INTERPRETATIONAL ERRORS IN THE "MAPPING METHOD" AS A CENSUS TECHNIQUE

LOUIS B. BEST

THE "mapping method" (sometimes referred to as the "spot-map method," after Williams 1936) is frequently used by ornithologists when surveying bird populations (Kendeigh 1944, Pough 1947, Udvardy 1957, Williamson and Homes 1964, Hall 1964). Many workers place considerable confidence in the method, using it as an absolute measure of bird density, to delimit territorial boundaries (Johnston 1947; Williamson 1964, 1971), or even as a control in evaluating the accuracy of other census procedures (Howell 1951, Stewart et. al. 1952, Enemar 1959). Stewart et al. estimated the accuracy of the method to be above 90% for nearly every species they studied, and to average over 95%.

Two major sources of error are inherent in such a census procedure: (1) observational bias, resulting from variability in the identification skill of observers, observation conditions (weather, time of day, etc.), screening effect of the habitat, and conspicuousness of the bird species (Emlen 1971); and (2) interpretational bias, resulting from differing interpretations of census data. The compounding effect of these sources of error could result in gross inaccuracies (or less likely, they might offset each other). One major difficulty with the method is the absence of reliable controls to estimate the magnitude and direction of error.

Snow (1965) investigated observational error by comparing results from independent censuses conducted on the same areas. He discounted the importance of interpretational error, reporting that individual estimates of census results "rarely differed by more than 10 per cent." Other workers are of a different opinion. Emlen (1971) has expressed concern over "the wide-range of interpretations that can be extracted from composite maps," and Enemar (1959) feels that error in census work "depends more on inherent properties in a bird population's behaviour as interpreted by an ornithologist, than on special qualities inherent in the census-taker." Bell et al. (1973) discussed sources of discrepancy between actual population sizes of three passerine species (as determined by intensive studies using marked birds) and the estimates from census results using the mapping method.

I first became aware of the difficulty in interpreting census data while studying the effects of habitat alteration on avian communities (Best 1972). Later, while conducting an intensive investigation of the breeding ecology of the Field Sparrow (*Spizella pusilla*), the opportunity presented itself to evaluate interpretational errors in the mapping method.

