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Wild Turkey Prenesting-resource Selection in a Landscape Managed with Frequent Prescribed Fire

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Abstract - Forage and nesting cover available to female *Meleagris gallopavo* (Wild Turkey) prior to nesting can influence nest success. Prescribed burns commonly are conducted during the dormant season in southern *Pinus* (pine) forests in part to improve vegetation conditions for prenesting Wild Turkeys and reduce risk of fire-related nest failure associated with growing-season burning. However, prescribed burning during the early growing season may provide beneficial food and cover for Wild Turkeys. Therefore, we investigated the influence of fire season and frequency and vegetation characteristics on female Wild Turkey habitat selection during prenesting in a *Pinus palustris* (Longleaf Pine) community managed with frequent growing-season prescribed fire in North Carolina. Growing-season fire history was not predictive of prenesting habitat selection. Females selected forest stands burned during the preceding dormant season, edges of non-forested cover, and creek drainages. On our study area, ericaceous shrubs along creek drainages provided nesting cover, and greater probability of use near creeks likely reflected females searching for potential nest sites. Recent dormant-season burns may provide an important source of nutrition for pre-nesting females and should be used in addition to growing-season burns when managing for Wild Turkeys.

Introduction

Meleagris gallopavo L. (Wild Turkey; hereafter, Turkey) habitat selection during prenesting (i.e., flock breakup until onset of incubation) can influence nest success and population growth (Chamberlain and Leopold 2000). Prior to nesting, female Turkeys selectively forage in non-forested areas and open forest stands with grass–forb-dominated understories (Chamberlain and Leopold 2000, Hurst and Dickson 1992, Palmer et al. 1996). Often, arthropod availability is positively correlated with herbaceous cover, and in addition to grass seeds and forbs, invertebrates provide protein and calcium for egg production (Harper et al. 2000, Hurst and Dickson 1992). Females search for potential nest sites during prenesting, and the duration of time spent searching has been positively correlated with nest success (Badyaev 1995, Chamberlain and Leopold 2000, Miller et al. 1999).

Prescribed burns may be used in part to manage vegetative cover and forage for prenesting Turkeys. Forest stands burned during the dormant season start growing earlier the following spring than unburned stands and provide relatively open

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understories selected by prenesting females (Palmer et al. 1996, Sisson et al. 1990). Additionally, periodic dormant-season burns stimulate shrub and hardwood sprouting, which provides nesting cover in subsequent years (McCord and Harper 2011, Palmer and Hurst 1998, Waldrop et al. 1992). Alternatively, repeated, short (1–2 year) dormant-season fire return intervals may decrease understory shrub cover and favor herbaceous species (Brockway and Lewis 1997, Waldrop et al. 1992).

Southeastern *Pinus* (pine) forests historically burned primarily during spring and early summer, and frequent growing-season (15 March–15 October) prescribed burns may produce understory vegetation conditions more beneficial for prenesting females than periodic applications of dormant-season fire (Cox and Widener 2008, Knapp et al. 2009). Prescribed burning during the early growing season, especially on short (1–3 year) return intervals can more effectively top-kill shrubs and fire-sensitive hardwoods than a similar application of dormant-season fire and produce a more open forest understory dominated by grasses and forbs (Drewa et al. 2002, Glitzenstein et al. 1995, Waldrop et al. 1992). Consequently, herbaceous vegetation and associated arthropods promoted by growing-season fire could increase protein and calcium availability for egg production and allow greater sight-distance in the understory as a result of woody-stem reduction that may decrease predation risk for prenesting females (Thogmartin and Schaeffer 2000). Furthermore, growing-season burns applied at a landscape scale, even on a short, 3-year return interval, pose minimal risk to nesting Turkeys and may improve nesting cover (Jones 2001, Kilburg et al. 2014). However, habitat selection by female Turkeys during the prenesting season has not been evaluated in the presence of growing-season fire.

We assessed habitat selection by female Turkeys during prenesting in a landscape managed with both dormant- and growing-season burns. We hypothesized that females would select forest stands managed primarily with growing-season burns more strongly than stands managed with dormant-season burns, and that females would select more recently burned forest stands regardless of season of burn. Finally, we expected that the season of burn and the time since burn would shape vegetative cover to influence selection.

