a million voices for nature

Wild Bird Index

Guidance for national and regional use

Version 1.2

This guidance document is one of a series produced with the support of the 2010 Biodiversity Indicators Partnership (2010 BIP) to assist Parties to the Convention on Biological Diversity (CBD) to track their progress towards the 2010 Biodiversity Targets. The Wild Bird Index has been selected as one of the indicators suitable for assessing progress towards and communicating the 2010 target at the global level. The aim of this document is to provide guidance to support the calculation and interpretation of the Wild Bird Index at the national and regional scales.

The 2010 Biodiversity Indicators Partnership (2010 BIP) intends this guidance to be a 'living document'. Updated versions will be produced based on users' feedback, and will include lessons learned and new examples of the indicators use. Please send requests for advice and feedback on this guidance to: gwbi@rspb.org.uk

This guidance document has been co-authored by the Royal Society for the Protected of Birds (RSPB), and UNEP-WCMC, including:
Philip Bubb, UNEP-WCMC
Anna M Chenery, UNEP-WCMC
Mark A. Eaton, RSPB
Richard D Gregory, RSPB
Danaë K Sheehan, RSPB

Version 1.2
September 2010

For information on other guidance documents and the 2010 BIP please see www.twentyten.net or contact info@twentyten.net.

The 2010 BIP has been established with major support from the Global Environment Facility (GEF).

Citation: Sheehan, D.K., Gregory, R.D., Eaton, M.A., Bubb, P.J., and Chenery, A.M. (2010). *The Wild Bird Index – Guidance for National and Regional Use.* UNEP-WCMC, Cambridge, UK.

Cover photo UNEP

Wild Bird Index

PURPOSE

Birds are recognised as good indicators of environmental change and as useful proxies of wider changes in nature. The Wild Bird Index (WBI) measures average population trends of a suite of representative wild birds, as an indicator of the general health of the wider environment. The WBI is an easy-to-understand indicator that can be calculated for different geographic areas and habitats. This means that different Wild Bird Indices (WBIs) can be produced for areas such as farmland and woodland, or inside and outside protected areas if suitable data is available. It is useful for analysis, interpretation of environmental issues and communication.

The proven strengths of this indicator include:

- sensitivity to environmental change;
- statistical robustness;
- relative simplicity and hence ease of communication and comprehension;
- efficient use of existing data and the ease and frequency of update (which is often possible annually).

WBIs are based on systematic data collection, formal stratified survey designs and formal hierarchical analysis. This means that WBIs deliver scientifically robust and representative indicators for birds to support formal measurement and interpretation of national, regional and global targets to reduce, or halt, the rate of biodiversity loss. Additionally, WBIs:

- measure extinction and colonisation processes at a local scale among widespread and familiar birds in the environment (the survey methods count all bird species detected). In doing so, they shed light on the sustainability of the human use of that environment and how human impact is changing;
- are scaleable: they can be aggregated or disaggregated to regional, and national (even sub-national) scales. In time, a global scale index will be available;
- can describe the fortunes of entire bird assemblage (in so far as the entire assemblage is sampled) and thus potentially general trends in birds and other biodiversity;
- by grouping species tied to particular habitats, it is possible to create habitat-based indices, hence providing an insight into the health of those habitats and an indication of the sustainability of human use.

By definition, WBIs are taxonomically limited to only covering birds, and often only covering a subset of breeding birds amenable to standardised survey methods. WBIs measure biodiversity change in a fashion similar to the Living Planet Index (LPI), but whereas the LPI takes all data available from any source, the WBI only uses trend data from formally designed bird surveys. WBIs compliment the Red List Index that focuses on extinction risk at a global scale, and site-based indices that focus on the condition and performance of specially designated site networks. In combination, these three indices form a vital part of how we are able to track and understand the fate of nature.

WHY BIRDS ARE GOOD INDICATORS

- Birds are a very widespread and diverse group, living in most habitats across the globe.
- They are relatively easy to detect, identify and survey.
- They are high in food chains and thus sensitive to land use and climatic changes.
- In many countries, long-time data series exist: a mass of ancillary knowledge and information is available to aid interpretation and analysis.
- Bird data are realistic and inexpensive to collect (most often by skilled volunteers), then analyse and report.
- Methods of survey and analysis are highly developed and proven
- In most respects, birds are better known than any other taxa.
- Birds are popular and connect to people's lives: they have a resonance with the public and decision makers alike.
- Birds are very useful in communication to raise awareness of biodiversity issues.
- In many cases, bird trends faithfully reflect trends in other animals and plants.

PLACE IN THE 2010 BIODIVERSITY TARGET FRAMEWORK

The WBI has been adopted by the CBD as an indicator for immediate testing, under the 2010 Target focal area *Status and trends of the components of biological diversity* and the headline indicator *Trends in abundance and distribution of selected species*. It complements directly two other headline indicators within this focal area*:*

1 *trends in extent of selected biomes, ecosystems, and habitats*;
2 *change in the status of threatened species*.

Versions of the WBI are relevant to three other CBD 2010 focal areas:

1 under *Threats to biodiversity* and the headline indicator *Trends in invasive alien species*, WBIs can be developed to show trends in the impacts of invasive species and their management of biodiversity;
2 under the focal area *Sustainable use*, WBIs showing trends in the impacts of use and its management provide a useful measure;
3 under the focal area *Ecosystem integrity and ecosystem goods and services* and the headline indicator *Biodiversity for food and medicine*, a WBI showing trends in the status of species used for food and medicine is relevant.

The WBI is constructed from direct counts or estimates of bird species populations, and therefore provides a basis for assessing the importance of change in habitat extent, which is in many cases among the underlying causes of change in species populations. A WBI for wetland birds can provide a basis for tracking progress under the Ramsar Convention and a WBI for migratory birds is relevant for the Convention on Migratory Species. A WBI of bird populations subject to trade can help to assess the effectiveness of CITES in reducing the impacts of trade on some endangered species.

National and Regional Use

Birds have many useful characteristics that make them good potential indicators, including their public appeal, ease of identification and survey, their relative abundance, moderate diversity, and our level of knowledge about their ecology, numbers and ranges. At the same time, birds use the environment in a fashion and at a spatial scale quite unlike most other taxa. They are highly mobile and many species are migratory thus integrating environmental changes over huge areas. WBIs are designed to be indicators of the state of environment as they are comprised of common native species, with each species weighted equally. It is also a composite indicator integrating the balance of population trends of a basket of species and is potentially sensitive to a number of different drivers and pressures in the environment (ones we perceive now and potential unforeseen emerging issues). Its purpose is to act as a barometer of environmental change and as a surrogate of changes in wildlife more broadly. Composite trend indicators, such as WBIs, provide a simple way of measuring progress towards targets of reducing biodiversity loss at a number of spatial scales.

NATIONAL RELEVANCE

At national scale, WBIs are highly relevant for reporting progress towards international policy targets under the CBD, Ramsar, CMS and other relevant Conventions and processes. They have also been shown to support national policy and decision-making processes in conservation and many other sectors affecting use of land and other natural resources. Most decisions with respect to protected area designation are taken at national level, and these decisions need to be informed by relevant information and analysis.

Indicators of environmental health based on wild bird populations, for example those developed for the UK (Figure 1) and other European countries, have been very successful in reporting on trends in one element of biodiversity and thus influencing policy at a range of levels, as well as communicating to a wider, non-specialist audience. Naturally, WBIs need to be supported by complementary information on other aspects of species, sites and habitat conservation. Frequent updates allow the WBI to become familiar to both policy-makers and the general public, and national media often reports new updates.

WBIs are being used at a national level in at least 18 European countries, including in Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Latvia, the Netherlands, Norway, Portugal, Slovenia, Spain (Catalonia), Sweden, Switzerland, and the United Kingdom, and are in development in several others. More information on existing national and regional WBIs can be found on the internet, see Annex 1 for a full list of website links. A national implementation case study for the UK is available in Annex 2.

In the United States, government wildlife agencies and conservation groups have recently come together to produce the first comprehensive analysis of the state of the nation's birds (The State of the Birds 2009: United States of America www.stateofthebirds.org). To assess the health of habitats in the U.S., bird population indicators were created based on the best available monitoring data for groups of species in each habitat. The concept of wild bird index has been applied widely throughout the world in other State-of-the-Birds reports and has been accepted as an important measure of environmental health. Each indicator represents the change in abundance for a group of bird species combined into a single indicator line from a variety of data sources.

Figure 1: The UK wild bird indicator from 1970 to 2008, showing trends in widespread and common seabirds, water and wetland birds, woodland birds, farmland birds, and all common species, with the number of species included in each multi-species indicator shown in brackets.

Source: RSPB/BTO/JNCC/Defra

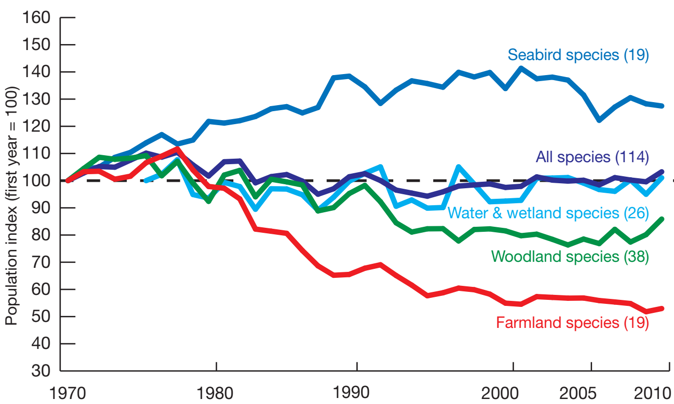
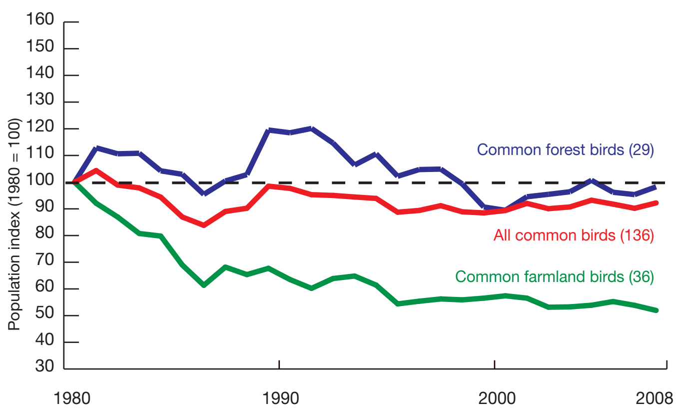


Figure 2: The European WBI from 1980 to 2007, showing trends in widespread and common forest birds, farmland birds and all common species, with the number of species included in each multi-species indicator shown in brackets. The indicator is set to a value of 100 in 1980.

