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WINTER MACRO- AND MICROHABITAT USE OF WINTER ROOST SITES IN CENTRAL MISSOURI

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ABSTRACT

Northern bobwhite (*Colinus virginianus*) managers and biologists have expressed concern regarding the apparent decline of northern bobwhite populations throughout the Unites States. The decline has been attributed to habitat loss; however, the decline may be the result of multiple factors. Several studies concluded that reproduction was not a limiting factor, and recommended that investigations of winter habitat use at the microhabitat level are needed. In our study, we used data from 166 roost sites obtained from 194 radiomarked bobwhites to analyze winter macrohabitat use and microhabitat characteristics of roosts selected by bobwhites in central Missouri. At the macrohabitat level, bobwhites showed a preference for early successional vegetation (ESV), native warm-season grass (NWSG), and old (idle) fields. Most roost locations (5l.2%) were in old fields, in ESV (23%), and NWSG (l7%). For all 3 habitat types (old fields, ESV, NWSG), litter at the roost site was higher ($P < 0.05$) than the surrounding vegetation. In the 2 most preferred habitat types, visual obstruction reading (VOR) and maximum vegetation height were higher ($P < 0.05$) than the surrounding vegetation. In NWSG and old fields, litter depth was significantly higher ($P < 0.05$) than the surrounding vegetation. Habitat management of winter cover in central Missouri will benefit from the maintenance of dense ground litter (>65%), tall vegetation (>91 cm), VOR (29 cm), and litter depth about 1.5 cm in ESV, NWSG, and old fields.

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Key words: *Colinus virginianus,* macrohabitat, microhabitat, Missouri, northern bobwhite, winter habitat

INTRODUCTION

The abundance of northern bobwhites has declined in North America at a rate of 2.4% per year, and continues to decline (Robbins et al. 1986, Droege and Sauer 1990, Brennan 1991, Church et al. 1993). Bobwhite populations in Missouri have shown similarly declines (Dailey and Truitt 1998). The decline has been attributed to habitat loss and degradation (Dixon et al. 1996). Efforts to restore bobwhite populations have emphasized the need to understand seasonal habitat needs (Burger et al. 1994).

During the 1930's Errington and Hamerstrom (1936) and Stoddard (1931:45) conducted the first winter habitat studies of northern bobwhites. These studies were descriptive, but stimulated additional research on bobwhite winter ecology. Klimstra and Ziccardi (1963) were the first to describe bobwhite winter habitat selection by analyzing roost-site microhabitat characteristics. In Illinois farmland, bobwhites selected winter roost-sites with a mean vegetation height of 59 cm and a density of 181 stems/m^2. In the Oklahoma tallgrass prairie, bobwhites selected roosts with a maximum height of 68 cm and a density of 136 stems/m^2 (Wiseman and Lewis 1981). In Missouri farmland, bobwhite winter roosts were characterized as 27% forb cover and 23% bare ground (Burger et al. 1994).

The objective of this study was to determine macro- and microhabitat use of bobwhite winter roost-sites in Saline County, Missouri. We also developed roosting habitat models for old fields, ESV, and NWSG.

METHODS

Study Area

The study was conducted at the Blind Pony Conservation Area (BPCA) in Saline County, Missouri. Blind Pony Conservation Area is managed for northern bobwhites with habitat management focused on early successional stage vegetation. The plant diversity on BPCA provided an opportunity for bobwhites to select among a wide range of cover densities and habitat types. Blind Pony Conservation Area contains many small fields separated by relatively small patches of woody cover. Stands of NWSG were distributed throughout the area. Native warm-season grass stands were vegetated by Indian grass (*Sorghastrum* spp.), big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), and switchgrass (*Panicum virgatum*). Woody vegetation consisted of oak trees (*Quercus* spp.), multiflora rose (*Rosa multiflora*), red cedar (*Juniperus virginiana*), and blackberry (*Rubus* spp.). Cropland is common with corn, soybean, wheat/lespedeza (*Lespedeza* spp.). Three to 6 m of crop field borders are unharvested. Food plots containing millet were interspersed among old fields and stands of NWSG.

