Evaluating Micro–habitat Selection by Northern Bobwhite in Virginia

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Abstract: We monitored radio–tagged northern bobwhites (*Colinus virginianus*) from January through July of 1990 and 1991 to determine if preferential habitat use occurred within the covey home range. We generated estimates of percent bare ground, average height of herbaceous vegetation, percent canopy cover of herbaceous vegetation and honeysuckle (*Lonicera* spp.), proportion of the herbaceous canopy represented by grasses, herbaceous quail foods, and woody vegetation <2 m tall at used and unused sites within 12 covey home ranges. We pooled the data within each home range and used 2 approaches to evaluate the extent to which these 7 variables influenced habitat use. First, we compared means from used and unused sites for each of the 7 parameters with a Wilcoxon signed–rank test. Additionally, we regressed means from used sites on estimates from unused sites. The 2 approaches used to evaluate habitat selection yielded different results. Whereas the signed–rank test yielded significant ($P = 0.04$) results for only herbaceous quail foods (sites with higher cover of food were selected), results from the regressions were all significant ($P < 0.05$), indicating disproportional use of habitat characteristics except for cover of woody vegetation <2 m tall. Finally, we used data from use–sites to construct Suitability Index (SI) curves for bare ground, herbaceous quail foods, and woody vegetation <2 m tall. Our SI curves for bare ground and herbaceous quail foods were similar to the curves in the HSI model (Schroeder 1985). Our findings suggest that proportion of herbaceous canopy that is grass, total herbaceous cover, honeysuckle, herbaceous quail foods, and most especially bare ground, likely influence habitat use within the covey home range.

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Northern bobwhite populations have declined in Virginia and other parts of the species' range over the past 50 years (Flather and Hoekstra 1989, Brennan 1991, Fies et al. 1992). Loss of habitat to development, "clean farming," and the reversion of croplands to woodlands are, in part, responsible for these declines. An increase in idle farmland and forested habitats, including monocultures of pine, has resulted in the loss of quail habitat in Virginia and other portions of the Southeast.

Given the status of the species, the inevitable loss of habitat to development, and the likelihood of change in agricultural policy and practices, it is imperative that we replace qualitative descriptions of quail habitat with more precise and quantitative means for evaluating northern bobwhite habitat. The Habitat Suitability Index (HSI) model for the northern bobwhite (Schroeder 1985) represents 1 of the most widely used summaries of quantitative data for the species (Rice et al. 1993). Presently, a modified version of this model is being used in a comprehensive nationwide evaluation of the effects the Conservation Reserve Program on farmland wildlife. Like many wildlife habitat models, neither version has been tested. Our objectives were to (1) test the null hypothesis that habitat use within a covey's home range was independent of 7 habitat components, including 3 HSI variables; and (2) to develop suitability index (SI) curves and compare these to the HSI model for the northern bobwhite.

We thank all the participating landowners of Halifax County, the county Agricultural Stabilization and Conservation Service and Soil Conservation Service personnel, and others who helped make the 6–year study a success. The dedication and hard work of R. H. Bruleigh and M. Barbour made the project possible. We thank R. L. Kirkpatrick, P. Curtis, and T. Daily for earlier reviews of this manuscript.

Study Area

This study was conducted in Halifax County, Virginia. Relief is nearly level along streams and rolling to gently rolling on the ridges. Elevations range from 90 to 180 m. Mean daily temperatures range from 3° C in January to 26° C in July (Va. Crop Rep. Serv. 1982).

About 66% (140,580 ha) of the county is forested (Cent. for Public Serv. 1992). Common woodland trees included oaks (*Quercus* spp.), yellow poplar (*Liriodendron tulipifera*), hickories (*Carya* spp.), ashes (*Fraxinus* spp.), sweetgum (*Liquidamba styraciflua*), loblolly pine (*Pinus taeda*), Virginia pine (P. *virginiana*), dogwood (*Cornus* spp.), and sassafras (*Sassafras albidum*).

Mean annual production of small grains, tobacco, and soybeans accounted for 26%, 18%, and 14% of the open cropland, respectively (L. White, pers. commun., Halifax County, Va., SCS). Mean farm size and mean field size were 78 ha and 1.7 ha, respectively (Cent. for Public Serv. 1992).

