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Wordbirds: developing a web-based data collection system for the global monitoring of bird distribution and abundance

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Abstract. There is an urgent need to develop simple and effective methods for monitoring bird populations that are cheap to deploy in resource-poor countries. This paper describes a newly developed system, provisionally referred to as, Wordbirds, that will provide a platform for the collection, storage and retrieval of new and existing data from bird observations recorded worldwide. This Internet-based global network of databases will capture field lists and *ad hoc* sightings routinely gathered by individuals observing birds recreationally and professionally. Huge numbers of lists are collected annually and could provide information on population trends spanning many years. By collecting these records, a valuable resource will be secured with the potential to map and monitor bird distributions and estimate trends in species abundance.

Introduction

Monitoring long-term trends in the abundance and distribution of species has become an essential pillar of conservation, and represents a more sensitive and informative way of tracking anthropogenic impacts on the global environment than the estimation of extinction rates (Balmford et al. 2003). In most countries, an overwhelming majority of taxa are not monitored systematically (Balmford et al. 2003), often because many schemes are complex and involve standardised methods that are costly in both financial and human resources. However, as most of the world's countries are now parties to the Convention on Biodiversity and have an obligation under Article 7 of that agreement to monitor biodiversity, there is a real need for simple and inexpensive monitoring methods to be identified, particularly in resource-poor countries.

Many countries now have in existence a well-organised cadre of professional and recreational observers competent in identifying species within their group of interest. For example, the BirdLife International global partnership now operates in over 100 countries and territories, and most of these organisations have local memberships numbering in the hundreds or thousands. Furthermore, each year many amateur naturalists and environmental professionals travel the world to view wildlife recreationally. Bird watching is an immensely popular activity that attracts approximately 2.6 million people in the UK (Target Group Index (c); British Market Research Bureau 2003) and approximately 45 million in the U.S. (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2001). A considerable, and rising, proportion of these observers visit countries rich in biodiversity to watch birds recreationally. From the UK alone, there were over 1000 fixed-date international departure wildlife tours in 2001/2002 visiting roughly12,500 destinations in 107 different countries (45% of the 239 countries in the world) (Martin Davies, pers. comm.). Fixed-date departure tours are only a small part of the international wildlife tourism market; substantially more people arrange their own trips or organise tailor made excursions through specialist companies.

Much of the information that individuals record on birding trips, usually in the form of day lists, remains unavailable in personal notebooks or databases/spreadsheets; it also sits in unpublished trip reports or on data sheets that have not been computerised. In many areas of the world, this may be the only source of information on bird populations that exist. If these records could be captured, they could yield valuable information on distribution and population trends and would help to understand birds more completely on a local, national and international level.

The challenge, therefore, is to design a system for collecting and analysing data that is accessible and useful both to under-resourced experts within their own countries, and to amateurs visiting other countries. Recent advances in Internet-based technology and an increasingly computer literate global population are creating a climate that allows for the exploitation of new electronic tools for data input and retrieval. These can be used to collect a previously untapped resource of data from individuals and supply it to a much wider range of audiences.

In this paper, we describe the scientific and conceptual development of a system that aims to provide a platform for the collection of new and existing data on birds that can be used by amateurs and professionals alike. It will collect *ad hoc* and list data, such as those recorded by recreational observers, and provide a starting point for the development of systematic bird monitoring schemes using simple and repeatable methods. The base system – Wordbirds – has been developed as a joint initiative between BirdLife Secretariat, Audubon and the Royal Society for the Protection of Birds (RSPB), with input from the Svalan team (Swedish Environmental Protection Agency) and Kusbank (Erciyes University, Turkey).

Methods

Development and objectives of the system

Development of Wordbirds has focused on designing a generic core system that can be tailored to provide each participating country with a database that will support its individual preferences and requirements (e.g. language and cultural changes, country species lists and names, maps, toponyms and site lists). The focus of Wordbirds will be mainly on countries with a BirdLife Partner, so that each will eventually have and manage its own discrete system (named by and branded to that partner). Wordbirds will also extend globally to countries that already have existing initiatives, such as those in Sweden (Swedish Environmental Protection Agency), Turkey (Erciyes University), USA (Audubon), Denmark (Dansk Ornitologisk Forening/BirdLife Denmark) and the UK (RSPB, British Trust for Ornithology and BirdWatch Ireland). They can link into the network via a global map, without having to adopt a new system.

