Ann. Zool. Fennici 15:290—293. 1978

Estimating relative densities of land birds by point counts

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JÄRVINEN, O. 1978: Estimating relative densities of land birds by point counts. — Ann. Zool. Fennici 15: 290—293.

Estimates of breeding density (pairs/km^2) can be obtained in point counts (Swedish type) if the decrease in detectability with increasing distance from the counting point is described by some mathematical function. Assuming a linear relation, a simple formula is derived for computing densities. The accuracy of the method proposed should be sufficient for detecting major differences in bird densities between two areas censused with different methods. Point counts are contrasted to line transects, and the evidence available suggests that, for various reasons, line transect densities are more accurate than those obtained from point counts.

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1. Introduction

In Europe, three methods are widely applied for censusing breeding land birds: mapping, line transects and point counts. Mapping is based on eight or more visits to a well-defined study plot. The number of stationary males is estimated from the maps according to standard rules (ANON. 1970). The results of mapping censuses are not absolutely accurate, but for studying bird densities in small census plots mapping is certainly better suited than line transects or point counts, which are useful for studying extensive areas. Line transects (MERIKALLIO 1946, JÄRVINEN & VÄISÄNEN 1976b) are made by censusing all birds observed along transects so planned that all habitats of a large region are included in their true proportions. Point counts (BLONDEL et al. 1970, SVENSSON 1975), on the other hand, are based on 5- to 20-min stops, during which the birds observed are recorded. Comparison of the results obtained with the three methods, however desirable, is not yet possible in all cases. Experimental data are available on the efficiency of line transects compared with mapping (JÄRVINEN et al. 1978a, b), but conversion of line transect data to densities directly comparable with mapping densities is still premature (though see JÄRVINEN 1978). Coefficients for transforming line transect (I.K.A.) or point count (I.P.A.) data of the French type to mapping densities have been devised by BLONDEL et al. (e.g. 1970; see also AFFRE 1976), but French coefficients cannot be used in northern Europe. There the most serious obstacle to collating census data seems to be the present inability to make meaningful comparisons between point counts (mainly Swedish) and line transects (mainly Finnish). Such comparisons would, no doubt, be of great ecological and biogeographical interest. This paper presents a simple method which can be used for rough comparisons, although subtle differences should be approached with more refined methods.

2. The model

The following assumptions are made:

(1) The data are based on point counts made according to the standard Swedish method (SVENSSON 1975);

(2) an attempt has been made to cover the whole range of habitats; and

(3) counts have been made in the early morning in the breeding season.

In brief, the point counts should resemble Finnish line transect censuses (JÄRVINEN &

VÄISÄNEN 1976b, 1977b) as fully as possible. Walking speed along line transects (1 km/h or slightly more) seems to give about the same chances of observing as the 5-min periods used for observing birds in Swedish point counts.

It has been suggested (AFFRE 1976, HAKILA 1976) that there is a species-specific observation radius (r), and that density (D) may be computed as the ratio of the number of observations per counting point (N) to the area within r, or

$$D = N/\pi r^2. \qquad (1)$$

The AFFRE-HAKILA formula incorporates an empirical species-specific constant, r, which has to be determined separately for each species; it is the distance at which detectability, on average, becomes zero. (AFFRE's analysis has been simplified here. He takes into account singing frequency, which implies that detectability within the observation circle is not 100 %, but a constant fraction of 100 %.)

The main objection to eq. (1) seems to be that the concept of an observation radius is too simple. Empirical data (MERIKALLIO 1946, EMLEN 1971) suggest that detectability decreases with distance, first slowly or not at all, and then more rapidly. Part of the slowness of the initial decrease may be due to the disturbing effect of the observer on birds. It is thus safest to conclude that detectability is a monotonically decreasing function of distance, but the exact shape of this function is not known. However, for most species rather different assumptions lead to virtually indistinguishable estimates of relative densities in line transects (JÄRVINEN & VÄISÄNEN 1975), and so I shall here assume that species-specific detectability (H) decreases linearly with distance (d, in m) from the counting point and that H is 100 % (or unity) at $d = 0$ (i.e. the counting point). These assumptions were made because of their simplicity. The model is described by the following equation:

$$H = -cd + 1 , \qquad (2)$$

where c is a species-specific constant to be determined empirically. Of course, the model is valid only for values of d between 0 and $1/c$.

Equation (2) has the following biological interpretation: individuals of a certain species can be detected within an "observation circle" with a radius of $1/c$ metres. Detectability is not constant, as in the AFFRE-HAKILA model, but decreases from 1 to 0 as distance increases from 0 to $1/c$.

