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Home range and habitat selection of the female eastern wild turkey at its northern range edge

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In recent decades, the range of the eastern wild turkey *Meleagris gallopavo silvestris* has expanded north of its historical distribution in North America. The major limiting factors for wild turkeys beyond their historical range are not well understood, and little is known about turkey resource use at their new range periphery. We evaluated the home range size of female turkeys at their northern range edge in Ontario, Canada, and we took a hierarchical approach to assess habitat selection. To accomplish this, we analyzed data from 36 females fitted with VHF and GPS transmitters. Season had a significant effect on home range size, with the greatest home range sizes found in the spring and autumn, and the smallest in the winter and summer. There was also an effect of flock membership on winter home range size. We found evidence of habitat selection by turkeys at both the second order, placement of home ranges within the landscape, and the third order, use of habitat within home ranges. In both cases, female turkeys primarily selected deciduous forest and fields and avoided coniferous forest. Areas close to supplemental food sources were also selected during the autumn and winter. As populations expand into novel landscapes, continued efforts to understand resource limitation and habitat selection strategies of northern turkeys will guide effective management of these game birds.

A species range limit is dictated by biotic and abiotic environmental conditions; climate, resources, predators and disease influence where a species is able to persist (Caughley et al. 1988, Lesica and Allendorf 1995, Hardie and Hutchings 2010).

We are currently in a period of rapid environmental change, which is causing a shift in species distributions (Walther et al. 2002). Understanding the potential for changes in limiting factors as distributions shift, may reveal important effects of environmental change on biodiversity. Such understanding may also facilitate management for species where rapid changes in abundance may affect the ecosystem services they provide (Whelan et al. 2008, Wenny et al. 2011).

The eastern wild turkey *Meleagris gallopavo silvestris* is a temperate subspecies of the wild turkey, which is an important game bird throughout its range. In recent years the wild turkey has exhibited exceptional flexibility expanding its range northwards. Turkeys at their northern periphery face increased challenges compared to those in the species' range core, stemming from winter severity, food availability, habitat quality, and predation (Niedzielski and Bowman 2015), which affect the species home range size and habitat selection (Porter 1977, Dickson 1992, Nguyen et al. 2003). Despite these limiting factors, the wild turkey continues to expand its northern range limit. A greater understanding of how the wild turkey uses the space and resources at its northern periphery will facilitate management of this species (Manly et al. 2002).

The size of a female turkey's home range depends on the resources available throughout the year (Morgan et al. 2006); in northern environments resources may be sparsely distributed, resulting in greater space use and larger home range sizes. In spring, females have to increase their space use, while searching for a nest site that provides adequate herbaceous cover and access to nearby food (Porter 1977, Badyaev et al. 1996). Similarly large movements have been observed in autumn when hens are foraging on hard mast and moving back to their winter roost (Dickson 1992, Badyaev et al. 1996). Home range size is typically reduced in summer when females are brood-rearing; juveniles are precocial but remain with their hen to forage (Dickson 1992, Badyaev et al. 1996). Space use may be restricted in winter due to poor weather conditions such as deep, powdered snow ($\geq$ 25 cm) (Porter 1977, Badyaev et al. 1996). When the availability of natural food is reduced in the winter turkeys may seek out supplemental food sources (Roberts et al.

1995, Kane et al. 2007). Turkeys with access to reliable supplemental food have been noted to have greater winter survival (Kane et al. 2007) and reduced range sizes (Porter 1977). When deep snow does not limit turkey movements they have been noted to have larger winter home range sizes, particularly if they have to use more of the landscape to find food (Dickson 1992).

It was once thought that turkeys required large tracts of unaltered temperate hardwood forests to survive, which would have limited the species' ability to occupy northern environments, given the prevalence of coniferous trees in the north (Porter 1977, Dickson 1992, Gustafson et al. 1994, Chamberlain and Leopold 2000, Morgan et al. 2006, Miller and Conner 2007). Studies in the United States have demonstrated the flexibility of turkeys to a variety of managed habitats including pine plantations and agricultural land (Vander Haegen et al. 1989, Dickson 1992, Badyaev 1995, Miller et al. 1999, Chamberlain and Leopold 2000, Morgan et al. 2006, Miller and Conner 2007). Recent research also indicates that turkeys in northern environments can persist with as little as 10% forest cover (Shields and Flake 2006). The flexibility of the eastern wild turkey across its range has made it difficult to generalize the species-specific resource needs. While deciduous forests with interspersed fields have been documented to be ideal turkey habitat, habitat use appears highly variable across the turkey's range (Dickson 1992).