In order to link into the global map portal, a partner system should include the nine key fields (or relevant substitutes) of the core data model (Table 1). These core fields will help to ensure compatibility between datasets for regional and global comparisons, as well as influence the way in which data are collected. A further aim of Wordbirds is to guide individuals into recording better

Table 1. Core fields and their description required for each country database.

Core field	Description
Date	Day, month and year – no partial dates (e.g. June 2003) or observations that span more than one date (e.g. a trip list)
Time spent observing	Time spent observing or start and end time of observation period – the duration relates to a visit to a location i.e. users will be encouraged to submit separate 'visits' for cases where they observe birds at one site, spend time travelling to another, and observe birds at the new site (this may be blank for ad hoc observations, which are essentially momentary counts)
Species	All observations must select a species
Count	0 (to show absence), a number, or present
Full checklist marker	Binary variable to specify whether or not the submitted list is a full record of all species seen on a visit
Latitude & Longitude (two separate fields)	Self-explanatory
Distance travelled	Not relevant to most observations, but used for some methodologies such as transects
Validation marker	Not entered by the observer; used to show state of validation: valid, invalid or unvalidated

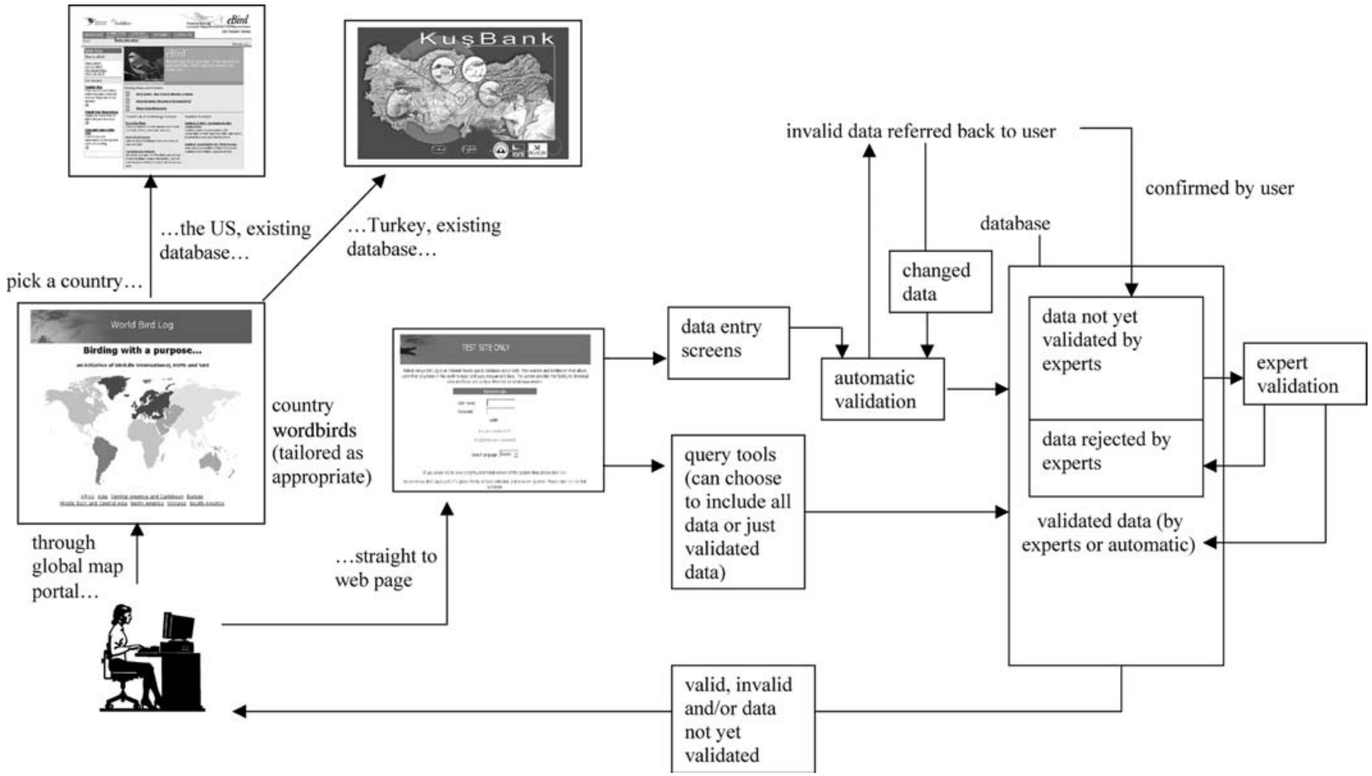

Figure 1. Illustration of the data input and retrieval protocol of the Wordbirds base system.

quality data, so that in the future they become more scientifically rigorous for use in conservation research.

