

COUNTING BIRDS FOR A RELATIVE MEASURE (INDEX) OF DENSITY

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ABSTRACT.—Counts of birds from points or transect lines give an index of population density, even when distances have not been accurately estimated. Factors which influence the counts include the species, age, sex or reproductive group of each bird, the season, habitat, time of day, weather, environmental noise, the observer, the number of other birds being recorded and details of the counting technique. If valid deductions about bird densities are to be made, such influences must be standardized, or their effects removed.

In this paper I review the characteristics of techniques which use counts of birds from points or transect lines, and which do not map territories or estimate accurately the distance of every bird from the point or line. The population density of a species (individuals per hectare, d) may be inferred from the total counted, c , in the area under consideration by the relationship $d = kc$, where k is a coefficient of conversion. This coefficient can be considered as the reciprocal of the effective area sampled, and is large for inconspicuous birds and small for conspicuous ones. The use and applicability of these techniques are determined by the influences which affect the value of k .

INFLUENCES ON THE COUNT

SPECIES

Species differ in how easy they are to see or hear, so the effective area sampled from a point or a line will differ between species. Each species is therefore measured on a separate scale, and the counts of different species may not be added together or used in species-diversity calculations (Sammalisto 1974, Dawson et al. 1978)—a common error.

Within a species, each age, sex or reproductive group may also have its own value of k . For example, Slagsvold (1973b) found that male Song Thrushes (*Turdus philomelos*) in spring could be divided into two groups: mated birds with a very low singing rate, and unmated birds that sang much more. Thus the counts may be weighted heavily towards one section of the population and affected by movement of birds into and out of that section. Some counting techniques register singing males twice (i.e., as representing a pair) and interpret other observations in terms of 'pairs' (e.g., Ferry 1974, Purroy 1974, Järvinen and Väisänen 1976c). I have seen no study to justify the implicit assumption that such weighting corrects for differences in conspicuousness. Only detailed studies such as that of Slagsvold (1973b) can yield useful weighting.

SEASON

Many authors (Kimball 1949, Howell 1951, Amman and Baldwin 1960, Davis 1965, Gates 1966, Robbins and Van Velzen 1967, Blondel et al. 1970, J. T. Emlen 1971, 1977a; Sammalisto 1974, Weber and Theberge 1977, Bibby 1978, Dawson et al. 1978, Lancaster and Rees 1979, Shields 1979, Gill 1980) have demonstrated that for many species the numbers counted, c , varies with the time of the year. We may expect bird densities, d , to vary seasonally with breeding, mortality, immigration and emigration, but we can also expect seasonal changes in conspicuousness, and hence in k . These will be due to changes in behavior, such as singing, and also to changes in the habitat, such as the length of grass or the loss of foliage from deciduous trees. Thus, the effects of seasonal variation in d and in k are impossible to distinguish without information beyond the count alone. At times the numbers counted change much more than density could be expected to (Robbins and Van Velzen 1967, and Fig. 1), so we can deduce a change in k , but not its magnitude. Järvinen et al. (1976, 1977b) found little variation in their measure of k or in total counts over five weeks in the breeding season, but Slagsvold (1973b) demonstrated that at least some species have a very short singing period which may also differ in timing between years, so that k may vary most awkwardly.

The most common response to the problem of seasonal variation in k (and in d when an annual index of density is sought) is to confine field work to a few months of the year or less (Kimball 1949, Purroy 1974, Robbins and Bystrak 1974, Robbins and Van Velzen 1974, Sammalisto 1974, Raynor 1975, Järvinen and Väisänen 1976c, Crook et al. 1977, Källander et al. 1977, Ratowsky and Ratowsky 1977, 1978; Svensson 1977a, Shields 1979). The French Indice Ponctuel d'Abondance method (I.P.A.) uses at each point the highest of two counts several weeks apart in the breeding season (Ferry 1974, Blondel 1975, see also Purroy 1974); and Shields (1979) and Connor and Dickson (1980) recommend counting in experimental and control areas both before and after some treatment is applied

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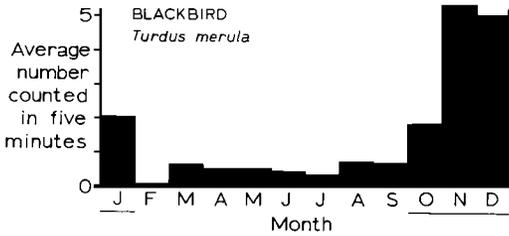


FIGURE 1. Monthly averages of 5-min counts of Blackbirds in New Zealand forest. Based on a minimum of 120 counts a month in each of four study areas in Fiordland, by K. Morrison (pers. comm.), counted as described by Dawson and Bull (1975). The months when young are leaving the nest are underlined. Falla et al. (1970) give the period of full song as August to November in New Zealand. The counts in January and February are much lower than would be expected if the birds were as conspicuous as they were in November and December.

to the experimental one, to overcome seasonal problems.

