

Seasonal Space Use and Habitat Selection of Female Wild Turkeys in a Louisiana Bottomland Forest

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Abstract: Space use and habitat selection of wild turkeys (*Meleagris gallopavo*) has been well studied in various upland landscapes, but information within bottomland hardwood systems is lacking. Turkeys in bottomland systems face unique situations (e.g., flooding) and turkey behavior observed in upland systems may not directly apply to bottomland systems. Therefore, we evaluated seasonal (pre-incubation, incubation, brood rearing, and fall-winter) space use and multi-scale habitat selection of adult female wild turkeys in a bottomland hardwood forest in south-central Louisiana during 2002–2004 and 2007–2010. Space use varied with the largest home ranges during pre-incubation and the smallest during brood-rearing. Female turkeys selected dry, upland forests relative to available habitat types at all spatial scales. Because upland forests are free of flooding and have adequate understory vegetation, they likely provide consistent foraging opportunities and suitable nesting habitat. Turkeys did not select forest stands managed with selective cutting likely because of dense woody understory growth. Our results indicate that forest management strategies that promote understory growth may not be useful to female turkeys and managers should concentrate on ensuring the presence of mature forests in areas not prone to flooding within bottomland hardwood systems.

Key words: bottomland hardwood, forest management, habitat use, Louisiana, *Meleagris gallopavo*, nesting, space use, wild turkey.

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Burt (1943) first described an animal's home range as the space where an individual conducts their normal daily activities, and Samuel et al. (1985) later defined the core area as the area within the home range that receives the most concentrated use. However, space use (home range area) and habitat selection may vary in response to season, age, population density, and overall habitat quality (Orians and Wittenberger 1991, Pulliam and Danielson 1991, Rosenzweig 1991, Mysterud and Ims 1998). Thus, understanding space use and habitat selection is an important step in understanding the ecology of any species within a given environment.

Habitat selection and space use of female wild turkeys (*Meleagris gallopavo*) has been extensively studied in a variety of upland landscapes (Everett et al. 1985, Smith and Teitelbaum 1986, Bidwell et al. 1989, Kurzejeski and Lewis 1990, Miller et al. 1999, Thogmartin 2001, Miller and Conner 2007), but information within bottomland systems is sparse (Zwank et al. 1988, Cobb et al. 1993), particularly in the lower Mississippi Alluvial Valley (but see Wilson et al. 2005). However, bottomland hardwood forests are regarded as high quality turkey habitat (Dickson 2001). Furthermore, although ecological processes are known to operate at varying spatial scales (Wiens 1989) previous studies have focused on habitat selection at a single spatial scale (e.g., concentrating only

on habitat selection within home ranges), potentially creating misleading inferences about overall selection (Johnson 1980, Orians and Wittenberger 1991). Proper management of wild turkeys requires knowledge of space use and habitat selection. Wild turkeys in bottomland hardwood forests face regular flooding; therefore, wild turkey space use and habitat selection in bottomland hardwood forests may differ from upland landscapes. Hence, our objective was to determine space use and multi-scale seasonal habitat selection for adult female wild turkeys in a bottomland hardwood forest in Louisiana to better inform management decisions.

Study Area

We conducted our research on a 17,243-ha tract (hereafter Sherburne) of bottomland hardwood forest in Iberville, St. Martin, and Point Coupee parishes, Louisiana, located in the Atchafalaya floodway system. Sherburne included Sherburne Wildlife Management Area (4,767 ha) owned by the Louisiana Department of Wildlife and Fisheries (LDWF), Bayou des Ourses (6,317 ha) owned by the U.S. Army Corps of Engineers, and the Atchafalaya National Wildlife Refuge (6,159 ha) owned by the U.S. Fish and Wildlife Service. Additionally, there were approximately 770 ha of private lands interspersed throughout the state and federal lands.