How does Wordbirds work?

Observers submit and retrieve data by logging onto the global map portal and choosing the relevant country. The system is designed to be as user-friendly as possible, with a smooth flow of logical data entry procedures. Adding a visit requires the user to fill in as much information as possible about that visit, which includes the core fields of Table 1 and additional fields including location, how many observers were present and any notes for the visit. The location can be selected using a drop-down list of toponyms or by clicking on a map. If a toponym does not exist in the list of options, it can be added.

Figure 1 illustrates the process of data submission and retrieval and the validation procedure. Sophisticated validation tools are built into the system that allows thresholds to be set for each species in each month. Thresholds are set so that a sensible limit can be put on numbers of species a user enters so that erroneous or fraudulent entries are flagged as errors. This is useful for solitary species or those where flocks are likely to be small. For example, when entering a species in which flocks of 10 are likely, but not flocks of 100, thresholds can be set to guard against the common error of adding an extra zero in error. Any records exceeding prescribed thresholds (which for rare species will be set to zero) will be returned to the user with a query. If confirmed by the user, the records are then flagged to that particular system's validators as potential errors. Records of sensitive species or records that observers wish to remain confidential will always be hidden from other users, except the validation committee. Some data, for example all common species, will be automatically validated using validation rules already set for specific months. All other data will be set as unvalidated until a committee scrutinises them.

Background to Wordbirds development

Identification of pilot countries

Two pilot countries, India and Kenya, were selected because both have strong BirdLife Partners with a well-established group of amateur and professional observers, and because both are well visited by individuals observing birds recreationally. In both countries, the development of a monitoring scheme is regarded as a priority, and the capacity for data collection is high. Furthermore, the National Museums of Kenya have been recording list data of the type Kagu aims to collect for almost 10 years, allowing the prototype to be populated with existing data.

Collecting data to guide development of Wordbirds

Before the design of the database was considered, it was necessary to assess the needs of conservationists working in countries without dedicated monitoring schemes, levels of computer access and literacy, and the types of data routinely collected by observers. A questionnaire survey was therefore carried out before any system development was started. Questionnaires were given to a wide range of individuals and groups representing the potential end-users in Kenya and India and included conservation organisations, recreational birdwatchers, site support groups, bird guides and local tour companies. The questionnaires were distributed to, and collected from, this target audience by the Bombay Natural History Society (the BirdLife Partner in India) and Nature Kenya (the BirdLife Partner in Kenya).

In addition to the user perspective, research was undertaken to test the scientific rigour of the simple list-based data Wordbirds aims to collect. Information that can be fed into the Wordbirds system includes trip, day and site lists, and *ad hoc* sightings. There was a need to determine whether this information could be used effectively to answer questions about the distribution and abundance of birds. To do this, we looked at advancing the use of list-based methods to determine whether the changes in the rates at which individual species are recorded on simple lists could be used for monitoring birds in resource-poor countries (Roberts et al. in prep). Temple and Cary (1990) provide evidence that regional checklist data relate well to datasets from independent survey methods. They stated that the advantages of using checklist data to monitor population trends was the cost-effectiveness, the ease of data collection and management, and that data recording took place throughout the year. Furthermore, Cyre and Larivée (1993) found that a checklist approach yielded very significant results for the analysis of neotropical and temperate migrant bird trends in Québec.

Selection of taxonomic authority

Wordbirds uses a single taxonomic authority that will be adopted by each participating partner country. This is the taxonomic list maintained by BirdLife International of all the world's bird species (BirdLife International, 2004). This list is based on many taxonomic sources, but for the recognition of species limits globally Sibley and Monroe (1990, 1993) is the main source. The BirdLife list is based on:

- well recognised and established sources adopted by the BirdLife Taxonomic Working Group (BTWG) – each year, these sources are reviewed and, where possible and appropriate, updated or revised;
- peer-reviewed papers reviewed by the BTWG;
- original taxonomic research;

- some deviations from the adopted sources where treatment is judged to be mistaken and/or controversial.