We used Roseberry and Klimstra's (1984:13–15) criteria for defining old fields (idle) as 2 to 3-year old tracts dominated by perennial vegetation, and characterized by increasing amounts of woody vegetation and decreasing annual species such as ragweed (*Ambrosia* spp.). On the study area, old fields consisted of goldenrod (*Solidago* spp.), smartweed (*Polygonum* spp.), asters (*Aster* spp.), oak saplings, red cedar (*Juniperus virginiana*), maple (*Acer* spp.), and hickory (*Carya* spp.). Early successional fields were dominated by annuals such as ragweed, lespedeza, foxtail (*Setaria* spp.), dropseed (*Sporobolus* spp.), and millet (Roseberry and Klimstra 1984:13–15, 31). Cool-season grasses (CSG) consisted of crabgrass (*Digitaria* spp.), brome (*Bromus* spp.), and fescue (*Festuca* spp.).

Covey Locations

The study of roost site selection and habitat characteristics was conducted from January through March 1995–96. We randomly selected 3–5 radiomarked bobwhites each day from a population of 194 radiomarked bobwhites on the BPCA (11–16 coveys). From 0300 until 1 hour before sunrise, we determined the location of each covey. The general area was flagged, so we could find roost fecal piles at daylight. We recorded ambient temperature (minimum/maximum), snow depth, soil temperature, precipitation (presence/absence), wind speed (measured with hand-held wind gauge), and wind direction about 15 m from the estimated covey location. If the ground was frozen, we recorded soil temperature as 0° C. During daylight searches for roosts, we identified the previous night's roost from the freshest fecal pile (e.g., containing no frost).

Vegetation Measurements

To determine whether microhabitat characteristics of roosts differed from that of surrounding vegetation, we measured the microhabitat characteristics of 4 randomly selected points in the field containing each roost. The random sites were chosen by placing a grid scaled at 15-m intervals over an aerial photograph of the roost fields, and randomly selected 4 sites.

We measured VOR using the method described by Robel et al. (1970). A Daubenmire frame was used to measure percent canopy cover (CC), maximum vegetation height (MH), percent basal cover of the vegetation (BC), percent bare ground (BG), percent snow cover (SC), snow depth (SD), percent litter cover (LC), and litter depth (LD)(Daubenmire 1959). We estimated LD by averaging 5 random measurements within the Daubenmire frame. The same procedure was used to estimate SD.

Statistical Analyses

Macrohabitat Use and Preference.—Using PC ArcView and ARC/INFO, we developed a land use/land cover spatial data layer for the BPCA. We used this data layer to quantify the extent of land cover types in ha. Supporting information, including roads, streams, and section lines were used as location references for establishing the boundaries of the study area.

Relative preference indices were calculated as described by Taylor and Guthery (1980), Wiseman and Lewis (1981), Byers et al. (1984), and Anderson and Gutzwiller (1994). Indices indicate habitat preference ranging from highly preferred (+10) to avoidance (−10). We estimated habitat availability as the proportion of the study area covered by each habitat type, defined by the dominant vegetation (Thompson and Fritzell 1988, Janvrin 1991, Anderson and Gutzwiller 1994). Relative use of habitat types was determined by the proportion of telemetry locations recorded in each habitat type.

Microhabitat Use.—To assess the influence of microhabitat variables on roost site selection, we used stepwise logistic regression (SAS Institute 1990) to determine how independent variables relate to microhabitat selection across a range of low ambient temperatures. We selected 9 independent variables a priori that we predicted might be related to bobwhite microhabitat selection. Each habitat type was modeled separately, and the analysis progressed by introducing 1 independent variable at a time. The probability rejection level was 0.10 to determine the best model.

We used multivariate analysis to detect differences ($P < 0.05$) in microhabitat variables between roost and random sites. The mean of the 4 random sites was compared with the corresponding characteristics of the roost site.