To develop accurate management guidelines, more information is needed on the habitat selection and home range size of turkeys at their northern range periphery. The first objective of our study was to estimate the mean seasonal and annual home range size of female turkeys at the species' northern range edge. We hypothesized that home range size would be greatest in the spring while females are searching for a nesting site, and the smallest in the winter and summer. We also hypothesized that home range size at the species' northern range would be larger than those reported in the south due to reduced food availability and habitat quality. The second objective of our study was to evaluate seasonal habitat selection by female wild turkeys. We analyzed habitat selection in a hierarchical manner, using Johnson's (1980) second and third orders of selection during each of the four annual seasons. We hypothesized that habitat selection would change between the seasons, with turkeys primarily selecting deciduous and mixed forests, but selecting open habitat while brood-rearing in the summer. Our final objective was to assess whether supplemental food influenced wild turkey habitat selection. We hypothesized that northern wild turkeys require supplemental food in the winter; therefore, we predicted that females would be found close to supplemental food sources from bird feeders and livestock operations in the autumn and winter.

Methods

Study area

We studied wild turkey ecology from January 2012 to March 2013 on the Northern Bruce Peninsula, located in Ontario, Canada (Fig. 1). The Bruce Peninsula contains a mix of land cover types, with the dominant cover being coniferous forest, mixed forest, fields, and deciduous forest (Table 1). In this rural community the dominant industries are agriculture and tourism. The main form of agriculture is small-scale beef farming, and many tourists visit in the summer because of two national parks in the area.

Trapping and handling wild turkeys

In winter, turkeys congregate in large flocks, making it possible to trap multiple birds at once. We trapped turkeys from January to March 2012 at five locations across the study area. Turkeys were baited with corn and captured using a rocket net (Grubb 1988). Bait piles were established in fields close to where turkeys were roosting. Once turkeys were trapped, they were removed from the net and placed into transfer boxes for holding. All turkeys were processed on site immediately after trapping. When retrieving a turkey from its box, its legs were secured and a sock was placed on its head. Before attaching the transmitter, each turkey was aged (juvenile or adult), sexed and weighed. Animal care approval was granted by Trent University's Animal Care Committee (protocol no. 22238).

We captured 53 turkeys, including 47 females and six males. We did not put transmitters on two females because of feather loss on their backs. We fit 45 female turkeys with either a 73-g very high frequency (VHF) transmitter (model A1540 Advanced Telemetry Systems, Isanti, Minnesota) or an 85-g micro global positioning system (GPS) transmitter (model G1H 261A Sirtrack, Havelock North, New Zealand). Thirty seven of the female turkeys were adults and eight were juveniles.

Transmitters were attached using a backpack style harness made of shock cord (Norman et al. 1997). The micro GPS transmitters were modified before deployment by attaching neoprene to the underside of each device to prevent chaffing (Guthrie et al. 2011). To prevent water damage we secured the port with a waterproof silicone sealant and a small strip of vinyl tape (Guthrie et al. 2011). Both types of transmitters weighed less than the recommended maximum of 3% of adult female weight (Millspaugh and Marzluff 2001). For identification purposes each turkey was fitted with a numbered aluminum butt-end leg band. We also took blood samples from each bird and made several morphological measurements (length of tarsus, wing, beard and tail).

We excluded six females from the analysis that died within two weeks of trapping, in the event their deaths were due to capture myopathy (Palmer et al. 1993, Nicholson et al. 2000). An additional three females were not included in the analysis because we obtained only a few relocations before they died. Therefore, our analysis included data from 36 females: 27 outfitted with VHF transmitters and nine outfitted with GPS transmitters.

Land cover sampling

For the habitat selection analysis, we used the Ontario Land Cover Database (Ontario Ministry of Natural Resources 1998), a raster database identifying 28 vegetation and land cover types across the province. A more recent land cover was available for southern Ontario however it was not used

