On the efficiency of the line transect method: a study based on nest searching[1]

Pekka Helle & Erkki Pulliainen

Helle, P. & Pulliainen, E. 1983: *On the efficiency of the line transect method: a study based on nest searching.* — Ornis Fennica 60:35—41.

A comparison between line transect counts and the real number of nests was made on the remote island of Ulkokrunni in the northern Bothnian Bay, about 20 km off the Finnish coast. The comparison does not include all the nesting species but only those whose nests were sufficiently easily detectable to be counted in their entirety. On the basis of 12 species, the mean efficiency of a single line transect count is shown to be 50 %. The census efficiency for hole-nesting species appeared to be 35 %. The species with the lowest values were *Jynx torquilla, Turdus philomelos, T. iliacus* and *Ficedula hypoleuca,* while the best results were obtained for *Dendrocopus major, Parus major* and *Turdus pilaris.* Two nesting species were missed altogether in the two transect counts, but six species observed in the transect censuses, were probably not breeding on the island. The two transect censuses, carried out on consecutive mornings in similar weather conditions by the same person, gave very similar results. From a number of sets of data it seems that the efficiency of one-visit census methods is higher for common species than for less abundant and rarer species. Some features of the census techniques contributing to this difference are discussed.

Pekka Helle, Oulanka Biological Station, and Department of Zoology, University of Oulu, Torikatu 7, SF-90100 Oulu 10, Finland.
Erkki Pulliainen, Department of Zoology, University of Oulu, and Värriö Subarctic Research Station, University of Helsinki, SF-90100 Oulu 10, Finland.

Introduction

Increasing attention has been paid recently to the methods used in censuses of breeding land bird populations (for references, see Oelke 1980, Ralph & Scott 1981), to the results obtained and to the purposes for which the censuses are carried out. Perhaps due to local conditions and different traditions, different census methods have been used in different parts of the world, especially for population monitoring, e.g. the mapping method in Great Britain and Sweden (see Marchant & Hyde 1980, Svensson 1981), the point count method in Denmark and also Sweden (see Braae & Laursen 1980, Svensson 1981), the "auto-stop method" in the United States (Robbins & van Velzen 1970) and the line transect method (Merikallio 1946, Väisänen & Järvinen 1981) and homogeneous census plot method in Finland (e.g. Palmgren 1930, 1933, 1981).

The reliability of the results obtained by the traditional Finnish line transect method based on a single visit (Merikallio 1946), and the relevance of generalizations made from these results have been the subject of keen discussion (Berthold 1976, Järvinen et al. 1978a, b, Mikkola 1978, Lehtonen 1979, Tiainen et al. 1980, Hildén 1981, among others). It is significant that the methods used in estimating numbers of breeding land birds produce data of different "quality": a line transect "pair" is much more loosely determined than the territory used as a unit in the mapping method (Enemar 1959, Tiainen & Haila 1981); the correlation between territories and nests can also vary with the species and the circumstances (Snow 1965, Enemar et al. 1976, 1978). Therefore, a great many studies and experiments are needed to elucidate the relationships between line transect results, territory mapping results and the real numbers of breeding pairs (number of nests; for transforming the line transect results to true densities, see Järvinen 1978).

The purpose of the present paper is to report the results of a comparison made between line transect counts and the real number of nests on the remote island of Ulkokrunni in the northern Bothnian Bay in the Baltic Sea.

Study area and methods

The study area, the island of Ulkokrunni (65°25′N, 25°00′E), lies about 20 km off the Finnish coast and has been under a total protection order since 1936. The

[1] *Report No. 128 from the Värriö Subarctic Research Station.*

Table 1. The results of the two line transect counts, the mean densities according to the main belt (MB) and survey belt (SB) data and the number of nests of certain forest bird species on Ulkokrunni.

