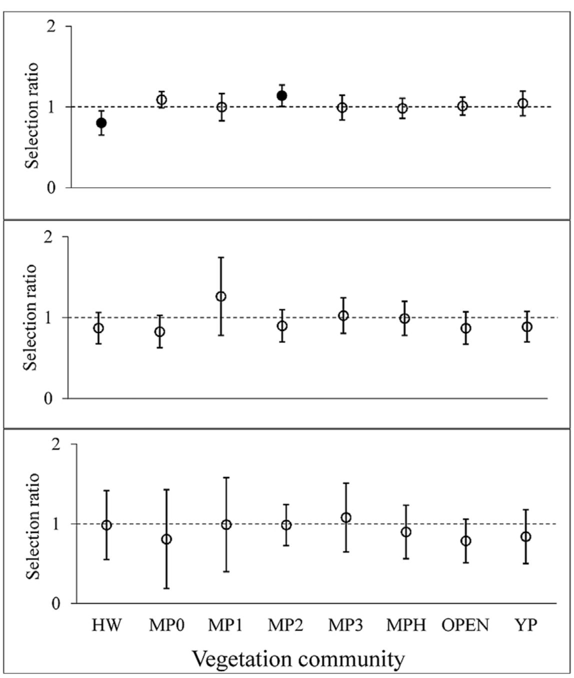

Figure 1. Selection ratios of reproductively active female eastern wild turkeys during pre-nest 1 (prior to initial nest attempt; 15 Feb–22 May; $n = 40$), pre-nest 2 (following loss of first nest or brood and before initiation of second nest; 12 Apr–12 Jun; $n = 21$), and pre-nest 3 (following loss of second nest or brood and before initiation of third nest; 17 May–30 Jun; $n = 7$) reproductive phases at Kisatchie National Forest, west-central Louisiana, USA, 2014 and 2015. Estimates >1 indicate avoidance and estimates <1 indicate selection, with deviation from 1 indicative of effect size. Error bars show 95% confidence intervals. Black-filled estimate markers indicate statistically significant selection or avoidance as indicated by 95% confidence intervals. Vegetation community types included hardwood (HW), mature pine (≥20 yr old) burned 0–5 months prior to the laying period (MP0), mature pine burned 1 year prior (MP1), mature pine burned 2 years prior (MP2), mature pine burned ≥3 years prior (MP3), mixed pine-hardwood (MPH), open areas (OPEN), and young pine (5–19 yr old; YP).

DISCUSSION

Prescribed fire immediately alters vegetation communities (Thaxton and Platt 2006, Ellair and Platt 2013, Wiggers et al. 2013), is often applied during turkey's reproductive season (Streich et al. 2015, Little et al. 2016, Yeldell et al. 2017), and may affect habitat availability for turkeys. Our findings suggest that prescribed burning, and the associated fire history, influences resource selection of female turkeys during their reproductive cycle. Moreover, we observed that use of pine stands managed with prescribed fire varied relative to the reproductive phenology of individual birds. Alternatively, female turkeys became more generalized in their selection and avoidance of vegetation communities later in the reproductive period (i.e., pre-nest 2, pre-nest 3, lay 2, and lay 3).

After 2 growing seasons, mature pine stands managed with prescribed fire were no longer attractive to female turkeys prior to or after nest incubation. However, female turkeys at our study area selected to nest in pine stands burned 2 years prior (Yeldell et al. 2017), which demonstrated the importance of that vegetation class in the reproductive cycle. Stands burned 0–5 months prior to the laying period were selected for during females' first laying period but were not selected or avoided by the population in any other reproductive phase. Turkeys in our study did not select to nest in forest stands burned 0–5 months prior (Yeldell et al. 2017). Therefore, it is unlikely turkeys were selecting stands burned 0–5 months prior because they were searching for suitable nest sites (Chamberlain and Leopold 2000). Use of recently burned areas during the laying phase may have been related to forage availability. Fire immediately removes ground vegetation and leaf litter (Cronan et al. 2015), which may increase foraging efficiency on insects and facilitate meeting the physiological demand for protein associated with egg-development during the laying period (Hurst 1992). Insects are an important component of the wild turkey's spring and summer diet (Hurst 1992), and recent evidence suggests time-post-burn does not substantially affect macroarthropod biomass in frequently burned pine-dominated landscapes (Chitwood et al. 2017).

