METHODOLOGY FOR CENSUSING LAND BIRD FAUNAS IN LARGE REGIONS

OLLI JÄRVINEN[1,2] AND RISTO A. VÄISÄNEN[1]

ABSTRACT.—As the biological context determines the accuracy needed in bird censusing, no ideal all-purpose methods exist. In particular, many problems in the borderland between ecology and biogeography can, for economical reasons, only be solved with the aid of rapid, one-visit census methods. Using biologically meaningful examples, we here review methodological problems encountered by us in an extensive line-transect project in Finland and adjacent countries in 1973–77. As line transects do not aim at giving absolutely accurate estimates of density, the methodological program is simply to minimize error variance, and minimize bias. The following points are discussed:

(1) The methods adopted in field-work must be well standardized, for example, with respect to dates, census hours, and the time used per unit area. Further, standards for weather conditions must be sufficiently strict. (2) Field tests for determining the accuracy of the census compared with other standardized methods are necessary. (3) All areas should be sampled on phenologically comparable dates in all years. (4) The censuses should be maximally dispersed over the region. (5) The censuses should sample all relevant habitats in approximately correct proportions. (6) Owing to interobserver variation, the consistency among censuses made by different observers should be carefully checked. (7) All major observers should cover as wide areas as possible, and all regions should be covered by more than one observer. (8) In interpreting the results, distrust deviating points. (9) In long-term comparisons, where interobserver variation cannot be checked in field tests, devise tests examining the null hypothesis that the patterns observed can be accounted for by changes in the ability to census.

Finally, we list several problems connected with analysis of transect data.

Population ecologists study the distribution and abundance of organisms in relation to different factors, while biogeographers usually focus on broad patterns of geographical distribution. However, population ecology and biogeography do not seem to be as close to each other as would be desirable, but the patterns studied in the two disciplines appear to be separated by a substantial gap. We can illustrate this best by means of examples.

Example 1.—It is presumably generally agreed that densities tend to decrease towards the geographic periphery of the species range. But the data available are scattered, often inconclusive, and in many cases simply nonexistent. *Densities may decrease towards the range boundary, but how much? What are the typical patterns in different species? Are smooth declines or abrupt drops the dominant pattern?*

Consider the most abundant passerine breeding in southern Finland, the Chaffinch (*Fringilla coelebs*). Its densities (Fig. 1) show a consistent decrease towards the northern range boundary in Finland. Maximum regional densities, as determined from transect data, exceed 50 pairs/km^2, while the species becomes very scarce near the Arctic Circle, about 500 km north of the southern peak densities in Finland. As the density classes used in the map are logarithmic, the decrease is actually very steep; the range of the

Chaffinch thus seems to come to a fairly abrupt end in the north. In southern Finland our censuses (Haila et al. 1980a) have often revealed densities of over 100 pairs/km^2 in favorable habitats for the Chaffinch (maxima near 200 pairs/km^2). Reports from southern Scandinavia or Central Europe (e.g., Enemar 1966, Grempe 1973, Williamson and Williamson 1973, Witt 1976) indicate similar densities, implying that the densities of the Chaffinch are fairly high in a large region extending from Central Europe to southern Finland, but then the densities suddenly decrease. This decrease coincides with the increase of the ecologically similar congener, the Brambling (*F. montifringilla*); the density ratio of the two species changes about 10,000-fold within 600 km in Finland (Fig. 2; for additional data and discussion, see Järvinen and Väisänen 1979a).

We conclude that data on quantitative distribution patterns should be available for elucidating details of geographical distribution and for finding out possible ecological causes for range limitation. Let us take another example.

Example 2.—Data on the quantitative aspects of faunal dynamics are meager, but they are often essential in understanding ecological or zoogeographical patterns. An instructive example is provided by the remarkable range expansion of the Scarlet Rosefinch (*Carpodacus erythrinus*) in Finland, studied in detail by Stjernberg (1979). The species breeds both in closed forest habitats, particularly edges of luxuriant forests, and in various bushy habitats created by man. The proportion of birds breeding

---

[1] Department of Zoology, University of Helsinki, P. Rautatiekatu 13, SF-00100 Helsinki 10, Finland. Permanent address of both authors.

