EUROPEAN BIRD MONITORING: GEOGRAPHICAL SCALES AND SAMPLING STRATEGIES

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ABSTRACT

Svensson S. 2000. *European bird monitoring: geographical scales and sampling strategies.* Ring 22, 2: 3-23.

I briefly review the suitability of different alternatives for a pan-European bird monitoring system, that is: (1) breeding bird counts (best option for good geographical resolution and for conservation requirements), (2) trapping at constant effort sites (provides much needed data on reproduction and mortality but unsuitable for wide use), (3) winter bird counts (sometimes the only option and as suitable as summer counts for resident birds), (4) migration counts (limited to migratory species but appropriate for coverage of remote regions without other counts), (5) nest record collection (unsuitable), (6) national ringing totals (unsuitable), (7) garden counts and feeding watches (of limited use but suitable for promotion activities), and (8) atlas surveys (usually not suitable for quantitative monitoring).

The density of monitoring sites, the census methods, choice of habitats and species, sampling strategies, continuity, and many other things, are likely to differ between countries for the foreseeable future. Some countries already have efficient monitoring programmes whereas other countries have very restricted activities with limited resources for necessary improvements. I believe that pan-European bird monitoring must develop along two lines. One is to strengthen national projects and gather suitable summary data from them. The other is to start a new, common activity for the whole of Europe. I propose such a new programme based on a very simple counting method (line transects or point counts), using permanent sites distributed regularly in a grid. Each count must be possible to complete during a few hours in a single morning. Each site must be so defined that it can be easily and uniquely identified on a map by any ornithologist in order to avoid central bureaucracy of distributing route maps. The system of reporting results must be such that manual handling is minimised. I demonstrate the new sampling strategy that is now used in Sweden, and perform some extrapolation to the whole of Europe based on the data collected so far.

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Key words: birds, bird monitoring

INTRODUCTION

The total population size of a bird species can be precisely and accurately monitored over wide geographical areas in only a very small number of rare, conspicuous or habitat-specific species, and only in regions with a sufficient number of ornithologists. All other species (the vast majority) must be monitored by sample counts. Of course, some remote and sparsely populated regions may be unpractical to monitor at all, providing impetus for alternative kinds of monitoring programmes, such as counts of migrating birds or at winter concentrations.

There are many good examples of species, some time ago very rare and with the location of almost every pair well known, whose population size has grown so much that it is no longer possible to keep track of it by total counts. Conversely, the same situation is disturbingly common for declining species, which suddenly have become available for a total count – it is not often possible to reconstruct that species' former history with the precision we would like to have.

In my own country, Sweden, it was, for example, possible to make a total count of the Red Kite (*Milvus milvus*) in 1972 (Svensson 1974), when the species was near extinction and comprised less than 50 pairs. After much work to restore population size, the number of pairs increased rapidly, and now, with a population that is approaching one thousand pairs, it is no longer possible to keep track of the growth with total counts. As an alternative, small sample areas are checked every year (mainly in order to monitor breeding performance) and the development of the whole population is followed by a combination of counts at winter roosts and during autumn migration at Falsterbo (Kjellén 1997). The work to restore the population of the Eagle Owl (*Bubo bubo*) demonstrates the opposite problem. When the population was almost extinct and confined to a small area in southeastern Sweden, the number of pairs was rather well known (Olsson 1997). The restoration process was based on the release of birds produced by captive breeding all over the country. The population is now rapidly recovering and no longer endangered. However, because of the paucity of historical data, and of course total absence of any reliable sample counts, it is not possible to determine population size before the drastic decline, and hence not possible to determine the exact extent of success of recent management. These are small-scale parallels to similar situations for the majority of species in most parts of Europe.

The only solution for monitoring all or most species of a whole biome or continent, in this case Europe, is by a sampling strategy that provides both unbiased and reasonably precise estimates of population trends. There are two main roads to that goal. One is to combine estimates from existing schemes in different countries into a common estimate for the whole of Europe. The other is to start a new programme. The first alternative means that it will not be necessary that countries, which already have good monitoring activities, start anything new. All efforts can be directed to the implementation of monitoring projects in countries with no or insuf-

ficient activities. This may be the most efficient, and perhaps the only practical way to obtain pan-European bird population indices within reasonable time. However, the second way, supplementing the existing national schemes with a new pan-European one, is attractive. Here I will look a bit into that possibility.

Before I go on, however, I will cite part of the summary of one of the talks at the U.S. „Partners in Flight" planning conference in 1995. Douglas H. Johnson (1999) wrote: „The proper design of a monitoring effort depends primarily on the **objectives** desired, constrained by the **resources** available to conduct the work. Typically, **managers** have numerous objectives, such as determining **abundance** of the species, detecting **changes** in population size, evaluating **responses** to management activities, and assessing **habitat associations**. A design that is optimal for one objective will likely not be optimal for others. Careful consideration of the importance of the competing objectives may lead to a design that adequately addresses the priority concerns, although it may not be optimal for any individual objective. Poor design or inadequate sample size may result in such weak conclusions that the effort is wasted."

There are several important key words in that statement. First: „objectives", „resources" and „managers". It is extremely important to be precise about the objectives. Too many monitoring programmes have been started with very loose objectives, and with a rather naive ambition or expectation that the data retrospectively should prove to solve a great deal of problems. Available resources, in terms of field workers, subjected to administrators with capacity of sustained leadership and funds, have often not been realistically considered. The word „managers" (or authority, government, or whatever) refers to the ultimate goal of the exercise, namely that the monitoring results shall be used in bird conservation. Too often workers have been disappointed by the lack of influence on decisions concerning their work. Close co-operation with conservation authorities is essential.

Returning to the „objectives", the four other key words are appropriate. A monitoring programme may have one or more of the objectives, such as determining „abundance" (true densities), „changes" (long-term trends), „responses" (to environmental change or assessment of management effects), and „habitat descriptions" in conjunction with the bird counts.