Mature pine stands that had experienced only 1 growing season post-burn were not selected or avoided, although there was large variation among individuals. Females avoided mature pine stands 2 growing seasons post-burn prior to initiating their first nests, and avoided mature pine stands 3 growing seasons post-burn when brooding. Females with

Table 2. Vegetation community selection rankings (most preferred [1] to least preferred [8]) as determined by Euclidean distance analysis of reproductively active female eastern wild turkeys during phases of the reproductive period at Kisatchie National Forest, west-central Louisiana, USA, 2014 and 2015. An asterisk (*) indicates significant non-random use of a vegetation community by the population as determined by 95% confidence intervals around estimate of the selection ratio.

		Vegetation community ranking[a]							
Reproductive phase	***n*[b]**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Pre-nest 1	40	HW*	MPH	MP3	MP1	OPEN	YP	MP0	MP2*
Lay 1	40	MP0*	YP	OPEN	MP2	MPH	MP1	HW	MP3
Pre-nest 2	21	MP0	OPEN	HW	YP	MP2	MPH	MP3	MP1
Lay 2	21	MP0	OPEN*	MPH*	MP2	MP1	YP	HW	MP3
Pre-nest 3	7	OPEN	MP0	YP	MPH	HW	MP2	MP1	MP3
Lay 3	7	MP1	YP	MP3	OPEN	MP0	MPH	HW	MP2
Brood	9[c]	MP1	MP2	OPEN	MPH	MP0	YP	HW*	MP3*
Post-nesting	31	MPH*	OPEN*	YP	MP1	HW	MP0	MP3	MP2

[a] Vegetation community types included hardwood (HW), mature pine (≥20 yr old) burned 0–5 months prior to the laying period (MP0), mature pine burned 1 year prior (MP1), mature pine burned 2 years prior (MP2), mature pine burned ≥3 years prior (MP3), mixed pine-hardwood (MPH), open areas (OPEN), and young pine (5–19 yr old; YP).

[b] Sample size (n) of female turkeys for which we analyzed selection.

[c] Brood-rearing selection ratios pooled for 1 female turkey that raised 2 broods in 1 year.

broods likely avoided pine stands with ≥3 years since fire disturbance because understory plant communities were dominated by woody stems and lacking herbaceous vegetation. Female turkeys prefer vegetation communities offering an open understory and herbaceous ground cover for foraging and concealment (Lehman et al. 2008, Little et al. 2016), which frequent, low-intensity fire provides (Kirkman et al. 2004, Thaxton and Platt 2006, Ellair and Platt 2013, Wiggers et al. 2013). Our findings add to growing evidence that in pyric-influenced forests of the southeastern United States, frequent fire regimes are important in maintaining vegetation communities that turkeys select for (Moore et al. 2010; Martin et al. 2012; Kilburg et al. 2014; Little et al. 2014, 2016).

Selection of mixed pine-hardwood and hardwood stands was dynamic and affected by reproductive stage. Similar to previous research (Palmer et al. 1996, Miller et al. 1999, Miller and Conner 2007, Little et al. 2016), turkeys selected for hardwood stands prior to laying their first nest, which corresponded with late-winter and early spring. Conversely, hardwood stands were avoided by brooding females. Previous work in pine-dominated systems has noted females selected

