Studies in Avian Biology No. 6:538–542, 1981.

CORRELATING HABITAT VARIABLES AND BIRDS

STANLEY H. ANDERSON[1]

ABSTRACT.—A brief overview of habitat correlation with birds by the use of multivariate statistics is presented. Examples taken from studies conducted in different forest habitats show that many species are correlated with macro features of the community such as habitat size and distance to the edge of the woods. Few data are available to distinguish clearly habitat where species are present or absent.

Analytic tests must be carefully selected. It is important that the assumptions of the tests are met. Care must be taken to determine that habitat variables found in one part of the range of the species are applicable to other parts. It is necessary to select habitat variables that discriminate between places where a species is found and is not found. To accomplish this goal, it is necessary to sample habitat or a species' territory. Finally, the results of correlation tests must be verified with field tests to assure their reliability.

Bird populations and species have often been associated with different plant communities (e.g., Adams 1908, Beecher 1942, Kendeigh 1948, Twomey 1945). Progression of bird habitat studies has led to more quantified studies in which actual features within the habitat have been associated with different birds. Stages in plant community succession have often been associated with changing bird species composition (Bond 1957, Anderson 1970a).

MacArthur and MacArthur (1961) indicated that they found bird species diversity associated with foliage height diversity. Although their studies have been disputed in different forest types, the work they conducted assisted ornithologists in defining habitat variables that characterize species habitat versus nonhabitat. Multivariate techniques came into vogue in the late 1960s. Using such techniques, James (1971) was able to show how a perceptual cue of the environment, called a "niche gestalt," could be defined for each bird species based on information from multivariate tests. For example, stepwise multiple regression indicates which variables, in association with others, appeared to be most commonly associated with the birds. Discriminant function analysis lists habitat variables that appear to be important in locations where bird species were found as compared with areas where the species were not found.

All multivariate analyses can only provide information based on input values. Thus, tests might well indicate variables that are important simply because they are measured in many areas in which the birds are found. In situations where biologists fail to measure important variables, results are distorted to reflect the inadequacies in input data.

Today, wildlife managers and land use planners seek to define habitat quantitatively for different species of birds. Such habitat classification schemes take specific characteristics that are identified as important to a particular population and classify habitat containing those features as optimal for that species. Some wildlife habitat classification schemes seek to prescribe means of trade-off whereby one area can be made suitable for a species as the original habitat is altered.

The purpose of this paper is to identify from field studies and published data, different features of the habitat that appear to be important to bird species. Most studies try to correlate individual species with habitat variables from data collected in one or several field seasons; very few completed projects, however, verify that the results obtained from the correlation studies are indeed important to the bird species. Such verification would often involve prescribed habitat alteration with observations following for several years. There are some before-after studies on habitat disturbance, such as strip mining or cutting of transmission line right-of-ways (Anderson 1979a). A study involving paired comparisons between burned and unburned areas in Michigan's Upper Peninsula (Anderson 1979b, 1979c) produced ambiguous results, primarily because it was not always known if the correct habitat features to prescribe management activities were being measured.

WHAT TYPE OF VARIABLES ARE MEASURED?

Data from different publications show that a number of features of the habitat, such as canopy volume, diameter at breast height (DBH), tree abundance, and ground cover, are commonly used. A comparison of data collected in several parts of the United States is made using stepwise multiple regression with bird abundance as the dependent variable and habitat factors as independent variables (Table 1). These data show which habitat variables are important. In these four study sites (the eastern deciduous forest in Tennessee and West Virginia, northern mixed forest in Michigan, and western deciduous forest in Oregon), forest size, distance to the edge, canopy volume, and trees per hectare

[1] Wyoming Cooperative Research Unit, U.S. Fish and Wildlife Service, Laramie, Wyoming 82071.

TABLE 1
NUMBER OF BIRD SPECIES SHOWING A CORRELATION WITH HABITAT FACTORS IN VARIOUS STATES BY MEANS OF STEPWISE MULTIPLE REGRESSION

Habitat factor	Mary-land	Minn.	Ore-gon	Tenn.
Trees per hectare	10	14	18	10
Canopy volume per hectare	20	10	17	15
Canopy cover per hectare	19	9	17	10
Snags per hectare	2	13	4	
Average trunk height	4	7	4	3
Logs	2	5		
Shrubs per hectare	11	16	6	8
Forest size	24	18	19	
Distance to edge	26	14	12	
Bird species considered	36	35	26	28

are associated with more species. Relatively few species are associated with features such as trunk height, logs, or snags. Michigan is an exception, as fire apparently left many snags that are associated with the birds coming into the area.