Sherburne was bordered on the south by Interstate 10, on the north by Highway 190, on the west by the Atchafalaya River, and the east by the East Protection Guide Levee.

Individual overstory species most commonly found on Sherburne included eastern cottonwood (*Populus deltoids*), nuttall oak (*Quercus texana*), water oak (*Q. nigra*), overcup oak (*Q. lyrata*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanicus*), black willow (*Salix nigra*), and baldcypress (*Taxodium distichum*). Understory vegetation was relatively sparse because of shading and annual, persistent flooding. Forest openings consisted of wildlife food plots, right-of-ways (electric and natural gas) maintained through mowing and herbicide application, levees, and natural regeneration from forest harvesting.

Due to logging practices of previous landowners (i.e., high-grading) relatively few hard mast-producing species were present away from riparian zones or sites where persistent flooding made logging difficult. Although Sherburne was logged extensively during the 1950s, some areas have remained virtually undisturbed. Forest management practices including group selection cuts, individual selection cuts, clear cuts, and shelterwood cuts designed to promote regeneration of dominant canopy species and increase stand diversity have been applied to portions of Sherburne since 1986. Due to construction of levees and water control structures, Sherburne does not experience direct flooding from the Atchafalaya River. River-induced flooding was manifested in the form of back-water flooding moving north from southern areas of the Atchafalaya Basin and varied in severity from year to year. Most seasonal flooding on Sherburne could be attributed to local precipitation during the rainy season (February–April).

Methods

We captured female wild turkeys using cannon nests at bait sites distributed throughout the study area during summer (June–August) of 2007 and 2008. We fitted each captured female with a standard serially-numbered leg band and a 75g ($\leq 3\%$ body weight) mortality-sensitive radio transmitter (Advanced Telemetry Systems, Isanti, Minnesota) attached backpack-style. We released all birds at the capture site immediately following processing. Previous researchers captured and radio-marked females during summers of 2001–2004 using similar methods (Wilson et al. 2005). All capture and handling procedures were covered under Louisiana State University Agricultural Center Institutional Animal Care and Use Protocol number AE2010-09.

We located radio-marked females via triangulation and homing (White and Garrot 1990). We obtained locations by triangulation of azimuth readings taken from 2–5 fixed telemetry stations within a time interval ≤ 20 minutes to minimize error caused by turkey

movement. We estimated telemetry error by placing radio transmitters ($n=10$) in representative habitat types within the study area and triangulating 20–30 locations on each radio. We plotted the average distance for each estimated location from the radio transmitter's actual position against the distance from the closest station where we recorded an azimuth. We discarded locations estimated at a distance $\geq 1,000$ m with most locations (70%) taken from a distance ≤ 500 m.

From 9 June 2007–1 March 2010, we monitored turkeys throughout the year, collecting approximately 3 locations per week for each female from September to early February, and ≥ 1 location daily for the remainder of the year. We used LOCATE III (Pacer; Truro, Nova Scotia, Canada) to obtain Universal Transverse Mercator (UTM) coordinates for all triangulations. When a radio-marked female was visually sighted, we recorded her location on a Garmin GPSmap 76CSx hand-held GPS unit. Previous researchers collected locations from 11 February 2002–27 August 2004 using the same methods (Wilson et al. 2005).

We delineated biologically relevant seasons (pre-incubation, incubation, brood rearing, and fall-winter) based on previous work conducted on our study area (Wilson et al. 2005). We defined pre-incubation as the period from 15 February (approximate timing of winter flock break-up) until the onset of incubation or until 9 April for non-reproductive females. We defined incubation as the onset of incubation until hatch or nest failure for females that successfully achieved nest incubation or until 10 April–31 May for females in which incubation activities were not detected. Brood-rearing was defined as the period from hatch out or nest failure until 30 September for nesting females or 1 June–30 September for non-reproductive females. We defined the fall-winter season as 1 October–14 February for all females.

