Studies in Avian Biology No. 6:372–376, 1981.

THE INFLUENCE OF OBSERVER AND ANALYST EFFICIENCY IN MAPPING METHOD CENSUSES

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ABSTRACT.—Four observers of varied census experience conducted independent mapping method censuses of a 28.7 ha scrub habitat in the English Chiltern Hills during the 1977 and 1978 breeding seasons. Three trained analysts independently assessed each of the 1977 maps and showed a high degree of mutual consistency of interpretation, independent of field experience on the census plot. The four observers differed significantly as to the density of territorial clusters (all species pooled) they recorded but the absolute range of the four estimates was only 19%. A team of two very experienced field workers detected more birds than did a similarly experienced observer operating alone, and he in turn detected more birds than solo observers with no and two years previous census experience; these differences were partly explained by experienced workers spending longer on each field visit. Pairing of observer results across years eliminated the influence of these observer differences on the four estimates of the year on year change in bird density. The coefficient of concordance between the four observers' estimates of population changes was 0.64, based on data for 21 different species. Thus, population changes can be assessed accurately from mapping method data if the same observer is involved in both censuses and the analysts are properly trained but use of absolute densities requires consideration of observer field ability.

The mapping method (Enemar 1959) is widely regarded as the best available approximation to the true distribution/density of territorial birds in a census area. As such it has been used as a standard to calibrate other census methods, such as the French IPA system (Blondel et al. 1970) and to calibrate studies of census efficiency. There has, however, been little effort to assess the reproducibility of results acquired with the mapping method, despite the known existence of potentially serious sources of error in both fieldwork and interpretation components of the method (Svensson 1974b, Best 1975, Moss 1976). In the Common Birds Census (CBC) scheme of the British Trust for Ornithology—the major systematic users of the mapping method—the censuses are used primarily to compute an annual index of population change (Williamson and Homes 1964, Bailey 1967) and observer effort has been found to be sufficiently consistent from year to year to remove the effects of differences in census efficiency between observers (Taylor 1965). A number of field investigations have reported comparisons of observer census efficiency and broadly agree in reporting significant correlation but recognizable discrepancies between censuses (Snow 1965, Enemar 1962, Hogstad 1967, Enemar et al. 1978).

The present paper reports preliminary results of a systematic field trial of the effects of observer and analyst on the assessment of population densities and year-to-year population changes, using the mapping method of the BTO Common Birds Census scheme. The paper is a written version of a poster paper displayed at the present symposium, to make the principal findings of the study immediately available. The full findings will be described in a report on this and related matters in preparation for the UK Nature Conservancy Council (O'Connor and Marchant in prep.).

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MATERIALS AND METHODS

The field experiment consisted of four observers independently censusing a common plot with their results subsequently interpreted independently by each of three analysts. The observers repeated their census of the plot a year later, to provide data on observer influence on estimation of population changes.

The observers and analysts were chosen to provide a cross-section of census experience (Table 1). All were competent ornithologists but their prior census work differed widely. One was previously familiar with the census plot chosen (Observer C), the other three being unfamiliar with that particular plot. Since Best (1975) suggested an observer familiar with the census plot produced more accurate interpretations of the registration maps later, the three analysts included one who also conducted field census on the plot (Observer A = Analyst W), one with a slight knowledge of the plot through conducting two sets of point count and belt transects there (Analyst X), and one totally unfamiliar with the plot except through sight of the habitat map for the plot. All three had, however, previous training in the interpretation of the IBCC and BTO guiding principles for map interpretation, it being established within the BTO experience that naive analysts do not follow these instructions adequately.

Fieldwork was conducted on a 28.7 ha census plot on Beacon Hill, within the National Nature Reserve at Aston Rowant (Oxfordshire, England). The Hill forms a prominence (244 m asl) extending northwest from the Chiltern escarpment which itself runs mainly southwest to northeast. The Reserve exists for its chalk grassland but the Hill carries much scrub and small woodland. Thus, the plot boundaries encompassed a wide range of habitats, from open well grazed chalk grassland to rough grass paddocks, de-

TABLE 1
INDIVIDUAL OBSERVER AND ANALYST EXPERIENCE OF MAPPING METHOD AND OF THE CENSUS PLOT AT ASTON ROWANT

OBSERVER EXPERIENCE

Observer	Previous field census experience	Previous experience of Aston Rowant
A	Variety of census plots over 10 years	Nil
B	Nil	Nil
C	Two years census work at Aston Rowant	2 years
D[a]	Variety of census plots over 10 years	Nil

ANALYST EXPERIENCE

Analyst	Previous CBC analysis experience, years	Knowledge of Aston Rowant census plot
W	9	Census work as Observer A above
X	4	IPA and belt transect work for this study
Y	0	Nil

[a] Two field workers operating as a team and in field together.

