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REVIEW

Citizens, science and bird conservation

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Abstract Collaborative research by networks of amateurs has had a major role in ornithology and conservation science and will continue to do so. It has been important in establishing the facts of migration, systematically recording distribution, providing insights into habitat requirements and recording variation in numbers, productivity and survival, thus allowing detailed demographic analyses. The availability of these data has allowed conservation work to be focussed on priority species, habitats and sites and enabled refined monitoring and research programmes aimed at providing the understanding necessary for sound conservation management and for evidence-based government policy. The success of such work depends on the independence of the science from those advocating particular policies in order to ensure that the science is unbiased. Wetland birds are surveyed in much of the world. Most countries also have a ringing scheme. Other forms of collaborative ornithology are strong in North America, Australia and Australasia, more patchily distributed in Asia (but with strong growth in some countries) and even patchier in Africa and South America. Such work is most successful where there is a strong partnership between the amateurs and the professional, based on their complementary roles. The participation of large numbers of volunteers not only enables work to be done that would otherwise be impossible but also facilitates democratic participation in the decisions made by society and builds social capital. The recruitment to and subsequent retention of people in the research networks are important skills. Surveys must be organized in ways that take into account the motives of the participants. It is useful to assess the skills of potential participants and, rather than rejecting those thought not to have adequate skills, to provide training. Special attention needs to be paid to ensuring that instructions are clear, that methods are standardized and that data are gathered in a form that is easily processed. Providing for the continuity of long-term projects is essential. There are advantages to having just one organization running most of the work in each country. Various sorts of organizations are possible: societies governed by their (amateur) members but employing professional staff to organize the work seem to be a particularly successful model. Independence from government and from conservation organizations is desirable.

Keywords Amateur · Census · Collaboration · Conservation · Distribution · Habitat · Monitoring · Survival

Introduction

Ornithology is a "science in which the amateur tradition is still of first-rate importance" (Nicholson 1959). Indeed, Barrow (1998) described it as a classic example of "an inclusive scientific field", in the sense of a well-established profession that continues to interact with its avocational practitioners (amateurs) in a significant way. Exemplifying this, though all members of the National Committee for the Hamburg International Ornithological Congress (IOC) are professionals, seven of the 16 members of the Local Committee are amateurs. While amateurs are also strong in other fields of natural history and in astronomy,

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archaeology and local history (Finnegan 2005a; Mims 1999), there are few disciplines that approach ornithology in the extent of the amateurs' contribution. This has enabled ornithology to contribute to ecological science and conservation biology to a degree unmatched by other taxon-based disciplines. It is therefore important that ecologists, science administrators, conservationists and governments understand and appreciate the contribution of the amateur. They often do not, as exemplified by a recent British paper on the democratization of science that completely ignored the role of the amateur scientist (Wilsdon and Willis 2004).

By "amateurs", I mean those who contribute to ornithological science for the love of it, not for payment. They usually have no formal qualifications in ornithology or related sciences; their qualification comes from having a level of expertise appropriate to the studies in which they participate, expertise gained largely through extensive field experience. The work of some—field work, analysis and publication—is comparable to that of professionals; more common is "purposeful birdwatching", where simple observations are made as part of a systematic investigation led by others (often professionals). Unfortunately, at least in the English language, the word "amateur" has come often to be used with a negative meaning: "The old positive meaning of 'connoisseur' has gradually been overthrown by the pejorative sense of 'dilettante', emphasizing a lack of seriousness and reliability" (Drouin and Bensaude-Vincent 1996). The word "volunteer" has often been used instead, but for some people this has the negative connotation of being merely a helper in an enterprise headed by others. The term "citizen scientist" has also been widely used, but it has apparently suffered two different devaluations. One stems from the widespread public perception of scientists as people responsible for technologies that many think do more harm than good, such as nuclear power and pesticides; the other from the misuse of the phrase to cover "surveys" that have no scientific value. The latter comprise projects deliberately designed for purposes other than science—for example, to raise awareness of environmental issues, to recruit members to other surveys or to obtain names and addresses to be used in later fund-raising or campaigning—but which are promoted to participants as being research projects. Since they are not planned with the objective of producing peer-reviewed, published science, they are not science projects. To promote them as such consequently devalues citizen science in the eyes of both the participants and the wider community. There is thus no ideal term. I shall use all three here, but always in a positive sense.

Two hundred years ago, there was no perceived difference between amateur and professional naturalists. The trends leading to the separation have been described by contributors to the book edited by Jardine et al. (1996) and, for Britain, by Allen (1976, 1985, 1998). At first there were very few professionals. The increase in their numbers, at different times in different countries, roughly coincided with the increasing awareness of the "new biology", especially physiology and comparative anatomy. This "new biology" was more attractive than natural history for the professionals, for its novelty demonstrated that they were forward-looking and progressive, and it was not attractive to amateurs because its pursuit demanded well-founded laboratories and technical training. So arose the division: the professional in the laboratory, and the amateur in the field. The amateurs did not stand still. In addition to their traditional interests in distribution, habits and life histories, they took up more systematic studies of ecology and behaviour. Indeed, they could afford to be innovators, working on topics that had not yet become academically respectable: "the amateur is free to tread the by-ways of inquiry, without pressure for immediate results or conformity to current themes" (Mayfield 1979). In the UK (which is not atypical), the ringing scheme was set up by amateurs, constant-effort ringing sites were pioneered by amateurs, the first national bird census were organized by amateurs and the first atlas project (a local one) was an entirely amateur effort.

It is true that professionals have moved into fields where amateurs led the way, developing bodies of theory and technical methodologies (especially statistical) that act as fences to the amateur. However, the independent amateur ornithologist is not an extinct breed. Some amateurs operate as independent scientists, distinguished from professionals merely by not being paid. An outstanding current example from Germany is the surgeon, B.-U. Meyberg, a leading raptor biologist who chairs the World Working Group on Birds of Prey and Owls and who specializes in satellite-tracking studies (e.g. Meyberg et al. 2002); at the IOC, the symposium on the House Sparrow *Passer domesticus* was co-organized by J.D. Summers-Smith, a tribologist by profession but a sparrow biologist by vocation (Summers-Smith 1963, 1988, 1995). Other people work in collaborative groups on particular sorts of birds or in particular localities. A key example has been the Wash Wader Ringing Group, which has led a major increase in our knowledge of the waders of the West European flyway (Kew 1999; Minton 1999) (it could list 79 published papers and reports in its 40th anniversary report). Not only has its lead encouraged similar work elsewhere in the UK and Europe, but the emigration of one of its leaders, C.D.T. Minton, to Australia contributed to a great development of knowledge of waders there, again much of it through teamwork by skilled volunteers (Minton 2005; Straw 2005). Such groups may benefit from having a wider range of expertise among their members than is easily possible to assemble in a professional team. In addition to such amateur-led work, professionals may enrol volunteers as unpaid members of their team or request amateur ringers to gather material for them.

One advantage that amateurs have over professionals is their large numbers, and it is large-scale collaborative surveys that have been the major contribution of amateurs to ornithology for much of the last century. In the early days, such surveys were often wholly amateur enterprises but, as the scale of the work and the technical demands of organization and data analysis have increased, it has been found effective to extend the collaboration beyond the amateurs, to draw in the complementary contributions of professionals. Such large-scale contributions are the subject of this paper. I begin by reviewing the areas of ornithology to which amateurs have contributed and summarize the scientific contributions that have come from their work; then I consider how they contribute to conservation science (of much interest to many of the participants and funders); finally, I describe how such surveys are organized and how they may be more effectively developed across the world.

Unfortunately, my approach suffers from unavoidable bias for two reasons. The first is that my direct experience is limited to the UK, though through the European Bird Census Council and personal contacts I have some knowledge of the amateur contribution in other European countries. Colleagues in the rest of the world have, however, been generous with their time in educating me about what happens in their countries (see Acknowledgments), which has allowed me to take a broader view. My second problem is that few nations are as interested in birds as Britain, whose citizens make huge contributions to ornithology; indeed, it is probably still true that “Another field in which Britain has led—and is still leading—is the mobilization of the amateur for co-operative studies and projects” (Huxley 1959). As a result, my account may be biased towards the UK. It is important, however, to recognize that amateur ornithology flourishes in many other countries; and where it does not yet do so, there is great potential.

Subjects of study

Migration

The first large-scale collaborative ornithological survey was started in Finland in 1749, when Professor Johannes Leche of the Turku Academy began collecting the first arrival dates of spring migrants. The work has been continued under various auspices (currently the Ornithological Society of Turku) ever since, with few gaps (unpublished correspondence with Esa Lehikoinen 24 July 2006). In 1839 the Belgian Adolphe Quetelet requested observations on periodic phenomena in nature, including bird migration, so that when Professor G. G. Hälström gave a talk at a meeting of the Economical Society in Turku in 1844, he was able to measure the progress of migration in spring and autumn based on both the Finnish and the Belgian data. During the rest of the nineteenth century there were similar efforts in various European countries (Berthold 2001; Boubier 1932; Newton 1896; Stresemann 1975; Thomson 1926). An innovation was the production of lines of equal arrival date to summarize large volumes of data in Alexander von Middendorf’s “Die Isepiptesen Russlands” in 1855. Another was the collection of data from lighthouse keepers around the coast of the Britain and Ireland between 1880 and 1889 by a team led by John Cordeaux (a farmer), J.A. Harvie Brown (a landowner) and W. Eagle Clark (a civil engineer and surveyor) (Clark 1912; Pashby 1985).

Interest in migration was so great that it was the main reason for calling the first and second IOCs (Vienna in 1884; Budapest in 1891). The first decided that there should be the “initiation of bird observatories all over the inhabited world” (Fiedler 2001). This was not a new idea, for the British naturalist J.D. Salmon (1834) had called, unsuccessfully, for the study of coastal passage migrants “by the cooperative agency of naturalists residing near headlands on the coasts”, but this time the call was heeded. Bird observatories, often with professional staff but usually with substantial amateur input, began to be established, the first at Rossiten (Fiedler 2001), with other productive Baltic stations established at Falsterbö (Rudebeck 1950) and Ottenby (Edelstam 1972). Many reports were written from this early work, but the level of synthesis was limited: the volume of data overwhelmed the methods of data handling, statistical analysis and presentation then available.

In North America, the schoolteacher W.W. Cooke asked for arrival dates to be reported to him by ornithologists, birdwatchers and interested members of the public. He produced preliminary reports of the 1882 and 1883 data and then a major report for 1884 and 1885 in which he plotted “isochronal lines”, a somewhat less jaw-cracking term than von Middendorff’s “isepipteses” (Cooke 1888). Cooke turned professional, eventually with the Biological Survey, where he transferred the submitted data to file cards (writing with both hands to overcome writer’s cramp) and published many papers (Palmer 1917); he had received 600,000 cards by 1910, and material continued to flow in until the 1930s but was no longer worked up for publication (Barrow 1998). Erica Dunn (unpublished correspondence, 15 March 2006), who has seen the file cards, now kept at the U.S. Geological Survey Patuxent Wildlife Research Center, estimates that they would take

1–3 years to computerize. Whether this would be worthwhile is debatable, but selective analysis of such historical data can certainly be useful. Thus, from 20 selected years of data for the Swallow *Hirundo rustica* from the Royal Meteorological Society's records for 1883–1947, Huin and Sparks (1998) were able to plot isochronal contours for early, normal and late years of arrival in the Britain; these plots showed that the birds moved northwards more rapidly in years when they arrived late and demonstrated the influence of temperatures in both Iberia and the Britain on arrival dates.

Two limitations to such data are that the fieldwork is unsystematic and the data are not corrected for effort. It is well-known that these limitations can cause serious distortions, an example being the occurrence of Bearded Tits *Panurus biarmicus* in Western Poland: systematic observations show a strong peak in early October but casual observations peak a month later—when there is a national holiday and when special counts of waterbirds are organized (Surmacki 2005). On a finer temporal scale, 40% of the rare birds found in the Britain are first found on Saturdays or Sundays, although the bias is less marked in areas with more frequent coverage during the week (Fraser 1997). More systematic observations were attempted several decades ago—for example, through co-ordinated observations of waders and terns at approximately 20 inland sites in the Britain in the springs of 1947 and 1948 (Hinde and Harrison 1949; Hinde 1951) and a scheme to cover all species at approximately 100 "Inland Observation Points" (IOP) in England and Wales, which were censused at least four times a week in the early 1960s (Dobinson 1962, 1963a, b). The IOP scheme appears to have foundered because the volume of data gathered once again proved too great to handle. The recent Migration Monitoring Programme of the Gulf Coast Bird Observatory, based on censuses in both spring and fall at many sites (93 by 2002) has, in contrast, web-based data entry. Though most sites are in the south-east USA, the ease of data entry should allow it to become multi-national, to cover the whole Caribbean Basin (Hamel et al. 2005). Computers have also solved the problem of turning large volumes of data into useful information. The first step was the Southern African Bird Atlas project, which entailed birdwatchers submitting complete lists of what they saw whenever they were recording for the project. The proportion of lists recording a species in a particular area during a particular period could then be used as an index of the relative abundance of that species in that place at that time, thereby allowing migratory movements to be tracked year round (Harrison et al. 1997). A similar approach was adopted by the Migration Watch project run by the British Trust for Ornithology (BTO) and BirdWatch Ireland, but in this case observers submitted their data on-line, allowing a rapid feedback of the results, including maps showing how species were moving into the UK and Ireland as spring advanced. By fitting smoothed curves to the data, it was possible to identify the date on which all of the birds of a species had arrived, plus medians and percentiles. Comparison of the curves allows one to see and estimate the magnitude of differences between species and between years and to estimate the rate of northward progress of the main body of migrants (Baillie et al. 2006). Working with the proportion of lists rather than just the number of records circumvents variations in recording effort, while medians are more stable descriptors. The UK Phenology Network and BBC Springwatch and Autumnwatch programmes have drawn large numbers of people into recording migration and other seasonal events (Collinson and Sparks 2005; Sparks and Collinson 2006).

Many individual or small groups of observers operating at single sites have studied birds actually migrating, not just seabirds passing headlands in numbers, and the spectacular concentrations of raptors at internationally renowned sites (see, for example, Bildstein 2006), but also birds making less concentrated movements over the general landscape. Early work on Swifts *Apus apus* migrating through the Britain by using squads of mobile observers (on bicycles) in a limited area (Darlington 1951) or by obtaining countrywide observations on a specific day (Hurrel 1948) seems not to have been developed.

Much migration takes place by night, but this can be observed by watching migrants crossing the face of the moon. The Swiss Ornithological Institute has led collaborative moonwatching in Central and southern Europe in recent years, sometimes involving hundreds of sites. This approach has been checked against radar observations and found to be reliable up to a height of 1 km and a distance of 2 km (Liechti et al. 1995), and the patterns revealed are reliable with as few as three to five observers per 10,000 km^2 (Liechti 2001). The results show clearly how most night migrants in Western Europe move through Iberia to cross the Mediterranean (Bruderer 2001), while those in the east cross the sea on a broad front (Zehtindjiev and Liechti 2003), with movements in mountainous areas being influenced by local topography (Bruderer 2001; Liechti et al. 1996a, b). There seems to have been little use of collaborative moonwatching elsewhere. A project involving over 1000 observers across North America on four consecutive nights in October 1952 (Lowery and Newman 1966) appears not to have been repeated, though Jennifer Johnson organized a pilot study in South America in fall 2004 (Jahn et al. 2004).

The study of migration was revolutionized in 1899 when the Danish schoolteacher Hans Christian Mortensen began to place individually numbered rings on the legs of birds (Mortensen 1950; Preuss 2001). Mortensen continued his studies for many years, and ringing was quickly taken up in other countries, not only by individual researchers (both amateur and professional) but also by groups working collaboratively in local areas. Bird observatories undertook ringing as well as direct observation of migration. In 1903, J. Cole used the example of the Rossiten observatory when calling for ringing to be started in North America, as it was in the following year by P.A. Tavener (for the subsequent development of North American ringing, see Jonkel 1978; Lincoln 1933; Tautin and Metras 1998; Tautin et al. 1999; Yunick and Pantle 1978). Many other countries soon established ringing schemes. Worldwide, most ringers are amateurs, but even when the ringers are professionals, birdwatchers and members of the public contribute by reporting birds that they find dead. The reporting networks, like the birds, cross political boundaries, so the work is facilitated by collaboration between schemes. EURING facilitates collaboration across Europe through establishing common standards, promoting joint projects and running a common database. Canada and the USA have separate ringing offices but run a joint scheme, with common reporting systems and data-sharing being developed across Western Hemisphere countries; Ireland is covered by the British scheme; and the Japanese scheme extends to some neighbouring countries. Even war has not disrupted the networks: Danish neutrality allowed Mortensen to facilitate exchange of ringing data through the First World War (Preuss 2001) and the British continued to exchange data through the Second World War via neutral countries (Leach 1945).

Through the efforts of ringers and the input of people reporting ringed birds, we now have huge data sets, the analyses of which have produced thousands of papers on migration, many written by amateurs. An atlas of recoveries was produced by Schüz and Weigold as early as 1931, followed by several others in more recent years (Bakken et al. 2003, 2006; Bønløkke et al. 2006; Brewer et al. 2006; Fransson and Pettersson 2001; Wernham et al. 2002; Zink 1973, 1975, 1981, 1985; Zink and Bairlein 1995). Thanks to computers, these atlases show increasingly powerful analyses and modes of displaying the results (see also Crick et al. 2006). Alerstam (1990), Bairlein (2001), Berthold (2001) and Newton (2003) have summarized what we have discovered about migration, much of it based on ringing. For many species, we know: (1) where birds are at different seasons, their routes and their stop-over sites; (2) that most migration is broad-front (even when leading lines are followed locally) but that some is narrow-front; (3) that species spread over a broad latitudinal range at one season may be more concentrated at another but that leap-frog migration, preserving but inverting the latitudinal spread, is common; (4) that birds are generally faithful to breeding sites and often to wintering and stop-over sites, though abmigration may occur as a result of birds from different breeding areas pairing up on the wintering grounds; (5) that individuals participating in irruptions are doing so to enhance their chances of survival and subsequent reproduction (contrary to the bizarre view that individuals that irrupt are sacrificing themselves in order that the resources of the breeding area are not overstretched). We can see such details as (1) neighbouring populations that migrate on parallel tracks; (2) other neighbouring populations that migrate to widely separate areas in the non-breeding season; (3) populations that return to the breeding areas by a different route from that used to travel to the non-breeding area; (4) differential migration of the sexes or of age groups (even differences in the migration of juveniles hatched earlier or later in the season); (5) dismigration of juveniles after fledging; (6) immatures that remain in non-breeding areas during the breeding season; (7) species that may migrate to quite different areas in different winters. We can discern broad patterns in migration strategies (Newton 2003). We have been able to observe changes in the direction, destination and timing of migration and in the proportion of birds moving short or long distances (Fiedler 2003). And general ringing, key for many of these discoveries, can even provide information on orientation mechanisms (Mouritsen 2001).

Sustained migration studies are conducted at many individual ringing stations, often largely manned by volunteers. The value of the work has been much enhanced where networks of stations have worked collaboratively (Bub 1991). Operation Recovery, started in 1955, established ringing stations down the east coast of North America (Tautin et al. 1999); Operation Baltic, started in 1961, has drawn together stations in northern Europe (Busse and Kania 1970); the Mettnau-Reit-Illmitz (MRI) programme, started in 1972, drew together stations in Central Europe to provide information on weight changes during the course of migration and on moult (Berthold and Schlenker 1975; Berthold et al. 1991; Kaiser and Berthold 2004); Progetto Piccole Isole, with its 41 stations and over 500 ringers, has revealed much about spring migration across the Mediterranean, especially about the importance of islands as stop-over sites and the differences between species in migration strategy (Rubolini et al. 2004; Spina et al. 1993; Spina and Pilastro 1998); the European Science Foundation project of 1993–1997, based on 40 widespread stations, identified the routes, timing and speed of migrations and the fuelling strategies used (Bairlein 1998, 2003; Schaub and Jenni 2000a, b, 2001a, b). The recent EURING Swallow Project (Spina 2001) has already produced information on fuelling and moulting in Italy (Rubolini 2000) and on the different strategies for crossing the western and the central Mediterranean (Rubolini et al. 2002). Training ringers in countries of eastern Europe, the

Balkans and the Middle East, regions that previously had little or no ringing activity, has been a primary aim of the SE European Migration Network (Anon 2004; Busse 2000). The success of such projects has depended on establishing standard protocols, on sustained efforts to draw sites together and to provide representative coverage, as well as on the use of computers to analyse the masses of data that sustained work at several sites produces (Bairlein 2003).

