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VEGETATION STRUCTURE OF BACHMAN'S SPARROW BREEDING HABITAT AND ITS RELATIONSHIP TO HOME RANGE

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Abstract.—The vegetation structure of Bachman's Sparrow (*Aimophila aestivalis*) breeding habitat and its relationship to home range size was studied on pine plantations in central Arkansas. Univariate and multivariate analyses showed that breeding areas had less litter, fewer trees and shrubs, shorter woody vegetation, and more forbs than unoccupied sites. Few differences in density of ground vegetation and cover were found between occupied and unoccupied sites. Size of home range was negatively correlated with percent forb cover, percent ground cover, forb height, percent grass cover, and vertical vegetation density between 0–90 cm, but was positively related to percent canopy cover. Management practices that reduce litter, maintain relatively low tree and shrub densities, and that encourage the growth of forbs and cespitose grasses (e.g., *Andropogon* and *Aristida*) are recommended. Stands that are thinned and periodically burned may provide the most suitable habitat.

ESTRUCTURA DE LA VEGETACIÓN DEL HABITAT DE ANIDAMIENTO DE *AIMOPHILA AESTIVALIS* Y SU RELACIÓN CON EL ÁREA QUE OCUPA

Sinopsis.—Se estudió la estructura de la vegetación del habitat de anidamiento de *Aimophila aestivalis* y su relación con el área que ocupa en una plantación de pino en la parte central de Arkansas. El análisis univariable y multivariable demostró que las áreas de anidamiento tienen más yerbajos, pero menos horajazca, arbustos, árboles y vegetación leñosa de poca altura, que las áreas no ocupadas. Se encontraron muy pocas diferencias en la densidad de la vegetación del suelo y cobertura entre las áreas ocupadas y no ocupadas por las aves. Se encontró una correlación negativa, entre el tamaño del área que ocupan las aves (home range) con el porcentaje de cobertura de yerbajos, porcentaje de la covertura del suelo, porcentaje de cobertura de las yerbas, altura de los yerbajos y densidad vertical de la vegetación entre 0–90 cm. No obstante, se encontró una correlación positiva con el porcentaje de covertura del docel. Se recomiendan prácticas de manejo que reduzcan la hojarasca, mantengan los árboles a poca altura, baja densidad de los arbustos y que permitan el desarrollo de los yerbajos y yerbas (e.g., *Andropogon* y *Aristida*). Rodales que sean limpiados (thinning) y quemados periódicamente podrían proveer del tipo de habitat más adecuado para este gorrión.

The Bachman's Sparrow (*Aimophila aestivalis*) is a ground-nesting and foraging species that breeds primarily in open pine forests and early successional seres following clearcutting or pasture abandonment in the southeastern U.S. (American Ornithologists' Union 1983; Dunning 1993; Haggerty 1988, 1995). Presently, populations are declining, especially in the northern portions of the species' range (Dunning 1993, Dunning and Watts 1990). Because declining populations may be attributed to relatively strict habitat requirements and a loss of suitable habitat (Dunning and Watts 1990), research on habitat use is of value. Further, investigations relating home range size and habitat characteristics are lacking and may prove useful to resource managers.

This study, (1) quantifies the vegetation structure of Bachman's Sparrow breeding habitat by comparing occupied areas with unoccupied sites, and (2) examines the relationship between vegetation structure and home range size.

STUDY AREA AND METHODS

Research was conducted from May through September, 1983–1985, in Hot Spring Co., Arkansas, approximately 19 km south of Malvern (34°15′N, 92°47′W). Vegetation samples were made on tracts owned by International Paper Company and used to grow shortleaf (*Pinus echinata*) and loblolly (*P. taeda*) pines.

To quantify the vegetation structure of occupied sites, 2–9 ($\bar{x}$ = 5) 0.04-ha sample circles were randomly selected within each home range (i.e., area occupied during breeding season) of a tract. Sample circles from each home range were then pooled to insure an appropriate level of independence. Because some areas of the tracts were not occupied and because the vegetation structure within a tract often varied, the home range was used as the sample unit. Occupied vegetation samples were collected from tracts that were <1-yr-old (n = 1 home range, 1 tract), 2-yr-old (11, 3), 3-yr-old (4, 1), 4-yr-old (3, 1), 5-yr-old (2, 2), 44-yr-old (1, 1), >70-yrs-old (8, 1). The 0.04-ha sample circle was used as the sample unit for unoccupied tracts because of within-tract variation in vegetation structure. Unoccupied vegetation samples were collected from tracts that were 4-yr-old (n = 10 sample circles, 1 tract), 5-yr-old (1, 1), 10-yr-old (4, 1), 16-yr-old (3, 1), and 28-yr-old (10, 1). The 4-yr-old unoccupied tract had been occupied the previous two years. The age of a tract was based on age of planted pines. Tracts ranged in size from 14–102 ha ($\bar{x}$ = 23.3 ha, n = 11).