Trapping and Monitoring

We trapped quail with baited funnel traps during January–early March 1990 and 1991 (Stoddard 1931). Birds were sexed, aged, weighed, and fitted with 6–g bib–mounted radio–transmitters (Holohill Inc., Ontario, Canada). Sixty–six birds representing 12 coveys from 8 sites were radio–tagged during the 2–year study. We monitored 19 birds in 4 coveys in 1990 and 47 birds in 8 coveys in 1991. An average of 5.5 birds were radio–tagged per covey with a range of 3–11.

Vegetation Sampling and Analysis

Radio locations were compiled and a generalized home range for each covey estimated by delineating the outermost locations. Extreme outliers were excluded. Because our goal was to determine what factors influenced micro–habitat selection *within* the covey home range, we initially chose to sample the vegetation at individual radio locations and compare these data to that collected at unused sites of comparable size within the home range. However, because single radio locations are nearly instantaneous observations, we chose to sample the vegetation within a plot centered on multiple observations (radio locations per vegetation plot varied from 5 to 18, Fig. 1). We sampled the vegetation within a 35–m radius circular plot. This plot size represented a compromise between the density of locations within the plot and required sampling time. We attempted to sample those sites with the greatest density of locations. For those sites with an equal number of observations, we randomly selected a site. We sampled vegetation at 3 use sites within each home range. Use sites did not encompass all radio locations within the home range and did not overlap each other. Point sampling (Hays et al. 1981) was used to generate canopy cover estimates for herbaceous cover, woody vegetation <2 m tall, honeysuckle, proportion of the herbaceous canopy represented by grasses, and herbaceous quail foods and the amount of bare or lightly–littered ground. A graduated dowel was used to estimate herbaceous vegetation height. All measurements were taken at 1–m intervals along 2 70–m transects bisecting the plot in the cardinal directions. We randomly selected 3 sites of equal size from the unused portion of the home range and sampled these in an identical manner.

Means for the 7 habitat variables were computed for each home range by first pooling over the 2 transects within each site and then pooling site means. Distributions for all variables were non–normal. Subsequent analyses were based on this sample of 12 means.

Differences in means between used and unused sites for each of the 12 home ranges were generated for each of the 7 habitat variables. A signed–rank (Statistix 1991) test was used to test the hypothesis that the mean difference between the used and unused samples was 0. We also used simple linear regression (SAS 1985) to test the null hypothesis that habitat selection within the home range was not occurring. We regressed means for the 7 habitat variables from used sites on the means from unused sites and tested the resulting slopes to determine if they differed from 1.

Suitability Index Curves

For herbaceous quail foods, bare ground, and woody vegetation <2 m tall, we computed the difference in means for used and unused sites for each of the 12 home ranges. For each variable we then derived a suitability index by dividing this difference by the maximum difference for the respective variable and then subtracted the quotient from 1. We assumed that the smaller the difference, the more suitable the conditions. The resulting index was plotted against the range of possible values (0%–100%) for each variable and a curve was subjectively determined based on the distribution of points.