The conservation uses of large-scale ringing work are various (Baillie et al. 1999a, b) and conservation an important element of the scientific strategies of ringing schemes (Baillie et al. 1999c). Major uses include the identification of flyway networks, including stop-over sites, and the demonstration that over the course of a season a site may be used by many more birds than are seen there at any one time (Baillie 2001; Davidson et al. 1999). With connections demonstrated, studies in one part of the world may reveal or illuminate conservation problems in another: thus, population declines recorded by wader ringers in Australia are relevant to the conservation of habitats in the Yellow Sea (Barter 2005; Milton et al. 2005). The analysis of recoveries can also reveal some of the impacts of man. For example, while some of the wildfowl ringed in Britain and Ireland may be shot there, the ratio of deliberately killed birds to other deaths is significantly greater among those that are recovered overseas; for passerines, however, this ratio is the same in Britain and Ireland as overseas (Wernham et al. 2002), notwithstanding the substantial number of deaths of passerines through hunting in southern Europe (McCulloch et al. 1992). Ringing data on the timing of migration have also illuminated discussions on possible changes to hunting seasons (e.g. Dall' Antonia et al. 1996).

Turning to matters of human welfare, recent concerns over avian influenza have brought politicians and the administrators to the doors of ringing offices across Europe in their desire to know which species come from where, and when. This has spurred new methods of analysis aimed at determining more clearly the chief breeding areas of birds that winter in Western countries and where birds from these areas are throughout the year. Volunteer ringing and recoveries reported by the public have thus contributed to public health planning.

Short-distance movements, such as the dispersal between birth and breeding or between successive breeding seasons, have also been studied through ringing, and such work has led to several generalizations: (1) females tend to move further than males; (2) movement between breeding seasons is commoner than after breeding failure; (3) species dependent on scattered or ephemeral resources tend to disperse further (Newton 2003). The chief influences on dispersal were investigated in a comprehensive review of the British avifauna by Paradis et al. (1998), who found that both natal and breeding dispersal were more extensive in less common species and those inhabiting wetlands. By combining extensive census data with the ringing recoveries, Paradis et al. (1999) showed that population fluctuations were more synchronous across Britain in species that dispersed further. Population models built on empirical data show that dispersal may greatly influence density and distribution, which has important conservation implications in terms of the size and isolation of protected areas (Baillie et al. 2000).

Only a small proportion of birds marked with conventional rings are ever recaptured or recovered—less than 1% in small species characteristic of habitats that are little visited by people. Marking with colour rings or other forms of identification that can be read in the field without the bird being captured typically increases "recovery" rates by two orders of magnitude. The internet makes it easy for birdwatchers to report their sightings of such marks and to have information about the birds' origins fed back to them. Indeed, there is now a website dedicated to this increasingly popular form of birdwatching (http://www.cr-birding.be), run by Dirk Rees (a forester). It is possible to track individuals as they move between breeding, non-breeding and stop-over areas, with a considerable mobility of individuals during the non-breeding season being revealed. The value of new technology in supporting ornithological collaboration is shown in the studies of two major invasions of Britain by Waxwings *Bombycilla garrulus* by the amateur Raymond Duncan (personal communication). In the 1990/1991 and 2004/2005 invasions, there were only six and eight conventional recoveries, respectively; but there were 30 and over 300 reports of colour-ringed birds, respectively, with this increase in reports being associated with the use of e-mail (all of the 30 in 1990/1991 were by conventional letter, but the latter accounted for only one of the 300 in 2004/2005). Furthermore, 45 of the reports in 2004/2006 were supported by photographs, 44 of them digital.

The identification of individuals in the field through natural differences in appearance has typically been the province of specialists and restricted to species where the differences are obvious, such as Bewick's Swans *Cygnus columbianus* (Rees 2006). However, the ability to record appearances by digiscoping allows minute differences to be used, as for the Caspian Gull *Larus cachinnans* seen in central England in October 2005 and resighted in Northern Ireland 10 weeks later (Lewington 2006). The ease with which photographs can be exchanged by e-mail or posted on the internet may lead to such methods being more widely used to track the movements of individuals, especially those beyond the normal range of the species.

Thus, amateurs have played and will continue to play a key role in migration studies by virtue of the volume and extensive nature of the work required, although the data volumes alone mean that professionals are needed at least to organize the work.

Distribution and habitat

Distribution maps were traditionally based on the blocking-in of areas on maps for which there were positive records of the species, a method that exaggerates the continuity of distributions. Changes in range are in some ways easier to assess than range itself because birdwatchers notice when species are seen in places where they are normally absent and vice versa: for example, the recolonization of the city of Wellington (New Zealand) by forest birds (Miskelly et al. 2005) and the expansion of the Collared Dove *Streptopelia decaocto* across Europe (Hengeveld 1988; Novak 1971), its colonization of Britain (Brown and Grice 2005; Gibbons et al. 1993; Hudson 1965, 1972) and its recent invasion of North America (http://www.birdsource.org/features/doves/index.html). Similarly, the amateur ornithologist I.J. Leach (1981), having noticed an increase in the number of reports of Blackcaps *Sylvia atricapilla* wintering in Britain, organized a collaborative survey that confirmed the increase. (Now known to be the result of an evolutionary change in the migratory behaviour of the population breeding in southern Germany; Berthold et al. 1992; Berthold 1995.) Another amateur, C.A. Norris (1944), organized a survey of Corncrakes *Crex crex* because he observed them recolonizing some sites: the survey showed that such recolonizations were transient and the species' total range was shrinking, as it has continued to do (Brown and Grice 2005; Gibbons et al. 1993). The electronic gathering of large numbers of ordinary bird-watching records enhances their use for establishing distributions because it increases the density of data and, if complete lists are requested, rather than just unusual records, these allow one to distinguish apparent gaps in the distribution arising from an area not having been visited from real gaps in well-watched areas.

The best way of establishing distribution is the systematic recording of presence or apparent absence of each species on a regular grid. Such "atlas" surveys, dependent on armies of volunteers because of the scale of the work involved, are now a key element of ornithology. The effect of such grid-based surveys can be seen on the maps produced by Snow and Perrins (1998), where distributions in Russia (mainly based on traditional "blocking in") appear to be much more continuous than those in western Europe (largely based on systematic atlases). The first grid-based atlas, covering an area of central England, was an entirely amateur undertaking (Lord and Munns 1970). Nonetheless, the methods that it used for establishing whether a species could be considered as definitely breeding in an area, or only probably or possibly breeding, have been used with little change in many countries since. The first national atlases quickly followed—the UK in 1968–1972 (Sharrock 1976), France in 1970–1975 (Yeatman 1976) and Denmark in 1971–1974 (Dybbro 1976). To date, over 400 bird atlases have been published, involving an estimated 160,000 observers (Gibbons et al. 2007). However, their geographical distribution is patchy: 75% are from Europe and almost 20% from North America (though none of the latter cover the entire continent, the winter (Root 1988) and summer (Price et al. 1995) atlases for North America being based on interpolations from a set of irregularly distributed census sites); the wet tropics are particularly poorly covered. The areas covered range from 12 km^2 to 7.7 million km^2. The scale of the grid varies roughly in relation to the size of the total area: about 4000 cells seems to be the maximum that can be covered in a survey lasting 4–5 years (Underhill and Gibbons 2002). In some countries, a coarser grid has been used in the less populated regions than elsewhere, which leads to difficulties of interpretation. (It would be better to use the same grid throughout but to survey only a proportion of the cells in the less-populated regions.) The Southern Africa atlas (Harrison et al. 1997), covering six countries with great logistical, economic and political difficulties, shows just what determined collaboration can achieve. Similarly, the Europeans overcame the problems of differences between their countries in language, organizational structures and methodology to achieve their atlas (Hagemeijer and Blair 1997), though this was a compilation of separate nations' data rather than an integrated pan-European survey.

Attempts to map relative abundance have been made in about 30% of the atlases. Even though this involves more intensive fieldwork than the simple mapping of occurrence, it does not seem to result in the survey periods having to be longer (Underhill and Gibbons 2002). Various methods have been used in such attempts: formal censuses, standardized counts, frequency of occurrence in lists provided by different observers, frequency of occurrence in subdivisions of the grid cells and even subjective estimates made by fieldworkers (which Estrada et al. 2004 have shown to be remarkably well-correlated with independent formal censuses in Catalonia). The quality of relative abundance measures depends on the extent to which fieldworkers are prepared to adopt systematic approaches, rather than simply recording lists of species seen in which there is no control over the methods or time spent in the field. Experience has shown that volunteers can be persuaded to use systematic methods, especially if the survey accepts casual records in addition to the results from their systematic surveys. Modern information technology has enhanced our ability to handle the greater volumes of data that are produced with more advanced atlas surveys, particularly in terms of data-entry. *The Atlas of the Breeding Birds of Ontario 2001–2005* was a pioneer in this field (http://www.birdsontario.org/atlas/atlasmain.html).

In all atlas work there is the problem of determining whether coverage has been sufficiently intensive and uniform for the picture not to be too biased by any failure to detect a species when it is present. In France, for example, atlas data suggest that the south-west is an area of rather low avian species richness, but a model using finer-scale information and habitat correlations shows that this picture is biased (Jiguet et al. 2005). That this problem might be a widespread one is suggested by the common finding that avian species richness is higher in areas of greater density of human populations, where the recording effort for atlases may be greater. However, using the data from the standardized recording efforts employed in the second atlas of birds breeding in Britain, Evans et al. (2006a) showed that the correlation is genuine, not artefactual; furthermore, the number of further species recorded by additional (non-standardized) work is only weakly correlated with human population density. In addition, recent statistical techniques can provide estimates of probability of occurrence of a species or of total species richness in each cell of the atlas grid even when not all of the species have been detected (Cabeza et al. 2004; Jiguet and Julliard 2006).

An important use of atlases has been in the planning of more intensive single-species surveys—for example, in stratifying so that sampling intensity is greatest in regions where the species is most abundant, or in areas at the edge of range, etc. Such stratification not only increases the statistical efficiency of surveys (Greenwood and Robinson 2006), but it can assist in increasing observer satisfaction by reducing the number of observers who are directed to places where there is little likelihood of their finding the target species. Other uses of atlas data are many (Donald and Fuller 1998; Gregory et al. 1998; Rahbek 2004; Underhill and Gibbons 2002). In countries in which atlases have been produced, they are generally regarded as the most significant piece of volunteer-based ornithology in terms of conservation benefits. At the most basic level, this is simply because we need to know where a species is if we are to protect it. Resources are invariably limited, so only the key sites can be protected; atlases allow us to identify these sites. The importance of atlases for such purposes is indicated by data gathered by the BTO on the uses of data from its second atlas of breeding birds during the first 4 years after the survey: 48% of the uses were for site assessment and 22% for conservation policy (Donald and Fuller 1998). In the UK today, atlas and other distributional data are used to identify key areas for the targeting of agri-environment schemes.

An obvious use of distributional data has been to identify priority areas for protection. The main criteria used have been high species richness and high levels of endemism, with the key approach of "complementarity" integrating these (Balmford and Gaston 1999; Balmford 2002; Williams et al. 1996; Williams 2001), although alternative and additional criteria have been used (Araújo et al. 2002; Balmford et al. 2000; Balmford 2002; Gaston et al. 2001; Wessels et al. 2000). Even where reserve networks have been established before atlas data became available, reserve-selection procedures based on the atlas data are not irrelevant. The atlas information is useful in identifying both high-priority areas not yet included in a network and those established reserves that are of little value (which can be removed from the network). Gap analysis can identify species not well protected by the existing network (Balmford 2002; Glazer 2001).

Comprehensive atlas data allow a broader perspective than merely the identification of high-priority areas, showing that the latter approach may not be sufficient in itself for conserving overall biodiversity (Bonn et al. 2002) as the wider countryside is also important (Evans et al. 2006b). These data enable assessment of the potential impact of both local and global anthropogenic pressures (van Rensburg et al. 2004), provide data for working out biogeographic zones for conservation planning and allow the assessment of local biodiversity relative to that of larger regions (Gregory et al. 1998). Given that environments are constantly changing, it is important that conservation science identifies not only current priority areas but also which environmental factors determine the distribution of individual species, so that key habitats can be conserved and the effects of change predicted (Beissinger et al. 2006). Atlas data are particularly valuable for such analyses because they cover the whole range of environmental predictors and provide great volumes of data—which is important for modern methods of analysis are data-hungry (Beissinger et al. 2006). Some atlases have themselves documented such aspects as the altitudinal distributions of species; these include the Swiss atlas, which also showed how these differ north and south of the Alps (Schmid et al. 1998), the atlas of North-East Scotland, which show how these change seasonally (Buckland et al. 1990) and the Catalan atlas, which also shows habitat distributions and preferences (Estrada et al. 2004). Many analyses have gone further, modelling the distributions in terms of environmental variables. Satellite imagery now provides great volumes of environmental information, Geographical Information Systems (GIS) provide the means to manipulate it and information-theoretic methods provide more refined approaches to model-building than mere hypothesis-testing (Rushton et al. 2004). Recent examples of such work in ornithology are the analyses covering a large area of North America (Venier et al. 2004) and a single city in Australia (Shukuroglou and McCarthy 2006). British atlas data have shown that the environmental characteristics that best predict presence or absence at one time are often the best predictors of subsequent persistence or loss (Gates and Donald 2000).

Like ringing data, atlas data have found application to be the management of avian influenza. For example, they have been crucial in assessing which areas of Britain are at greatest risk from infection of poultry by wild birds, so that surveillance and management can be concentrated there (Crick et al. 2006).

Repeat atlases comprise 12% of bird atlases worldwide (Gibbons et al. 2007). They are a particularly important means of measuring changes in distribution when systematic methods have been used, as there is then some control over effort involved. While distributional changes are generally less marked than changes in numbers, the latter provide additional and complementary information. Of particular importance in this context has been the identification of habitat-specific changes. For example, the ranges of birds characteristic of farmland have declined in recent decades in several European countries, whereas those of species characteristic of other habitats have been stable or even increased (Estrada et al. 2004; Fernandez and Gainzarain 2004; Gibbons et al. 1993). This is an important component of the body of evidence relating to the decline of farmland birds in Europe (see Donald et al. 2006). Distributional changes in British birds are comparable to those in butterflies and plants, indicating that birds can be used as approximate indicators for changes in biodiversity more generally in areas where there is little direct evidence for biodiversity more generally (Thomas et al. 2004). The patterns of changes in distribution can be compared with those of changes in habitat variables to test hypotheses about the causes of changes in range. For example, Siskins *Carduelis spinus* in Britain expanded their range in areas with plenty of 10- to 40-year-old conifer plantations, confirming an expectation; but changes in the range of Corn Buntings *Miliaria calandra* did not seem to correspond to changes in barley acreage and cultivation, which had previously been thought important (Gibbons and Gates 1994).

Short-term changes in distribution resulting from migration rather than from long-term changes in range have been shown up in year-round atlases, with those for southern Africa (Harrison et al. 1997) and Australia (Griffioen and Clarke 2002) being outstanding examples. The British winter atlas shows how the number and distribution of some winter visitors varies from year to year (Lack 1986), and the data even show major movements within single winters (Gillings 2001).

Macroecology, the study of distribution and abundance at large spatial and temporal scales, has benefited hugely from data provided by atlases and other collaborative work of amateur ornithologists—to the extent that Gaston and Blackburn (2006) were able to base their macroecological textbook on the British avifauna (See Blackburn and Gaston (2003) for a general review of macroecology, Newton (2003) for a further reveiw of avian macroecology, Rahbek (unpublished data) for a review of the use of avian atlas data in macroecology, and Gregory et al. (1998) for macroecological uses of the European atlas data). Patterns of species richness have been a major focus. How is it related to the size of the study area (Storch et al. 2003)? How does apparent species richness increase with survey effort? How is local richness related to regional richness? What is the frequency distribution of richness over study areas? What are the patterns of local extinction and colonization and what are the effects of isolation? How does species richness vary with latitude, longitude and altitude, and how is it affected by energy availability, primary productivity and habitat heterogeneity (van Rensburg et al. 2002)? What are the contributions of more and less widely distributed species to the patterns of species richness (Evans et al. 2005b; Lennon et al. 2004)? How are they related to human population density? How does the richness of coastal areas compare with that of adjacent inland areas and how does that relationship vary geographically (Gregory et al. 1998)? How does the percentage of migrants in breeding bird assemblages vary with latitude? What are the patterns of overlap between species and what are the geographical patterns of spatial turnover in assemblages? Range sizes themselves have been studied, in terms of their frequency distributions, how ranges in local areas relate to those over large regions and how range size relates to latitude.

Amateurs have also produced extensive sets of information on bird numbers (see below), which macroecologists have used to describe and to attempt to explain the frequency distributions of abundance, the effect of latitude on mean abundance and how local abundance is related to the position of the population in the species range. There is an almost universal positive relationship between local abundance and range size (Gaston et al. 2000), although Australian passerines provide an exception (Symonds and Johnson 2006). Similarly, it is generally—but not always—true that changes in local abundance are positively correlated with changes in range (Böhning-Gaese and Bauer 1996; Donald and Fuller 1998; Robbins et al. 1989), and this holds even for the year-to-year changes in individual species (Gaston et al. 2000). This relationship is not just of theoretical interest as it has implications for monitoring. If atlases show that a species' range has changed, it is reasonable to conclude (even without census data) that its numbers have similarly changed—which in turn has an important implication for conservation as rare species are in double jeopardy, not only being rare in the places in which they occur but also occurring in relatively few places.

Few of these patterns could have been documented, and even fewer could have had their causes investigated, without the voluminous data sets provided by collaborative surveys by volunteers. Equally, because of the technical expertise required, macroecology is not a discipline that lends itself to a wholly amateur approach.

Atlases provide some information on habitat preferences (see above), although this is generally limited by the coarseness of the grids and of the habitat information available. Census schemes (see below) have also been used to describe habitat preferences (e.g. Gregory and Baillie 1998), having the advantages that the individual study sites are usually smaller than atlas grids and that the fieldworkers can also provide detailed habitat descriptions of the sites. Experience shows the importance of having carefully defined categories that fieldworkers can use to record habitats; if observers are asked to describe habitats in their own terms, the analysis is severely limited by the difficulty of interpreting the descriptions and comparing the information from different people.

The occurrence and numbers of rare species can be surveyed in their entirety and their habitat use relatively easily described (e.g. Woodlarks *Lullula arborea* breeding in England; Sitters et al. 1996). Similarly, birdwatchers may be asked to report major concentrations of patchily distributed species and the habitat at those locations (e.g. Golden Plovers *Pluvialis apricaria* in Britain in winter; Fuller and Lloyd 1981). For species for which the core range is fairly well-known, a complete survey of known sites can be combined with a sample survey of other areas (e.g. Nightingales *Luscinia megarhynchos* breeding in Britain; Wilson et al. 2002). More widespread species require a sampling approach. For some sorts of studies, it is not important that the samples are random; for example, Fuller et al. (2001) demonstrated that the bird communities breeding in hedgerows in England and Wales were not merely diluted versions of the communities of farm woodland by using data from the Common Bird Census (see below), in which the plots are chosen by the observers. Indeed, in their investigations of the habitat distribution of British woodland birds, Elton (1935) and Lack and Venables (1939) asked fieldworkers to choose woods of "pure types", to aid their contrasting of the different types (though this approach does not, of course, allow the discovery of species characteristic of mixed habitats). Nowadays, however, sample locations are usually random, often stratified to ensure that all major habitats are covered or so that sampling intensity can be reduced in regions where there are few observers or few birds. British examples are Skylark *Alauda arvensis* surveys in both the breeding season (Browne et al. 2000) and winter (Gillings and Fuller 2001) and the breeding Lapwing *V. vanellus* survey (Wilson et al. 2001). These have not only allowed habitat preferences to be described but have produced insights, in terms of the loss of preferred habitats, into the reasons for the decline of these two species in the UK, insights that have ultimately been incorporated into recommendations for agri-environment measures. The power of such volunteer-based surveys results not only from careful design but from the ability (because of the volunteer network) to survey many hundreds of sites and thus cover the complete range of habitats across the whole country. Even 70 years ago, Lack and Venables (1939) were able to include over a hundred sites.