RESULTS

From January through March 1995–96, we measured 166 roost sites from 194 radiomarked bobwhites. Individual bobwhite coveys did not use the same roost more than once. During the study, daily minimum ambient temperatures ranged from −20° to 13° C, and recorded wind velocities did not exceed 13 m/sec.

Macrohabitat Use and Preference

Bobwhites roosted in old fields more than any other habitat type. Old fields accounted for 51% of roost sites, compared to 24% in ESV, and 17% in NWSG (Table 1). Despite the high intensity of use of old fields, relative-use data indicated that bobwhites preferred ESV and NWSG to old fields (Table 2). Woody vegetation, agricultural fields, and CSG were used in-

Table 1. Percentage and number of northern bobwhite roost sites in 6 types of vegetation on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar, 1995–96.

Habitat type	1995	1996	Total
*Old fields	47% (22)	53% (63)	51% (85)
*ESV[a]	26% (12)	23% (27)	23% (39)
*NWSG[b]	19% (9)	16% (19)	17% (28)
Woody vegetation	6% (3)	4% (5)	5% (8)
Crop fields	2% (1)	3% (4)	3% (5)
Cool-season grass	0% (0)	1% (1)	1% (1)
Total number of roosts	47	119	166

* The 3 vegetation types used for all statistical analyses.
[a] ESV represents early successional vegetation.
[b] NWSG represents native warm-season grass.

Table 2. Relative preference of northern bobwhite roosts in 6 types of vegetation on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar, 1995–96.

Habitat type	Proportion available	Proportion used	Relative preference
Old fields	0.290	0.510	2.86
ESV[a]	0.060	0.240	5.78
NWSG[b]	0.090	0.170	3.12
Woody vegetation	0.210	0.050	−10.00
Crop fields	0.120	0.030	−5.85
Cool-season grass	0.240	0.006	−9.50

[a] ESV represents early successional vegetation.
[b] NWSG represents native warm-season grass.

frequently, and accounted for a combined total <10% of the roost sites (Table 1).

Microhabitat Characteristics

Roost Sites vs. Random Sites.—We analyzed roost microhabitat characteristics for each habitat type, and there were several influential microhabitat variables. Using the SWLR procedure, the probability (p) of an old field site being a bobwhite roost was:

$$\ln (p/1 - p) = -0.52 - 0.006\mathrm{CC} + 0.28\mathrm{LD} - 0.02\mathrm{BC}.$$

The probability of a site being a roost site in ESV was:

$$\ln (p/1 - p) = -3.5 + 0.04\mathrm{VOR} + 0.02\mathrm{MH} + 0.03\mathrm{BG}.$$

In NWSG, the probability (p) of a site being a bobwhite roost was:

$$\ln (p/1 - p) = -3.36 + 0.01\mathrm{MH} + 0.02\mathrm{LC}$$ (Table 3).

We compared roost and random site characteristics to determine if roosts differed from the surrounding field. Old field roosts had a lower CC (37%), BC (31%) and SC (14%) than the random sites ($P < 0.05$). Litter depth (1.65 cm) and LC (79%) were higher ($P < 0.05$) at roosts (Table 4). Roosts in early successional vegetation had higher VOR (21 cm), MH (94 cm), LC (65%) and BG (13%) than random sites ($P < 0.05$). Snow depth (0.40 cm) and snow cover (19%) were lower ($P < 0.05$) at roost sites (Table 5). Roosts in NWSG had higher VOR (29 cm), MH (106 cm), LD (1.44 cm) and LC (67%) than random sites ($P < 0.05$) (Table 6).

DISCUSSION

Although there was a greater proportion of old fields on BPCA, bobwhites roosted in ESV 4 times more often than expected based upon the proportional availability of this cover type, and used old fields and NWSG at almost twice their proportional availability. Preference for ESV supports the findings of studies conducted in Illinois (Klimstra and Ziccardi 1963) and Missouri (Burger et al. 1994). The high relative use ranking of NWSG on our study area seems consistent with the findings of a study conducted in Oklahoma (Wiseman and Lewis 1981), that showed high numbers of roosts in native grasslands.