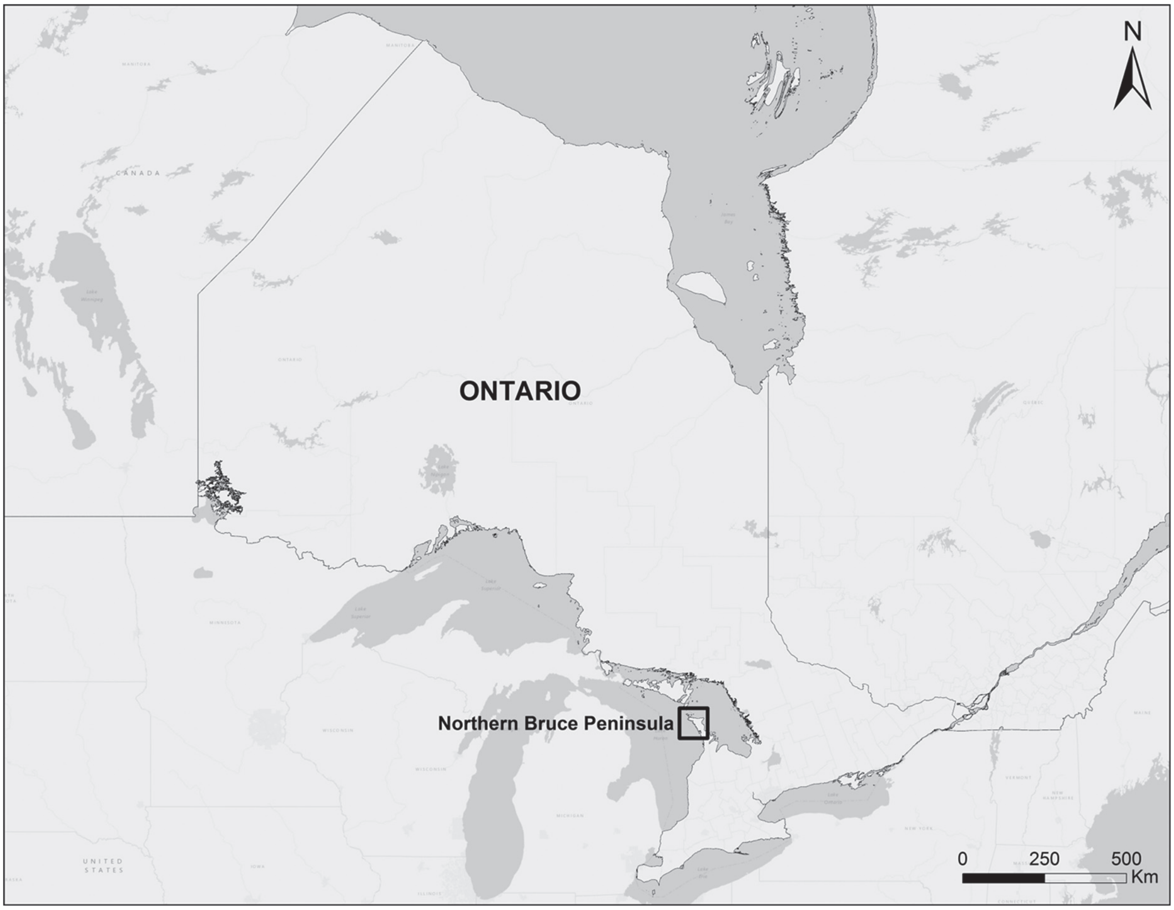

Figure 1. The Northern Bruce Peninsula study area in Ontario, Canada for the wild turkey *Meleagris gallopavo* research project during 2012–2013 (45°09′N, 81°40′W).

because large tracts of the study area were classified as undifferentiated (Ontario Ministry of Natural Resources 2008).

We analyzed habitat selection using a Euclidean distance-based analysis (Conner and Plowman 2001); therefore, we were interested in correlations between distributions of different land cover types. To evaluate this we calculated the distance from 2100 random points in the study area to the closest occurrence of each land cover type, and assessed correlations of the outputs. For the purpose of the study, land cover types that were functionally similar and highly correlated ($r > 0.60$) were merged. We also conducted a principal components analysis (PCA) on the same data to uncover any associations among the land cover types which could affect the Euclidean distance analysis that we used for analyzing habitat selection (Bingham et al. 2010). We used the Kaiser–Guttman method for determining how many components of the PCA to retain (Jackson 1993), which states that components with eigenvalues > 1 should be interpreted. The correlation matrix and PCA were generated in R (< www.r-project.org >).

Table 1. Habitats found in the Northern Bruce Peninsula wild turkey *Meleagris gallopavo* study area in Ontario, Canada. Land cover was determined from the Ontario Ministry of Natural Resources (1998) Ontario Land Cover Database.

Land cover/features	Area (km²)	(%) of study area	Merged land cover types
Coniferous forest	256	32	Dense coniferous forest, sparse coniferous forest
Mixed forest	224	28	Mixed forest deciduous dominated, mixed forest coniferous dominated
Fields	107	13	Pasture, abandoned fields, cropland
Deciduous forest	88	11	Dense deciduous forest, sparse deciduous forest
Water, fen, coniferous swamp	69	8	Open water, open fen, coniferous swamp
Marsh	24	3	
Alvar	20	2	
Deciduous swamp	12	2	
Settlement/developed land	1	0.5	
Mines, quarries, bedrock	3	0.5	

Telemetry

We used VHF triangulation to relocate each turkey 2–5 times per week, predominately during the day while the birds were active, but also at night to ensure identification of roosts. We completed the majority of the triangulations from roads, taking all bearings in < 20 min. We used a hand-held three-element directional antenna and a receiver to determine the direction from the observer to each turkey, including turkeys that were outfitted with GPS transmitters, which also had VHF beacons. A minimum of three bearings were taken to estimate an animal's location; however, in some situations where three bearings were not possible, we estimated locations with two bearings. We estimated 2639 locations in total for the VHF-outfitted turkeys; 2% of those were calculated using only two bearings. We used the software Location of a Signal (LOAS) (ver. 4.0.3.8) (Ecological Software Solutions 2010) to estimate all locations. We did not include an error model in our analysis as distance analysis is less sensitive to telemetry error compared to compositional analysis for habitat selection (Conner and Plowman 2001, Conner et al. 2003).

The GPS transmitters collected locations based on a programmed duty schedule which changed slightly throughout the year (Table 2). Locations were recorded throughout the day and night. The GPS locations were stored on board the transmitters, so each unit was retrieved to download the data, either by recovering the transmitter following death of the bird, or by recapturing the bird. Both the GPS and VHF transmitters were equipped with mortality mode sensors which activated when the animal had not moved for eight hours. This feature informed us of when mortality occurred so that we could retrieve the GPS units and assess cause of death.