Field-site Description

We assessed female Turkey habitat selection during prenesting on a 10,000-ha portion of Fort Bragg Military Reservation, NC, in the Sandhills physiographic region of the Atlantic Coastal Plain. Topography was rolling with xeric, sandy uplands interrupted by numerous blackwater streams. Firebreaks and streams divided the study area into 34-ha (SE = 0.98) fire-management units that were managed with prescribed burns during the growing season, primarily April–June, on a 3-year return interval. Few fire-management units within our study area were unburned for >4 years. Initiation of the growing season was determined by personnel at the Fort Bragg Forestry Branch and typically was 15 March (± 3 days) (J. Monroe, Fort Bragg Forestry Branch, Fort Bragg, NC, pers. comm.). Large areas used for ordnance detonation in the center of the study area were burned annually or biennially during the dormant or growing season. Fire and soil moisture interacted to produce numerous vegetation communities (Sorrie et al. 2006). Generalized communities included pine (85%), non-forested (11%), and lowland hardwood (4%).

The pine vegetation type included upland and lowland pine communities. Upland pine stands had an open *Pinus palustris* Mill. (Longleaf Pine) canopy with *Aristida stricta* Michx. (Wiregrass), *Gaylussacia dumosa* (Andrews) Torr. and A. Gray (Dwarf Huckleberry), scrubby *Quercus laevis* Walter (Turkey Oak), and *Quercus marilandica* (L.) Münchh. (Blackjack Oak) dominating in the understory. Lowland pine communities were located along ephemeral streams and as ecotones between upland pine and lowland hardwood communities. Longleaf Pine, *Pinus taeda* L. (Loblolly Pine), and *Pinus serotina* Michx. (Pond Pine) were common overstory species, and ericaceous shrubs dominated the understory of the lowland pine habitat. Non-forested areas included managed and unmanaged openings. Managed openings were mowed and burned annually during the dormant season. Vegetation in these openings was dominated by *Eragrostis curvula* (Schrad.) Nees (Weeping Lovegrass), *Lespedeza cuneata* (Dum. Cours.) G. Don (Sericea Lespedeza), and *Rubus* spp. (Blackberry). Unmanaged openings located within impact areas burned frequently and unpredictably from artillery fire. Wiregrass, Dwarf Huckleberry, and *Toxicodendron pubescens* Mill. (Poison Oak) were dominant in uplands, and *Arundinaria tecta* Muhl. (Switchcane), *Dicanthelium* spp. (panicgrasses), ericaceous shrubs, *Eupatorium* spp. (snakeroot), and *Smilax* spp. (greenbrier) were dominant in lowlands. Closed canopy bottomland-hardwood communities were located along permanently flowing streams. Overstory species in these areas included *Acer rubrum* L. (Red Maple), *Liquidambar styraciflua* L. (Sweetgum), *Liriodendron tulipifera* L. (Yellow-poplar), and *Nyssa sylvatica* Marshall (Blackgum). Dense thickets of *Ilex coriacea* (Pursh) Chapm. (Gallberry), *Lyonia* spp. (fetterbush), and greenbrier were common in canopy gaps and along edges.

Methods

We captured female Turkeys using rocket-nets from February to April 2011 and January to March 2012 (Grubb 1988). We used trail camerals to monitor hen activity at bait sites and to identify capture locations. Also, trail cameras allowed us to pinpoint the timing of break-up of hen flocks and the corresponding initiation of the prenesting season. We attached 85-g Micro GPS backpack-style data loggers (Model G1H271 Sirtrack LTD, Havelock North, New Zealand), programmed to obtain and store on-board 4 locations daily (1 location approximately every 6 hours) to 34 birds. We set the fix rate to maximize sampling frequency while maintaining battery life >1 year to allow potential recapture and recovery of data loggers. Data loggers were equipped with a 12-hour motionless switch and very high frequency (VHF) transmitter. We recovered the data loggers as the backpack harness wore naturally, when Turkeys were depredated, or recaptured. We aged Turkeys as juveniles or adults by the contour of the rectrices and censored mortalities that occurred within 7 days of capture (Pelham and Dickson 1992). All capture and handling protocols were approved by North Carolina State University Institutional Animal Care and Use Committee (#10-149-A), Raleigh, NC.