Fourteen variables were measured in the sample circles (radius = 11.28 m) using the methods of James and Shugart (1970) and Weins (1973) (Table 1). Tree (dbh > 7.66 cm) density was determined by counting the number of live and dead trees within the sample plot. Shrub (dbh < 7.66 cm) density was measured by counting the number of contacts of shrub vegetation along two perpendicular, arm-length transects that bisected the circle. Vertical vegetation density was measured by counting the number of vegetation hits at two 90-cm intervals along a 180-cm rod held vertically (6-mm diameter) at ten equally spaced points along a transect that bisected the circle. Average woody, forb, and grass heights were calculated by measuring the height of the closest vegetation type at ten equally spaced points. Percent woody, forb, grass, and litter covers were estimated by noting if these vegetation types came in contact with a vertically held rod that was placed at ten equally spaced points. Percent canopy and ground cover values were estimated by the presence or absence of standing vegetation at a cross-hair position in a sighting tube at 20 equally spaced points along two randomly oriented transects that bisected the plot.

I determined home ranges by uniquely color banding individuals and marking their positions on a map throughout the breeding season using a compass, range finder, and a 50-m grid system. On average, 52 obser-

TABLE 1. Comparison of vegetation variables between occupied habitat and unoccupied habitat and correlation between vegetation variable and canonical variable. Values are untransformed means (SE).

Vegetation variables	Occupied sites $n = 30$	Unoccupied sites $n = 28$	Correlation with canonical variable
Tree density, 0.04 ha	2.8 (0.6)	15.1 (2.7)***[a]	0.4***
Shrub density, 0.004 ha	64.2 (6.1)	173.8 (34.9)*	0.3*
Vegetation density, 0–90 cm	0.4 (0.1)	0.8 (0.1)NS	−0.1NS
Vegetation density, 91–180 cm	6.2 (0.4)	6.4 (1.0)**	0.4***
Woody height, cm	100.7 (6.0)	147.9 (14.5)**	0.4***
Forb height, cm	46.8 (1.7)	39.8 (2.3)*	−0.2NS
Grass height, cm	36.3 (1.4)	36.7 (3.0)NS	0.0NS
Litter depth, cm	1.4 (0.2)	4.2 (0.5)***	0.8***
% canopy cover	9.5 (2.7)	40.0 (6.7)***	0.5***
% forb cover	55.6 (3.3)	36.1 (3.5)***	−0.4***
% litter cover	78.0 (2.5)	88.9 (4.9)**	0.4**
% ground cover	87.0 (2.4)	74.6 (4.3)NS	−0.1NS
% woody cover	45.2 (2.8)	50.0 (3.8)NS	0.2NS
% grass cover	76.0 (4.5)	58.2 (6.0)NS	−0.2NS

[a] Significance of two-tailed t-test.
*** = $P < 0.001$, ** = $P \leq 0.01$, * = $P \leq 0.05$, NS = not significant.

vations per male were used to calculate home ranges (range = 30–84, n = 25). A polygon was then drawn by connecting the outermost positions, and a compensating polar planimeter was used to estimate size of home ranges.

Two-tailed t-tests and canonical discriminant analysis (PROC CANDISC; SAS 1982) were used to compare vegetation structure between occupied and unoccupied sites. Arcsine and logarithmic transformations were performed to normalize percentage and nonpercentage data, respectively (Zar 1974). Variables used in canonical discriminant analysis were approximately normal; therefore, it was assumed that the vector of variables associated with each sample point had an approximate multivariate normal distribution. Pearson's product-moment correlations were used to assess the relationships among habitat variables, the canonical variables, and home range size. Statistical significance was set at $P < 0.05$.

RESULTS

Univariate comparisons showed that 8 of 14 variables differed significantly between occupied and unoccupied sites (Table 1). Unoccupied sites had a greater percentage and a thicker layer of litter cover, as well as taller woody vegetation. Occupied sites had greater percent forb cover, but lower mean densities of trees, shrubs, vegetation in the 91–180 cm interval, and a lower percent canopy cover.

