

## ECOLOGICAL AND BEHAVIORAL CORRELATES OF VARIATION IN SEASONAL HOME RANGES OF WILD TURKEYS

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**Abstract:** We examined the effects of habitat distribution, age, sex, and body mass on variation in seasonal home ranges of eastern wild turkeys (*Meleagris gallopavo silvestris*). During 1992–94 we obtained and analyzed 11,354 locations of 156 wild turkeys in the Arkansas Ozarks. In particular, we tested the prediction that home range size and seasonal range juxtaposition covary with social status and physiological condition of an individual. Participation in breeding, age, and body mass strongly influenced spring and summer range sizes and range use in both sexes. As predicted, adult wild turkeys had smaller home ranges during the breeding season and greater overlap among seasonal ranges than yearlings. Successful females had a higher probability of using their breeding area during fall and winter than unsuccessful females. Habitat availability and distribution and acorn harvest were significant correlates of winter range size and use for females. Spring and prenesting ranges of females in our study area were the largest reported for eastern wild turkeys. We attributed this pattern to high nest predation which might cause extensive nest site selection movements.

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Extensive movement by individuals among parts of an annual range (such as between winter and breeding areas) can be costly in terms of reduced survival and increased time required

for relocation (e.g. Dingle 1980, Gaines and McClenaghan 1980, Gauthreaux 1982, Ketterson and Nolan 1983). At the same time, greater familiarity with a given area can improve foraging efficiency, predator avoidance, and reproductive success (e.g. Myers 1981, Ketterson and Nolan 1983, Schieck and Hannon 1989, Beletsky and Orians 1991). Familiarity with an

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area often is a major factor contributing to social dominance (e.g. Dhindsa et al. 1989, Koivula et al. 1993). Consequently, non-migratory animals should select habitats that provide all their annual needs in the smallest possible area.

We examined ecological correlates of individual variation in dispersal and home range use patterns in eastern wild turkeys. In wild turkeys, as in many other species, social status is determined largely by age; young individuals are subordinate to older individuals (Healy 1992). In addition, individuals of each age class can differ in body mass at breeding (Porter et al. 1983). In wild turkeys, body mass provides information on physiological condition in spring since body mass at breeding correlates with reproductive performance and intensity of movements (Porter et al. 1983, Badyaev 1994). In this paper, we examine the prediction that home ranges of individuals of higher social rank, or in better physiological condition, should include habitat areas which are adequate for a variety of seasonal activities and therefore require less movement among ranges.

We also examined the possibility that high nest predation and limitation of suitable nest sites in the study area (Badyaev 1994, 1995) favor larger spring ranges than other seasonal ranges. Furthermore, habitat type distribution in our study site differs from that in the majority of other studies because there are no large agricultural areas. We therefore expected to find differences between home range dynamics in our study area as compared to other studies.

Numerous studies have documented seasonal home ranges in wild turkeys (e.g., Ellis and Lewis 1967, Porter 1977, Everett et al. 1979, Bidwell et al. 1989, Smith et al. 1989, Kurzejeski and Lewis 1990). However, few investigators have attempted to identify factors that might explain observed variation in home ranges (Porter 1977), and no study has documented patterns of home range use. In addition, most of these studies suffered from small sample sizes or inadequate sampling designs (see also Brown 1980).

In this paper, we evaluate components of wild turkey seasonal home ranges in two populations in the Arkansas Ozarks. We first identify factors that correlate with variation in seasonal ranges. We then examine mutual distribution of areas used during different times of the year and identify factors that contributed the most to overlap among these areas. We also examine the potential influences of food supply (differences be-

tween high and low acorn production years) and habitat type distributions (differences between study sites) on juxtaposition of seasonal ranges.

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## STUDY AREA

Wild turkeys were studied in two areas in the Ozark Mountains, northwestern Arkansas. White Rock (hereafter WRS) and Piney Creek (PCS) sites, located 80 km from one another, were mostly hills (elevation up to 746 m) with numerous valleys. White oak (*Quercus alba*), northern red oak (*Q. rubra*), oak (*Quercus* spp.) and hickory (*Carya* spp.) forest covered 69.2% of WRS and shortleaf pine-oak-hickory forest covered 53.9% of PCS. Additional major habitat types included clearcuts and forest openings (8.8% in WRS and 12.2% in PCS), immature poletimber areas (5.7% in WRS vs. 11.9% in PCS) and pine stands (10.2% in WRS vs. 22.0% in PCS). Both availability and distribution of major habitat types differed between study sites ( $\chi^2 = 8.78$ , 3 df,  $P = 0.03$ , see above). In PCS, habitat types were evenly distributed, whereas in WRS, habitat distribution was patchy and major habitat types presented in large blocks distant from each other. For detailed description of the study sites, see Badyaev (1995).