Because of concerns about the impact that management of the countryside will have on birds, it has become common for surveys to be directed at specific questions; for example, the effect of forest fragmentation on Scarlet Tanagers *Piranga olivacea* in eastern North America (Hames et al. 2001), the value of "set-aside" land for farmland birds in Britain (Henderson et al. 2000), and the possible benefits of organic farming (Chamberlain et al. 1999b; Fuller et al. 2005). The questions asked in such studies are so specific that the methods have tended to be more rigorous than those included in the general surveys, so the participants and study sites may be numbered in the dozens rather than the hundreds. However, this is still substantially more than could be achieved in purely professional work. The special surveys of the distribution of shorebirds at low water on British estuaries have been combined with data on sediments, estuary shape and tidal range to produce models that predict how bird numbers may change in response to such things as the development of ports, the building of barrages and sea-level rise (Rehfisch et al. 1999, 2000). Analysis of the same counts in relation to the proximity of footpaths, roads, railways and towns has shown how numbers may be reduced by disturbance (Burton et al. 2002).

The results of volunteer-based work have not just been used for descriptive studies and conservation science, but they have been used to address ecological principles. For example, census data gathered (see below) have demonstrated several examples of birds expanding the diversity of habitats used when populations have built up (O'Connor 1980a, b, 1981, 1985, 1986; O'Connor and Fuller 1985; Williamson 1969; Williamson and Batten 1977). Thus, for habitat studies as for other work the collaboration of amateurs and professionals has been immensely fruitful.

Population studies

The Atlantic Gannet *Morus bassanus*, though widespread and not scarce, was the subject of a world census by

J.H. Gurney (an amateur), as long ago as 1913, who using mostly published sources but also information from correspondents. Gannets are easy to count because they breed in a small number of colonies (42: Nelson 2002), and the colonies are easy to find and count because they are on open sites and the birds are large and white. For similar reasons—easily recognizable birds and conspicuous nests—it was possible to organize a collaborative census of White Storks *C. ciconia* over the whole of Europe in 1934 (and on five subsequent occasions; Schulz 1999) and of British Grey Herons *Ardea cinerea* in 1928 (and annually since; Marchant et al. 2004; http://www.bto.org/birdtrends2005/wcrheron.htm). Today, individual colonies of seabirds are well-studied in many countries. However, most of such work is carried out by professionals, and there is comparatively little networked research across whole countries or regions. In Britain and Ireland, however, which have long coastlines and many breeding seabirds, there have been three complete censuses of breeding numbers since 1969 in which the fieldwork has been conducted mostly by volunteers (Mitchell et al. 2004). There is also some annual surveillance of numbers, productivity and food, although the role of volunteers in this is small compared with that for most bird surveillance programmes in Britain.

Waterbirds are also popular among birdwatchers, often occurring in large concentrations in places that are easy to observe. Their spectacular long-distance migrations attract particular devotees who are prepared to use special methods to catch them for ringing, such as the nocturnal mist-netting and cannon-netting of waders. Species that occur on open water or the seashore are relatively easy to count, and populations of those that are concentrated in relatively few places (as many are) are particularly easy to count almost completely. Furthermore, it is relatively easy to persuade people to count particular sites because the conservation value of doing so (especially if the sites hold many birds) is more obvious than that of surveying a random piece of the countryside.

Species that are less conspicuous, not tied to traditional sites and more numerous have proven less easy to count, although many such species have now been censused, even if only in limited areas, through amateur collaborations. What is clear, however, from a close examination of these surveys, is that many of them will have overlooked significant parts of the population through the fieldwork not being sufficiently systematic and comprehensive. Sample surveys are usually a more effective use of the available man-power (which is limited, even for volunteer-based work) than attempts at complete coverage, so long as the sampling is unbiased.

Although the British heronries census has for many years provided a textbook example of change and stability in a wild population, demonstrating both density-independent and density-dependent processes, the idea of keeping wild bird numbers under surveillance was slow to develop and it took a major ecological crisis to establish such surveillance as a necessary approach. Charles Broley, a retired Canadian bank manager, began studying Bald Eagles near his winter home in Florida in 1938. Over the years he banded around two thousand chicks. but his observations of increasing reproductive failure led him, in the late 1950s, to be one of the first to suggest that agricultural pesticides were affecting birds. Birdwatchers in Britain had similar concerns as a result of finding dead birds in the countryside, and surveys were organized to collate such evidence. By around 1960 organochlorine poisoning was being increasingly found in these birds. There was, however, no evidence that bird numbers were being reduced until, in response to calls for Peregrine numbers to be reduced (to cut predation on racing pigeons), surveys of Peregrines *Falco peregrinus* breeding in Britain were carried out in 1961 and 1962 (Ratcliffe 1993). These showed that there were only about half the numbers that there appeared to have been (though not formally surveyed) during the 1930s. Such incontrovertible evidence led to controls on pesticide use being introduced in stages. Censuses at decadal intervals since have shown population recovery, with almost double the 1930s population being found in 2002 (Banks et al. 2003). Volunteer-based fieldwork thus led to action and demonstrated that the action was successful.

Clearly the plight of the Peregrine would have been detected earlier if there had been proper surveillance of its numbers before 1961. This was a major factor in the establishment of the Common Bird Census (CBC) in the UK, to provide annual surveillance of common and widespread birds and thus, it was hoped, to enable problems to be detected at an earlier stage than had hitherto been possible. Territory mapping was chosen as the method of fieldwork, on the grounds (later shown not to be wholly correct) that this led to accurate estimates of breeding populations on study sites. This method is so labour-intensive in terms of both fieldwork and analysis that observers had to be allowed to survey sites of their own choosing and even then only 200 sites could be covered, limiting the survey to farmland and woodland sites only. The use of simpler methods (line transects) in the Breeding Bird Survey (BBS) not only increased the sample size (now over 3000) but allowed the organizers to direct field-workers to sites rather than letting them choose their own. Although the data for each site are less precise than those for the CBC, the greater number of sites more than compensates, so greater overall precision is attained. As a result of these schemes, some 100 species are under satisfactory surveillance, with many of the data series stretching back over 40 years. The results are updated annually (http://www.bto.org/birdtrends/), which allows us to detect the impact of agricultural intensification on bird populations (leading to focused conservation science and management), to discover other species that are faring badly, and much more. Most European countries have similar schemes, and the European Bird Census Council, a non-government organization (NGO) that draws together atlas and census work across the continent, is now producing pan-European indices for the commoner species (http://www.ebcc.info). A BBS based on roadside point counts (now incorporating 3000 sites annually) was established in the contiguous United States and southern Canada in 1966–1968 (Bystrak 1981; Faanes and Bystrak 1981; Gough et al. 1998; O'Connor et al. 2001; Sauer et al. 2005). It has delivered many products, including maps not only of relative abundance but of changes in relative abundance (Sauer and Link 1999; Sauer et al. 2005). Winter birds have been counted in the Christmas Bird Count (CBC) since 1900, which covers not only similar areas to the BBS but (much less intensively) also some other parts of the Americas and the Pacific, involving some 50,000 observers annually (http://www.audubon.org/bird/cbc). In the early years there was little systematic control over the fieldwork in terms of either effort or methods, leading to difficulties of interpretation. Thus, an apparent 2.5-fold increase in Red-bellied Woodpecker numbers between 1959 and 1988 is probably a result merely of increased effort (Link and Sauer 1999). However, the work has since become more systematic, and ways of enhancing its scientific value have been identified (Dunn et al. 2005a). The particular values of the CBC are the length of the data series and the information that it provides for the various species that are rarely encountered in the BBS. For species for which both surveys have good sample sizes and include a high proportion of the range, the results are broadly consistent, providing reassurance that they are reliable (Butcher 1990).

Population surveillance schemes based on attempts at true censuses on the individual sites (using territory-mapping, for example) can be used to provide national population estimates (see, for example, Gibbons et al. 1993). Most schemes, however, produce only indices of the true population, such as the number of birds observed in a given area using a standard methodology. Changes in the index from year to year are taken to parallel changes in the population, on the assumption that the index bears a constant relationship to the population. The extent to which the relationship may not be constant needs to be taken into account when changes in the index are interpreted.

Because common and widespread species provide large sample sizes, surveillance of them is a sensitive approach to monitoring avian biodiversity. Scarcer species are less useful in this respect, but it is important to have schemes for the rarest and most threatened species in order to detect any declines that occur. However, even in countries with the greatest numbers of birdwatchers, the systematic annual surveillance of all rare species is impossible. In the UK, the Rare Breeding Birds Panel fills many of the gaps in knowledge by collating unpublished observations of individuals and local groups and the information in local bird reports (Stroud 2004). This provides some information on population trends in these species, shows up gaps in knowledge (which people can then be encouraged to fill) and provides background information for the planning of occasional systematic surveys of individual species. The system has two major drawbacks, both of which are currently being addressed: the data are poorly localized (because observers are reluctant to reveal precise localities in case they are leaked), and it is difficult, in the absence of systematic surveys, to tell if a species was apparently absent from a site because it was actually absent or because the site was not visited that year.

Special methods are also required for waterbird species that are widespread over large numbers of small sites rather than concentrated on large bodies of water. The small sites are probably not well covered by the usual counting schemes, and this can result in considerable underestimation of the populations of some species (Jackson et al. 2006); on the other hand, these sites are too patchy to be well covered by schemes for monitoring common and widespread birds. River birds are good example, and in the UK there are special schemes to monitor samples of linear waterways so as to complement the data of the BBS.

Raptors and owls are often too scarce and elusive to be well-covered by general censuses of widespread birds. However, many amateur ornithologists are particularly attracted to raptors and owls, with the result that there are many individuals or groups conducting intensive studies of one or more of these species in local areas. These workers tend to census the breeding population, assess breeding success and ring chicks. If has often proved difficult, however, to draw raptor workers together into schemes covering more than a local area. Having established a programme in their own area, the lone individuals or local groups are reluctant to surrender their independence and to adopt common protocols. In addition, in some countries at least, the persecution of raptors results in those that study them being reluctant to supply detailed information to a central organization for fear that sufficient confidentiality will not be maintained. So, even in Scotland, which is a small country where raptors are perhaps monitored as well as anywhere in the world, with local Raptor Study Groups covering the whole country and a long-standing umbrella group that has published annual reports (Etheridge et al. 2006), it has taken long negotiations to establish an integrated monitoring scheme with professional organization and common methodology (Greenwood et al. 2003; Hardey et al. 2006). The programme Monitoring Owls and Raptors in Europe, started in 1988, still has few participants outside Germany (Mammen and Stubbe 1999; Mammen 2003; Stubbe et al. 1996), although European ornithologists are now actively seeking to establish a properly funded pan-European scheme for raptors similar to that for "common birds". The result of this general failure to develop large-scale co-ordinations is that much useful fieldwork does not get fed into general surveillance.

There are many programmes for the systematic recording of diurnally migrating raptors at places where they are concentrated. A few are largely professional, but most rely largely or wholly on amateur observers for the surveillance of population levels (especially for populations that are difficult to study on the breeding grounds), for studying migration itself and for public education. For the first two of these goals, it is clearly advantageous for stations to be networked, and a number of collaborations have been established. The Hawk Migration Association of North America has collected data for three decades from stations in Canada and the USA and, more recently, from Middle America and the Caribbean basin. The internet has made data collection easier and now allows feedback and dissemination of the results in the form of animated maps, etc. (http://www.hmana.org; McCarty and Bildstein 2005). Particular uses of the data have been to demonstrate the recovery of Bald Eagle *Haliaeëtus leucocephalus* numbers (preceded by an increased percentage of juvenile birds) following controls on the use of DDT and to document changes in migration behaviour of some species. The Association now collaborates with the Hawk Mountain Sanctuary Association and Hawkwatch International to produce the Raptor Population Index, which determines the population trends in North and Central America (http://rpi-project.org/). The Asian Raptor Research and Conservation Network has been running since its launch at a meeting in Japan in December 1998 (http://www5b.biglobe.ne.jp/~raptor/index.htm) its objectives are to conduct research on migratory raptors and common and widespread species and to run training programmes. The aims of the current research programmes are to determine the migration routes and wintering areas of migrant raptors, to collate information on breeding areas and to compile data on population levels on migration. The setting-up of the network before there were many stations with long histories of independent work will no doubt work to its advantage in terms of the cohesiveness of its work.

Just as seasonal changes in abundance can be determined from the proportion of lists in which a species is included (above), so can longer term changes (Baillie et al. 2006). The gathering of such data via the internet has much promise, especially in countries without the manpower to run a census programme—so long as people are encouraged to submit compete lists rather than just the records they consider to be unusual, preferably also recording time spent in the field.

Catching birds can complement observation. If a constant number of traps is used at a ringing station, and these are set in the same places and at the same times, the numbers of birds caught is an index of population size. This method produces results similar to those of other methods in terms of the relative abundance of species, population trends and annual variations in abundance, for both breeding and migrating populations (Dunn and Ralph 2004). Furthermore, for some (but not all) species, there are good long-term correlations between numbers caught at Baltic ringing stations and censuses of breeding populations (Svensson 2000), trends at different stations in the eastern Baltic (which get birds from the same breeding areas) are well-correlated (Nowakowski 2003) and trends in the MRI catches correlate with what is known from the breeding areas (Berthold et al. 1993). Recommendations on the use of constant-effort mist-netting for the surveillance of relative abundance were produced by a conference held in 1993 (Ralph et al. 2004). Constant-effort mist-netting had been started by some British amateurs in 1978, and a British and Irish collaborative scheme started in 1983 (at first with an amateur organizer). Within 20 years, 470 sites were being operated across 12 different European countries (Peach et al. 2004; http://www.bto.org/ringing/ringinto/CES/index.htm; http://www.euring.org/research/ces_in_europe/index.htm). Local breeding populations in North America are the focus of the Monitoring Avian Productivity and Survival (MAPS) constant-effort scheme, incorporating ca. 500 sites by 2002 (DeSante et al. 2004; http://www.birdpop.org). Populations breeding north of the well-populated parts of Canada (and thus inaccessible to the BBS) are covered by the Canadian Migration Monitoring Network, comprising approximately 20 sites strung out across southern Canada (Badzinski and Francis 2000; Dunn 2005; Hussell 1997). There are hopes of similar work in the USA (Ralph and Rich 2005); the Landbird Migration Monitoring Network of the Americas (http://www.klamathbird.org/lammna) has recently been established.

To understand what causes populations to change, we need to measure not just their size but also their rates of reproduction and survival. Measuring the proportion of juveniles in the post-breeding population allows one to assess overall productivity (though only after immediate post-fledging mortality has taken its toll). Direct visual observation has been used to obtain such data (e.g. Rogers et al. 2005) and while much such work is done through intensive (often professional) studies, collaborative networks can be established for the purpose, especially now that data can be gathered on the internet. Ageing is often easier and more reliable when birds are in the hand, so ringers routinely can gather much useful information. The 1993 conference on monitoring birds using mist-nets (Dunn and Ralph 2004) established the use of constant-effort ringing for the surveillance of productivity, and this approach is now widely used for passerine populations on or close to their breeding grounds, for example in the British Constant Effort Sites scheme (http://www.bto.org/birdtrends) and the North American MAPS scheme (http://www.birdpop.org). One of the groups of volunteers that began constant-effort ringing also undertook censuses of the breeding population on their study site and attempted to find every nest. As a result, they were able to show correlations between the proportion of juveniles caught in their nets and the number of chicks produced in the woods, at least for the four species providing enough data (du Feu and McMeeking 2004). Similar correlations were found for two species on a Californian site (Nur and Geupel 1993). The optimum distribution of sites in such networked schemes, in terms of the best information for a given amount of man-power, has been worked out, but this must vary according to the size of the study area. Furthermore, if the scheme is mainly volunteer-based, the distribution of volunteers will largely constrain the distribution of sites.

Wader ringers routinely assess productivity using the age-ratios of birds caught far from their breeding grounds (Minton et al. 2005). Similarly, the productivity of species breeding well to the north of North American ringing stations, for which there are no other data, is potentially measurable in this way. However, the data cannot be used uncritically, as even at a single catching station the birds are likely to originate from a large and ill-defined area, and the percentage of juveniles caught is influenced by many factors influencing migration behaviour (Dunn et al. 2004a, 2004b; Hussell 2004).

Their habit of depositing eggs in nests that are fairly easy to find makes it easier to study the breeding of birds than that of many other animals. Even in ornithologically well-studied countries, systematic knowledge of basic breeding biology was, however, sufficiently sketchy in the 1930s that it was considered useful to publish papers recording the details of just small samples of nests of even common species. Ornithologists began to realize that much could be gained if information on nests found by birdwatchers was gathered systematically, and the BTO Nest Record Scheme was launched in 1939 (Crick et al. 2003), to be followed by similar schemes in various other countries. In the UK alone, tens of thousands of nests are now recorded annually, the grand total surpassing a million some years ago. It has proved valuable, in terms of data processing, to formalize the recording; for example, to use a coding system for habitat information rather than using written descriptions by the observers (Crick 1992b). Better statistical techniques have vastly improved the analysis of nest failure rates (Mayfield 1961, 1975; Shaffer 2004; Shaffer and Thompson 2007), computers now allow the great volumes of data to be digested and the internet has greatly eased data entry because it allows the observers to submit data electronically rather than using data-entry clerks to do so. The annual analysis of data from nest record schemes to allow breeding output to be kept under surveillance is increasingly important, alongside the methods of studying the proportion of juveniles in the population.

All studies based on birds' nests face the problem that the work itself may cause undue disturbance. This can undoubtedly be a real problem for colonial nesters, but available evidence suggests that visiting the nests of other species does not increase failure rates, providing care is taken to minimize disturbance (see, for example, Mayer-Gross et al. 1997). Many birdwatchers are nonetheless concerned about this and may refuse to engage in nest-recording as a result. Volunteer-based nest record schemes have a number of limitations that well-designed intensive studies can circumvent. The most significant of these are that they do not distinguish between first and subsequent nests of a pair in a season (so overall breeding output is not measured, only output per nest) and that effort varies through the season (so that the sample of nests is temporally biased, and it is difficult to assess the temporal distribution of breeding effort). (The BTO is undertaking a pilot study of Constant Nest Monitoring Plots, in which volunteers will attempt to find all of the nests every year, both to overcome sampling biases and to improve the precision of surveillance of breeding output.) Observers also tend to miss the less conspicuous nests, potentially biasing the data in various ways. Different observers use different methods of finding nests, which may help to reduce these biases but could introduce others. It has also been claimed that success rates of nests differ between observers (Rodewald 2004), but this claim was based on a statistical test for which P was greater than the normally used significance level of 5% and for which the value of χ^2 was clearly miscalculated in any case. Another problem that has to be guarded against is that a large proportion of the data for a species (especially species of restricted distribution) may come from a single observer operating in a single area, so the data may not be truly representative of the national population.

