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STRIP TRANSECT SAMPLING AND ANALYSIS FOR AVIAN HABITAT STUDIES

RICHARD N. CONNER, ***Wildlife Habitat and Silviculture Lab,***[1] ***Southern Forest Experiment Station, USDA Forest Service, Nacogdoches, TX 75962***

JAMES G. DICKSON, ***Wildlife Habitat and Silviculture Lab,***[1] ***Southern Forest Experiment Station, USDA Forest Service, Nacogdoches, TX 75962***

Abstract: Censusing procedures that detect effects of habitat treatment on birds are outlined. We suggest that only relative values of bird species diversity, equitability, abundance, and species richness need be obtained. We also suggest that 4, 250-m strip transects per treatment and 8–10 trips over each transect are adequate. Aspects of sampling design that affect within-treatment and among-treatment variation are discussed.

The effects of habitat alterations on bird populations are a needed component of environmental impact studies and forest management plans. But uniform guidelines for selecting study areas, establishing transects, censusing, and making statistical analyses of results in such studies are lacking. We suggest some practical procedures that will permit statistical comparisons of bird population measurements. The procedures are based on the fact that only relative differences in bird populations, rather than absolute values, are needed in such studies.

Difficulties and time constraints usually imposed by field studies often prevent adherence to *perfect* experimental designs. Compromises are often necessary. We hope to show where such compromises can be made without biasing the results of studies.

Of the many techniques to census birds, the spot map (International Bird Census Committee 1970) and the transect method (Eberhardt 1978, Emlen 1971, Haapanen 1965) are the most widely used. In the present paper we discuss the use of strip transects, which should not be confused with line transects. Eberhardt (1978) provides an excellent description of differences between these 2 sampling methods.

We recommend the strip transect method for 2 reasons. First, although spot-mapping yields higher and more accurate estimates of bird populations than transect sampling (Dickson 1978*a*, Franzreb 1976), more area can be covered per unit census time with transects (Emlen 1971, Robbins 1978). Because only relative differences among treatments are needed, the faster method is preferred.

Second, strip transect censusing can be designed with replications of transect samples that isolate control and treatment effects on bird populations and permit data analysis by standard parametric statistical procedures, such as analysis of variance (ANOVA). Statistical analyses of bird abundance data from spot-mapping is normally not feasible because of the enormous time and manpower required to obtain sufficient replication of treatments.

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[1] In cooperation with the School of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962.

STUDY DESIGN

Optimal study design to determine the effects of habitat treatment on birds includes measurement of pre- and post-treatment effects on 1 study area as well as concurrent measurements on an identical, untreated control area (Green 1978). The null hypothesis in this case would state that changes in bird species abundance in the treatment area over time would be identical to changes occurring in the control area. Contained within this design are controls for both space and time. This type of study design requires knowledge of a habitat treatment before it occurs and is necessarily a 2-way areas-by-time factorial design where evidence for treatment effects is a significant areas-by-time interaction. A 2-way multivariate ANOVA is an appropriate statistical analysis for this design using the abundance of individual species as variables. Green (1978) provides an excellent coverage of optimal impact study design and analyses for readers desiring a more detailed description.

The above design is ideal for studies where information on the immediate effects of a habitat treatment is desired. Such study designs are best applied to impacts measured over short time periods. It would not be feasible to use this design to measure the total effects of a long-term environmental alteration, such as a 70-year timber rotation, on bird populations. A compromise is necessary and involves the selection of several areas that represent the treatment of a habitat type over time. In the example of timber rotation treatment, several study areas with timber stands of different ages to represent successional stages would be selected. Measurements made on mature habitat (pre-treatment condition), in effect, serve as a control. When such a compromise is made, the necessity to have all study areas as similar as possible, except for treatment effects, cannot be overemphasized.

Selection of Study Areas

Study areas—areas of uniform habitat treatment in which transects will be located—should be as similar as possible in all respects (e.g., size, slope, aspect, elevation, timber type, soil types, and presence or absence of streams) except treatment effect. Differences among study areas that are not caused by treatment effects can severely bias results, especially in study designs where optimal spacial and temporal controls are not possible. In such designs, the assumption that all study areas are the same in non-treatment respects cannot be tested.

Marking Transects and Field Data Sheets

Strip transects should be well marked. We recommend that a flagged pole be placed every 50 m along the center line of the transect and every 50 m along each edge. Such poles enable the census taker to know his or her position on the transect and to plot bird observations accurately.

Field data sheets should be a miniature reproduction of the transects with poles, center line, and edges indicated. Thus, in order to avoid censusing the same bird twice, the observer can record the position of each bird in the transect and its direction of movement.