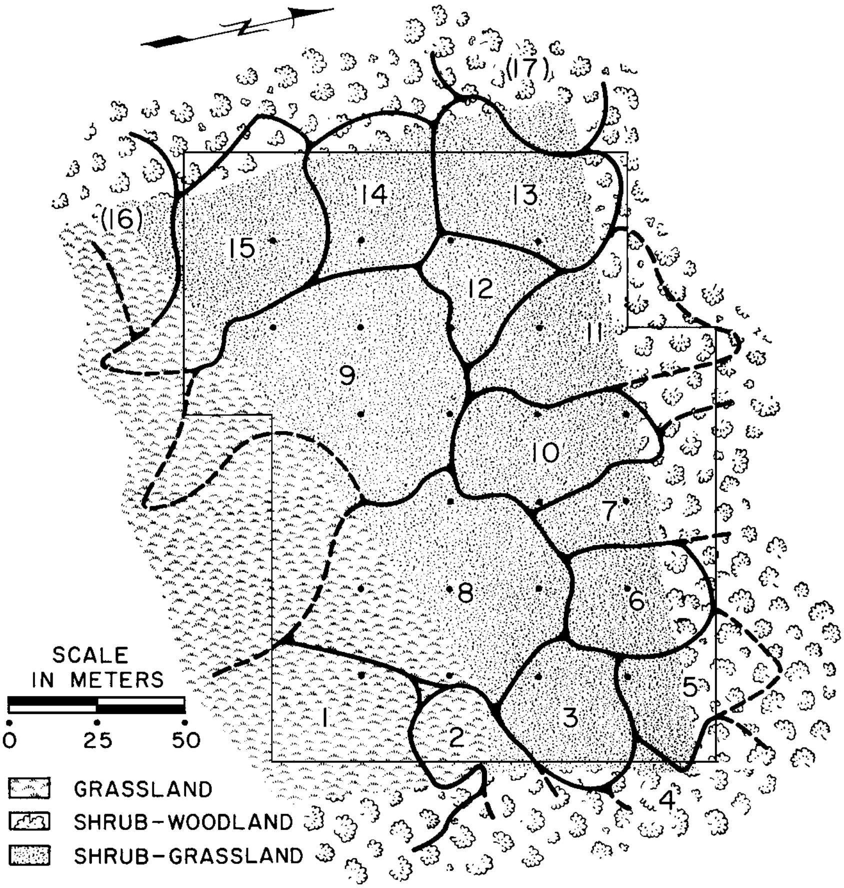

Fig. 1. Census plot showing the actual location of territories. Territories 16 and 17 were included because of their proximity to the census plot.

Methods

The study tract was at Allerton Park near Monticello, Illinois. Most of the 2.25-ha census plot, gridded throughout at 25-m intervals, was covered with shrub-grassland, bordered to the north, east, and west by shrub-woodland and to the south by grassland (Fig. 1). Censusing began after all territories had been established and most males were mated. During the 1972 breeding season the plot was censused 7 times in May, 11 in June, 12 in July, and 7 in August, distributed uniformly over each monthly period. Censuses were conducted between 0600 and 0900 and generally lasted 1 h. During each census the grid lines were followed in a north-south direction until the plot had been completely covered, alternately walking the even- and odd-numbered lines on successive censuses. Censuses were begun alternately on the east and west side of the plot. East-west movement was avoided to prevent walking directly into the rising sun during half the census. All Field Sparrows seen during each census (including sightings adjacent to the study tract) were recorded on a grid map; various symbols were used to indicate singing males, pairs, aggressive territorial interactions, movements, juveniles, and nests. Composite maps were constructed of the census results over biweekly and monthly intervals and each observation dated to facilitate interpretation. Sightings of the same individual bird within 50 m of each other on the same day were indicated.

The completed maps were submitted to five competent avian ecologists for interpretation. These individuals were familiar with the study tract, had conducted censuses involving the Field Sparrow, and had used the mapping method in their own researches. My familiarity with the breeding population (see below) precluded my making an unbiased population estimate from the census data. All individuals were instructed to evaluate the census data as they customarily would using the mapping method. (No specific guidelines or constraints were imposed on the manner in which the data were to be interpreted.) As the five individuals were presented with identical census data, differences in interpretation would reflect the error and variability in estimating the actual breeding population. In the following, these individuals will be referred to as A, B, C, D, and E and their territory determinations as composite maps A, B, C, and D, respectively (Fig. 2). A composite map for E is not included in Fig. 2 because the variability in the monthly interpretations precluded the construction of an overall composite for the season.

The census tract was part of a larger plot used to study the breeding ecology of the Field Sparrow. Adults and nestlings were marked for individual identification using colored leg bands and airplane paint applied to the tail of adults. The study tract was visited 133 times during the course of the breeding season. During each visit the location, movements, and noteworthy behavior of all Field Sparrows were recorded on a grid map and the status of all active nests determined. Composite maps were drawn at the end of the breeding season and used to delineate territorial boundaries. In addition, the breeding activity on each territory was known throughout the season. This information served as a reliable control for comparison with the census results.

RESULTS

On the outset, it should be pointed out that all five individuals interpreting census data commented on the difficulties involved and acknowledged the arbitrary nature of their territory assignments. All concurred that their delimitations of territories represented only rough approximations and did not reflect the actual territory boundaries. Nonetheless a comparison of their composite maps is instructive in assessing sources of error. It is realized that the major purpose of the mapping method is to estimate absolute population size and not accurately delimit territories. However, for this method to be a valid census technique, there should be a reasonable correspondence between estimated territories and those actually present.