	Census results				Calculated number of pairs according to		Number of nests
	23.6.		24.6.				
	MB	SB	MB	SB	MB	SB	
Dendrocopos major	0	1	1	1	2.5	1.2	2
Jynx torquilla	0	0	0	1	0	0.3	4
Parus major	0	1	1	1	2.5	1.8	3
Certhia familiaris	0	0	0	0	0	0	1
Turdus pilaris	1	4	1	3	4.9	5.8	6
T. iliacus	2	7	2	7	9.9	9.3	23
T. philomelos	0	1	0	0	0	0.5	8
Phoenicurus phoenicurus	1	5	0	4	2.5	3.7	8
Sylvia borin	3	4	1	4	9.9	4.7	4
Muscicapa striata	1	3	1	3	4.9	7.7	6
Ficedula hypoleuca	0	2	0	2	0	3.0	10
Pyrrhula pyrrhula	0	0	0	0	0	0	1
Total	8	28	7	26	37.1	38.0	76

area of the island amounts to 145 ha, of which 90 ha is covered by forests, mainly of the *Cornus-Deschampsia* type (Vartiainen 1980).

The nest-hunting group, organized by E. Pulliainen, consisted of four persons and worked from the end of May to the beginning of August 1981. The search was concentrated on those species whose breeding biology was of special interest and those whose nests were sufficiently easily distinguishable to ensure that they could in fact all be counted (see Table 1). When searching for the nests, the group first tried to map the territories, and then started an extensive nest search, which lasted until the nest was found, or, as in many cases, the male was observed to lack a nest or a mate. The group worked daily and systematically in all parts of the island before the line transect counts, spending altogether about 400 man hours, i.e. about 4 1/2 hours per hectare. Territory mapping according to the standardized rules was not, however, undertaken by the group.

The hole-nesting birds, the nests of which were easy to find in their entirety, provided good cases for comparison with the other species in this study.

The constant line transect surveys, amounting in length to 4050 m, were carried out by P. Helle at 04—07 a.m. on 23 and 24 June in excellent weather conditions (Fig. 1). This seemed to have been timed somewhat too late in the season (see earlier censuses, Helle & Helle 1979), although the phenology of the late spring — early summer was complicated, since late May was exceptionally warm and June was very cold up to midsummer. The numbers of pairs of breeding birds were calculated (or estimated) from the transect data in three ways: (1) according to the main belt data, (2) the common species according to the main belt data and the rarer species with the aid of the supplementary belt (this has also been used in the earlier studies dealing with the land birds of the Krunnit islands, see Merikallio 1950, Helle & Helle 1979), and (3) according to the survey belt data with species-specific correction coefficients (Järvinen & Väisänen 1977).

The results of the nest hunting were accepted as representing the situation on 23—24 June, i.e. the nests in use at that time. The study was restricted to the forest area of the island, and the "forest species" were defined by reference to Helle & Helle (1979), excluding *Acrocephalus schoenobaenus*. The results of the line transect counts were used to calculate densities for the forest area of the island (Table 1).

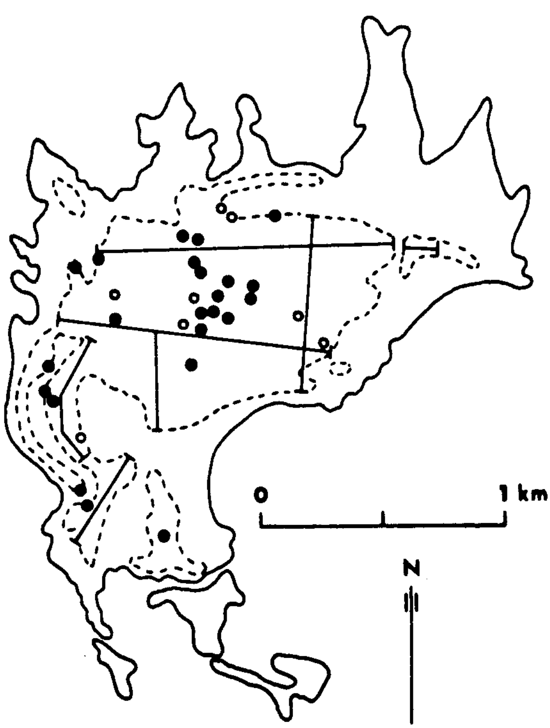

Fig. 1. The island of Ulkokrunni, its forested areas (bounded with broken line) and the constant census routes. The nests of the Redwing (●) and the Song Thrush (○) are shown as examples of the nest search results.