Results

Questionnaire results

About 116 completed questionnaires were received out of approximately 200 sent out, 93% from India. The greater number received from participants in India appeared to reflect the strong organisational skills and dedicated network which underpins the Indian BirdLife Partner. Unfortunately, the BirdLife partner in Kenya faced a number of logistical problems in the distribution of the questionnaires, hence the low return of responses. Conceptually, respondents strongly supported Wordbirds, with 83% confirming that they would be willing to submit observations to an Internet-based database in the future. The questionnaire provided detailed information that allowed us to develop the system to complement the users' needs and requirements. We were able to get a clearer picture of the latter by asking about details of their activities when out recording birds (in their own country or abroad), and their views on using an Internet system as a way of storing and managing their own bird records.

In a typical year, most respondents spent more than 50 days recording birds. If each respondent recorded a day-list for each day spent birding, in India alone this would equate to approximately 6000 day-lists (and the number of respondents represents a tiny proportion of all the competent observers in that country). Typically, the majority of bird recording experiences consisted of regular visits made to one or more sites, and over half of respondents made casual recordings of birds wherever they happened to be. This has important implications for Wordbirds, as the system aims to encourage users not only to submit *ad hoc* data, but also to improve their collection methods and supply complete checklists when they visit sites. Observers will also be encouraged to increase the value of their checklists by revisiting sites regularly and by collecting quantitative data. These repeated observations will be beneficial from a scientific perspective to reveal how populations in a given area are changing over time and, in doing so, will provide a very basic monitoring scheme at a local level.

When recording observations, most respondents already usually record the date, site and time. Approximately half of the respondents record other details, such as counts of the number of birds, abundance measures and a complete list of species recorded. Scientifically, these details are important; for example, a species' absence from a list indicates either its absence (a true negative) or simply the fact that it was present but not recorded (a false negative). Accurate distribution maps need to reflect where birds are present and where they are not. From the questionnaire results we felt that we could not rely on these factors always being recorded, so we included within the data entry screen core fields to ensure that the completeness or otherwise of checklists can be determined.

To determine how useful Wordbirds will be, we needed to get a clearer idea of whether or not observers were computerising their data already, whether they were using them (and if so, what for), and whether they would be prepared to contribute their data to a system in which it could be used by others. Many respondents (83%) indicated that they would be willing to submit their observations to an Internet-based database. There was no difference in this response whether the information on the database could be viewed by anybody with Internet access or by a conservation organisation only. Approximately half of the individuals of the survey confirmed that they had access to the Internet at home and, encouragingly, 80% of respondents said they would use outputs from Wordbirds for personal research.

Scientific research results

While the feasibility of Wordbirds was being explored through a questionnaire survey, we undertook scientific research to examine how the type of data being collected by Wordbirds could be used. This focussed on statistically examining the relationship between long-term trends in the proportion of day-lists on which a species occurred at a particular site, or *list reporting rate*, and long-term trends in its abundance. If the two were found to be closely correlated, this would indicate that collecting multiple checklists from individual sites, as Wordbirds aims to do, will allow estimation of trends in numbers there.

Studies have shown that the list reporting rate of a species tends to be positively correlated with its abundance (e.g. Bart and Klosiewski 1989; Gibbons et al. 1993; Harrison et al. 1997; Kemp et al. 2001). This relationship arises from two general ecological principles (Lawton 1996): rare species tend to have more restricted distributions than common species, so an observer is less likely to be within the range of a rare species than a common one, and even where they do occur, rare species tend to occur at lower densities than common species and hence are less likely to be recorded. The relationship between list reporting rates and abundance is sufficiently close and general that a number of methods for estimating the relative abundance of different species have been developed from it (e.g. Bibby et al. 2000; Mackinnon and Phillips 2000).

The scientific research focused on developing the use of species lists in monitoring abundance through analyses of data from a bird mist netting project ringing carried out at a nature reserve in southern England. At this site, numbers of each species caught and the total level of ringing effort (measured as metre-net hours) have been recorded for over 30 years, with between 10 and 20 visits each year. These data were reduced to simple species lists, and the relationship between the effort-corrected estimate of abundance and list reporting rate examined statistically (Roberts et al., in prep).

The total number of species on a day-list was used as a proxy for variation in recording effort, as our objective was to develop methods of analysis that could be used when the only data available are complete lists of species recorded on particular dates. For the majority of species (excluding the most abundant ones), there was a strong relationship between list reporting rates and relative abundance (Roberts et al. in prep). Therefore, the measurement of changes in list reporting rates over time is likely to be of value for monitoring long-term trends in abundance in most species apart from those that most commonly occur.