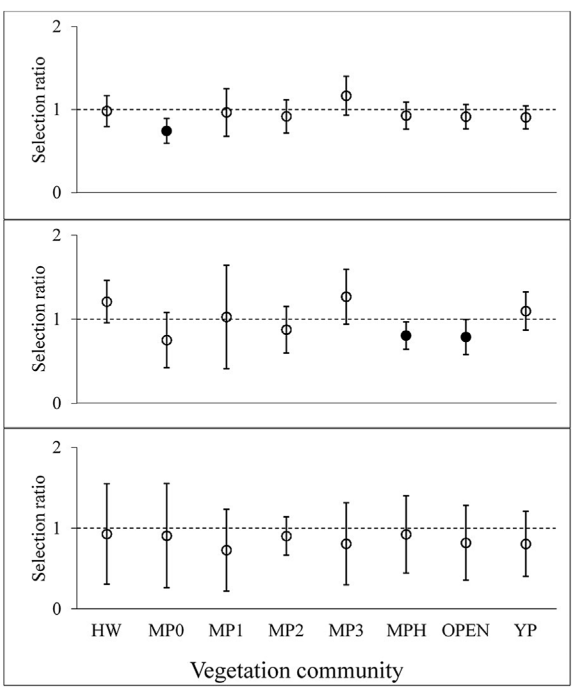

Figure 2. Selection ratios of reproductively active female eastern wild turkeys during lay 1 (laying first clutch; 25 Mar–3 Jun; $n = 40$), lay 2 (laying second clutch; 18 Apr–24 Jun; $n = 21$), and lay 3 (laying third clutch; 17 May–30 Jun; $n = 7$) reproductive phases at Kisatchie National Forest, west-central Louisiana, USA, 2014 and 2015. Estimates >1 indicate avoidance and estimates <1 indicate selection, with deviation from 1 indicative of effect size. Error bars show 95% confidence intervals. Black-filled estimate markers indicate statistical significance. Vegetation communities included hardwood (HW), mature pine (≥20 yr old) burned 0–5 months prior to the laying period (MP0), mature pine burned 1 year prior (MP1), mature pine burned 2 years prior (MP2), mature pine burned ≥3 years prior (MP3), mixed pine-hardwood (MPH), open areas (OPEN), and young pine (5–19 yr old; YP).

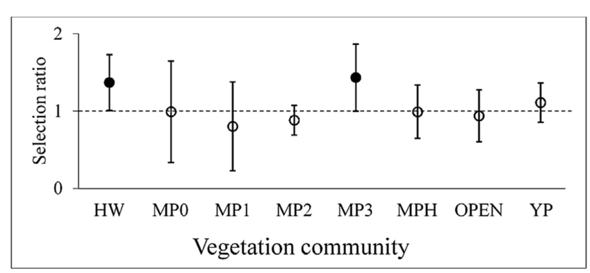

Figure 3. Selection ratios of reproductively active female eastern wild turkeys during the brood-rearing phase (beginning on date of nest hatch and extending 56 days or until brood is lost to predation or other mortality; 1 May–1 Aug; $n = 9$) at Kisatchie National Forest, west-central Louisiana, USA, 2014 and 2015. Estimates >1 indicate avoidance and estimates <1 indicate selection, with deviation from 1 indicative of effect size. Error bars show 95% confidence intervals. Black-filled estimate markers indicate statistically significant selection or avoidance as indicated by 95% confidence intervals. Vegetation community types included hardwood (HW), mature pine (≥20 yr old) burned 0–5 months prior to the laying period (MP0), mature pine burned 1 year prior (MP1), mature pine burned 2 years prior (MP2), mature pine burned ≥3 years prior (MP3), mixed pine-hardwood (MPH), open areas (OPEN), and young pine (5–19 yr old; YP).

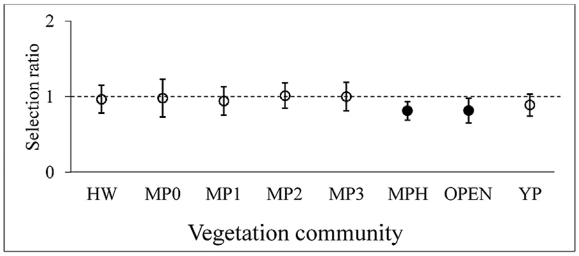

Figure 4. Selection ratios of reproductively active female eastern wild turkeys during the post-nesting phase (following all nesting attempts, loss of brood, or after broods reach 56 days old; 1 May–13 Aug; $n = 31$) at Kisatchie National Forest in west-central Louisiana, USA, 2014 and 2015. Estimates >1 indicate avoidance and estimates <1 indicate selection, with deviation from 1 indicative of effect size. Error bars show 95% confidence intervals. Black-filled estimate markers indicate statistically significant selection or avoidance as indicated by 95% confidence intervals. Vegetation community types included hardwood (HW), mature pine (≥20 yr old) burned 0–5 months prior to the laying period (MP0), mature pine burned 1 year prior (MP1), mature pine burned 2 years prior (MP2), mature pine burned ≥3 years prior (MP3), mixed pine-hardwood (MPH), open areas (OPEN), and young pine (5–19 yr old; YP).

hardwood stands following nest incubation (Phalen et al. 1986, Miller et al. 1999, Jones et al. 2005). However, use of hardwood stands documented in these studies may have been due to a lack of appropriate habitat conditions in upland pine stands in that landscape (Phalen et al. 1986, Miller et al. 1999). We found females without broods selected for mixed-pine hardwood stands, and the inability of aforementioned studies to distinguish between females with or without broods, or measure availability as an individual's own home range, may have influenced these contrasting results. Hardwood forests are important vegetation communities for mesopredators in pine-dominated systems (Gehrt and Fritzell 1998, Godbois et al. 2003, Kirby 2015), and lack of understory vegetation in these areas may affect poult susceptibility to predation (Godfrey and Norman 1999). Hardwood stands are also an important vegetation community for turkeys in winter but may be less important for brooding females in landscapes where upland pine stands are managed to create appropriate habitat conditions.