## METHODS

We captured 116 females and 40 males with cannon nets during winters 1992–93. Capture sites were evenly distributed throughout study sites and among available habitat types to ensure unbiased sampling of wild turkey populations. All birds were weighed and instrumented with mortality-mode 120 g backpack-style radiotransmitters. Birds were located in different periods of the day at least twice a week. Nest sites were marked by circling incubating hens at 40–50 m distance and flagging vegetation. We calculated nest initiation date for most of the nests either by analyzing movement data

Table 1. Variables used in analyses of wild turkey home ranges and range use.

Females	
NstSt	Participation in nesting, Yes or No
NstSuccess	Nest success (at least one chick produced), Yes or No
SurvDs	# of days nest survived (from initiation to predation)
NstAtt	# of nesting attempts
InitDay	Day of first nest initiation
Males and Females	
AgeN	Known age in years
Bmass	Body weight, kg
S	Study site
SpringConv	Minimum Convex Polygon (MCP) of spring range
SprN	# of discrete activity centers used in spring
SprP_A	Partial Area of spring home range
SprSI	Simpson Index of spring home range
SumConv	MCP of summer range
SumN	# of discrete activity centers used in summer
SumP_A	Partial Area of summer home range
SumSI	Simpson Index of summer home range
FallConv	MCP of fall range
FallSI	Simpson Index of fall home range
WinConv	MCP of winter range
WinN	# of discrete activity centers used in winter
WinP_A	Partial Area of winter home range
WinSI	Simpson Index of summer home range

from telemetry, or by subtracting the days of the egg-laying period (based on clutch size) from the first date of incubation (Table 1).

We obtained 11,354 locations of birds by radiotracking in 1992–94. Based on wild turkey phenology in study area and for comparison with other studies (e.g., Kurzejeski and Lewis 1990), we determined seasonal ranges for four periods: winter (16 Dec–15 Mar), spring (16 Mar–15 Jun), summer (16 Jun–15 Sep), and fall (16 Sep–15 Dec). Only locations of birds which survived at least 1 entire season were used. Successive locations separated by more than 36 hours were independent (Swihart and Slade [1985] criterion,  $t^2/r^2 > 2.05$  for 2 days,  $P < 0.05$ ). Locations were determined by plotting at least 4 compass bearings taken within 60 minutes. Es-

timated distances to each radiomarked bird were  $\leq 0.7$  km for  $>85\%$  of observations. Repeated field tests of telemetry error showed that this protocol ensures collection of adequate data for seasonal home ranges estimates (unpubl. data).

We used three methods to estimate home ranges and their use with RANGES IV software (Kenward 1990) and the Statistical Analysis System (SAS Institute 1989). First, we calculated 90% minimum convex polygons (Mohr 1947). With this method, we estimated home range by connecting outer locations of an animal with exclusion of 10% of locations farthest from the arithmetic mean of all coordinates (Kenward 1990). We employed this method for comparison with other studies. Simple examination of location distribution in our study area revealed that home ranges often contained isolated areas of activity connected by areas which animals never visited, except during relocation movements. Thus, we used the incremental cluster analysis in RANGES IV (Kenward 1990) to obtain 90% multiple polygons by clustering (hereafter cluster analysis). Here, the three closest locations form nuclei from which the first cluster starts. We based cluster formation on the minimum nearest neighbor distance to the next fix. If the next closest location was already assigned to another cluster, the 2 clusters join. When 90% of locations had been assigned, cluster polygon areas are summed (Kenward 1990). In addition, this method produces the following parameters (after Kenward 1990); (1) Number of activity centers, (2) Partial Area—a measure of patchiness in range use. This is calculated as the area of all the cluster polygons divided by the area of a total polygon around all of them (low values indicate high patchiness in range use); and (3) Simpson Index—a measure of diversity in location distribution in cluster areas. It is calculated as the difference in the number of fixes assigned to clusters divided by the difference in cluster areas (high values indicate high diversity in range use). Finally, we estimated home ranges by using the 90% probability harmonic mean analysis (Dixon and Chapman 1980). To reduce bias and increase accuracy of this method, locations were centered on grid cells before isoline calculations (Spencer and Barret 1984) and as many grid cells as possible were used for isopleth fits [40x40 in Ranges IV (Kenward 1990)].