Source: EBCC/RSPB/BirdLife International/Statistics Netherlands



To help detect and interpret long-term trends, Birds Australia has developed a statistical methodology for calculating multi-species indices of trends in common birds. This is based on the methodology used for the UK and EU wild bird indices; headline 'Quality of Life' indicators adopted by governments for reporting on national wellbeing. The methods have been adapted for the type of data in the Atlas of Australian Birds and commonly collected in Australia. The method will be used to calculate a set of standard indicators, for example, the woodland bird index and the winter migrant index, to report on the overall state of Australia's birds.

The production of WBIs is not limited to countries with extensive monitoring systems in place. New bird monitoring schemes are being initiated in a number of countries with limited data and resources. This approach, currently being piloted in the Africa region will help to generate data to allow national WBIs to be produced. A national case study on the implementation of a new bird population monitoring scheme in Uganda is available in Annex 3. For countries with a wealth of bird monitoring data readily available, challenges often exist in data selection to ensure the indicator is a true measure of the state of the environment. This issue is illustrated in the UK example below.

REGIONAL RELEVANCE

Problems of species selection and application at different spatial scales and in different systems complicate comparisons, and highlight the need for involving experts in their production and interpretation. Nevertheless, although population trends for individual species (and by extension particular landscape-associated indicators) will be influenced by a diverse array of factors, these approaches have proved successful in identifying the main drivers of change in the group of species included in the indicators. To identify and understand the effects of particular issues in, for example, management of old-growth forests, it will always be necessary to disaggregate the headline indicator into sub-groups of species that are expected to show the strongest response to a particular driver.

GLOBAL RELEVANCE

There is growing recognition across the globe that the inexorable decline of nature may have profound consequences for the lives of people and their economies through the loss of the natural resources and the ecological services they provide. There is the equally compelling case for biodiversity to be conserved for its intrinsic and irreplaceable value to mankind. Catalysed by this observation and the direct link between nature and human economies, world leaders have pledged to achieve a significant reduction of the current rate of biodiversity loss at global, regional and national levels. With such ambition comes a recognised need for powerful measures of how nature is changing. We know that birds can act as excellent sentinels or indicators of how the world

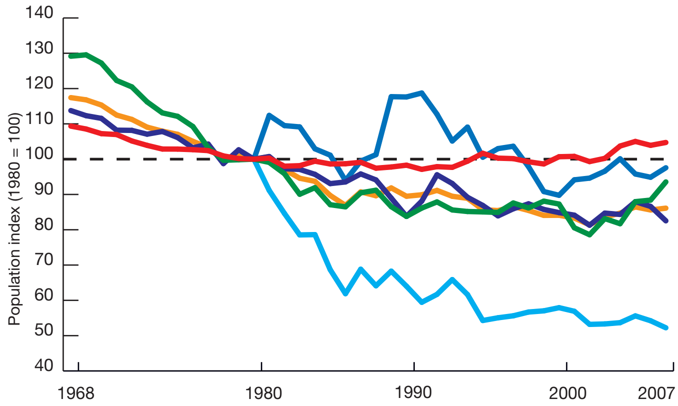


Figure 3: Provisional Wild Bird Indices for two continental regions, North America and Europe.

- US grassland specialists (24)
- All specialists (202)
- US aridland specialists (17)
- US forest specialists (96)
- European forest specialists (29)
- European farmland specialists (36)

Source: European Bird Census Council/RSPB/BirdLife International/Statistics Netherlands, and U.S. NABCI Committee. 2009. State of the Birds 2009: United States of America. U.S. Department of Interior: Washington, DC.

is changing, and a global Wild Bird Index will deliver the first scientifically robust and representative indices of bird trends at this scale.

WBIs are already operational and in use in Europe and North America (Figure 3), and are development in Australia and Africa. A regional implementation case study for Europe is available in Annex 4. A further challenge arises if the bird indicators were to be expanded to cover wider geographical regions and in time to produce continental or global wild bird indicators, an ambition currently being promoted and developed by BirdLife International and the RSPB. Indeed, Pereira and Cooper (2006) recommended the use of birds with vascular plants, as part of a new global biodiversity monitoring network responding to the 2010 targets. Information on continent-wide trends of common bird species is available for Europe, as well as for North America, and perhaps beyond in some form. BirdLife's global wild bird indicator project aims to develop indices from existing national or sub-national monitoring data, to set up tools to implement similar data collection and synthesis across a representative set of countries in other regions (building upon the an existing system using: http://www.world birds.org/mapportal/worldmap.php), and to develop prototype indicators from these data sources. In many parts of the world, however, one might expect data for widespread birds to be collected from only a limited number of sites, where most probably the species composition will vary considerably between the sites. It is then much more difficult to use this information to assess supranational trends as we have done in Europe. We would then need to think carefully about combining the site/habitat-specific trends, with habitat-specific trends for species groups at different scales.

GLOBAL IMPLEMENTATION

There is a huge amount of ongoing and historic bird monitoring information (bird surveys and atlases) available across the globe; the challenge is to collate such data and to assess the degree to which it might contribute meaningfully to a global WBI. Development of a global WBI will require the development of national capacity for bird monitoring across the globe, the coordination and connection of ongoing bird monitoring initiatives, and the successful delivery of national, regional, and global indicators for policy users and decision makers to gauge and better understand how the environment is changing. WBIs have a proven record for communicating on the state of nature to a broad audience and in raising the profile of birds and wildlife more generally. They have a proven record in influencing policy processes and decision makers to include and value nature in a range of policy decisions and deliver conservation action for birds and wildlife.

Data Sources

Indicators should be useful and useable - that is, they should give some indication of why the numbers they provide are fluctuating, so that policy decisions can attempt a remedy. We need to be able to generalise from an indicator, and to establish a link to the driving causes. Without ecological knowledge of what makes a species thrive or decline, it is not much use as an indicator. The output we want is a number, or a map, that provides, reasonably correctly, the big picture. It will not give all the answers. Fundamentally, we are looking for a bridge between policy and science.

An "umbrella" species would be ideal: a single species whose thriving or failure can be followed and whose conservation could be expected to confer protection over a larger suite of co-occurring species and their ecosystem. The downside is that it does not often work. Finding a single species that genuinely represents the diversity of a whole ecosystem is difficult. One might be tempted to focus on the rarities since they have an intrinsic worth: if they thrive, things must be getting better. However, it does not necessarily work that way either. Often, rare species are the focus of significant investments in their conservation, and their populations as a result, can perversely, be doing very well. Clearly, it would be absurd to pretend that overall biodiversity would have responded similarly and so rarities alone do not work as good indicators.

Nor are increases among the commonest species alone necessarily good indicators of increasing biodiversity. Paradoxically, they may show the reverse. When ecosystems degrade, a few "generalist" species that can thrive in a wide variety of man-modified habitats take over from a large number of "specialist" species, ones which need precise conditions, or ecological niches to survive. The process of wholesale change is called "biotic homogenisation". Under biotic homogenisation, regional differences in plants and animals begin to disappear, small populations of native species become extinct, and a few generalist species dominate.

Therefore, neither the rarest nor the commonest species are reliable indicators of biodiversity. In the "focal species" approach, populations of several different species are combined to act as "umbrellas" to protect a community. At this point, the thing does start to become useful. Selecting the right combinations of species is at the heart of it.

FORMALLY DESIGNED BIRD POPULATION MONITORING SCHEMES

WBIs should only incorporate trend data from formally designed Bird Population Monitoring surveys to deliver scientifically robust and representative indicators. However, not all of these may be suitable for WBI development, and the requirement for robust data from formally designed surveys means that data coverage may initially be patchy in many countries.

Common Bird Monitoring (CBM) Schemes

Common bird monitoring schemes that incorporate systematic data collection and that are based on formal stratified survey designs produce indices that can be updated annually, for all common bird species within participating countries. A number of different methodologies and survey designs are used. For example, in the UK, Poland and Bulgaria volunteers walk line transects to survey birds within randomly sampled 1km grid squares; in the Netherlands the scheme is based on territory mapping methods within sites chosen by observers; and in Hungary and Spain point count transects are used with a stratified sampling design. There are no requirements for survey methodology to be standardised across countries: as long as the national approaches are robust and employed to a high standard (in field methodology, sampling design and statistical analysis), the species indices produced by a variety of methodologies are all eligible for use in indicator production.

Contributing data are generated at the local level so WBIs are scalable and can be aggregated or disaggregated at the global, regional and national (sub-national) level. WBIs can also be disaggregated by the habitat or guild a bird occurs in, or by aspects of species' ecology, in order to aid interpretation. WBIs are particularly suited to tracking trends in the condition of habitats.

Other formally designed surveys

There are many other forms of Bird Population Monitoring scheme that may be considered for WBI development, although they are rarely immediately suitable as properly designed multi-species generic surveys. Nevertheless, in some cases they may provide a good starting point for the development of a wider, formally designed scheme.

Single species survey and monitoring schemes (often on large conspicuous species) are generally not suitable, as trends in a single species cannot be treated as representative of trends in wider biodiversity. However, many of these schemes could readily be expanded to include data collection for a wider number of species (i.e. all waterbirds, seabirds or raptors), more sites, or a particular habitat (i.e. wetland, forest or farmland), and would thus be able to contribute habitat and species-specific WBI data. In a few cases, it may be possible to use data from existing schemes to contribute towards a WBI, despite biases, with the intention that these are enhanced and expanded in time, or superseded by data from other sources: this would have to be assessed on a case by case basis.

In general, Important Bird Area (IBA) or other such protected area monitoring schemes are not suitable for WBI development as they tend to be biased towards areas not representative of the wider countryside. However, such schemes are often designed to monitor a wide range of species in a robust manner, and if coupled with an additional element of sampling outside of protected areas, may be enhanced in such a way that data collected may contribute to a national WBI.