Females in our study selected for open areas after cessation of reproductive efforts, which corresponded with summer (May–Aug; Yeldell et al. 2017). Wild turkey use of open areas in spring and summer has been widely documented (Lewis 1964, Kurzejeski and Lewis 1990, Sisson et al. 1990, Sisson and Speake 1994) and is likely attributable to presence of important food resources in the form of insects, green foliage, soft mast, and grass seeds (Baughman and Guynn 1993). Our research continues to demonstrate this vegetation community as selected by turkeys in the summer. Young pine stands were not selected or avoided by turkeys in our study during any reproductive period. Pine stands at this age on our study area generally develop open understories (Haywood 2012), and previous research indicates turkeys avoid similar stands upon canopy closure (Miller et al. 1999).

Our inability to detect selection or avoidance of vegetation communities in some reproductive phases (i.e., second and third laying phase, second and third pre-nesting phase), may have been an artifact of relatively low sample sizes. This suggests the strength of selection during some reproductive periods is not strong enough at the population scale to be detected at our sample size or selection at the population scale is not occurring. Although we were unable to detect selection or avoidance of some vegetation communities, our methods allow a more accurate estimate of selection for each individual and the population. Aggregation of information across coarse temporal periods fails to acknowledge the significant individual variation in reproductive phenology of wild turkeys (Yeldell et al. 2017) and may result in incorrect inferences (Oetgen et al. 2015). By comparison, we defined our reproductive phases based on known periods for each individual and not by grouping broad calendar dates. Concurrently, the landscape an individual selected from changed every day in our analysis as we incorporated application of prescribed fire onto the landscape. Therefore, the proportional area that was burned and unburned changed daily for each individual. Future research on turkey habitat selection would benefit from a similar analytical structure.

Wild turkeys are considered a generalist species (Hurst 1992). At the population level, turkeys in our study area tended to be generalists; the population rarely selected or avoided any vegetation community, particularly later in the reproductive period. However, confidence intervals surrounding our selection ratios suggest individual selection within the same vegetation communities varied largely, particularly for mature pine stands burned ≤2 years ago, regardless of sample size. This variation makes population-level inferences concerning prescribed fire difficult. Individuals may value trade-offs between foraging opportunities and predation risk differently based on physiological condition (Nord et al. 2014, Adelman et al. 2017, Visscher et al. 2017), or experience (Ibáñez-Álamo et al. 2015), which may affect population-level processes (Dingemanse and Wolf 2013). Future research should try to understand underlying processes mediating selection of the population, and the resulting effect on demographic outcomes (e.g., survival, productivity) to strengthen future management efforts.

MANAGEMENT IMPLICATIONS

Across most vegetation communities, and specific to time since fire, selection and avoidance changed depending on reproductive phenology of individual female turkeys. We recommend managers retain hardwood and mixed pine-hardwood stands in pine-dominated landscapes to provide vegetation communities selected for during winter and portions of turkeys' reproductive cycle. Turkeys did not select for pine stands that have experienced ≥3 growing seasons post-burn during any part of the reproductive period, and may actually avoid these stands during pre-nesting and brooding. In areas with similar fire regimes, our data suggests frequent (i.e., 1–3 yr) fire return intervals maintain vegetation communities that females select at some point during the reproductive season. We recommend managers of pine forests create a mosaic of forest types and apply fire to pine stands on a rotational basis to provide the various vegetation communities that female turkeys select for throughout the reproductive cycle.

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LITERATURE CITED

Adelman, J. S., C. Mayer, and D. M. Hawley. 2017. Infection reduces anti-predator behaviors in house finches. Journal of Avian Biology 48:519–528.

Andersson, M., J. Wallander, and D. Isaksson. 2009. Predator perches: a visual search perspective. Functional Ecology 23:373–379.

Baughman, W. M., and D. C. Guynn Jr. 1993. Wild turkey food habits in pine plantations in South Carolina. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 47:163–169.

Beckage, B., W. J. Platt, and L. J. Gross. 2009. Vegetation, fire, and feedbacks: a disturbance-mediated model of savannas. American Naturalist 174:805–818.

Benhamou, S., and D. Cornélis. 2010. Incorporating movement behavior and barriers to improve kernel range space use estimates. Journal of Wildlife Management 74:1353–1360.