Despite these caveats, nest record schemes have produced great quantities of information, summarized in ornithological handbooks and on websites (e.g. http://www.bto.org/birdfacts). The British scheme alone had provided data for at least 300 published papers by 2002. Exemplifying the range of topics covered, Brooke and Davies (1987) were able to show that parasitism of

British birds by Cuckoo *Cuculus canorus* decreased as Cuckoo numbers dropped (except for parasitism of Reed Warblers *Acrocephalus scirpaceus*, which increased, possibly because Cuckoos using Reed Warbler nests were more successful than others), and data on the time of breeding have been used to inform decisions on the timing of muirburn (heather-burning), an important management technique for grouse moors in Scotland (Moss et al. 2005). Nest record schemes, because they cover many species, are especially useful for studying general patterns. For example, Fuller and Crick (1992) were able to compare the breeding performance and habitat use of resident and migrant species, not only interesting in its own right but important because of concerns about the decline of long-distance migrants in the UK. On a grander scale, it has long been known that clutch sizes tend to be smaller in the southern hemisphere than at comparable latitudes in the northern hemisphere, but it was not clear whether the reason was ecological or phylogenetic (given that northern and southern species tend to belong to different families) (Martin 1996; Martin et al. 2000). Using British and New Zealand nest record data for European species introduced to New Zealand, Evans et al. (2005a) showed that the New Zealand birds laid smaller clutches, establishing that ecology rather than taxonomy underlay the difference. Another pattern is that, within hemispheres, clutch size increases (independently of phylogeny) with latitude (see Cardillo 2002). Dunn et al. (2000) used the data for Tree Swallow *Tachycineta bicolor* from several North American net-record schemes to show that once latitude, longitude, elevation and date of breeding were accounted for, clutch size was strongly related to relative resource abundance, which was a possible cause of the latitudinal pattern. As a final example, Crick et al. (1993) showed that the clutch size of multi-brooded species in Britain has a mid-season peak, whereas that of single-brooded species declines monotonically during the breeding season, in accordance with theoretical predictions about how birds can respond to seasonal variation in the availability of resources. Taking this further, Dhondt et al. (2002) used the Cornell Nestbox Network data for the multi-brooded Bluebird *Sialis sialis* to show that clutch size showed a mid-season peak in southern North America but not in the north. This difference could be because seasonality is greater in the north and the birds can produce fewer second clutches there, an hypothesis confirmed by the data showing that northern Bluebirds have a shorter breeding season than those in the south and reuse nest boxes less often (consistent with producing fewer second clutches) (Cooper et al. 2005a). All these studies depend on large samples being obtained, usually over large areas, illustrating again how collaborative work can answer questions scarcely amenable to intensive studies. In a significant development that shows great promise, the Cornell Laboratory of Ornithology (CLO) has recently begun to supply volunteers with simple data loggers that can be used to gather information on incubation through the continuous recording of temperature (Bhattacharjee 2005; Cooper et al. 2005b).

Turning to the other side of the demographic equation, ringing schemes often gather information on the causes of death of birds reported to them. This information is highly biased, because some causes of death are more likely to be observed or reported than others. Nonetheless, it can be used with care to illuminate some issues. For example, geographical, seasonal and long-term variation in hunting mortality of European migratory birds and of Snipe *Gallinago gallinago* and Woodcock *Scolopax rusticola* has been established from ringing recoveries (Henderson et al. 1993; McCulloch et al. 1992; but see also Aebischer et al. 1999). The biases apply equally to any surveys of dead birds by birdwatchers, but again these can be used for limited and specific purposes. Thus, BTO members were encouraged during the 1950s to send in corpses so that the cause of death could be ascertained. The results were strongly biased because most people did not submit birds for which the cause of death was known (such as those killed by man) or obvious (such as predation and collision with vehicles). However, around 1960, the data showed a surge of deaths apparently resulting from pesticides, which was a valuable piece of evidence demonstrating that pesticides were affecting wild birds (Macdonald 1962). Subsequently, schemes were established in the UK (and in a number of other countries) for members of the public to submit carcases, especially of raptors, for post mortem examination as a means of monitoring the levels of pesticides and other pollutants in wildlife (Shore et al. 2006).

Collaborative surveys can also be used to provide information on specific causes of death. For example, the results of a 1-year survey of birds killed on roads in the UK suggested that the total annual kill was over 2.5 million individuals (Hodson and Snow 1965). The figure is a lower limit because some of the birds will have ended up in the roadside vegetation or in the bellies of scavengers, but it allows some assessment to be made of the importance of road-deaths which, in the absence of any data, some people assume must be significant. Given that the estimate is a small number compared with the total mortality in a population amounting to about 140 million adult birds, this assumption is probably incorrect; however, road-deaths may be important for some species; for example, Hodson and Snow suggest that in the House Sparrow *Passer domesticus*, road deaths account about one death in eight. A survey of participants in Project Feederwatch, who were asked to report birds killed by striking windows, suggested that one to ten birds are killed annually for every building in North America (Dunn 1993); these results are, however, undoubtedly biased in terms of the buildings included and by respondents failing to find all the casualties. While the figure is rough, it perhaps shows that windows are neither a negligible nor an overwhelming cause of death. Feeder-watch participants were also asked to record incidents of predation in their gardens and to undertake systematic observations to establish the numbers of potential prey (Dunn and Tessaglia 1994). This survey identified which predators were responsible for most predation, which species were the commonest victims and the differences between predators in the prey taken. Overall, the species most frequently reported as prey were those which appeared most frequently at feeders, although flocking species were more vulnerable than solitary feeders. Hawks were attracted to feeders with high levels of bird activity, but cats were not.

Despite Mayr (1963) flagging up our profound ignorance of the importance of disease in wild birds, the gap remains largely unfilled. The CLO, working with networks of amateurs, has, however, undertaken one study of great importance—the effect of *Mycoplasma gallisepticum* infection on House Finch *Carpodacus mexicanus* populations (Altizer et al. 2004; Hochachka and Dhondt 2000). This disease was first observed in February 1994 in Washington D.C.; within 2–3 years it had spread to much of population of the host in eastern North America, the spread being tracked by volunteers from the network that was already recording backyard birds for the CLO. House Finches themselves were still expanding their range in the east at this time, and the CBC data showed that, following colonization of a new area, local populations generally increased along a typical sigmoid curve. Hence, Hochachka and Dhondt were able to predict the numbers expected for any local population at a particular stage of its expansion should it remain free from *Mycoplasma* infection. These researchers found that infected populations were typically only at 40% of the level expected in the absence of the disease. Comparing populations in which the disease reached 20% prevalence in different years, they found that all had declined to the same level after 3 years. This was the first evidence of density-dependent population control by a parasite in a wild animal. Dhondt et al. (2005) subsequently listed 23 questions raised by the current state of knowledge of this disease, some of which will be answered by further work by the volunteers. The disease has now appeared in the western (natural) part of the bird's range, where volunteers are also monitoring its spread.

For demographic analysis, it is important to know the rate of mortality. This is best estimated through studies of marked individuals. M.J. Magee appears to have been the first to use recaptures of live birds for this purpose (Lebreton 2001). His work and that of other pioneers in the 1920s and 1930s were based on intensive studies, and it was not until 1943 that recoveries of dead birds were also used (by D. Lack; Lack 1943), heralding the use of general bird ringing for the study of survival. Both approaches have problems. As intensive studies are rarely based on more than one site, they lack generality; general ringing usually provides rather few recoveries, so estimates have wide confidence limits. (In addition, until recently, the lack of large-scale computerization of primary ringing data restricted analyses.) The European Constant Effort Sites (CES) schemes and MAPS in North America circumvent these problems: each involves many sites, so the results can be generalized, and the work at each site is sufficiently intensive to provide many recaptures. British CES data have been used to establish the statistical methodology for drawing the data together across sites and to demonstrate the value of the method (Peach et al. 1990, 1991, 1999; Peach and Baillie 2004); there has been similar work with MAPS data (Rosenberg et al. 1999; DeSante et al. 1995, 1999, 2001, 2004). Both the British and the North American schemes now include survival estimates in annually updated monitoring reports (http://www.bto.org/birdtrends; Michel et al. 2006). The Retrapping Adults for Survival (RAS) project was launched to extend such work in Britain. Participants run their own intensive ringing programmes of single species at individual sites, just like professional studies but usually rather less intensive because the participants are amateurs. They are asked to choose a species that returns to breed at the same place in successive years, to aim to catch all the breeding adults each year (or to colour-mark them and engage in intensive resighting work) and to keep the study going for at least 5 years. The RAS projects have high frequencies of recapture or resighting, they cover species not well covered by CES (that is, ones in different habitats or requiring special capture techniques) and the work can be carried out according to the field-worker's own schedule, not the strict timetable of the CES. Of course, each study covers only one species. and most species included in the scheme are covered by only a few people—but even a few sites are better than just one, and one is better than none at all. Preliminary results indicate that RAS has great potential (Newson and Marchant 2006; Robinson et al. 2006).

Ringing has also been used to measure the survival of birds rehabilitated after oil pollution or injury and of those released in attempts to re-establish species in their former ranges (Baillie 2001; Balmer et al. 2000).

Having observed that a population has changed, we then wish to know why. One approach to exploring the possible causes is to examine the statistical relationship between the population change and changes in the environment. To this end, Piha et al. (2004) modelled the relationship between Skylark numbers and both weather and agricultural land-use in both the breeding and the wintering areas. Habitat contrasts can also be informative: the breeding output of Golden Plover *Pluvialis apricaria* has remained stable on British moorlands dominated by heather but has declined on those dominated by grasses, probably one of the many effects of over-grazing by sheep (Crick 1992a). Demographic data themselves indicate the causes of population change. Thus, for farmland seed-eaters generally (but not without exception), the declines in British populations have not been associated with periods of poor breeding output, suggesting that they have been caused by factors operating outside the breeding season (Siriwardena et al. 2000b). For Corn Bunting *Miliaria calandra*, in particular, after a decline in the 1960s (probably caused by organochlorine pesticides), breeding performance picked up, but the population did not (Crick 1997). However, while the decline of British House Sparrows *Passer domesticus* was associated with a decline in survival, the population did not recover when survival rates improved because reproductive rates had by then also declined (Crick et al. 2002).

Taking such an approach further, DeSante et al. (2001) simultaneously examined the spatial variation in numbers, productivity and survival in MAPS data for several species. Siriwardena et al. (1998, 1999, 2000a) used data from the British monitoring schemes to assess whether it was productivity or survival that had been reduced during periods of decline of granivores characteristic of farmland. For most species, it was survival (with breeding output actually being higher during declines in most cases), suggesting that the causes of the declines were probably changes in the habitat outside the breeding season. When numbers, productivity and survival are all surveyed annually, "integrated population monitoring" (IPM) is possible in which the data are drawn together to build population models (Baillie 1990; Greenwood and Carter 2003). The simplest approach is to estimate the population changes and the vital rates independently and then to draw them together in a population model (e.g. Freeman and Crick 2003; Peach et al. 1999; Siriwardena et al. 2001). Alternatively, one may estimate the vital rates and fit them to the census counts directly rather than to the index of numbers (Freeman et al. 2007). More fully integrated approaches are to combine the statistical likelihood of the index of numbers with the likelihoods of the vital rates to estimate the population trend and the vital rates simultaneously (Besbeas et al. 2002, 2003; Brooks et al. 2004) or even to combine the likelihoods of the counts (rather than the index of numbers) with those of the vital rates to make simultaneous estimates (Besbeas et al. 2005; Besbeas and Freeman 2006).

Thus, citizen science is valuable not only in providing coverage of large areas but also in measuring a range of demographic variables that allow the collaborating professionals to build detailed population models using sample sizes large enough to provide precise parameter estimates, which in turn enable the causes of population change to be identified.

Other areas of study

Network research has contributed to many other areas of ornithology. For example, some of the manifold effects of weather on birds (Elkins 2004) have been revealed through the collaborative surveys of migration and population described above, others through large-scale enquiries into the effects of particular weather events. Thus, by means of a questionnaire to birdwatchers, Dobinson and Richards (1964) were able to document the effects of the 1962/1963 winter, the coldest in England since 1740, in terms both of mortality and consequent population reductions; similar evidence was gathered in other parts of Europe. The Common Birds Census, just started, showed that the effects were only temporary, and populations built up over the next few years (Marchant et al. 1990). Once a long span of CBC data had accumulated, it was demonstrable that weather, especially prolonged snow, affected the numbers of many species (Greenwood and Baillie 1991). The even longer data set for British Grey Herons *Ardea cinerea* shows that survival is reduced in hard winters, with consequent reductions in the breeding population (Marchant et al. 2004). The population levels of Dutch Purple Herons *Ardea purpurea* (Cavé 1983; Den Held 1981), Alsatian White Storks *C. ciconia* (Kanyamibwa et al. 1990) and British Sedge Warblers (*Acrocephalus schoenobaenus*) (Peach et al. 1991) are similarly affected by weather conditions in the wintering grounds in Africa. Summer weather is also important: using data from the French breeding bird survey to measure population change between 2003 and 2004 and data from the European bird atlas (Hagemeijer and Blair 1997) to determine the "thermal range" covered by each species' European range, Jiguet et al. (2006) showed an apparent effect of the 2003 summer heat-wave, with species that had the smaller thermal ranges suffering the sharpest decreases in population growth-rate.

Given these weather effects, one would expect that climate change would also affect birds. Volunteer-based surveys have, indeed, demonstrated changes in range. For example, those species of breeding birds limited to the south of Britain have extended their ranges northward in the two decades between two successive atlases, consistent with the northern limit of their distribution being temperature limited and the overall warming of the British climate in that period (Thomas and Lennon 1999). Changes in distribution of birds breeding in the western USA were more complex and were probably influenced by increased rainfall in areas outside former ranges (Johnson 1994). In winter, the populations of eight out of nine species of waders have tended to move from western to eastern coasts of Britain, the extent of the shift being correlated with temperature; this is consistent with the evidence that eastern shores generally provide better feeding and with the hypothesis that in cold winters many birds nevertheless move west to benefit from the warmer conditions there (Austin and Rehfisch 2005). Migratory species may be particularly vulnerable to climate change (Robinson et al. 2005). Sparks et al. (2003) and Lehikoinen et al. (2004) have reviewed how migration is affected by climate. Most of the evidence comes from collaborative surveys of spring arrival dates. In Europe, Russia and North America, the first arrivals have almost without exception been earlier in recent decades. (Although there are some statistical problems associated with the use of first arrival dates, such as the increasingly later dates for first Nightingales *Luscinia megarhynchos* recorded in Britain being explicable as the declining total numbers of records rather that later arrival of the population (Huin and Sparks 2000), these are generally not severe (Sparks et al. 2001) and although the first arrival dates may not reflect the arrivals of the bulk of the population, they tend to be correlated with them.) Arrival dates have been variously correlated with local temperature, with temperatures further south on the migration routes and with the North Atlantic oscillation. The changes and correlations are less marked in species that arrive later in the breeding area or that migrate long distances (see also Hagen et al. 1991). Autumn departure has been much less studied than spring arrival: there are trends in the recent data, but they are fewer and more variable than in spring. Birdwatchers' records also show how partially migratory populations may become less migratory as winters warm.

A large body of evidence indicates that birds in temperate regions have started breeding earlier than in recent decades, generally in response to temperature cues (reviewed by Sparks et al. 2003). Many of the data come from intensive studies of single species, but Nest Record Scheme data from the UK show that the majority of species have responded to these changing temperature cues (Crick et al. 1997; Crick and Sparks 1999), with a general influence of the North Atlantic Oscillation being apparent (Forchhammer et al. 1998). Nest record data for North American Tree Swallows *Tachycineta bicolor* in areas that have warmed show a similar trend (Dunn and Winkler 1999). Integrating ornithological data from different sources, Sparks et al. (2001) were able to show that the annual median nesting date of British Willow Warblers *Phylloscopus trochilus* (data from the Nest Record Scheme) is correlated with the mean first arrival date (from coastal bird observatories).

Large-scale ringing programmes have produced data on subjects other than migration. For example, they have accumulated large amounts of biometrical data, some of it using sufficiently standardized methods as to be useful. Traditionally published in individual research papers or huge books (e.g. Licheri and Spina 2002, 2005; Spina et al. 2001; Spina and Licheri 2003), such data can now be made available on the web (e.g. Robinson 2005). Ginn and Melville (1983) described the moult of many British species from data collected by ringers.

Various aspects of behaviour have been the subject of special surveys. A study of Yellowhammer *Emberiza citronella* dialects in Denmark used recordings from some 50 amateurs, recruited through a radio programme (Hansen 1985). Alexander (1942–1943) made an early attempt to study the seasonal distribution of song through a collaborative survey. Although this was not a great success, it is odd that few other such studies (if any) have been attempted. The communal roosting of British Starlings *Sturnus vulgaris* was the subject of an early survey based on appeals in the press and on the radio (Marples 1934); a later survey was run through the normal BTO system (Potts 1967). These studies established the distances travelled to roosts, the types of cover used and the seasonality of the behaviour as well as the fact that the large and conspicuous roosts in urban areas involved only a small part of the population. The spread of the practice of feeding on *Daphne mezereon* berries by Greenfinches *Carduelis chloris*, of opening milk bottles by tits and of taking artificial foods in gardens by Siskins *Carduelis spinus* remain some of the best examples of apparent cultural diffusion in wild animals; they were studied through surveys after birdwatchers had noticed the new habits (Fisher and Hinde 1949; Hinde and Fisher 1951; Pettersson 1959, 1961; Spencer and Gush 1973). Feeding has generally proved difficult to study through collaborative surveys, however, because the exact identity of the food being taken can usually be established only through prolonged, intensive and close observation. Thus, an early collaborative study of the destruction of buds by birds was unable to establish the extent to which the buds themselves or insects within them were the target (Fryer 1939). The enquiry into the food of Little Owls *Athene noctua* in Britain, undertaken in part because of assertions about the species feeding on the chicks of game birds, was a triumphant exception, establishing that such predation was rare (Hibbert-Ware 1937–1938). It was possible because the data comprised prey remains from gizzards of shot birds, from nests and from pellets rather than direct observation of feeding. Pellets have proved useful in collaborative studies of the diets of other owls (e.g. Glue 1974).

Birdwatchers have even contributed to genetics. The survey of the distribution of the bridled form of the Guillemot *Uria aalge* in Britain in 1938–1939, twice repeated at decadal intervals, was an important contribution to the study of morph-ratio clines and the rate at which morph-frequencies may change (Southern 1962).

Contributions to conservation

Citizens, science and conservation

Birdwatchers taking part in collaborative studies and those funding such studies often do so because they believe that the results will help bird conservation. As indicated repeatedly above, this belief is fully justified. Knowledge of where birds are and of their migration routes is fundamental to their conservation, especially to the identification of priority sites. If such sites are few, their surveillance can be done by professionals; but in some countries the special sites are so numerous that the amateur network has to be involved. The Dansk Ornitholigisk Forening is therefore adding "The IBA Caretaker Project" as the third component of its overall monitoring programme (the others being the common birds survey and the survey of rare and threatened species); the new project is aimed at large concentrations of roosting waders, migrating raptors and cranes at major "bottle-necks", and sites holding breeding populations of European significance (Vikström 2004). Conservation management rests on knowing the habitat requirements of species and on understanding what habitat changes have driven population changes, for which large-scale surveys provide much evidence—just as they have for the impacts of climate change—with nest record data providing the earliest evidence of impacts on organisms other than Man. The data on distributions are sufficiently extensive and precise that it is possible to predict how distributions will change under various climate change scenarios by modelling the "climate envelope" occupied by a species, assuming that suitable habitat is available in the climate-based predicted range, that islands can be reached and that evolutionary responses do not occur. Berry et al. (2001) provide examples based on the European breeding bird atlas (Hagemeijer and Blair 1997). Such studies lead to predictions of extinction as ranges become reduced (Thomas et al. 2004). For shore birds, the likely impact of possible sea-level rise, acting via changes in coastal geomorphology, can be described (Austin et al. 2001; Austin and Rehfisch 2003).

