Journal of the Alabama Academy of Science, Vol. 71, No. 3, July 2000.

A GEOGRAPHIC STUDY OF THE VEGETATION STRUCTURE OF BACHMAN'S SPARROW (*AIMOPHILA AESTIVALIS*) BREEDING HABITAT

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ABSTRACT

The vegetation structure of Bachman's Sparrow (*Aimophila aestivalis*) breeding habitat was studied in Arkansas, Alabama, Florida, South Carolina, and North Carolina. Bachman's Sparrows occupied areas with relatively low values (i.e., < 34%) in percent woody cover, tree density (203/ha) and percent forb cover, but with higher (i.e., > 58%) values in percent ground cover, percent grass cover, and percent litter cover. Vertical vegetation density was much higher under the 90 cm mark than above it. Univariate and multivariate statistics indicated significant differences in vegetation structure among the five study regions. Variables that showed little variation (e.g., percent litter cover, percent grass cover, litter depth, and vegetation density 0-90 cm) among the five regions may be more important in determining habitat suitability for Bachman's Sparrows, than variables that showed considerable variation (e.g., woody vegetation height, percent forb cover, and grass height).

INTRODUCTION

Species occupy a particular habitat for breeding because the habitat contains those environmental factors that allow a species to carry out its life history (Hilden 1965, James et al. 1984). One environmental factor that has been identified as being of considerable importance to avian species habitat occupancy is vegetation structure (MacArthur and MacArthur 1961, Hilden 1965, James 1971, Cody 1981, 1985). Birds are specifically adapted to a vegetation structure that meets their nesting, singing, and foraging requirements (Hilden 1965, Robinson and Holmes 1982, Cody 1985). For avian species that are declining and are of management concern, a thorough knowledge of the vegetation structure of the habitats that it occupies is critical (Martin 1992).

In most studies of habitat selection, the vegetation structure of occupied sites is compared to unoccupied sites and sampling is usually done in one general location within a species range (e.g., Haggerty 1986, 1998, Dunning and Watts 1990, Plentovich et al. 1998). Although this method may indicate the major features that determine occupancy, it does not necessarily indicate those features that may be the most critical for occupancy.

Another approach, and the one used in this study, is to compare the vegetation structure of occupied sites from a broad geographic perspective (James et al. 1984). If we assume that a species has similar foraging and nest-site selection behaviors throughout its range, then we can expect to see similarities in the vegetation structure of different localities, even though other variables (e.g., floristics, sere age, management practices) may be different. Similarities and differences in the vegetation structure from different localities may help identify structural features that are more or less critical for occupancy, respectively. Further, this approach may give a better understanding of the vegetation structure that may constrain the distribution of a species (James et al. 1984, Parrish 1995).

The Bachman's Sparrow is found primarily in open, grassy pine woods and early successional seres following clearcutting or pasture abandonment (Haggerty 1986, Dunning and Watts 1990). It nests and forages on the ground throughout its range (Dunning 1993). Although Bachman's Sparrow habitat studies have been done at different locations (Hardin et al. 1982, Wan A. Kadir 1987, Gobris 1992, Haggerty 1995, 1998, Plentovich et al. 1998), few comparative studies have been done (but see Dunning and Watts 1990).

Because declining Bachman's Sparrow populations may be due to strict habitat requirements and a loss of suitable habitat (Dunning and Watts 1990, 1991), research on its habitat use is of value. The objectives of this study were to quantify and compare the vegetation structure of Bachman's Sparrow breeding habitat from five geographic regions.

STUDY AREA AND METHODS

Vegetation samples of seven sites from Arkansas were made in June, July and August 1983-1985 in Hot Spring Co. and were part of a larger study (Haggerty 1986, 1998). Samples from Conecuh National Forest, Covington Co., Alabama (7 sites or tracts), Croatan National Forest, Carteret Co., North Carolina (4 sites), Ocala National Forest, Marion Co., Florida (5 sites), and Francis Marion National Forest, Berkeley Co., South Carolina (4 sites) were made between 8-20 July 1987. National forest sample sites were selected by playing a tape of a male song near sites that appeared to be suitable breeding habitat based on published descriptions (e.g., Brooks 1938, Meanley 1959, Mengel 1965, Wolf 1977, McKitrick 1979, Hardin et al. 1982) and personal experience. Once a male was located, sample circles (0.04 ha) were centered on the song perchs. In most cases, two samples were taken for each male. Twenty 0.04 ha sample circles were taken from each of the four national forests in the study and 65 were taken from the Hot Spring Co., Arkansas area. To insure an appropriate level of independence, data from sample circles for each site were pooled and the site was used as the sample unit in all statistical analyses.