Many current schemes are not of direct relevance to WBI efforts as they are designed and conducted for other survey and monitoring purposes, and others are not amenable to WBIs, as they were never intended to be. This is not to say they are without merit. Some have been designed and are conducted for other conservation purposes, many contribute to monitoring of GTBs, others contribute to IBA monitoring (through monitoring trigger species at IBAs), or monitor the condition of migration routes etc. All participatory bird monitoring, whatever its nature, serves to engage people in bird watching and monitoring activity, and raises awareness and willingness to support and participate in conservation action.

ESTABLISHING NEW MONITORING SCHEMES FOR WBI DEVELOPMENT

New National Bird Population Monitoring schemes that produce robust data require resources: manpower to oversee schemes, funding to cover costs, and, most crucially, observers willing and able to survey sites. Before rushing in to undertake a survey or set up a monitoring programme, it is first necessary to clarify the objectives and review available resources. This is a key stage in planning and any uncertainty at this point might limit the usefulness of the results and waste valuable time and money. It is not just that the objectives should determine the survey design, but that the practical limits on what can be done (which should be clear when the design is being planned) may cause you to modify the objectives (Figure 4). It is better to have less ambitious but achievable objectives than to stick with over-ambitious objectives that one fails to achieve. This section outlines how to go about planning a rigorous survey.

Some the key considerations for establishing a new common bird-monitoring scheme are:

- Where will the survey be undertaken? Should the whole area of interest be covered, or part of it sampled?
- If sampling is to be used, how should study sites be selected within this?
- What geographical sampling units will be used? Mapped grid squares, forest blocks, or other parcels of land?
- What field method will be used? Line or point transects, territory/spot mapping, or some combination of methods?
- What are the recording units for the birds? Individuals, singing males, breeding pairs, nests, territories etc?
- Is the aim to estimate population size accurately, or more likely, will a population index be sufficient? In other words, is the interest in relative or absolute abundance?
- What traditions and experiences of bird monitoring already exist, both within country and how can they be used effectively?
- Can the experience of other countries be useful in designing the programme of work?
- How will the subsequent data analysis be carried out? What kind of expertise and software will be needed for this task?

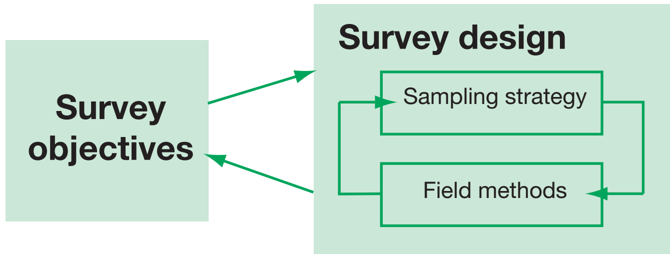


Figure 4: Feedback loops operating in survey design between the survey objectives, sampling strategy and field methods.
Source: European Bird Census Council/RSPB/BirdLife International/Statistics Netherlands, and U.S. NABCI Committee. 2009. State of the Birds 2009: United States of America. U.S. Department of Interior: Washington, DC.

A key product will be national population indices for individual species and multi-species indices (= indicators); is it clear how these will be derived from the data that is obtained?

- How will the national/sub-national results be reported and used? Who will be the key targets for different reporting e.g. the volunteer counters, statutory conservation agencies, and policy and decision makers in government, politicians, and the general public?

Many of these issues are covered in detail in Gregory *et al*. 2004a, 2004b and Voříšek *et al.* (2008).

Census or sample?

If a species occurs in relatively few places, and particularly if the birds or their nests are conspicuous and if they use traditional breeding sites, it may be possible to count every individual in the population by surveying its entire range. Such complete censuses require strong organization, to ensure that all potential sites for the species have been included in the survey. Many censuses are marred because it is not clear whether areas from which no birds have been reported have been surveyed or not; if they have not been surveyed, one cannot assume that they hold no birds, unless the habitat is known to be definitely unsuitable.

For most species, it is impossible to arrange full coverage of the entire study area, especially if the latter is an entire country. The solution is to count the birds in representative sample areas, extrapolating from them to the whole country.

Note that it is possible to mix censuses and samples. One may census those parts of the study area that are easiest to survey or hold the greatest numbers of birds and then just sample the rest of the study area.

Reliability: accuracy and precision

The reliability of a sample-based estimate of numbers (or of change in numbers over time) is a matter of both accuracy and precision. Accurate estimates are ones that are not consistently too low or two high; that is they are not biased. An obvious source of bias is under- or over-counting during fieldwork, so it is important to use well-tried methods that are appropriate to the species and habitats being studied. Bias will also arise if the samples are not truly representative of the whole study area: for example, if remote regions, steep mountains, or urban areas are underrepresented in the sample compared with the whole study area. It is never possible to know for sure that one‘s estimates are unbiased. All one can do is to adopt practices that are likely to minimise the bias.

Even if an estimate is unbiased, it may not be close to the true population size (or trend); that is, it may not be precise. Poor fieldwork may produce counts that, even though they are not consistently biased, are sometimes much too high and sometimes much too low. Even if the fieldwork is perfect, population densities and trends always vary from place to place, so getting a precise estimate for the study area as a whole depends on taking enough samples to ‘average out’ these variations. Unlike bias, the extent of which is never definitely known, precision can be measured, as either the standard error of the estimate or its confidence limits. When quoting a population estimate (or trend), one should always state the sample size on which it is based and its confidence limits (or standard error).

Random sampling is the only way to ensure that samples are unbiased. Furthermore, if samples are not random then the confidence limits that one calculates for one‘s estimate will not be correct, so one will also be misled about the precision of the estimate. Stratification is an extension of simple random sampling, which has advantages in some situations. For example, simple random sampling may, just by chance, result in more samples being taken in some parts of the study area than in others; one may want to ensure a more even distribution of samples. To do so, one simply divides the study area into smaller areas, technically termed ‘strata’, and samples randomly within each of them.

Field methods

The choice of field methods is as important as the choice of sampling strategy, and these choices are not independent: what field method is possible may influence one‘s decisions about sampling strategy and vice versa (Figure 4).

There is no uniformly best method, as what is best depends on the species under study, the habitat, and the resources available – particularly the fieldworkers. The three most common field methods in bird monitoring are mapping, line transects and point transects. These and other methods are covered by Bibby *et al*. (2000), Sutherland *et al*. (2004), Gregory *et al*. (2004b), Greenwood and Robinson (2006b).

Wherever possible, it is best to use a method that allows detectability to be estimated or in which an assumption that detectability is perfect is reasonable. Whatever the method chosen, it is important to standardize the fieldwork as much as possible, in order to ensure comparability between observers and, even more important, comparability over time (and over space).

There are some general issues to consider in planning fieldwork:

- The season of the year the survey is to be carried out. If one is monitoring breeding populations, for example, visits that are too early will encounter birds that are still migrating through the area and those that are too late will miss birds that have stopped singing.
- The time of day the survey is to be carried out, which should be the best time for detecting birds. This may not be the time when singing is at its peak, when the level of song may overwhelm the observer.
- The recording units and behaviour of the birds to be noted (ages, sexes, nests, singing, calling males etc).
- The size of the survey plots. If they are too small, they will yield only imprecise data; if they are too large, observers may be reluctant to undertake the work or may carry it out with insufficient care.
- The number of visits to be made to each sample plot site. This is commonly around 10 visits for mapping, in order to generate enough data to map territories reliably. For transects, 2-4 visits is the norm, spaced out over the breeding season, so that early breeding species are detected on the early visits and late breeders on the late visits).
- The recommended search effort. This covers not only walking speed (particularly important for line transects) or count duration (for point counts) but also such things as frequency of scanning with binoculars, stopping to identify the origin of distant calls, etc.

Detection probability

While indices may be used for the purposes of population monitoring, they rest on the core assumption that detectability does not change systematically over the years. If it does, changes in the index are not a reliable indication of changes in the population. Similarly, one may wish to compare the results of surveys in different areas. Even if the methods used are identical, differences between habitats or the behaviour of the birds may cause detectabilities to differ. Unless one can allow for differences in detectability, comparisons between different habitats surveyed at the same time (i.e. densities) and between the same places surveyed at different times (i.e. trends) rest on foundations that are in principle insecure. Buckland *et al*. (2001, 2004), Thomas *et al*. (2005) and others have argued that this is unsatisfactory.

The solution is to adjust counts to take account of detectability. Various methods have been proposed, although ‘Distance sampling’ underlies modern transect methods (Buckland *et al*. 2001, 2004; Thomas *et al*. 2005). It takes account of the fact that the number of birds one sees or hears declines with distance from the observer. The shape of this decline, the distance function, differs among species, among observers and, importantly, among habitats even when they occur at the same densities. Distance sampling models the 'distance function' and estimates density taking into account both the birds that were observed, plus those that were likely to be present but were not detected. Further information and freely available software relating to this can be found at: http://www.ruwpa.st-and.ac.uk/distance/. Density estimates improve with the number of birds recorded – a minimum of about 80 records is recommended.

Distance sampling methods, however, rely on a number of assumptions that need to be evaluated carefully in the field and steps taken to lessen and understand their effects. The key assumptions of distance methods are:

- that all the birds actually on the transect line or at the counting station are recorded;
- that birds do not move away from the line or point in response to the observer prior to being detected;
- that the birds are uniformly distributed across the landscape or, at least, that the transect lines (or points) are randomly distributed with respect to variations in bird density.

These assumptions are not completely realistic. Cryptic and shy birds that are right on the line may be missed; birds are likely to move before the observer detects them; and transect routes may tend to follow tracks, waterways, etc. – features that birds are commonly attracted to or avoid. Thus, the estimates of density derived from distance sampling may not be as accurate as we would wish. Nonetheless, because they have been consistently corrected for detectability, they are probably more reliable for monitoring purposes than indices that are not so corrected.

Resources

The list below details the minimum resources necessary to launch a Bird Population Monitoring scheme, based on experience in Europe. New schemes will only be successful in countries were there is a significant chance of success both in the short term, and in the scheme being sustainable in the long term. To that end, countries starting new schemes would ideally have sufficient experience in running nationwide projects and the staff resources to ensure that schemes are well run, with attention to handling sampling design and volunteer surveyors.

Specifically, when starting a new scheme, countries would require the ability to:

- design an appropriate monitoring scheme;
- produce survey instructions;
- produce survey forms;
- recruit and retain volunteer observers;
- run training workshops – potentially two in the first year of survey and one per annum subsequently;
- maintain close contact with volunteers to ensure that surveying is done as expected, where and when as expected;
- collect data from observers and collate in a basic electronic database;
- perform simple analyses on monitoring data;
- report survey results in a timely and suitable fashion, including an annual newsletter for observers;
- work to ensure sustainability of the scheme in the long-term.