I believe that a new pan-European bird monitoring scheme must be very restrictive with two objectives only. It should declare itself restricted to recording changes and trends with the explicit goal to provide decision-makers with information and alerts required for management and conservation. This means simple registering methods and sustainable administration and data handling without any additional requirements on the field workers, such as detailed habitat descriptions or complicated reporting systems. In other words, we must distance us from requirements coming from workers needing detailed data for research with great explanatory power, making the project as easy and attractive as possible to the vast majority of amateur ornithologist. In fact, to explain a trend, it is usually better to do well-designed experiments rather than retrospective correlation analyses.

THE SITUATION IN SWEDEN – EUROPE IN MINIATURE

The situation in Sweden reflects rather well the situation for the whole of Europe. There are large areas with few ornithologists, and this problem is likely to increase in the future because of migration of people from rural to urban areas. After general bird monitoring started in the 1970s, the scheme rapidly became well established in southern Sweden, whereas the number of samples in northern Sweden only marginally contributed to countrywide indices (Fig. 1). Apart from this geographical bias, another problem became successively quite disturbing, namely the lack of representativeness in terms of habitats chosen by the volunteers. I could argue with confidence that the indices correctly described the population trends even in the regions with many counts. Certain habitats were clearly under- or over-represented. Open farmland, mires, commercial coniferous forest, for example,

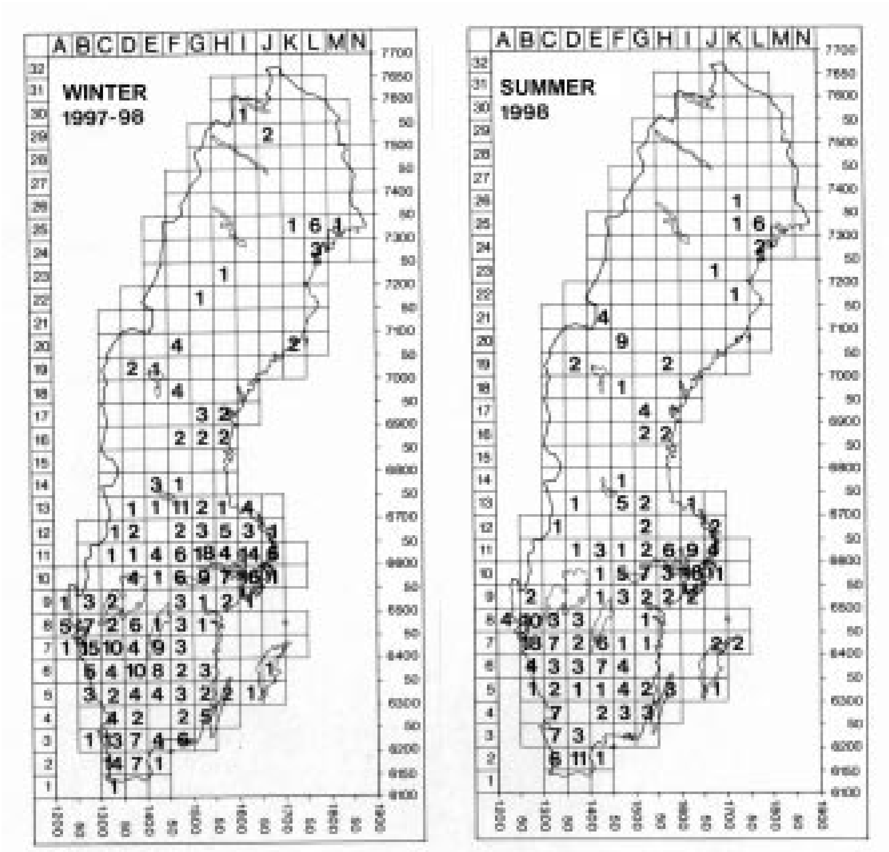

Fig. 1. Distribution of point count routes in Sweden (winter left, summer right). These counts have been made since 1975. They have always shown a strong geographical bias to the southern part of the country and to urbanised regions.

were under-represented, while certain types of broad-leaved forest, mixed habitats, and other bird-rich habitats were over-represented. There were also accessibility and distance biases on a smaller scale in relation to where the volunteers lived, *i.e.* concentration of counts in the heavily urbanised regions of Stockholm, Gothenburg and Malmö. All such biases are well known in other similar programmes, and various efforts are made to handle them. The randomisation of sampling in the new Breeding Bird Survey that will replace the Common Birds Census in Britain and Ireland is an example, as is the looser recommendation for Finnish line transects (Koskimies and Väisänen 1991), which should be planned to „*ensure that all major terrestrial habitats are included in proportions approximately characteristic of the region*". In Sweden, no requirement about habitat choice existed.

It is vital to know, however, if habitat biases really affect the indices significantly. It is not certain that they do so. And if they do not, a system based on the volunteers' own choice of samples is more attractive and cost-efficient than any kind of sampling strategy with sometimes paid people counting birds at sites that they have not chosen themselves. Regrettably, there are still little data from formal tests of biased versus unbiased sampling. However, such data will soon become available in Britain (BBS *vs* CBS – Gregory *et al.* 1997) and Sweden. In 1996, the Swedish sampling strategy, based only on volunteers choosing their own sites, was supplemented with a grid of systematic samples that were laid out over the whole of Sweden (Fig. 2). It is already clear that the order of species abundance is different, reflecting the representative habitat sampling of the new grid. It is important to remember, however, that a new source of error (or rather of increasing variance) is introduced with the new sampling method. The traditional method is based on the same observer making the count in all the years during which a specific site is active. The new method cannot retain this requirement, but new observers must often be assigned to a site in order to get the census made. This is particularly obvious for remote areas to which paid personnel must be sent in order to cover them. Another weakness is that all sites cannot be censused every year, as it is almost invariably the case that the observer has chosen a site of his own, usually near home. Missing values will be more common. Nevertheless, the benefit in this respect is, of course, that there will be no drift of index values because of shifting preferences among the field-workers. It is obvious that a statistically more satisfying sampling strategy will require both more money for fieldwork and more administration. Using a systematic sample with permanent routes removes, however, the problem of distributing information about new samples every year.