Twelve variables were measured in a 0.04 ha circular plot using the methods of James and Shugart (1970) and Wiens (1973) (Table 1). Tree (dbh > 7.6 cm) density was determined by counting the number of live and dead trees within the sample plot. Vertical vegetation density was measured by counting the number of vegetation hits at two 90 cm intervals along a 180 cm rod held (6 mm diameter) vertically 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. Litter depth was measured within 2 cm of the base of the vertically held rod. Percent 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.

Table 1. Descriptive statistics of 12 vegation variables and their correlation with two canonical variables from Bachman's Sparrow breeding habitat within five geographic regions (n=27).

Variable	Mean(STD)	Min	Max	Can 1	Can 2
Grass Height, cm	34.5(9.0)	18.7	59.8	-0.21	0.31
Forb Height, cm	34.9(11.4)	13.0	57.0	0.38	0.38
Woody Veg. Height, cm	68.4(37.9)	21.0	157.5	0.75***	0.23
Litter Depth, cm	1.1(0.8)	0.3	3.1	0.15	-0.56**
% Ground Cover	71.0(18.7)	35.0	95.0	0.38	-0.4
% Grass Cover	59.4(22.1)	20.0	97.5	0.37	-0.12
% Forb Cover	33.7(19.7)	2.5	67.8	0.79***	-0.16
% Woody Cover	31.1(17.9)	0.0	70.0	0.46*	0.03
% Litter Cover	76.8(16.7)	40.0	0.0	0.43*	0.12
Veg. Density 0 - 90 cm	5.3(3.3)	1.3	2.4	0.58**	-0.08
Veg. Density 91-180 cm	0.2(0.4)	0.0	2.0	0.46*	-0.44*
Tree Density/0.04 ha	8.1(6.1)	0.0	21.0	0.21	0.59**

***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$

One-way ANOVA's (PROC GLM), Duncan's multiple range test, and canonical discriminant function analysis (PROC CANDISC) were used to compare the vegetation structure between locations. 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. Statistical significance was set at $P < 0.05$ for univariate tests. To help reduce the likelihood of type I error, a $P < 0.01$ was used for canonical discriminant analyses (Rextad et al. 1988). Pearson's product-moment correlations were used to assess the relationships among habitat variables and the canonical variable. All analyses were run using PC SAS (Version 6.01).

RESULTS

Univariate results of the five study regions combined indicate that Bachman's Sparrows occupied areas with relatively low mean values (< 34%) for percent woody cover, percent forb cover, and tree density, but higher values (> 58%) in percentages of ground cover, grass cover, and litter cover (Table 1). Average ground cover plant heights were less than a meter and the mean litter layer thickness was relatively thin. Vegetation vertical density was considerably higher under the 90 cm mark than above it (Table 1).

Univariate comparisons among regions showed that percent forb cover and woody vegetation height had the greatest amount of variation (Fig. 1A). These variables were significantly different among 6 and 8, of 10 possible regional comparisons, respectively (e.g., percent forb cover differed significantly between the Arkansas and Florida regions and between the Florida and South Carolina regions, Fig. 1A-1B). Grass height, forb height, tree density, and vegetation density 91-180 cm were significantly different among 4 of 10 possible regional comparisons (Fig. 1C-1F). Percent ground cover, percent woody cover, litter depth and vegetation density 0-90 cm showed less variation among the five regions, but were still significantly different (Fig. 1G-1J). Percent litter cover and percent grass cover were the only variables that did not significantly differ among the five regions (Fig. 1K-1L).

Specifically, univariate comparisons among the regions found that the sites in Arkansas and Florida, Arkansas and South Carolina, and Arkansas and North Carolina differed the most with seven variables being significantly different. Univariate comparisons showed that the vegetation structure of Alabama and South Carolina was the most similar (i.e., 2 variables differed). The other regional comparisons fell somewhere in between (Fig. 1).