Tonkovich and Stauffer (1993) attributed the preference of bobwhite for ESV and NWSG to the availability of high energy seeds such as lespedeza, ragweed, milo, and millet. We believe the greater availability of such seeds in close proximity to roost sites may augment bobwhite overwinter survival by reducing the amount of time spent foraging; therefore increasing foraging efficiency and reducing exposure to predators.

Our study results indicate that although northern bobwhites utilize a variety of habitat types for roosting, microhabitat characteristics of selected winter roosts differ significantly from that of the surrounding vegetation. Of the 9 microhabitat variables measured, LC was the only variable that differed from the random sites for all 3 habitat types. This finding is not in accordance with other studies (Klimstra and Ziccardi 1963, Burger et al. 1994), which found that bobwhites utilized roosts with little to no litter accumulation. The difference between our LC results and others could be attributed to litter availability resulting from different management practices. At BPCA, NWSG stands were burned on a 3–5 year rotation, and haying was limited. Litter biomass has been found to decrease immediately following a burn, and then increase as the time since

Table 3. Stepwise logistic regression predicting the occurrence of northern bobwhite winter roosts in old fields, early successional vegetation, and native warm-season grass on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar 1995–1996.

Habitat type / Microhabitat variables	Coefficient	Odds ratio	χ^2	*P*
Old fields	−0.515[a]			
Canopy cover	−0.006	0.994	2.758	0.009
Litter depth	0.282	1.326	4.721	0.030
Basal cover	−0.017	0.983	6.789	0.009
Early successional vegetation	−3.500[a]			
VOR[b]	0.037	1.037	5.558	0.018
Maximum height	0.016	1.016	6.040	0.014
Bare ground	0.026	1.027	2.768	0.096
Native warm-season grass	−3.358[a]			
Maximum height	0.010	1.010	3.481	0.062
Litter cover	0.019	1.020	7.922	0.005

[a] Intercept for the linear portion of the logistic regression equation.
[b] VOR represents visual obstruction reading.

Table 4. Microhabitat characteristics of northern bobwhite roosts and random sites in old fields on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar, 1995–96. Values displayed are least squares mean ± least squares standard error (SE).

	Roost sites (n = 87)		Random sites (n = 313)		
Microhabitat variables	$\bar{x}$	SE	$\bar{x}$	SE	P
VOR[a] (cm)	16.04	0.87	16.19	0.34	0.3911
Maximum height (cm)	91.35	3.81	83.90	1.03	0.0698
Canopy cover (%)	37.13	3.11	52.89	0.85	*0.0001
Litter depth (cm)	1.65	0.07	1.44	0.02	*0.0070
Percent cover of litter (%)	78.77	2.28	67.60	0.63	*0.0001
Percent basal cover (%)	30.80	1.93	41.33	0.64	*0.0001
Percent bare ground (%)	7.64	0.99	5.97	0.34	0.1267
Snow depth (cm)	0.86	0.24	0.68	0.02	0.4620
Percent snow cover (%)	14.44	1.40	19.25	0.36	*0.0004

[a] VOR represents visual obstruction reading.
* Denotes significant difference.

the burn progresses (Gibson 1988). Litter also accumulates rapidly with planting age. Four to 6 years after planting, litter accumulation leveled off at 70% (Burger et al. 1994).

In ESV and NWSG, bobwhites utilized roosts characterized by tall vegetation (94 and 106 cm, respectively), which was taller than the surrounding vegetation. Roosts in Illinois had a mean vegetation height of 59 cm (Klimstra and Ziccardi 1963), which is considerably lower than the mean vegetation height used by bobwhites on the BPCA. In northeast Oklahoma, roosts were characterized by an average height of 68 cm (Wiseman and Lewis 1981). The differences in vegetation characteristics of roosts might be attributed to study site differences in plant species composition, differences in winter severity among regions, and differences resulting from differences in methodology.