DIFFERENT KINDS OF MONITORING SCHEMES

There are many possible ways, by which monitoring of bird population changes may be implemented. Although counts in the breeding season is the most direct and obvious approach, other methods may also be good, at least – be able to contribute to the total picture, or sometimes the only practical way of obtaining some informa-

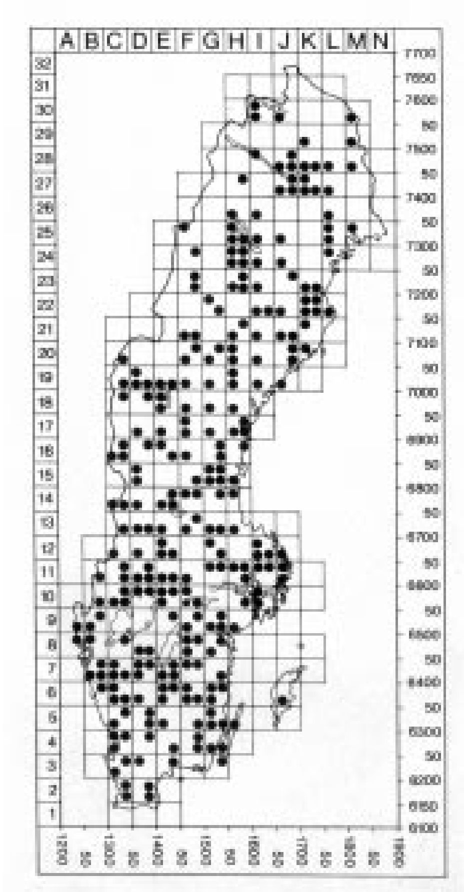

Fig. 2. The distribution of routes in 1996-1999 (for 1999 returns not yet complete) censused by the new Swedish system using permanent standard routes with pre-determined location. Each route consists of 8 km continuous line transect (2x2 km square) and 8 independent stops for 5 minutes point counts. The plan is to include four routes within each grid square of 50x50 km.

tion. Since I will concentrate on the design of a pan-European breeding bird census, I will only list some other methods with brief comments, without examining them in detail. Some of these methods have not been designed for population monitoring, but have occasionally been used in absence of better information.

Breeding bird counts

For most conservation applications, it is necessary to know the bird population trends of specific geographical regions, usually rather small regions. It is so, because bird conservation, habitat preservation and management are largely a national matter and often even a matter at lower administrative level. Although, from the point of view of implementation of legislation and concrete conservation work, this has been true for a long time, now the situation is rapidly changing as the European

Union takes over some of the national responsibilities and is still joined by new member states. Concurrently, internationalisation of industry, trade and economy make ongoing habitat transformations and land use shifts more similar everywhere, *e.g.* by the Common Agricultural Policy. From a historical perspective, it is no surprise that we lack a common European bird monitoring system, but the current events make such a system not only necessary and timely, but also feasible, perhaps partly with resources provided by the European Union.

The situation in North America is very different from that in Europe. The greater degree of federalism among the states there, both in the U. S. and in Canada, has made it possible to develop continental-wide bird monitoring schemes, primarily the Breeding Bird Survey, which has proven to be an extremely powerful tool for bird conservation not only at the federal level, but also regionally and (at times) even within separate states. In Europe, similar projects have started at different times in different countries, and they have not been co-ordinated, uniformed or standardised, yet.

Trapping in breeding season (CES)

Constant Effort Sites are ringing stations operated in a standardised way during the breeding season (usually 10-12 trapping days spread from April through August), with two goals beyond simply counting of the number of birds (to estimate local population trends), that is: recording the proportion of yearlings (to estimate trends in breeding success) and the proportion of birds returning from the previous year (to estimate winter mortality). This provides a powerful explanatory tool. It seems that so far European CES have achieved a long-term success only in Britain and Ireland (Peach *et al.* 1998). The number of sites is currently above 100, with less than 10% turnover rate and reasonably good maintenance of standards. Some other countries have tried to develop or are developing such activity. In Finland, for example, a similar project started in 1986 (Haapala *et al.* 1999). The number of sites rose rapidly during the first decade, but then the project lost impetus and the number of sites declined, so that only 26 sites were active in both 1997 and 1998.

A special benefit of CES is that they may be located in special and rare habitats, which would normally not be included in the breeding bird counts. There is, for example, a tendency that many CES are located in bushy or reedy areas as they are attractive to ringers. On the other hand, this introduces the problem of habitat change by vegetation successions, which may cause regionally unrepresentative changes of species composition and trapping totals, if the same site is used over many years. A disadvantage is, of course, that most species are common passerines, *i.e.* the same species that are also best covered by ordinary breeding bird counts. The additional information will often be marginal for population monitoring. Hence, it is likely that the main benefit will prove to be monitoring of the relative importance of reproductive success (including early mortality) and winter mortality.

I believe that the reason for the limited success of CES is the considerable workload and discipline that is required. Hence, the reason is the same that has pre-

vented in most countries the development of large-scale monitoring projects based on territory mapping plots, making it necessary to turn to simpler counting methods.

In conclusion, CES would in principle fit well within an integrated framework of breeding bird monitoring, and should be encouraged. Finally, I would like to add a further argument for supporting the establishment of CES. In some parts of Europe, the field skill of the potential participants may still be relatively limited. To take part in census work it is necessary to be able to tell all species apart, either when seen or heard. Identifying species in the hand requires less skill. Trapping at CES would perhaps be a fruitful alternative.