Results

Efficiency of the line transect method. For those species whose nests were presumably all found, the mean efficiency of a single line transect count is 50 % (Table 1). Since it is still possible that the nest findings were incomplete, this percentage must be regarded as the maximum. The census efficiency for the hole-nesting species appeared to be 35 %. The species which are active at night to some extent, *Turdus philomelos, T. iliacus* and *Phoenicurus phoenicurus,* were detected with an efficiency of 35 %, while the species with the poorest efficiency values were *Turdus philomelos* (survey belt efficiency 6%), *Jynx torquilla* (13 %), *Ficedula hypoleuca* (30 %) and *Turdus iliacus* (41 %). The "best" results were obtained for *Dendrocopos major, Parus major, Turdus pilaris, Sylvia borin* and *Muscicapa striata,* although the values for the last two (see Table 1) suggest that not all the nests of these species had been found, that they had not yet all commenced breeding, or that not all the individuals concerned were breeders.

During the consecutive censuses, 12 and 13 species were identified in the main belt, and a further 10 and 12 species in the supplementary belt, which gives totals of 22 and 25 species, respectively. Although the breeding data obtained in the nest search are partly qualitative in this sense, it can be concluded that at least some, and probably the majority, of the species observed in small numbers in the line transect counts were not actually breeding on the island. Such a deduction can be made only if the study area and all its habitats are perfectly known. Otherwise these species should be classified into breeding pairs according to the general rules of the method (see the 'quality' of the results as discussed in the introduction). Species with nest finds which were not observed in either of the censuses were *Certhia familiaris* (1 nest find) and *Pyrrhula pyrrhula* (1).

Table 2. The results of two line transect counts, made along the same route in similar weather conditions by the same person on Ulkokrunni.

	23.6.	24.6.
Main belt: number of species	12	13
number of pairs	44	46
Survey belt: number of species	22	25
number of pairs	157	172
Pair density (per km^2): according to		
— main belt observations	217	227
— estimate based on one-visit census	211	220
— survey belt observations	180	203

Reproducibility of the line transect method. The two line transect censuses carried out on consecutive mornings gave very similar results: 44 and 46 main belt observations and 157 and 172 survey belt observations (Table 2). Species observed in only one census were *Columba palumbus* and *Turdus philomelos* (23.6.), and *Erithacus rubecula, Jynx torquilla, Corvus corax, Phylloscopus sibilatrix* and *Prunella modularis* (24.6.), all of which were represented by only one pair or a single individual. Some of these at least were non-breeding birds.

The different modes of application of the line transect method gave consistent results (Table 2), and the high positive correlation between the methods using the main belt and survey belt data shows only that the birds were observed in these belts in the expected manner (see also Järvinen & Väisänen 1977). The consistency of the results of the methods using supplementary belt data (methods 2 and 3) is also as expected, the basic difference between these methods being that one uses these observations subjectively (2) and the other objectively (3).

Discussion

In calculating the survey belt densities, we used the species-specific correction coefficients (Järvinen & Väisänen 1977), which are based on the extensive Finnish line transect data. The coefficients are somewhat too low for the Ulkokrunni data, but the scanty material did not justify deriving new values. That the coefficients are too low can be seen from the mean main belt percentage, which is greater than in the data from which the correction coefficients are calculated. On account of this, the survey belt densities remain lower than the main belt densities (Table 2). The relatively high main belt percentage in Krunnit is mostly due to the fact that the supplementary belts include seashore or even open water (see Fig. 1).