[2] Department of Biological Science, Florida State University, Tallahassee, Florida 32306.
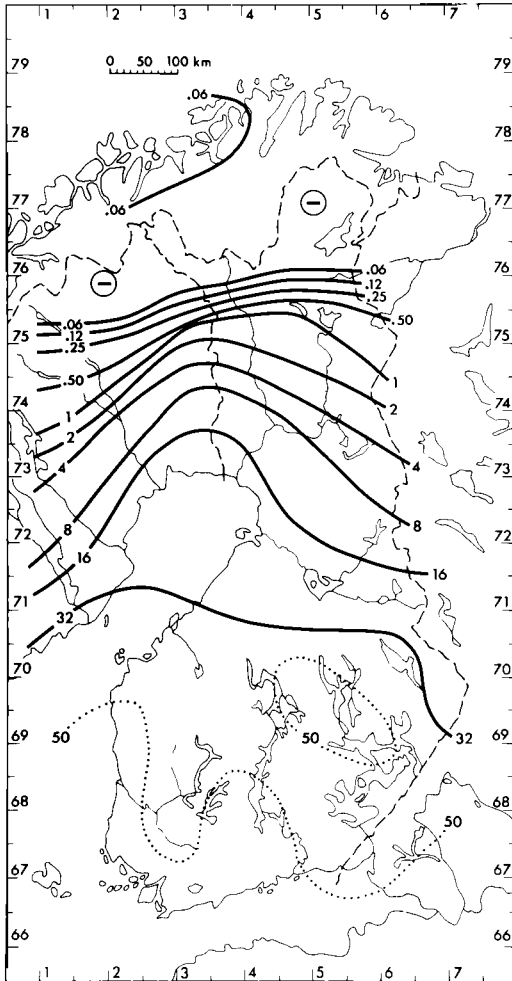
FIGURE 1. Transect density (pairs/km²) of the Chaffinch in Finland and adjacent areas (total 495,000 km²) in 1973–77. The lowest density given is 0.06 pairs/ km², and the highest 32 pairs/km², in geometric progression (ratio of adjacent curves 1:2). Densities of 50 pairs/km² and greater are also shown. The encircled minus signs in the north indicate that Chaffinches were not observed in the censuses, though they may breed in the area in low densities. The coordinates refer to the 100-km squares of the Finnish uniform grid.
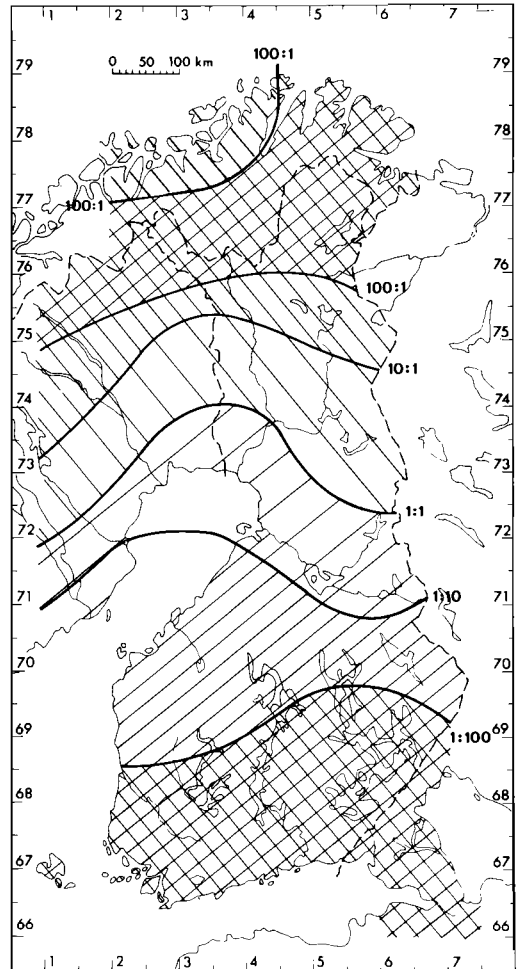
FIGURE 2. The ratio of the density of the Brambling to that of the Chaffinch according to line transects censused in 1973–77. From Järvinen and Väisänen (1979a).

in open habitats has increased considerably in recent decades; the breeding success was twice as high in the new open habitat as in closed forest habitats. *But is this a sufficient explanation for the range expansion observed in Finland?* Stjernberg could, on the basis of quantitative estimates on changes in the breeding numbers in Finland during the three past decades (Järvinen and Väisänen 1976c, 1979b), show that the changes he had observed in breeding success

were a sufficient explanation for the range expansion and population increase of the species in Finland.

