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RESIDUAL EDGE EFFECTS WITH THE MAPPING BIRD CENSUS METHOD

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ABSTRACT.—Edge effects on mapping census plots are an important consideration where density estimates are required. The IBCC recommended method for dealing with edge clusters is not fully efficient: in this study between 10% and 27% of edge clusters were found to have been wrongly included on census plots, leading to inflated estimates of density. The sources and implications of these results are discussed.

The mapping method (Enemar 1959, Williamson and Homes 1964) aims to index bird densities by means of selected census plots. One problem with this approach is that territories intersecting the chosen boundaries of the plot are only partially censused; edge effects may generate significant errors (Cousins unpubl. data and 1977).

Standard practice for the Common Birds Census is to include all "edge clusters" (clusters with some registrations inside, and some outside, the plot boundary). For the purpose of indexing population levels, edge effects are eliminated by the process of pairing plot cluster totals across years. Edge effects are similarly unimportant for ecological studies where the positions of registrations are being compared with the habitat structure of the plot. However, for comparison of cluster densities across habitats or between regions, standard measures of density are required and here edge effects are important. Clearly, a proportion of edge clusters should be included in the totals used for the calculation of cluster density, and the rest discarded. The recommendations of the International Bird Census Committee are that clusters should be included only if more than half of the registrations lie within the plot or on the boundary (IBCC 1969). (The application of this rule resulted in an average 3.7% of total territories being discarded from a sample of 20 farmland census plots in 1979.) The present study makes a preliminary assessment of the errors involved with this procedure, using data drawn from the 1979 Common Birds Census.

If a proportion of edge clusters is wrongly included or discarded, the relative error in the estimate of cluster density can be modelled approximately as shown below:

Let: A be the area of a plot with length of edge L; N be the total of clusters on the plot; n be the number of edge clusters; x be the number of wrongly assigned edge clusters; d be the characteristic linear dimension of a cluster, such that cluster area is proportional to d^2; p be the proportion of edge clusters wrongly assigned; and k, k', α be constants, such that $k = k'/\alpha$.

Assuming that—(1) d is much smaller than L; (2) the plot edge is not excessively convoluted; (3) territories are not clumped; (4) edge habitat is representative of the plot; and (5) all parts of the plot are included in one territory or another, then—

(1) the number of wrongly assigned clusters $x = pn$

(2) the number of edge clusters n is proportional to L/d, or

$$n = \frac{k'L}{d} \text{ and } x = \frac{k'pL}{d}, \text{ and}$$

(3) the total number of territories $N = \dfrac{\alpha A}{d^2}$

Thus the relative error in the cluster total

$$\frac{x}{N} = \frac{k'pL}{d} \times \frac{d^2}{A\alpha} = \frac{kpdL}{A}$$

MATERIALS AND METHODS

The relationships predicted by this model were examined using two large plots composed of independently-censused subplots.

Plot A was composed of two subplots (Fig. 1) to which census visits were made quite independently, although by the same team of two observers (one of whom was the author). The common boundary between the subplots ran along the center of a canal bank, wooded on both sides for much of its length; this was the best single feature of plot A in terms of number of territorial species and overall territory density. Plot B (Fig. 2) comprised five subplots, again censused independently, in this case by five separate observers. In contrast to plot A, the common subplot boundaries were ordinary hedgerows, roadways or wood-edges, differing little ornithologically from the external boundaries of the plot. For each plot species maps for each species were drawn up both for the whole plot as a single unit and for each subplot in isolation. After clustering had been completed, edge clusters were selectively discarded according to the IBCC recommendations.

By comparing the subplot species maps with those from the plot as a single unit, it was possible to identify

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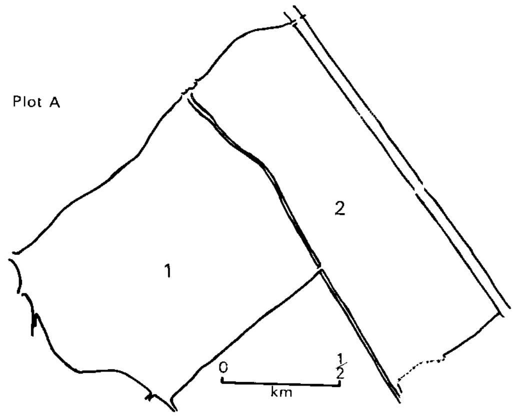

FIGURE 1. Map of plot A showing the distribution of subplots.