Benson, J. F. 2013. Improving rigour and efficiency of use-availability habitat selection analyses with systematic estimation of availability. Methods in Ecology and Evolution 4:244–251.

Bowman, G. B., and L. D. Harris. 1980. Effect of spatial heterogeneity on ground-nest predation. Journal of Wildlife Management 44:806–813.

Brockway, D. G., and C. E. Lewis. 1997. Long-term effects of dormant-season prescribed fire on plant community diversity, structure, and productivity in a longleaf pine wiregrass ecosystem. Forest Ecology and Management 96:167–183.

Burk, J. D., D. R. Smith, G. A. Hurst, B. D. Leopold, and M. A. Melchiors. 1990. Wild turkey use of loblolly pine plantations for nesting and brood rearing. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 44:163–170.

Byrne, M. E., J. C. McCoy, J. W. Hinton, M. J. Chamberlain, and B. A. Collier. 2014. Using dynamic Brownian bridge movement modelling to measure temporal patterns of habitat selection. Journal of Animal Ecology 83:1234–1243.

Campo, J. J., W. G. Swank, and C. R. Hopkins. 1989. Brood habitat use by eastern wild turkeys in eastern Texas. Journal of Wildlife Management 53:479–482.

Chamberlain, M. J., and B. D. Leopold. 2000. Habitat sampling and selection by female wild turkeys during preincubation. Wilson Bulletin 112:326–331.

Chitwood, M. C., M. A. Lashley, B. L. Sherrill, C. Sorenson, C. S. DePerno, and C. E. Moorman. 2017. Macroarthropod response to time-since-fire in the longleaf pine ecosystem. Forest Ecology and Management 391:390–395.

Cohen, B. S., T. J. Prebyl, N. J. Stafford, B. A. Collier, and M. J. Chamberlain. 2015. Space use, movements, and habitat selection of translocated eastern wild turkeys in northwestern Louisiana. Proceedings of the National Wild Turkey Symposium 11:165–174.

Collier, B. A., and M. J. Chamberlain. 2010. Redirecting research for wild turkeys using global positioning system transmitters. Proceedings of the National Wild Turkey Symposium 10:81–92.

Conley, M. D., J. G. Oetgen, J. Barrow, M. J. Chamberlain, K. L. Skow, and B. A. Collier. 2015. Habitat selection, incubation, and incubation recess ranges of nesting female Rio Grande wild turkeys in Texas. Proceedings of the National Wild Turkey Symposium 11:117–126.

Conner, L. M., M. D. Smith, and L. W. Burger. 2003. A comparison of distance-based and classification-based analyses of habitat use. Ecology 84:526–531.

Cronan, J. B., C. S. Wright, and M. Petrova. 2015. Effects of dormant and growing season burning on surface fuels and potential fire behavior in northern Florida longleaf pine (*Pinus palustris*) flatwoods. Forest Ecology and Management 354:318–333.

Dalke, P. D., W. K. Clark, and L. J. Korschgen. 1942. Food habit trends of the wild turkey in Missouri as determined by dropping analysis. Journal of Wildlife Management 6:237–243.

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

Dingemanse, N. J., and M. Wolf. 2013. Between-individual differences in behavioural plasticity within populations: causes and consequences. Animal Behaviour 85:1031–1039.

Drewa, P. B., W. J. Platt, and E. B. Moser. 2002. Fire effects on resprouting of shrubs in headwaters of southeastern longleaf pine savannas. Ecology 83:755–767.

Ellair, D. P., and W. J. Platt. 2013. Fuel composition influences fire characteristics and understory hardwood stands in pine savannas. Journal of Ecology 101:192–201.

Exum, J. H., J. A. McGlincy, D. W. Speake, J. L. Buckner, and F. M. Stanley. 1987. Ecology of the eastern wild turkey in an intensively managed pine forest in southern Alabama. Tall Timbers Research Station Bulletin 23, Tallahassee, Florida, USA.

Gehrt, S. D., and E. K. Fritzell. 1998. Resource distribution, female home range dispersion, and male spatial interactions: Group structure in a solitary carnivore. Animal Behaviour 55:1211–1227.

Glidden, J. W., and D. E. Austin. 1975. Natality and mortality of wild turkey poults in southwestern New York. Proceedings of the National Wild Turkey Symposium 3:48–54.

Glitzenstein, J. S., D. R. Streng, R. E. Masters, K. M. Robertson, and S. M. Hermann. 2012. Fire-frequency effects on vegetation in north Florida pinelands: another look at the long-term Stoddard Fire Research Plots at Tall Timbers Research Station. Forest Ecology and Management 264:197–209.