Winter bird counts

One winter bird count has been formidably successful. It is the mid-winter count of waterfowl, co-ordinated by Wetlands International. The reason for the success is, of course, that the project includes so many species breeding in remote arctic and boreal regions that it would be extremely difficult to count them at other than winter concentration sites. The drawback of this project is that it is difficult to infer much about local breeding populations.

A similar project is the goose count, organised by a special goose group of Wetlands International. This project benefits from the possibility to distinguish between different breeding populations even in the winter quarters, partly because of the abundant recoveries obtained by the use of neckbands. The considerable knowledge about population trends among the geese has been efficiently exposed in the new book „Goose Populations of the Western Palearctic" (Madsen *et al.* 1999).

The drawback of winter counts of waterfowl is well appreciated, and there are plans to launch a waterfowl project for the breeding season, too. This plan was discussed at the early May 2000 meeting „Limnology and Water Birds 2000" organised at Trebon, Czech Republic, by the Aquatic Bird Working Group of Societas Internationalis Limnologiae. Wetlands International supports the meeting, and one of the themes is the „development of a breeding water bird monitoring system in Europe". This initiative is commendable, and the European Bird Census Council should take appropriate action to maximise the benefits of co-operation.

Apart from waterfowl and geese, winter bird counts have proven an efficient monitoring tool for a great number of species. The Christmas Count in North America, for example, has provided much information on long-term population trends of many species. However, data from winter bird counts, of course, can be used for small regions only if the species is resident. Nevertheless, for resident species, winter counts will give exactly the same information as breeding bird counts. An extra bonus is that there are fewer competing projects in winter than in summer! There are several good examples of winter bird counts showing the same trends as breeding bird counts. Hence, winter counts of resident birds should be encouraged as a valuable supplement to breeding bird counts.

I should also mention that waders are being monitored at winter concentrations sites with the same rationales as for waterfowl and geese. These counts are coordinated by the Wader Study Group, affiliated with Wetlands International, but so far, are not as efficient as the waterfowl and geese counts because of the much larger areas that must be covered, the much higher numbers of birds and the less accessible sites, many of them in areas with as few ornithologists as the arctic and boreal areas, from where these species come.

Migration counts

Several bird ringing stations, particularly at coastal sites in the Baltic and North Sea region (but also elsewhere, for example the Mettnau-Reit-Illmitz programme) operate standardised trapping schemes. The trapping and ringing primarily serve various purposes connected with migration research, but are also used for monitoring population trends of the recruiting area. However, there are many difficulties with the interpretation of the data. The birds that are trapped do not constitute a representative sample of those passing the station. In the case of day-migrants, only the portion flying low can be trapped, and in the case of night-migrants, it is only the land-fallen portion (Payevski 1998). None of these measurements is related to the real migration volume as shown by contemporary radar studies and other independent methods. Especially the landfall of night-migrants seems to be poorly related to true migration volume. Weather is the main factor influencing the number of birds that become available for trapping at a specific site, both because weather conditions may affect landfall and shift migration routes. It has also been shown that „short-term changes" in number of birds at a bird station often do not reflect population changes. Nevertheless, several studies have also shown that the number of trapped birds in many cases does reflect the „long-term trends" (*e.g.* Fig. 3). This means that standardised trapping often is a good monitoring tool. The errors in individual years seem to cancel out each other over a longer period of years, indicating that there are few long-term systematic shifts of the weather effects. The main difficulty in using trapping totals is, nevertheless, the high annual variation, making it necessary to wait many years before an existing trend can be determined with significance.

Counts of visible migration are a similar tool, particularly used at concentration sites such as Falsterbo, Gibraltar and the Bosporus. They are in principle affected by the same problems as the trapping counts, but for certain species they may be particularly reliable, namely species that concentrate very much to a specific route, making it possible to count a very high proportion of the migration, so that the count is no longer just a sample but almost a total count. The benefits of such counts are about the same as those for winter counts of waterfowl. It becomes possible to estimate population changes in some rare species that do not provide sufficient sample size in breeding counts and species from remote areas that would otherwise not be possible to study. This latter benefit has recently been exploited by

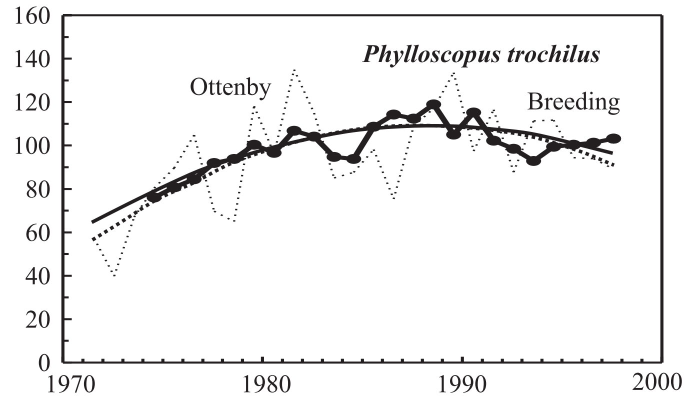

Fig. 3. Population indices for the Willow Warbler based on the Swedish Breeding Bird Census and annual trapping totals at Ottenby bird station. This is one of the best examples of a good fit between the two counts, although the variance is larger at the trapping site.

several North-American bird stations situated along a west-east transect along the US-Canadian border in a joint effort to monitor migrants from far north, where few breeding bird counts can be made.