Similarly, it has been possible to show that several species associated with spruce forests have increased roughly in proportion with the increased coverage of spruce in Finnish forests, and that species associated with old forests have decreased more dramatically than the area of old forests (e.g., Järvinen and Väisänen 1979b and references there). As an example, consider the guild of foliage-gleaning resident insectivorous passerines of coniferous forests in Finland (Fig. 3). Their densities have crashed in northern Finland where old forests have been extensively cut, but, as the forestry statistics show, consid-
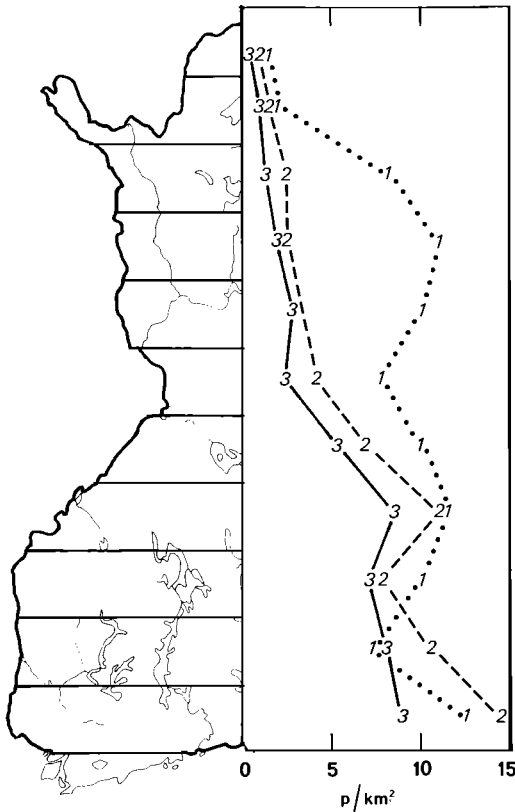
FIGURE 3. Density (pairs/km²) of the guild of foliage-gleaning resident insectivorous passerines of coniferous forests (*Parus cristatus, P. ater, P. montanus, P. cinctus, Certhia familiaris,* and *Perisoreus infaustus*) in 100-km zones in Finland in the 1940s (1), 1950s (2), and 1970s (3). The population crash in the north is due to similar decreases in those species of the guild which are abundant in northern Finland. From Järvinen and Väisänen (1979b). See also Järvinen and Väisänen (1979a).

erable areas of old forests are still standing in northern Finland (Järvinen et al. 1977a, Järvinen and Väisänen 1979b).

It is obvious that censusing land-bird faunas in large regions cannot be so accurate as censusing birds in a 10 ha woodlot. The problem is to develop a methodology for eliminating errors or at least estimating quantitatively the probable magnitude of the errors involved. The program is certainly simple—*minimize error variance and minimize bias*—but it is abundantly clear that the problems are complicated.

In the following, we shall sketch the major methodological problems we encountered in an extensive project in Finland in 1973–77. We used the line-transect method (Järvinen and Väisänen 1976c), but we attempt to discuss the

problems on a more general level, paying special attention to problems that are still, in our opinion, poorly understood.

CHOICE OF THE METHOD

The first problem is clearly to choose the census method. This tends to be an economical problem, as sampling large regions implies high costs. In our transect project, more than 120,000 pairs of land birds were censused in 1973–77, and only the time used for censusing in the field required about 5000 hours. Therefore, the only economically feasible alternative seems to be to accept rapid one-visit census methods, even if more accurate choices, such as mapping or multiple-visit censusing, exist. This is especially so because the study area must be covered fairly evenly.

STANDARDIZATION OF THE FIELD-WORK

It is an essential requirement that the census method be standardized as well as possible. Before discussing specific problems, we first describe the field procedure (for details, see Järvinen and Väisänen 1976c).