Discriminant function analysis results indicated that the five regional centroids were significantly separated by the first (Wilk's Lambda = 0.0001, $F = 4.9$, $P < 0.0001$, eigenvalue = 17.0) and second (Wilk's Lambda = 0.01, $F = 3.4$, $P < 0.0001$, eigenvalues = 8.0) canonical variables. These two variables accounted for 58% and 28% of the variation among the regional tracts, respectively. The first canonical variable was significantly and positively correlated with percent forb cover, woody height, vegetation density 0 - 90 cm, and vegetation density 91 - 180 cm (Table 1). Regional points along the first canonical variable indicate that Florida and North Carolina have low values for these variables, whereas South Carolina, Alabama and Arkansas have higher values (Fig. 2). The second canonical variable was positively correlated with tree density and negatively correlated with litter depth and vegetation density 91–180 cm (Table 1). Sites from South Carolina had higher tree density and lower litter depth values compared to Florida and Arkansas (Fig. 2).

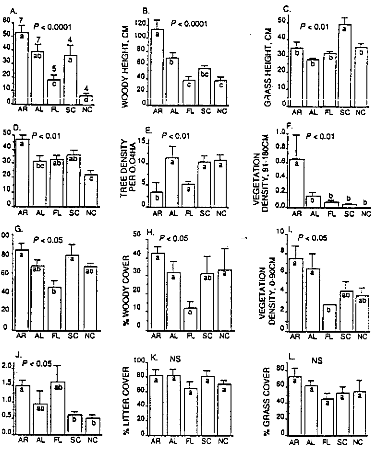
DISCUSSION

My results concur with others that have quantified the vegetation structure of Bachman's Sparrow breeding habitat (Hardin et al. 1982, Wan A. Kadir 1987, Dunning and Watts 1990, 1991, Plentovich et al. 1998). For example, studies in South Carolina (Dunning and Watts 1990) and Florida (Plentovich et al. 1998) found that Bachman's Sparrows also occupied sites that had more vegetation below the one meter point than above it and had relatively few trees and shrubs. Further, others have reported the dominance of grasses in the ground cover (Hardin et al. 1982, Wan A. Kadir 1987, Gobris 1992, Plentovich et al. 1998).

Some sampled tracts had zero or near zero values for percent forb cover, tree density, vegetation density 91-180 cm, and percent woody cover, indicating that Bachman's Sparrows may occupy areas where these structural features are absent or insignificant (Table 1). In South Carolina (Dunning and Watts 1990) and central Georgia (Gobris 1992), however, Bachman's Sparrows did not occupy open areas that had similar ground cover measurements to the occupied sites, but lacked scattered shrubs, trees, and other structures due to site preparation methods. Male and female Bachman's Sparrows regularly perch during song bouts and nest visits (Haggerty 1986, Haggerty 1992, pers. obs.) and occupied habitats may have to contain a vegetation component that can support the weight of a perched individual (Dunning and Watts 1990, Gobris 1992).

The preference throughout the species range for a ground cover composed primarily of grasses is not surprising considering Bachman's Sparrows foraging habits. Bachman's Sparrows forage relatively slowly and methodically, walking on the ground much like a foraging Ovenbird *(Seiurus aurocapillus)* (Allaire and Fisher 1975, pers. obs.). They feed on seeds and capture arthropods on the ground and on vegetation near the ground (Allaire and Fisher 1975, Haggerty 1992, pers. obs.). Short jumps at food items also occur and immobilized, captured prey are sometimes placed on the ground while the foraging adult strikes at a new food item (pers. obs.). This behavior allows for multiple food item delivery to growing nestlings (Haggerty 1992, 1994). A relatively dense, but patchy grass cover

Figure 1. Comparisons of the means (± 1 SE) of 12 vegetation variables from five regions within the breeding range of Bachman's Sparrow. Numbers above SE bars in (A) are number of tracts sampled from each region. Significant differences among regions were examined using one-way ANOVA's. Regional bars that do not share similar letters are significantly different using Duncan's multiple range test.