SAMPLING BIASES

Many factors can affect within-treatment variation and among-treatment variation of sampling results. Factors that increase within-treatment variation decrease the ability of statistical tests to detect significant differences among treatments.

Other than treatment effects, factors that affect among-treatment variation decrease the reliability of statistical tests. Sampling design and methodology must attempt to ensure that only treatment effects influence among-treatment variation.

Transect Factors

Usually a series of 4–10 strip transects should be established in each habitat treatment to obtain sufficient sampling and provide replications of habitat treatments.

In most areas, strip transects should be long (200–300 m) and narrow (70–100 m). We suggest a census width of 35–50 m on either side of the transect center line because detection of most bird species decreases rapidly at greater distances (Dickson 1978*b*). Transect length is probably best determined by the number of birds that need to be sighted to provide adequate data rather than the actual area to be walked. Thus, studies conducted in regions where bird densities are low need to have longer transects than studies made in regions where bird densities are high. In certain regions, such as forest habitat in the Southern Appalachians, high breeding-bird densities allow the use of 100-m strip transects to obtain sufficient data for statistical analysis (Conner et al. 1979). In arid regions, transects may have to be 400–500 m in length.

Transect length is also influenced by uniformity of vegetation, topography, and time limitations of the census. As transect length increases, more minor variations in habitat conditions likely will be included, thus increasing the chance of transect commonality and reducing within-treatment variation of bird abundance. Unfortunately, some study areas are too small for several 200–300-m transects, so 100-m transects must be used. Smaller transects may increase within-treatment variation, but often allow researchers to sample a greater range of conditions within the habitat treatment. As a general rule, we suggest a combination of transect numbers and lengths totaling about 1,000 m per habitat treatment.

Time of Day

During the breeding season, transect sampling should be conducted in early morning when singing is most intensive (Hall 1964, Internationl Bird Census Committee 1970, Järvinen et al. 1977). Because a few species are most conspicuous at other times (e.g., later in the day for vultures, night for owls, dawn and dusk for goatsuckers), additional samples can be taken at such times if desired. Instructions for the *Breeding Bird Survey* of the U.S. Fish and Wildlife Service advise completion of routes by 3.5–4 h after sunrise. Shields (1977) counted fewer birds on transects starting at 0730 than on transects starting at 0600. Based on our observations, we suggest that censusing be completed within 3 h after sunrise to minimize the effect of variation in bird conspicuousness.

In winter, time of censusing is not as critical. Bird activity and conspicuousness often depend more on weather than on time of day (Grubb 1978). Although afternoon censusing is allowed in some procedures (Kolb 1965) and may be desirable in the northern United States, our observations suggest that bird conspicuousness in the south varies less in the morning, and counts should be conducted then. Robbins (1972) censused significantly more birds ($P < 0.01$) in the morning than in the afternoon in Maryland. Shields (1977) detected more birds in late morning than in early morning in New Jersey, but Robbins (1971) observed slightly more birds in early morning than in late morning in Maryland.

Time of Year

The middle of the breeding season (May–June in most areas) is probably the best time for censusing most breeding song birds. Censusing should be evenly distributed over the middle of the breeding season so that sampling will not be biased toward early- or late-season birds. Hall (1964) recommended late May and June for censusing breeding birds in northern states. In the North during early May, transient birds are still present and not all summer residents have arrived. Robbins (1978) recommended May and early June in the Southeast, and a similar time is also optimum in other southern states. Monthly censusing in a bottomland hardwood forest in south-central Louisiana (Dickson 1978*b*) showed that April was too early for effective censusing of most breeding birds and July was too late. Bird observations decreased in July; of the 13 common species in Louisiana forests, observations of individuals from 10 species decreased in frequency from June to July. Although many young birds were fledged in July, the dwindling conspicuousness of adults more than compensated for this rise in populations.

Spring censusing in an East Texas clearcut also showed May and June were the best months. Mourning doves (*Zenaida macroura*), which were uncommon breeding birds in that area, and wintering white-throated sparrows (*Zonotrichia albicollis*) dominated the transect counts in March; doves were also abundant into April (J. G. Dickson and R. N. Conner, unpubl. data). Detections of indigo buntings (*Passerina cyanea*) and yellow-breasted chats (*Icteria virens*), the 2 most abundant breeding birds, were consistent by the first week of May in Texas. Fledglings of both species were being seen by July, and adult chat observations had decreased.

Winter censusing is best conducted from late December through early or mid-February (Kolb 1965). Densities of 13 common winter avian residents in a hardwood forest in Louisiana were highest, and month-to-month differences were lowest during this period (Dickson 1978*b*). Species composition of the bird community at this time was also relatively stable.