Home range size

Home range size was calculated using three common methods: 100% minimum convex polygons (100% MCP), 95% minimum convex polygons (95% MCP), and kernel density estimation (KDE) with 95% contour and least squares cross validation smoothing (LSCV) (Kernohan and Gitzen 2001). The 100% MCPs and 95% MCPs were created in ArcMap10 (ESRI ArcMap 10.0) using the minimum bounding feature. We created the KDEs using the software Geospatial Modelling Environment (GME) (ver. 0.7.2.0, Spatial Ecology, LLC). We separated the data into four periods based on the calendar seasons: winter (21 December – 19 March), spring (20 March – 19 June), summer (20 June – 21 September), and autumn (22 September – 20 December). We chose to create these seasonal home range estimates because calendar seasons are aligned with seasonal changes in turkey ecology (Kurzejeski et al. 1987, Harris et al. 1990, Badyaev et al. 1996, Humberg et al. 2009).

We estimated annual and seasonal home range sizes separately using the GPS and VHF data. To determine whether there was an effect of season or transmitter type we compared our seasonal home range estimates using a two-way analysis of variance (ANOVA) with telemetry mode (GPS, VHF) and season as factors. We then used a Tukey's post hoc test to determine where differences existed. We also used a one-way ANOVA with a Tukey's post hoc test to determine whether winter home range size varied by winter flock membership. We then compared our seasonal estimates to other home range sizes reported in the literature.

We created area–observation curves to determine the minimum number of locations required to calculate home range size for the VHF transmitter data (Odum and Kuenzler 1955). We re-calculated home range size after each tracking day and plotted the results; one turkey location was added for each day. A location was gathered for every bird on average 2–5 times per week. We considered a sufficient number of locations to have been obtained when the curve reached an asymptote (Kernohan and Gitzen 2001). For the birds outfitted with GPS transmitters, all locations gathered were used to calculate home range size.

Table 2. Programmed duty cycle for the 85 g micro GPS transmitters used during a wild turkey *Meleagris gallopavo* study in Ontario, Canada.

Time period	Duty schedule
1 Feb – 31 March	1 fix every 1.55 h (3.15 days on, 3.15 days off)
1 April – 30 Sept	1 fix every 1.55 h
1 Oct – 31 Dec (or until battery dies)	1 fix every 6.5 h

Habitat selection

We used a Euclidean distance analysis (EDA) to evaluate turkey habitat selection (Conner and Plowman 2001). We analyzed hierarchical habitat selection at both the second and third order (Johnson 1980) for each season. Second-order selection occurs when an animal chooses its home range within the broader landscape, whereas third-order selection occurs when animals choose specific habitats within their home range (Johnson 1980). We analyzed selection of ten land cover types in each season, and the selection of supplemental food from bird feeders and cattle farms (cow manure, standing corn, and waste grain) solely in the autumn and winter. In EDA distance ratios are used to identify disproportional habitat use (the mean observed distance/the mean expected distance to a land cover type or feature). If habitat use is random then the distance ratio (d) should approximately equal 1. A $d < 1$ indicates selection whereas a $d > 1$ indicates avoidance (Conner and Plowman 2001, Conner et al. 2003). For second-order selection, we calculated the distance ratio by comparing the mean expected distance of land cover types within the home range to the mean expected distance to the same cover types within the study area. Since the Northern Bruce Peninsula is bounded by Lake Huron and Georgian Bay, it was straightforward to delineate the study area and estimate availability. For third-order selection, the distance ratios were calculated by comparing the mean observed distance to a land cover type within each seasonal home range to the mean expected distance within the same home range (Conner and Plowman 2001).

To calculate expected distance, we generated random points within each turkey's seasonal 95% MCP and within the study area. To determine an appropriate number of random points, we calculated the mean distance to two representative habitats with an increasing number of random points within the study area, and continued to increase the sample of points until the distribution was uniform (Conner and Plowman 2001, Conner et al. 2003). We chose 1000 random points within each seasonal home range and 2100 random points within the entire study area.

We used a multivariate analysis of variance (MANOVA) to determine whether habitat selection differed from random. We also tested whether the factors season and transmitter type had an effect on habitat selection. Using a MANOVA, distance ratios were compared to a vector of ones, which indicated no selection. If the MANOVA was significant, we then used univariate t-tests to determine which specific habitats were selected or avoided in each season (Conner and Plowman 2001, Conner et al. 2003).

Results

Home range size

Based on the area–observation curves, we determined that observations from a minimum of 36 days should be used to estimate annual home range size for the VHF transmitter data. This number was used as a guideline for the minimum required, however for all turkeys in the study we had observations from more than 36 days. For the seasonal home range estimates we used observations from a minimum of 13 days. For the GPS data all locations collected were used to estimate annual and seasonal home range size.