Inconsistency characterized the five interpretations of census data, both when compared with the actual territories as well as when compared among themselves. Composite map A approximately delimited territories 7 and 11; map B territories 5, 6, 11, and 15; map C territories

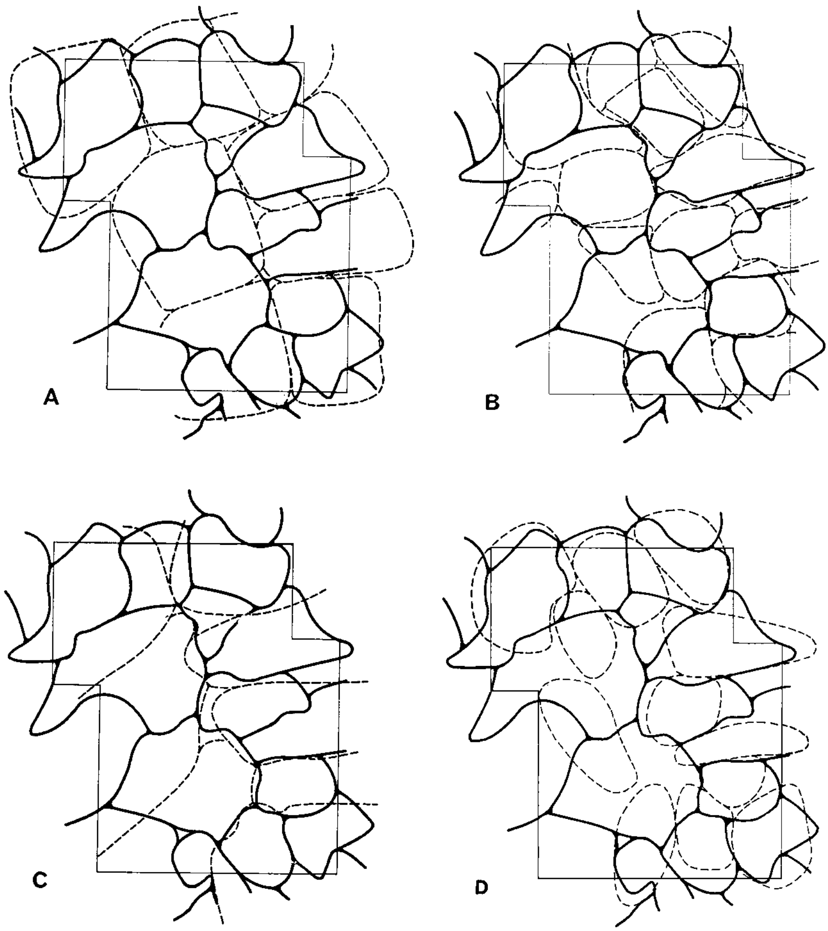

Fig. 2. Comparison between the estimated territories (dashed lines) and those known actually to be present (solid lines).

6 and 11; and map D territories 3, 5, 6, 7, 10, 11, 13, 14, and 15 (Fig. 2). These approximations represented the only apparent relationships between estimated and actual territories. Territory 11 was undoubtedly easier to define because the male was unmated during half of the breeding season and was often noted singing and moving around on his territory. Delimitation of territory 6 was probably facilitated by its confined dimensions and the numerous sightings of movements across the territory.

Before constructing the overall season composites (mentioned above) territories were delimited on a monthly basis by A, B, C, and E (D estimated the breeding population on the basis of May data alone). All four individuals denoted considerable change in territorial configurations from month to month, even during the early summer. In actuality, the territories remained essentially stable (with four exceptions to be mentioned later) until August, when territorial tenacity began to wane and infractions became frequent.