TABLE 2
TWO-WAY ANALYSIS OF VARIANCE FOR 1977 TERRITORY TOTALS WITH RESPECT TO OBSERVER AND ANALYST

DATA TABLE

Analyst	Observer A	Observer B	Observer C	Observer D	Totals	Mean
W	292	259	239	305	1095	273.8
X	277	254	255	294	1080	270.0
Y	277	256	254	302	1089	272.2
Total	846	769	748	901	3264	
Mean	282.0	256.3	249.3	300.3		272.0

ANOVA TABLE

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	28.5	14.25	0.19
Observers	3	4986.0	1662.00	13.87*
Residuals	6	359.5	119.83	

* $P < 0.01$.

veloping scrub (particularly elder) and mature closed beech woodland. This diversity of habitat provided a dense and varied bird community further increased by the "leading line" effect of the Chilterns in bringing migrants to the census plot. The site thus provided a severe test of observer and analyst consistency, mitigated only by an abundance of numbered marker posts and a good network of paths across the plot. The general convexity of the hill precludes very distant sight and sound registrations except within an area of paddocks. There was also some loss of song registration on the southern edge of the plot, due to traffic noise from the adjacent M40 motorway.

Four observers conducted independent ten-visit mapping censuses on the plot in both 1977 and 1978, working to the Common Birds Census guidelines issued by the British Trust for Ornithology. As far as possible, clashes in visit dates and times were avoided by prior arrangement amongst the observers, but occasional spells of poor weather resulted in three cases of two observers on the site simultaneously and one case of three observers simultaneously present. Fieldwork was confined to fore-noon visits. Data from mapping visits were recorded on blank maps prepared for the study and incorporating sufficient detail to allow those observers new to the plot to position themselves accurately at all times. On completion of fieldwork the observers collated their visit map data to generate species maps. These were then photo-copied for systematic assessment by the analysts involved in the study.

The interpretation of the clustered data of these maps was performed in the standard manner defined by the published Common Birds Census Principles (Williamson et al. 1968). Three trained CBC analysts on the BTO staff independently assessed all species maps in 1977, each using his own copy of the maps. In 1978, when assessment of analyst variation was not desired, the map interpretation task was shared by the two analysts then available, each analyzing approximately 120 maps. The analysts differed substantially in experience and knowledge of the census plot (Table 1), this variation being part of the experimental test. However, all three analysts had previously been trained to adequate standards of compliance to the standards defined in Williamson et al. (1968) and were engaged in routine analysis of the annual Common Birds Census returns in parallel with the present study.

Other details of the study site, field procedure and analytical criteria will be documented in O'Connor and Marchant (in prep.).

RESULTS

INFLUENCES ON POPULATION DENSITY ESTIMATES

Table 2 presents the overall results of the 1977 fieldwork, without regard for the specific identity of the species mapped. With each analyst interpreting independently the mapped registrations of each of the four observers, the total range of cluster estimates amongst the three was only 3.8 or 1.4% of the average population of 272 clusters. By contrast, the range in estimates obtained from the four field workers was 51 clusters or 18.8% of the average estimate. Table 2 includes a formal analysis of variance of the data and shows that the differences between observers were statistically significant, whilst those between analysts were negligible.

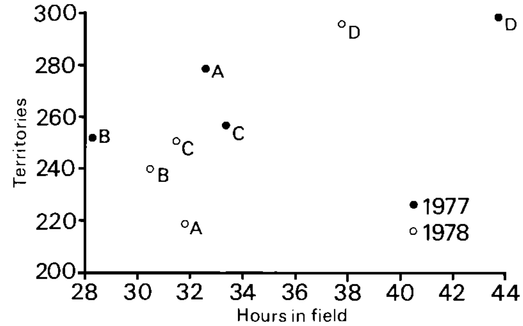

FIGURE 1. The relationship of territories assessed and time spent in field for a constant ten census visits. Letters indicate the observers described in Table 1.