We found that the greatest home range sizes occurred in the spring and autumn, and the smallest in winter and summer (Table 3). A two-way ANOVA indicated that there was an effect of season on home range size ($F_{3,104} = 7.75$, $p = < 0.001$, $eta^2 = 0.18$). The Tukey's post hoc test revealed that winter and autumn were significantly different ($p = 0.04$), summer and spring were significantly different ($p = 0.001$) and winter and spring were significantly different ($p < 0.001$). Transmitter type had no effect on home range size ($F_{1,104} = 1.04$, $p = 0.31$, $eta^2 = 0.008$). The one-way ANOVA indicated that winter flock membership influenced winter home range size ($F_{4,26} = 3.93$, $p = 0.01$, $eta^2 = 0.38$). The mean home range sizes of flock 1 and flock 4 were significantly different from each other ($p = 0.008$). Turkeys in flock 1 had the largest winter home range sizes in the study ($M = 4.72$ km^2). Turkeys in our study were members of five different flocks.

Table 3. Wild turkey *Meleagris gallopavo* home range sizes from a study in Ontario, Canada. Seasonal home range sizes are displayed (winter: 21 December – 19 March), (spring: 20 March – 19 June), (summer: 20 June – 21 September), (autumn: 22 September – 20 December) along with an annual home range size. Home range size was calculated using GPS and VHF transmitter data. The estimation methods used were 95% minimum convex polygon, 100% minimum convex polygon, and 95% kernel density estimation with LSCV smoothing. Home range size between transmitter types was not significantly different so data was combined.

	Annual	Winter	Spring	Summer	Autumn
95% MCP					
n	32	31	33	25	20
Mean (km²)	31.25	2.88	13.10	3.62	9.85
SD	33.59	2.58	15.71	3.09	10.81
± SE	5.94	0.46	2.73	0.62	2.42
100% MCP					
n	32	31	33	25	20
Mean (km²)	40.85	4.26	19.47	6.73	11.56
SD	45.19	4.81	19.35	8.83	10.80
± SE	7.99	0.86	3.37	1.77	2.41
95% KDE					
n	32	31	33	25	20
Mean (km²)	49.64	8.81	33.36	9.36	26.52
SD	57.45	11.62	35.68	8.88	28.42
± SE	10.16	2.09	6.21	1.78	6.35

Habitat correlations

We retained the first three components of the PCA. The principal component loadings indicated that the land cover type's dense deciduous forest, sparse deciduous forest, mines quarries and bedrock, settlement/developed, and fields loaded weakly on component 1. Settlement/developed loaded weakly on component 2 and was negatively correlated with every other land cover type. Deciduous swamp and settlement/developed were strongly correlated with component 3.

The correlation matrix indicated that the strongest correlations were between water and open fen ($r = 0.82$), water and coniferous swamp ($r = 0.71$), coniferous swamp and open fen ($r = 0.78$), and between dense deciduous forest and sparse deciduous forest ($r = 0.76$). Due to the strong correlation between distributions of water, fen, and coniferous swamp the three habitats were amalgamated into one habitat for further analysis (WFC) (Table 1). Dense deciduous forest and sparse deciduous forest were also merged into one habitat (DFO) (Table 1). There were no strong negative correlations between habitats.

Habitat selection

Habitat selection occurred at both the second ($F_{20,2250} = 18.01$, $p < 0.001$, Wilk's $\lambda = 0.74$) and third order ($F_{20,2250} = 3.50$, $p < 0.001$, Wilk's $\lambda = 0.94$). There was no effect of season or transmitter type on habitat selection. At the second order, turkey's consistently selected deciduous forest, deciduous swamp, fields, and mixed forest habitats (Fig. 2). They also selected areas close to supplemental food in the autumn and winter. The only habitat avoided was coniferous forest. At the third order, turkey's selected deciduous forest, fields, and settlement (Fig. 3). They avoided coniferous forest and mixed forest habitats within their home range. In the autumn and winter they also selected areas close to supplemental food sites.

Discussion

We identified similarities and differences in home range size and habitat selection between turkeys in our northern study area compared to previously studied populations. We found a significant difference in home range size based on season. Females in our study had the greatest home range in the spring and autumn and the smallest during winter and summer. We also found a difference in winter home range