The result, that about 50 % of the breeding land birds are detected in a single count, agrees well with many earlier studies (the census efficiency of a single line transect count being roughly the same as the efficiency of a single territory mapping, see e.g. Ralph & Scott 1981 for the literature). In a similar nest search — one-visit census test made by P. Helle in a forest area of 7 ha in Central Finland in 1972, the mean efficiency amounted to 60 %:

	Nest search	One-visit census	Efficiency (%)
Number of pairs	40	24	60
Number of species	16	12	72

The efficiency of a one-visit census is known to vary greatly from one species to another and within the same species from one habitat to another (e.g. Enemar 1959, Williamson 1964, Snow 1965, Bell et al. 1968, Haukioja 1968, Jensen 1974, Mannes & Alpers 1975, Nilsson 1977, Järvinen 1978, Järvinen et al. 1978a, b, Hildén 1981). In most studies the species efficiencies are calculated by comparing the one-visit result with the territory mapping result, the latter often being assumed to be 100 %. This assumption may have caused some extra variation in the results, because the mapping efficiency does not always amount to 100 % (Mysterud 1968, Mannes & Alpers 1975, Nilsson 1977 and references therein; but see Enemar et al. 1973, 1976). Another factor causing overestimates of the efficiencies achieved in one-visit censuses is non-breeding, floating individuals which are interpreted as breeding pairs, e.g. in the line transect method (e.g. Järvinen et al. 1978b). The very high efficiency values for the line transect method reported by Järvinen et al. (1978a, b; 2/3—5/6) may be at least partly due to the above-mentioned factors. The large number of species efficiency values greater than 100 % recorded in previous studies serves to confirm this. Haila & Kuusela (1982) have reported the very high single line transect efficiency of 91 % (compared with the mapping result) in an experiment made in the Åland archipelago, which was, however, probably a consequence of biased distribution of the different habitats in the transect.

Järvinen et al. (1978a) suggest that there may be geographical differences in the efficiency of the line transect method, the best result being achieved in northerly areas. This would be understandable, since the forests of the north are not so dense as those in Southern Fennoscandia, for example, and hence the birds are more easily detectable. The efficiency results from a primeval oak-hornbeam forest in northeastern Poland are high, however, about 80 % (Järvinen et al. 1978b), and thus contradict this "geographical cline". Similarly, the present result fails to confirm this hypothesis, but we must also remember here that (1) the forests of the island of Ulkokrunni are physiognomically similar to those in southern Finland in spite of their northerly location, and (2) the efficiency values reported here originate from comparisons with nest hunting, not with a territory mapping result.

Table 3. Census efficiency (%) for abundant and other species (for definition, see text) in single line transect counts.

	Census efficiency (%)		
	Abundant species	Other species	Total
A Northern Sweden	87/56	87/79	87/74
B Poland	114/119	77/94	93/105
C Southern Finland	55	43	49
D —"—	67	51	59
E Åland archipelago	67	122	91
F Central Finland	63	57	60
G Ulkokrunni	?	49/50	?

Data:
A — Järvinen et al. 1978a: main belt (MB)/survey belt (SB) densities vs. territory mapping
B — Järvinen et al. 1978b: MB/SB densities vs. territory mapping
C — Hildén 1981: MB density vs. nest hunting
D — Hildén 1981: mean MB density vs. the highest density achieved in six counts on the same transect
E — Haila & Kuusela 1982: SB density vs. territory mapping
F — this study: MB density vs. nest hunting
G — this study: MB/SB densities vs. nest hunting

In general, *Parus* and *Turdus* species and many species which sing at night are the most difficult to detect on a single visit (with most non-passerines) and *Jynx torquilla* and *Ficedula hypoleuca* also proved difficult in this study. The present results for *Turdus philomelos* and *T. iliacus* are poorer than in many previous reports (Fig. 1 and Table 1). The best efficiency values in the Central Finland experiment were obtained for *Fringilla coelebs* (71 %) and *Phylloscopus trochilus* (63 %) the other 13 species showing an efficiency of 50 %.