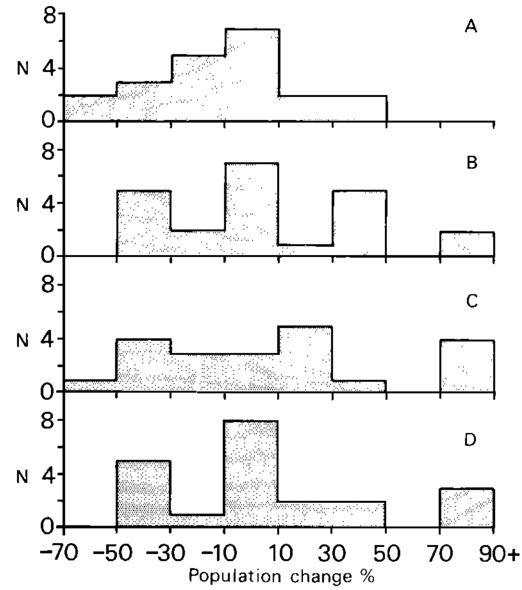

FIGURE 2. The distributions of estimates for 1977–78 population change in 21 species, as assessed by four independent observers A–D (described in Table 1). See text for statistical analyses.

Table 2 shows that observer D—a pair of very experienced census takers in the field together—provided registrations yielding the greatest number of clusters when analysed. The other three observers averaged 262.5 clusters against the maximum 300.3, the difference of 37.8 clusters having a confidence interval of 15.5 (Snedecor and Cochran 1967:301). Similarly, comparisons of the results obtained by the highly experienced solo observer A—mean of 282.0 clusters—against those of the less experienced observers B and C (cluster averages of 256 and 249 respectively) show a difference exceeding their LSD (ibid.) of 18.9 clusters. Thus, even amongst the solo workers extensive experience of the mapping method—in the form of CBC participation—can lead to an improved detection of breeding pairs on the plot.

Figure 1 suggests that the duration of fieldwork was a component in the better field performance of observer D. The CBC fieldwork guidelines do not set down specific targets for field time, though observer *consistency* of effort between years is requested. The figure shows that observer D spent substantially longer on the plot both in 1977 and in 1978 and that their link with greater cluster totals was reflected in an overall (across years and observers) correlation with field time. Since bird density on the site could (and did) vary between years there is no a priori requirement for overall correlation. Within each year the correlations were positive but not significant with only four data points (1977: $r = 0.802$, $P < 0.3$; 1978: $r = 0.870$, $P < 0.2$). Combining the within year correlations by z transformation (Snedecor and Cochran 1967) gave a pooled correlation corrected for differences in bird density of 0.840 ($P = 0.085$).

Influences on Population Monitoring

Although the analysis of Table 2 established the existence of significant differences of census efficiency between observers it left open the possibility that estimates of year on year population changes were independent of observer efficiency. That is, if observers differed between themselves as to absolute census efficiency but maintained those differences from year to year the resulting estimates of population change would be insensitive to observer ability. Figure 2 shows the population changes assessed by each of the four observers for 21 species with adequate sample sizes on the census plot in both 1977 and 1978. The four distributions are similar (Median test $\chi^2 = 2.46$, n.s.), indicating the observers showed no gross differential in census bias between years. A more powerful test for observer influence is to match observers across species since some species increased whilst others decreased on the census plot between the two years. Use of the non-parametric Friedman two-way analysis of variance (Siegel 1956) gave $\chi^2_r = 8.24$ ($0.05 < P < 0.10$). The data thus come close to demonstrating a slight statistical bias on the part of observer A (Fig. 2) but the effect is very slight and dependent on the collective analysis of all 21 species. More detailed analyses for individual species show that in no case was there evidence of observer bias in estimating species population changes.

An alternative analysis of the same problem asks not if the four observers differ in estimating population changes but whether these estimates show significant correlation across species. The agreement between the four field workers was therefore assessed by computing Kendall's coefficient of concordance (Siegel 1956) for the data of Figure 2. The coefficient obtained was W = 0.642 ($\chi^2 = 51.38$, df = 20, $P < 0.001$), to be compared with the value of unity for perfect consistency. There was, therefore, very significant agreement between observers to the population changes undergone by this group of 21 common species.

DISCUSSION

The finding that analyst variation in the interpretation of the mapping method results was negligible is of some significance in the light of previous reports by Best (1975) and Svensson (1974b) who found major differences present. Svensson's study was the more substantial and reports a comparison of interpretation of a common set of species maps by 58 ornithologists of varied experience. Coefficients of variation in estimates for the six species tested ranged from 16 to 36% with some evidence of a slight increase (not statistically significant) with analyst experience. A major complaint of these workers was that they lacked habitat details for the test maps, a point relevant to Best's (1975) report of more accurate results from workers well acquainted with the plot. In the present study the analysts had access to the habitat maps, undoubtedly a factor in improving their performance relative to Svensson's workers. On the other hand, the present data provide no evidence that analyst W was systematically biased in interpretation procedure as a result of his field knowledge of the census plot. It must be remembered, though, that all three analysts had been trained to achieve consistent standards of interpretation of CBC, to allow them to undertake routine analysis of CBC returns, and this would appear to be the most important conclusion of this aspect of the present study.