Depending on the circumstances, country size, tradition and interest in bird counting, funding available etc, pilot national projects might aim to cover 50 sampling squares, chosen using a predefined strategy, using line or point transects. This should grow to cover a minimum of a hundred, up to several hundred, or thousand sample plots, where appropriate through time.

WORLDBIRDS OR SIMILAR WEB-BASED MONITORING

Web-based bird recording offers a process of systematic collection and capabilities through a new global system called 'WorldBirds'. The WorldBirds project is working to cover the whole globe with a family of intelligent web-based systems to pull together important information on birds from members of the public. RSPB and Birdlife support many of these schemes, but many are run entirely independently, but critically, because they share core data fields, all data can contribute to the WorldBirds family.

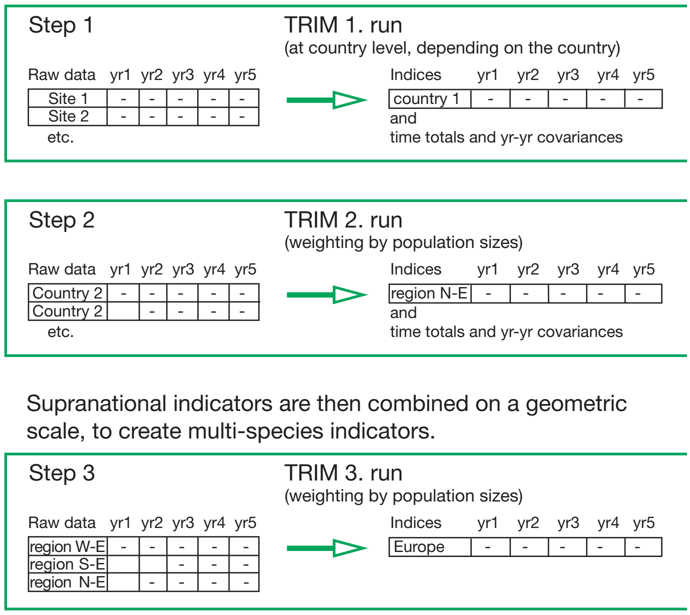
WorldBirds contributors range from people new to bird watching and wishing to learn more and contribute, to those highly skilled bird watchers who wish to store their bird records, but also see those records contributing to bird conservation. There are many people with an interest in viewing and recording birds recreationally and bird watching is an immensely popular activity that attracts huge numbers of people around the world. A considerable and rising proportion of these bird watchers not only make local trips to view birds, but also visit countries rich in biodiversity to pursue their interest.

The bird records themselves range in variety too, from a single species record in one place at one time, through more systematic complete lists of species recorded in one place at one time, to species records from formally designed surveys in one place at one time. All of the different kinds of information have their use and all are valuable.

However, often these records stay locked away in notebooks and in Excel spreadsheets on PCs, when in fact they could be making an important contribution to the conservation of birds, habitats and sites. Over the last decade, Internet-based projects involving large-scale public participation have proved to be a successful way to enable people to get involved in conservation. The aim of the WorldBirds project is to enable people to participate at a level at which they are comfortable, gain skills, improve their ways of recording, and so increase their enjoyment, sense of achievement and contribution to conservation. By standardising the way data is captured, WorldBirds ensures that such data is available for use, both for science and as a way to bringing together and nurturing a birding community. The Worldbirds model has been developed based on the simple collection of bird species records. We know that single species records are useful in their own right, but that complete lists of species encountered are potentially much more useful scientifically. Furthermore, we know that species records captured according to pre-designed survey protocols (sampling strategies and fieldwork methods) are even more valuable still and WorldBirds has developed scheme-specific screens to capture these data. We know that both complete species lists and data from formally designed surveys can form the basis of robust WBIs, so in time Worldbirds will make a valuable and increasing contribution to bird and biodiversity monitoring and reporting nationally, regionally and globally.

Calculating Wild Bird Indices

The statistical approach to indicator production combines national single-species indices to produce a multi-species indicator represented by a single line on a graph, indexed to an arbitrary year for presentational purposes (usually 100 in the start year). Rises and falls in this line indicate changes in common bird populations overall. This composite indicator is simple and easily comprehensible. It reflects the average behaviour of the populations of the selected constituent species; as each species is weighted equally in the indicator, trends in the indicator measure changes in species composition. In fact, the indicator measures the process of local extinction and colonization of species. The overall aim of the indicator is to act as a barometer of change in the wider landscape and as a surrogate for changes in other wildlife.



CALCULATING A MEAN POPULATION INDEX

Since population size is measured in a variety of units (e.g. pairs or indices, often with different base years for indices), it is necessary to standardise all figures to a base year. This may give the impression that the base year value is some kind of target to be regained, particularly with an index that declines, but this is not the intention. Species for which no data for the base year are available or which cannot be extrapolated from later years (because of incompatible survey techniques, for example) should be excluded.

Indicators (multi-species indices) are a geometric mean of the set of individual (or supranational) species indices. The index for each group of species is constructed by setting the first year in the series for each species trend to 1 and taking the geometric mean of the population trend across species, so that each species is given equal weight in the multi-species index. It is necessary to take the geometric mean rather than the arithmetic mean because of the skewed nature of the distribution of a simple index value; i.e. population increases can be infinite, but population decreases can be no more than 100%. Using this approach, a population doubling (index going from 1 to 2) is balanced by a population halving (index going from 1 to 0.5). Hence, each indicator is simply the average population trend of the species that it includes. When positive and negative changes of indices are in balance, then we would expect their mean to remain stable. If more species decline than increase, the mean should go down and vice versa.

CALCULATING INDICES AND TRENDS USING TRIM

The software package TRIM (TRends and Indices for Monitoring data) has been developed for analysis of count data obtained from monitoring wildlife populations. It is currently the standard to analyse count data obtained from bird monitoring schemes and is freely available from Statistics Netherlands via www.ebcc.info (Pannekoek and Van Strien 2001). TRIM allows yearly indices and trends (with standard errors) to be calculated by way of log-linear Poisson regression, with corrections for over-dispersion and serial correlation. The analyses allow for plot-turnover, and missing counts from sites are estimated from other sites within the same country, and (wherever possible) from sites with similar characteristics.

Supranational indices for species are produced by combining national indices, weighted by the national population size of each species. This means that changes in larger populations have a greater influence on the overall trend. Although national schemes may differ in count methods in the field, these differences do not influence the supranational results because the indices are standardised before being combined. Similarly, the fact that national schemes may have been running for different lengths of time may mean that there are missing year totals. However, TRIM is able to estimate these based on values from neighbouring countries in the same region.

Why Poisson regression?

One might consider applying ordinary linear regression to yearly count data. However, that would not be a valid approach because linear regression assumes the data to be normally distributed. However, that assumption does not hold for most count data and log transformation to make the data more normally distributed does not work properly when there are many zero values in the data. Generalized Linear Models (GLM; McCullagh and Nelder 1989) offer a better alternative to analyse count data (Ter Braak et al. 1994). In GLM models, the normality assumption is replaced by the assumption of a distribution of the user's choice. For count data, this distribution is often the Poisson distribution and this is implemented in TRIM. To apply the GLM models, transformation of raw data is no longer required.

Why use TRIM and when?

TRIM produces similar results to corresponding GLM models in statistical packages. In general, statistical packages are less easy

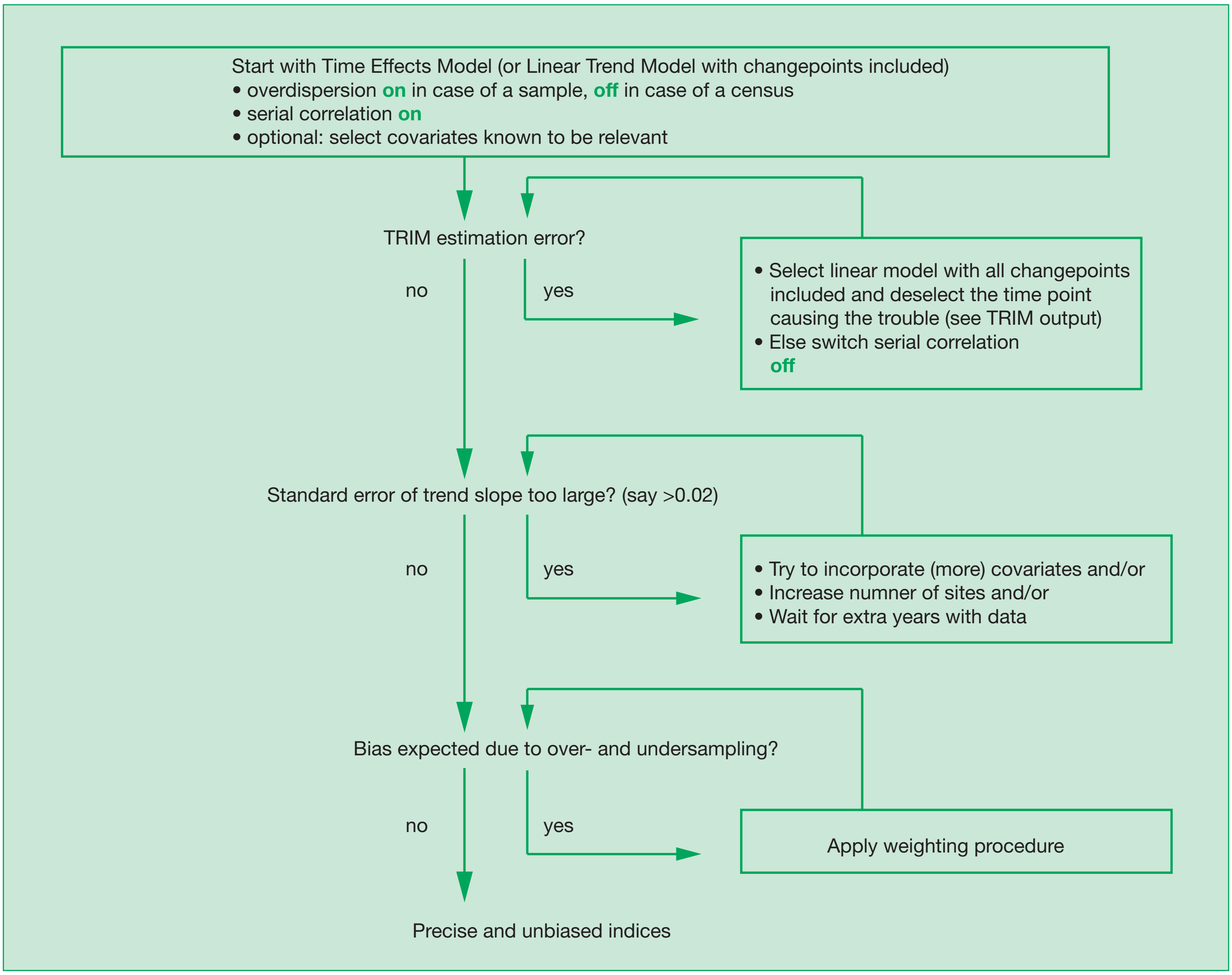


Figure 5: Model selection in TRIM

to apply and some of them cannot handle large datasets with many sites.