Some workers have treated seasonal changes as if they might be due to changes in d alone, and have only acknowledged that k may change when their results made no sense (e.g., Sammalisto 1974). This approach could lead to serious error and should be avoided.

HABITAT

Surprisingly few authors have noted that the effective area sampled will vary with such things as the density of the surrounding vegetation, or topography (Howell 1951, Blondel et al. 1970, J. T. Emlen 1971, Svensson 1977a, Weber and

Theberge 1977, Shields 1979), perhaps because many studies were confined to a limited range of habitat types and the (often tacit) assumption was made that the limited variation in the habitats did not materially affect the value of k (Ferry 1974, Crook et al. 1977, Dawson et al. 1978, Shields 1979, Conner and Dickson 1980, Gill 1980). Others have tried to sample habitats representative of the geographical area, and stratified their analysis by broad geographical habitat types (Robbins and Van Velzen 1970, Järvinen and Väisänen 1976c). There seems no way of studying the effect of habitat on k without having good independent estimates of d , but something may be made of the ratio of counts between two species in different habitats, or between the counts of a single species in two seasons and different habitats, if one can assume that there is a characteristic (although unknown) value of k for each habitat in each season (Fig. 2).

Another effect of habitat is on the onset of singing. Slagsvold (1973b) found a correlation between the time that Song Thrushes began singing and the leafing of birch trees (*Betula* spp.); there was a delay in song of 2–3 days for every 100 m rise in altitude. This interaction between habitat and the seasonal course of k could be studied and corrected for.

TIME OF DAY

As with season and habitat, in most published work the time of day has been kept to a limited range, often round and a few hours after dawn, to maximize the numbers counted (Kimball 1949; Blondel et al. 1970; Robbins and Van Vel-

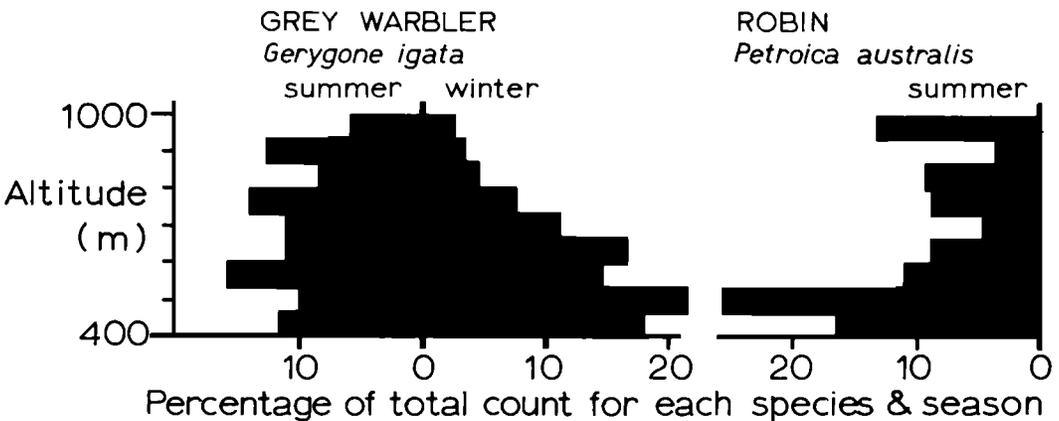


FIGURE 2. Altitudinal distribution of Grey Warblers and Robins in summer (December to February, 33 counts) and of Grey Warblers in winter (June to August, 42 counts) in a mountainside forest in New Zealand. (H. A. Best, pers. comm.). Nine counting stations in forests on the Victoria Range were counted each time, using the technique of Dawson and Bull (1975). In summer the Robin clearly favors lower altitudes than does the warbler. The warbler favors lower altitudes in the winter than it does in the summer.