Glover, F. A., and R. W. Bailey. 1949. Wild turkey foods in West Virginia. Journal of Wildlife Management 13:255–265.

Godbois, I. A., L. M. Conner, and R. J. Warren. 2003. Habitat use of bobcats at two spatial scales in southwestern Georgia. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 57:228–234.

Godfrey, C. L, and G. W. Norman. 1999. Effect of habitat and movement on wild turkey poult survival. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 53:330–339.

Grady, J., and W. A. Hoffmann. 2012. Caught in a fire trap: recurring fire creates stable size equilibria in woody resprouters. Ecology 93:2052–2060.

Gross, J. T., B. S. Cohen, B. A. Collier, and M. J. Chamberlain. 2015. Influences of hunting on movements of male wild turkeys during spring. Proceedings of the National Wild Turkey Symposium 11:175–185.

Gurarie, E., R. D. Andrews, and K. L. Laidre. 2009. A novel method for identifying behavioral changes in animal movement data. Ecology Letters 12:395–408.

Guthrie, J. D., M. E. Byrne, J. B. Hardin, C. O. Kochanny, K. L. Skow, R. T. Snelgrove, M. J. Butler, M. J. Peterson, M. J. Chamberlain, and B. A. Collier. 2011. Evaluation of a global positioning system backpack transmitter for wild turkey research. Journal of Wildlife Management 75:539–547.

Hart, N. S., J. C. Partridge, and I. C. Cuthill. 1999. Visual pigments, cone oil droplets, ocular media, and predicted spectral sensitivity in the domestic turkey (*Meleagris gallopavo*). Vision Research 39:3321–3328.

Haywood, J. D. 2009. Eight years of seasonal burning and herbicidal brush control influence sapling longleaf pine growth, understory vegetation, and the outcome of an ensuing wildfire. Forest Ecology and Management 258:295–305.

Haywood, J. D. 2010. Effects of prescribed fire on vegetation and fuel loads in longleaf pine stands in the bluestem range. Proceedings of the 14th Biennial Southern Silvicultural Research Conference 14:213–217.

Haywood, J. D. 2012. Frequency and season of prescribed fire affect understory plant communities in longleaf pine stands. Proceedings of the 16th Biennial Southern Silvicultural Research Conference 16:137–143.