Although considerable uncertainty about territorial boundaries existed from one month to the next, the monthly estimates of the breeding population by A, B, and C remained relatively constant. The population estimates by E varied over the season from 7 to 12 breeding pairs. The overall estimates for the season were highly variable: A and C estimated 8 breeding pairs, E estimated 9 to 10 pairs, D estimated 12 pairs, and B estimated 13 pairs (10¼ excluding portions of territories extending off the census plot). The actual number was 15 (or approximately 11½ if excluding portions off the plot). Although the breeding pair estimates by A and C were identical, the interpretations of census data were no more similar between A and C than between either A or C and any other interpretation (Fig. 2). Likewise the similarity in the estimates of B and D resulted from markedly dissimilar interpretations. Although no apparent relationship was evident between similarity of population estimates and similarity of territory delimitations, there was a rough correlation between the accuracy of the population estimates and the accuracy of the associated territory delimitations. B and D estimated most accurately the number of breeding pairs, and they also successfully delimited the greatest number of territories.

Sources of error become evident when comparing the composite maps with the actual territories. (1) The pair on territory 12 was much less conspicuous in its activities than other pairs, owing partly to its confined movements. This pair was observed about half as often as other centrally located pairs. All composite maps estimated a portion of this territory to be unoccupied and included portions of the actual territory within two or three other territories (Figs. 1 and 2).

(2) Territories located on the periphery of the study area with only a fraction of their total expanse extending into the census plot were generally either overlooked or included in some other territory(s). Territories 1, 2, 4, (16), and (17) are good examples. Peripheral pairs were observed much less frequently than those more centrally located. The pair occupying territory 1 was never recorded during any of the censuses. Other workers have recognized the problems in evaluating fractional, boundary line territories (Enemar 1959, Williamson 1964, Emlen 1971).

(3) With territories 2 and 4 the interpretation is further complicated

by shifts following territory abandonment. Territory 4 was deserted by its original occupant on 2 June and territory 3 on 19 June. Abandoned territory 4 was first occupied by the male in territory 3, but soon after it was totally incorporated within territory 5. When territory 3 was deserted by its original occupant, the male on territory 2 moved into the area and abandoned the grassland portion of his original territory. In composite maps A and B territories 4 and 5 and territories 2 and 3 are combined, and in composite map C all four territories are lumped together. Composite map D best approximates territories 2, 3, and 5, but in this case interpretation was confined to May data before any territory shifting had occurred. An evaluation of the May composite maps of A, B, and C failed to show any significant improvement in estimating territories 2, 3, 4, and 5 when compared with the overall season composites. The shifts in territories had gone undetected. The May territory estimates by E coincided almost exactly with those of D for territories 2, 3, and 5, while the June estimates lumped territories 2, 3, 4, and 5 together into one territory. In this case the territory shifting was detected, but the interpretation did not reflect what actually occurred.

(4) Large territories (such as 8 and 9) were split between from two to five territories on the composite maps. At least three factors contributed to these errors. Females nested on different regions of the territory during subsequent renesting attempts, resulting in localized, apparently disjunct observations. The proportion of time spent on various regions of the territories differed markedly. The dispersion of observations per unit area tended to increase with territory size. The first two factors were also sources of error on smaller territories but to a lesser extent.

(5) Territorial infractions were seen occasionally (even prior to August) and undoubtedly contributed to the confusion in interpreting census data. Renesting on different regions of the territory and territorial infractions could give the false impression of changes in territorial configuration. Transient and nonbreeding resident males, frequently a source of error in other studies, were absent in the present investigation. All males seen during censuses occupied territories and were mated, at least during part of the breeding season. Another potential source of error, although absent in the present study, is large seasonal fluctuations in territory boundaries and dimensions (aside from territory flux resulting from desertions).