We imported all triangulated locations into ArcGIS 9 (ESRI, Redlands, California) and converted them to point themes. We calculated kernel density home ranges (95% utilization distribution) and core-use areas (50% utilization distribution) seasonally for each female using the Home Range extension (Rodgers and Carr 1998) in ArcGIS. We performed area observation curves on five representative turkeys with > 40 locations in a season and determined that home range sizes stabilized at ≥ 20 locations; therefore, only individuals with ≥ 20 locations in a season were used for analyses. Additionally, we excluded birds that were monitored for $< 75\%$ of a given season. We used a one-way analysis of variance (ANOVA) to test whether home range and core area sizes (ha) were different between seasons. We pooled data from all years because sample sizes were low in some seasons and the number of individuals tracked varied considerably between years.

We created a digital land cover of Sherburne in ArcGIS 9 us-

ing 2004 digital orthophoto quarter quadrangles (DOQQs) and digital elevation models (DEMs, 5m² resolution) derived from 2003 LIDAR data (available at <http://atlas.lsu.edu>). Because stand-specific information was not readily available for Sherburne, we delineated habitat types into three broad categories using visual characteristics of the landscape visible on the DOQQs, elevation data from the DEMs, and ground truthing. Habitat types included water-influenced forests (forests that experience seasonal flooding and hold standing water for a considerable portion of the year, cypress-tupelo swamps, and riparian areas immediately adjacent to waterways), drier upland forests (bottomland hardwood forests of relatively high elevation not associated with regular flooding, including ridges, natural levees, terraces, and higher flats), and openings (right-of-ways, levees, foot plots, roads, etc.). For analysis purposes we classified waterways as water-influenced forests because relocations within a bayou meant the bird was likely on the bank or near the water (Grisham 2007). To delineate upland and water-influenced forests we first generated 0.25-m contour lines from DEMs using spatial analyst in ArcGIS. Because the average elevation of Sherburne varies along a north-south gradient, we separated large contour datasets into small enough parcels that a specific elevation value would be hydrologically consistent across the whole parcel. For instance, an elevation of 19 m may flood regularly in the north whereas 19 m may represent the highest point of land in the southern part of the study area. In each parcel, we considered the area below the specific elevation contour that represented the highest elevation to regularly flood each year as water-influenced. We determined the cut-off elevation based on personal experience during flood-periods and from cross referencing by overlaying contour data-sets over DOQQs.

We intersected home ranges, core areas, and point themes with the land cover in ArcGIS to quantify habitat selection across seasons. We used compositional analysis (Aebischer et al. 1993) to examine habitat selection at three spatial scales based loosely on the recommendations of Johnson (1980); home ranges vs. habitat types available on the study area (1st order), core use areas vs. habitat types available in home ranges (2nd order), and individual locations vs. habitat types available in home ranges (3rd order). To address issues associated with values of zero-use, we replaced zero values with 0.7 following recommendations of Bingham and Brennan (2004). We examined differences of log-ratio habitat use and availability percentages using a multivariate analysis of variance (MANOVA) with season as a main effect to test whether habitats were used in proportion to their availability (Aebischer et al. 1993). If significant differences between habitat availability and selection were detected within a spatial scale, we constructed a ranking matrix of *t*-tests to determine order of habitat selection for

each season (Aebischer et al. 1993). We pooled data across years due to small sample sizes in some seasons and wide variation in the number of individuals tracked between years.

Results

We estimated 144 seasonal home ranges and core areas for 45 female turkeys from 11 February 2002–27 August 2004, and from 1 October 2007–30 March 2010. All home ranges included every habitat type, and 107 of 144 core areas included every habitat type (in the remaining 37 core areas, openings were the missing habitat type). We failed to locate any bird in the process of incubation away from the nest, so we considered any individual that incubated a nest for ≥ 5 days ($n=21$) as reproductively active and excluded them from analysis during the incubation period. Additionally, because females known to be reproductively unsuccessful were commonly observed associating with brood flocks during the summer months, we pooled reproductively active and inactive females together during the brood-rearing season. Home ranges had a mean value of 672.26 ha during pre-incubation to 362.8 ha during brood rearing (Table 1) and differed between seasons ($F_{3,140} = 10.89, P < 0.001$). Core areas had a mean value of 111.79 ha during pre-incubation to 61.01 during incubation (Table 1) and differed between seasons ($F_{3,140} = 6.67, P < 0.001$).