In Finnish line transects the observer records all birds (pairs) observed, those within 25 m of the transect separately. The transects are previously planned on a map, and an attempt is made to include all major terrestrial habitats of the region in approximately correct proportions; the observer also reports the coverage of different habitats on the transect, as determined in the field. The censuses are made in early morning from 04:00 to 09:00, with little flexibility; censusing is not permitted if wind or rain impair detectability. The recommended census dates are June 1–20 in southern Finland and June 10–30 in northern Finland, but somewhat earlier and later censuses are accepted, according to exact rules depending on latitude, that is, on phenological differences in different parts of the country (see Järvinen and Väisänen 1977c). Two features of Fenno-Scandia make the transect method especially favorable: the breeding season of land birds is much more compact than in more southern regions, and there are, thanks to a long Fenno-Scandian tradition, only few legal restrictions to conducting bird censuses—or other undamaging and nondisturbing activities— in areas of one's free choice.

ACCURACY OF THE METHOD

Line transects, as one-visit censuses in general, do not give absolute densities, but underestimate the true numbers. Three experiments have compared the efficiency of the line transects with mapping, which is certainly a more

accurate method (see Enemar et al. 1976, 1979) than any of the one-visit methods, though not faultless (Svensson 1974b, Nilsson 1977b, and references there). One experiment was made in a Polish forest, another in a south Finnish forest area, and a third one in north Swedish mountain birch forest. Two of the experiments (Järvinen et al. 1978a, 1978b) were made in optimal conditions and suggested an average efficiency of 80% or more of the mapping result, while an experiment in a boreal forest area in southern Finland made under more typical conditions (Tiainen et al., in press) suggested an average efficiency of 60–65%, which agrees with estimates derived from mapping studies (Järvinen 1978b and references there). However, too few experiments have still been made. There are no definite data on whether census efficiency varies latitudinally or according to habitat, and data on interspecific differences in detectability are scanty (see Järvinen 1978b). Well-conducted comparisons between standardized methods are thus badly needed, and we urge that primary data be published as extensively as possible.

DISTRIBUTION OF CENSUSES IN SPACE AND TIME

As phenological differences are a major source of error in bird censusing (Järvinen et al. 1977b and especially Slagsvold 1977), these should be eliminated as completely as possible. For example, we compared older censuses, especially those of Merikallio (1958), with new censuses made in the 1970s. Because he continued his censusing to about mid-July, parts of Merikallio's data were obviously not comparable. After imposing identical constraints on census dates, however, the average census dates became very comparable: the average date for the censuses made in 1936–49 was June 22, while it was June 17 for 1952–63 and June 19 for 1973–77; incidentally, the average for 1936–63 was also June 19. In these calculations we eliminated the bias that different latitudinal zones were studied with variable intensity. At the same time, the censuses should be phenologically comparable within the region; for example, in our censuses the average dates for southernmost Finland are June 15, but for northernmost Finland June 25. Finally, alleged annual population fluctuations involve a considerable source of error if different areas are sampled in different years. The methodological rule is thus clear: *Sample all areas on phenologically comparable dates in all years.*

In studying population changes, it is usually not realized that the spatial distribution of the censuses has a prominent role. This comment applies both to the regional and to the habitat
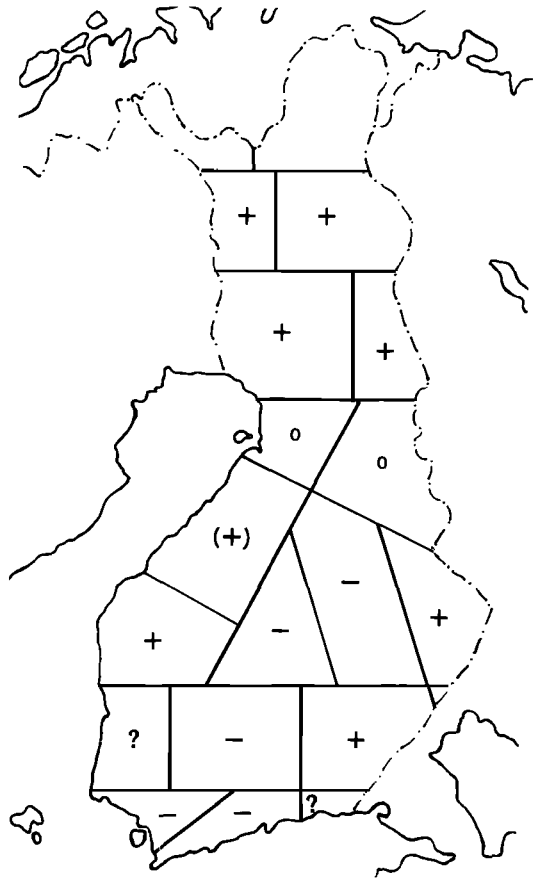