We used non-parametric tests (Kruskal-Wallis and Mann-Whitney tests) for univariate comparisons. Tukey and Kruskal-Wallis tests were

Table 2. Descriptive statistics (mean [range]) for wild turkey home range estimates (ha) and attributes in 1992–94 at the Arkansas Ozarks.

Range parameter	Adult		Yearling	
	Males	Females	Males	Females
	Annual <sup>a</sup>			
Cluster estimate	846.0 (909.8)A	777.8 (2233.4)AC	1634.4 (2200.2)BC	1079.7 (3110.1)B
No. of centers	1.6 (2.0)A	2.8 (5.0)B	2.3 (3.0)	2.9 (4.0)
Partial area	0.8 (0.6)A	0.6 (0.8)B	0.7 (0.7)	0.4 (0.9)A
Simpson index	1.1 (0.6)	1.2 (1.5)	1.2 (0.4)	1.3 (1.0)
Harmonic mean	1367.9 (1296.9)A	1891.5 (5089.9)AC	4600.1 (5615.3)BC	3628.0 (9710.6)B
Convex polygon	1211.4 (1702.0)A	1414.3 (3204.1)AC	3146.9 (4923.8)BC	3929.2 (10501.9)B
	Spring <sup>b</sup>			
Cluster estimate	359.6 (1291.9)A	309.6 (1555.3)B	877.8 (1704.2)C	732.4 (2921.6)
No. of centers	1.3 (1.0)A	2.1 (3.0)B	1.5 (1.0)	1.8 (2.0)
Partial area	0.8 (0.7)A	0.5 (1.0)B	0.7 (0.7)	0.6 (0.9)
Simpson index	1.1 (0.8)	1.2 (2.3)	1.1 (0.5)	1.1 (0.7)
Harmonic mean	325.1 (741.7)A	953.5 (7621.6)B	2077.3 (3361.4)	1478.7 (4341.1)
Convex polygon	538.1 (1719.7)A	951.7 (14611.7)B	1465.1 (2298.1)C	1358.9 (3801.5)
	Summer <sup>c</sup>			
Cluster estimate	341.1 (630.4)A	265.8 (1532.8)AC	514.1 (771.6)BC	324.7 (495.9)B
No. of centers	1.0 (0.0)A	1.7 (3.0)B	1.5 (1.0)B	2.0 (2.0)
Partial area	1.0 (0.0)A	0.7 (0.9)B	0.7 (0.8)B	0.6 (0.9)
Simpson index	1.0 (0.0)	1.1 (1.1)	1.2 (0.6)	1.3 (1.0)
Harmonic mean	215.9 (345.7)A	455.2 (3172.2)AC	692.4 (944.6)BC	651.4 (652.2)B
Convex polygon	349.7 (630.4)A	410.0 (1788.4)A	650.6 (528.5)B	669.4 (866.9)B
	Fall <sup>d</sup>			
Cluster estimate	183.1 (311.8)	167.8 (481.4)	181.7 (26.6)	199.2 (298.3)
No. of centers	1.4 (1.0)	1.3 (1.0)	1.5 (1.0)	1.0 (0.0)
Partial area	0.7 (0.9)	0.7 (0.9)	0.7 (0.7)	1.0 (0.0)
Simpson index	1.1 (0.4)	1.1 (0.8)	1.0 (0.1)	1.0 (0.0)
Harmonic mean		97.6 (249.4)		
Convex polygon	338.9 (500.1)	306.3 (906.1)	338.7 (287.4)	215.7 (298.3)
	Winter <sup>e</sup>			
Cluster estimate	143.3 (319.4)A	255.3 (596.2)B	295.1 (1091.4)	66.6 (120.5)A
No. of centers	1.2 (1.0)	1.3 (1.0)	1.0 (0.0)	1.4 (1.0)
Partial area	0.8 (0.8)	0.8 (0.9)	1.0 (0.0)	0.7 (0.7)
Simpson index	1.1 (0.3)	1.1 (0.8)	1.0 (0.0)	1.0 (0.2)
Harmonic mean	130.2 (187.3)	253.2 (411.5)		163.2 (368.6)
Convex polygon	152.7 (258.3)A	361.4 (808.1)B	295.1 (1091.4)A	138.4 (310.3)A

<sup>a</sup> n(ad ♂♂) = 8, n(ad ♀♀) = 33, n(yr ♂♂) = 6, n(yr ♀♀) = 9.

<sup>b</sup> n(ad ♂♂) = 12, n(ad ♀♀) = 51, n(yr ♂♂) = 6, n(yr ♀♀) = 10.