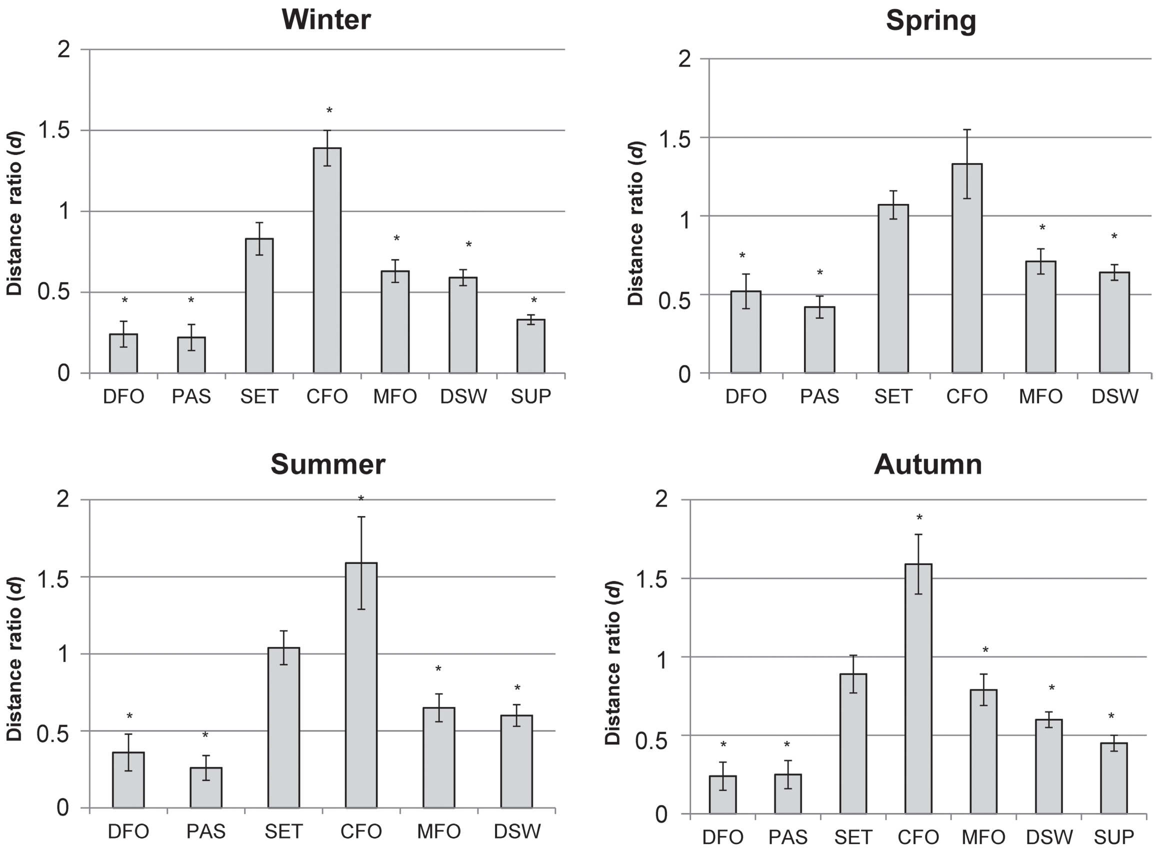

Figure 2. Wild turkey *Meleagris gallopavo* habitat selection results at the second order. Habitat selection was determined using a Euclidean distance analysis. Distance ratios < 1 indicate selection and ratios > 1 indicate avoidance. Significant distance ratios ($p < 0.05$) are indicated by an asterisk above the bar. Distance ratios are displayed for six habitat types (deciduous forest (DFO), pasture and fields (PAS), settlement/developed (SET), coniferous forest (CFO), mixed forest (MFO), deciduous swamp (DSW) and the landscape feature supplemental food (SUP).

size based on winter flock membership. Using a hierarchical approach we identified habitat selection at both Johnson's (1980) second and third order. Wild turkeys consistently selected deciduous forest and fields, which are historically noted to be important wild turkey habitat (Gustafson et al. 1994). Similar to other northern turkey studies, we also found that turkeys selected habitats close to supplemental food sources in autumn and winter (Kane et al. 2007).

Our hierarchical approach demonstrated that habitat selection occurred at both the second and third order. Habitat selection exhibited at higher orders identifies habitats and features that influence a species' fitness (Rettie and Messier 2000, Herfindal et al. 2009). The limiting factors affecting the wild turkey at its northern range edge are: predation, food availability, habitat quality, and snow depth (Porter 1977, Dickson 1992). The selection for deciduous forest and fields at the second order, suggests these habitats allow turkeys to avoid predation and provide the greatest foraging and nesting opportunities. In autumn and winter, selection for habitats close to supplemental food may indicate that turkeys require access to reliable food to avoid starvation. Nevertheless, wild turkey females in our study area had somewhat low survival (annual survival = 0.37; Niedzielski and Bowman 2015), suggesting that this marginal population may be maintained via immigration from the south.

The preference of habitats may be conditional on availability, if high quality habitats were selected at the second order, no further selection would be required (Mysterud and Ims 1998). With this said, turkeys in our study exhibited strong third order selection, indicating at different times of the year, turkeys have to increase their space use to actively seek out required habitats within their home range to meet their resource needs (Johnson 1980). This strong third order selection indicates potential critical needs for turkey feeding or nesting at particular times of the year (Johnson 1980). Turkeys selected fields in the spring indicating their importance as nesting and feeding habitat (Dickson 1992, Nguyen et al. 2004a, Ontario Ministry of Natural Resources 2007). In the autumn, fields, supplemental food, and deciduous forest were all selected within the home range. These land cover types and features provide food for turkeys in the form of hard mast, bird seed, agricultural corn, and cow manure. The selection for these habitats in the autumn likely indicates the importance of these food sources for building fat stores before winter.