In consequence, detectability decreases in all directions from the counting point, so there is a theoretical "detectability cone" (height 1, radius $1/c$). The base of this cone is the observation circle, with an area of π/c^2. Average detectability is equal to the average height of this cone, which is the ratio of the volume of the cone ($\pi/3c^2$) to the area of the base, or simply 1/3. This means that 2/3 of the pairs occurring within the observation circle will not be detected (cf. JÄRVINEN & VÄISÄNEN 1975, their section 3.6). Hence, density within the observation circle will be $3N$ divided by the area of the observation circle, or

$$D = 3 \cdot 10^6 Nc^2/\pi . \qquad (3)$$

The constant 10^6 in eq. (3) stems from the assumption that densities are expressed as pairs/km². The species-specific constants c can be determined empirically, but it is also possible to use the constants (k) derived for line transect data (JÄRVINEN & VÄISÄNEN, 1977a, give a list of empirical estimates for more than 170 species). Notice, however, that the linear model used for line transects (JÄRVINEN & VÄISÄNEN 1975) and the present linear model for point counts are not equivalent, even though based on similar equations (eq. 2). Two different concepts of distance are involved: right-angle distance from a transect versus distance from a point. My unpublished calculations indicate that, theoretically, substitution of k for c leads to an error of roughly 10 %, though the effect depends on many variables, such as walking speed, singing frequency and the magnitude of c. In most applications the error introduced by the substitution is tolerable.

The above method was applied to S. Svensson's (pers. comm.) point count data from Grimsjö, central Sweden. The results for most species were relatively close to line transect densities estimated on the Åland Islands (the area of Finland closest to Grimsjö). Discrepancies were observed in several species, but the point count data were based on 20 points only (this corresponds to about one standard line transect). Details of these calculations are omitted here, as the comparison between Grimsjö and the Åland Islands is not biologically illuminating.

Another test of the present method was based on HAKILA's (1976) experiment made on 15—18

May 1976 in southernmost Finland. He censused two line transects totalling 8.2 km and made point counts (17 points, total counting time 60 min) in the same area. Equation (3) was used in analysing Hakila's data, though his point counts took an average of less than 5 min. each. Therefore, I calculated a lower estimate (interpreting the data as being for 17 points) and an upper estimate (interpreting the data as being for 60/5 = 12 points) for each species. (The upper estimate overestimates densities, because new observations accumulate most rapidly during the first minutes of counting.)

The results (Table 1) should not be considered a valid census of a spruce-dominated forest, as the census was made earlier in the season than is recommended for line transects (Järvinen & Väisänen 1976b). Fortunately, possible bias of correction coefficients does not prevent comparisons between line transects and point counts. As seen in Table 1, the estimates for *Fringilla coelebs* differ considerably, but differences in the estimates for other species may be due to the small samples and the effect of using k instead of c for computing densities.

Table 1. Line transect and point count densities (pairs/km^2) of birds in a spruce-dominated *OMaT* forest in Vantaa, S Finland, as calculated from HAKILA's (1976) data according to the method of JÄRVINEN & VÄISÄNEN (1977a). Line transect densities are based on eq. (4), and point count densities on eq. (3) (the two figures for each species are a lower and an upper estimate, see text). The 1000k values used are also shown, as they illustrate the range of k in a sample of common species. N = total numbers of pairs observed. Sample sizes for single species can be computed from equations (3) and (4).

Species (1000k)	Line transects (8.2 km, N = 795)	Point counts (17 or 12 points, N = 252)
Columba palumbus (1.702)	5	2 – 3
Cuculus canorus (0.697)	2	0.3 – 0.5
Parus major (6.645)	50	40 – 60
Erithacus rubecula (6.408)	55	40 – 55
Turdus merula (5.616)	25	25 – 35
T. iliacus (4.926)	30	25 – 35
T. philomelos (3.858)	10	8 – 12
Phylloscopus trochilus (3.772)	35	20 – 25
Ph. sibilatrix (5.498)	40	35 – 50
Regulus regulus (8.874)	40	40 – 60
Anthus trivialis (3.759)	30	20 – 25
Carduelis spinus (3.431)	5	2 – 3
Fringilla coelebs (4.632)	120	65 – 90
Total	450	320 – 455

3. Discussion

Formula (3) is an improvement on previous methods suggested for comparing point count and line transect data, as its assumptions about H are more realistic than in the Affre-Hakila model (eq. 1). If data on singing frequency are available, the approaches of Affre (1976) or Emlen (1977) may certainly be used in combination with equation (3), and the results will then be roughly comparable with mapping densities (cf. the distinction between lateral and basal detectability, Järvinen & Väisänen 1975, Järvinen 1978).

In planning census programmes, different aspects need to be considered in the choice of methods. Point counts are here compared with line transects, as these are alternative methods for similar purposes. Point counts may be preferred owing to convenience (Hakila 1976), and may be easier for observers who have no previous experience of bird census work. However, they have two serious drawbacks.