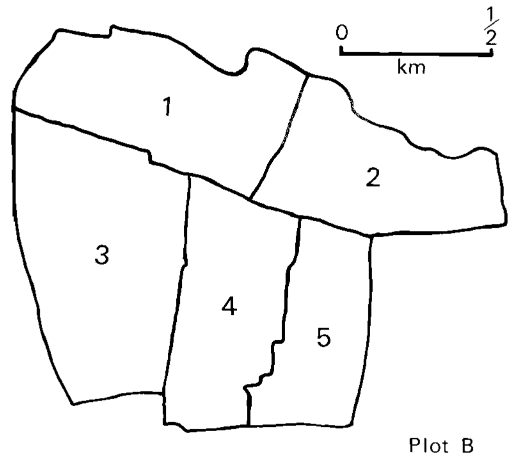

FIGURE 2. Map of plot B showing the distribution of subplots.

clusters included for both of two adjacent subplots. Such double-counted clusters would have given an inflated estimate of density on one of the subplots, were the subplots censused in isolation.

In order that the errors resulting from duplication could be considered a feature of the subplots rather than of their common boundaries, it was necessary to assign duplicated clusters to subplots on a 50:50 basis. Where the distribution of clusters changed markedly as a result of joining the subplots into a single unit, each decrease by one in the total number of clusters was assessed as a duplication, whether or not the subplot clusters leading to the duplication actually overlapped. In most cases, however, the duplicates were similarly positioned on the two subplots. Clusters present on the species maps for the whole plot, but on none of the subplots, were few in number and were not considered in the present study. Such clusters were an artifact of the double amount of visiting effort to the area of the subplot boundaries when considering the plot as a whole.

For each subplot, the number of clusters estimated to have been wrongly included was considered in relation to the length of common subplot boundary and to the total number of edge clusters included along those common boundaries. Further, data from plots A and B were combined so that species could be compared in the percentage of edge clusters double-counted.

RESULTS

On plot A thirty-six clusters were found to have been duplicated and these were assigned equally between the subplots as shown in Table 1. Since the common boundary of plot A bisected the best ornithological feature of the farm, the number of wrongly assigned clusters per kilometer was high. For each subplot an estimate was made for the proportion of edge clusters along the common boundary which were wrongly included. Note, however, that since the thirty-six duplicated clusters were divided equally between the subplots, these two estimates were not independent.

The results from plot B are shown in Table 2, the first part of which has equivalent headings to Table 1 for plot A. Ten duplicated clusters were assigned as shown.

Since there was a much lower frequency of clusters crossing the subplot boundaries on this plot than on plot A, owing to the poorer quality of the habitat for the birds, the number of wrongly assigned clusters per kilometer was much lower on plot B. However, the five estimates of the proportion of the total edge clusters which were wrongly assigned were reasonably consistent and encompassed the estimates from plot A in range. Again for plot B it must be noted that these estimates were not wholly independent.

Since for plot B the outside edges of the plot were similar in habitat to the internal, subplot boundaries, it was possible to estimate the total error in the number of clusters on each subplot due to wrongly included edge clusters. The results of this exercise are also shown in Table 2. These estimations were made on the basis of the number of wrongly assigned clusters per km, and not from the percentage of edge clusters which were wrongly assigned, because edge clusters around the outer boundary of plot B seemed to have been poorly recorded by the observers. It was not possible to make directly equivalent estimates for plot A, because the subplot boundary was so much richer in birds than the external boundaries of the plot.

According to the simple model, the relative error in the cluster totals should be proportional

TABLE 1
ERRORS FROM DUPLICATION OF CLUSTERS ON PLOT A, COMPOSED OF TWO SUBPLOTS

	Subplot 1	Subplot 2
Wrongly assigned clusters (all species)	18	18
Length of common subplot boundary (m)	952	952
Wrongly assigned clusters per km of boundary	18.9	18.9
Total edge clusters along subplot boundary	90	83
Wrongly assigned clusters/100 edge clusters	20%	21.7%

to cluster size, and inversely proportional to the edge:area ratio of each subplot. No cluster sizes were measured on plots A and B, but since the territory size of a species is known to be related to its body weight, the effect of increasing cluster size was examined using body weight as an approximate measure. Larger species tended to be double-counted more frequently, although the trend was not significant: a regression of percentage of total number of edge clusters which were duplicated for each species against log body weight gave $r = 0.053$, df = 54. An angular transformation was performed on the percentage data. As an alternative approach, the square root of the reciprocal of total cluster density was taken as a measure of d, since from the model

$$N \alpha \frac{A}{d^2} \quad \text{or} \quad d \alpha \sqrt{\frac{A}{N}}.$$

The relationship of this measure with the relative error in the estimation of total clusters is shown in Figure 3a for the five subplots of plot B. The correlation was short of significance, however ($r = 0.78$, df = 3, $P = 0.14$).