FIGURE 4. The direction of changes in the numbers of the Curlew in different provinces of Finland from the 1940s to the 1970s. Even in total numbers in Finland have changed little, decreasing trends (minuses) dominate in the south and increasing trends (pluses) in the north.

scale, as population trends in different habitats and different parts of the range may be different. An example illustrates the importance of this methodological remark.

The range dynamics of the Siberian Tit (*Parus cinctus*) and the Crested Tit (*P. cristatus*) have been cited as an example of the climatic amelioration influencing the balance of two presumed competitors (Lack 1954). Quantitative censuses from recent decades reveal, however, that the actual pattern is much more complicated (Järvinen and Väisänen 1979a). Both species seem to have decreased owing to forestry, and—quite to the contrary as expected from competition theory—the region of *maximum* decrease has been in the overlap zone of the two species.

It is probably agreed by the majority of ornithologists that peripheral populations fluctuate

more than central populations, but it is a fact that quantitative studies of population changes seldom consider the regional patterns. It is certainly true that country-wide population indexes can be useful, but it should be realized that they mask regional differences in population trends. Fig. 4 shows population trends of the Curlew (*Numenius arquata*) in Finland. The species is classified as stable on the basis of country-wide data, but what has happened is that the decrease in the south has been approximately compensated by increasing numbers in the north.

Similarly, it is probably generally agreed that avian numbers in suboptimal habitats fluctuate more than in optimal habitats (Fretwell and Lucas 1969, von Haartman 1971), but it is a fact that quantitative studies of population changes seldom make an attempt to cover all habitats in approximately true proportions. We thus insist on the following methodological rule: *Censuses should be maximally dispersed over the region, and they should sample all relevant habitats in approximately correct proportions.*

INTEROBSERVER VARIATION

A major problem is that different ornithologists must be used in censusing large areas, so interobserver variation is introduced into the results. Part of the differences can be eliminated easily. For example, the census reports sometimes clearly show that the standard rules have not been followed; such censuses should naturally be discarded. In our own work we have analyzed the results of each transect census (total number about 1000) separately and checked whether or not the results conform to the general pattern: are the densities reported similar to those reported by other observers censusing similar habitats in the same region? It has been our experience that very few censuses deviate on the basis of this criterium; less than 1 per cent of all censuses were discarded on this basis. So we suggest the following rule: *Search for consistency among censuses made by different observers.*

The following rule guarantees that no larger area merely reflects the effect of an exceptional observer: *Cover all regions by more than one observer.* Another important rule is clearly: *See that all major observers cover very different areas.* For example, most of the major observers in our transect project made censuses both in southernmost and northernmost parts of Finland, and all major observers traveled hundreds of kilometers owing to the census work. This methodological rule gives a solid basis for evaluating geographical trends in the results, as it can be checked that different observers report the same trends.

A peculiarity of the Finnish line transects is that each census report has two parts: the observer must report all birds observed, but give a separate list for the so-called main belt, that is, the birds observed within 25 m of the transect. In analyzing the data for each transect we have thus different possibilities for evaluating interobserver differences: we calculate, for each transect separately, the results for the main belt and the results based on all observations, using two different methods (see Järvinen and Väisänen 1980:68). We see two main types of discrepancy. Firstly, certain observers, none among the most experienced, reported average densities based on all observations, but their main-belt data indicated substantially higher densities. We attributed this type of discrepancy to errors in estimating the width of the main belt and ignored the main belt data. Secondly, we have developed certain correction methods for analyzing transect data (Järvinen and Väisänen 1976b), but the applicability of the correction method has been checked for each transect separately (for details, see Järvinen and Väisänen 1980:68).