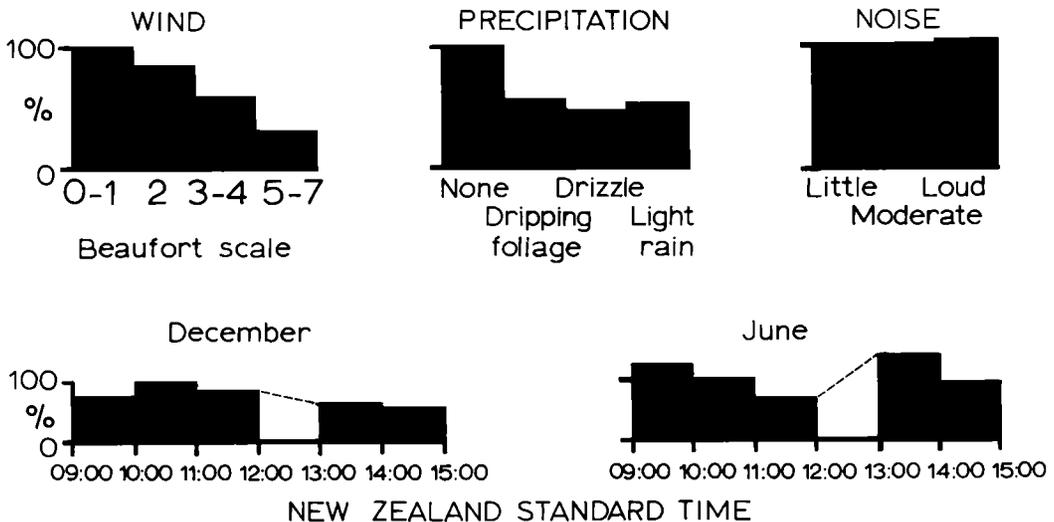


FIGURE 3. Effect of wind, precipitation, noise, and time of day on the number of Grey Warblers counted in New Zealand forests. Data from the study described by Dawson et al. (1978). For each of wind, precipitation, and noise the analysis of each factor was confined to counts with minimal values of the others. Only wind and precipitation affected the counts significantly ($P < 0.01$ in analyses of variance). The results are expressed on a relative vertical scale, with 100% being arbitrarily set at minimum values of wind, precipitation, and noise and at 10:00–11:00 for the time.

zen 1970, 1974; Slagsvold 1973b; Nilsson 1974b; Järvinen and Väisänen 1976c; Ratowsky and Ratowsky 1977, 1978; Connor and Dickson 1980), but some species are more vocal later in the day (Shields 1977). Some studies do not mention time of day (e.g., Amman and Baldwin 1960, Lancaster and Rees 1979). Dawson and Bull (1975) counted between 09:30 and 15:30 to avoid "the rapid change in birds' conspicuousness near dusk and dawn," and Yapp (1956) gave similar advice. Figure 3 is typical of the numbers counted of five common New Zealand species, and it shows that the numbers counted vary little in the middle hours of the day. The effect of time of day may be expected to vary with season (Shields 1979), and in very hot regions such as deserts.

There are few good studies of the effect of time of day, where the counts of individual species have been examined over a range of hours (Kimball 1949; Davis 1965; Robbins and Van Velzen 1967; Slagsvold 1973b; Järvinen et al. 1976, 1977b; Shields 1977, 1979). Analyses of the total number of individuals regardless of species (e.g., Figure 2 in Hogstad 1967, Figure 2 in Robbins and Van Velzen 1970, and Figure 18 in Svensson 1977a) are misleading because species may peak at differing times and cancel each other. The better studies suggest that time of day near dawn will make such a substantial contribution to the variance of the counts of

many species that it should be studied, so that it may be allowed for (e.g., Shields 1977, 1979); most work is deficient in this regard. The alternative of counting over a very short (e.g., half hour) standard period is usually impractical, as a large number of such samples would be needed to yield enough data. The best solution may be to count over a longer period near the middle of the day (Dawson and Bull 1975).

WEATHER

The effect of weather on k , and hence on the numbers counted, is mentioned as an anecdote in several studies and the prescription often mentions that high wind, rain or cold are to be avoided (Yapp 1956, Robbins and Van Velzen 1967, Blondel et al. 1970, J. T. Emlen 1971, Dawson and Bull 1975, Järvinen and Väisänen 1976c, Svensson 1977a, Shields 1979, Connor and Dickson 1980). Analysis of the effects of weather is particularly difficult because weather variables are often intercorrelated and also correlate with season, habitat and time of day. Ratowsky and Ratowsky (1979) found that wind reduced the number of species recorded in transect counts in Tasmanian forest, but that rain had no detectable effect; Hogstad (1967) suggested that both high wind and rain depress counts. Figure 3 summarizes some typical results from my unpublished study of the effects of weather on bird counts and confirms that the

usual advice to avoid strong wind and rain is well founded.

Bad weather is likely to affect the performance of the observer as well as that of the birds, but the two effects cannot be distinguished in the counts.

ENVIRONMENTAL NOISE

Like weather, this factor is covered only anecdotally in published work. Figure 3 illustrates a typical example of its effects, which appear not to be important. It, too, could act through effects both on the observer and on the birds.