Data analysis

We used resource-selection Design II (Manly et al. 2002) to assess female Turkey prenesting-range selection by comparing vegetation type, stream and non-forested edge density (m/ha), and fire-history attributes between Turkey prenesting ranges and 30 circular simulation (i.e., random) ranges (Katnik and Weilgus 2005, Miller and Conner 2007). We plotted diurnal GPS locations from the beginning of prenesting (~20 March as determined from trail cameras at bait sites) until onset of incubation (mean = 26 April) using GIS. We determined the spatial extent (i.e., perimeter) of each prenesting range by creating 95% kernel home-ranges from GPS locations. We created a minimum convex polygon around prenesting kernel ranges of all Turkeys to define availability, and simulation ranges were randomly placed inside this availability polygon using ArcMap 10 (Environmental Systems Research Institute, Inc., Redlands, CA). Simulation ranges had variable areas between the minimum (255 ha) and maximum (1571 ha) values of observed Turkey prenesting ranges. In each prenesting and simulation range, we determined percent pine, bottomland hardwood, and non-forested cover types; stream density (m/ha); non-forested edge density (m/ha); percent of each range burned during the prenesting season, previous dormant season, and previous growing season; and percent unburned for >2 years.

We developed 10 a priori logistic regression models to assess predicted habitat relationships and the relative influence of fire history. The global model included vegetative cover types, stream and non-forested edge densities, and fire-history attributes. The landcover model compared proportions of pine, bottomland hardwood, and non-forested cover types in used and simulation ranges. The landscape-features model included stream density (m/ha) and non-forested edge density (m/ha). The fire-history model compared the proportion of used and simulation ranges burned during the prenesting season, preceding dormant season, and previous growing season, and unburned for >2 years. Finally, we assessed landscape-feature and fire-history variables individually. We used Akaike's information criterion (AIC) for model selection and considered any model with $\Delta AIC \leq 2$ as a candidate model (R Core Development Team 2012).

We used resource-selection Design III (Manly et al. 2002) to assess resource selection within female prenesting ranges. We did not include renesting attempts in our analyses because resource availability may have changed significantly between first and subsequent nesting attempts. We created 95% utilization distributions for each Turkey from GPS locations and sampled intensity of use (i.e., the height of the utilization distribution) at 200 randomly generated points in each utilization distribution (Marzluff et al. 2004, Millspaugh et al. 2006). Using multiple regression (R, version 2.15.1), we regressed distance to nest (m), stream (m), and non-forested edge (m); pine and hardwood basal area (m^2/ ha); hardwood midstory density (index 1–9; 1 = low and sparse, 9 = tall and dense); time since burn (years); and the number of times a location was burned since 1991 on the height of the utilization distribution for each Turkey (Marzluff et al. 2004, Millspaugh et al. 2006). The number of times a site was burned since 1991 produced a better model-fit than either the number of growing- or dormant-season burns. Therefore, we used number of total burns in the model. We log-transformed the response variable to normalize residuals. We included distance to nest as a variable in the model because the prenesting season included egg-laying, and the nest location likely influenced selection during that period. Because hardwood midstory density and overstory basal area often are inversely correlated with herbaceous cover and spring forage availability, we included these forest attributes in the model. We standardized model coefficients by multiplying the unstandardized coefficients from individual Turkey models by a ratio of the standard deviation of the parameter in each Turkey's prenesting range to the standard deviation of the log-transformed heights of the utilization distribution (Marzluff et al. 2004). We averaged standardized coefficients from individual Turkey models to calculate a population-level model, and compared the relative influence of each parameter on the response. We determined parameter significance from the overlap of the 95% confidence interval with zero (Marzluff et al. 2004, Millspaugh et al. 2006).