A final point in eliminating errors due to the effect of single observers was our interpretation of the final results: we ignored all patterns based on deviating values in single 100-km squares, which were the basis used in analyzing the data. As adjacent squares were generally censused by a considerably different set of observers, interobserver differences were certainly decreased on the basis of the following rule: *In interpreting the results, distrust deviating points.*

The problems become more intricate when population changes over long periods of time are studied. We have studied long-term trends in Finnish land bird populations on the basis of transect data, but, of course, some of the trends may be artifacts caused by interobserver differences. It may be argued that we should expect to see a bias towards increased numbers in the results of the census, because field ornithological skills have undoubtedly hugely improved in recent decades.

If this hypothesis is a scientific one, it is testable. It is clear that direct tests in the field cannot be made. But, for example, the hypothesis would predict that population trends do not show geographical patterns, but they do (Figs. 3–4 and our unpubl. data on many other species); and it would be predicted that most population increases are observed from the 1950s to the 1970s, but, in actual fact, many population changes occurred from the 1940s to the 1950s, according to our analyses (e.g., Järvinen et al. 1977a, Järvinen and Väisänen 1978, 1979b). This is significant, because most cen-

suses in the 1940s and the 1950s were made by a single man, Einari Merikallio. Tests based on methodological ideas can also be devised.

In line transects, birds within 25 m of the transect can certainly be censused more easily than those outside the 25 m belt. For example, two European pipits, *Anthus pratensis* and *A. cervinus*, breed in similar open habitats, and their song is similar. However, *pratensis* is much more common than *cervinus*. In view of their similar behavior and habitats we would expect that the proportion of the close (within 25 m) observations is similar in both species, but this is not true (Järvinen and Väisänen, unpubl. data): if the bird is singing far from the transect, many observations on *cervinus* are overlooked or the species is confused with *pratensis*. In other words, the proportion of close observations is an efficient index of observer ability. Essentially this effect has been experimentally demonstrated by Hutto and Mosconi (1981).

Therefore, if the ability of census-makers has improved in recent decades, we expect that the proportion of close observations is higher in the old censuses of Merikallio than in present censuses; but the contrary is true (Järvinen and Väisänen 1975). Another version of this test omits all species observed more often than 10 times in Merikallio's censuses—we may expect that the species observed rarely by Merikallio were especially difficult for him. There were 46 land bird species observed at most 10 times in Merikallio's censuses. Data for single species are, of course, not testable because the sample size is at most 10 by definition. However, the percentage of close observations was more often *lower* than higher in Merikallio's censuses, as compared with the corresponding percentage in modern censuses (lower in 30 species, identical in 4, and higher in 12; 30 is significantly different from 12, $\chi^2 = 7.71$, $P < 0.01$). We also calculated the expected numbers of close observations for Merikallio's censuses, assuming that the percentage of close observations is identical with that observed for the same species in present censuses. We would have expected 48.8 close observations and 156.2 far observations on the 46 rare species, but Merikallio had 29 close observations and as many as 176 far observations. The difference is significant ($\chi^2 = 10.54$, $P < 0.01$), but in the *opposite* direction as predicted from the "observer ability" hypothesis.

The above tests are actually tests of the null hypothesis that no population changes have really occurred but all changes observed are merely artifacts due to interobserver variation. As indicated, these tests, as well as direct comparisons of our data with von Haartman's censuses in SW Finland (see Haila et al. 1980b), allow us to reject the "observer ability" hypothesis for this data set, although we agree that interobserver variation is an important potential source of error in transect studies.

DATA ANALYSIS

Analyzing data is certainly also a problem, but it is not specific to studying large areas. Some of the open problems in analyzing transect data should, however, be mentioned.

(1) The proportion of close observations changes during the census hours and during the season (Järvinen et al. 1976 and our unpubl. data). We use averages in our analysis; but what are the sources of error involved?

(2) Our analytical method (Järvinen and Väisänen 1975) involves the assumption that detectability decreases linearly from the transect, but other functions might better represent reality. Carefully devised experiments are certainly needed here.

(3) Are there realistic possibilities for devising reliable species-specific methods in order to correct for the incompleteness of the census?

Of course, these or other methodological problems should not be studied in isolation, without consideration of the specific needs of the research problem. The science of bird censuses may be regarded as an art of developing the perfect method, and studies in this direction are helpful in illuminating potential sources of error in census work. But bird censuses are also a tool, and we should sometimes give serious consideration to the fact that the ultimate problem is not perfecting the tool, but using it for meaningful purposes.