A.
% FORB COVER
P < 0.0001
7 a
7 ab
5 c
4 b
4 d
B.
WOODY HEIGHT, CM
P < 0.0001
a
b
c
bc
c
C.
GRASS HEIGHT, CM
P < 0.01
b
b
b
a
b
D.
FORB HEIGHT, CM
P < 0.01
a
bc
ab
ab
c
E.
TREE DENSITY PER 0.04HA
P < 0.01
b
b
F.
VEGETATION DENSITY, 91-180CM
P < 0.01
a
b
b
b
b
G.
% GROUND COVER
P < 0.05
a
a
b
a
ab
H.
% WOODY COVER
P < 0.05
a
a
b
ab
I.
VEGETATION DENSITY, 0-90CM
P < 0.05
a
a
b
ab
ab
J.
LITTER DEPTH, CM
P < 0.05
a
ab
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K.
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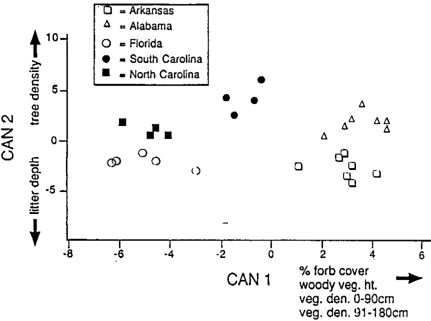

Figure 2. The location of sampled tracts from five state regions along two canonical discriminant function axes. Variables significantly correlated with canonical axes are shown.

offers a plentiful substrate for prey near the ground, yet permits Bachman's Sparrows good visibility and maneuverability for capturing and manipulating food. High percentages of forb and woody vegetation cover may provide less surface area for arthropods at ground level. Trees and shrubs shade out grasses and therefore reduce foraging sites for arthropods. Further, the base of grass clumps are the preferred nest site for Bachman's Sparrows (Haggerty 1988, 1995). In Arkansas, 50 of 71 (70%) nests were placed at the base of *Andropogon* spp. grass clumps (Haggerty 1988).

The low variation in percent litter cover among regions also indicates that structural features at ground level may be important for occupancy. Litter may provide habitat for potential prey, yet too much litter may impede movement and reduce the foraging success of this obligate ground-feeding sparrow. An increase in ground level debris following a hurricane was suspected for the failure of previously occupied sites in being selected by Bachman's Sparrows (Dunning and Watts 1991). Haggerty (1998) found that unoccupied sites had significantly more litter than occupied sites providing additional evidence that Bachman's Sparrows may be sensitive to litter cover.

In conclusion, although all the regions sampled are in the same physiographic region (i.e., Coastal Plain Province; Brouillet and Whetstone 1993), six of the 12 variables measured were significantly different among regions at the 0.01 level, four at the 0.05 level, and only two were not significant. Further, three canonical discriminant functions significantly separated the five study regions. This variation may be due to numerous factors, such as differences in population preferences, floristics, management practices, and sere age. The dissimilarity in vegetation structure among regions, however, may also indicate that Bachman's Sparrows are more tolerant of a wider range of variation for some variables (e.g., percent forb cover, woody vegetation height, grass height, forb height, tree density and vegetation density 91-180 cm) than for others (e.g., percent ground cover, percent woody cover, vegetation density 0-90 cm, litter depth, percent litter cover, and percent grass cover). These findings may have important management implications. Variables that showed the greatest amount of variation among regions may be less important in determining if a habitat is suitable for occupancy. Likewise, variables that showed little variation among locations (e.g., percent grass cover, percent litter cover, litter depth) may be structural features that Bachman's Sparrow are more sensitive to and should be more closely managed.

ACKNOWLEDGEMENTS

Thanks to D. James, K. Smith, M. Parker, H. Parker, C. Self, B. DeYoung, D. Simbeck, and L. Haggerty for their help with various aspects of my study. P. Kittle, T. Richardson, T. Engstrom and K. Groschupf improved the manuscript. International Paper Company kindly allowed me to conduct research on their property. Funding was provided by grants from the Arkansas Audubon Society Trust, Sigma Xi Grant-in-Aid of Research, the Arkansas Nongame Preservation Program, the Chapman Memorial Fund of the American Museum of Natural History, and the University of North Alabama.

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