Considering, however, the recent successful establishment of distributed breeding bird counts in particularly north-European countries and the fact that the vast majority of species with high numbers at the trapping stations are the same abundant birds that supply the best data from the breeding bird counts, these migration counts may become partly redundant for breeding population monitoring. Only a limited number of species can be reliably monitored during migration, namely species with the majority of individuals being migrants. Resident species cannot at all and partial migrants only unreliably be monitored (Fig. 4). However, for large parts of northern Russia, where it is unlikely that breeding bird counts can be made widely within the near future, the counts (particularly at the eastern Baltic stations) constitute the only source of information about population trends of boreal and north-temperate birds in this vast region, and they are consequently extremely important. It should also be remembered that supplementary data that are useful for the interpretation of population changes are collected at many bird stations, for example the proportion of juvenile versus adult birds, information about the condition of the birds, and recoveries that show migration routes and winter-quarters. Until a satisfactory monitoring system of the breeding populations is established, the standardised trapping and counting of visible migration at the bird stations should be encouraged. The most urgent thing to do, from a monitoring point of view, is to combine and compare counts from several bird stations. Here the migration stations face the same problem of co-operation as the different national breeding bird monitoring programmes have had for so many years.

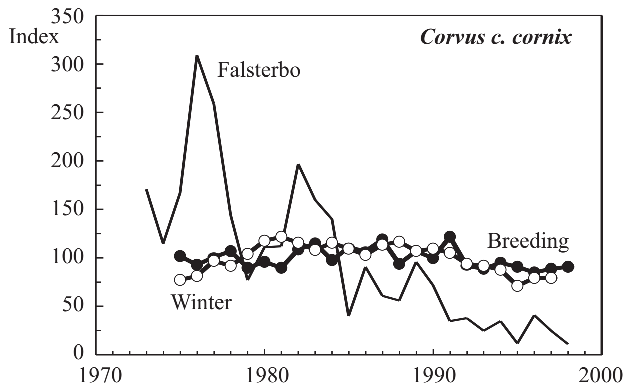

Fig. 4. Population indices for the Hooded Crow based on the Breeding Bird Census, the Winter Bird Count, and migration counts at Falsterbo. The Swedish population has change very little since 1975, but the numbers on migration has declined to almost nothing. The Hooded Crow is one example of several partial migrants, which cannot be reliably monitored by migration counts. The decline at the migration site most likely reflects a shift of migration strategy rather than a population trend.

Nest record collection

Although the number of nest record returns has been found in several cases to vary in parallel with population size established with other methods, it is not a method to build on for long-term monitoring purposes. The number of nest cards depends too much, in the long run, on preferences among the participating ornithologists, and on shifting emphasis and campaigns by the nest card administrators and researchers, caused by many various conservation and research problems that rise or fall with time. The data from such programmes are, however, extremely useful in analysing the causes of population trends when the causes are connected with reproductive success, and nest record collections have been successfully used in many studies of population change causation.

In connection with nest record collection, I should also mention the ringing centres, which are increasingly collecting breeding data beyond the mere number of ringed nestlings in each brood. The average number of ringed nestlings per brood has already been used in several long-term comparisons of breeding success. In spite of the fact that many studies indicate that brood size is rather insensitive measure of breeding performance (because it neglects complete losses and because clutch and brood size in many cases do not change even in a rapidly declining population), it could be an important alert, especially in long-living species. Ringing centres could be much more important if they could broaden their data collection profiles to regular including nesting data from several visits to a nest. This would be particularly important, of course, in countries where separate nest record collection does not exist.

National ringing totals

In the same way as for nest record returns, national ringing totals sometimes have also been shown to vary with true population size. However, as for nest record cards, the ringing totals are exposed to many sources of error connected with different preferences, fashions and project campaigns among the ringers. New trapping methods, changing preferences for ringing adults *vs* nestlings, different proportions of birds ringed at bird stations and by private ringers, special campaigns for selected species (*e.g.* the *Acro*-project), and, perhaps increasingly important in the future, possible restrictions enforced by legislation about handling wild birds, may cause so many sources of variation that the totals must be interpreted with greatest caution. The importance of traditional ringing may also change drastically as new methods for migration studies are being developed. The neck-banding of larger birds, colour-ringing for individual identification, and the use of radio-transmitters and satellites may make traditional ringing less attractive or even obsolete for certain species in the future.

It seems that the role of many ringing centres is slowly shifting from having been mainly service centres for ringers and recoveries storage bodies to being active research institutions that increasingly take initiatives and govern different specific projects. This is, of course, something that should be strongly supported, but it also means that we must expect larger shifts in ringing intensity of different species, making it more uncertain that the total number of ringed birds will reflect population size.

Garden Counts and Feeding Watches

I mention this kind of count since it has proven to be an extremely attractive activity for the general public. „Project FeedingWatch" has been well established in North America for more than two decades. The British Trust for Ornithology operates a similar project, the „Garden BirdWatch", with over 9000 (*sic*!) participants, and with promising preliminary results (Cannon 1999). Recently BTO tried to expand that project to other European countries, but, as far as I know, without sustained success. As a long term monitoring tool widely used over the European continent, garden bird counts cannot for several reasons contribute more than marginally to a pan-European scheme, particularly as only a very small number of species can be included. However, it is an excellent way of introducing bird counts to a broader audience, among which some may later be recruited to other types of monitoring. It will also contribute very positively to public attitudes about birds and bird conservation, which will greatly increase the possibility of raising resources for other monitoring and conservation activities.

Atlassing

The value of atlassing for different purposes has recently been reviewed by Donald and Fuller (1998). Intuitively, one would expect abundance and range changes

to correlate. In reality, this was found, but the correlation was weak. Major range changes were observed only for the few species that had declined very much. This is what one would expect since (when a species becomes very rare) the addition or loss of occurrence in a few atlas squares may represent a substantial part of the total population. In common birds that occur in most squares substantial numerical changes may pass undetected by comparison of atlas maps only. In some atlases, the presence/absence records are supplemented with quantitative data, and then it will be possible to determine at least major changes also among more common birds.