The Convention on Biodiversity requires that biodiversity be monitored, and birds are good indicators of biodiversity generally. They are easy to monitor because they are easy to identify and to observe and because there are many potential observers (Furness and Greenwood 1993). The monitoring of bird populations in the wider countryside—not just in special places—is needed because government policies, especially with respect to agriculture and forestry, affect the way in which the countryside is managed and this affects the birds. In addition, knowledge of birds in the wider countryside is needed as a point of reference against which to assess the success (or failure) of any management of specially protected areas (Jiguet and Godet 2004). Indeed, "It is difficult to think of a major wildlife issue for which monitoring has not provided essential information" (Bart 2005).

Most of the bird "census" schemes undertaken by volunteer networks are actually surveillance schemes designed to measure changes in numbers over time. This approach is often referred to as monitoring—but it is not. Surveillance is at the core of monitoring but is only part of it (Greenwood and Robinson 2006). Monitoring should begin with the setting of targets, such as "We want the British Peregrine population to be at least 1500 territorial pairs". This objective is a matter for the whole community, not just ornithologists; the role of the latter is simply to provide scientific advice, such as the historical changes of the population in question, the likely ecological impact of various population levels on other wildlife and (in collaboration with economists) the likely impact on economic interests. Surveillance, which is a matter for the ornithologists (professional and amateur), is then needed to assess whether the target is being met. If it is not, then we need to know why not, another role for the ornithologist. If the surveillance programme has been designed to gather other relevant information, such as habitat condition, this question may be answerable at once, but commonly it will require further research, which again is largely a matter for the ornithologists but is hedged about with various questions that draw in the wider community. Do people wish to put the problem right? Do people wish to undertake (pay for) the necessary research? If people wish to put the problem right, how should it be done? Ornithological science has an important role in providing possible solutions but so do other specialists, such as economists, and the final decision is one for the politicians, whose role it is to weigh up both the relevant evidence and the associated value judgements. Once a decision has been made, action can be undertaken. Surveillance must be continued, so that the effectiveness of that action can be assessed. Monitoring thus underpins adaptive management.

If the wider community is to be properly involved in the decisions that monitoring requires, then they must be informed about the scientific findings and their implications. This communication is supplementary to feedback to the volunteer participants and to the publication of the key scientific work in the peer-reviewed literature (to establish its validity and integrity). Full and detailed reports need to be produced for policy-makers, less detailed summaries for interested members of the public. The web should be used to provide annually updated outputs from the surveillance programmes. Simple (but accurate) stories should be made available to newspapers, including not just those read by the intelligentsia but also the "less serious" papers. (Note that producing press releases that will get the attention of journalists and establishing the rapport with journalists that results in their using your press releases is as skilful a task as writing scientific papers, though the skills are different.)

Surveillance programmes can produce masses of information, covering many populations, all of which are subject to changes in both the short and long term. A system for deciding which changes are important is essential if this volume of information is not to overwhelm the capacity for action. In the UK, we have a system of "alerts" to flag up potential problems (http://www.bto.org/birdtrends). The data for each species are assessed annually in terms of trends over the last 5, the last 10 and the last 15 years as well as over the entire data span. The aim is to provide a long-term perspective as well as to have the ability to detect developing trends at an early stage. Using specified criteria, the alert level for each species is then set as red, amber or green. Trends are traditionally regarded as important only if they are formally statistically significant, but it may be preferable to use a Bayesian approach, particularly with scarce species for which the estimate of a trend may be large but with such large confidence limits as to be non-significant (Greenwood and Robinson 2006). For waterbirds, where surveillance takes place at the level of individual sites as well as the whole country, the mass of results is potentially even more overwhelming. A system has therefore been produced for filtering out those alerts that are probably less important, using criteria based on the biology of the species and its conservation importance (Atkinson et al. 2006).

Another useful tool for assessment and communication is the composite "indicator", in which data for species characteristic of a particular habitat are combined. The development of such indicators in the UK, promoted particularly by the late Colin Bibby, coincided with a government initiative to produce Quality of Life indicators, so the indicators of wild bird populations became part of that bundle, which is now published annually by the government. The indicator for farmland birds is used by government to assess its success in achieving its target of reversing the decline in the populations of farmland birds. Not only have similar indicators been developed in other European countries, but the European Bird Census Council is now producing Pan-European indicators (http://www.ebcc.info). Furthermore, these have been adopted by the European Union, with the farmland bird indicator being on the long lists of both structural and sustainable development indicators (http://epp.eurostat.ec.europa.eu/).

Thus, birdwatchers across Europe are providing information that feeds into environmental policy across much of the continent.

A prime example of the manner in which collaborative studies by volunteers have been used as the evidential base for the development of environmental management and policy is the work on farmland birds in Britain. This approach shows how collaborative work by amateurs has been essential in identifying a problem, in diagnosing its cause, in developing solutions, in the establishment of policy aimed at implementing the solutions and in monitoring the success of the policy. The intensive work on Grey Partridges *P. perdix* by Potts (1986) and the synthesis of O'Connor and Shrubb (1986), the latter based largely on evidence from volunteer-based studies, had given rise to some concerns about farmland birds, but it was not until a review of the trends shown by the Common Birds Census and the comparison of the second breeding atlas with the first in the early 1990s that the extent and ubiquity of the losses of farmland bird species during the previous two decades was fully appreciated (Fuller et al. 1995). This led to much research to diagnose the causes of the declines, much of it based on extensive surveys. Demographic analyses of census, nest-record and ringing data showed that for most species, reduced survival rather than lowered breeding output was chiefly to blame, though not universally (Siriwardena et al. 1998, 1999, 2000a, b). Some of the environmental drivers were identified through a series of focused studies, such as the surveys of Skylarks *Alauda arvensis* in both the breeding season and winter, which showed that the switch from sowing cereals in early spring to sowing them in autumn was the major cause of the decline of that species (Chamberlain et al. 1999a, 2000). That switch resulted in there being fewer fields left in stubble over winter, depriving Skylarks of a key feeding habitat. As a further consequence, autumn-sown cereals were too tall and dense by the second half of the breeding season to allow the birds to breed in them, thus reducing breeding output.

Research such as this, which both documents the losses and identifies some of their causes, resulted in the British government adopting a Public Service Agreement (PSA) in late 1999 to reverse the decline of farmland birds by 2020. The government uses the index of farmland birds (based on Breeding Bird Survey and similar data) as an indicator of Quality of Life and also to assess its success in achieving its PSA target. Potential solutions then had to be sought. Surveys by volunteers were again important, such as investigations into the value of various "game cover crops" for non-game species (Henderson et al. 2004), the importance for the successful breeding of Lapwings *Vanellus vanellus* of having damp pastures in which the chicks were able to feed next to the arable fields that are the preferred sites for nesting (Wilson et al. 2001) and how extensive areas of stubble need to be available in order to provide a real benefit to farmland bird populations (Gillings et al.

2005). The particular importance of the volunteer-based studies is that they have been geographically extensive, for analyses have shown that "it should not be assumed that management recommendations that are based on habitat associations derived from studies in a small subset of a species range will necessarily solve that species conservation problems over its entire range" (Whittingham et al. 2007). The investigation of potential solutions has allowed recommendations to be made as to the measures that might be taken to benefit farmland birds, such as the provision of more stubble and of areas of arable within predominantly pastural landscapes (Vickery et al. 2004). This has allowed the British government to put in place agri-environment schemes aimed to support such measures and thus to achieve its targets for farmland birds and other wildlife (Grice et al. 2007). The Breeding Bird Survey is being used to assess the success of these schemes. Furthermore, this and similar evidence from other European countries have been important drivers of reforms of the EU Common Agricultural Policy that aim to switch support from production to environmental benefits. In North America, the continent-wide Partners in Flight conservation initiative is also underpinned by data gathered by citizen scientists.

From science to policy: some principles

Conservation issues are often politically controversial. As such, it is important to separate the science from policy advocacy for, to be of real use, science must be unbiased. A situation where unbiased science leads to policy is likely to lead to sound policy, but if policy is decided first and science is then conducted just to provide evidence supporting that policy decision, then the science will be biased and the policy unsound. Furthermore, if science is to be trusted by decision-makers (as it must be, if it is to be used effectively), then it must not only be unbiased, but it must be seen to be unbiased. Hence, the relationship between scientists and conservationists has to be handled with care: if it is seen to be too close, then the science may be thought to be tainted, even if it is not. On the other hand, a close relationship between the scientists, conservation bodies and government has definite advantages: the science will then be relevant, directed to the questions that are important for the decision-makers and policy decisions will be made in the light of the science; furthermore, funding will be easier to obtain for the science because government and conservation agencies will be able to see its relevance. The balance of advantages and disadvantages is no doubt different in different countries. It is something that organizations running collaborative research need to consider particularly carefully because many of their volunteers participate because of the value of the work for conservation.

Because governments are the main decision-makers, relations with them are particularly important. In the UK, environmental campaigners (such as the Royal Society for the Protection of Birds, RSPB) and research bodies (such as BTO) are independent—both of each other and of the government—but there is generally a consultative and collaborative approach between all three. I believe that this combination of independence and collaboration has been an important element in the successes exemplified by farmland birds.

Most independent research organizations are not completely independent financially, and funding will always be seen as a potential source of bias. Funding from conservation bodies may cause people to suspect bias in one direction; funding from business may cause them to suspect bias in the opposite direction; funding from government may cause them to suspect bias in either direction, depending on the government interest at the time. There are two ways of dealing with this: purists accept money from no source that could possible be considered biased; pragmatists accept money from all sources, so long as they come under no direct pressure to bias their science. The second approach, which is based on demonstrating independence through the balance of different funding sources, is clearly the more beneficial financially (and therefore in terms of the amount of work that can be done), but it requires more attention to be paid to ensuring and displaying one's independence and scientific integrity.

One aspect of independence is being prepared to make data and information available to all who want it. Some volunteer fieldworkers may not want their results being made available to developers or consultants, on the grounds either that these are people whose activities are inimical to conservation or that they are making money by using data based on the unpaid labour of the volunteers. In my experience, emphasizing the importance of decisions being based on the best possible information generally overcomes such negative attitudes. Of course, a developer may misuse data in order to strengthen his case; this possibility has to be guarded against by monitoring the way in which the data are used. A more subtle issue is the unintentional misuse of data by people who do not understand it. For this reason, the provision of raw data needs to be carefully managed. It is generally better to provide information based on the proper analysis of the data rather than the raw data themselves.

How the work is organized

Citizen ornithology around the world

Most countries survey wetland birds, often largely through volunteer networks, because of the widespread concern for wetlands as important resources often threatened by over-exploitation, drainage and pollution and because of the requirements of international agreements, such as the Ramsar Convention. The concerns led to the establishment of three international organizations to study and conserve wetlands and their birds (in 1954 in Europe and the Middle East, in 1983 in the Asia-Pacific region and in 1989 in the Americas) and their coming together as Wetlands International in 1995. The latter has a key role not only in gathering and interpreting data on waterbirds but in encouraging the further development of counter networks in countries where they are weak or non-existent. The chief data-gathering exercise is the International Waterbirds Census (IWC) scheme. Simon Delany (personal correspondence 7 July 2006) estimates that 80% of the IWC counts are undertaken by volunteers. These may include hunters as well as birdwatchers, although in some countries this potential is wasted because of antagonisms between hunters and birdwatchers. More than a hundred countries now have waterbird counting schemes and each year around 30 million waterbirds are counted at 15,000 sites, through perhaps 50,000 h of fieldwork. (Note that this relates to counts made in January. In some countries, counts are also made in other months, so the total counting effort is much greater: another 50,000 man-hours are delivered by volunteer wetland bird counters in Britain alone; Greenwood and Carter 2003.) Boere et al. (2007) provide accounts of waterbird monitoring in different regions, and Wetlands International (2007) summarizes these data. Over two-thirds of the birds included in the IWC are counted in Europe (which is well covered), but counting activities are increasing in Asia, Africa and South America. Some of the work is promoted by formal agreements or by being organized at the regional level (e.g. the African–European Waterbird Agreement, the Asian Waterbird Census and the Asia-Pacific Migratory Waterbird Conservation Strategy). North America is the one continent not involved in the IWC. Using professionals, government bodies conduct the monitoring of waterfowl in the breeding season across the Prairies, boreal Canada and in the Arctic as well as across the USA in the winter; volunteers play a large role in the monitoring of shorebirds. There have also been analyses of CBC data to assess trends in some North American waterbird populations (Butcher et al. 2005; Link et al. 2006). Waterbird counting in the Africa–Eurasian region is comparatively well-funded by European governments. In addition, the Dutch-based Working Group on International Wader and Waterfowl Research (WIWO) functions as an intermediary between financing and government organizations on the one hand and volunteer ornithologists who are interested in studying waterbirds in countries with little current indigenous potential for such studies on the other. This organization places a strong emphasis on capacity-building in those countries (WIWO 1999). Despite such support, it is still difficult to maintain wetland monitoring in the tropics (Bennun 2001). Japan and Australia have funded much counting work in countries of the Asia–Pacific flyway. Latin America has had difficulties in maintaining counts because such funding has not been available on a continuing basis: much of the funding from the North is focussed on "policy-relevant" countries. The Western Hemisphere Migratory Species Initiative may be able to provide better capacity-building and support, but its focus is solely on the migratory species, so species and sites of purely South American interest may be neglected. The Western Hemisphere Shorebird Reserve Network may also help to raise interest in a more integrated pan-American approach. As a result of this work around the world, we have built up a good knowledge of the distribution and numbers of wetland birds (Boere et al. 2007; Wetlands International 2007). This information, combined with distributional studies of birds in general and with general birdwatching observations, has been particularly important in the designation of Important Bird Areas. IBAs often provide a focus for monitoring efforts in countries where there is little other monitoring (see Bennun et al. 2006): "If properly designed and carefully tailored to local issues, locally-based monitoring can provide valuable data, cost-effectively and sustainably, while simultaneously building capacity among local constituents and promoting practical and effective management interventions." (Danielsen et al. 2006).

There is now a ringing scheme in most countries although their sizes vary greatly even within Europe, both in terms of the number of birds ringed and the number of ringers (Spina and Pilastro 1996). Recent accounts have been published for the schemes in South Africa (Oatley 1996), Malta (Sultana 1998), the Britain and Ireland (Baillie et al. 1999d), Finland (Saurola 2001) and Slovenia (Sere 2001). In some countries all ringers are professionals, but in countries with large schemes the majority of ringers are amateurs (or professionals ringing in their spare time). Schemes are usually run by government institutes or museums, sometimes by universities and in a few cases by NGOs. Outside North America and Europe, intensive collaborative ringing programmes (such as constant effort sites and work to study survival) are rare. However, in 2002–2003, the Institute of Bird Populations (which instigated MAPS) launched the MoSI project—Monitoreo de Sobrevivencia Invernal (Monitoring Overwinter Survival). This is a co-operative effort among organizations, individual researchers and bird banders in Mexico, Central America and the Caribbean which aims to evaluate the quality of winter habitats for migratory birds. The monitoring goals are estimates of monthly, overwinter and annual survival rates and indices of late winter physical condition for a suite of 25 landbird species in various habitats and regions (http://www.birdpop.org/MoSI/MoSI.htm). This could be a good opportunity for drawing more amateurs into neotropical ornithology.

Turning to citizen ornithology more generally, most countries in Europe have census schemes (Voříšek and Marchant 2003) and have undertaken at least one atlas survey, mostly with strong volunteer input but organized in varying degrees by NGOs, universities and government institutes. Many countries also undertake a variety of other surveys and research programmes. Countries differ in the volume of such work, in its refinement, in how integrated the various schemes are (there may be several institutions organizing such work in a single country) and in how well the science feeds into policy. In general, amateur ornithology flourishes less well in eastern than in western Europe. This is partly a matter of scale: there is a birdwatcher for every 2 km^2 in Britain but for only one for every 8500 km^2 in Russia (Mikhail V. Kalyakin, poster at 2006 IOC). Culture also plays its part: it is difficult to build a dynamic civil society in countries where there has been a strong totalitarian bureaucracy for many decades, with little opportunity for the participation of individual citizens in the life of the nation. In such countries it may be difficult to persuade people to undertake serious ornithological fieldwork unless they are paid for it, a problem exacerbated by the economic situation in some East European countries. Economic problems may also mean that there are few professionals to encourage the development of amateur networks.

The participation of citizens in some kinds of conservation science is less concerned with nature itself and more with the mankind's own environment, and Lawrence (2006) has pointed to some clear examples of this from North America. However, there is also much collaborative ornithology there, undertaken for many of the same motives as in Europe and elsewhere. A significant difference in North America, however, compared with the UK at least, is that it is organizationally rather fragmented. The US Geological Survey runs ringing and the BBS; the Institute for Bird Populations (IBP) runs MAPS; the National Audubon Society runs the CBC; the Cornell Laboratory of Ornithology runs Feederwatch, the nest record scheme and many special projects; various other bodies conduct a variety of investigations. Furthermore, the considerable activity is useful but may actually hinder national-level, integrated work; For example, there is no grid-based Atlas for the whole of even the contiguous states. Indeed, Bart (2005) has argued that much of the North American bird survey effort is wasted. He estimates that there are over 100 different "monitoring schemes" there, with little co-ordination; many are short-lived, and most of their data are lost after a few years. He advocates a North American Coordinated Bird Monitoring Plan to improve coordination, integrate the data sets and provide overall management. In Canada, Bird Studies Canada has built itself up as a national body, and it runs most major projects, though ringing is organized by the Canadian Wildlife Service and MAPS by the IBP. Despite the variety of bodies involved within each of the two countries, there is good collaboration between Canada and the USA. Partners in Flight was set up 1990 with the aim of drawing together government organizations (at all levels), NGOs, academics and private individuals across both North and South America (Rich et al. 2004; http://www.partnersinflight.org). The initial focus was on species that breed in the north and winter in the neotropics, but it has broadened to include most landbirds. Partners in Flight has formulated action plans and identified gaps in research and monitoring (Dunn et al. 2005b). It is thus working towards the 1978 vision, but it is still only an umbrella body rather than an incorporated organization. Various established monitoring programmes (including the CBC or BBS) are rapidly expanding in Mexico.

In Australia, there is no census of common birds because of the nature of the country and the extremely patchy distribution of humans in it. Instead, other methods are used, based on the continuous accumulation of data on a similar basis to that used for the distribution atlas. However, even with such methods it is difficult to get data from much of the country because of its remoteness. There is also a nest record scheme and much work on waders generally. The fieldwork is conducted largely by amateurs through NGOs (with professional staff at the national level but many volunteer organizers at the regional level). Birds Australia takes the lead, but much work is done at the state level, which many feel needs better co-ordination. There is no general census scheme in New Zealand either, although one is planned, but there is an annual census of waders, a moult recording scheme, a nest record scheme and a beach patrol scheme; a national bird atlas has been finished recently. More specialized work includes studies of seabirds of various islands, wader colour-marking and surveys of invertebrates on mudflats (in relation to shorebirds). Most of the citizen ornithology is lead by the Ornithological Society of New Zealand.