Discussion

The relationships between the territories delimited in the five independent interpretations and the actual territories were fragmentary, at best (with the possible exception of composite map D). All five estimations of the actual number of breeding pairs were underestimations. This agrees with Enemar (1959), who concluded that, "the mapping work results in some underestimation rather than overestimation of the stationary population's number when many repeated surveys are carried out." He felt that such underestimations resulted either from (1) males or pairs completely escaping observation or (2) the unintentional inculsion of observations belonging to a given male within adjacent territories, particularly when the observations were few and the area densely populated. The former was a minor source of error in the present study (territory 1), but the latter occurred with high regularity.

Some workers rely exclusively on aural observations when censusing a population. Such a practice severely limits the usefulness of the mapping method, particularly with a species like the Field Sparrow, whose singing is most evident when unmated. There was a total of 286 male observations during the censuses, only 110 (38%) of which were singing males (individually marked birds permitted sex recognition of nonsinging males). Of these singing observations 74 (67%) were of males unmated at the time. Recording additional information on movements, simultaneous observations, territorial interactions, nest sites, parents carrying nest building material or food for young, and juveniles (all of which were included in the present study) certainly add to the accuracy of the results, particularly when territories are contiguous (Pough 1947, Stewart et al. 1952, Williamson 1964, Hall 1964). Adhering less rigorously to specific census routes (i.e. wandering at random throughout the study area) might also provide additional observations valuable in interpreting field data (Pough 1947). The most reliable territory delimitations are possible using methods similar to those of Pough (1947), Odum and Kuenzler (1955), Hall (1964), and Wiens (1969), where the movements of individual males are watched for extended periods and recorded on maps. Individually marked birds would maximize the accuracy of such methods and would make possible the detection of territory shifting and replacements.

Several characteristics of the present study on the Field Sparrow may have made interpretation of census data more difficult when compared with other species or other studies. (1) The Field Sparrow is not sexually dimorphic, making distinction between males and females impossible unless the male is singing or the female either nest-building or incubating. (2) Generally singing intensity was much greater for unmated males than for mated males. (3) Territories were small and contiguous, which tended to condense all observations rather than produce distinct clusters. As pointed out by Williamson (1964), "Judgment in delimiting territories is more likely to be at fault with the diffuse than the close groupings." The composite maps illustrated by Williams (1936) and Kendeigh (1944) represent oversimplifications of what may be encountered when censusing dense populations of fringillids, often with contiguous territories. (4) Aggressive encounters at territory boundaries were minimal. (5) The study area was small (less than one-quarter the minimum size recommended by the International Bird Census Committee, Robbins 1970), thus increasing the proportion of peripheral territories (see Results). (6) All five individuals felt that firsthand field experience would have enhanced their interpretations of the census data. This was a necessary limitation of the study, as my objective was to evaluate interinterpretational bias while controlling sources of interobservational bias. While firsthand experience may be important, that this factor alone could cause the observed discrepancies in interpretation is unlikely.

Conclusions

Results from the present investigation indicate that the mapping method can provide highly variable (and at times only very approximate) estimates of absolute numbers, at least for dense populations of species with small territories. The magnitude and variability of interpretational error are well illustrated in the present study. If results from the mapping method are ultimately to be used in determining avian biomass, energy flow through an ecosystem, or any other application requiring absolute population numbers, it should be done realizing the approximate nature of the method. Caution should also be exercised in comparative studies using data interpreted by different individuals. Further research is necessary to determine if interpretational errors of the magnitude herein reported are similar for other species under different conditions of density, habitat, social structure, and behavior.

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Summary

Using the "mapping method," five avian ecologists independently interpreted identical census data collected on a Field Sparrow population. Their results were then compared with the actual population known to be present as determined by an intensive study using marked birds. The five interpretations were highly variable; estimates of absolute

population size ranging from 8 to 13 breeding pairs for a population actually numbering 15 pairs. Sources of interpretational error are discussed, and a word of caution given to users of this census technique.

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Provisional Department of Ecology, Ethology, and Evolution, University of Illinois, Champaign, Illinois 61820. Present address: Department of Animal Ecology, Iowa State University, Ames, Iowa 50010.
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