<sup>c</sup> n(ad ♂♂) = 8, n(ad ♀♀) = 39, n(yr ♂♂) = 6, n(yr ♀♀) = 11.

<sup>d</sup> n(ad ♂♂) = 8, n(ad ♀♀) = 31, n(yr ♂♂) = 3, n(yr ♀♀) = 3.

<sup>e</sup> n(ad ♂♂) = 5, n(ad ♀♀) = 21, n(yr ♂♂) = 4, n(yr ♀♀) = 5.

<sup>f</sup> Estimates followed by different letter are significantly different among age and sex classes (i.e. across the rows) (Tukey test, *P* < 0.05).

used for multiple comparisons of range parameters among seasons, age, and sex groups. Most variables (Table 1) were log, arcsin, or square root transformed to meet the assumptions of regression and correlation analyses (Montgomery and Peck 1992). We used simple and multiple linear regressions to determine which parameters explained the most variation in the dependent variables. We employed PROC RSREG of the SAS software (SAS Institute 1989) and examined residual plots and statistics to determine the factor level of the optimum response in the model. PROC AUTOREG was

used to estimate correct regression coefficients when Durbin-Watson D-statistics or residual plot patterns indicated significant autocorrelation in the error structure (Montgomery and Peck 1992). We assessed model adequacy using influence, multicollinearity, and residual statistics (SAS Institute 1989, Montgomery and Peck 1992). Sample sizes varied among tests because some data were missing. Except for fall and winter seasons, range parameters did not differ among years and study sites. Thus, unless otherwise indicated in the text, data were pooled across years and study sites (Tables 2, 3).

Table 3. Descriptive statistics (mean %, [range]) for overlap among wild turkey seasonal home ranges (cluster estimate) in 1992–94 at the Arkansas Ozarks.

Range overlap	Adult		Yearling	
	Males (n = 8)	Females (n = 33)	Males (n = 6)	Females (n = 9)
Spring with summer	25.8 (68.8)	<u>21.5 (80.1)</u>	<u>5.0 (16.8)</u>	<u>18.3 (70.2)</u>
Spring with fall	<u>27.1 (63.1)A</u>	<u>8.8 (45.5)B</u>	8.6 (5.2)A	0.9 (3.5)B
Spring with winter	<u>16.2 (61.1)</u>	<u>13.0 (52.0)</u>	0.7 (2.6)	<u>2.6 (10.8)</u>
Summer with fall	<u>24.6 (70.5)A</u>	12.4 (65.6)B	<u>44.5 (0.3)</u>	<u>12.6 (25.8)</u>
Summer with winter	<u>5.9 (10.3)</u>	<u>10.5 (66.9)</u>	<u>16.2 (62.9)</u>	1.8 (10.8)
Fall with winter	18.0 (42.7)	<u>13.0 (53.7)</u>	...	8.4 (14.2)

Note: Means underlined differently indicate significant differences in overlaps among seasons within age and sex groups. Means followed by different letter indicate differences in seasonal overlaps among age and sex groups within seasons (Tukey test,  $P < 0.05$ ).

## RESULTS

### Seasonal Home Ranges

Adult females used the largest areas in spring as compared to winter, summer, or fall (all  $P$ s  $< 0.002$ ) (Table 2). Fall ranges of adult females were smaller than areas occupied either in summer ( $P = 0.02$ ) or winter ( $P = 0.01$ ). Yearling females used larger areas in spring than in winter ( $P = 0.05$ ) and their winter ranges were also much smaller than their summer ranges ( $P = 0.03$ ). Average seasonal ranges of males were similar throughout the year with two exceptions. First, adult males used larger areas in summer and fall than in winter ( $P = 0.05$  and  $0.01$ ) and, second, areas occupied by yearling males in fall were larger than in summer ( $P = 0.02$ ) (Table 2).

### Seasonal Home Range Use

There were no differences in the number of centers of activity or pattern of range use among seasons in males (all  $P$ s  $> 0.1$ ). Adult females used areas in fall more evenly as compared to areas occupied during other seasons. This was indicated by the smaller number of activity centers and lower patchiness of fall range use (Table 2, all  $P$ s  $< 0.001$ ). Also, in adult females, use of spring areas was more patchy than in winter, summer, or fall (all  $P$ s  $< 0.04$ ). Yearling females' summer range use was more uneven and their activities concentrated around more centers than in fall ( $P = 0.04$  and  $0.03$ ).