OBSERVER

Differences between the counts of individual observers could reflect judgement (e.g., of whether a new sound came from a bird already counted or not), ability to follow a prescribed plan, acuity of hearing and vision, knowledge and experience. For these reasons several studies have been careful to keep the same observers, where possible (Robbins and Van Velzen 1967, Sammalisto 1974, Lincoln 1975, Källander et al. 1977, Dawson et al. 1978, Shields 1979, Conner and Dickson 1980). If observers are rotated between study areas they can be included as a factor in the analysis and their differences estimated and allowed for (e.g., Dawson et al. 1978). Svensson (1977a) suggests 'calibrating' observers by having them count simultaneously on the one area.

NUMBER OF REGISTRATIONS

Walankiewicz (1977) reported that, in a study of five forest areas in Poland, an estimate of k for I.P.A. counts of several individual species increased with increasing total number of birds counted. This suggests a saturation effect: more cues are missed when an observer is busy recording a large number of birds. Frochot et al. (1977) reached a similar conclusion. Järvinen and Väisänen (1976b) suggested that the proportion of records from an inner transect belt to the total counted was greater the more birds there were, although they later commented that their correction factor to allow for this was not necessarily applicable elsewhere and could sometimes lead to error (Järvinen et al. 1978b). Table 1 illustrates an attempt to examine this question, and shows that a high total number recorded did not seem to reduce the number of distant birds detected.

Another problem is that there may be an upper limit to the number of any one species that can be distinguished when many of that species are singing. This is certainly the subjective impression of some New Zealand observers, but

TABLE 1
EFFECT OF THE TOTAL NUMBER OF BIRDS
COUNTED ON THE PERCENTAGE OF ALL RECORDS
THAT WERE 'FAR' RECORDS^a

Species	Percentage 'far' records when the total number of birds counted was:	
	Few ^b	Many
Myna (<i>Acridotheres tristis</i>)	67	78
Silvereye (<i>Zosterops lateralis</i>)	30	16
Goldfinch (<i>Carduelis carduelis</i>)	14	14

^a 'Far' records were those estimated to be 50–200 m from the observer. Data from 112 transects (of 200 m) made in pastoral and orchard land in Hawke's Bay, New Zealand, March 1980. If a large number of records impedes an observer's ability to discriminate, this would result in a lower percentage of far records, but the two percentages did not differ significantly for any of the three species.

^b 'Few' was less than the median total number.

it will probably have to await calibration studies for confirmation.

THE TECHNIQUE

The number of birds counted will vary with details of the technique used. I leave a comparison of transect and point counts, and an examination of the effect of the observer's speed to another paper in this symposium.

Dawson and Bull (1975) compared point counts of 5 and 10 min duration, and Dawson and Robertson (unpubl.) compared 2 min with 5 min; in both comparisons the alternatives gave measures of closely comparable efficiency. The first few species were detected quickly with short counts, and many sites could be sampled per unit time—but these advantages were offset by the greater time spent moving between counts. The duration of a point count therefore seems an arbitrary choice, at least over the range 2–10 min. However, a long duration does not permit many points to be sampled and so impedes replication of study areas. For this reason most techniques use a short duration (Robbins and Van Velzen 1967, Dawson and Bull 1975, Svensson 1977a). I consider the 20 min count used in the Indices Ponctuels d'Abondance (Ferry 1974) and in the Échantillonnages Fréquents Progressifs (Blondel 1975) to be too long.

The spacing of point counts is usually regular, along transect lines or on a rectangular grid, at intervals of between 0.2 km and 0.8 km (Robbins and Van Velzen 1967, Ferry 1974, Crook et al. 1977, Svensson 1977a, Dawson et al. 1978). If the counts are too close to each other, the chances of a bird being counted twice are increased, but if they are too far apart, much time is spent moving between them. For this latter

reason, and if the observer is to walk between the points, I prefer a short spacing (0.2 km).

Both point and transect counts may use a cut-off distance beyond which no birds are recorded. Burnham et al. (1980) argue against such truncation, except to remove a small percentage of outliers, because the distant birds aid in estimating numbers. Dawson and Bull (1975) used a long (0.2 km) cut-off for this reason. Smaller, or variable, cut-off distances may be needed in the study of habitat selection, so that the birds may be associated with the correct habitat.

Most techniques do not specify what the observer should do when uncertain whether or not a new cue comes from a bird already counted. Järvinen and Väisänen (1976c) counted only in front of the observer, to minimize the risk of double records. Dawson and Bull (1975) proposed an arbitrary rule that unless the observer is reasonably sure the cue comes from the same individual it is taken as new. Some such rule

should always be used, so as to lessen the variation between observers that would otherwise occur.

CONCLUSION

This paper has reviewed a large number of influences on the number of birds counted. Some of them (technique, season, and time of day) may be avoided by standardizing the observations, others (observer, weather, and noise) may be documented as the counts are done, so that their effects may be studied and corrected or avoided. The effects of species, age, reproductive group, habitat and cues from other birds require special study.

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