During all seasons, female turkeys selected habitat types within their home ranges relative to habitat availability across the study area (1st order selection, $F_{2,139} = 69.18, P < 0.001$). In all seasons, dry forests were the most selected habitat type at the landscape scale (1st order), with openings the least selected during all seasons except for brood-rearing (Table 2). Turkeys selected dry forests within their core areas relative to availability within home ranges (2nd order selection, $F_{2,139} = 11.85, P < 0.001$), with openings being the least selected habitat type during all seasons except pre-incubation. Habitat use within home ranges differed from availability within home ranges (3rd order selection, $F_{2,139} = 9.48, P < 0.001$). Dry forest was selected relative to all other habitat types at this spatial scale in all seasons, with openings being the least selected habitat type in all seasons except for during fall/winter (Table 2).

Table 1. Mean seasonal home range (HR) and core area (CA) size (ha) and associated standard errors (SE) from radio-marked female wild turkeys on Sherburne Wildlife Management Area, Louisiana, from the years 2002–2004, 2007–2010. *n* represents the number of home ranges estimated in each season.

Season	<i>n</i>	HR \pm SE	CA \pm SE
Preincubation	40	672.26 \pm 55.08	111.79 \pm 11.09
Incubation	15	415.36 \pm 83.84	61.01 \pm 16.19
Brood-rearing	46	362.80 \pm 24.24	67.74 \pm 4.83
Fall-winter	43	430.09 \pm 34.89	81.51 \pm 7.24

Table 2. Seasonal and mean ranks (0 = lowest, 2 = highest) of habitat selection across three spatial scales (habitat selection in home ranges vs. habitat availability across study area [1st order], habitat selection in core areas vs. habitat availability across home ranges [2nd order], and habitat used vs. habitat availability across home ranges [3rd order]) based on compositional analysis of female wild turkeys on Sherburne Wildlife Management Area, Louisiana, during 2002–2004, and 2007–2009.

Habitat	1st Order					2nd Order					3rd Order				
	Season ^a					Season					Season				
	PI	I	BR	FW	Mean	PI	I	BR	FW	Mean	PI	I	BR	FW	Mean
WIF ^b	1	1	0	1	0.75	0	1	1	1	0.75	1	1	1	0	0.75
UF ^c	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Opening	0	0	1	0	0.25	1	0	0	0	0.25	0	0	0	1	0.25

a. Seasons are preincubation (PI), incubation (I), brood-rearing (BR), and fall-winter (FW)

b. Water-influenced forest

c. Upland forest

Discussion

Comparing estimates of home range among studies is difficult due to differences in seasonal delineations, data collection, and home range estimation methodologies; however, our mean seasonal estimates fall within what has been previously reported for eastern wild turkeys (range: 66 ha [Smith and Teitelbaum 1986] – 1,630 ha [Thogmartin 2001]). Our estimates of space use were less than previously reported for females on Sherburne (Wilson et al. 2005) and attributable to a difference in methodologies used to estimate space use. Despite these discrepancies, seasonal space use was similar across the years of the study (see Wilson et al. 2005) with greatest space use during preincubation and least during brood-rearing. The combination of consistent yearly flooding on portions of Sherburne and shading from dense canopy cover results in sparse understory vegetation, limiting availability of suitable nesting areas on portions of the study area. Increased habitat sampling during preincubation may improve nesting success, as females that sample more areas improve their chances of locating ideal nesting sites (Badyaev et al. 1996, Chamberlain and Leopold 2000). Home range size is often interpreted as a surrogate for habitat quality (Burt 1943, Kurzejeski and Lewis 1990, Thogmartin 2001), hence the substantial increase in space use observed during preincubation may be indicative of poor nesting habitat, requiring females to sample a large area to find a suitable nesting location. Cobb et al. (1993) noted that space use of female turkeys increased significantly when optimal nesting habitat was flooded in a North Carolina bottomland area.