Since the efficiency of the line transect method has not been studied here for all species occurring in the area, one may ask whether the species concerned (Table 1) may be the least suitable for studying by the line transect method. This question is complicated and we will concentrate on only one part of it. Järvinen & Lokki (1978) have analysed one-visit census efficiencies in numerous mapping studies and pointed out that the census efficiency of a species may increase with increasing density; as all the species studied in our efficiency comparison are among the less abundant, the mean efficiency value obtained by us (50 %) may be expected to be too low for the total community. The question whether the census efficiency for a given species is dependent on its abundance was studied by us using several comparisons of single line transect counts with the results of territory mapping or nest searching (Järvinen et al. 1978a, b, Hildén 1981, Haila & Kuusela 1982, this study).

The species of each set of data were divided into two groups, abundant species and others, the abundant species making up about 50 % of each community.

It seems that there is a difference in the mean census efficiency between the abundant species and the others: in four cases the efficiency value for the abundant species is higher and in two cases lower than that of the other species (the difference is statistically significant in one "higher" and both "lower" cases when tested with the 2x2 contingency table (Table 3). So the exceptation that the mean efficiency value of the Ulkokrunni test would be somewhat higher if all species had been studied seems to be right.

Although the data presented in Table 3 were obtained under widely varying circumstances and our test is rather rough, one can see that when the line transect result is compared with the territory mapping result the census efficiency is higher than when comparison is made with the result of nest hunting.

The reasons for the better census efficiency in the abundant species are discussed by Järvinen & Lokki (1978). The first reason lies in the census technique; there is perhaps a greater danger of counting individuals of a common species twice, or even more often, than there is with rarer ones. The second, more ethological hypothesis is that the activity of birds may increase with an increasing number of conspecific individuals and that this might increase the probability of observing individuals belonging to abundant species.

When a remote island is used as a study area, caution should perhaps be exercised in generalizing the results. An advantage of an insular environment is its clear limits, but, on the other hand, it is not known whether the proportion of nonbreeding individuals on a remote island during the breeding season corresponds to that on the mainland, where it can be quite substantial in some habitats (see Cederholm et al. 1974). The proportion may also be very high in the present area, but severe difficulties are encountered in evaluating the number of species breeding on an island (see also Haila & Kuusela 1982).

The fact that the line transect method yields incomplete data would not be serious, if the (low) efficiency level were constant, but since this is not the case, due to seasonal and diurnal differences in the detectability of birds (Bell et al. 1973, Slagsvold 1977, Nilsson 1977, Hildén 1981) and due to personal differences between observers (Enemar 1962, Hogstad 1967, Svensson 1974, Enemar et al. 1978), serious difficulties are encountered in using this method. In the latest application of the line transect method, for monitoring breeding bird populations (Väisänen & Järvinen 1981), the results from the constant routes are used as relative values, without density transformations, as in the Finnish winter bird census (e.g. Sammalisto 1974), the main sources of error being the interpersonal variation and weather conditions. It must be noted, of course, that in estimating bird communities over very large geographical areas or studying general ecological principles, the line transect method is the only one which supplies sufficient data, even though it is somewhat biased (e.g. Järvinen & Väisänen 1981). Palmgren (1981) stresses that the answer to the question of what is the real breeding bird population depends on the purpose of the study.