### Variation and Covariation in Seasonal Home Ranges

*Age and Sex.*—Table 2 shows the results of tests for difference in ranges among different age and sex classes. Home range sizes were more

different between age groups than between sex classes, i.e., age contributed the most to variation in home range size (Tables 2 and 4). It was especially prominent in analyses of spring and summer ranges. However, use of home ranges was better predicted by sex (Table 2). Neither age nor sex were significant covariates of fall ranges size and fall and winter range use patterns (Table 4).

*Reproductive Performance, Social Status, and Habitat Distribution.*—Spring home ranges of females that nested were significantly smaller than those of females that did not (convex estimate: 918.1 vs. 2142.5 ha,  $P = 0.01$ ). Among females that nested, successful females tended to have smaller spring ranges than females without broods (613.7 vs. 1186.4 ha,  $P = 0.09$ ). In addition, spring range size was negatively correlated with area covered during the preceding winter and positively correlated with body mass during spring in each age class (Table 5). Similarly, reproductive performance and previous winter range characteristics accounted for most of the variation in spring home range use (Table 5). Patchiness (Partial Area) and diversity of use patterns (Simpson Index) were positively correlated with the number of nesting attempts, and negatively correlated with female body mass, age, and winter range (Table 5). The number of activity centers in spring ranges was also negatively correlated with nest success. The area of female movements before initiation of the first nest (prenesting range) was highly correlated with total spring range size ( $r = 0.75$ ,  $P < 0.05$ ; Badyaev 1994).

In males, ages of birds and the size of areas covered in the preceding winter negatively covaried with spring home ranges. Body mass and previous range use was also negatively corre-

Table 4. Factorial analyses of variance of wild turkey seasonal ranges and range use in the Arkansas Ozarks. The analyses examine joint effects of age and sex on range components.

Response variable	Source of variation						Error MS
	Age		Sex		Age × Sex		
	F	P	F	P	F	P	
	Annual						
Range	18.58	<0.01	0.20	0.65	1.83	0.18	0.07
No. centers	1.08	0.30	4.83	<0.05	0.65	0.42	0.14
Partial area	5.34	0.05	8.19	<0.01	0.20	0.65	0.22
Simpson index	0.41	0.52	0.39	0.53	0.10	0.75	0.01
	Spring						
Range	11.59	<0.01	0.74	0.39	5.65	<0.04	0.17
No. centers	0.00	0.96	5.64	<0.05	1.41	0.23	0.07
Partial area	0.00	0.95	4.99	<0.05	0.79	0.38	0.01
Simpson index	0.16	0.69	0.38	0.39	0.35	0.55	0.01
	Summer						
Range	14.95	<0.01	2.16	0.14	1.03	0.31	0.09
No. centers	3.28	0.07	7.56	<0.01	0.41	0.52	0.06
Partial area	3.68	0.06	5.43	<0.01	0.97	0.33	0.01
Simpson index	2.83	0.09	3.89	<0.05	0.09	0.76	0.01
	Fall						
Range	0.73	0.41	0.34	0.57	0.11	0.74	0.12
No. centers	0.17	0.68	1.65	0.15	0.88	0.35	0.03
Partial area	0.33	0.57	1.23	0.26	0.59	0.44	0.01
Simpson index	0.53	0.47	0.01	0.92	0.19	0.66	0.01
	Winter						
Range	5.89	<0.01	2.04	0.16	0.39	0.53	0.18
No. centers	0.07	0.79	2.73	0.14	0.62	0.43	0.03
Partial area	0.14	0.70	1.33	0.25	0.60	0.44	0.01
Simpson index	0.92	0.34	0.37	0.54	0.01	0.91	0.00

lated with patchiness of spring range use by males (Table 6).

Reproductive performance and preceding spring range size strongly influenced female summer ranges and their use. Females that nested had smaller summer ranges than females that did not nest (426.1 vs. 1149.1 ha,  $P < 0.01$ ).

Summer ranges and range use decreased with the number of nesting attempts and increased with spring range size (Table 5). In males, age was a highly significant negative predictor of summer range size and its use, Table 6).

Successful females had smaller fall ranges than females without broods (71.3 ha vs. 152.1 ha,  $P$

Table 5. Results of regression analyses of seasonal home ranges and their use in female wild turkeys in 1992–94 at the Arkansas Ozarks. The analyses examine effects of reproductive performance, body weight, study area, year, and previous ranges on seasonal home ranges.