First, eq. (3) shows an interesting feature when compared with a similar equation derived for line transect data (Järvinen & Väisänen 1975),

$$D = 10^3 nk/L\,, \tag{4}$$

where n = number of observations along transects and L = length of transects (in km). The basic difference between (3) and (4) is that (3) includes the second power of c, but (4) includes the first power of k. As k (or c) is experimentally determined and may have considerable variance if based on scanty data (Järvinen 1976), densities estimated in line transects (eq. 4) are less sensitive to sampling errors than those estimated in point counts (eq. 3), provided that c cannot be more exactly determined empirically than k. This conclusion follows because a v-fold error in k is a v^2-fold error in k^2 (or c^2). This result appears to be independent of the exact assumption we make about the effect of distance on the detectability of birds (eq. 2), as in point counts two dimensions must be taken into account, but in line transects one dimension (right-angle distance from the transect) is sufficient. For the same reason, the exact shape of the function describing the effect of distance on detectability (here eq. 2) is more critical in point counts than in line transects.

Second, observations in point counts show a saturation effect: it is easy to distinguish between a few pairs from a counting point, but if density is high too few records are made (e.g. FROCHOT et al. 1977, WALANKIEWICZ 1977; see also *Fringilla coelebs* in Table 1). This effect can be ignored in line transects, as shown by two experiments (JÄRVINEN et al. 1978a, b); a related effect (JÄRVINEN & VÄISÄNEN 1976a, 1977a) can be corrected with the aid of a simple formula.

Acknowledgements. Dr. S. PANELIUS and Dr. R. A. VÄISÄNEN kindly criticized the text, and Dr. S. SVENSSON provided me with some unpublished data. I am also grateful to Mrs. JEAN MARGARET PERTTUNEN, B.Sc. (Hons.), for revising my English.

References

AFFRE, G. 1976: Quelques reflexions sur les méthodes de denombrement d'oiseaux par sondages (IKA et IPA): une approche théorique du probleme. — Alauda 44: 387—409.

ANON. 1970: Recommendations for an international standard for a mapping method in bird census work. — Bull. Ecol. Res. Comm. (Lund) 9: 49—52.

BLONDEL, J., FERRY, C. & FROCHOT, B. 1970: La méthode des indices ponctuels d'abondance (I. P. A.) ou des relevés d'avifaune par "stations d'écoute". — Alauda 38: 55—71.

EMLEN, J. T. 1971: Population densities of birds derived from transect counts. — Auk 88: 323—342.

—»— 1977: Estimating breeding season bird densities from transect counts. — Auk 94: 455—468.

FROCHOT, B., REUDET, D. & LERUTH, Y. 1977: A comparison of preliminary results of three census methods applied to the same population of forest birds. — Polish Ecol. Studies 3(4): 71— 75.

HAKILA, R. 1976: Pistetakseeraus — linnuston karkea arviointimenetelmä. — Satakunnan Linnut 15: 3—7.

JÄRVINEN, O. 1976: Estimating relative densities of breeding birds by the line transect method. II. Comparison between two methods. — Ornis Scand. 7: 43—48.

—»— 1978: Species-specific census efficiency in line transects. — Ornis Scand. 9: 164—167.

JÄRVINEN, O. & VÄISÄNEN, R. A. 1975: Estimating relative densities of breeding birds by the line transect method. — Oikos 26: 316—322.

JÄRVINEN, O. & VÄISÄNEN, R. A. 1976a: Estimating relative densities of breeding birds by the line transect method. IV. Geographical constancy of the proportion of main belt observations. — Ornis Fennica 53: 87—91.

—»— 1976b: Finnish line transect censuses. — Ornis Fennica 53: 115—118.

—»— 1977a: Constants and formulae for analysing line transect data. — 10 pp., Helsinki (Mimeogr.).

—»— 1977b: Line transect method: a standard for field-work. — Polish Ecol. Studies 3(4): 11— 15.

JÄRVINEN, O., VÄISÄNEN, R. A. & ENEMAR, A. 1978a: Efficiency of the line transect method in mountain birch forest. — Ornis Fennica 55: 16—23.

JÄRVINEN, O., VÄISÄNEN, R. A. & WALANKIEWICZ, W. 1978b: Efficiency of the line transect method in Central European forests. — Ardea, in press.

MERIKALLIO, E. 1946: Über regionale Verbreitung und Anzahl der Landvögel in Süd- und Mittelfinnland, besonders in deren östlichen Teilen, im Lichte von quantitativen Untersuchungen. I. Allgemeiner Teil. — Ann. Zool. Soc. Zool.-Bot. Fennicae "Vanamo" 12(1): 1—140.

SVENSSON, S. 1975: Handledning för Svenska häckfågeltaxeringen med beskrivningar av revirkarteringsmetoden och punkttaxeringsmetoden. — 34 pp., Lund. (Mimeogr.).

WALANKIEWICZ, W. 1977: A comparison of the mapping method and I.P.A. results in Białowieża National Park. — Polish Ecol. Studies 3(4): 119—125.

Received 31. VII. 1978
Printed 30. XII. 1978