Finally, attention should be paid to one point involved in the line transect method, which to some extent also applies to other census methods. The transect lines (or study areas) should be very carefully located in the field, to cover the right proportions not only of the different habitats, but also of the different edge habitats, since the bird densities there may be extremely high compared with those in homogeneous habitats (Sammalisto 1957, Helle & Helle 1982, P. Helle, unpubl.). In the island of Ulkokrunni, for example, the transects used are not distributed in the right manner among the different edge zones, but lay excessive weight on the centre of the island, where the bird density is low compared with that in the marginal forest; therefore the densities calculated directly from the line transect results are about 38 % too low (Helle & Helle 1982). This does not, however, markedly affect the present efficiency values, because the species involved in our test are among those distributed fairly evenly over the island.

Acknowledgements. We wish to express our sincere gratitude to Kari Koivula, Jari Mikola, Matti Tynjälä and Ilkka Vatanen for their assistance in the field and to two unknown referees for constructive criticism and difficult questions. Financial support from the Tauno Tönning Foundation is gratefully acknowledged.

Selostus: **Pesimälinnuston linja-arviointimenetelmän tehokkuus: pesien etsintään perustuva vertailu**

Iin Ulkokrunnin saarella Perämerellä tehtiin kesällä 1981 lintulaskentamenetelmällinen tutkimus. Neljän hengen voimin etsittiin pesiä noin kolmen viikon ajan ennen linja-arviointeja, jotka suoritettiin kahtena perättäisenä aamuna (linjat samat, pituus 4.05 km).

Linja-arvioinnin ja pesien etsinnän tuloksia verrattaessa pesätilanne hyväksyttiin mukaan linja-arviointiajankohdan mukaisena (ts. mukana eivät ole myöhemmin käynnistyneet uusintapesyeet). Edelleen mukaan otettiin vain ne lintulajit, joiden pesien voitiin olettaa löytyneen osapuilleen täydellisesti.

Yhden linja-arvioinnin laskentatehoksi saatiin 12 lajin perusteella 50 %. Tulos oli olennaisesti sama, käytettiinpä pää- tai tutkimussaran tuloksia. Kololinnuille, joiden pesien löytyminen oli todennäköisesti 100 %, laskentatehokkuudeksi saatiin 35 %. Yksittäisistä lajeista kehnoimmin yhden kerran laskenta tavoitti käenpiian, laulu- ja punakylkirastaan sekä kirjosiepon. Suhteellisesti paras laskentatehokkuus oli käpytikalla, talitiaisella ja räkättirastaalla. Kaksi pesivää lajia jäi linja-arvioinneissa tavoittamatta. Toisaalta linjoilla havaittiin yhteensä kuusi lajia, jotka eivät todennäköisesti saarella pesineet.

Perättäisten aamujen linja-arvioinnit tuottivat erittäin samankaltaisen tuloksen.

Useiden eri lintulajien laskentatehokkuutta kuvaavien aineistojen perusteella vaikuttaa siltä, että runsailla lajeilla tehokkuus on korkeampi kuin vähälukuisilla lajeilla. Kirjoituksessa pohditaan mm. laskentatekniikkaan ja eri lajien elintapoihin liittyviä seikkoja, jotka voisivat vaikuttaa tähän suuntaan.

References

Bell, D. B., Catchpole, C. K. & Corbett, K. J. 1968: Problems of censusing Reed Buntings, Sedge Warblers and Reed Warblers. — Bird Study 15:16—21.

Berthold, P. 1976: Methoden der Bestandenerfassungen in der Ornithologie: Übersicht und kritische Betrachtung. — J. Ornithol. 117:1—69.

Braae, L. & Laursen, K. 1980: Populationsindex for danske ynglefugle 1978—1979 (Summary: Population index for Danish breeding birds, 1978—1979). — Dan. Ornithol. Foren. Tidsskr. 74:141—145.

Cederholm, G., Flodin, L.-Å., Fredriksson, S., Gustafsson, L., Jakobsson, S. & Patersson, L. 1974: Ett försök att med nätfångst och ringmärkning bestämma andelen icke häckande fåglar i en småfågelpopulation (with English summary). — Fauna och Flora 69:134—145.