TRIM is meant as a tool to produce yearly indices for many species on a routine basis, year after year. TRIM takes into account site effects in the calculation of year effects and takes into account the serial correlation between counts in consecutive years. TRIM also has options to incorporate covariates, changepoints and weight factors (see Table 1), and other methods for models that are more complex, such as GAM's (Generalized Additive Models) or Hierarchical models (Sauer and Link 2003). In addition, TRIM is not able to take into account any changes in detection probability.

Smoothing of indices is possible by applying GAM's to the raw data (see for an example Siriwardena *et al*. 1998). An alternative way of smoothing is to apply the programme TrendSpotter to the TRIM results. TrendSpotter is currently used for smoothing the multi-species indicators and is based on structural time series analyses and the Kalman filter (Visser 2004; Soldaat *et al*. 2007).

What to look for in the TRIM output?

The following details in the output are most relevant:

- TRIM provides a summary of the data. Use the summary to check if TRIM has indeed recognized missing counts;
- TRIM highlights any sites with more that 10% of the total counts (across all years together), as such sites can be very influential to the results. It is important to understand that indices computed by TRIM are based on the sum of the counts of all sites per year and not based on the average trends per site. A few sites with high counts can thus make a difference;
- TRIM provides a list of the number of observations per year.

AIM	METHOD
Assessing indices and trends using sampling data	TRIM time-effects model with overdispersion switched on
Assessing indices and trends for a complete census	TRIM time-effects model, but with overdispersion switched off
Testing change points	TRIM linear model with selected change points
Testing effects of factors on indices and improving uncertain trends and indices	TRIM with covariates
Smoothing yearly indices	GAM's or a combination of TRIM and TrendSpotter
Adjusting for oversampling of, for example, particular regions or habitat types	TRIM with weight factors per site
Taking into account observer differences, different sampling efforts, both date as well as year effects etc.	More complex models than available in TRIM, e.g. GLM's in statistical packages, GAM's or Hierarchical models

Table 1: Possibilities of TRIM and some other methods

Check if all years have observations, especially the first and last few years. If not, TRIM may extrapolate the indices beyond the years without data, with sometimes unexpectedly large changes. This happens only if the linear trend model is specified in TRIM;

- the most relevant things in the output are, of course, the indices and the overall trends. If the standard errors of the overall slope are large, say >0.02, then there is a problem (Figure 5). If this is the case, the statistical power to detect any trends is low and trends will be classified as "uncertain". One may try to incorporate covariates to reduce the standard error. If this does not help, there is not much more you can do, but the power will gradually improve as the time series get longer.

The following details in the output are less important:

- information on model fit. TRIM constructs a model based on the observed data to estimate (impute) missing values. Please note that there is no problem if the model does not fit, because the lack of fit is already incorporated in the standard errors of indices and trends;
- information on the percentage of missing counts. What counts is the amount of data for the model, not the amount of missing data.

Presentation and Interpretation

PRESENTATION

Ultimately, WBIs as developed from the results of monitoring schemes are ineffectual if they are not communicated to the right people in the right way. The publication of results, achievements, analysis and messages helps in raising awareness of biodiversity, nature conservation, the funding of monitoring schemes, and generally supporting evidence-based nature conservation. The crucial point in communication is to consider what is the main message and who is the main target group. Each target audience may need to be approached differently to gain maximum benefit and to communicate in an appropriate fashion.

NARRATIVES (AND RELATION TO OTHER INDICATORS)

The state indicators based on wild bird populations have been very successful in reporting on trends in one element of biodiversity and thus influencing policy at a range of levels, as well as communicating to a wider, non-specialist audience. Naturally, our indices need to be supported by complementary information on other aspects of species, sites and habitat conservation.

MEANING AND CAUSES OF TRENDS

We know birds can be good umbrella indicators of the broad state of wildlife and the countryside, on practical and scientific grounds. They are diverse, widespread, and mobile; they are present in all habitats, worldwide; they are high in the food chain, which makes them sensitive to changes lower down – if insects decline, so do the birds that feed on them; they are sensitive to persistent pollutants, which become more concentrated as they travel along the chain of consumption; their ecology is well studied and on the whole well understood, so the driving forces behind their fluctuations can be identified.

The WBI is an average trend in a group of species. They are particularly suited to tracking trends in the condition of habitats. A decrease in the WBI means that the balance of species' population trends is negative, representing biodiversity loss. If it is constant, there is no overall change. An increase in the WBI means that the balance of species' trends is positive, implying that biodiversity loss has halted. However, an increasing WBI may, or may not, always equate to an improving situation in the environment. It could in extreme cases be the result of expansion of some species at the cost of others, or reflect habitat degradation. In all cases, detailed analysis must be conducted to interpret accurately the indicator trends. The composite trend can hide important trend patterns for individual species.

Implications for policy and management

The development of WBIs should involve crucial dialogue between scientists and policy makers; advice from the European Environment Agency, the European Topic Centre on Biological Diversity and the European Commission, in particular, has been instrumental in guiding the PECBMS and the development of European WBIs. The involvement of key policy makers from the outset enables the development of summary statistics and information that specifically target the policy needs. By maintaining this focus, and demanding the highest scientific standards in data collection, analysis and peer review, the PECBMS has been successful in promoting the official use of its biodiversity indicators in Europe. To do this, the indices have had to meet a range of quality criteria, both statistical and in terms of country representation. The strengths of this approach are its simplicity, transparency, temporal sensitivity, scientific credibility, policy relevance, relative ease of update, and, critically, the clarity of message. WBIs have shown their ability to connect and communicate with the public and decision makers alike, allowing policy makers to understand changes in the environment and then make better decisions about how we manage natural resources.

Limitations

Care is needed when using birds as indicators and birds are not always going to be the best environmental indicators in all situations. The following limitations should be considered:

- birds are less specialised in micro-habitat use than many other taxa;
- their distribution at one scale may not match the patterns of other taxa;
- population trends may not always correlate with those of other taxa;
- environmental degradation can result in 'perverse' positive population trends in some situations;
- populations may respond to integrated sets of factors, rather than single ones, so their trends need to be interpreted with care.

It is self evident that any indicator should be designed and used for a specific purpose and care is needed in its interpretation. Questions on the rationale for the indicator development, the users and legislation linked to an indicator, the appropriate indicator name (label), the frequency of update, the nature of any bias and representative coverage, and how it will be communicated, should all be considered very carefully before an indicator can be promoted for use.

It is important to have a large and representative set of sample points and species – in the case of an indicator based on multi-species index of changes in abundance, in general the more species contributing to the indicator, the more reliable it is. Individually, many species may show annual changes in abundance that may reflect a variety of environmental factors, such as extreme weather conditions during the breeding season, poor conditions on the winter grounds, changes in predation pressure, and simple sampling error and statistical noise. Consequently, indicators based on one or a few species are prone to show quite marked volatility, which may have very little to do with real changes in the environment. By using a more representative group of species that, for example, all breed in the same habitat, such variability can be reduced, and directional changes in the abundance of a whole suite of birds – and wider biodiversity – become more apparent. If the majority of species in the group decline, then the indicator trend line goes down, and vice versa. Overall, this can provide a balanced picture of what is happening in the environment (Gregory *et al*. 2002, 2005, 2007).

There are some technical issues regarding the construction of indicators that will also need addressing. For example, species selection and the way in which species are assigned to habitats within the indicators are important: such choices can have impacts on the resulting indicators. In the regional/global context there is the added complication of combining data from countries with dissimilar species complements. This will likely require the creation of indices and indicators at a regional level before combination into global indicators.

All biodiversity indicators illuminate just one or a few facets of this complex concept. Indicators need to be treated as a set, without placing undue reliance on any single measure. As with all other biodiversity indicators, care is needed when interpreting WBIs. They represent one small element of bird diversity (common and widespread bird species), which in turn is one small element of biodiversity. Nevertheless, the Wild Bird Index represents an important, useful and accepted element of the larger suite of environmental indicators.

Elements of Good Practice

COLLABORATION AND ENGAGEMENT/BUILDING SUPPORT AND SUSTAINABILITY

It is important to engage fully with the national agencies and non-governmental organisations responsible for nature conservation and protected areas management and with communities of scientists and other experts who may have relevant data sets and be able to provide guidance on their limitations and appropriate use. Some of these may be academic researchers based outside the country who may be able to help with repatriation of relevant data. It will also be important to engage with amateur networks, which may be sources of important data and can be encouraged through such engagement to ensure that their methods are consistent and provide usable trend data.

To maximise support from national stakeholders (especially statutory institutions), whether financial, technical, statutory, moral or publicity, it is important that Bird Population Monitoring schemes feed into national priorities (for example, National Biodiversity Strategy and Action Plans, or national reports to Conference of Parties for relevant Conventions). Consequently, at the onset, it is important to identify potential national end users of the data, and ensure that their concerns and needs (relating to general biodiversity indicators) are adequately addressed by the scheme. These would include government departments, particularly those responsible for habitats and wildlife, especially those reporting to Multilateral Environmental Agreements. There are also several forums where Bird Population Monitoring data will be useful at the regional and global scales. In this respect, the regional and global BirdLife secretariats may be best placed to promote the use of Bird Population Monitoring data.