We found a strong effect of season on home range size, with spring being significantly larger than summer and winter and autumn being significantly larger than winter. These seasonal differences in home range size may reflect the turkey's resource requirements and seasonal changes in

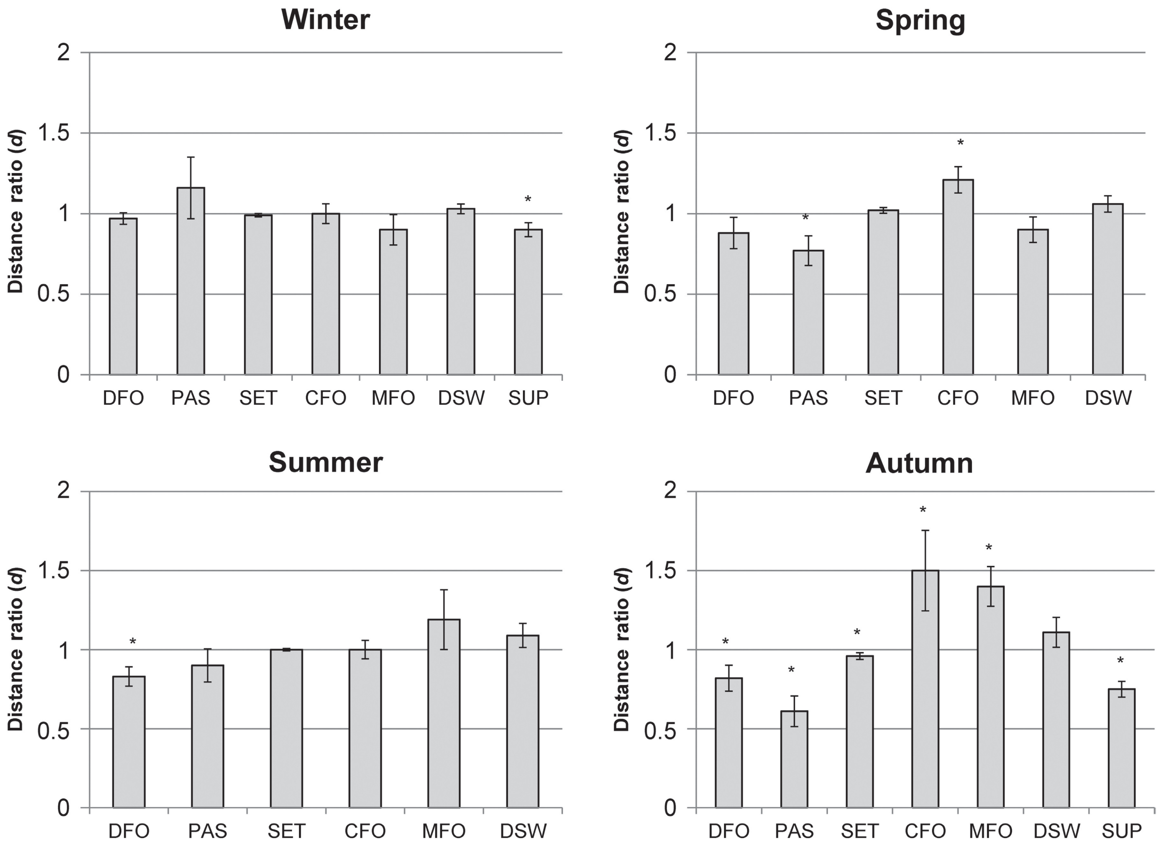

Figure 3. Wild turkey *Meleagris gallopavo* habitat selection results at the third order. Habitat selection was determined using a Euclidean distance analysis. Distance ratios < 1 indicate selection and ratios > 1 indicate avoidance. Significant distance ratios ($p < 0.05$) are indicated by an asterisk above the bar. Distance ratios are displayed for six habitat types (deciduous forest (DFO), pasture and fields (PAS), settlement/developed (SET), coniferous forest (CFO), mixed forest (MFO), deciduous swamp (DSW) and the landscape feature supplemental food (SUP).

behaviour in the spring and autumn (Harris et al. 1990). The turkeys within the study area likely have to increase their home range size in the spring to find adequate nesting habitat. They may also be increasing their home range size in the autumn to seek out required food, or are increasing space use because turkeys are returning to their winter roost sites.

The spring and autumn home range estimates in our study (Table 3) were larger than what have been reported across the species' range in the United States (Table 4). It is well documented that home range size increases as habitat quality and forage opportunities decline (Badyaev et al. 1996). Our large spring estimates may indicate poor habitat quality for nesting in northern environments, or at least a low density of suitable nesting locations. While there are limited studies with which to compare our autumn home range estimates, the studies that exist indicate that turkeys in our study had

Table 4. Literature review documenting seasonal home range sizes (km^2) throughout the eastern wild turkeys range *Meleagris gallopavo*. Home range comparisons are limiting because of differences in estimation methods, and seasonal time periods. For some estimates the mean was taken over multiple years, or monthly estimates were averaged to make a seasonal estimate. All home range estimates were also converted from ha to km^2.