Enemar, A. 1959: On the determination of the size and composition of a passerine bird population during the breeding season. A methodological study. — Vår Fågelvärld, Suppl. 2:1—114.

Enemar, A. 1962: A comparison between the bird census results of different ornithologists. — Vår Fågelvärld 21:109—120.

Enemar, A., Sjöstrand, B. & Svensson, S. 1978: The effect of observer variability on bird census results obtained by a territory mapping technique. — Ornis Scand. 9:31—39.

Enemar, A., Höjman, S.-G., Klaesson, P. & Nilsson, L. 1976: The relationship between census results and the breeding population of birds in subalpine birch forests. — Ornis Fennica 53:1—8.

Enemar, A., Höjman, P., Klaesson, P., Nilsson, L. & Sjöstrand, B. 1973: Bestämning av småfågelbeståndets täthet i fjällbjörkskog genom boletning och revirkartering i samma provyta (Summary: Estimation of the density of a passerine bird community by counting nests and mapping territories in the same study plot). — Vår Fågelvärld 32:252—259.

Haila, Y. & Kuusela, S. 1982: Efficiency of one-visit censuses of bird communities breeding on small islands. — Ornis Scand. 13:17—24.

Haukioja, E. 1968: Reliability of the line survey method in bird census, with reference to Reed Bunting and Sedge Warbler. — Ornis Fennica 45:105—113.

Helle, E. & Helle, P. 1979: Changes in land bird populations on the Krunnit Islands in the Bothnian Bay, 1939—77. — Ornis Fennica 56:137—147.

Helle, E. & Helle, P. 1982: Edge effect on forest bird densities on offshore islands in the northern Gulf of Bothnia. — Ann. Zool. Fenn. 19:165—169.

Hildén, O. 1981: Sources of error involved in the line-transect method. — *In* Ralph, C. J. & Scott, J. M. (eds.): Estimating numbers of terrestrial birds. — Stud. Avian Biol. 6:152—159.

Hogstad, O. 1967: Factors influencing the efficiency of the mapping method in determining breeding bird populations in conifer forests. — Nytt. Mag. Zool. 14:125–141.

Jensen, H. 1974: The reliability of the mapping method in marshes with special reference to the internationally accepted rules. — Acta Ornithol. 14:378—385.

Järvinen, O. 1978: Species-specific census efficiency in line transect method. — Ornis Scand. 9:164—167.

Järvinen, O. & Lokki, J. 1978: Indices of community structure in incomplete bird censuses based on a single visit: effect of variation in species efficiency. — Ornis Scand. 9:87—93.

Järvinen, O. & Väisänen, R. A. 1977: Constants and formulae for analysing line transect data. — Mimeo, 10 pp., Helsinki.

Järvinen, O. & Väisänen, R. A. 1981: Methodology for censusing land bird faunas in large regions. — *In* Ralph, C. J. & Scott, J. M. (eds.): Estimating numbers of terrestrial birds. — Stud. Avian Biol. 6:146—151.

Järvinen, O., Väisänen, R. A. & Enemar, A. 1978: Efficiency of the line transect method in mountain birch forest. — Ornis Fennica 55:16—23.

Järvinen, O., Väisänen, R. A. & Walankiewicz, W. 1978: Efficiency of the line transect method in Central European forests. — Ardea 66:103—111.

Lehtonen, L. 1979: Kvantitatiivisen linnustotutkimuksen metodeista ja niiden luotettavuudesta (Zusammenfassung: Über die Methoden der quantitativen Vogelforschung und deren Zuverlässigkeit). — Lintumies 14:1—8.

Mannes, P. & Alpers, R. 1975: Über Fehlergrössen bei Siedlungsdichteuntersuchungen an höhlerbrutenden Singvögeln nach der Kartierungsmethode. — J. Ornithol. 116:308—314.