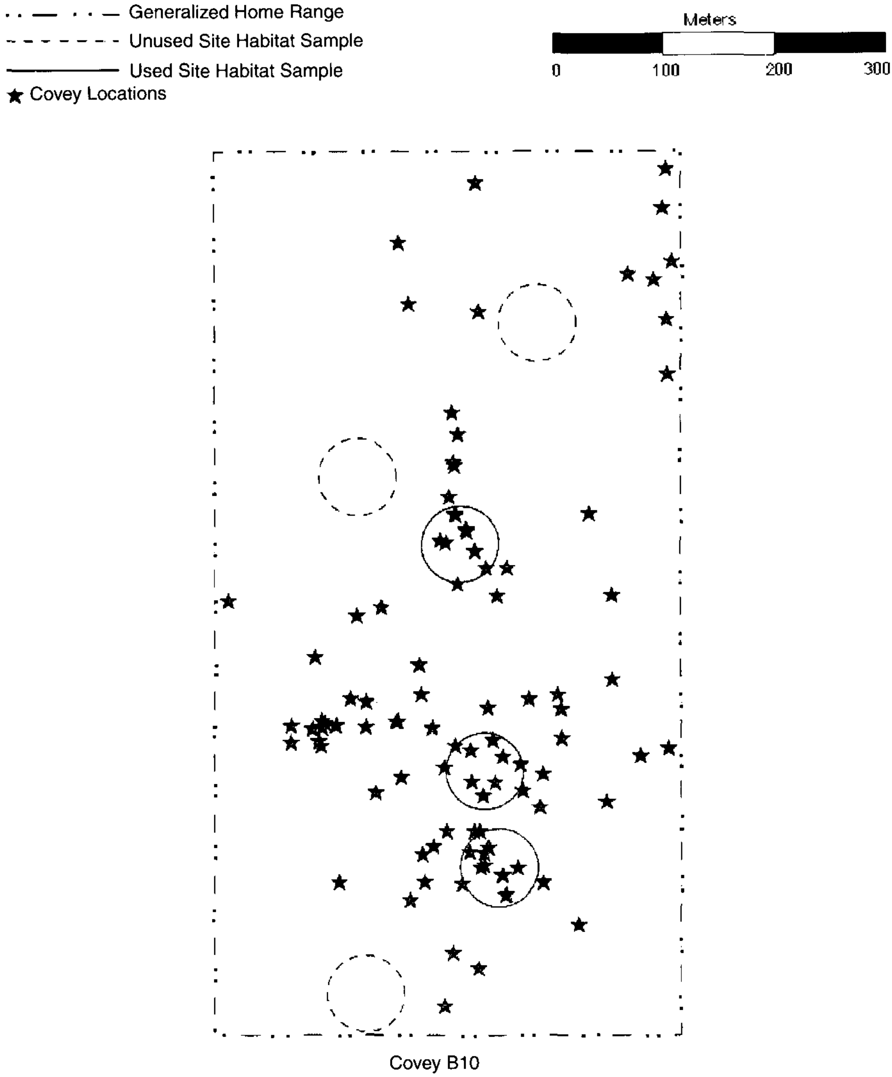

Figure 1. Sampling protocol used to compare micro–habitat conditions at used and unused sites within 12 northern bobwhite covey home ranges. Home range estimates and use sites are based on radio telemetry data collected from January to July, 1990 and 1991, Halifax County, Virginia, 1990–91.

Results

Analyses were based on a total of 986 independent radio locations collected from mid-January–July 1990 ($N = 605$) and mid-January – mid-March 1991 ($N = 381$). Except for occasions when a covey was scattered, the sampling unit was the covey, not individual birds. We averaged 151 observations (range: 60–306) per

Table 1. Analysis of northern bobwhite habitat selection, Halifax County, Virginia, 1990–91. Signed-rank tests of 7 micro habitat measurements from used and unused sites within 12 home ranges and a simple linear regression of means for each variable from used sites on corresponding means from unused sites were used to test the null hypothesis of no selection.

	Wilcoxon signed-rank						Regression			
	Used		Unused							
Variable	$\bar{x}$	SE	$\bar{x}$	SE	Σ^{+a}	P^b	β_1^c	P^d	β_0^e	P^f
Bare or lightly-littered ground	75.3	2.9	67.7	6.2	52	0.33	0.12	<0.01	67.0	<0.01
Honeysuckle	14.9	2.2	11.5	2.2	54	0.26	0.28	0.04	11.7	0.02
% herbaceous canopy that is grass	48.9	2.9	54.2	5.9	25	0.29	0.24	<0.01	35.7	<0.01
Herbaceous quail foods	18.5	2.0	14.9	2.7	66	0.04	0.23	<0.01	15.0	<0.01
Woody vegetation <2m	16.3	2.3	15.1	1.1	45	0.67	0.42	0.38	9.9	0.34
Herbaceous vegetation height (cm)	14.2	2.1	16.3	2.7	32	0.61	0.28	<0.01	9.7	0.05
Herbaceous vegetation	37.1	4.6	42.2	6.3	28	0.41	0.27	<0.01	25.8	0.03

[a] Signed-rank statistic.
[b] Significance of 2-tailed signed-rank test.
[c] Slope of regression. Slopes differing significantly from 1 indicate selection.
[d] Probability of $\beta_1 = 1$.
[e] Intercept of regression line.
[f] Probability of $\beta_0 = 0$.

covey in 1990 and 48 (range: 19–84) in 1991. We located coveys an average of 8 times weekly. Telemetry data were collected from 0500–1930 hours. Except for the period from 1800–1930 hours (which represented approximately 7% of all locations), results indicated that observations were nearly equally distributed in 3 hour periods from approximately 0530–1800 hours. Sixty–one observations represented nocturnal roost sites.