Response variables	R <sup>2</sup>	MS <sub>E</sub>	F	P	Best predictors
SprConv	0.78	0.04	10.47	<0.01	WinConv***, SurvDs***, NstSt**, Bmass**
SprN	0.20	0.08	3.99	<0.05	NstSuccess*, WinConv <sup>NS</sup>
SprP <sub>A</sub>	0.42	0.01	4.44	<0.01	NstAtt**, WinConv**, Age*
SprSI	0.86	0.00	17.90	<0.01	NstAtt***, Bmass***, InitDay***, WinSI <sup>NS</sup>
SumConv	0.22	0.09	3.86	<0.01	NstSt**, NstAtt**, SprConv*
SumN	0.19	0.05	4.9	<0.01	NstAtt*, SprConv**
SumP <sub>A</sub>	0.24	0.01	4.04	<0.05	NstAtt*, SprConv**
SumSI	0.45	0.00	11.47	<0.01	Age**, SprConv***, NstSt**
FallConv	0.37	0.09	6.14	<0.01	NstSuccess***, SumConv**, S <sup>NS</sup>
WinConv	0.20	0.20	3.86	<0.05	Year**
WinN	0.22	0.02	4.53	<0.05	S**
WinP <sub>A</sub>	0.20	0.01	4.14	0.05	S**
WintSI	0.13	0.00	3.59	<0.10	S*

Significance of parameters indicated by: \*  $P < 0.1$ , \*\*  $P < 0.05$ , \*\*\*  $P < 0.01$ , NS = nonsignificant.

Table 6. Results of regression analyses of seasonal home ranges and their use in male wild turkeys in 1992–94 at the Arkansas Ozarks. The analyses examine the effects of age, study area, year, and previously occupied areas on seasonal home ranges.

Response variables	R <sup>2</sup>	MSE	F	P	Best predictors
SprConv	0.79	0.07	9.51	<0.01	WinConv*, AgeN***
SprN	0.42	0.03	3.29	0.11	WinP_A <sup>NS</sup> , Bmass*
SumConv	0.58	0.04	15.78	<0.01	AgeN***
SumN	0.36	0.02	6.86	<0.05	Age**
SumP_A	0.32	0.01	5.70	<0.05	Age**
SumSI	0.23	0.01	3.48	<0.10	Age*
FallConv	0.32	0.04	3.54	<0.10	S*
WinN	0.98	0.00	238.46	<0.01	FallSI***
WinP_A	0.96	0.00	238.46	<0.01	FallSI***
WintSI	0.98	0.00	238.46	<0.01	FallSI***

= 0.06). In fall, males occupied larger ranges in WRS (patchy distribution of habitat types) than in PCS (even distribution of habitat types) (412.7 ha vs. 265.0 ha, *P* = 0.08).

Females used smaller winter ranges in 1992 than in 1993 (77.7 ha vs. 207.0 ha, *P* = 0.02). Females used their winter range in WRS less evenly and had more discrete centers of activity than in PCS (Partial Area: 0.67 vs. 0.93, *P* = 0.05; No. centers: 1.5 vs. 1.1, *P* = 0.04).

For females, annual range use was different between study sites. Females had more discrete and unequally used centers of activity in their annual ranges in WRS than in PCS (No. centers: 4.0 vs. 2.44, *P* < 0.05, Simpson Index: 1.4 vs. 1.2, *P* = 0.07). There were no differences between either years or study sites in male annual ranges.

### Overlap Among Seasonal Ranges

In adult females, overlap of spring range by summer was the largest (Table 3). In yearling females, overlap between winter and previous spring ranges was smaller than the overlap between spring and summer ranges. In adult males, overlap of summer ranges by winter ranges was

the smallest (Table 3). In yearling males, there was little overlap between winter and previous spring range and large overlap of summer by fall range.

### Variation and Covariation In Overlap Among Seasonal Home Ranges

*Age and Sex.*—Overlap of spring range (breeding area) by subsequent seasonal ranges covaried significantly with age (Table 7). Isolation of fall ranges from previous seasonal ranges covaried significantly with sex (Table 7).

*Reproductive Performance, Social Status, and Habitat Distribution.*—Spring and summer ranges overlapped more in nesting females than in females that did not nest (34.3 vs. 14.0%, *P* = 0.09). Nesting females used areas closer to their former nesting area during the next fall and winter than non-nesting females (Table 8). Winter ranges of females were closer to their previous spring ranges if they were successful but not if they did not produce a brood (21.5 vs. 3.9%, *P* = 0.08). Similarly, successful females were closer to their spring ranges in fall than females that failed to produce brood (24.9 vs. 10.3%, *P* = 0.1). Female winter ranges were more isolated from preceding fall and summer

Table 7. Factorial analyses of variance of overlap in wild turkey seasonal ranges (cluster estimate) in the Arkansas Ozarks. The analyses examine joint effects age and sex on seasonal range overlaps.