Rate of Traverse

Rate of traverse of transects depends on many variables such as terrain, vegetation, experience of census taker, and abundance and conspicuousness of birds. The number of birds observed is usually inversely proportional to census speed. Based on our present studies and recommendations by Emlen (1971, 1977) and Shields (1979), census takers should be able to census transects at the rate of 0.75–1.50 km/h. As long as each census taker maintains his or her rate in all treatments, among-treatment variation of bird abundance will not be affected.

Number of Transect Counts

Eight to 10 census trips over transects seem generally satisfactory. In winter censusing, Robbins (1972) found a minimum of 6 trips was ample to record nearly all the species for a total bird population estimate, but 8–10 visits were required for valid population estimates for individual species. Kolb (1965) similarly recommended at least 6 counts, but preferred 8 or 10. A similar number of counts (8–10) was suggested for the breeding season (Dickson 1978*a*, Shields 1979). If censusing time is limited, 6 census trips over each transect should not affect results severely. Generally, the greater the number of census trips, the lower the within-treatment variation of the census data. However, if censusing is spread out over an entire season, within-treatment variation may increase due to seasonal variations in bird abundance.

Number and Ability of Observers

Ideally, censusing should be done by 1 highly experienced person, but this is usually not possible because of time constraints. Differences in ability of observers can affect among-treatment variation of bird and species abundance. If several observers census birds, we recommend that each person census all the transects a *whole* number of times. For example, if a study has 2 treatments with 4 transects in each treatment, each census taker must sample all 8 transects 1, 2, 3, or whatever number of times is necessary. If 1 observer censuses 4.5 times through the 8 transects and another person 3.5 times, among-treatment variation will be biased.

This does not mean that 1 observer must census all transects in 1 day. One census taker can census half the transects and another census taker the other half in the same morning. On following days they can alternate, and each person can census the other set of transects. If it is not possible to eliminate observer bias of among-treatment variation through census design as suggested above, variation caused by observer bias can be partitioned out with a 2-way ANOVA.

Weather

Generally, extreme weather conditions that affect bird activity should be avoided. We usually do not census birds if the wind is above 20 km/h or if there is substantial rain or snow. A light sprinkle of rain or brief snow flurry does not appear to decrease bird observations. If different treatments are sampled during different weather conditions, high weather variability can increase within-treatment variation of bird abundance and bias among-treatment variation.

Which Birds to Count

Some confusion can arise over which birds to count when censusing. We suggest that all birds seen or heard in the strip transect be counted. This would include birds that flew out of, or landed in, the strip transect. Birds sitting on boundary markers of the transect should also be censused. Some observers may wish to count birds that fly through the transect area if the bird is within a pre-set distance (e.g., 20 m) above the ground. Whatever system is used, it is important that all observers follow the same guidelines on all transects in order to minimize within-treatment variation.

When comparing treatment effect on resident breeding or wintering birds, it is important to exclude transient species as well as migrating flocks of species that breed or winter in study areas. Large migrating flocks of birds can greatly bias treatment effects if included in census counts.

Artificial Attraction of Birds

Any artificial attraction of birds is strongly discouraged. Such techniques attract birds that are not within the boundaries of the strip transect and allow those birds to be censused. Only certain species are sensitive to such techniques and may be attracted, although other species may intentionally hide and avoid detection by the observer.

Visibility Differences Among Treatments

If treatments being sampled have great differences in vegetation density, among-treatment variation can be biased. Most well-trained ornithologists census birds mainly by sound rather than sight, thus variable vegetation densities among treatments should not seriously alter bird detections if transect boundaries are well marked and the census taker can determine the location of vocalizing birds.

ANALYSIS OF DATA

Values for bird species diversity, equitability, relative abundance, species richness, and perhaps species composition (a percentage similarity index) can be calculated for each census of each transect. The data for these variables can then be tested for independence, homogeneity of variances, and normality (Sokal and Rohlf 1969:368). A sound experimental design normally ensures homogeneity of variance and independence of error terms.

If data meet the parametric assumptions, they can be analyzed with a parametric Student's *t*-test (2 levels of treatment), or 1-way ANOVA (3 or more levels of treatment), and if significant differences are detected, a multiple comparisons test such as Duncan's New Multiple Range Test can be used to determine which treatments are significantly different.

Alternate parametric tests are available. A 2-way ANOVA design can be used to partition out measurable levels of variation not caused by treatment effects. Multivariate ANOVA is an excellent test to evaluate treatment impacts on biotic communities (Green 1978). If data do not meet the assumptions for parametric tests, 2 options are open to researchers. Sokal and Rohlf (1969) recommended use of parametric techniques when statistical assumptions are nearly met, especially if only 1 assumption, such as normality, is not met. If data deviate greatly from the assumptions for parametric statistical techniques, we suggest use of the non-parametric Kruskal-Wallis test to test for differences among habitat treatments.

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