Results

In 2011 and 2012, we captured and attached GPS data loggers to 29 (6 juvenile, 23 adult) and 5 (0 juvenile, 5 adult) female Turkeys, respectively. Of the 34 data loggers deployed, we recovered 11 (all adults) with data suitable for analysis. The remaining 23 data loggers were either unrecovered (n = 12), contained an insufficient number of data points (n = 7), or were attached to females that did not nest (n = 4). The number of locations per Turkey used in our analyses ranged from 39 to 125 (mean = 87, SE = 9), spanning a range of 24 to 54 days (mean = 37, SE = 3).

Prenesting ranges averaged 614 ha (SE = 108 ha, range = 210–1233 ha). Attributes were largely similar between prenesting and simulation ranges except that Turkey prenesting ranges had greater percent area burned during the previous

Table 1. Mean and standard error of resources in female Wild Turkey prenesting ranges and circular simulation ranges at Fort Bragg, NC, 2011–2012.

Feature	Prenesting range mean ± SE	Simulation range mean ± SE
% pine	85.0 ± 4.0	85.0 ± 2.0
% bottomland hardwood	3.0 ± 1.0	4.0 ± 1.0
% non-forested	12.0 ± 4.0	11.0 ± 2.0
stream density (m/ha)	12.3 ± 1.6	14.5 ± 1.0
non-forested edge density (m/ha)	6.9 ± 1.3	6.5 ± 0.5
% burned prenesting	4.0 ± 2.0	8.0 ± 2.0
% burned dormant season	40.0 ± 8.0	22.0 ± 4.0
% burned growing season	21.0 ± 4.0	25.0 ± 2.0
% burned 1–2 years previously	12.0 ± 3.0	15.0 ± 1.0
% unburned >2 years	23.0 ± 5.0	30.0 ± 3.0

dormant season than simulation ranges (Table 1). The model that included percent area burned during the previous dormant season was the top model explaining prenesting-range selection and no other models were competitive (i.e., within 2 AIC units) (Table 2).

Distance to stream and distance to non-forested edges were the only significant covariates that predicted use within prenesting ranges; intensity of use was greatest nearer to streams and non-forested edges (Table 3). Activity also appeared to be greater nearer to the nest location, although the confidence interval of the estimate slightly overlapped zero (Table 3). Neither time since burn nor the number of times a site was burned since 1991, regardless of season, were predictors of use intensity.

Table 2. Number of parameters (K), second-order Akaike's information criterion (AIC_c), difference from lowest AIC_c (ΔAIC_c), and Akaike weights (w_i) from logistic regression models of Wild Turkey prenesting-resource selection at the landscape scale at Fort Bragg, NC, 2011–2012.

Model	K	AIC_c	ΔAIC_c	w_i
% burned dormant season[A]	2	47.60	0.00	0.43
% burned growing season[B]	2	50.21	2.61	0.12
% unburned >2 years	2	50.25	2.65	0.19
% burned prenesting[C]	2	50.42	2.82	0.11
Stream density (m/ha)	2	50.71	3.11	0.09
Non-forested edge density (m/ha)	2	51.97	4.37	0.05
Landscape features[D]	3	53.02	5.42	0.03
Fire history[E]	5	53.38	5.78	0.03
Landcover[F]	4	55.45	7.85	0.01
Global[G]	10	58.20	10.60	0.00

[A]% of prenesting range burned during the preceding dormant season (i.e., 1–6 months previously).
[B]% of prenesting range burned during the preceding growing season (i.e., 6–12 months previously).
[C]% of prenesting range burned concurrent with prenesting activities.
[D]Landscape features = stream density (m/ ha) + non-forested edge density (m/ ha).
[E]Fire history = % burned prenesting + % burned dormant season + % burned growing season + % unburned > 2 years.
[F]Landcover = % pine + % bottomland hardwood + % non-forested.
[G]Global = landcover + landscape + fire history.

Table 3. Model parameters (β_i) and upper (UCL) and lower (LCL) confidence limits from a multiple regression global model of Wild Turkey resource selection within prenesting ranges at Fort Bragg, NC, 2011–2012. Index values for hardwood midstory density (1–9): 1 = short and sparse, 9 = tall and dense.