Figure 3b shows the relationship of the edge: area ratio of the five subplots to the relative error in cluster totals. No significant correlation was present ($r = -0.42$, df = 3) and, against the predictions of the model, the correlation coefficient was negative. However, a partial correlation allowing for the strong effect of d (Figure 3a) gave a positive but still not significant value ($r_p = 0.30$).

Finally, a further attempt was made to characterize the species most likely to lead to the mistaken inclusion of edge clusters. A subjective index of "ease of detection of CBC territories" was prepared from the combined results from four experienced fieldworkers who each scored ease of detection from 1 (difficult) to 5 (easy). There was, however, no correlation between this index and the percentage of edge clusters which were duplicated for each species, transformed to angles ($r = 0.04$, df = 29).

DISCUSSION

The results from both plots A and B suggest that a sizeable fraction (estimated at between 10% and 27%) of edge clusters included according to the IBCC recommendations for the mapping method will not strictly belong to the plot under consideration, and will thus lead to inflated estimates of cluster density. It is probable that observer biases towards censusing more

TABLE 2
ERRORS FROM DUPLICATION OF CLUSTERS ON PLOT B, COMPOSED OF FIVE SUBPLOTS

Subplot	1	2	3	4	5
Wrongly assigned clusters	1	0.5	3	3.5	2
Common subplot boundaries (m)	1280	798	1351	1898	1036
Wrongly assigned clusters/km	0.8	0.6	2.2	1.8	1.9
Edge clusters along subplot boundaries	4	5	11	14	16
Wrongly assigned clusters/100 edge clusters	25%	10%	27.3%	25%	12.5%
Total length of subplot edge (m)	2522	2213	2605	2316	1968
Total clusters on subplot	63	80	70	38	120
Estimated total of wrongly assigned clusters, based on no./km	2.0	1.4	5.8	4.3	3.8
Estimated total of wrongly assigned clusters, as % of total clusters	3.1%	1.7%	8.3%	11.2%	3.2%
Area of subplot (ha)	28.4	25.1	40.1	25.9	18.2

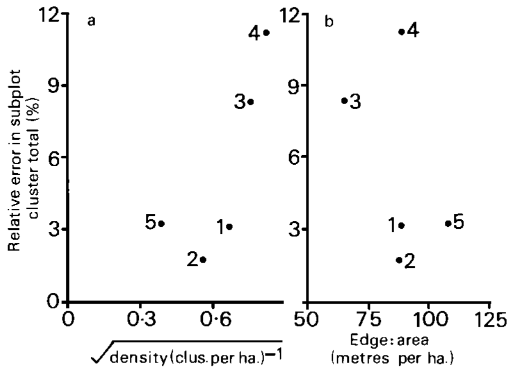

FIGURE 3. Data from plot B showing the relative error in subplot cluster total in relation to (a) a measure of cluster size (see text) and (b) the edge:area ratio of the subplot. Subplots are numbered 1–5.

thoroughly the areas within the boundary than just outside, and towards registering birds seen to cross the boundary as within the plot, are responsible for the inclusion of extra clusters.

Too few data were available to enable the thorough testing of the simple model but, assuming it to be a helpful one, it is apparent that the errors in cluster totals (and hence in density estimates) will be greatest where territory size is large and where the edge:area ratio of the plot is high. The implications of the present study for plot design are that the edge:area ratio should be minimized (as recommended by IBCC 1969), and that boundaries should as far as possible not be drawn through ornithologically rich areas, where as along the canal on plot A a significant number of clusters may be wrongly included.

The similarity between the two plots in the estimates of p, the proportion of the total of edge clusters which were wrongly included, suggests that it may be possible to estimate p in advance and thus produce from mapping census plots estimates of cluster density which are free from this source of edge error.

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