Space use was least during brood-rearing. Brooding females have been known to restrict their movements to localized areas of high food abundance when broods are young (Miller et al. 1997). We did not partition females into successful and unsuccessful nesters because reproductively unsuccessful females were often observed associating with brood flocks. Unsuccessful females may

associate with brood flocks to reduce risk of mortality (Jullien and Clobert 2000) or to attempt an adoption event (Mills and Rumble 1991, Metz et al. 2006), and females engaged in this behavior would be restricted to the limited movements of the brood flock. Bottomland hardwood forests are productive ecosystems (Conner and Day 1976, Mitsch et al. 1991) and high quality vegetation is widely available on Sherburne during summer, hence adequate brooding habitat is likely abundant enough to allow females to greatly restrict their movements when foraging and protecting broods (see Phalen et al. 1986). A similar trend of reduced space use during summer in bottomland hardwood forests was observed for male turkeys (Grisham et al. 2008), white-tailed deer (*Odocoileus virginianus*, Thayer et al. 2009), and raccoons (*Procyon lotor*, Byrne and Chamberlain 2011).

Space use during fall-winter was greater than that observed during brood-rearing but less than that observed during preincubation. Winter habitat use is strongly dependent on distribution of food resources (Porter 1992) and in some regions space use is least during the winter months (Speake et al. 1975, Bidwell et al. 1989, Kurzejeski and Lewis 1990). During winter, turkeys may be forced to concentrate around areas of localized food abundance, for instance, near agricultural lands in northern areas (Vander Haegen et al. 1989, Kurzejeski and Lewis 1990) or around mast-producing stands in mixed pine/hardwood systems (Bidwell et al. 1989). High-grading on Sherburne lasted into the 1970s and has reduced distribution of hard mast-producing trees into pockets of abundance (primarily in areas where water made logging difficult) distributed sporadically across the landscape. The observed increased space use during fall-winter was likely a function of turkeys moving between these pockets of mast producing hardwoods and may be further influenced by the fact that flooding may limit access to some stands.

In the present study, drier upland forests were selected relative

to other habitat types at all spatial scales in all seasons. Earlier work (Wilson et al. 2005) suggested that other habitat types, particularly cypress-tupelo swamps and riparian areas (water-based forests in Wilson et al. 2005) were important, especially at the 2nd and 3rd order scales. The discrepancy between our results and those of Wilson et al. (2005) is likely a result of the differences in delineation of habitat types. Use of elevation data in this study allowed for a more hydrologically accurate distinction between upland and lowland areas than in previous studies. Additionally, water-influenced forests in this study represented two separate habitat types in the previous study (water-based and lowland forest) that we did not believe could be accurately separated. Water-based forests constituted a small portion of the study area (Wilson et al. 2005), and even a small number of radio-telemetry relocations in these areas would influence analyses and interpretation. Nevertheless, water-influenced forests are likely important to female turkeys. When not flooded, water-influenced forests may provide similar foraging resources as upland forests, especially hard-mast during the fall-winter period (Chamberlain et al. 2000, Wilson et al. 2005, Grisham 2007).

Female turkeys on Sherburne were likely forced to concentrate their nest site selection to upland areas to avoid flooding (Kimmel and Zwank 1985, Zwank et al. 1988, Cobb et al. 1993), contributing to the selection of upland forests during the preincubation and incubation seasons. Preincubation was the only time period that openings were selected relative to water-influenced forests in core areas. All nests located during the study ($n=42$) were in either drier upland forests ($n=36$) or in openings ($n=6$, M. Byrne, unpublished data). Nests in forests were often placed close to forest edges (mean distance = 55.8m), and several nests were located <1m from a forest edge. Logically, upland forests and openings would be selected in core use areas relative to their availability across home ranges during a time when females are searching for potential nest sites.