When variables used by biologists are examined, one can identify two classes. First, major features of the habitat such as habitat size, distance to the edge, canopy volume, DBH, and trees per hectare are correlated with many of the species. Such variables represent broad or "macro" habitat features and might be associated with the community as a whole. Second, features that can be associated with individuals, such as snags and logs, are not listed as correlators with large numbers of species. This "micro" level is associated with features that can potentially be correlated with individual species. We are often sampling macro features on a micro level, such as viewing the canopy through a camera on a tripod to measure openness or through a visual scope to determine the presence or absence of ground cover. This approach can provide useful data; however, when macro information are the only data required, they can often be sampled with aerial photos which are quicker and cheaper than tedious on-site sampling.

When biologists try to discover what habitat variables are associated with bird species, they often start by collecting habitat data in a circular grid around nest sites. Additional habitat data are collected in unoccupied areas. Correlation tests are then run between birds and variables in the two areas. Since results are based on the type of habitat data collected, if only macro data are collected little can be said about micro factors responsible for a species' presence. The

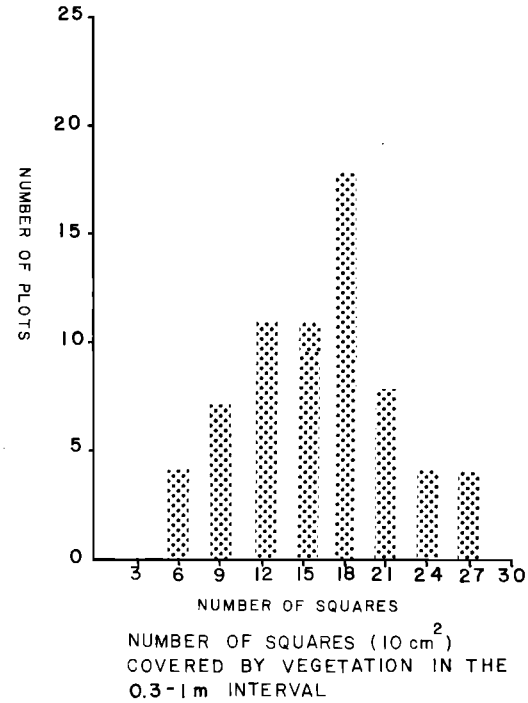

FIGURE 1. Number of 10 cm² squares covered by vegetation in the 0.3–1 m height interval on vertical drop cloth on plots in western Maryland.

type of habitat data collected also limits the investigator's ability to discuss optimal versus suboptimal habitat.

It is very important that habitat variables and sample sites be selected so that they discriminate between areas where a species is present or absent. For example, in an eastern deciduous forest of western Maryland, 56 of 68 sample sites are 120 ha or smaller. If habitat size is a discriminating factor and a species is present in forested areas up to 300 ha, this is not a good discriminator.

A better discriminator is one that shows some form of distribution between classes that can be used for discrimination. For example, to estimate foliage density, a drop cloth is used in the center of a 0.04 ha circle. Observation of the cloth indicates the number of 10 cm² circles covered by vegetation at different height intervals. At the 0.3–1 m interval, the study sites show a distribution of squares in each category (Fig. 2). As a result, this variable could be a potential discriminator for bird species.

Micro features of the habitat associated with individual species are difficult to distinguish. As yet, we probably do not have a good understanding of many of the micro features that can

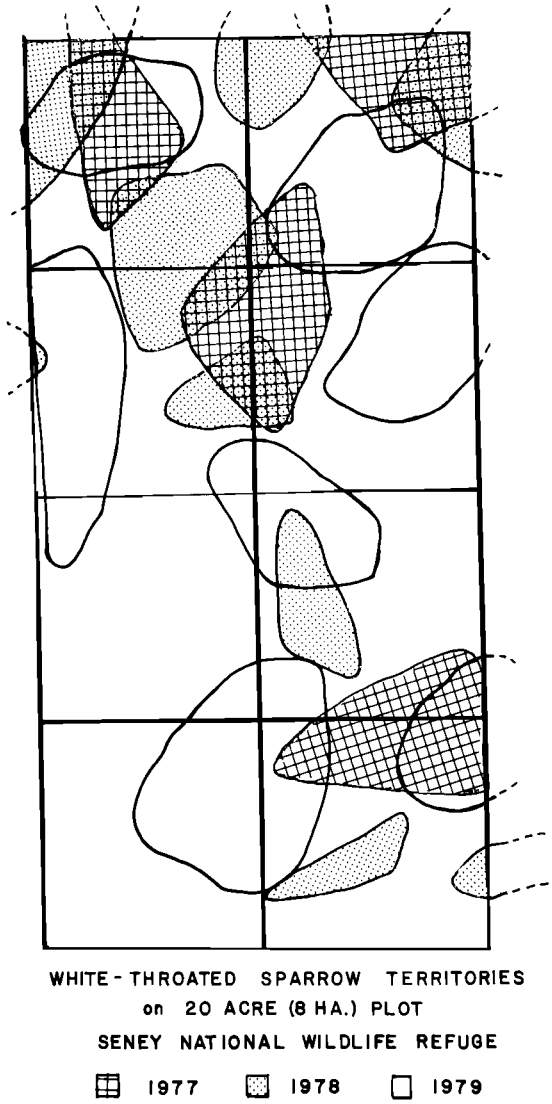

FIGURE 2. Shift in White-throated Sparrow territories on 8-ha (20-acre) plot in Michigan over three-year period.