Another aim of the study was to assess whether changes in list reporting rate at the single ringing site reflected changes in abundance more widely. We used trends taken from the Common Bird Census (CBC), a dedicated national monitoring scheme operated by the British Trust for Ornithology, and found a remarkably strong correlation between the CBC population trends and the population trends recorded at a single site covering a considerably smaller area. This suggests that collecting relatively small numbers of lists from a few sites can produce useful information on trends in abundance over large areas, although how the lists derived from capture data might differ from field lists collected by observers is unclear.

List-based monitoring schemes could therefore be extremely useful in countries high in biodiversity and low in conservation resources, since lists can be derived from a number of different sources and converted into a 'common currency' for analysis. For example, enthusiasts recording their observations recreationally already collect huge numbers of lists in many different countries, and many quantitative observations, such as standardised counts or trapping methods, can also be degraded into simple lists. Furthermore, list-based monitoring schemes would be easy and cheaper to establish in those countries where there are few trained observers than systemised schemes involving complicated field methods.

As well as using checklist data to help estimate abundance trends, it can also be a valuable tool for documenting birds' distributions. Data collected by each partner database will record the presence (and ideally absence) of species at a particular time and location. Using all these observations for a species over time allows its range to be determined, including movement patterns and tracking changes in distribution. The bird atlases of South Africa (Harrison et al. 1997) and Australia (Blakers et al. 1984) are prime examples of the use of list reporting rates to plot distribution and relative abundance. The reporting rate is the proportion of checklists on which a species is recorded, so differences in reporting rate between different areas and different times of the year may be interpreted as an indication of changes in abundance. Wordbirds will be able to track changes in distribution using listing rates. However, changes in distribution crudely reflect changes in abundance, since massive declines in numbers need to occur before changes in distribution become apparent (Donald and Fuller 1998).

Discussion

That large numbers of individuals are highly committed to collecting data on birds and share such data in a system like Wordbirds indicates that there is the potential to gather a vast amount of previously un-captured data. As a global network with links to the databases of each partner country, these data can be used to gain a more complete picture of the state of the world's birds.

The results of our research do not advocate Wordbirds as a monitoring scheme to replace existing methods that have well-defined and complex sampling designs, such as those used in America and parts of Europe. Wordbirds is an embryonic scheme with a step-wise approach to gaining data on the distribution and abundance of birds in resource-poor countries. It sets a monitoring device in place – albeit a simple one – which, over time, will collect more scientifically rigorous data as users are directed to record specific details of their observations. Any data that can be gathered and stored in a central system is clearly better than no information at all, particularly if that data can be procured at little or no cost (as is the case of records donated by travelling birdwatchers). Future development of the system, with more scientifically rigid schemes, will parallel the growth and dedication of its recording-base.

Wordbirds focus is on raising the profile and interest of people involved in gathering bird data. The system will allow users to download species lists for a chosen location, which should guide observers into more accurate recording, including the completion of comprehensive checklists. Users will also be able to determine the likelihood of seeing a particular species at a particular site and produce distribution maps of a species of their choice. Furthermore, on a national level, the element of competition between users should encourage visits to less popular birding locations, or places that have not been visited at all. Maps are powerful visual tools on the system as they are used to highlight locations that observations have taken place and so show clearly those areas not visited.

Financial considerations

The major financial cost of Wordbirds is the initial development of the core system (€150,000) plus staff time. Once the system has been developed, the main costs involved will be tailoring the system for each country and support of the system as it becomes established. This should take about two years per country, but will probably vary depending on the country involved.

While the initial development cost is high, it is a one-off payment; the actual future running costs for each partner country will be low. We anticipate that there will be ongoing hosting costs (per country), and some ongoing support costs from BirdLife/RSPB that should tail off over time. This is difficult to quantify due to a variation in the level of support being predicted for each country. However, Wordbirds does provide some possibilities for the generation of income that would need to be individually exploited by each country partner. Advertising opportunities could have high potential for generating revenue, particularly if targeting relevant businesses such as bird tours and tourist companies.

Sustainability

For Wordbirds to be sustainable, it will rely on the enthusiasm of the BirdLife partners to adopt and manage their individual database, and on its popularity amongst the target audience of professional and recreational observers. Since Wordbirds is a global programme, with all countries linked by a main map portal, the users of one system are potentially users of others. As a result, PR events promoting the system in a single country should effectively promote the entire global network.