Canonical discriminant analysis significantly discriminated between the occupied (−1.8 ± 0.4 [95% CI]) and the unoccupied habitat centroids (1.9 ± 0.4) (Wilks' lambda = 0.23, F = 11.0, P = 0.0001; eigenvalue =

3.5). The canonical variable was positively and significantly correlated with litter depth, canopy cover, tree density, woody height, vertical vegetation density between interval 91–180 cm, percent litter cover, and shrub density (Table 1), indicating that tracts with high values for these variables were less suitable for breeding. The canonical variable was negatively correlated with forb cover, indicating higher values of forb cover are associated with breeding sites.

Mean home range size was 2.5 ha (± 0.22 [SE], range = 0.70–4.49, n = 25). Home range size was negatively related to percent forb cover ($r = -0.67$, $P < 0.001$, $n = 25$), percent ground cover ($r = -0.54$, $P = 0.005$), forb height ($r = -0.53$, $P = 0.006$), percent grass cover ($r = -0.46$, $P = 0.02$), and vertical vegetation density interval 0–90 cm ($r = -0.45$, $P = 0.02$). Percent canopy cover was positively related to home range size ($r = 0.38$, $P = 0.05$).

DISCUSSION

On pine plantations in central Arkansas, Bachman's Sparrows bred on tracts with a thin layer of litter, low tree and shrub densities, short woody vegetation, and high forb cover. These habitat features most commonly occur on clearcuts and young stands (<7-yr old), but also in the more mature stands that were thinned and burned to reduce the understory. Similar findings have been reported for pine plantations in Georgia (Gobris 1992, Johnson and Landers 1982) and South Carolina (Dunning and Watts 1990, 1991).

The presence of more forb cover in occupied areas is most likely due to the greater openness of these sites, but also may indicate a difference in soil conditions between occupied and unoccupied sites. It is also unclear if litter depth and cover have a direct effect on selection or are simply correlates of age or burning frequency of a site. Possible evidence of a direct effect comes from South Carolina where site preparation methods (e.g., drumchopping) were suspected of affecting vegetation structure and ground debris and made areas less suitable for breeding (Dunning and Watts 1991, but see below).

With the exception of percent forb cover and woody height, my data provide little evidence that ground vegetation features affected selection. Univariate results showed that occupied and unoccupied areas had similar vegetation densities between 0–90 cm and similar percentages for ground, grass, and woody covers. Similarly, multivariate analysis showed a weak correlation between these habitat features and occupied sites. This may indicate that litter depth and cover, percent forb cover, tree and shrub densities, and shrub height were more important selection parameters than the other ground cover and ground density variables. It also may indicate that features that were not measured (e.g., floristics and vegetation patchiness) may influence selection. For example, *Panicum* has been found to be an important component of the Bachman's Sparrow diet (Allaire and Fisher 1975), as well as serving as nesting material (Meanly 1989, pers. obs.). Succession or other factors (e.g., site preparation methods, soil conditions) that affect *Panicum* density, may affect suitability of a site for breeding. Further, factors altering ground vegetation patchiness may affect selection. Bachman's Sparrows prefer areas dominated by cespitose grasses (e.g., *Andropogon* and *Aristida*) (Dunning 1993, Haggerty 1986, Hardin et al. 1982, Wan A. Kadir 1987). Not only are these grasses important sites for nesting (Haggerty 1995), they also create a patchy ground vegetation pattern that may enhance foraging success (see Whitmore 1981). Sites that do not have the appropriate level of patchiness may make the capture of fast-moving prey for nestlings more difficult (Haggerty 1992). This may explain why some young stands in my study were not occupied with Bachman's Sparrows (see also Gobris 1992).

Finally, certain vegetation structural characteristics related to home range. Smaller home ranges occurred on tracts that had lower values for percent canopy cover, but higher values for percent forb cover, percent ground cover, forb height, percent grass cover, and vertical vegetation density interval 0–90 cm. Although it is not clear why these variables relate to home range, forest management practices that enhance these features may lead to greater breeding densities. Relatively open pine forests that are regularly burned to reduce understory, but that increase cespitose grass and forb cover densities, provide the most suitable habitat for this species (Dunning and Watts 1990, Gobris 1992, Haggerty 1986, Meanly 1988). Even though no difference in Bachman's Sparrow reproductive success was found between clearcuts and more mature stands (Haggerty 1988), clearcuts are only used for 4–7 yr (Dunning 1993, Haggerty 1986, Johnson and Landers 1982, Meanly 1988) and possibly lead to a landscape pattern that does not enhance successful dispersal (Dunning et al. 1995, Dunning and Watts 1990). Managed, more mature forests can be used for many years (Meanly 1988).

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