be individually associated with species. It is true that studies such as those conducted by Anderson and Shugart (1974) indicate that the number of saplings is indicative of the number of Downy Woodpeckers (*Picoides pubescens*). The corollary may simply be that Downy Woodpeckers are found in early successional sequence or second-growth timber stands. We do know that Western Wood Pewees (*Contopus sordidulus*) are found in open sites in the forest where snags protrude. Clearly, studies on some endangered species, such as the Red-cockaded Woodpecker (*Picoides borealis*) (Jackson 1977) and Kirtland's Warbler (*Dendroica kirtlandii*) (Line 1964), identify habitat features that can be used to manage those populations. On the other hand, we do not have a good source of data on some of the more generalist or wide ranging forest species, such as the Red-eyed Vireo (*Vireo olivaceus*) or Scarlet Tanager (*Piranga olivacea*). General or community descriptions are often used to describe areas where these birds are found.

WHAT DOES HABITAT MEAN?

Habitat is an area where an organism's needs for survival are found. Many ecologists list food as an important resource that can be in limited supply. Some feel that differences in foraging behavior, habitat utilization, and morphological and temporal variation all occur because of competition for food. Sexual dimorphism is thought to occur in some species when males and females forage on different parts of trees or select different size prey items. If competition for food is responsible for differences in habitat utilization, methods of measuring habitat variables should indicate competition.

Studies of birds present along different habitat gradients, e.g., moisture (Smith 1977), altitude (Anderson 1970a), succession (Bond 1957), and competition (Cody and Walter 1976), show which species of birds inhabit different communities. Habitat structural characteristics are measured and correlated with species in those communities. Island biographic investigations report the absence of different species on smaller islands with presumably less habitat to allow all species to find food (Morse 1971). Such findings appear to be related to the habitat gradient studies where forest species are characterized as associated with dense understory, heavy canopy, or other variables that are part of the changing structure in forest succession.

Are habitat selection studies really measuring adaptability of forest birds? If so, then we should be able to show that each species is associated with unique features of the habitat. We should be able to identify habitats where species occur. Conner et al. (1975) states that selection of certain habitat types for nesting by woodpeckers probably reflects the prevalence of the habitat type more than the preference by any species. Still, requisite needs for a species must be satisfied. We must therefore identify those factors that allow a species to survive in an area.

With many bird and habitat sampling techniques, collection of habitat data for breeding birds does not always occur on the defended territory. For example, a study plot on a burned mixed forest site in the Upper Peninsula of

Michigan shows that White-throated Sparrow (*Zonotrichia albicollis*) territories do not generally abut one another. Because it is likely that a series of habitat features provide suitable areas for nesting sparrows, it is important that these features be sampled where the species actually uses the territory. Counting only singing males heard can be misleading. These sites must be compared with sites in which the species is not found. Random sampling therefore must be stratified to reflect a clear presence or absence before habitat sampling begins. It is also possible to partition data with presence or absence sets after sampling.

Territories do not remain constant from year to year (Figure 3). After three years of the study in the burned site of Michigan's Upper Peninsula, White-throated Sparrows showed territorial shifts that were presumably due to changes in the habitat structure and competition from other species following the fire. Thus, relocation of the habitat sampling units would be necessary each year to maintain sampling within the territory of the species.

Problems of study plot size also arise on sampling birds. Some census techniques do not adequately cover the larger bird territories. Habitat samples then do not yield accurate information about that species. In fact, some plots of 20 ha and less may not provide adequate microhabitat to sample.

Results are at times difficult to verify because objectives have not been clearly stated. Many studies looking at habitat selection in birds are very general in nature. A clear hypothesis is not distinguishable, although it may be there in vague terms. Biologists need to clearly define what they are trying to do. This is very important if they are to develop management guidelines. Managers cannot relate to such things as the total canopy volume of a deciduous forest to maintain a species. Often it is necessary for biologists to translate data results to useful information for managers. Managers would, however, be able to consider the total size of a habitat necessary to support a bird community. Furthermore, habitat classification schemes are being developed on the basis of inadequate data sources that do not clearly identify places where the bird is found with places where the bird is not found. Results do not identify optimum and suboptimum habitat and relate these results to field verification.