The Wilcoxon signed–rank tests yielded no differences ($P < 0.05$) in means for any of the 7 habitat variables except canopy cover of herbaceous quail foods ($\Sigma = 66$, $P = 0.04$). Mean percent cover of herbaceous quail foods at used and unused sites was 18.5% and 14.9%, respectively (Table 1). Used sites tended to have more bare ground, grass, and woody vegetation <2 m tall than unused sites, but generally less honeysuckle and total herbaceous vegetation. Herbaceous vegetation height tended to be lower at used sites ($\bar{x} = 14.2$ vs. 16.3 cm).

Under the null hypothesis (i.e., no preferential use of habitat within the home range) mean values for each of the habitat variables estimated should be similar for both used and unused sites. Thus, plotting used vs. unused data pairs should generate a curve with a slope not significantly different from 1 and an intercept of 0 (Dodge et al. 1990). Except for woody vegetation <2 m tall, all slopes tested differed (honeysuckle, $P = 0.04$; all others $P < 0.01$) from 1 and all intercepts from 0, suggesting that use was not random with respect to these parameters (Table 1, Fig. 2). As with the signed–rank test, the regression analysis suggests that, at least for the range of conditions sampled, the amount of woody vegetation <2 m tall had little impact on habitat use during the period examined.

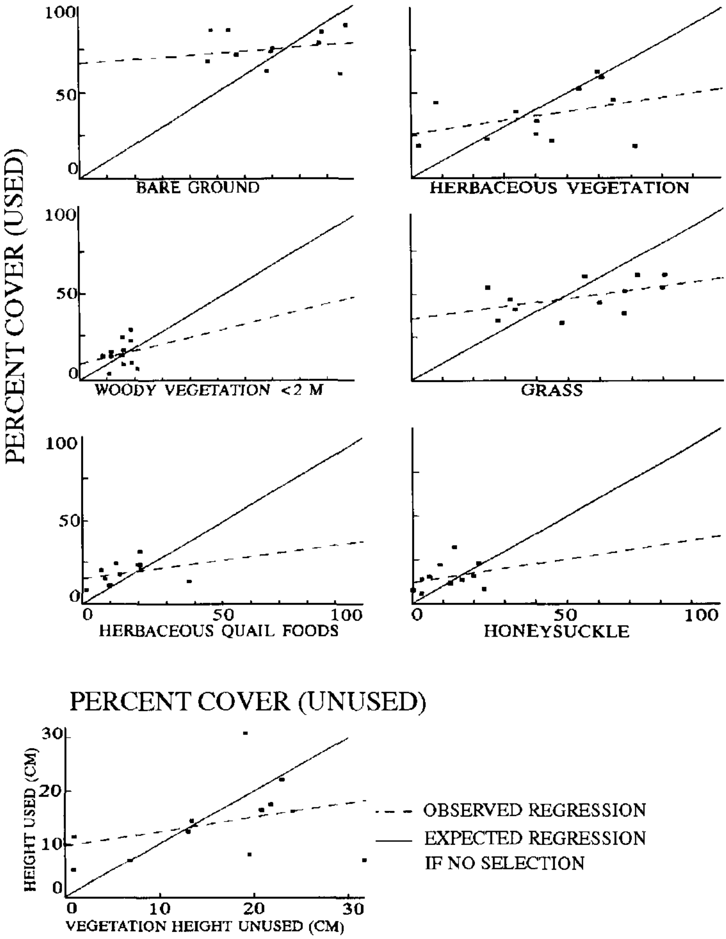

Figure 2. Regressions of means of 7 habitat variables estimated at used sites on means from corresponding unused sites within the home ranges of 12 coveys of northern bobwhite, Halifax County, Virginia, 1990–91. Under the null hypothesis that habitat selection is not occurring, a line with a slope of 1 and intercept of 0 is expected.

Although we found that the amount of bare ground within the home range varied from 30% to 100%, areas consistently used by quail had ≥61% bare ground. Only in cases where bare ground at unused sites within the home range averaged between 65% and 85% did we find quail using habitats as predicted under the null hypothesis that conditions at used sites should be similar to those at unused sites when there is no selection occurring. Observations deviated considerably from the prediction line outside the 68%–85% range (Fig. 1). When unused sites within the home range averaged <20% canopy cover of quail foods, quail tended to select sites that provided more food than what would have been found had use been random. For honeysuckle, we found that when unused sites within the home range averaged from 0%–10%, used sites fell above the prediction line. However, when unused conditions ranged from about 12%–25%, the points fell very close to the predicted line. For percent of the herbaceous canopy that is grasses, we found that used sites fell above the prediction line when unused levels <40%, and were below this line where cover at unused sites was >50%. We found little if any noticeable pattern in the data for total herbaceous cover and herbaceous vegetation height (Fig. 1). For most of the range sampled, we had sites both above and below the prediction line.