Marchant, J. H. & Hyde, P. A. 1980: Bird population changes for the years 1978—79. — Bird Study 27:173—178.

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—II. — Ann. Zool. Soc. 'Vanamo' 12, 1:1—143, 2:1—119.

Merikallio, E. 1950: Krunnien linnusto. Kvantitatiivinen tutkielma v. 1939. — Oulun Luonnonyst. Yhd. Julk., A 1(4):1—11.

Mikkola, K. 1978: Linnustoko runsastunut? Vanhojen ja uusien linja-arviointien vertailemisesta. — Lintumies 13:101—103.

Mysterud, I. 1968: Comments on the check method and mapping method as census techniques, with special regard to the problem of estimating the discovery change. — Nytt Mag. Zool. 16:53—60.

Nilsson, S. G. 1977: Estimates of population density and changes for titmice, Nuthatch, and Treecreeper in southern Sweden — an evaluation of the territory mapping method. — Ornis Scand. 8:9—16.

Oelke, H. (ed.) 1980: Bird census work and Nature Conservation. — Dachverband Deutscher Avifaunister, Göttingen.

Palmgren, P. 1930: Quantitative Untersuchungen über die Vogelfauna in den Wäldern Südfinnlands. — Acta Zool. Fenn. 7:1—218.

Palmgren, P. 1933: Die Vogelbestände zweier Wäldchen, nebst Bemerkungen über die Brutreviertheorie und zur quantitativen Methodik bei Vogelbestandaufnahmen. — Ornis Fennica 10:61—94.

Palmgren, P. 1981: What is the true breeding bird population of a census area? — Ornis Fennica 58:141—150.

Ralph, C. J. & Scott, J. M. (eds.) 1981: Estimating numbers of terrestrial birds. — Stud. Avian Biol. 6.
Robbins, C. S. & van Velzen, W. T. 1970: Progress report on the North American breeding bird survey. — Bull. Ecol. Res. Comm. 9:22—30.
Sammalisto, L. 1957: The effect of woodland-open peatland on some peatland birds in South Finland. — Ornis Fennica 34:81—89.
Sammalisto, L. 1974: The status of the Finnish winter bird census. — Ornis Fennica 51:36—47.
Slagsvold, T. 1977: Bird song activity in relation to breeding cycle, spring weather, and environmental phenology. — Ornis Scand. 8:197—222.
Snow, D. W. 1965: The relationship between results and the breeding population of birds on farmland. — Bird Study 12: 287—304.
Svensson, S. 1974: Interpersonal variation in species map evaluation in bird census work with the mapping method. — Acta Ornithologica 14:322—338.
Svensson, S. 1981: Svenska häckfågeltaxeringen 1969—1980: Provytor, punktrutter och vattenfågelområden. — Vår Fågelvärld 40:125—132.
Tiainen, J. & Haila, Y. 1981: Lintujen laskenta. — *In* Tiainen, J. & Hublin, P. (eds.): Lintuharrastusopas, pp. 130—139. — LYL & Luonto-Liitto, Forssa.
Tiainen, J., Martin, J.-L., Pakkala, T., Piiroinen, J., Solonen, T., Vickholm, M. & Virolainen, E. 1980: Efficiency of the line transect and point count methods in a south Finnish forest area. — *In* Oelke, H. (ed.): Bird census work and Nature Conservation, pp. 107—133. — Göttingen.
Vartiainen, T. 1980: Succession of island vegetation in the land uplift area of the northernmost Gulf of Bothnia, Finland. — Acta Bot. Fennica 115:1—105.
Väisänen, R. A. & Järvinen, O. 1981: Pesimälinnuston kannanmuutokset vuosina 1978—80 (Summary: Population monitoring of Finnish land bird species in 1978—80). — Lintumies 16:111—117.
Williamson, K. 1964: Bird census work in woodland. — Bird Study 11:1—22.

Received February 1982, revised November 1982