Optimal brood habitat is herbaceous ground cover that provides food resources that meet the nutritional needs of developing poults and cover from predators, yet is sparse enough for movement and for predator detection (Healy 1985, Porter 1992, Godfrey and Norman 1999). Upland forests on Sherburne are structurally similar to the brood-rearing areas used in a Mississippi mixed pine/hardwood system: mature bottomland hardwoods with continuous canopy, sparse understory, and moderate herbaceous ground cover (Phalen et al. 1986). Juxtaposition of landscape features is important in habitat selection and we contend the apparent selection for openings at the landscape level (1st order selection) during brood-rearing may be an artifact of the proximity of openings to selected forests. While openings are generally regarded as necessary brood-rearing habitat (Porter 1992), a number of studies have shown that openings are

not always used extensively during this time (Pack et al. 1980, Ross and Wunz 1990, Phalen et al. 1986, Smith and Teitelbaum 1986). Considering most openings within brood home ranges on Sherburne were comprised of narrow, linear rights-of-way set within the context of the prevailing forest, it is possible that turkeys used these areas because they functioned as travel lanes between suitable foraging patches. However, by early summer, vegetation in openings has grown dense and may actually be detrimental to safe and successful brood foraging. Conversely, vegetative structure within forested habitat types provided suitable brood-rearing habitat, allowing broods to stay under canopy cover and reducing importance of open areas relative to other forest systems.

Several authors have observed a seasonal shift towards selection of hardwood forests during the fall and winter months (Speake et al. 1975, Everett et al. 1985, Porter 1992, Miller and Conner 2007). Acorns and other hard mast constitute an important part of the wild turkey diet at this time of year (Eaton 1992, Hurst 1992, Dickson 2001) and likely accounts for the selection of forested habitat types over openings observed on Sherburne during fall/winter.

Portions of Sherburne have been under active forest management since 1986, and although these management actions provide benefits to anurans, songbirds (LeGrand 2005), and raccoons (Byrne and Chamberlain 2011), home ranges of female turkeys rarely encompassed the managed stands and individual relocations in these were essentially nonexistent. We contend that turkey avoidance of the managed stands was related to the consistently dense understory growth associated with the reduction of canopy cover in management plots. Succession was rapid in these plots and was dominated by woody vegetation, allowing only a short window of opportunity for use by turkeys. Within two growing seasons, height of understory vegetation exceeded 2 m, and was dominated by woody saplings, particularly within stands managed with clear cutting and group selection (LeGrand 2005).

Management Implications

Our results indicate that openings were the least selected habitat type despite the fact that forest openings are often considered important especially during brood-rearing (Porter 1992). Of 144 core areas within established home ranges, 37 (25.7%) contained no openings. The highly productive nature of bottomland forests allows female turkeys to locate most of their habitat requirements under canopy cover. Additionally, vegetation in openings is often too dense for optimal turkey use during the brood-rearing season, when turkeys would be expected to most heavily rely on these areas. Our results demonstrate that mature forests in areas not prone to flooding are important to female turkeys year round. Further, mature forests provide nesting cover free from flooding and qual-

ity brood-rearing habitat. Forest management techniques aimed at reducing overstory canopy cover and promoting understory growth were not used by radio-marked wild turkeys on Sherburne. Within two growing seasons, understory vegetation becomes too dense for turkey use and management in bottomland systems should concentrate on ensuring the presence of mature stands in drier, upland forests. Frequent disturbance of openings during summer may create additional brood-rearing habitat, especially in areas adjacent to mature higher-elevation forest cover.

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