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MEASURING SHRUBLAND VEGETATIONAL STRUCTURE USING AVIAN HABITATS AS AN EXAMPLE

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ABSTRACT

Vegetational sampling of avian habitats stresses the use of methods primarily designed for forest birds. This paper describes a technique for sampling vegetational structure in uneven patchy habitats such as shrublands. Using the method, avian habitats in old field shrublands of northwestern Arkansas were analyzed.

INTRODUCTION

The sampling of vegetational structure in avian ecological studies has stressed forest habitats and forest birds (James and Shugart, 1970) or ignored fine details emphasizing instead overall characteristics of vegetation (MacArthur and MacArthur, 1961). Because of the uneven character of shrubland vegetation produced by the mosaic pattern of alternating patches of grasses, shrubs and small trees, the task of measuring vegetational structure in this habitat is especially challenging. Early successionist old fields and various scrub and shrubland associations are examples of this type of environment. I have been studying avian microhabitats in these environments on four continents and found it necessary to adopt a method for sampling vegetational structure that was suited to this unique situation. This study describes the sampling technique I developed and used. It is designed to determine the fine structure of old field shrubland vegetation and also depict overall configurations. The example of its use that is presented is the analysis of avian habitats in old fields of northwestern Arkansas.

MATERIALS AND METHODS

Positions of birds encountered in the field were marked and these points became centers of circular plots measuring 14.6 m in radius, thus equating 669.7 square meters. Within these plots 11 vegetational factors were measured. The height of the tallest tree or bush in the plot was recorded. Also, an estimate of the average vegetation height was obtained from several measurements throughout the plot using a calibrated pole. The calibrated metal pole was 3.0 m long and 10 mm in diameter, and was marked off into 0.6 m intervals. The 0.6-m intervals were accentuated using different colored paints. The pole was positioned vertically from the ground at random points in the plot and the total numbers of leaves touching it in each of the 0.6-ft intervals were recorded in the following eight sections: 0.0-0.6 m, 0.6-1.2 m, 1.2-1.8 m, 1.8-2.4 m, 2.4-3.0 m, 3.0-3.7 m, 3.7-4.3 m, and over 4.3 m. This constituted 8 vegetational factors. For making leaf counts above the 3-m height of the pole, the pole was lifted overhead to appropriate heights. For the unusual very high trees leaves were counted using an overhead range finder.

There were a total of 40 random pole positions used in counting leaves. These were distributed in four orthogonal line transects originating at the center point of the plot, the first transect being defined by following the direction indicated by a random twirl of a compass dial. Ten random pole positions were located in each of the four transects. The total leaf counts for the plot in each of the 0.6-m intervals was obtained by summing across all forty pole positions for each interval. The 11th and final factor measured was the count of all live woody stems, regardless of size, encountered along each of the four line transects and summed to give a total for the plot. The stem count was made in a 0.3-m wide band along the transects at a height of 1.2 m.

From the vegetational factors measured in the field five additional factors were calculated. These added ones pertain to vegetational patterns. Four of the added factors indicated degree of evenness in the vegetation. These all were based on the commonly used measure J' for expressing evenness in ecological communities (Pielou, 1975),

\[ J' = \frac{H'}{H'^*} \]

where \( H'^* \) is the log of the number of categories under consideration and \( H' \) is the Shannon index for diversity,

\[ H' = -\sum p_i \log p_i \]

in which this case \( p_i \) is the proportion of the total vegetation existing in each category. Evenness has been used in studies of vegetational pattern (Pielou, 1966), high values of \( J' \) indicating an even distribution of vegetation, low values being associated with uneven or patchy mosaic patterns.

Foliage vertical evenness was a pattern factor that summed the total leaves in each 0.6-m level across all 40 sample points. The parameter \( p_i \) then became the proportion of the grand total number of leaves \( (N) \) that occurred in each of the levels \( (p_i = n/N, \text{where } n \text{ is the number of leaves in the } i\text{th level}) \). High diversity and evenness existed when the leaves were uniformly distributed through all strata, low values were associated with uneven distributions between vertical strata. Foliage coarse grained horizontal evenness was calculated using total leaves in each of the four transects summed across all strata, \( p_i \) representing the proportion of the overall total number of leaves that occurred in each transect. This produced a measure relating to the distribution of vegetation from sector to sector over the circular sample plot, a low evenness value showing a very patchy distribution of vegetation between sectors, a high value indicating an uniform density in vegetation from place to place in the plot. Foliage fine grained evenness used the total number of leaves touching the pole at each of the 40 random pole-sample positions. The parameter \( p_i \) was the proportion of leaves found at the ith random position compared to the total number of leaves counted over the whole plot. In this case a low evenness value was associated with a highly irregular pattern of vegetation density from place to place within sectors of the plot as well as between sectors. High values of evenness indicated a uniform rather than patchy pattern of vegetation on a fine scale from place to place in the plot.