Sustainability of the system relies on the country partner finding suitable funding for subsequent years. This will become easier as the system becomes better known but, in the early stages, BirdLife and the RSPB will provide guidance and assistance in securing sponsorship and promoting the product to increase its profile amongst the birding community. As a worldwide network of systems, there may be opportunities to make fundraising easier by exploiting its links from a national to the global level.

Interpreting the results from Wordbirds

It is important to recognise that there are problems with using list data that need to be taken into account when interpreting the results of data collected by Wordbirds. Any monitoring scheme based upon list reporting rates will need to address a number of problems, relating largely to the way that such lists are collected.

Firstly, it is essential that the lists used are complete records of all species encountered. Most lists will only record a proportion of the species actually present at the site, but lists that exclude species that were observed will be systematically biased. It may be, for example, that some observers compile only lists of species of interest, and may exclude the most abundant species. Such lists would bias estimates of relative abundance. Because of this caveat, a data entry field has been included to signify whether a checklist is full or not. From our questionnaires, however, we found that the majority of respondents recorded observations of rare and common birds on most days they were out watching birds. The system will be designed to encourage this practice.

A second problem of using lists is that scarce or rare species might be over-represented; some observers may continue to record birds until a particular species of interest, usually a rare one, has been recorded, or may target habitats or types occupied by that species. However, including list length when estimating reporting rates reduces this problem to some extent, since for lists collected from the same site, list length provides a surrogate estimate of effort. Thirdly, there is the problem of observers' attraction to the more desirable places for recording species. As Telfer et al. (2002) point out, some groups or habitats become attractive for no apparent reason, and recorders lose interest in others. This is likely to be particularly pronounced for areas that have suffered extreme degradation or complete destruction. Such areas will no longer attract observers so any declines or increases in population will fail to be recorded.

Variation in effort is another inevitable source of bias, as increasing effort (or ability) will increase the likelihood of any particular species being recorded. Differences in the completeness of species lists arise through factors such as variability in observer expertise and the time spent recording (Gaston 1996). Standardising effort during data collection is one method to reduce this variability; asking observers to record a crude estimate of effort would be desirable.

Changes over time in fieldwork techniques might also invalidate the method if they affect the probability of detection of species differently. For example, changes in the use of tape lures or guides with specialist knowledge of nest or roost locations of rare or difficult to locate bird species could result in spurious trends.

Further research on the efficiency of list-reporting rates relative to more complex and established methods is necessary before list methods can be advocated as a protocol for dedicated monitoring schemes in resource-poor regions. Further development and validation of list-based methods would pay dividends in extending the taxonomic and geographic scope of biodiversity monitoring. In particular, an assessment of the relative efficiency of list-based methods compared with more sophisticated count methods is required. However, in less developed countries systematic list-based monitoring schemes would be easier to establish and would gain key information on how abundant species are and whether their numbers are changing over time; any loss in precision might be compensated to some extent by increased sample sizes (Bart and Klosiewski 1989). Further research is also needed on how to effectively make use of data from Kagu, especially in resource-poor countries. If the monitoring is to lead to decision-making and conservation action, it is critical that mechanisms for feeding results directly into decision-making are established (Danielsen et al. 2005 (this issue)).

With a strong emphasis on citizen science, Kagu puts a system in place that aims to get many different types of people involved in gathering and submitting their data on birds. In the near future, local site support groups monitoring specific areas can add their observations to the system and use its tools to analyse data and build individual reports (see Bennun et al. 2005 (this issue)). This will complement other monitoring schemes in place by providing additional information, possibly from locations where data has not been previously collected. In areas where Internet accessibility is widespread, such as India, the network of users should be diverse and observations can be submitted from most areas throughout the country. In countries where access to the Internet is limited, users can submit paper lists of their observations to the BirdLife Partner who will add them to the system.

Conclusion

There is a pressing need to identify new protocols for monitoring biodiversity that require fewer resources than existing methods (Chamberlain et al. 2004). We believe that Wordbirds offers a valuable web-based approach to data collection and provision in countries that are low in resources but where potentially important information is already routinely collected on birdwatchers' lists. Participating countries will have a system to harness data that have been previously unavailable to conservation, and will encourage the collection of new data in a more systematic and repeatable way. By establishing a global network of such systems, there is a greater opportunity to capture data on those species and locations that are currently not monitored.

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