Healy, W. M. 1992. Behavior. Pages 46–65 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Healy, W. M., R. O. Kimmel, and E. J. Goetz. 1975. Behavior of human-imprinted and hen-reared wild turkey poults. Proceedings of the National Wild Turkey Symposium 3:97–107.
Healy, W. M., and E. S. Nenno. 1980. Growth parameters and sex and age criteria for juvenile eastern wild turkeys. Proceedings of the National Wild Turkey Symposium 4:168–185.
Healy, W. M., and E. S. Nenno. 1985. Effect of weather on wild turkey poult survival. Proceedings of the National Wild Turkey Symposium 5:91–101.
Holbrook, H. T., M. R. Vaughan, and P. T. Bromley. 1987. Wild turkey habitat preferences and recruitment in intensively managed Piedmont forests. Journal of Wildlife Management 51:182–187.
Horne, J. S., E. O. Garton, S. M. Krone, and J. S. Lewis. 2007. Analyzing animal movements using Brownian bridges. Ecology 88:2354–2363.
Hurst, G. A. 1992. Foods and feeding. Pages 66–83 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.
Ibáñez-Álamo, J. D., R. D. Magrath, J. C. Oteyza, A. D. Chalfound, T. M. Haff, K. A. Schmidt, R. L. Thomson, and T. E. Martin. 2015. Nest predation research: recent findings and future perspectives. Journal of Ornithology 156:247–262.
Javůrková, V., A. L. Šizling, J. Kreisinger, and T. Albrecht. 2012. An alternative theoretical approach to escape decision-making: the role of visual cues. PLoS ONE 7:e32522.
Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.
Jones, B. C., J. E. Inglis, and G. A. Hurst. 2005. Wild turkey brood habitat use in relation to prescribed burning for red-cockaded woodpecker management. Proceedings of the National Wild Turkey Symposium 9:209–215.
Kennamer, J. E., J. R. Gwaltney, and K. R. Sims. 1980. Food habits of the eastern wild turkey on an area intensively managed for pine in Alabama. Proceedings of the National Wild Turkey Symposium 4:246–250.
Kilburg, E. L., C. E. Moorman, C. S. Deperno, D. Cobb, and C. A. Harper. 2014. Wild turkey nest survival and nest-site selection in the presence of growing-season prescribed fire. Journal of Wildlife Management 78:1033–1039.
Kirby, R. B. 2015. Effects of forest management practices on raccoon ecology in a longleaf pine ecosystem. Thesis, University of Tennessee-Knoxville, Knoxville, USA.
Kirkman, L., P. Goebel, B. Palik, and L. West. 2004. Predicting plant species diversity in a longleaf pine landscape. Ecoscience 11:80–93.
Kolowski, J. M., and A. Woolf. 2002. Microhabitat use by bobcats in southern Illinois. Journal of Wildlife Management 66:822–832.
Kranstauber, B., R. Kays, S. D. LaPoint, M. Wikelski, and K. Safi. 2012. A dynamic Brownian bridge movement model to estimate utilization distributions for heterogeneous animal movement. Journal of Animal Ecology 81:738–746.
Kurzejeski, E. W., and J. B. Lewis. 1990. Ranges, movements, and habitat use of wild turkey hens in northern Missouri. Proceedings of the National Wild Turkey Symposium 6:67–71.
Kush, J. S., R. S. Meldahl, and W. D. Boyer. 2000. Understory plant community response to season of burn in natural longleaf pine forests. Tall Timbers Fire Ecology Conference 21:33–39.
Lavoie, M., G. Starr, M. C. Mack, T. A. Martin, and H. L. Gholtz. 2010. Effects of a prescribed fire on understory vegetation, carbon pools, and soil nutrients in a longleaf pine-slash pine forest in Florida. Natural Areas Journal 30:82–94.
Lehman, C. P., M. A. Rumble, L. D. Flake, and D. J. Thompson. 2008. Merriam's turkey nest survival and factors affecting nest predation by mammals. Journal of Wildlife Management 72:1765–1774.
Lewis, J. C. 1964. Populations of wild turkeys in relation to fields. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 18:49–56.
Little, A. R., M. J. Chamberlain, L. M. Conner, and R. J. Warren. 2016. Habitat selection of wild turkeys in burned longleaf pine savannas. Journal of Wildlife Management 80:1280–1289.
Little, A. R., M. M. Streich, M. J. Chamberlain, L. M. Conner, and R. J. Warren. 2014. Eastern wild turkey reproductive ecology in frequently-burned longleaf pine savannas. Forest Ecology and Management 331:180–187.
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 for field studies. Second edition. Kluwer Academic Publishers, Dordrecht, Netherlands.
Martin, J. A., W. E. Palmer, S. M. Juhan, Jr., and J. P. Carroll. 2012. Wild turkey habitat use in frequently-burned pine savanna. Forest Ecology and Management 285:179–186.
Miller, D. A., and L. M. Conner. 2007. Habitat selection of female turkeys in a managed pine landscape in Mississippi. Journal of Wildlife Management 71:744–751.
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, J. H., B. R. Zutter, S. M. Zedaker, M. B. Edwards, and R. A. Newhold. 1995. Early plant succession in loblolly pine plantations as affected by vegetation management. Southern Journal of Applied Forestry 19:109–126.
Moore, W. F., J. C. Kilgo, W. D. Carlisle, D. C. Guynn Jr. and J. R. Davis. 2010. Nesting success, nest site characteristics, and survival of wild turkey hens in South Carolina. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 64:24–29.
New, T. R. 2014. Insects, fire and conservation. Springer International Publishing, Cham, Switzerland.
Niedzielski, B., and J. Bowman. 2016. Home range and habitat selection of the female eastern wild turkey at its northern range edge. Wildlife Biology 22:55–63.
Nord, A., S. Sköld-Chiriac, D. Hasselquist, and J. Nilsson. 2014. A tradeoff between predation risk and energy conservation revealed by an immune challenge experiment. Oikos 123:1091–1100.
Oetgen, J., A. Engeling, A. Dube, K. L. Skow, M. J. Chamberlain, and B. A. Collier. 2015. Evaluating Rio Grande wild turkey movements post catastrophic wildfire using two selection analysis approaches. Proceedings of the National Wild Turkey Symposium 11:127–141.
Palmer, W. E., G. A. Hurst, and B. D. Leopold. 1996. Pre-incubation habitat use by wild turkey hens in central Mississippi. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 50:417–427.
Pelham, P. H., and J. G. Dickson. 1992. Physical characteristics. Pages 32–45 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.
Phalen, P. S., G. A. Hurst, and W. J. Hamrick. 1986. Brood habitat use and preference by wild turkeys in central Mississippi. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 40:397–404.
Provencher, L., B. J. Herring, D. R. Gordon, H. L. Rodgers, G. W. Tanner, J. L. Hardesty, L. A. Brennan, and A. R. Litt. 2001. Longleaf pine and oak responses to hardwood reduction techniques in fire-suppressed sandhills in northwest Florida. Forest Ecology and Management 148:1–15.
R Core Team. 2013. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
Reiss, M. J. 1987. Optimzation theory in behavioural ecology. Journal of Biological Education 21:241–247.
Rolley, R. E., and W. D. Ward. 1985. Bobcat habitat use in southeastern Oklahoma. Journal of Wildlife Management 49:913–920.
Schemnitz, S. D. 1956. Wild turkey food habits in Florida. Journal of Wildlife Management 20:132–137.
Sisson, D. C., and D. W. Speake. 1994. Spring burning for wild turkey brood habitat: an evaluation. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 48:134–139.
Sisson, D. C., D. W. Speake, J. L. Landers, and J. L. Buckner. 1990. Effects of prescribed burning on wild turkey habitat preference and nest site selection in South Georgia. Proceedings of the National Wild Turkey Symposium 6:44–50.
Steffen, D. E., N. W. Lafon, and G. W. Norman. 2002. Turkeys, acorns, and oaks. Pages 241–255 *in* W. J. McShea and W. M. Healy, editors. Oak forest ecosystems: ecology and management for wildlife. Johns Hopkins University Press, Baltimore, Maryland, USA.
Still Jr. H. R., and D. P. Bauman Jr. 1990. Wild turkey nesting ecology on the Francis Marion National Forest. Proceedings of the National Wild Turkey Symposium 6:13–17.
Streich, M. M., A. R. Little, M. J. Chamberlain, L. M. Conner, and R. J. Warren. 2015. Habitat characteristics of eastern wild turkey nest and ground-roost sites in 2 longleaf pine forests. Journal of the Southeastern Association of Fish and Wildlife Agencies 2:164–170.
Stys, J. E., G. A. Hurst, B. D. Leopold, and M. A. Melchiors. 1992. Wild turkey use of control-burned loblolly pine plantations. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 46:37–45.