Stem evenness represents the pattern of shrubbiness in the sample plot where \( p_i \) is the proportion of total stems occurring in each of the 4 transects. High values show an even distribution of low woody vegetation throughout the plot, low values indicate a irregular patchy pattern of shrubs. The measure of stem variability was calculated by summing the absolute values of the differences in number of stems between successive transects in the plot. This was not adjusted for relative number of stems in the sample plot so the calculation of \( J' \) was not performed in this case. Starting with a transect, the number of stems in that transect was subtracted from the number in the adjacent transect in the circle. The absolute value of that difference was then summed with the absolute value of the difference between the second transect and its adjacent one in the circle, and so forth until four such values were totaled from the four transect comparisons. If this index of stem variability was high it showed that there was considerable variation.
RESULTS AND DISCUSSION

This method of vegetational sampling has been used in my studies of avian community ecology in shrubland habitats on a global scale in Ghana in West Africa (1970-1971), Nepal in South Asia (1981-1982), Belize in Central America in (1988-1989), and North America in northwestern Arkansas in 1972 (Posey, 1974) plus northern Michigan beginning in 1987 and still in progress. An example of the kinds of results that are obtained are presented here (Table 1) portraying the

Table 1. Mean values for vegetational factors measured in shrubby old field habitats in northwestern Arkansas, comparing random samples with the habitats occupied by three bird species.

<table>
<thead>
<tr>
<th>Vegetational Factor</th>
<th>Random Sample</th>
<th>Meadow Sparrow</th>
<th>Indigo Bunting</th>
<th>Blue-gray Gnatcatcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. vegetational height (m)</td>
<td>1.5</td>
<td>0.9</td>
<td>1.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Height tallest tree (m)</td>
<td>2.4</td>
<td>3.0</td>
<td>8.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Total stem at 1.2 m height</td>
<td>21.9</td>
<td>12.5</td>
<td>26.8</td>
<td>91.9</td>
</tr>
<tr>
<td>Total leaves 0-0.6 m high</td>
<td>88.1</td>
<td>85.4</td>
<td>89.3</td>
<td>83.8</td>
</tr>
<tr>
<td>Total leaves 0.6-1.2 m high</td>
<td>17.3</td>
<td>15.0</td>
<td>13.3</td>
<td>27.0</td>
</tr>
<tr>
<td>Total leaves 1.2-1.8 m high</td>
<td>3.6</td>
<td>3.0</td>
<td>7.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Total leaves 1.8-2.4 m high</td>
<td>2.6</td>
<td>1.9</td>
<td>5.3</td>
<td>17.5</td>
</tr>
<tr>
<td>Total leaves 2.4-3.0 m high</td>
<td>2.4</td>
<td>2.1</td>
<td>4.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Total leaves 3.0-3.7 m high</td>
<td>2.1</td>
<td>1.7</td>
<td>3.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Total leaves 3.7-4.3 m high</td>
<td>1.8</td>
<td>1.5</td>
<td>2.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Total leaves above 4.3 m high</td>
<td>3.9</td>
<td>2.5</td>
<td>6.1</td>
<td>19.9</td>
</tr>
<tr>
<td>foliage vertical evenness</td>
<td>0.43</td>
<td>0.44</td>
<td>0.46</td>
<td>0.74</td>
</tr>
<tr>
<td>foliage coarse-grained horizontal evenness</td>
<td>0.90</td>
<td>0.58</td>
<td>0.59</td>
<td>0.93</td>
</tr>
<tr>
<td>foliage fine-grained horizontal evenness</td>
<td>0.95</td>
<td>0.54</td>
<td>0.93</td>
<td>0.94</td>
</tr>
<tr>
<td>stem evenness</td>
<td>0.31</td>
<td>0.33</td>
<td>0.73</td>
<td>0.93</td>
</tr>
<tr>
<td>stem variability</td>
<td>17.8</td>
<td>13.0</td>
<td>23.6</td>
<td>46.2</td>
</tr>
</tbody>
</table>

in shrubness among sectors in the plot circle, a low value indicated the existence of a rather uniform shrubness throughout the plot.

