A Weighted-Means Ordination of Riparian Birds in Southeastern Wyoming[1]

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Abstract.--Variation among habitat associations of 31 riparian bird species in southeastern Wyoming was analyzed using a weighted-means ordination. Three principal components explained 86.7% of the variation among habitat associations of bird species. The components showed high positive loadings for variables associated with canopy, shrub size, and vegetation height.

INTRODUCTION

Riparian communities in the central Rocky Mountains are comprised of shrub willow (Salix sp.) alone or cottonwood (Populus angustifolia, P. sargentii) with a shrub understory (Cannon and Knopf 1984). Cottonwoods are found in plains river bottoms, but shrub willow continues up mountain drainages to subalpine elevations of 3050 m. At high elevations, shrub willow is short and uniform, but as streams descend in elevation, shrub willow gains in volume and heterogeneity so that a vegetational gradient is formed.

This paper demonstrates the use of weighted-averages ordination for analyzing bird distributions along a riparian gradient in southeastern Wyoming. I used a procedure recommended by Maurer et al. (1981) in which several habitat variables measured randomly in different study areas are the basis for predicting species habitat associations. Variation among species is analyzed by computing a mean score for each species for each habitat variable, and then subjecting the species-habitat variables matrix to ordination analysis. Other techniques for evaluating habitat associations of bird species involve measurements of habitat variables at activity centers, perch sites, or nest sites. These methods typically require greater time and effort in data collection, and often involve logistical difficulties in the field (e.g., impeding physical structure of vegetation at nonrandom sites). The advantage of a weighted-means ordination is that it evaluates species preferences on a broad habitat scale; habitat and bird census data can be easily and quickly gathered, standardized, and interpreted by habitat managers (e.g., Anderson 1979).

STUDY AREAS

Seven riparian study grids were established in shrub willow communities 24 km southeast of Laramie, Wyoming and 64 km west of Laramie in the Medicine Bow National Forest. Three additional sites were established in cottonwood and willow habitat. One site was located 2 km north of Arlington, Wyoming and two plots were established on the North Platte River near Saratoga, Wyoming. Ten study grids of 8.1 ha each were distributed over an elevational range of 933 m.

METHODS

Avian populations were censused using the spot-map method during the breeding seasons (May to July) of 1982, 1983, and 1984. A minimum of eight censuses were conducted on each study area each year. The number of territorial, breeding pairs averaged across years for each study plot was used in the analysis. (Scientific names of bird species are listed in the Appendix.)

Vegetation structure was sampled in 1982 at 40 randomly selected grid intersections within the boundaries of each study plot. The point-centered quarter method was used to estimate plant densities. Thirty-four vegetation characteristics were measured following the sampling procedure suggested by Noon (1981) for shrub habitats. Redundant data were deleted, therefore reducing the data set to eight variables for statistical analysis (table 1).

I weighted the mean value of each habitat variable for each study plot by relative frequency of each bird species averaged over all years on a study plot (Maurer et al. 1981). A data matrix (31 species x 8 habitat variables) of weighted mean values for each habitat variable for each species was computed. The SPSS principal

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Table 1.--Factor loadings using weighted averages of 8 habitat variables for 31 bird species.

Variable	Principal Components		
	1	2	3
Shrub crown width (cm)	-0.46	0.78	-0.15
Shrub height (m)	0.07	0.92	0.26
Vertical foliage density (2-9 m)[a]	0.45	0.79	-0.10
Vertical foliage density (>9 m)[a]	0.89	-0.06	-0.07
Canopy cover (%)	0.91	0.20	-0.37
Effective vegetation height (m)[b]	-0.33	-0.21	0.87
Shrub density (#/m)	-0.06	0.15	0.26
Canopy height (m)	0.93	-0.01	-0.36
Eigenvalue	3.59	2.28	1.07
Variation explained	44.8	28.5	13.4

[a]Vertical foliage density is the number of contacts of vegetation falling against a vertical rod graduated into the following intervals: 0-0.3 m, 0.3-1 m, 1-2 m, 2-9 m, and >9 m.

[b]Effective vegetation height is the height at which a 20-cm wide board is more than 90% obscured by vegetation at a distance of 5 m.

components procedure was used to analyze this matrix (Nie et al. 1975). Interpretation of the axes was improved by varimax-rotation of the components.

RESULTS

The first three principal components had eigenvalues >1.0 and accounted for 86.7% of the variation among habitat associations of 31 bird species (table 1). The varimax-rotated factors showed high loadings for those variables most important in explaining variation in habitat selection among species.

Component 1 accounted for 44.8% of the total variance, and was characterized by high positive loadings for canopy height, % canopy cover, and vertical foliage density in the >9 m interval. Thus, component 1 emphasized canopy characteristics that varied as riparian sites changed from those dominated by trees to those dominated by shrubs. Component 2 accounted for 28.5% of the total variance and showed high positive loadings for shrub height, shrub crown width, and vertical foliage density at the 2-9 m interval. It therefore stressed characteristics associated with the upper stratum of shrubs. Component 3 explained 13.4% of the variation and indicated a high positive loading for effective vegetation height, an index of herbaceous vegetation volume.