DATA QUALITY STANDARDS

To assess the quality of data included in the index, it is important to ensure that the survey methods and area covered are clearly documented and comparable for each survey of the population time series. Assessments of national or regional extinction risk should if at all possible be based on the IUCN Red List Categories and Criteria and meet the appropriate documentation standards. BirdLife International is the official Red List Authority for birds for the IUCN Red List, supplying the categories and associated detailed documentation for all the world's birds to the IUCN Red List each year (see http://www.birdlife.org/action/science/species/global_species_programme/red_list.html).

METADATA

Data should be archived in a way that guarantees that they will be available indefinitely into the future, which means multiple copies in multiple locations, and with the archives being accompanied by the relevant ‘metadata’, describing exactly how they were obtained. It is vital to document thoroughly the versions and sources of each data set used for the analysis and that a common standard of metadata is used to enable easy cross comparison and data management.

When setting up a database it is vital to use proper database software. The biggest mistake, committed by many people, is to use a spreadsheet (e.g. Microsoft Excel) for data storage. Spreadsheets are designed for data processing, not for safe data storage. The basic feature of every database is that related data remain related forever. There is not one best all-purpose database solution. However, MySQL with PHP running on webserver (http://www.mysql.com, http://www.php.net) and Microsoft Access (http://office.microsoft.com/en-gb/access/default.aspx) are probably the most widespread alternatives.

Creating the right data structure is the crucial point in the process of setting up a database. A poor data structure limits future use of the data and can lead to further problems and extra costs. The data structure must accurately reflect described reality. There is no general data structure as it depends on the monitoring scheme.

All electronic data storage systems are prone to data losses due to equipment failure, misuse, abuse or other reasons. Security measures must be clear before putting data into the system and must be operated on a regular basis (manually or automatically) from the beginning. Main security measures comprise authorising all accesses (by usernames and passwords) and regular backups.

METHODOLOGICAL DOCUMENTATION AND CONSISTENCY (CROSS-CALIBRATION)

Full details should be documented of all methodologies relating to collection of the source data, species groupings and of how the analysis is performed, including weightings applied during this process. Monitoring programmes and WBIs, in principle run forever. This does not, however, mean that they should use the same methods forever. The methods should be regularly reviewed, to ensure that they remain appropriate and that developments in thinking, technology or resources have not caused them to become out-of-date. Some changes, designed simply to make things easier, can be introduced without raising concerns about their effects on the comparability of future with past data, though the change should always be recorded for the benefit of future interpreters of the data. Other changes, which may happen without any intervention from the organisers, may influence the results, but there is little that the organisers can do about it. It is critical however, to ensure that when improved data or methods become available, previous assessments are updated to take account of them, thus ensuring that any trend line is accurate and consistent.

Sometimes, however, it may be considered sensible to introduce significant changes deliberately, such as a change in survey design or field methods. This should only be done with the greatest of care, so that continuity of results is maintained despite a change in methods. The best way to do this is to have a period of overlap, when a scheme based on the new methods is run alongside a scheme based on the old methods. Towards the end of the planned overlap, the data need to be analysed to determine whether the two schemes are telling essentially the same story. If they are, it is a simple matter to link the two data sets statistically, so that the long-term continuity is unbroken when the old scheme is terminated.

FREQUENCY OF UPDATING

The development of prioritised lists of threatened species, such as the IUCN Red List of threatened birds is a key aspect of nature conservation. Such lists help to prioritise the allocation of resources for conservation effort and are often part of national or international legislation. Such lists are compiled using various criteria, but changes in population size are among the most frequently used. These lists need to be updated at a regular interval (perhaps every 5-10 years), which is an opportunity to use information from monitoring schemes to shed new light on the status and development of particular species and populations.

The assessment of the conservation status of a species can take a long time and conservation action has a better chance of success if the process begins as soon as a problem is detected. Annual monitoring schemes can provide such early warning signals to highlight significant declines in species. This might then trigger a more detailed investigation on the pattern and strength of trends, on the potential causes of population decline/increase and the appropriate conservation action to reverse a perceived problem. One of the difficulties in such systems is that there is a real danger of raising false alarms due to statistical noise and fluctuations in trend data, which might then waste valuable conservation effort and discredit the monitoring work. Hence, careful consideration of statistical error is an important part of such systems, but when they work properly, they do provide a highly useful early warning system.

References

Aebischer, N. J., Evans, A. D., Grice, P. V. & Vickery, J. A. (Eds) 2000. *Ecology and conservation of lowland farmland birds.* Tring, United Kingdom: British Ornithologists Union.

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. 2000. *Bird Census Techniques.* 2nd Edition. Academic Press, London.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. (eds.) 2001. *Introduction to distance sampling.* Oxford University Press, Oxford.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. (eds.) 2004. *Advanced Distance Sampling.* Oxford University Press, Oxford.

Butchart, S.H.M., Stattersfield, A.J., Bennun, L.A., Shutes, S.M., Akcakaya, H.R., Baillie, J.E.M., Stuart, S.N., Hilton-Taylor, C., and Mace, G.M. 2004. Measuring global trends in the status of biodiversity: Red List Indices for birds. *PLoS Biology* 2: e383.

Butchart, S.H.M., Akcakaya, H.R., Chanson, J., Baillie, J.E.M., Collen, B., Quader, S., Turner, W.R., Amin, R., Stuart, S.N., and Hilton-Taylor, C. 2007. Improvements to the Red List Index. *PLoS ONE* 2(1): e140.doi:10.1371/journal.pone.0000140.

Gibbons, D. W., Reid, J. B. and Chapman, R. A. 1993. *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991.* – T & AD Poyser, London, UK.

Greenwood, J.J.D. and Robinson, R.A. 2006. General census methods. In: Sutherland, W.J. (ed). *Ecological Census Techniques.* 2nd Edition, Cambridge University Press, Cambridge, pp. 87-183.

Gregory, R.D., Gibbons, D.W., Impey, A. and Marchant, J.H. 1999. *Generation of the headline indicator of wild bird populations.* BTO Research Report 221. BTO & RSPB. Thetford and Sandy, UK.

Gregory, R.D., Wilkinson, N.I., Noble, D.G., Brown, A.F., Robinson, J.A., Hughes, J. Procter, D.A., Gibbons D.W. and Galbraith, C.A. 2002. The population status of birds in the United Kingdom, Channel Islands and Isle of Man: an analysis of conservation concern 2002-2007. *British Birds* 95: 410-448.

Gregory, R. D., Noble, D., Field, R., Marchant, J.H, Raven, M. and Gibbons D.W. 2003. Using birds as indicators of biodiversity. *Ornis Hungaria* 12-13: 11-24.

Gregory, R.D. and Baillie, S.R. 2004a. Survey design and sampling strategies for breeding bird monitoring. *Bird Census News* 13: 19-31.

Gregory R.D, Gibbons D.W and Donald P.F. 2004b. Bird census and survey techniques. In: Sutherland W.J, Newton, I. and Green, R.E. (eds.). pp. 17-55. *Bird ecology and conservation: a handbook of techniques.* Cambridge University Press, Cambridge.

Gregory, R. D., van Strien, A. J., Vorisek, P., Gmelig Meyling, A. W., Noble, D. G., Foppen, R. P. B. and Gibbons, D. W. 2005. Developing indicators for European birds. *Phil. Trans. R. Soc. Lond.* B. 360: 269–288.

Gregory, R. D., Vorisek, P., van Strien, A. J., Gmelig Meyling, A. W., Jiguet, F., Fornasari, L., Reif, J., Chylarecki, P. and Burfield, I. J. 2007. Population trends of widespread woodland birds in Europe. *Ibis* 149 (S2), 78-97.

Gregory, R.D., Vorisek, P., Noble, D.G., van Strien, A.J., Pazderová, A., Eaton, M.E., Gmelig Meyling, A.W., Joys, A., Foppen, R.P.B., and Burfield, I.J. 2008. The generation and use of bird population indicators in Europe. *Bird Conservation International* 18, S223-S244.

Loh, J., Green, R.E., Ricketts, T., Lamoreux, J., Jenkins, M., Kapos, V. & Randers, J. 2005. The Living Planet Index: using species population time series to track trends in biodiversity. *Phil. Trans. R. Soc. Lond.* B. 360: 289-295.

McCullagh, P. and Nelder, J.A. 1989. *Generalized Linear Models*, 2nd Edition. Chapman and Hall, London.

Pannekoek, J. and van Strien, A.J. 2001. TRIM 3 Manual. Trends and Indices for Monitoring data. Research paper no. 0102, *Statistics Netherlands*, Voorburg.

Pereira, H.M. and Cooper H. D. 2006. Towards the global monitoring of biodiversity change. *TREE* 21, 123-129.

Pomeroy, D., Lutaaya, B. and Tushabe, H. (2006). *The state of Uganda's biodiversity 2006.* Kampala, MUIENR.

Sauer, J.R. and Link, W.A. 2003. Hierarchical models and the analysis of bird survey information. *Ornis Hungarica* 12-13: 217-222.

Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H. and Wilson, J.D. 1998. Trends in the abundance of farmland birds: a quantitative comparison of smoothed Common Birds Census indices. *Journal of Applied Ecology* 35: 24-43.

Soldaat, L., Visser, H., van Roomen, M. and van Strien, A.J. 2007. Smoothing and trend detection in waterbird monitoring data using Structural Time Series Analysis and the Kalman filter. *Journal of Ornithology* 148 (Suppl. 2): 351-357.

Sutherland, W.J., Newton, I. and Green, R.E. (eds.) 2004. Bird *ecology and conservation: a handbook of techniques.* Cambridge University Press, Cambridge.

Ter Braak, C.J.F., van Strien, A.J., Meijer, R. and Verstrael, T.J. 1994. Analysis of monitoring data with many missing values: which method? In: Hagemeijer, E.J.M. and Verstrael, T.J. (eds.). Bird Numbers 1992. *Distribution, monitoring and ecological aspects. Proceedings of the 12th International Conference of IBCC and EOAC*, Noordwijkerhout, The Netherlands. Statistics Netherlands, Voorburg/ Heerlen & SOVON, Beek-Ubbergen, pp. 663-673.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. In press. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*. DOI: 10.1111/j.1365-2664.2009.01737.x

Van Strien, A. J. 1999. From monitoring data to policy-relevant summary statistics. Bird Numbers 1998. *Vogelwelt* 120: 67-71.
Vickery, J.A., Evans, A.D., Grice, P., Brand-Hardy, R. and Aebischer, N.A. (Eds) 2004. Ecology and Conservation of Lowland Farmland Birds II: The Road to Recovery. *Ibis* 146 (suppl).