Study	Annual	Winter	Spring	Summer	Autumn
Swanson et al. 1994 (West Virginia)	–	–	5.32	6.31	–
Badyaev et al. 1996 (Arkansas)	14.14	3.61	9.51	4.1	3.06
Chamberlain and Leopold 2000 (central Mississippi)	–	–	3.06	–	–
Holbrook et al. 1987 (Virginia)	–	1.75	1.02	2.80	–
Morgan et al. 2006 (Georgia)	–	–	–	4.50	–
Porter 1977 (southeastern Minnesota)	–	0.06	3.65	–	–
Vander Haegen et al. 1989 (Massachusetts)	–	1.09	–	–	–
Kurzejeski and Lewis 1990 (northern Missouri)	–	1.13	–	–	–
Porter 1980 (Minnesota)	–	1.00	–	1.00	–
Speake et al. 1975 (Alabama)	–	–	–	1.00	–
Miller and Conner 2005 (Mississippi)	8.02	5.24	3.26	3.92	5.24
Zwank et al. 1988 (Louisiana)	–	3.14	2.80	2.01	2.01
Mean (± SE):	11.08 ± 3.06	2.13 ± 0.61	4.09 ± 1.02	3.21 ± 0.65	3.44 ± 0.95

to move farther to meet their forage requirements (Zwank et al. 1988, Chamberlain and Leopold 2000, Miller and Conner 2005). During autumn many turkeys are also beginning their travels back to their winter roost which is reflected in an increase in daily movements (Dickson 1992, Badyaev et al. 1996). This may also contribute to the large autumn home range estimates.

The mean summer and winter home range estimates (Table 3) in our study were similar to those reported from other areas within the species range (Table 4). If habitat quality is poor, or there is a lack of fields across the landscape summer home range size increases as broods search for adequate food (Badyaev et al. 1996, Morgan et al. 2006). Female summer home range sizes are also noted to be larger for unencumbered hens (Badyaev et al. 1996). The similarity of our summer estimates to those from elsewhere in the species' range suggests that forage distribution and quality during this time of year is adequate for broods in our study area. Our mean winter home range size (Table 3) was comparable to some previous studies (Table 4) (Zwank et al. 1988, Badyaev et al. 1996, Miller and Conner 2005), however it was greater than what a similar northern study found outside the turkey's historical range on the Precambrian Shield of Ontario (2.04 km^2; Nguyen et al. 2004b). When snow is not a limiting factor, a large home range indicates that food availability is low. The large winter estimates in our study indicate that turkey movements were not limited by snow and that they may have been increasing their space use during this season to find an adequate food supply (Miller and Conner 2005).

As latitude increases, an animal's home range size will also increase due to the reduced primary productivity at northern latitudes (Harestad and Bunnell 1979). If an animal cannot meet its resource requirements, it has to increase its movements to find them (Kaufmann 1995). Large northern home range sizes have also been documented for other species in North America (Arvisais et al. 2002, Martino et al. 2012). Wood turtles in Quebec and grassland snakes in Saskatchewan were all found to have larger home range sizes compared to their southern populations (Arvisais et al. 2002, Martino et al. 2012).

It is worth noting that cross-study home range comparisons may be limited by use of different home range estimators and seasonal time periods. While comparisons may be somewhat biased, the general trend suggests that home range size increases when food availability and habitat quality are poor (Swanson et al. 1994, Badyaev et al. 1996, Miller and Conner 2005). Our relatively large seasonal home range estimates indicate that wild turkeys may have to increase their space use to meet resource needs at different times of the year in our northern study area.

The current wild turkey management plan for Ontario focuses on the sustainable management of populations (Ontario Ministry of Natural Resources 2007). The provincial management framework has three pillars: landscape-level population management, human–turkey interactions, and habitat management (Ontario Ministry of Natural Resources 2007). An aim of the habitat management framework is to provide scientific knowledge on important turkey habitat and features to improve habitat quality or available habitat. Results from our study add to the current knowledge that deciduous forest and fields are important wild turkey habitat. The results also indicate that these habitats may limit the northern distribution of the species, particularly given the avoidance of coniferous cover, which dominates the boreal forest. The selection for habitats close to supplemental food sources is also noteworthy because it indicates that turkeys are attracted to areas with bird feeders and cattle farms, which means that the birds will tend to be closely associated with people at northern latitudes.

Based on our findings, and a review of the literature, we expect that wild turkeys in northern landscapes will have large home ranges because of reduced habitat and forage quality. We also expect that northern turkeys will select deciduous forest and fields at both second and third orders of habitat selection. Turkeys will actively seek out these habitats, which may result in greater space use in order to find them. This may be particularly true in northern environments where coniferous forests dominate the landscape. The future northern range of the eastern wild turkey is also likely to be limited by the distribution and availability of supplemental food across the landscape, particularly in autumn and winter. All of these factors should be considered when developing management strategies for northern wild turkey populations.

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