The main conclusion by Donald and Fuller (1998) was that atlas data should not be used as a substitute for population monitoring. This conclusion is also well supported by visual inspection of the maps in the atlases that has been repeated (Britain and Ireland – Gibbons *et al*. 1993, Finland – Väisänen *et al.* 1998, and Denmark – Grell 1998). Large-scale geographical patterns can be revealed very well, but considerable numerical changes remain hidden if they have not been accompanied by expansion or retraction of range. It is also impossible to repeat atlas studies with the frequency required for population monitoring.

THE STRUCTURE OF A PAN-EUROPEAN BIRD MONITORING PROGRAMME

As my review has shown, there are many different kinds of activity that could be included in an integrated European monitoring system. However, here I will only consider one project, namely a pan-European breeding bird monitoring scheme, and more precisely a scheme that best suites the monitoring of fairly common and widely spread birds.

The two different ways are (1) to combine data from national programmes and (2) to start a new, independent programme. The former alternative has recently been carefully analysed by van Strien and Pannekoek (1998). They compared two ways of using data from existing national programmes. First, they used the raw data from all the programmes and calculated species indices directly from them. Then they used the separate national indices and combined them into the common ones. The two ways produced exactly the same index series. Hence, they could conclude that for the calculation of a pan-European bird index, there is no need of time-consuming processing of raw data. It is sufficient to base a future index on national indices provided by national schemes. Because of this very clear conclusion I will not discuss this alternative further – what is needed, if we base future European monitoring on existing schemes, is „only” to see to that good monitoring programmes become implemented in all parts of Europe.

It is important to remember that this analysis only tells that the two methods of combining data from a number of nations give the same final result. It does not tell whether the common index is correct or not. It will, of course, suffer from the same biases as the original national data sets did. However, such biases can be removed if every national scheme adjusts its sampling strategy properly. Then it is only necessary to weigh the national indices with population size.

The other alternative – a new project, requires consideration that is more careful. The greatest benefit of starting a brand new activity is that the design of it need not take into consideration any of the historical loads that may prevent old programmes of being transformed as one would wish, and one can select the best strategy from the very beginning.

THE PATTERN OF DISTRIBUTION OF SPECIES ABUNDANCE

In order to provide a frame for planning, one needs to know a little about the rate, with which one can accumulate records of birds in the field, which depends primarily on population density at the sample sites. I have used data from the permanent standard census routes of the new Swedish sampling system in order to provide a picture of how the species abundances are distributed over the range of species (Fig. 5). As expected from numerous other similar studies, the logarithm of abundance of a species is linearly related to its sequence number if all species are sorted according to abundance. From a diagram with such a plot, it is easy to graphically estimate the number of species that will satisfy any selected requirement of sample size.

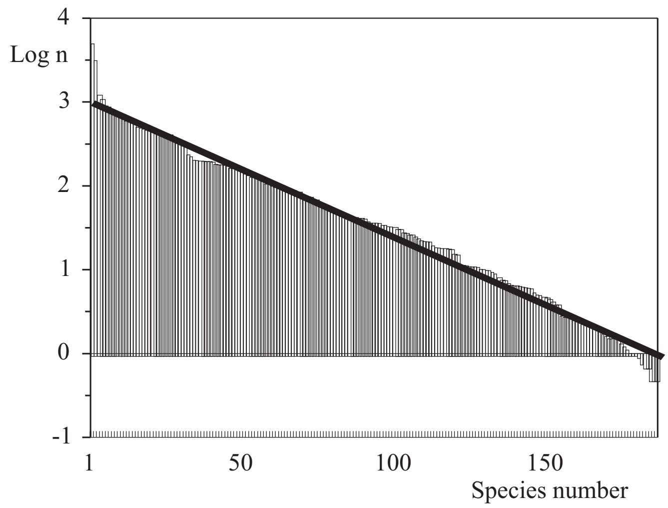

Fig. 5. Relative abundance of the 190 most common species along the Swedish permanent standard routes (average for 1996-1998; bars). The regression line shows a good linear fit with abundance log-transformed. The two most common species (no. 1 and 2, *Phylloscopus trochilus* and *Fringilla coelebs*) were „over-abundant" and the least common species „under-abundant" in relation to the regression line. The abundance figures are the totals from 100 routes.

Using this diagram for estimating the sample size needed in a pan-European programme requires, of course, that the bird fauna of Sweden is reasonably similar to that of the rest of Europe in its general composition and density, and that the

counting method is the same. It is easy, however, to translate the result to any other method, which will accumulate records in the same way. We used 8 km routes, which take about 6 h each to count. We collect about 30 000 records per 100 routes, which is about 300 birds per route or 6 h of field work on average. I would guess that about 300 birds per 6 h of line transect is roughly valid for large parts of Europe (at least there is not much overestimation) making estimates based on Swedish data on the safe side for the whole of Europe.

CALCULATION OF REQUIRED SAMPLE SIZE

Assume that variance is equal to sample mean, which is roughly expected for line and point count samples, and that it does not vary between years. Then *SD* (standard deviation) = $\sqrt{m}$, where m is sample mean. Then let m_1 and m_2 be the sample means of two different years and n_1 and n_2 the number of routs in these years. To test the difference between the years we use:

$$t > \frac{m_2 - m_1}{SD} \times \sqrt{\frac{n_1 \times n_2}{n_1 + n_2}}$$

Assuming that the number of routes is about the same in both years ($n_1 = n_2 = n$) and m is the average sample size, we simplify by writing:

$$t > \frac{m_2 - m_1}{\sqrt{m}} \times \sqrt{\frac{n}{2}}$$

Let R be the change between the two years:

$$R > \frac{m_2 - m_1}{m} \Rightarrow m_2 - m_1 = R \times m$$

Inserting Rm for $m_2 - m_1$ we obtain:

$$t > Rm \times \sqrt{\frac{n}{2m}} \Rightarrow t^2 = \frac{R^2 mn}{2}$$

Then:

$$n > \frac{2t^2}{R^2 m} \quad \text{or} \quad T > \frac{2t^2}{R^2} \quad (= 8/R^2 \text{ for } t = 2,\ p < 0.05),$$

where the total number of individuals of the species in the sample – $T = m \times n$.