Visser, H. 2004. Estimation and detection of flexible trends. Atmospheric Environment 38: 4135-4145.

Voríšek P., Klvaňová A., Wotton S., Gregory R. D. (eds.) 2008. *A best practice guide for wild bird monitoring schemes.* First edition, CSO/RSPB.

Annex 1

REGIONAL AND NATIONAL INDICATOR LINKS

NORTH AMERICA:
- *The State of the Birds United States of America 2009*: Report (http://www.stateofthebirds.org/)

EUROPE:
- Pan-European Common Bird Monitoring (http://www.ebcc.info/pecbm.html)
- European wild bird indicators, 2008 update (http://www.ebcc.info/index.php?ID=368)
- Farmland Bird Index (http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007131627/IAssessment1116497137063/view_content)
- Farmland bird index Data (http://epp.eurostat.ec.europa.eu/portal/page/portal/structural_indicators/indicators/environment)
- Common Bird Index, Annual Environment Policy Review (http://ec.europa.eu/environment/policyreview.htm)
- Common Bird Index Data (http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/indicators/theme8)

UK:
- Wild Bird Index (http://www.defra.gov.uk/evidence/statistics/environment/wildlife/kf/wdkf03.htm)
- Wild bird populations 2008: Sustainable development strategy and Public service agreement indicators (http://www.defra.gov.uk/evidence/statistics/environment/wildlife/download/pdf/stats-release-wild-bird-populations2008. pdf)
- Sustainable Development Indicators: Wild Bird Index (http://www.defra.gov.uk/sustainable/government/progress/national/20.htm)
- Scottish Biodiversity Indicators: Terrestrial breeding birds, wintering waterbirds and breeding seabirds indices (http://www.scotland.gov.uk/Publications/2007/10/08091435/2)
- Wild bird population indicators for the English regions: 1994 – 2007 (http://www.defra.gov.uk/evidence/statistics/environment/wildlife/research/download/wdbrds200905.pdf)

Denmark:
- Wild Bird Indicator (http://www.blst.dk/Biodiversitet/Indikatorer/DK/Alm_fugle)

The Netherlands:
- Farmland Bird Index(http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl1479-Vogels-van-het-boerenland.html?i=4-27)

Latvia:
- Rural Bird Index (http://www.lvgma.gov.lv/produkti/liaip2006/Vide/biologiska_daudzveidiba.htm)

France:
- Common Farmland Bird Index (http://www2.mnhn.fr/vigie-nature/spip.php?rubrique14)
- Common Bird Index (http://www.ifen.fr/uploads/media/fiche_oiseaux.pdf)

Finland:
- Wild Bird Indicators (http://www.biodiversity.fi/en/indicators/farmlands/fa8-farmland-birds)

Germany:
- Wild Bird Indicators (http://www.bfn.de/0315_nachhaltigkeit.html)

Spain:
- Common Bird Index (http://www.mma.es/portal/secciones/calidad_contaminacion/indicadores_ambientales/perfil_ambiental_2008/index.htm)
- Catalonian Farmland Bird Index (http://www.ornitologia.org/monitoratge/socc2.htm)

Sweden
- Forest Breeding Bird Index (http://www.miljomal.se/Systemsidor/Indikatorsida/?iid=67&pl=1)
- Agricultural Breeding Bird Index (http://www.miljomal.se/Systemsidor/Indikatorsida/?iid=65&pl=1)
- Mountain Breeding Bird Index (http://www.miljomal.se/Systemsidor/Indikatorsida/?iid=65&pl=1)

Switzerland:
- Swiss Bird Index (SBI) (http://www.vogelwarte.ch/home.php?lang=e&cap=projekte&subcap=entwicklung&file=../detailprojects.php&projId=351)

Annex 2

NATIONAL IMPLEMENTATION CASE STUDY: BIRD POPULATION INDICATORS IN THE UK

A whole range of data sources are available on bird trends in the UK and the indicators that were developed attempted to make maximum use of what was available (Gregory *et al*. 1999, 2003). At present, the main data sources are annual surveys such as the BTO's Common Birds Census, the BTO/JNCC/RSPB Breeding Bird Survey, the BTO/WWT/RSPB/JNCC Wetland Bird Survey, the BTO Waterway Birds Survey, the JNCC Seabird Monitoring Programme and a small number of special surveys. For each species, the best dataset available was used considering representativeness, the time period covered by the survey and its periodicity.

SPECIES AND HABITAT SELECTION

Originally, the indicator focussed on two key groups, farmland and woodland birds, as they and their habitats are found across most of the UK countryside. It was based on common native bird species (i.e. those having more than 500 breeding pairs in the UK around 1990). Species were classified to habitat using Gibbons *et al*. (1993), who assigned species to habitats according to where they predominately breed and forage. Once allocated to a habitat, the trend for a species is generated using all available data, which in many cases will include those collected in other habitats – for example, trends for many woodland species will be based partly on data collected in farmland.

More recently, habitat-specific indicators have been developed for birds of water and wetland (in England), towns and gardens (England), uplands (Scotland) and seabirds (England, Scotland, UK), as measures of changes in biodiversity in these landscapes. By habitat-specific, we mean building indices based on species trends taken from specific habitats only. This work has demonstrated gaps in monitoring of key habitats, such as uplands, as well as the need to develop objective methods for determining representative species for each habitat. The town and garden indicator employed this kind of approach as many generalist species, widespread across a number of habitats use urban areas, few can be defined as specialists (i.e. only five are so defined by Gibbons *et al*. 1993). Therefore, the occurrence of species within urban transect-sections of the Breeding Bird Survey was used to determine species inclusion in the indicator, and only data from these transect sections was used in the generation of trends used to calculate the indicator.

The seabird indicator (now included in the main headline indicator) is based upon the monitoring of numbers at breeding colonies, but as long-lived seabirds may not show the population-level impact of reduced breeding success for some years, a complementary indicator based on annual productivity has also been developed. This makes use of good information on year-to-year changes in productivity, hence illustrating the worrying run of widespread breeding failure in recent years. Finally, a suite of wintering waterbird indicators, reporting on the UK's internationally important populations of wintering waterfowl and waders, are produced using data collected annually through the Wetland Bird Survey and WWT Goose Counts.

One of the weaknesses of such indicators in terms of biodiversity as a whole is that the rare and scarce species are underrepresented. This comes about because general bird surveys tend to focus on the commoner species by default – one requires more intensive survey methods and a specific sampling framework to census rare species. In this way, the wild bird indicator misses an important component of biodiversity and this emphasises the need for complementary measures that focus on rare species (van Strien 1999, Butchart et al. 2004, 2007). Rare birds, however, were excluded deliberately from the UK indicator because they are mostly the focus of dedicated conservation actions, are concentrated at a relatively small number of sites, and for this reason not particularly representative of the wider countryside (Gregory *et al*. 2003). In fact, a rare bird indicator developed by Gregory *et al*. (2003) showed populations to have more than doubled in the UK in the last thirty years, reflecting considerable investment of time and money in proactive and largely successful conservation initiatives. It would therefore be quite misleading to assume that rare bird populations are representative of the countryside in general.

TRENDS OF WIDESPREAD BIRDS IN THE UK

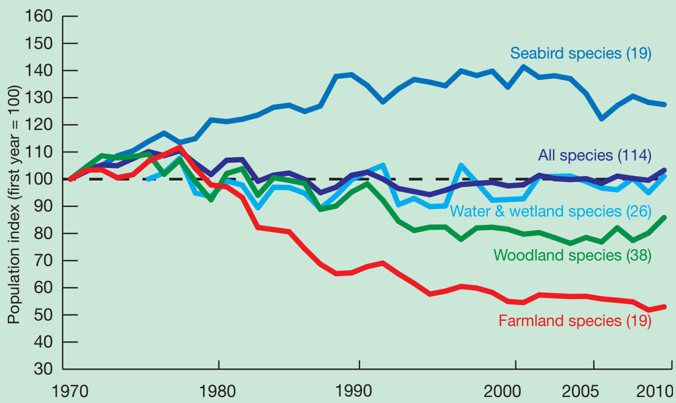
The UK wild bird indicator (see figure) shows marked declines in farmland birds and shallower but significant declines in woodland birds over the past four decades. A large body of research shows that the main driver of farmland bird declines, along with the parallel declines of other animals and plants in the UK, has been increased agricultural intensification (e.g. Aebischer et al. 2000, Vickery *et al*. 2004), although factors such as climate change, predators and changes in other habitats also influence the trends of some species. In contrast, the seabird indicator has increased markedly since the 1970s, largely as result of increases in the availability of fishing discards and breeding expansion in a group of opportunistic species. The seabird trend has faltered in the past decade as recent massive breeding failures start to have an impact on breeding populations.

TURNING SCIENCE INTO POLICY

The wild bird indicators described above are produced annually by a consortium of government and non-government organisations. The most recent update and details can be found on http://www.defra.gov.uk/evidence/statistics/environment/wildlife/index.htm alongside other indicators of sustainable development on a diverse array of topics including priority species and habitats, public attitudes, protected area networks, waste and recycling and water quality. The UK headline wild bird indicator (covering farmland birds, woodland birds and seabirds) was selected as one of 20 high-level UK sustainable development Framework Indicators, which are designed to monitor the priority areas for action identified by the strategy (http://www.defra.gov.

uk/sustainable/government/progress/policymonitoring/framework.htm). This has resulted in a high profile equivalent to that of other Framework Indicators that are more familiar to the public such as employment, poverty, education and life expectancy.

Wild bird population indicators based solely on English data, with a breakdown for farmland, woodland, water and wetland, towns and gardens, coasts and seas, are also used for measuring progress of the England Biodiversity Strategy (http://www.defra.gov.uk/evidence/statistics/environment/wildlife/wdbirdspop.htm). Similar country-based initiatives are underway in Scotland (http://www.scotland.gov.uk/Publications/2004/06/19410/37926) and in Wales.