Response variables	Source of variation						Error MS
	Age		Sex		Age × Sex		
	F	P	F	P	F	P	
Spring with summer	3.99	<0.05	0.39	0.53	1.68	0.20	0.08
Spring with fall	1.91	0.17	4.53	<0.05	0.01	0.92	0.07
Spring with winter	5.63	<0.05	0.00	0.97	0.25	0.61	0.06
Summer with fall	1.35	0.25	5.81	<0.05	0.51	0.47	0.07
Summer with winter	0.15	0.69	0.85	0.36	0.79	0.38	0.08
Fall with winter	0.03	0.86	0.23	0.63			0.07

Table 8. Results of regression analyses of overlaps in seasonal home ranges in wild turkeys in 1992–94 at the Arkansas Ozarks. The analyses examine effects of reproductive performance, body weight, study area, year, and previous ranges on seasonal home range overlaps.

Response variables	R <sup>2</sup>	MSE	F	P	Best predictors
Females					
Spring with summer	0.27	0.11	3.17	<0.05	NstSuccess*, Bmass*, SprConv*
Spring with fall	0.19	0.08	2.40	<0.10	Age*, NstSuccess <sup>NS</sup> , NstSt*
Spring with winter	0.35	0.07	2.90	0.05	NstSuccess**, Age*
Summer with fall	0.25	0.10	3.90	0.05	FallConv*
Summer with winter	0.45	0.07	2.50	0.10	NstSuccess**, S*, NstSt <sup>NS</sup>
Fall with winter	0.28	0.08	3.11	<0.10	S*, FallConv*
Males					
Spring with summer	0.72	0.03	7.48	<0.05	Age**, SprConv*
Spring with winter	0.89	0.00	18.5	<0.05	WinConv**, Age*

ranges in WRS than in PCS (fall with winter: 14.4 vs. 24.8%,  $P = 0.05$ , summer with winter: 11.0 vs. 19.5%, NS) (Table 8).

For males, age was highly significant covariate of spring range overlap by subsequent fall and winter ranges (Tables 2 and 7). In addition, size of spring and winter ranges were significant predictors of overlap with spring ranges (Table 8).

## DISCUSSION

Our results supported our a priori prediction; age was a significant predictor of both seasonal range size during the breeding season and magnitude of dispersal between ranges. As predicted, adult wild turkeys in the Arkansas Ozarks had smaller seasonal ranges during breeding season and greater overlap among areas used during different seasons than subadults.

Suitable nest sites are limited in the study area during the most suitable time for nesting, and searching for suitable sites partially determines prenesting range size in both adults and yearlings (Badyaev 1994, 1995). Females that move to their nesting grounds during winter, while still in the flock, have a higher probability of successful nesting (Table 5), possibly because of minimizing spring dispersal. In both adult and yearling females, the size and pattern of spring range use negatively correlated with size and use of previous winter ranges. Adult female spring ranges overlapped more with previous winter ranges (Tables 5 and 8). These findings potentially explain the mechanisms underlying differences in spring dispersal from winter ranges between adults and yearlings females. Adults disperse to their nesting areas in late fall and winter, while yearlings disperse most in early spring (Tables 3, 7, and 8). Similar explanations

of differential spring dispersal in females were suggested for blue grouse (*Dendragapus obscurus*) (Cade and Hoffman 1993), and greater prairie-chicken (*Tympanuchus cupido*) (Schroeder and Braun 1993). Female wild turkeys often form mixed flocks in winter allowing possible aggressive intrasexual interactions that force subdominant yearlings to leave areas selected by adult females during winter. For example, aggressive interactions between adult and yearling females influence spring dispersal and may regulate population density in several grouse species (Boag et al. 1979, Hannon et al. 1982, Nugent and Boag 1982). Schroeder (1985) documented behavioral differences between long-distance and short-distant migrants in spruce grouse (*Dendragapus canadensis*). He found that females that dispersed less in spring, formed smaller winter flocks than long-distance migrants and specifically avoided other short-distance migrants during winter. Although some anecdotal evidence of aggressive territorial interactions between dominant and subdominant female wild turkeys exists (A. V. Badyaev, pers. obs.), the influence of intrasexual interactions on dispersal patterns has not yet been determined.

As predicted, successful females had a higher probability of using their breeding area during fall and winter than unsuccessful females. Females that nested also had a higher probability of using their breeding range after nesting and in winter than females that did not nest.