Parameter	βi	LCL	UCL
Distance to nest	-0.71	-1.49	0.07
Distance to stream	-0.33	-0.63	-0.02
Distance to non-forested edge	-1.00	-1.73	-0.28
Times burned	-0.11	-0.39	0.18
Time since burn	-0.09	-0.38	0.19
Pine basal area	0.06	-0.24	0.37
Hardwood basal area	0.21	-0.11	0.52
Hardwood midstory density	-0.14	-0.53	0.25

Discussion

Forest stands burned the preceding dormant season attracted female Turkeys, likely because of forage resources made available following the fire. In forest stands burned during the previous dormant season, litter reduction may have increased light transmittance to the soil and increased soil temperature. Early vegetation production in warmer soils may have increased availability of protein-rich shoots (Hobbs and Schimel 1984, Knapp 1985, Stys et al. 1992). Additionally, frequent (1–2 year) application of dormant-season fire can be used to produce understory conditions with abundant grass and forb cover, similar to forest stands managed with growing-season fire, without reduction of food and cover during the prenesting period. Because female Turkeys commonly selected forest stands burned the preceding dormant season, understory conditions produced by these fires likely were beneficial to prenesting activities and potentially nest success (Palmer et al. 1996, Sisson et al. 1990).

For growing-season burns, vegetation conditions immediately following a burn, 1 year post burn, and >2 years post burn did not influence prenesting-resource selection, possibly because variation in vegetation conditions as a result of time-since-burn may not have been sufficiently great to cause selection. The frequent and fairly consistent application of fire prescriptions, in combination with low-productivity soils, produced homogenous vegetation conditions across uplands in fire-management units, regardless of time since burn. Females likely used open forest understories on our study area as available (with the exception of stands burned the previous dormant season) potentially to increase predator detection while traveling to feeding areas and sampling nesting cover (Palmer and Hurst 1998, Palmer et al. 1996).

Female Turkeys selected resources proximal to non-forested vegetation and streams, suggesting that these landscape features provided food or cover. Grass–forb cover was abundant in non-forested areas, and females likely selected the perimeter because forested escape cover was immediately adjacent. Additionally, arthropods typically are abundant on non-forested sites commonly selected by females prior to nesting (Harper et al. 2000, Hurst and Dickson 1992, Speake et al. 1975). Greater intensity of use near streams reflected cover availability for potential nest sites (Badyaev 1995, Chamberlain and Leopold 2000, Kilburg et al. 2014). Low ericaceous shrubs and ferns along stream corridors provided nesting cover that was selected by females on our study area, with 7 of the 11 GPS-telemetered females nesting within 25 m of a stream (Kilburg et al. 2014).

Although we had only 11 radio-marked Turkeys from which to draw conclusions on the effect of prescribed fire on prenesting-resource selection, GPS data loggers provided highly detailed and accurate information on resource use for each individual. The small sample size could have reduced the statistical power to detect relationships, but our results showed several significant, and intuitive, predictors of pre-nesting resource selection by Turkeys.

Using prescribed fire for Turkey management had minimal negative effects regardless of season of burn and likely produced a number of indirect benefits. In addition to selecting forest stands burned during the preceding dormant season, female Turkeys selected riparian areas during the prenesting season, and 55% of nests were located among low shrubs along riparian-upland ecotones maintained by periodic fire, especially growing-season fire (Kilburg et al. 2014). Nests located in these fire-maintained ecotones survived better than nests in uplands (Kilburg et al. 2014). Although ~20% of the study area was burned while radio-tagged Turkeys were nesting, only 1 of 30 monitored nests failed because of fire (Kilburg et al. 2014). Similarly, only 2 of 64 nests failed because of spring burns in a pine forest in Mississippi (Jones 2001). Therefore, we suggest including dormant-season burns, in addition to the growing-season burns necessary to reduce hardwood encroachment in Longleaf Pine forests, to diversify prenesting and nesting cover for Wild Turkeys in Longleaf Pine forests.

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