There is little citizen ornithology in many Asian countries. Even ringing is a professional activity. In some countries amateurs are discouraged by a hierarchical culture, with established professionals refusing to accept the validity of work by formally unqualified amateurs. However, at opposite ends of the continent, Israel and Japan have networks of amateur ornithologists not dissimilar to those in Europe and North America. Apart from Israel there is very little volunteer involvement in ornithology elsewhere in the Middle East, except by expatriates from

Europe and North America (who can usually not provide long-term commitment). The support of such temporary residents, the supportive work of Israeli ornithologists to their colleagues in neighbouring countries and the rapid development of birdwatching and volunteer-based data-gathering in Turkey (Baris 2004) are all reasons to hope for better things in future. Other hopeful signs are the rapid and exciting developments in some other Asian countries. The Malaysian Nature Society, with support and participation from the Malaysian Department of Wildlife and National Parks (Peninsular Malaysia), organizes much amateur participation in monitoring. The Bird Group of the Nature Society (Singapore) conducts a similar range of work. In Hong Kong there is a long and distinguished history of amateur ornithology led by the Hong Kong Birdwatching Society (Carey et al. 2001). Elsewhere in China, amateur birdwatching has a history of little more than 10 years but is increasing rapidly and volunteers have been involved in several major surveys of particular species or particular places. There is now a national newsletter and an annual bird report. In 2006, there were moves to draw organizations together across mainland China, with a conference on organizational developments that resolved to develop collaborative work across the country. Birdwatching is popular in Taiwan, but it has proven difficult to draw local societies together or to get birdwatchers to commit to sustained programmes of serious research or monitoring, although volunteers do play an important part in monitoring waders (Chiang and Liu 2005). In India, the size of country, the scarcity of professionals and the fact that the organization of conservation and ornithology is almost all at the State level all pose difficulties. However, the Bombay Natural History Society has been able to take something of a national lead, and many organizations collaborated to produce a massive IBA inventory (Zafar ul-Islam and Rahmani 2004). At time of the production of this book, the Indian Bird Conservation Network had 75 organizations belonging to it. Census work has focused on wetland birds, priority terrestrial habitats and endangered species (Urfi et al. 2005). Most Asian countries have the disadvantage of being in the tropics, where (especially in the wet tropics) bird census work is more difficult than in temperate regions because there are so many species, many of which are rare. They have wide foraging areas or sing infrequently, and most of which have cryptic nests and high nest failure rates. The density of the vegetation and the noise of cicadas are additional factors which make it difficult to detect birds, and the diversity of plant species makes it difficult to record habitat (Karr 1981).

There is little citizen ornithology in Africa, beset as the continent is with severe economic problems as well as the practical difficulties of tropical ornithology. Nonetheless, the remarkable Avian Demography Unit in South Africa (operating also in neighbouring states) shows what determined vision can produce, in terms of fine amateur-professional collaboration, even in countries wracked by political and economic upheavals. There is an active ringing scheme, the second atlas is about to start and there are programmes for monitoring wetlands, reserves and large birds in the wider countryside. The work of Nature Kenya is also showing good developments, with much volunteer involvement in the monitoring of key sites, although this is not easy to translate these data into national pictures (Bennun et al. 2005). Much effort goes into developing birdwatchers' interests in collecting useful data, which will surely lead to better monitoring in future.

South American ornithology is growing, but there is currently little birdwatching or citizen ornithology. However, things could change (Vuilleumier 2003), despite the problems of the lack of financial resources and political instability (Jahn et al. 2004).

In summary, citizen ornithology is patchily distributed across the world, with many gaps; however, there is strong growth in some of the gaps, and we may be optimistic about the future. The gathering of data and the feedback of results through the internet will greatly help in countries with little ornithological infrastructure; the provision of the necessary programmes to them by countries that have already developed these is speeding the spread of this technology. Some people in countries that do not yet have well-developed citizen ornithologist programmes sometimes feel that they are so far behind that they cannot possible catch up; the experience of the last few decades shows that this is not true. The example of those countries whose work is more developed can be used to show the feasibility of proposed projects to potential fieldworkers and funders. The experience of these more developed countries can be passed on, and practical help (such as the provision of computer-based data-capture and analytical programs) given.

The amateur–professional partnership

The decline in natural history work in the twentieth century (especially in the second half) in terms of professional status and funding has paradoxically coincided with a huge increase in concern for biodiversity and the environment (Secord 1996). Given this, it is fortunate that the amateurs have been on hand to fill the gap. Even citizens with no special or pre-existing interest in natural history can make significant contributions to knowledge. Thus, in Kinabulu (Malaysia), well studied by botanists for more than 110 years, engaging local people in collecting plants increased the number of palm taxa (excluding recent introductions) known in the area, from 48 to 79 in

4.5 years; there were similar (though generally less dramatic) increases noted for other plant families (Martin et al. 2002). In Canada, the decline of Ivory Gulls *Pagophila eburnea* was picked up because "Inuit hunters told researchers that they no longer saw the birds at sea or at town garbage dumps" (Krajik 2003). The widespread poisoning of wildlife by agrochemicals in the late 1950s was observed by naturalists, hunters and farmers before the professional authorities in the UK even became aware of it.

Turning to more systematic investigations, the large numbers of amateurs mean they can gather very large data sets, based on huge amounts of fieldwork. Volunteers collect 70% of biological records in the UK, and British collaborative ornithology involves about 1.5 million person-hours per year (Greenwood and Carter 2003). British Trust for Ornithology projects typically involve a volunteer input amounting to between 10- and 30-fold the time spent by the professional organizers. The next bird atlas for the Britain and Ireland, which will cover both summer and winter, will involve both systematic and non-systematic work; the former alone will require at least 250,000 person-hours of fieldwork. In Australia, the Threatened Bird Network programme benefited by volunteer work worth about $2.6 million (excluding travel expenses) in 1996–2000 (Weston et al. 2003). Similar levels of participation must occur in other countries. Furthermore, environmental volunteering is clearly increasing in the UK: environmental groups had 442,000 members in 1972, and around 6 million in 2002. While most of these are unlikely to be active fieldworkers, it is estimated is that there are 100,000 members of natural history societies, most of whom are likely to be so (Leadbeater and Miller 2004). In North America, although Putman (2000) has documented a general trend towards declining citizen participation, the volunteer input to ornithology is apparently undiminished. In most countries of the world—except those with almost no amateur ornithology—the level of amateur involvement appears to be increasing.

The variability of nature means that it is usually unsafe to generalize from single study sites, or even from a few. The large samples that amateur networks can provide enable safe generalizations to be made. In particular, the wide geographical area covered by amateur networks overcomes the problems of geographical variation. While it might be possible for a professional team to sample many sites in sequence over the course of a year, that is no use if everywhere needs to be covered at the same time (Sheil and Lawrence 2004): for example, if a study requires each site to be covered for a few hours on 1 day every month, a professional may be able to cover all the sites but at the cost of spending much of his or her time travelling between them; a network of local people wastes far less time in travelling. In addition, locally based amateurs can provide insights that visiting professionals might not have, placing the investigation in its local context by providing information on an environmental problem or on a locality that professionals coming as newcomers are unaware of (Stokes et al. 1990). In countries where the owners of land are allowed to exclude other citizens from it, local amateurs may be able to get access that is denied to government or to national NGOs through their personal contacts.

Standards of identification are probably higher today than ever before because of improved optical and other equipment, good field guides, birdwatching magazines with ID articles, local bird clubs that bring beginners into contact with experienced birders and rarities committees to assess records. Survey skills are also better because of the build-up of experience at both the individual and organizational level. Nonetheless, the competence of volunteers and the quality of the data that they produce are sometimes questioned by people who do not have much contact with volunteers, such as some of those working for government or other large institutions that are not run by members, especially in countries with no history of volunteer involvement in ornithology. The fact that, according to the people whom I have asked about this issue in Europe, such concerns are apparently not widespread among the people funding and using survey work by volunteers is a tribute to the care that the survey organizers take to maintain standards. The careful design of methods and instructions helps to ensure that the volunteers can do what is asked and know what they are being asked to do (Krasny and Bonney 2005). Many survey organizers take steps to assess the competence of volunteers (either directly or through local observers) and run training courses to improve fieldworkers' skills. Indeed, if the level of competence needed for a survey is explained to potential recruits, many will eliminate themselves. If one is recruiting completely new people, then they can be encouraged to assess themselves with a brief questionnaire—"Can you do A, B and C? If so, you can do this survey. If not, why not come on one of the training days?" (For a current example of this approach, see http://www.tucsonbirds.org). Most organizers also check the data coming in, using their own knowledge, the local knowledge of experienced people from the study areas and—what is now possible—automatic checks on data submitted electronically; this latter step highlights such aspects as unusual numbers, records at an unusual time of year or beyond the normal range, measurements outside the normal range, among others. These checks are, of course, driven by the organizers' own concerns about the competence of some of their fieldworkers, expressed by about half my informants.

Whether professionals are more reliable than amateurs is a moot point. As Barzum (1954) said in another context: "by applying rigorously any test of pure talent one would find many an amateur high up among the professionals and many a professional down among the duffers." Fieldwork mistakes arise through inexperience, carelessness, fatigue or a lack of familiarity with the study area (Robbins and Stallcup 1981). It is true that, on average (but only on average), amateurs may be less experienced than professionals, but it is likely that they are no more likely to be tired or careless and, because it is their local patch, they are more likely to be familiar with their study areas than professionals. The fact that someone has been paid to undertake some ornithological work does not guarantee that their data will be sound. There are certainly cases where a government, having decided that it needs certain places surveyed, perhaps to fulfil some international agreement, has sent out professional biologists or ecologists to do the work, not being aware that they may not be ornithologically competent. Indeed, it is clear that some data submitted by such professionals have at times been invented. It is particularly distressing that this may happen even when there are competent amateurs who would do the work but whom the government does not believe can do it properly because they are amateurs.

Whatever the status of the fieldworkers, the data are unlikely ever to be wholly correct. However, small numbers of errors are generally unimportant. There are numerous examples of this. Thus, although two experienced observers doing 3-min point counts simultaneously on North American Breeding Bird Survey routes rarely obtained identical species lists at individual stops, their lists on each block of 50 stops were similar (Robbins and Stallcup 1981), and four observers (two very experienced, two less experienced) working the same Common Bird Census site in England made similar estimates of year-on-year changes in numbers although the number of registrations that they obtained differed markedly (O'Connor 1981). Thus "the magnitude of the errors actually perpetrated is generally within an acceptable range in most types of bird survey work" (Robbins and Stallcup 1981).

Governments sometimes eschew the help of the voluntary sector because they think that the amateurs or the organizations through whom they work are biased. In 1994 the US Congress called—fortunately unsuccessfully—for the National Biological Survey to exclude data gathered by volunteers on the grounds that volunteers "would likely have a special environmentalist agenda and ... collect biased data", even calling them an "environment Gestapo" (Root and Alpert 1994). It is true that many volunteers participate in surveys because they want to aid conservation, which in principle could lead to bias; to argue that the volunteers in an environmental survey "have no political, economic or personal motives for influencing the data collected which is therefore completely impartial" (Rees and Pond 1995) is naïve. But professionals are just as likely to be biased, especially if they are paid by an organization that is more concerned with supporting its existing policy than basing its policy on sound evidence. It is important that all involved should recognize that the best way of supporting conservation is for decisions to be based on sound (hence unbiased) data. I believe that the organizations around the world that are involved in using volunteer networks to gather data for bird conservation science are mostly successful in promoting this view.

Citizen science and democracy

What should concern governments is not that the amateurs may produce biased data but that if they produce information that is embarrassing to the government, they are not likely to keep quiet about it, whereas government employees can often be silenced. In democracies, however, such openness should be welcomed. Indeed, it seems to be true that citizen science tends to flourish best in democratic countries. Several informants have commented to me that it is difficult to recruit volunteers in some (though not all) countries in the former communist bloc because attitudes are still influenced by the previous culture of non-involvement. In non-democratic (and formerly non-democratic) countries, individuals are not used to the idea that they can influence decisions, so they have less incentive to participate. Furthermore, some such countries tend to be hierarchically organized, such that only those in professional positions are considered to be capable of making a serious contribution. Equally, citizen science may help to build democratic participation in general. This is not a new idea: "Thirty years ago, British sociologist Richard Titmuss (1970), signalled that volunteering is an important aspect of freedom in modern societies, and that its essentially altruistic nature contrasted with the possessive egoism of the market" (Warburton and Dyer 2004). More recently, Jeffrey (2001) has argued that environmental NGOs "play an important role in safeguarding the long-term interests of the citizen against the state" and Ellis and Waterton (2004) and Lawrence (2005) have seen a link between volunteering in biodiversity work and citizenship. More generally, the expert amateur ("Pro-Am") has been seen as a counter to increasing corporate dominance by Leadbeater and Miller (2004), who maintain that "the more Pro-Ams there are in a society the healthier its democracy is likely to be". It is not just a matter of well-informed citizens being able to challenge corporations and government but also one of people being drawn into helping to solve problems: where volunteers are engaged in monitoring that is aimed at a particular issue: "The problem can change from a 'them' to an 'us' situation" (Stokes et al. 1990). Thus, the very involvement of citizens in the gathering of evidence can give greater political and financial support for the work (Sheil and Lawrence 2004).

Expert volunteers of any sort benefit society not just by the activities that are the object of their interest but by social-bonding together and bridging across gaps, such as those of income (Leadbeater and Miller 2004 and, specifically in relation to citizen ornithology, Bell et al. 2007). That is, they generate social capital, defined as "... features of social organisation, such as civic participation, norms of reciprocity and trust in others, that facilitate cooperation for mutual benefit" (Kawachi et al. 1997). Social capital, *pace* Bourdieu (1993/1999) and Blackshaw and Long (2005), who see it as benefiting mainly those who possess it, may contribute to a range of economic and social outcomes that are beneficial to society (Aldridge et al. 2002; Putman 2000). Overall, it has been declining in some countries such as USA (explored in detail by Putman 2000), and even though the level of social capital has been generally stable or rising in other OECD countries, some of its traditional forms (e.g. membership of political parties, the church and trade unions) have been declining in most of them. The general expansion of citizen ornithology thus contributes not only to science and conservation but to democratic participation more generally. It is particularly important for the public understanding of science, itself critical given the significance of science in modern life. Unfortunately, scientists are nowadays trusted less by the public than they used to be (especially scientists working for government or industry), and there are often poor relationships between environmentalists and scientists, despite the former needing science if their policies are to be soundly based. Active participation, albeit as an amateur, surely helps the public understanding of science.

While history and some current practice show that amateurs can carry through on collaborative research projects from conception to completion, it is broadly true that the full potential of the volunteer networks is realized only in collaboration with professionals (Mayfield 1979; Nicholson 1970; Tinbergen 1959; Warburton et al. 2005). The converse is equally true: professionals can do much less alone than when working with amateurs. In successful partnerships, the amateurs provide large and comprehensive data sets, provide links to the wider community, may provide their own special expertise (such as internet skills) and may help raise funds; the professionals have the time and facilities for the planning, organization and curation of the work and are generally more able to provide technical knowledge and scientific and applied context. However, the relationship between amateur and professional ornithologists has not always been harmonious (see Barrow 1998 in terms of North America). The need for the paid people to establish a professional status has often been a driver of their wish to distance themselves from the amateurs. Even today, professionals in disciplines in which there is a prominent amateur contribution may be looked down on by those working in other fields, especially if some of the amateur involvement is less than serious. As a result, the great amateur interest in birds results for some professionals in "a measure of embarrassment, lumping them with company they would prefer to disavow" (Mayfield 1979). This disgraceful attitude appears to be particularly strong among those professionals who themselves are least qualified; those who are clearly well-qualified (and who work in countries where their professional status and academic respectability is well established) do not need to distance themselves from their amateur colleagues. The resentment of the amateurs (and of paid workers who are less formally trained) may be a particular problem in countries where there are comparatively few professional positions: "Given that intellectually rewarding and remunerative employment is a resource in short supply in tropical countries, and especially in the biodiverse ones, the creation of parataxonomists increases the competition among those who already have equivalent positions by virtue of birth, urbanization or academic credentials ... Decentralization is a process not always embraced by those whose power is being decentralized" (Janzen 2004). Unfortunately, these countries tend to be those where there is greatest need for additional manpower to study biodiversity. In all countries, the role of professional should not be to undermine amateurs but to help develop their capacity to contribute to the joint endeavour.

The success of the amateur–professional collaboration depends on how it is managed. Bhattarai (2002) lists the ways in which professionals may regard the volunteers with whom they collaborate:

1. They know nothing; we just use them as servants or helpers.
2. Of course we know better, but they know the way and location better.
3. We know better but by asking them it will speed up our work; they also serve us.
4. We undoubtedly know better, but they also know few things that may help our work.
5. They know as good as we do, but their perception is different; let us consult each another.
6. They know a few things much better; let us work together because what we study concerns us all and belongs to everyone.

The first four attitudes have been common in natural history studies. Some professionals clearly become involved with citizen science merely in order to get hold of data for their own interests, using volunteers merely as unpaid labour (Krasny and Bonney 2005). Indeed, Ellis and

Waterton (2005) argue that the professionals are Latour's (1987) "fact builders" who need to control those they enrol into the continuing construction of fact and refer to Drouin and Bensaude-Vincent (1996) who wrote of nineteenth century naturalists forming "an undisciplined crowd which the professionals would like to keep under their control". I am convinced, in contrast, that it is better when the amateurs and professionals work as partners, with power relationships and influence flowing in both directions (see Lawrence 2005, 2006). Working in partnership, however, requires careful management because the different perspectives of amateurs and professionals may lead to difficulties in working together (e.g. Goodwin 1998). For example, professionals laying down the standards of working can lead to the volunteers just seeming like cogs in the machine (Lawrence 2005). Such difficulties may be exacerbated when the professional input to the planning, organization and publication of the work increases, so that some volunteers consequently feel marginalized. The natural imbalance resulting from the professional working full-time and the amateurs only part-time can be managed by the professionals consulting the amateurs, building teams with them and maintaining an egalitarian ethos. I believe this to be easier if the work is undertaken by membership organizations, for in these the members have the ultimate ownership, through the governance processes, and are effectively the employers of the professional staff. Furthermore, their membership results in greater commitment, including a willingness to provide financial as well as practical support for the work. Balancing the members' "ownership", the staff are responsible for executive functions and for advice to the governing body, so the partnership is inherent in the nature of such an organization. And, if attention is given to promoting personal interactions between members and staff, the partnership is a truly live thing, not just words on paper.

How to develop the work

Recruiting participants

Recruitment of new participants—and their subsequent retention—is as important a skill as scientific expertise. The key to success is to consider what motivates people to participate and what they feel they need from the experience (Weston et al. 2003). The organizations that are most successful in their network research are those that recognize that different people have different motives by, for example, running a range of surveys designed to cater to this diversity.

My conclusions as to what motivates and demotivates participants in network research are based on talking to many such participants and considering their complaints (mostly in the UK), discussing the matter with colleagues in the UK and around the world and reading the views of experienced people (e.g. Mayfield 1978) and the results of published surveys. The latter include studies of participants in bird projects in Australia (Weston and Paton 2002; Weston et al. 2003, 2006), North America (CWS no date, Ealey et al. 1994) and the UK and Slovenia (Bell et al. 2007); people involved in other biodiversity work in the UK (Ellis and Waterton 2005; Gillett and Lawrence 2003; Lawrence 2005) and The Netherlands (Lawrence and Turnhout 2005); older Australians engaged in volunteer research and environmental work (Warburton and Dyer 2004; Warburton and Gooch 2007); Americans engaged on restoration projects (Schroeder 2000). General reviews of amateur participation have also been useful (Finnegan 2005b; Leadbeater and Miller 2004). Given the diversity of motives and the likely differences between countries, one has to be careful in drawing general conclusions from the limited number of surveys conducted [though this does not inhibit some students of amateur work, such as Stebbins (1992), making generalizations and erecting conceptual frameworks across activities as diverse as baseball, magic and astronomy!]. Another limitation of the surveys is that they are almost wholly based on asking people about their motives, rather than observing how they actually respond to the opportunities presented to them; consequently, the surveys are dependent on people being able to assess their motives and reporting them properly. The surveys also do not provide much, if any, information on why many birdwatchers do not participate in surveys, knowledge which would allow us to recruit some of them by designing more attractive surveys.

The overriding consideration for most volunteers is that they find the work enjoyable. Of course, people can go birdwatching without undertaking a serious research activity, but the latter provides the excuse that many seem to need for engaging in an otherwise frivolous activity. Part of the enjoyment of such pursuits is that they are a recuperation from their paid work, partly because the people are more in control of how and when they engage. For this reason, the regimentation of survey methods, while it needs to be sufficient to obtain useful results, should not be overbearing. Because seeing birds is part of the enjoyment of fieldwork, people dislike being sent to places where there is not much to see, as may often happen in surveys, especially those based on a random sampling framework. Stratification can help (see below),and one can even decide not to try to cover areas where the species being surveyed is known not to occur. A more costly solution is to use professionals to cover areas where it is likely to prove difficult to get volunteers. Another approach is to add to the survey something that they are more likely to see in order to give them something to report. For example, in a BTO survey of Corn Buntings *Miliaria calandra*, a species that most of the observers did not see, we included all other buntings. This approach has the added advantage of reducing the likelihood of observers not submitting negative records of the target species, as they are inclined to do when there is nothing at all to report. (Constant reminders of the value of negative records also help with this problem.)