Suitability Index Curves

We developed a suitability index curve for bare or lightly-littered ground. Limited data (only sites with <25% woody cover were in our sample) precluded curve development for woody vegetation <2 m tall and we were able to evaluate the curve for herbaceous quail foods only at levels with <40% cover (Fig. 3). The U.S. Fish and Wildlife Service curve predicts that sites with 30%–60% bare ground are most suitable (Schroeder 1985). Based on the magnitude of the differences between means for used and unused sites, our data indicated that 60% may be the low, rather than the upper end of preferred conditions and that the optimum range should be extended to nearly 85% in Piedmont Virginia. Based on limited data for herbaceous quail foods, we assigned sites falling in the 0–25% range higher SI values than those given by the HSI model.

Discussion

We compared data for 7 habitat variables collected at used and unused sites within the home ranges of 12 coveys to assess the dependency between these 7 habitat parameters and overall habitat suitability. We assumed that use was an indicator of quality. Our data suggested that the distribution of radio locations within the 12 home ranges was partly influenced by 6 of the 7 variables estimated. Except for herbaceous quail foods, no differences in means between used and unused sites were detected. For several of the variables, we attribute this partly to the disparity in the variances between the used and unused samples. Although homogeneity of variances is not an assumption of the signed–rank test, large differences in variances may limit the power of this test. The availability of bare or lightly–littered ground clearly influenced habitat use within the home ranges examined. The importance of bare ground has been both qualitatively and quantitatively described elsewhere. Stoddard (1931) described ideal foraging conditions as areas with open vegetation interspersed with some bare ground. Abandoned agricultural fields and croplands with rough stubble have been shown to be suitable sources of bobwhite food (Ellis et al. 1969). Workers in West Virginia found a negative ($P < 0.05$) correlation between the percent ground cover and feeding rates for broods (Brown and Samuel 1978). More recently, Burger et al. (1990) noted the potential of CRP fields in Missouri to provide optimal brood foraging habitat due to the presence of

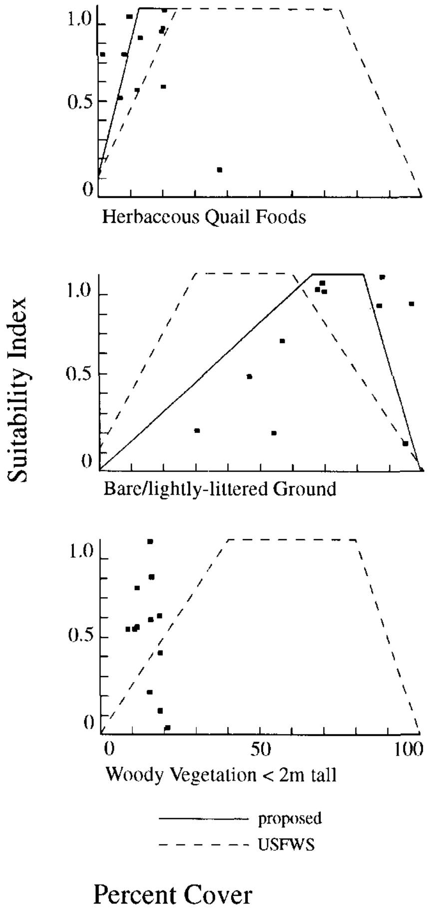

Figure 3. Comparison of SI curves from the HSI model (Schroeder 1985) for the northern bobwhite and those based on differences in means between used and unused sites within the home ranges of 12 coveys of northern bobwhite, Halifax County, Virginia, 1990–91. Data points were derived by dividing all differences between means from used and corresponding unused sites by the maximum difference observed for that variable and subtracting the quotient from 1.

bare ground at these sites. Additionally, studies of bobwhite roosting habits (Klimstra and Zicarrdi 1963, Ellis et al. 1969) found bare or lightly-littered ground to be a consistent feature of roost sites examined.