A plot of species on the first two principal components suggested a gradation of species associations along habitat continuums, although three general groups were distinguishable (fig. 1). A distinct group comprised of only three species, Wilson's Warbler, White-crowned Sparrow, and Lincoln's Sparrow, had low scores on the first

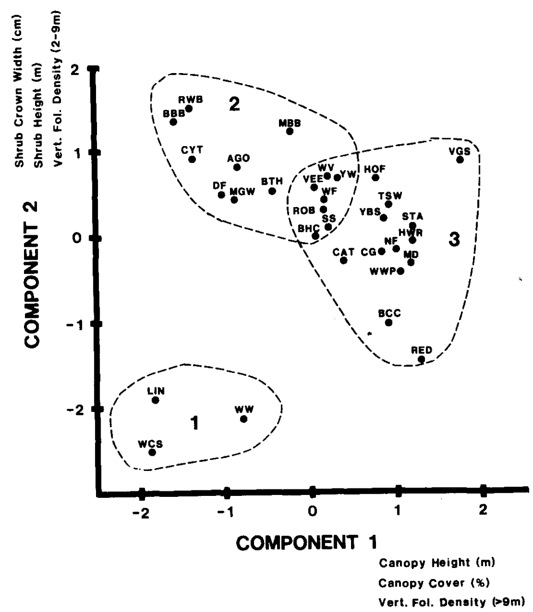

Figure 1. Ordination of 31 bird species. Species codes and number of pairs used in the ordination are given in the Appendix.

two components. This group contained those species confined to high elevation (2500-3000 m) riparian habitats dominated by short and uniform shrub willow and with no overstory canopy. A second group had low scores for the first component and high scores for the second component. This group was composed of species that were most abundant in mid-elevation (2200-2500 m) habitats with tall shrub willow and few trees. The third group had high scores on the first component and variable scores on the second. Species representative of mature cottonwood stands with a heterogeneous shrub understory comprised this group. Species common in both mid-elevation shrub willow habitats and low-elevation cottonwood habitats had scores approaching zero for both components and were plotted in the center of the ordination. These species formed an intermediate subgroup between the second and third aggregations and included such widely distributed species as American Robin, Veery, Yellow Warbler, Brown-headed Cowbird and Song Sparrow.

DISCUSSION

When the habitat associations of a group of species are described, the level or order of habitat selection should be implicitly recognized. In reviewing the concept of hierarchical ordering of habitat selection, Johnson (1980) stated that a selection process will be of higher order than another if it is conditional upon the latter. Habitat selection in this paper refers to second-order selection (i.e., selection of local site patterns) (Weins 1973) which is conditional upon geographical range (first-order selection) but does not define patterns of usage within a territory (third-order selection). The results of this analysis suggest that weighted-means ordination is a useful technique for examining second-order selection processes along a gradient of riparian habitat types. Many habitat models developed for managing single species (e.g., Habitat Suitability Index models, U. S. Fish and Wildlife Service 1981) are based on habitat measurements of second-order selection variables. Because these same variables are also used in weighted-averages ordination of multiple species, this type of ordination analysis may be a worthwhile method for selecting factors to be used in both single- or multiple-species management.

Weighted-means ordination may not provide the level of resolution needed to distinguish differences in habitat preference within a species or between ecologically similar species (Maurer et al. 1981). However, it offers more information than a simple list of species by habitat type because it 1) arranges species preferences along a continuum of environmental variables, thus identifying dissimilar species and grouping similar species, 2) weights selection of habitat types by estimates of density of each species, and 3) defines a limited subset of variables that habitat managers can measure and interpret.

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APPENDIX

Scientific names and codes of bird species mentioned in the text, and mean number of territorial pairs per year used in the ordination.

Species Name	Scientific Name	No. Pairs
Mourning Dove (MD)	Zenaida macroura	10.3
Broad-tailed Hummingbird (BTH)	Selasphorus platycercus	22.0
Yellow-bellied Sapsucker (YBS)	Sphyrapicus varius	3.3
Northern Flicker (Red-shafted) (NF)	Colaptes auratus	5.7
Western Wood-Pewee (WWP)	Contopus sordidulus	8.3
Willow Flycatcher (WF)	Empidonax traillii	3.0
Dusky Flycatcher (DF)	E. oberholseri	9.0
Tree Swallow (TSW)	Tachycieta bicolor	11.7
Violet-green Swallow (VGS)	T. thalassina	5.7
Black-capped Chickadee (BCC)	Parus atricapillus	3.0
House Wren (HWR)	Troglodytes aedon	38.3
Mountain Bluebird (MBB)	Sialia currucoides	3.0
Veery (VEE)	Catharus fuscenscens	20.0
American Robin (ROB)	Turdus migratorius	63.0
Gray Catbird (CAT)	Dumetella carolinensis	6.0
European Starling (STA)	Sturnus vulgaris	4.0
Warbling Warbler (WV)	Vireo gilvus	16.3
Yellow Warbler (YW)	Dendroica petechia	136.3
American Redstart (RED)	Setophaga ruticilla	3.0
MacGillivray's Warbler (MGM)	Oporornis tolmiei	6.7
Common Yellowthroat (CYT)	Geothlypis trichas	7.0
Wilson's Warbler (WW)	Wilsonia pusilla	42.7
Song Sparrow (SS)	Melospiza melodia	42.7
Lincoln's Sparrow (LIN)	M. lincolnii	86.7
White-crowned Sparrow (WCS)	Zonotrichia leucophrys	25.0
Red-winged Blackbird (RWB)	Agelaius phoeniceus	4.3
Brewer's Blackbird (BBB)	Euphagus cyanocephalus	19.0
Common Grackle (CG)	Quiscalus quiscula	3.0
Brown-headed Cowbird (BHC)	Molothrus ater	8.0
House Finch (HOF)	Carpodacus mexicanus	3.0
American Goldfinch (AGO)	Carduelis tristis	4.7