We can now roughly estimate the number of individuals that is required for each given population change and for a suitable significance. If $t = 2$ ($p < 0.05$) then we obtain, for example, at least 800 individuals for 10% change, at least 200 for 20% change, at least 90 for 30% change, *etc.* of the least abundant species that will be included. By looking up the corresponding figures in the diagram of Figure 6, we will obtain the results given in Table 1.

If we require that a change of more than 20% between two years should be significant at level $p < 0.05$, Table 1 shows that in order to be able to include 100 European species, the number of routes must be above 800. For more species, the number of routes required will rise very rapidly. If we want to include twice as many species – 200, we must count at least 256 000 routes. The question is: What should we opt for?

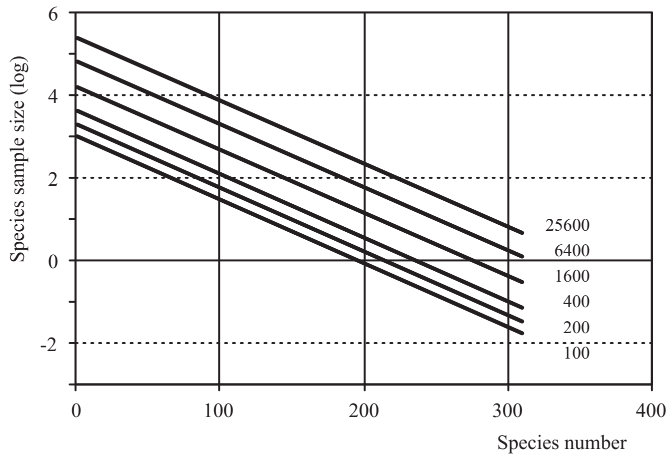

Fig. 6. The sample size that will be obtained for different species of birds when using different number of routes of the new Swedish type (5-6 hrs line transect). For example, if one needs to include at least 150 species with the requirement that the least abundant of these species is represented by 300 records, at least about 800 routes are needed.

Table 1
Number of species whose change between two years may be determined with a significance of $p < 0.05$ with different sample sizes. „No. of birds" – the number of individuals in the total sample required for the least abundant species satisfying the requirements.

No. of birds	Change %	Number of routes								
		100	200	400	800	1600	3200	6400	12800	25600
800	10	5	25	45	65	85	105	125	145	165
200	20	45	65	85	105	125	145	165	185	205
90	30	70	90	110	130	150	170	190	210	230
30	50	100	120	140	160	180	200	220	240	260

What does this mean for different participating countries? Europe west of the Urals is about 10 million square kilometres. Table 2 shows the number of routes that falls in each country if the total sample is 1000. Most countries are small and will get only 3-15 routes (together 120). The remaining countries are large or very large. They will get between 20 and 60 routes, and Russia as many as 400. All figures are easily multiplied by a suitable factor if more than 1000 routes will be needed. A reasonable requirement for a pan-European monitoring system would, in my opinion, be at least 3000 routes, or correspondingly more if the routes are shorter than the Swedish 5-6 h routes.

Table 2
Number of routes in different countries based on a sample of 1000 routes evenly distributed over the whole of Europe, and the number of routes per million inhabitants

Country	No. of routes	Millions of inhabitants per route
Russia	400	4
Ukraine	60	1
France	55	1
Spain	50	1
Sweden	45	5
Germany	36	0.5
Finland	34	7
Norway	32	7
Poland	31	1
Italy	30	2
former Yugoslavia	26	1
Britain	24	0.5
Rumania	24	1
Belarus	21	2
Small countries (18)	120 (3-13)	1

Considering the number of inhabitants in the different countries (I have no figures for the number of ornithologists!), most countries will get less than two routes per million inhabitants. Only the sparsely populated countries in the north will get more: Norway, Sweden, Finland, and Russia.

EQUAL OR UNEQUAL SAMPLE SITE DENSITY OVER EUROPE?

It would not be wise to recommend the same sample density everywhere. This would mean that the sample density in the whole of Europe would be the one acceptable for the region with fewest ornithologists. A system with unequal density will work quite well. The information from the different regions can easily be combined by suitable weights based on sample size. The important thing is to remove as much as possible of the biases. Really good long-term monitoring programmes reside today, to my knowledge, only in a restricted and fairly marginal north-western part of Europe. In the pan-European context it would, furthermore, be better to establish good monitoring programmes in a number of widely distributed sub-regions, if it proves not to be possible to establish them everywhere, and if resources become available for such geographic priorities.

The reason for this is that the long-term trends from several adjacent countries are similar in a great deal of species. One example is Cuckoo (*Cuculus canorus*) in Denmark, Sweden and Finland (Fig. 7). The three linear trend lines are indistinguishable. Even some of the annual changes are often similar (in the case of the Cuckoo a drop in numbers in 1980). Several such examples stress the need for infor-

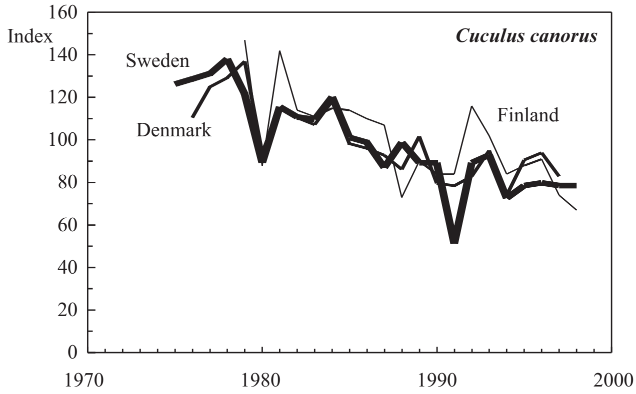

Fig. 7. Long term trends of the Cuckoo populations in Denmark, Sweden and Finland. The long term decline rates are almost identical.

mation from areas far away in order to learn whether these trends are regional or pan-European. Good data from only one or two more distant regions would be sufficient.