Although the HSI model for the northern bobwhite does not identify honeysuckle as a critical habitat component, we chose to quantify its availability because of its prevalence on the study area. We found that when available conditions averaged <10% cover of honeysuckle, quail tended to use sites with more honeysuckle than was generally available, suggesting that habitat quality may be improved by the presence of honeysuckle, up to a certain point. Because daily observations were collected over a 12-hour period, it would be speculation to suggest that this affinity for honeysuckle was the result of a single factor. Based on earlier work and personal observation, it is likely that sites with honeysuckle were used as loafing, protective, and roosting cover. Roseberry and Klimstra (1984) noted that Japanese honeysuckle (*L. japonica*) was frequently an understory component of woody headquarters of coveys in Illinois. Yoho and Dimmick (1972) noted the consistency with which covey activity centers in Tennessee were characterized by honeysuckle. Further, they reported that 63 of 107 roosts were located in honeysuckle.

From the regression analysis and the signed-rank test, it is apparent that habitat use within the home range varied with food availability, within the range of conditions examined. For nearly 70% of the observations, quail selected sites with more food than what was generally available within the home range. Except as presented in the HSI model for the bobwhite (Schroeder 1985), precise quantitative data on this variable are lacking. As noted, limited data precluded the development of a complete SI curve for comparison with the HSI model. However, for the range where our curves overlapped, we assigned higher SI values than the HSI model. The disparity may be partly a result of our determination of herbaceous quail food by underestimating their abundance.

Patches of woody vegetation <2 m in height are presumed to provide protective cover for the bobwhite (Schroeder 1985). That we found the slope not differing significantly from 1 nor the intercept from 0 suggests that habitat use within the home range varies independently of this parameter. The disparity between our conclusions and those of Schroeder (1985) may be a function of scale. Cover needs of the bobwhite are rarely quantitatively described, and have been qualitatively described as dense shrubby thickets providing refuge from both predators and the sun (Rosene 1969). Davis (1964) described those sites providing dense woody vegetation >1 m tall as escape cover. Although our data included midday observations, it is possible that the number of relocations during that period of the day when coveys are purportedly using cover conditions as described was limited, and thus we were unable to detect any significant use of these conditions. We more frequently observed birds using wooded areas in later successional, pole and mixed pole–saw timber stages as escape cover rather than early successional stages as described above. Perhaps we would have detected a preference for conditions more closely aligned with those described in the model had we sampled the home range more intensively and compared conditions to those outside the home range.

Herbaceous vegetation height, total herbaceous cover, and the percent of the herbaceous canopy that is grass, as used in the HSI model, are designed to evaluate nesting habitat. Because our study did not coincide with the nesting season we make no attempt to compare our findings for these variables with the HSI model or other studies that address the nesting ecology of the species. Regardless, these variables appeared to have some influence on winter habitat use. Caution is warranted when interpreting these findings. We found the rank correlations between these 3 variables and the amount of bare or lightly–littered ground to be quite high (r = 0.88, 0.66, and 0.77, $P < 0.05$, for grass, herbaceous cover, and vegetation height, respectively). Thus, it is possible that the association between winter habitat use and herbaceous vegetation height, total herbaceous cover, and the percent of the herbaceous canopy that is grass may be an artifact of the data resulting from the correlations between these 3 variables and the amount of bare or lightly littered ground within the home ranges.

The differences in the suitability index curves developed in or study and those of Schroeder (1985) may have resulted for 1 of several reasons. For most of the variables, estimated available conditions barely represented half of the potential range (0%–100%). This may be a reflection of inadequate sampling on our part, or that our sample was representative and that coveys simply used the best habitat available. It also may be that there are different suitability curves for different scales or geographic regions.

The temporal and spatial distributions of many species are the result of habitat selection at various scales. Many times, the factors that influence selection vary with the scale of investigation. Our study addressed those factors that influence selection within the home range. The 7 variables we quantified did not entirely account for the distribution of radio locations, suggesting that other factors are undoubtedly operating. However, because of the large amount of variation within the home ranges relative to the "core areas," it may be advantageous to consider focusing future management activities on core areas instead of home ranges. Although we have no data on how the variation within the home range compares to that outside its boundaries, the observed variation within the home range may be an indication that use of an area is more a function of the availability of 2–3 core areas than "average" conditions over the respective site.

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