Paradoxically, those that find leisure activities stressful and challenging are more likely to be absorbed and satisfied by them. Striking the balance between work that is challenging enough to be satisfying but not so demanding as to put off potential participants is not easy, especially because the balance is different for different people: methods regarded as too simple to be adequate by one person may be considered to be difficult by another; instructions regarded as condescending in their style by the one may be considered too complex by the other. This is an advantage of running a range of surveys: not only is their something to suit everyone, but people can graduate from the less to the more challenging as they gain experience and confidence. Undertaking challenging work adds to feelings of self-worth, which are important motivators for all sorts of volunteers. They can be enhanced through good feedback on the soundness and value of the work, especially if the feedback is personal and delivered by a respected figure. Another reason that people take part in collaborative projects is that they like to improve their knowledge and skills. Training, feedback and the provision of a range of surveys all help with this also. There is much evidence (though mainly anecdotal) that experience and training improve the competence of new recruits (Canadian Wildlife Service 2004; Ealey et al. 1994; McLaren and Cadman 1999). Many organizers run courses in both identification skills and survey methods: informal courses, or simple mentoring sessions, run locally by experienced volunteers, can be especially effective. Tapes and compact disks of calls are commonly provided (identification by sound being a general weakness) as, increasingly, are web-based training packages (e.g. http://www.pwrc.usgs.gov/BBS/participate/training). Such provisions not only improve skills but are important for persuading people who might otherwise be too doubtful of their competence that they do, indeed, have the ability to contribute.

Birdwatching used to be considered a solitary activity, when there were so few birdwatchers that they rarely encountered each other. However, many birdwatchers enjoy spending time in the field with other enthusiasts, and this can enhance the attractiveness of projects that involve teamwork. Even where the work itself is solitary, participating in a community of researchers can be motivating. As Niko Tinbergen (1959) wrote: "filling-in a nest record card or ringing one young Sandwich Tern after another gives satisfaction when one thinks of the pile of honest, reliable records one is helping to build up". Thus, the building of a "team spirit" around a project is important. How to do this no doubt depends on local cultural norms, but appropriate feedback is always valuable, telling participants not only what the results are but how the success of the project has depended on the whole team. When reports say "we have achieved ...", it should be plain that "we" means everyone, not just the organizers. The clear inclusion of the volunteers as members of a team also helps overcome the problem that some naturalists resent their records being used by an institution organizing a survey as "its" records. Membership organizations in which the members elect the governing body may have an advantage here, in that the institution belongs to the volunteers, rather than being some separate entity over which they have no control. A particular issue is that data or information often have to be passed to third parties, such as conservation agencies, if it is to be most useful. Such third-party users need, by providing feedback themselves and by making opportunities to meet the fieldworkers, to establish good links; otherwise, they may come to be regarded as parasites, exploiting the goodwill of the amateur network. A particularly sensitive issue is the sale of data to third parties. The charge often merely covers the administrative costs of supplying the data, but sometimes it is used to help defray the costs of running the surveys and of curating the data. Most volunteers expect commercial customers to pay handsomely for data; consequently, many clearly resent the data that they have given freely being sold on, unless the reasons for doing so are carefully explained.

Although people who do not volunteer or otherwise participate in civil society do not seem to be particularly short of time (Warburton and Crosier 2001), those who do participate often cite lack of time as a reason for not doing more. This means that it is just as important to design surveys in which the volunteer's participant's time is used effectively as it is when the participant is being paid. If the demands on time are too great, people will not take part: the BTO's Nest Sanitation enquiry (in the 1940s) recruited very few participants (and thus reached no conclusions) because it required people to conduct such intensive work.

The joy of discovery is important for most of the amateur participants in network research, which is exactly the same motive as that of the scientist (even if some of the amateurs would not describe themselves as scientists). This is another reason why feedback is important: the volunteers want to know what has been discovered through their efforts. Amateurs may, of course, have a different view of the science that they are doing from that of the professionals: tangible results, such as a set of distribution maps, may be of more interest to the birdwatcher than an analysis of the same data aimed at exploring the various hypotheses put forward by scientists to explain geographical patterns of species richness (though this is not to say that the latter will not interest the birdwatcher if it is presented in non-technical language). To engage their interest, the questions that a study is addressing should be real and understandable in their terms and relevant to their interests. Much of the science that is carried out through networks of amateur birdwatchers is aimed at providing the understanding required for effective conservation, and contributing to conservation is a major reason why people take part. The conservation value of a project is thus a major recruiting tool, and feedback explaining the significance of the findings for conservation makes it more likely that observers will continue to take part in the same or similar projects.

It is usual for survey organizers to be interested in the national picture, but individual fieldworkers are often more interested in their local sites, especially when the work has direct conservation significance for individual sites. At the local level, counters often act as caretakers for the sites that they cover because they see what is going on and are concerned for “their” sites. Such tension between the local and the national interests can be overcome by national organizers presenting surveys so that their local relevance is obvious (perhaps through the contact with the volunteers being at local level) but having the data gathered and submitted in the same way for all areas, so that they can readily be combined at national level. A good explanation of the importance of the work at more than one level also helps: “Citizen science at your local IBA becomes a global act” (Green and Gill 2004–2005). So does flexibility over the work, such as allowing volunteers to submit data for their favourite sites alongside data for the sites required for the national survey.

However well surveys are designed to make them attractive, it is useless if potential participants are not even aware of them. To draw people in, we need to publicize new surveys widely—not just in ornithological journals but in the more general press, on the internet and on the broadcast media. One advantage of established organizations is that they already have networks of contacts among the birdwatchers, other organizations and the media; these are important resources for publicizing surveys. In this publicity, it is important to strike a balance; it needs to catch the interest of people who have sufficient expertise to make a useful contribution but not to result in one being swamped by large numbers of insufficiently experienced people. Personal contacts are a particularly valuable way of recruiting people; this can occur through national organizers visiting local events to meet the birdwatchers “on the ground”, or through arranging special meetings to which potential participants are invited. Because volunteers are so numerous and widely distributed, they themselves can be particularly effective as recruiting (and training) agents. They can be very persuasive: during the course of a study of volunteers (Bell et al. 2007), a birdwatcher said of a BTO Regional Representative (himself a volunteer): “Fortunately we’ve got [name], who’s the local rep up here. Well, you know, he’s an active character. I mean even the most horrendous survey, he can sell it to the club because of the way he is. And you think “Oh here he goes again” but you end up signing up ... I think [name] is a big seller. He’s a massive asset to the Club I think, he’s so enthusiastic.”

It is not just the ranks of serious amateurs that can be recruited to survey work. Professional conservationists and scientists often work as honorary amateurs in their spare time. Birdwatching ecotourists not only have a great potential to help bird conservation through educating local people, promoting conservation initiatives and demonstrating the economic value of birdwatching (Sekercioglu 2002) but, especially given that they are often visiting countries in which the number of indigenous birdwatchers is small, they can often help by putting their observations into local databases, which systems for gathering records online make easy. Even members of the public who would not consider themselves to be birdwatchers can also be drawn into simple work, for most people are capable of identifying at least some of the birds around them. The value of recruiting local people in places where there are few experienced naturalists is well-known (Sheil and Lawrence, 2004). Not only can local people provide data, but they may have insights and ideas that are different from and complement those of outside “experts”. It is important, of course, both to limit the work to that which such people are capable of reliably delivering and not to fall into the trap of thinking that rural people know the birds that live around them or that traditional knowledge systems are superior to those of science. The recording of birds in people’s gardens (backyards), the gathering of simple birdwatching lists and the North American CBC are examples of work that is sufficiently simple for the inexpert but still yields useful data and, as such, is ideal for introducing newcomers to collaborative research.

Some survey organizers take a frankly elitist approach to recruitment, turning down people for irrelevant reasons, such as the lack of a university degree, not being a member of a particular society or not being personally known to the organizer. This is foolish and, perhaps, even wicked. People’s competence should be directly assessed, and if it is doubted then training should be provided.

Organizing surveys

Dunn et al. (2006) have considered methods for conducting bird surveys. I concentrate here on those issues that are particularly relevant to organizing collaborative surveys using a widespread network covering a large area.

As in any research project, one must begin by defining one's objectives to ensure that one gathers the right data using the right approach. This is particularly important when the research is a team effort; otherwise, the various members of the team may have different ideas, resulting in their gathering data that may not be fully relevant to the objectives but, even worse, that may not be compatible with those gathered by other members of the team. Clearly defined objectives are even more important in large-scale collaborations where the participants do not meet but get their instructions in writing and have no opportunity to ask questions if they are in doubt as to what they are being asked to do.

The next step, especially when setting up long-term projects, is to consider whether it is possible to build on existing programmes, rather than setting up new schemes; otherwise you may end up with a set of uncoordinated schemes, each too small to provide really useful data and too weak to be viable in the long term. It will generally be more efficient in the long term to conduct the work through an existing institution, rather than setting up an independent project. One should also consider whether it is possible to co-ordinate your work with that of neighbouring countries, so that the data can readily be drawn together, thereby increasing its value. (Thus the Countryside Bird Survey in the Republic of Ireland and the Breeding Bird Survey in the UK use the same methods. This has saved effort in that the methods only had to be worked out once and the same analytical programs can be used in the two countries. It also allows analyses to be done that cover the whole of Ireland, biogeographically more relevant than analyses for the two separate political administrations on the island.)

One must also consider exactly how best to use the potential workforce of amateur fieldworkers, remembering that they need to be treated differently from professionals. Their needs and motivations (considered above) must be taken into account, especially the aspects that they dislike, such as recording information that is apparently irrelevant or tiresome to record. For example, the usual vegetation classifications depend considerably on identifying plant species (which many birdwatchers dislike or find difficult), but the Crick (1992b) habitat classification for British birdwatchers rests more on structure (which is easier to assess and more relevant for birds). Consideration should always be given to the possibility of obtaining such ancillary information by other means: for example, if GPS is used to establish the precise location of an observation, its landscape context can be derived from satellite imagery. Account must also be taken of the amateurs' likely limits, especially in terms of time and scientific training.

Again, while all scientists know that they should consider at the planning stage how they will curate, process and analyse their data, this is particularly important for network research. The volumes of data are such that even minor inefficiencies in their processing can be costly, and the number of workers is such that one must lay down clear protocols to avoid being sent a mass of incompatible and uninterpretable data, such as happened in some early BTO projects.

Mistakes can often be avoided by using experience when planning surveys. This does not need to be experience in the running a precisely similar survey, for all surveys have some general lessons to teach. In the BTO we have had an internal document since 1985 (updated at intervals) that distils the corporate experience down into guidelines for survey organizers. The experience of others is also important—people who organize surveys (not necessarily of birds) in their own country and the many people in other countries who have carried out similar work. The experience of fieldworkers themselves is especially valuable: getting comments from some experienced volunteers on a set of draft survey instructions and recording forms can help to avoid a lot of problems.

For big projects, it may be useful to have a planning group that comprises people with relevant experience who can discuss the proposed methods and refine them. A comprehensive planning group would include people with experience in organizing surveys, volunteers, statisticians and scientists who will use and interpret the data. It will also include people from different parts of the country, for the problems that arise may be different in different parts. For long-term surveys especially, it is useful to conduct pilot studies. These enable one to test the methods, to obtain feedback from the fieldworkers and to anticipate their questions. Pilot studies also provide real data on which the proposed methods of analysis may be tested and power analyses conducted. The improvement in the methods will usually more than justify the time spent on the pilot. For example, in the 2007–2011 atlas for Britain and Ireland, the focus is on species occurrence and abundance within hectads, but this is being assessed through systematic surveys within several tetrads in each hectad. Pilot work showed that the hectad-level results were better if many tetrads were visited for a short time each rather than few for a long time each (S. Gillings: Designing a winter bird atlas field methodology: issues of time and space in sampling and interactions with habitat, in preparation). This pilot and consultations with fieldworkers also revealed that the latter preferred covering a few tetrads "properly" than many "superficially", because their focus was on the tetrads being visited rather than the hectads. So, as well as showing which survey design was preferable, the pilot also showed the need for careful explanation when the methods were finally presented to the fieldworkers.

Statistical advice is important—but it should be taken from people who understand the practical as well as the statistical issues and who can recognize, for example, that it is better to have some information, even if it slightly biased, than no information at all. Experience, as well as theoretical principle, shows that surveys are much improved if proper attention is paid to their design (see Greenwood and Robinson 2006), and the European Bird Census Council is preparing a guide to best practice. It is best if the samples are random rather than chosen by the observers, for observer-choice may lead to bias. Stratification, by such things as habitat or likely variation in population density, can much improve precision of one's population estimates. It can also be used to reduce problems arising because volunteers are unwilling or unable to visit randomly chosen sites. For example, one might stratify a country into the areas within 10 km of observers' residences and those beyond that limit; if samples are taken randomly within those strata, even if only a few are taken in the "remote" stratum, unbiased data will be obtained. If free choice of sample sites by observers has to be accepted, post-stratification can help to reduce bias so long as the right variables are chosen for the stratification (van Turnhout et al. 2007). Bias is most likely in single-species surveys, when observers are likely to choose sample places where they expect to find the species. It is less likely in multi-species surveys, except where there is marked variation in species richness or aesthetic quality of the habitat (observers generally do not like species-poor and urban areas). For example, in a 7-year overlap period, the British CBC (based on observer-chosen plots) and the BBS (stratified random samples) gave very similar results for population changes, at least within that part of the country well-covered by the CBC (Freeman et al. 2007). Thus, in practice, one should not be too precious: if you can, sample at random and use field techniques that are not affected by variations in detectability; however, be prepared to accept imperfect methods so long as the resultant biases are unlikely to be large enough to lead to grossly incorrect conclusions.

Even when the workforce is unpaid, there is no point in having sample sizes that are larger than is necessary to achieve one's objectives: volunteers not strictly needed for one project can be deployed on other projects. Power analyses should be carried out to determine what sample size is required. One also needs to consider how sample size and the precision of the work at individual sites interact to produce the overall precision of the project: the switch from CBC to BBS in Britain (see above) shows how a simpler method can, in terms of overall precision compensate for lower precision at each site by covering more sites.

The planning of long-term projects must include planning for their continuity in order to avoid the waste that occurs when a scheme closes down (even if only temporarily). Projects run by established institutions are less likely to fail in this way than independent projects, for institutions are more likely to be able to exert influence on defaulting funders or to have alternative funding sources. If, despite best endeavours, funding is withdrawn, it is important to keep the scheme going somehow, for gaps in a time series can never be filled: it should always be possible for volunteers to keep on gathering the data, even if lack of funding prevents their immediate analysis. Once a survey is established, it is important to introduce improvements in a way that does not disrupt the continuity of the data: when the CBC was abandoned in Britain in favour of the BBS, there was a 7-year overlap to ensure that continuity. (Seven years was chosen on the basis of a statistical assessment using data from the existing survey and from the pilot work for the new one.) Note that continuity is also compromised if the changes are the result of slow drift in the methods over time, which is another good reason for standardizing the methods as closely as possible.

Developing organizations

Most collaborative ornithology involves long-term programmes. It is therefore essential both to maintain continuity and to ensure that old data are not lost. This requires some form of organizational structure. How such can be developed is most relevant in countries where there is little existing collaborative work, but even in those with a long tradition there is always room for improvement in the way we do things. The remarks below are based merely on what I have concluded through talking to or corresponding with colleagues around the world rather that on proper social science, but I believe that they are nonetheless valid. Those starting from scratch may still benefit from reading the remarks that Max Nicholson (1978) sent to the North American conference on the amateur in ornithology (Appendix), for he not only founded the BTO but many other organizations.

The key to developing citizen ornithology is to be ambitious, to have a great vision as to what you can do and not to lose sight of it. Have faith in what you can achieve for, as it says in the Christians' Holy Bible, "Faith can move mountains". The success of what many countries has achieved shows what is possible, and experience shows that the success in recruiting people to the work often exceeds expectation (Bibby 1999). Of course, one should start with simple and easy projects (such as censuses of conspicuous, colonial birds) in order to build up the expertise for more difficult work, so that the long-term vision can be achieved. Even these simple projects must be of high quality, to provide a sound basis from which to develop.

It is always useful to learn from the experience of others. One should consider what has worked and not worked in other countries and then decide what seems likely to work in your country—each country is unique, so one should not just blindly adopt what other countries have done. History is important in determining what sort of organization may be possible. It is easy to dream up an ideal arrangement, but one rarely has the luxury of starting from scratch. There is usually some existing ornithological structure that needs to be taken into account and built upon. Therefore, the arrangements one sets up depend both on what is theoretically best and on where you start from. It is always possible to improve. It may even be possible to reach the ideal, but often getting there from where you start is impossible and you have to settle for a satisfactory alternative to the ideal. Thus, despite general agreement in North America that a single body to oversee or, at least, to co-ordinate collaborative ornithology was desirable and the actual setting up of a committee to develop such a body (McCrimmon and Sprunt 1978), nothing was achieved. The problem was that there were already many different organizations in the field who were presumably unwilling to give up their independence; the establishment of "Partners in Flight", to produce a measure of co-ordination and the identification of gaps is the workable alternative.

In most countries, more than one organization is involved in citizen ornithology. The division is sometimes taxonomic: the raptor enthusiasts or the seabird specialists often have their own societies. It is sometimes by subject: ringing is typically run by a different organization from census work. Sometimes the division is by local region, especially in countries with a federal political structure. Sometimes more than one organization is doing the same thing simply as a result of history. In all cases, this reduces the exchange of ideas, collaborations in the work and the integration of the information obtained. When the division is by subject, integration of analysis is hindered: it is difficult, for example, to undertake integrated demographic monitoring if ringing is organized by one body, census work by another, and nest-recording by a third. Local divisions may lead to refusals to collaborate or even to different methods being used in different regions, which hampers the development of a national overview; it is thus best to avoid local independence, even if one has some devolved organization in order to make use of local expertise and local contacts and to take advantage of local loyalties. There are many advantages to having a single national organization: expertise is built up in running projects and managing volunteers derived from work over all the areas; there is a critical mass of experts working together; it is easier for volunteers if they have to relate to just one organization; it is easy to build up cadre of loyal volunteers who can shift between projects (though if a volunteer gets annoyed by one scheme going wrong, he or she may then refuse to collaborate with any projects); the integration of surveys, to reduce the possibility of volunteers being overloaded, is easier; the integration of analysis is also easier. In addition, funders may find it confusing or think it wasteful to have several organizations doing similar work.

It is not just the number but the nature of the organizations that is important. As we have seen, a close partnership between amateurs and professionals is the key to success. I believe that it is not a coincidence that the countries with the greatest per capita involvement in collaborative ornithology are those where the work is organized by member-based organizations (such as the UK and The Netherlands) in which the members (mostly amateurs) have "ownership" of the system, being responsible for the governance of the organizing body and thus, ultimately, the employers of the professionals. Another model, given that government may be a source of funding for collaborative work (if only to fulfil their obligations under international conventions to monitor bird populations), is for government agencies to organize such work directly. This is best avoided. The work is then completely at the mercy of government decisions not to fund it in future; even worse, results embarrassing to the government can easily be suppressed, and some of the amateurs may not be prepared to work for a government agency. Yet another model is for a conservation NGO to organize the research. Indeed, in many countries there is just a single ornithological NGO that covers both science and conservation. This clearly works, but if one believes that it is important to separate science from policy, then an effective way of doing so is to have different bodies responsible for them. The disadvantage of separation is that the conservation and research bodies may then compete for members in a way that damages the overall enterprise. However, even in a combined organization, there is always a competition for funds between science and direct conservation activities, which may cause the science to be squeezed if funds become short, particularly because the members and the funders may be more interested in direct conservation actions than in the science that should underpin them.