Our study described winter roost characteristics at macro- and microhabitat levels. Several of the significant microhabitat variables (LC, LD, MH, VOR) may contribute to the thermal value of winter roosts. For example, tall vegetation reduces convective heat loss to the environment, where dense litter cover and depth minimizes conductive heat loss to the soil (Geiger 1965:297–308, Kendeigh 1969, Campbell and Norman 1998:72). Vegetation height and density not only minimize wind velocity at the level of the roost, but perhaps more importantly, reduces the loss of long-wave radiation (Geiger 1965:284–287, 290–293, 297–308; Campbell and Norman 1998:231). During the day, vegetative cover absorbs both the counter-radiation of the sky and terrestrial radiation rising from the ground. At night, the amount of radiation absorbed during the day is lost; however, the rate at which it is lost depends upon vegetation height and CC (Geiger 1965:297–308, 362; Campbell and Norman 1998:247–276). Although the microhabitat characteristics of selected roost sites appear to be related to their favorable thermal characteristics, more research is needed to determine the specific relationships between bobwhite thermostatic energy demands and winter.

Other ecological components such as depredation and food availability must also be considered when examining bobwhite winter habitat selection and survival. Depredation is the most apparent proximate cause of fall-spring bobwhite mortality in Missouri. Burger (1993) reported that mammalian depredation (21.6%) and avian depredation (25.2%) were the primary causes of bobwhite mortality in Missouri (Burger 1993). Therefore, bobwhite habitat selection is probably attributed to other factors, such as cover characteristics that reduce the risk of depredation. Ultimately,

Table 5. Microhabitat characteristics of northern bobwhite roosts and random sites in early successional vegetation on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar, 1995–96. Values displayed are least squares mean ± least squares standard error (SE).

	Roost sites (n = 39)		Random sites (n = 140)		
Microhabitat variables	$\bar{x}$	SE	$\bar{x}$	SE	P
VOR[a] (cm)	21.44	1.57	13.45	0.48	*0.0001
Maximum height (cm)	94.40	4.45	71.89	1.41	*0.0001
Canopy cover (%)	65.09	3.94	62.49	1.16	0.2673
Litter depth (cm)	1.00	0.11	1.06	0.03	0.5033
Percent cover of litter (%)	65.26	3.46	55.10	0.95	*0.0198
Percent basal cover (%)	31.13	2.94	35.53	0.99	0.1415
Percent bare ground (%)	12.81	1.71	7.70	0.53	*0.0083
Snow depth (cm)	0.39	0.17	1.13	0.03	*0.0008
Percent snow cover (%)	19.43	2.53	28.40	0.68	*0.0018

[a] VOR represents visual obstruction reading.
* Denotes significant difference.

Table 6. Microhabitat characteristics of northern bobwhite roosts and random sites in native warm-season grass on Blind Pony Conservation Area, Saline County, Missouri, Jan–Mar, 1995–96. Values displayed are least squares mean ± least squares standard error (SE).

	Roost sites (n = 28)		Random sites (n = 97)		
Microhabitat variables	$\bar{x}$	SE	$\bar{x}$	SE	P
VOR[a] (cm)	28.98	2.54	22.73	0.92	*0.0203
Maximum height (cm)	105.69	5.60	90.99	1.91	*0.0236
Canopy cover (%)	63.60	4.59	76.91	1.35	0.2445
Litter depth (cm)	1.44	0.11	1.02	0.04	*0.0017
Percent cover of litter (%)	67.48	4.20	43.02	1.23	*0.0001
Percent basal cover (%)	36.96	3.86	45.26	1.40	0.0586
Percent bare ground (%)	9.91	2.20	8.34	0.68	0.5169
Snow depth (cm)	0.56	0.48	1.25	0.13	0.2358
Percent snow cover (%)	20.20	3.16	23.43	0.93	0.1484

[a] VOR represents visual obstruction reading.
* Denotes significant difference.

winter habitat selection is likely the result of multiple factors, and bobwhites probably select winter habitats that maximize bioenergetic advantages and predator avoidance, optimize distance from nearby coveys, and increase accessibility to food resources (Roseberry and Klimstra 1984:23–35). These characteristics of winter habitat collectively enhance the potential winter survival of northern bobwhites.

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