Participation in breeding, social status, and physiological conditions strongly influenced spring and summer range sizes and range use in both sexes (see also Porter 1977, Porter et al. 1983, Badyaev 1994). The influence of nest success on home range parameters is partially determined by distribution of suitable brood hab-



itats in the study area and brood mobility (e.g. Speake and Metzler 1985). Because females with broods use a selected subset of available habitat types (e.g. Everett et al. 1979, Speake and Metzler 1985, Phalen 1986, Kurzejeski and Lewis 1990) their summer range is usually smaller than range of broodless hens (this study, Kurzejeski and Lewis 1990). Spring ranges of adult and yearling females did not differ, reflecting their equal participation in breeding, in contrast to differences between adult and yearling males (Badyaev 1994).

Use of display range (part of spring range) in males differed due to extent of participation in breeding (Hoffman 1991, Badyaev et al. In Press). Godwin et al. (1990) concluded that neither food availability and distribution, nor human disturbance (hunting) can explain large scale movements undertaken by males in spring. They concluded that social interactions among individuals and fidelity to previous display areas determined these long-distance movements. Most spring dispersal is done by 2-year-old males when they enter their first breeding season and need to establish their own display areas (Badyaev et al. In Press). Older males, however, spend winter near their spring display grounds thereby minimizing spring dispersal. In the populations under study, early-nesting hens had higher nest survival than females nesting later (Badyaev 1994). Thus, males that reach spring display grounds earliest could increase their reproductive success by mating with early-nesting females.

In the populations we studied, most relocations between seasonal ranges (e.g. spring and fall dispersals) were long-distance linear movements completed within 3–7 days (Badyaev 1994). Because no more than 90% of all radiolocations were used in all seasonal ranges analyses, areas covered during such dispersals were commonly excluded from home range estimates. Nevertheless, as predicted, areas used during the breeding season (spring and summer) were larger than fall and winter ranges. After adjusting for method differences, we found that spring and prenesting ranges of females in our study area are the largest reported for eastern wild turkeys (Ellis and Lewis 1967, Porter 1977, Speake and Metzler 1985, Wigley et al. 1986, Bidwell et al. 1989, Smith et al. 1989, Kurzejeski and Lewis 1990). Because spring ranges compose the largest part of annual range size, annual ranges in this study were also among the largest

reported for the eastern subspecies of wild turkeys (e.g. Kurzejeski and Lewis 1990, Gunn 1993). This finding is surprising considering the absence of large blocks of agriculture fields in our study that contributed to much smaller isolation between wintering and nesting grounds compared to other studies (e.g. Porter 1977, Kullowicz and Haufler 1985, Smith et al. 1989). For example, spring home ranges of females in this study were more than 11.5 times larger than in northern Missouri and southeastern Louisiana populations (e.g., 1,155.3 ha vs. 100.4 ha for Arkansas vs. Missouri) (Smith et al. 1989, Kurzejeski and Lewis 1990). There were fewer differences in summer, fall, and winter ranges between this study and others (e.g., Bidwell et al. 1989, Smith et al. 1989). We propose that selection of suitable nest habitat, which is determined by the distribution of suitable nesting sites (Badyaev 1994), requires more extensive movements than any other activities during the year in our study area. Nest predation rate documented for the populations under this study (79%) was also one of the highest reported for eastern wild turkeys suggesting that availability of suitable nesting habitats is one of the major limiting factors in the populations (Badyaev 1994, 1995).

For females, habitat type availability and distribution (differences between study sites) and acorn harvest (differences between years [pers. comm.]) were significant correlates of winter range size and use (Porter 1977, Kurzejeski and Lewis 1990). Females moved over larger areas in year with poor acorn production (1992) than in year with good harvest (1993). Acorns are the primary food of wild turkeys in the Arkansas Ozarks (Dickson 1990). Fluctuations in acorn production are especially important for wild turkeys because they accumulate considerable less lipid reserves before winter than other non-migratory gallinaceous birds (Oberlag et al. 1990). Females are more vulnerable to starvation than males during inclement weather (Gray and Prince 1988). In addition, because females are usually subdominant to males, female flocks might need to move farther to obtain resources. Our findings suggest that food availability and distribution during fall and winter affect females more than males. Thus, it is possible that physiological tolerances and social status also influence winter range use. In many wintering species, foraging efficiency is influenced by flock size (e.g. Pulliam 1973). The effects of group

size and inter- and intraflock interactions on movements of wild turkeys demand further studies.

In sum, body mass of an individual and its age was significantly correlated with the dynamics of seasonal home ranges. In both sexes, suitable nest site distribution (Badyaev 1994, 1995) and participation in breeding were prominent factors influencing movements.

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