However, contrary to this, there are also data that show considerable differences in the same species within a small region such as Fenno-Scandia. This is the case for Chiffchaff (*Phylloscopus collybita*) – data from three nearby countries show that in some species the trends may be drastically different (Fig. 8). The Chiffchaff is rapidly increasing in Denmark and rapidly declining in Finland. In Sweden, the trend is in between. Recent analysis of the Swedish data has shown that the decline in northern Sweden is identical with that in Finland (Berggren 1999), while the population in southern Sweden is growing and expanding, as in Denmark. In this case, however, we are dealing with two different subspecies, which have different ecologies

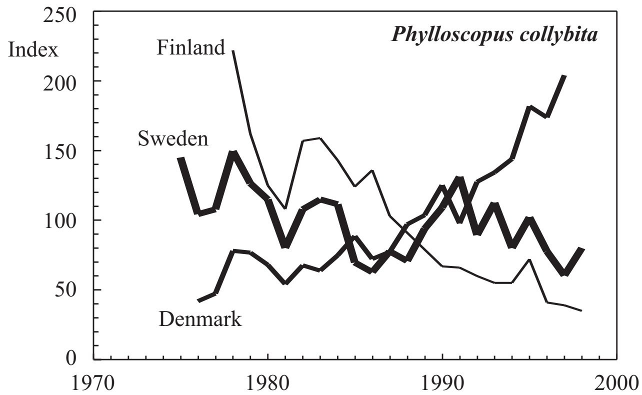

Fig. 8. Long term trends of the Chiffchaff in Denmark, Sweden and Finland. The trends are very different: strong decline in Finland (subspecies *abietinus*), strong increase in Denmark (subspecies *collybita*). The Swedish trend is a mixture of decline in the north and increase in the south (both subspecies breed there).

and migration strategies. The latter factor may be the important one, because no habitat changes have been observed in the breeding areas that can explain the two different trends. Hence, a summary of possible European sub-populations, based on morphology, migration separation or different wintering areas, would help to spread the sample sites optimally.

VARIABLE OR PRE-DETERMINED LOCATION OF PERMANENT SAMPLE SITES?

Both systematic (grid-based) and random (including stratified) location of sample sites will ensure that habitats will be sampled in proportion to their coverage. However, most information from existing monitoring, where one has distinguished between major habitats, usually woodland and farmland, shows that most trends are rather similar. This speaks in favour of letting observers choose their own routes, perhaps within strata. This will, of course, work well over brief periods of time, when habitat coverage changes little. However, since a European monitoring scheme must aim at very long-term sustainability, major changes in habitat coverage and land use must be seriously taken into consideration. In many regions, the forested areas have increased, in other regions, forests have been transformed into farmland, and urban areas have been expanded. If one would let observers choose their own routes, even within strata, it is almost certain that they will avoid certain habitats in preference for more bird-rich ones. As unfavourable areas expand and most counters concentrate in the remaining favourable areas, the indices may remain stable although the total population size changed. Hence, it is important to use a sampling system that is based on pre-determined routes, which must be censused whatever habitat changes occur. The routes may of course be pre-determined for a long period of time, or re-distributed more often, but they must be a systematic grid-based or a random sample.

HOW MANY TIMES SHOULD A SITE BE CENSUSED IN THE SAME YEAR?

The alternatives are, of course, to count once or more than once – the latter in order to cover the entire breeding seasons. However, in such case, with the same number of participants, we have the alternative of counting the same number of sites once, half this number twice, a third of that number three times, *etc*. If counts must be spread over a long season, which must be done at least over large areas of Europe except the very north, the best strategy is to use different subsets of sites, some to be counted early and others to be counted late but each only once. This is because at the same site, many birds will be counted on both of two visits, and the second time a bird is counted that record does not add to sample size.

HOW FREQUENTLY MUST A SITE BE CENSUSED?

This question is relevant only for permanent sites. If sites are distributed anew every year, counts at the same site will never be repeated. However, with permanent sites we have two options, either to include a small number of sites every year (or at least frequently), or to permit longer intervals. Present knowledge about annual variation among most species and known rates of habitat change and conservation implementation makes it unlikely that a frequency of more than once every 3-5 years would be absolutely necessary. This also permits the option of few sites being counted with high frequency or many sites being counted less often. In fact, one could have different subsets of sites, counting them with a rotation system of for example three years interval, permitting three times as many sites as if all sites were to be censused every year.

COUNTING METHODS

I will not discuss the precise counting methods that should be used. This is not of prime importance as long as the same site is always censused in the same way. It is obvious, however, that some very simple method must be chosen, and that means some kind of point or line transects, preferably without (but possibly with) distance estimates and with collection of as little supplementary information as ever possible. However, one strict requirement must be an integrated part of whatever method chosen, namely that the person making the count is able to tell all species apart on both sight and sound. Identification ability is difficult to standardise compared to counting rules, and the only way of ensuring a good standard through time is to require high species identification skill.

ACKNOWLEDGEMENTS

Swedish bird monitoring is a part of the environmental monitoring activities of the Swedish Nature Conservation Agency. The bird monitoring projects are operated by the Department of Ecology at Lund University (breeding and winter bird counts), University of Agricultural Sciences at Uppsala (Falsterbo migration counts), and the Swedish Ornithological Society (Ottenby migration counts). I warmly thank the hundreds of volunteers who collected the field data.

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