Differences between observers were far more important than those between analysts but were nevertheless surprisingly small (about 19% in range—Table 2) given the wide differences in observer census experience (Table 1). Enemar (1962) has previously compared the census efficiency of six ornithologists (one of whom had several years previous experience of the census plot) in the course of a single census visit and found considerable variation between observers, with a slight systematic bias in favour of the experienced observer. Within a ten-visit sequence, however, one would expect a reduction in variation because of the binomial cumulation of registrations against a fixed threshold for cluster acceptance (Svensson 1979a). On the average, any two of Enemar's (1962) observers had 75% of their birds in common, indicating a 50% visit efficiency. Such a value would fit Hogstad's (1967) study of four observers and Enemar et al.'s (1978) study of four and of three (in different years) observers. Variation amongst observers in this region of efficiency are greatly reduced by the process of visit cumulation (Svensson 1979a). Other multi-visit mapping censuses agree with the present findings as to relatively small overall variation in population estimates. Chessex and Ribant (1966) found a correlation of 0.990 between the results of two independent censuses of 21 species and Snow (1965) found that paired independent censuses of each of four farms in England were correlated at between 0.824 and 0.964. These reports thus agree with the findings here of significant but probably tolerable variations between different observers using the mapping method.

The link between observer efficiency and time in field indicated by Figure 1 is suggestive but, because of the confounding of variables present, not conclusive. Particularly interesting is the possibility that the confounding of time in field and previous census experience is genuine, with experienced observer's deliberately spending more time over each visit. Svensson (1979a) concluded that improving the effort of individual visits was the best option for improving the overall efficiency of a mapping census. In the same vein, Tomiałojć (1980) recommended concentrating on acquiring high quality registrations (simultaneous song, territorial boundary disputes, etc.) in enhancing census efficiency, a point met by greater time per visit.

The analysis of Figure 2 showed that observers were broadly consistent in their estimation of population changes between years, despite their differences in absolute efficiency. This is a particularly important validation of the large scale use of the mapping method for population monitoring, as in the BTO Common Birds Census, since it provides field data supporting the statistical evidence of between-year observer consistency provided by Taylor (1965). Nilsson (1977b) has previously reported that estimates of population changes for titmice (Paridae), Nuthatch (*Sitta europaea*) and Tree Creeper (*Certhia familiaris*) in two Swedish woodland plots were poorly correlated with changes assessed from intensive study of these populations (using intensive mapping, color-ringing, and nest searching). He identified the causes of these low correlations as phenological variation in breeding activity with respect to the census period. In Britain such variations are less pronounced (O'Connor 1980c) which presumably reduces a possible source of observer variation in assessing population change in the present study. The agreement between observers within the Aston Rowant data (Kendall concordance of 0.64) is very comparable with paired observer correlations of 0.65 and 0.88 for the changes assessed by three observers studying 13 species on a Swedish census plot (Enemar et al. 1978).

Overall, therefore, the present study indicates that with suitable training, map interpretation can be made highly consistent between individuals whilst observer pairing across years adequately eliminates the demonstrable observer bias. For population monitoring purposes, therefore, the mapping method is adequately accurate. For density assessment, on the other hand, observer differences must be taken into account, a point of particular importance when using mapping as a reference standard. Finally, it must be emphasized that the absolute efficiency of the mapping method—the proportions of territorial birds on the plot actually detected—has not been addressed at all by the work reported here.

ACKNOWLEDGMENTS

The fieldwork for this study was undertaken by L. A. Batten, A. J. Prater, P. Toynton and P. and E. Willson and their participation is gratefully acknowledged. Map interpretation was undertaken by L. A. Batten, P. A. Hyde and J. H. Marchant. R. K. Hicks and Caroline Hunt helped with the tasks of map preparation, sorting and collation of results. I am grateful to Drs. R. J. Hornby, P. M. North and to S. M. Taylor for advice in the design and analysis of the experiment. The study was commissioned by the Nature Conservancy Council under a contract with the British Trust for Ornithology for the supply of ornithological services; their support is gratefully acknowledged.