The UK wild bird indicator from 1970 to 2008, showing trends in widespread and common seabirds, water and wetland birds, woodland birds, farmland birds, and all common species, with the number of species included in each multi-species indicator shown in brackets. Source: RSPB/BTO/JNCC/Defra

Annex 3

NATIONAL IMPLEMENTATION CASE STUDY: ESTABLISHING A NEW BIRD POPULATION MONITORING SCHEME IN UGANDA TO DELIVER WBIs IN THE FUTURE

In Africa, as elsewhere in the world, many species of birds are declining and in need of more effective conservation. A recent review of former and current monitoring activities in Africa (RSPB, unpublished) listed 85 schemes in 13 countries, of which 69 are still ongoing. Some 25 African countries are currently monitoring waterbirds, but as yet there are far fewer schemes for landbirds, with only nine of those that do exist covering all species. In the absence of any standardised monitoring of widespread land bird species, there is the very real possibility that populations of those species we regard as 'common' may be facing declines without our knowledge, yet such declines would indicate a fundamental flaw in the way we treat our environment and thus influence the way we behave. There is clearly a huge gap in our knowledge, and one that must be addressed if we are to achieve a significant reduction of the current rate of biodiversity loss at global, regional and national levels.

In Uganda, the rate of loss of biodiversity as a whole has been estimated at about 1% per year (Pomeroy et al. 2006): similar to the global rate (Loh *et al*. 2005). In 1983, a standardised landbird monitoring programme was instigated in Uganda by Makerere University Institute of Environment and Natural Resources (MUIENR) and the National Biodiversity Databank (NBDB) in Kampala. By 2008, the programme had made more than 1,000 counts, recording nearly 500 non-forest species at 40 sites. With observers drawn from the staff and students of the University, birds were recorded by using Timed Species Counts (TSCs), which were originally developed to cope with species-rich habitats such as those encountered in Uganda (lists can go up to 50 species in an hour within a single habitat).As well as being geographically dispersed, the sites are stratified in two ways - by land use (natural, pastoral and agricultural) and by original natural vegetation (forest, moist savannah, dry savannah and impeded drainage). However, although counts began in 1983, regular twice-yearly counts at all sites only began in 2004.Following a review of the capacity of African BirdLife partners to initiate new Common Bird Monitoring (CBM) schemes in 2008, *Nature*Uganda, MUIENR and the NBDB joined forces with the RSPB/BirdLife Global Wild Bird Index Project to develop a new enhanced participatory CBM scheme.

The new CBM scheme:

- Has been developed in consultation with many local conservation organisations, including *Nature*Uganda, MUIENR, the NBDB and the Uganda Wildlife Authority (UWA). Incorporates many of the original land bird monitoring programme sites.
- Employs line transect methods to count birds every February and July.
- Uses volunteer observers, coordinated by *Nature*Uganda.

- Incorporates a training programme for volunteer observers and provides regular feedback to those taking part.
- Has shown steady growth in the number of observers, and the number and geographical spread of sites.
- As of February 2010, includes 64 transects that cover a wide range of habitats both within and outside protected areas.

Although previous counts were made using Timed Species Count (TSC) methods, the new CBM scheme was designed to use standardised line transects. In practical terms, integration of the new scheme with the existing monitoring has been relatively straightforward and has presented few problems. At sites that were monitored previously using TSC's, a period of overlap has been built in whereby both old and new count methods have been used side-by-side, thus providing comparative data. All data collected will, in time, be used to produce aggregated population trends as an indicator of the general condition of natural habitats in Uganda.

Thirty-three volunteers received training at an initial workshop in January 2009. Participants of the workshop included staff from all partner organisations, including researchers, bird guides and rangers from many National Parks and Wildlife Reserves. The aim of this training workshop was to develop a strategy and mode of operation of the programme and to develop and train key volunteers in the methods to be used in the programme. The vast majority of those trained have since participated in undertaking CBM counts across the country, with subsequent increases in the number of volunteer observers taking part as a result of the trained volunteers passing on their knowledge to others. This process has been so successful, that within one year of the scheme set up, the number of volunteer participants had doubled.

Although the majority of the CBM sites are currently in central, southern and western Uganda (see figure), the scheme aims to expand it's geographical coverage to include more sites in the Northern and Eastern parts of the country in the near future through the ongoing training programme.

In addition to the production and distribution of a variety of promotional materials, regular stakeholder meetings help maintain and build upon the collaborative nature of the scheme. The steady growth of the new scheme, in terms of both the geographic spread and number of sites, is some measure of the success of the ongoing training programme and the value of regular contact with those taking part. By developing the new scheme in partnership and collaboration with several conservation organisations and by engaging volunteer observers, the new CBM scheme has real prospects of long-term sustainability.

Experience in Uganda leads us to encourage other countries to develop national CBM programmes, either by adapting or enhancing ongoing monitoring or by developing new schemes to work in collaboration with other existing monitoring programmes.

Annex 4

REGIONAL IMPLEMENTATION CASE STUDY: EUROPEAN WILD BIRD INDICES

Ambitions to bring together bird population monitoring of various kinds in Europe go back many years. The advantages of pooling and comparing data are obvious from both scientific and conservation policy perspectives. From the outset, the work was strongly influenced by the experiences in developing workable indicators in UK and by parallel work in The Netherlands. Developing such an initiative at a European scale raised many new issues and challenges. Having considered a number of different options, the favoured one was 1) building a pan-European scheme for common breeding birds by combining data from the pre-existing national count schemes, 2) encouraging and initiating new schemes in those countries with the capacity to do so, and 3) building similar capacity and establishing a sample of survey plots in the remaining countries. Progress under the banner of the 'Pan-European Common Bird Monitoring Scheme' (PECBMS) has been considerable (Gregory *et al*. 2005, 2007, 2008 see: http://www.ebcc.info/pecbm.html).

Using data collected at a national level, the PECBMS produces annual updates of the European WBIs for 135 species, taking data from 21 countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom). The data were collected using a variety of field methods (spot/territory mapping method, line or point transects, each with between 1 and 12 visits to each site per year; see Bibby et al. 2000; Gregory et al. 2004a, 2004b). These sample surveys record all bird species encountered, but by their very nature, they are unlikely to cover very rare species and so the trends represent the commoner and more widespread birds in the environment.

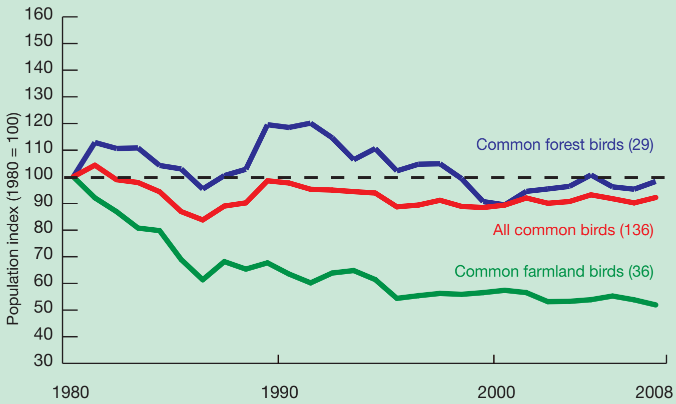
The procedure of European species indices computation is hierarchical. Individual national species indices are produced by annually operated national breeding bird schemes spanning different time periods. Currently 21 European countries of those that are involved in the PECBMS network provided their national indices. These national species indices are computed using a software package named TRIM, which allows for missing counts in the time series and yields unbiased yearly indices and standard errors using Poisson regression (Pannekoek and van Strien 2001). The national indices are weighted by estimates of national population sizes (derived from Birds in Europe 2 (2004)) when they are combined into supra-national species indices (regional or European indices). Weighting allows for the fact that different countries hold different proportions of each species´ European population. Although national schemes differ in count methods in the field, these differences do not influence the supranational results because the indices are standardised before being combined. National trends are then combined in a hierarchical fashion so that missing values were estimated from similar neighbouring countries. Supranational indices for species are then combined on a geometric scale to create multi-species indicators.

SPECIES AND HABITAT SELECTION

The intention of regional indicators is to tell us something about how the environment might be changing at a broad scale, and so for the European WBIs, focus is placed on the predominant landscapes of Europe: farmland and forest. Agricultural and grassland habitats cover around 50%, and boreal and temperate forests around 30%, of Europe's land surface area. To reflect regional variation in habitat use made by birds, PECBMS adopted a species-habitat classification based on assessments within bio-geographical regions of Europe, which were then combined to create a single European classification. Expert ornithologists acted as regional coordinators and were responsible for producing the regional species lists in cooperation with many other experts. The birds selected had large European ranges and were abundant enough to be monitored accurately in the majority of countries by common bird monitoring schemes, were well monitored by standard field methods and were considered to some degree dependent on the habitat for nesting or feeding. The majority of these species are resident in Europe, but several are long-distance migrants wintering in Africa.

TRENDS OF WIDESPREAD BIRDS IN EUROPE

The bird indicator paints a picture of what is happening to common bird across Europe (see figure). The group of all common birds has declined slightly by 10% over last 27 years. Common forest birds have declined a similar amount by 9%, but common farmland birds have declined severely by 48% over last 27 years. Agriculture intensification has been widely recognised as one of the main driving forces behind the dramatic decline of farmland birds. Although patchy, information on other taxa, e.g. insects, plants and mammals, confirms the broad extent of biodiversity decline in Europe. Farmland covers some 50%



The European WBI from 1980 to 2007, showing trends in widespread and common forest birds, farmland birds and all common species, with the number of species included in each multi-species indicator shown in brackets. The indicator is set to a value of 100 in 1980.

Source: EBCC/RSPB/BirdLife International/Statistics Netherlands

of European landscape and the farmland bird indicator is therefore a signal that we are losing an important part of biodiversity. The numbers of many species characteristic for European farmland are in decline, for example, Eurasian Skylark (*Alauda arvensis*), Yellowhammer (*Emberiza citrinella*) or Corn Bunting (*Miliaria calandra*), and very few farmland species in Europe have stable or increasing populations.

TURNING SCIENCE INTO POLICY

The farmland bird indicator has been adopted by the EU as a baseline indicator under the Rural Development Regulations, as an Agri-Environment Indicator, as a Sustainable Development Indicator, and Structural Indicator. Rural Development Regulations, for example, require EU member states to develop a plan for agriculture that is measured against farmland bird indices. The bird indicators also feature in the SEBI2010 (Streamlining European 2010 Biodiversity Indicators) set of biodiversity indicators developed by European Environment Agency and others.

2010 BIP Secretariat
(UNEP-WCMC)
217 Huntingdon Road
Cambridge CB3 0DL
United Kingdom

Tel +44 1223 277314
Fax +44 1223 277316

info@twentyten.net
www.twentyten.net