Another difficulty arises because of the dissimilarity of variables used in different areas. It is often very difficult to make comparisons among several study sites. Noon (in press) urges that similar features of the habitat be recorded in different studies, thus comparisons can be made. Although he suggests that the James-Shugart (1970) technique is a good start, he believes that further refinement is necessary to sample habitat adequately. Many of the results of the James-Shugart technique, however, do not provide good information on correlation with individual species because of the type of data collected. Microhabitat data necessary to discriminate individual species habitat are not available.

TABLE 2
HABITAT VARIABLES CONFORMING TO ASSUMPTIONS OF NORMALITY

	Ohio	Central Maryland	Western Maryland	Seney (unburned)
Foliage density 1	*		*	*
Foliage density 2		*		*
Foliage density 3	*	*	*	*
Foliage density 4		*		*
Number of trees	*		*	
Number of small trees		*	*	*
Number of medium trees	*	*	*	*
Number of large trees		*		
Ground cover	*	*	*	
Number of snags		*		
Tree height		*		
Average tree diameter		*	*	
Tree basal area	*		*	*

STATISTICAL EVALUATION

Multivariate analysis is used extensively to identify habitat variables important to bird species. Discriminant function analysis, a method of analyzing grouped multivariate data, is frequently used to identify important habitat variables. This technique is both predictive and explanatory. As a classifier, the technique aims at classification of individuals of unknown groups of membership. As a predictor, discriminant function analysis allows group separation by means of linear transformations (canonical analysis).

Recent evaluations of the canonical functions indicate that some assumptions of the tests are not met in utilizing the tests (Williams in press). For example, habitat variables do not always exhibit a normal distribution.

Evaluation of data from four study sites in the eastern deciduous forest (Table 2) indicates that only about half of the variables conform to the assumption of normality. This means that some results appearing in the literature that identify management criterion for birds may be in error. Correction of the deficiency in the discriminant function test is not always easy. Increasing sam-

ple size is apparently not the answer (Williams in press).

DISCUSSION

A number of macrohabitat features are felt to be important to birds. Robbins (1979) indicates the importance of habitat size to maintain populations of neotropical migrants in eastern deciduous forests. When the total area decreases below 810 ha, migrants begin to disappear. He shows how sections of forest habitat might be combined in different ways on tracts of land to attract the bird species.

Increased edge is a factor that does attract species, as shown by Lay (1938) and Johnston (1947). Such changes in forest habitat increase the diversity of the community by attracting different species. Most of those species attracted to the edge, however, are not migrant species (Anderson 1979a). Thus, edge may be good for resident species and poor for neotropical migrants.

Habitat structure is a very important component of the avian community. When comparisons between field and forest are made, distinct differences can be seen in the structure of the community. Likewise, structural differences within the successional seres in a forest can be recognized and correlations can be drawn between these structural features in the community. Actual comparisons of habitat structural components with the presence or absence of individual bird species, as may be done through a discriminant analysis, are difficult. It is often very hard to determine which exact features are responsible for a species being there. In fact, the total community structure could be the important component. Thus, it might not be possible to consider managing an individual species without looking at other populations within the community.

If the biologist's objectives are to prescribe a community management procedure, then macro level components may be the answer. Coupled with knowledge on the population biology of species, managers can maintain habitat to support communities of birds. When going beyond that to work with individual species, we may need to develop further sophistication in our measurement techniques to answer questions adequately.

If the objectives of the work are to classify habitat, then it is important to specify the level of involvement. Should we be discussing individual species? In most instances we cannot do so because we do not have the data. Quick surveys listing the habitat variables around an individual bird are inadequate to describe the general habitat of that species throughout its range. Some species have very similar requirements throughout their range whereas others show geographic variation (Noon et al. in press); however, such conclusions are reached only after considerable fieldwork.

After defining objectives, biologists need to select habitat variables to answer the questions asked. Then they must take a series of elimination steps to find habitat variables correlated with species. Breckenridge (1956) describes an interesting process of arriving at habitat characteristics associated with the Least Flycatcher (*Empidonax minimus*). He evaluates the abundance of trees, shrubs, and tree size. His attempt to correlate hazel stalks with the number of flycatchers is not effective. However, it leads to the suggestion that the degree of forest crown closure is related to flycatcher use. This approach discloses that the degree of openness just beneath the forest crown is the primary influencing factor. This factor is also related to the size of the forest in which the birds are observed.

Results from correlations drawn from data collected by biologists indicate that we have some information on communities of bird species. Thus by specifying general ecological features, such as forest size and degree of succession, we can discuss a form of community management. These data are useful when planning major community changes; we can specify which species might be eliminated when habitat size decreases.

At this time data are inadequate for managing all species in a community. Data repositories are not a substitute for fieldwork. Not only must we plan an adequate study at each site, but we must also continue to develop techniques to find parameters that define bird habitat relations.