Thaxton, J. M., and W. J. Platt. 2006. Small-scale fuel variation alters fire intensity and shrub abundance in a pine savanna. Ecology 87:1331–1337.
Thogmartin, W. E. 2001. Home-range size and habitat selection of female wild turkeys (*Meleagris gallopavo*) in Arkansas. American Midland Naturalist 145:247–260.
Tisdale, V., and E. Fernandez-Juricic. 2009. Vigilance and predator detection vary between avian species with different visual acuity and coverage. Behavioral Ecology 20:936–945.
Vangilder, L. D. 1992. Population dynamics. Pages 144–164 *in* J. G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.
Varner, J. M., J. S. Kush, and R. S. Meldahl. 2000. Ecological restoration of an old-growth longleaf pine stand utilizing prescribed fire. Pages 216–219 *in* K. W. Moser, and C. E. Moser, editors. Fire and forest ecology: innovative silviculture and vegetation management, Tallahassee, Florida, USA.
Visscher, D. R., E. H. Merrill, and P. K. Martin. 2017. Hierarchical trade-offs between risk and reward mediated by behavior. Mammal Research 62:129.
Walter, W. D., D. P. Onorato, and J. W. Fischer. 2015. Is there a single best estimator? Selection of range estimators using area-under-the-curve. Movement Ecology 3:10.
Werner, S. J., R. Buchholz, S. K. Tupper, S. E. Pettit, and J. W. Ellis. 2014. Functional significance of ultraviolet feeding cues in wild turkeys. Physiology and Behavior 123:162–167.
Wiggers, M. S., L. K. Kirkman, R. S. Boyd, and J. K. Hiers. 2013. Fine-scale variation in surface fire environment and legume germination in the longleaf pine ecosystem. Forest Ecology and Management 310:54–63.
Williams, L. E., D. H. Austin, T. E. Peoples, and R. W. Phillips. 1971. Laying data and nesting behavior of wild turkeys. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 25:90–106.
Yeldell, N. A., B. S. Cohen, A. R. Little, B. A. Collier, and M. J. Chamberlain. 2017. Nest site selection and nest survival of eastern wild turkeys in a pyric landscape. Journal of Wildlife Management 81:in press.

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