In addition to the plots around bird locations a series of samples were obtained the centers of which were randomly determined. This provided a characterization of the overall habitat in which the birds occurred, and served for comparison to the microhabitats occupied by the bird species. Because this technique has been employed by me on several continents and it was never possible to find poles of the same diameters in the same and in these diverse places, each pole used was standardized to a string line vertically suspended by a light plum through the vegetation. This essentially represented a dimensionless point piercing the vegetational structure. To standardize the measuring pole was positioned and the leaves counted in each 0.6-m interval. Then a longer pole was anchored in the ground at a slant with a string line and plum attached to its tip. This pole was carefully positioned so that the string line dropped right next to the measuring pole. Next the measuring pole was moved to the side so that the string line took up its position. The leaves touching the string line were counted in the 0.6-m intervals using the nearby pole as a measuring guide. Of course the string line touched fewer leaves than the wide diametered pole. The conversion needed was calculated by dividing the total number of leaves touching the string by the total touching the pole. This was repeated for a number of pole positions to obtain an average of the conversion ratio. When compiling the data obtained using this pole the leaf count totals per stratum were multiplied by the conversion factor to produce a standardized value converted to string line measurements. In the case of the study in old fields of northwestern Arkansas reported here the conversion factor was 0.6. Thus the pole leaf counts were multiplied by this value to standardize them.

The three species shown in Table 1 are representative of a total of 17 species sampled in the Arkansas study (Posey, 1974). As an example of the kinds of analyses that can be made using this information, ordinary principal components ordination (Cooley and Lohnes, 1971) of the species in habitat space can be performed using the combined set of vegetational factors (Fig. 1). The first principal component (abscissa) was associated with degree of foliage density in the vegetational factors, open country to the left, dense shrubland to the right. Notice the positions of the three species mentioned above; the Eastern Meadowlark at the open grassland edge on the left of the ordination, the White-eyed Vireo far to the right in the thick shrubby environs, and the Indigo Bunting in between. The second principal component (ordinate) was heavily weighted on factors relating to horizontal evenness in foliage density, an even distribution of vegetation from place to place occurring at the top of the ordinate in Figure 1, an uneven vegetational mosaic pattern positioned at the bottom. Note that although both species occupied a habitat of medium vegetational density on the shrubness axis (Figure 1), the Bobwhite (Colinus virginianus) selected environs having a uniformly dense vegetation while the Brown Thrasher (Toxostoma rufum) occurred in habitats characterized by having scattered bare areas.

When conducting the study in the shrublands of Nepal near Kathmandu, the four field personnel involved in taking the samples performed an exercise designed to test an aspect of the reliability of the method. Each of the four investigators sampled the same plot for each of two plots, one plot in open country, the other in dense shrubland. From the four samples on a given plot, and comparing two of the samples at a time, coefficients of community similarity (Cox, 1985) were calculated for that plot using the respective values obtained for the 11 vegetational factors measured in the field. All permutations of the four samples on a plot produced six community similarity coefficients, or a total of 12 such coefficients from the two plots. The average of these 12 coefficients was 85%, which is far short of the perfect similarity value of 100%. It is theoretically expected from replicate samples on the same plot. However, Cox (1985) points out that replicate samples of the same community commonly show similarity coefficients of around only 85%. Therefore, in this regard the method described here is comparable in reliability to other community sampling methods.
It should be noted that this method was developed in the late 1960s before the metric system of measurements was universally adopted in scientific publications. Therefore, English system units were used, and have continued to be used through the years for the sake of uniformity in data collection. Expressing the design of the method in metric units makes it look odd. To clarify things I now give the original English units used, which will assist those who want to perform vegetational analyses for comparison to my results. The radius of the plot was 48 ft. Therefore, the four transects were each 48 ft long. The pole used in counting leaves was 10 ft tall divided into 2-ft intervals; 0-2 ft, 2-4 ft, 4-6 ft, 6-8 ft, 8-10 ft, and was raised to count leaves at heights of 10-12 ft, 12-14 ft, and over 14 ft. The four narrow transects in which woody stems were counted were each 48 ft long and 1 ft wide.

LITERATURE CITED