Volunteers do not come free, for they have to be recruited, trained and nurtured; it also costs money to employ professionals to curate and analyse the data. The best ways to fund the work differ from country to country, but in all countries it is a good strategy to rely on a variety of different funding sources so that if one source fails, the work can still be maintained. In any case, if government is one of the sources of funding, it is often essential to have other sources because the government may not cover the full costs, especially of support activities, such as maintaining the general membership (J. Warburton: Finding community-based solutions to meeting environmental challenges: the role of volunteers, in preparation). This is not to say that government funding should be rejected—anything is better than nothing (unless it comes with unacceptable conditions)—but it is always important to have other sources in case government funds dry up. (Colleagues around the world have told me of many cases where work has had to be cut back because of shortages of funds. Almost all involve projects in which government had a key funding role, such as paying for staff or providing free equipment, and then decided to cut that support.) Charitable foundations and contracts from a variety of agencies (government and industrial) are obvious additional sources. Whoever the funders, it is important to guard against their interests deflecting projects from the original scientific aim. (For example, a funder interested in education may cause the methodology of a project to be changed in a way that is better for the education of the participants but which compromises the science.) We have found that members, other participants in surveys and even non-participants who are interested in birds can be amazingly generous in making donations and leaving legacies, in addition to paying their membership fees; this requires some degree of expertise in asking them for funds and sustained efforts to ensure that they feel that the organization is doing good work and that their support is appreciated. Sales of bird-watching equipment and similar items are often thought to be good revenue-earners; proper analysis of the costs (including staff time) should always be undertaken to check their profitability.

All collaborative ornithology is probably educational in that it improves the participants' knowledge, although the North American experience is that it does not lead to a better understanding of scientific methods or an appreciation of environmental issues (Brossard et al. 2005; Krasny and Bonney 2005). The training of potential participants certainly benefits collaborative projects. However, is there a role, or even a necessity, for those who organize collaborative projects to engage in more formal education, especially of children, to ensure that there will be enough potential volunteers in future? In some countries, it seems that education of children may be the only way to cope with the very poor development of amateur ornithology. Even in Britain, where the natural history tradition is strong and the television is replete with wildlife programmes, young people's real experience may be less than in the past because teachers and lecturers have less time for activities off the main curriculum (which has become more rigid), because children are less free to roam in countryside and because egg-collecting (which used to be the introduction to ornithology for many boys) is illegal (Bibby 2003). But education is a specialized activity requiring substantial investment and schools are limited by time and access to sites (Krasny and Bonney 2005). Furthermore, the pay-offs, in terms of future participants in surveys, are uncertain and not immediate. It is something that should be approached with caution.

The future

It is clear that collaborative ornithology in which the most numerous participants are amateurs has made huge contributions to both science and conservation. While it is still weak, even non-existent, in many countries, elsewhere it is growing, either from small and recent beginnings or on the basis of a long-established tradition. It has been argued that serious amateur pursuits are likely to increase, generally because people are living longer, are better educated, want more fulfilment out of life and are changing career more in their 40 and 50 s, often trading income for satisfaction (Leadbeater and Miller 2004). Even half a century ago, Nicholson (1959) wrote, from a British viewpoint, that "there is now developing so much leisure (automation, shorter working hours) that there is a danger of ornithology becoming swamped". Others are less optimistic, seeing the increased pursuit of material wealth as leading to long working hours and to that wealth providing many other ways of filling leisure time (Bibby 2003; Offer 2006; Putman 2000). Nonetheless, the empirical evidence is that volunteer ornithology is, indeed, buoyant across the world.

A specific concern for ornithology is that in some countries many birdwatchers seem chiefly interested in the pursuit of rarities and the length of their lists of species seen. This, of course, is not new: the nineteenth century collection mania was a manifestation of the same obsession, while Eagle Clarke's discoveries of extraordinary vagrants on Fair Isle in the early twentieth century fuelled an obsession with these birds and a neglect of broader migration work (Allen 1976). However, mobility and communication have improved. Not only can people learn about rare vagrants within minutes of their first being discovered, but they can travel hundreds of miles to see them within hours. More generally, the "best" places to watch birds are widely advertized, so people concentrate there, whether on a day off at a local nature reserve or on holiday in a far-away country (facilitated by burgeoning ecotourism businesses). In earlier days, far more birdwatching was done close to people's homes, recording the more routine run of events. The trick that we need to pull off is to encourage more of the rarity-hunters to devote some of their time and skills to helping with serious ornithology. Persuading them to participate in schemes for the web-based recording of check-lists, now rapidly spreading around the world, would be a step in the right direction. The future of collaborative ornithology will depend in part on our ensuring both that the fieldwork is enjoyable and that participation leads people to feel more satisfied with how they spend their leisure time than if they simply indulged in non-purposeful birding.

Another concern, at least in countries in which collaborative ornithology has been established for some time, is that the average age of participants is increasing. "We are not getting the young recruits" is the cry of the 65-year-olds who have been active for 50 years and who often conclude that the enterprise is doomed to shrink. I believe this concern to be misplaced. It is partly a consequence of a natural pattern of growth: when an activity begins, most of the recruits are young because they are more interested in new things; as these pioneers get older then, even if all the subsequent recruits are young, the average age goes up. In addition, as the activity becomes established, it probably becomes more attractive to older, more conservative people. Furthermore, not only is society as a whole becoming older (at least in Western countries) as both birth and mortality rates fall, but there seems to be a cultural change, with people putting more effort into paid work and family until their middle years, when they start to look at new ways of spending the leisure. We simply have to get used to the idea that future recruits may be much older than we used to think was the norm.

A final concern is that the long-heralded decline of the amateur is about to take place. Nowadays there is a background of theory, a huge volume of literature and a need for statistical expertise that make it difficult for those without professional training to take the lead in organizing studies, analysing data and publishing results (Bibby 2003). Furthermore, there is today more paid work in ornithology and related disciplines than before. As a result, many people who would previously have had to earn their living from other work while pursuing ornithology as amateurs are now able to pursue it professionally, so there may have been a decline in the number of amateurs working as independent scientists (Bibby 2003). This does not mean, however, that there is less room for the amateur participating in collaborative work. On the contrary, with more professionals available to support and encourage such work, there is every prospect of it continuing to expand.

The empirical evidence is that amateur ornithology across the world is stronger than it has ever been and that its future is bright. If we take into account the motivations of the amateurs, then they will engage in collaborative research in every greater numbers, expanding yet further our understanding of birds and their habitats and, thereby, our ability to conserve them long into the future.

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Appendix: Reprinted from McCrimmon and Sprunt (1978)

The role of organisation in field ornithology. Some notes based upon the BTO's experience. Prepared by E.M. Nicholson, 27 January1978

1. Much detailed and valuable experience now exists concerning the functions and successful operation of such a body as the British Trust for Ornithology once it is firmly established. That experience is widely shared and is current knowledge, the tapping of which in any desirable form should be a straightforward process. It will not be discussed in these notes, which concentrate upon the complementary problem of initiating such an organisation and programme in circumstances when it is strange and novel both to those seeking to develop it and to those to whom they look for support. To a substantial extent the shape of this initial problem must vary greatly according to national and cultural traditions, the stage of development already reached, and the immediate aims and activities envisaged, which may be modified considerably over the years of

operating experience. Specifically, these notes will seek to distil, from the embryonic and growth stages of the B.T.O., points which may be helpful in the case of some kind of parallel effort in North America.

2. This problem may be outlined under four heads:
   2.1 What needs to be done which calls for a new organisation?
   2.2 What kind of structure, resources and methods are called for?
   2.3 What is the existing climate of opinion, institutional background, population of ornithologists and bird-watchers, and relationship of ornithology to other activities, into which any new initiative must fit?
   2.4 Apart from such points as can be expressed in generalised terms, what particular experiences in the evolution of B.T.O. may be of special relevance?

These points can be dealt with only briefly here, but further information can be added if required.

3. Taking first 2.1, and assuming a general aim to learn as much about birds as possible, both for its own sake and to serve other ends, we may distinguish among others, the fields of:
   3.1 Population census, inventory, distribution, habitat and territory.
   3.2 Migration, movements, mortality, seasonal status, and use of banding.
   3.3 Behaviour, social pattern, communications/voice, pairing.
   3.4 Identification, plumage, distinctive field characters.
   3.5 Food and methods of foraging, nutrient requirements.
   3.6 Anatomy, taxonomy, moults, age and sex differences, evolution.

Some of these, e.g. 3.5 and 3.6, are mainly subjects for professionals; others, e.g. 3.1 and 3.2, can be greatly furthered by amateurs, while within a broad intermediate zone professional/amateur collaboration, if well conceived, directed and executed, can be of much value. If friction, abortive effort and misunderstandings are to be avoided, it is essential at the outset to ensure that any organization, partly or wholly based on amateur co-operation, involves a realistic and acceptable assignment of roles between professionals and amateurs, bearing in mind that the latter span many different types with widely divergent interests, capabilities, time, mobility and attitudes.

Apart from increasing knowledge for its own sake, what needs to be done ranges from satisfying practical conservation needs such as inventory of habitats and species on threatened areas or monitoring annual and season fluctuations in numbers, to many kinds of comparative studies between species and between areas, observing patterns of activity, obtaining specific data or material in support of particular researches and countless other projects or surveys.

The breadth and intensity of support for these will vary according to the effectiveness with which their significance and techniques are explained, the results digested and published or communicated and a sense of teamwork and comradeship established among those taking part. Sound and desirable projects have often wilted through lack of sustained attention to such aspects.

A need for a new organisation is not established merely by listing a number of functions which it might serve or tasks which it might do. To be successful, it must quickly create its own identity, a dynamic and loyal support base and win the respect if not the love of pre-existing bodies which it may overlap or at least impinge upon. The strength of a voluntary body is no more than the strength of its inner group of prime movers, not singly but as a close-knit united team. Those, however gifted and keen, whose personality unfits them for sustained, confidential end highly productive relationships are best omitted or placed in sufficiently self-contained positions to minimise personality clashes at the centre.

4. This leads on to the problem 2.2 of structure, resources and methods. Taking first:
   4.1 Structure, the choice is wide and must be decided by tastes and circumstances, but in field ornithology it is desirable to provide for a high degree of devolution of responsibility accompanied by regular but not too frequent accountability for resources used and results obtained. A lively and vigorous movement is best promoted by careful recruitment, clear broad guidelines and encouragement to as many participants as possible to seek or accept some kind of leadership rule, even if localised or specialised. A passion for tidy hierarchies, excessive co-ordination or bureaucracy, and the needless damping down of enthusiasm tend to incur costs much exceeding their benefits in terms of organic growth.
   4.2 Whether or not it is desirable to be liberally funded from the start, which may be questionable, most new organisations have for a time partly to lift themselves by their own boot-straps. In moderation this can be healthy, but while weeding out the fainthearted, and other undesirables, it can also tie down many talented or expert man-hours in routine chores and narrow

down the core group much too drastically. It is highly desirable to secure one or more participants, often without specialised qualifications or knowledge, who will cheerfully pursue the winning of financial and other resources, and will imbue the whole body with a sense of deserving and knowing how to secure essential support.

4.3 As to methods, an amateur composition does not excuse amateurish standards and practice. It is essential that knowledgeable and often professional assistance should be obtained in designing, monitoring and assessing results of projects, and in overcoming snags.

5. Passing on now to 2.3 it cannot be too much emphasised that the most exacting task in launching an organisation of a new kind in a field where plenty of different organisations already exist is to address the right kind of message in the right style and tone to the right people and organisations essential to successful launching. Looking now, for example, at the British Trust for Ornithology, it is hard to explain what is involved in recruiting for such a body the first few hundred ornithologists and bird-watchers who have never seen or heard of anything of the kind, and appeasing and conciliating innumerable critics who are sure either that all was well before or that something quite different was needed, or that the new enterprise has got into the hands of a bunch of incompetents/cranks/impractical idealists/inexperienced outsiders and so forth.

Learning the hard way which are the passengers and who are the doers and dedicated helpers, which subjects are winners and which are greeted with glassy eyes, and what kinds of inquiries combine usefulness with attractiveness and practicability are among many other interesting experiences which await the hardy promoters of such an enterprise. If they neglect such background and climatic factors, they do so at their own peril.

6. While the above notes are derived from the early struggles of the British Trust for Ornithology, a few specific points in its experiences are worth mentioning. While it failed for much too long to take the advice given in the last sentence of 4.2, it was extremely fortunate from the start in attracting a galaxy of respected leaders with strong followings in existing societies who lent not only their names but their wise counsel and active influence to bringing in support and neutralising objections.

It benefited also from a series of previous “dry runs” such as the Census of Heronries, the Oxford Bird Census and the Oxford University Research in Economic Ornithology which built up a partially trained and like-minded group of pioneers with some common background for the task.

It should be noted that outside Museums there were at the Trust’s foundation virtually no paid professional ornithologists in the UK; later experience suggests that had they pre-existed they would at best have been a drag and at worst an insuperable barrier to launching it. After the first twenty years, the substantial funding of the Trust on a more or less permanent basis as a national “chosen instrument” for certain lines of biological research, and the bringing in of a suitable professional to head the team went far to bridge the uneasy gap between professional and amateur.

From the outset the B.T.O. has recognised the importance of development at the grassroots through the country. Without that element it could have been almost stultified.

Many thought that individual observers would not take kindly to being organised and that would have been true if they had not continually been shown impressive results which could have been obtained in no other way, and been helped to become a lively brotherhood rather than a scattered tribe of cliques and loners. It was the sense of status, of participation and of solid achievement which, after several setbacks, got the B.T.O. going and, incidentally, converted “bird-watcher” from a standing joke to a widely admired type.

References

Aebischer NJ, Potts GR, Rehfisch M (1999) Using ringing data to study the effect of hunting on bird populations. In: Baillie SR, Wernham CV, Clark JA (eds) Proc JNCC/BTO Workshop Conserv Uses Ringing Data. Ringing Migration [Suppl]19:67–81

Aldridge S, Halpern D, Fitzpatrick S (2002) Social capital. A discussion paper. Performance and Innovation Unit, The Cabinet Office, London

Alerstam T (1990) Bird migration. Cambridge University Press, Cambridge

Alexander HG (1942–1943) Report on the bird-song enquiry. Brit Birds 36:65–72, 86–92, 102–109

Allen DE (1976) The naturalist in Britain: a social history. Allen Lane, London

Allen DE (1985) The early professionals in British natural history. In: Wheeler A, Price JA (eds) From Linnaeus to Darwin: commentaries on the history of geology and biology. Society for the History of Natural History, London, pp 1–12

Allen DE (1998) On parallel lines: natural history and biology from the late Victorian period. Arch Nat Hist 25:361–371

Altizer S, Hochachka WM, Dhondt AA (2004) Seasonal dynamics of mycoplasmal conjunctivitis in eastern North American house finches. J Anim Ecol 73:309–322

Anon (2004) SE European Bird Migration Network. Workshop 6–8 February 2004, Istanbul, Turkey. Ring 26:79–106

Araújo MG, Williams PH, Fuller RJ (2002) Dynamics of extinction and the selection of nature reserves. Proc R Soc Lond B 269:1971–1980

Atkinson PW, Austin GE, Rehfisch MM, Baker H, Cranswick P, Kershaw M, Robinson RA, Langston RHW, Stroud DA, van Turnhout C, Maclean IMD (2006) Identifying declines in waterbirds: the effects of missing data, population variability and count period on the interpretation of long-term survey data. Biol Conserv 130:549–559

Austin GE, Rehfisch MM (2003) The likely impact of sea level rise on waders (*Charadrii*) wintering on estuaries. J Nat Conserv 11:43–58

Austin GE, Rehfisch MM (2005) Shifting nonbreeding distributions of migratory fauna in relation to climatic change. Global Change Biol 11:31–38

Austin GE, Rehfisch MM, Viles HA, Berry PM (2001) Impacts on coastal environments. In: Harrison PA, Berry PM, Dawson TE (eds) Climate change and nature conservation in Britain and Ireland: modelling natural resource responses to climate change (The MONARCH Project). UKCIP Technical Report, Oxford, pp 177–228

Badzinski DS, Francis CM (2000) An evaluation of species coverage by the Canadian Migration Monitoring Network (unpublished report). Bird Studies Canada, Port Rowan

Baillie SR (1990) Integrated population monitoring of breeding birds in Britain and Ireland. Ibis 132:151–161

Baillie SR (2001) The contribution of ringing to the conservation and management of bird populations: a review. Ardea 89(Spec Issue):167–184

Baillie SR, Balmer DE, Downie IS, Wright KHM (2006) Migration watch: an internet survey to monitor spring migration in Britain and Ireland. J Ornithol 147:254–259

Baillie SR, Boobyer G, Perrins CM, Brenchley A, Bryant DM, Ormerod SJ, Rehfisch MM, Tasker ML, Wilson JD (1999b) The conservation uses of ringing data. Conclusions of the JNCC/BTO Workshop. In: Baillie SR, Wernham CV, Clark JA (eds) Proc JNCC/BTO Workshop Conser Uses Ringing Data. Ringing Migration [Suppl] 19:119–127

Baillie SR, Furness RW, Clark JA, Green RE, Gosler AG, Ormerod SJ, Peach WJ, Stroud DA, Sutherland WJ, Wilson JD (1999c) The scientific strategy of the BTO ringing scheme. In: Baillie SR, Wernham CV, Clark JA (eds) Proc JNCC/BTO Workshop Conser Uses Ringing Data. Ringing Migration [Suppl] 19:129–143

Baillie SR, Sutherland WJ, Freeman SN, Gregory RD, Paradis E (2000) Consequences of large-scale processes for the conservation of bird populations. J App Ecol 37[Suppl]:88–102

Baillie SR, Wernham CV, Clark JA (eds) (1999a) Proc JNCC/BTO Workshop Conserv Uses Ringing Data. Ringing Migration [Suppl], vol 19

Baillie SR, Wernham CV, Clark JA (1999d) Development of the British and Irish Ringing Scheme and its role in conservation biology. In: Baillie SR, Wernham CV, Clark JA (eds) Proc JNCC/BTO Workshop Conser Uses Ringing Data. Ringing Migration [Suppl] 19:5–19

Bairlein F (1998) The European-African songbird migration network: new challenges for large-scale study of bird migration. Biol Conserv Fauna 102:13–27

Bairlein F (2001) Results of bird ringing in the study of migration routes and behaviour. Ardea 89(Spec Issue):7–19

Bairlein F (2003) Large-scale networks in bird research in Europe: pitfalls and prospects. Avian Sci 3:49–63

Bakken V, Runde O, Tjøve E (2003) Norsk Ringmerkingsatlas vol 1. Stavanger Museum, Stavanger

Bakken V, Runde O, Tjøve E (2006) Norsk Ringmerkingsatlas, vol 2. Stavanger Museum, Stavanger

Balmer DE, Adams SY, Crick HP (2000) A report on Barn Owl Release Scheme Monitoring Project Phase II. BTO Research Report 250. BTO, Thetford

Balmford A (2002) Selecting sites for conservation. In: Norris K, Pain DJ (eds) Conserving bird biodiversity: general principles and their application. Cambridge University Press, Cambridge, pp 74–104

Balmford A, Gaston KJ (1999) Why biodiversity surveys are good value. Nature 398:204–205

Balmford A, Gaston KJ, Rodrigues ASL, James A (2000) Integrating costs of conservation into international priority setting. Conserv Biol 14:597–605

Banks AN, Coombes RH, Crick, HQP (2003) The Peregrine Falcon breeding population of the UK & Isle of Man in 2002. Research Report 330. BTO, Thetford

Baris S (2004) Bird monitoring in Turkey. In: Bird Numbers 2004: monitoring in a Changing Europe. Proc 16th Int Conf EBCC. Kayseri, Turkey

Barrow MV (1998) A passion for birds: American ornithology after Audubon. Princeton University Press, Princeton

Bart J (2005) Monitoring the abundance of bird populations. Auk 122:15–25

Barter MA (2005) Yellow Sea-driven priorities for Australian shorebird researchers. In: Straw P (ed) Status and conservation of shorebirds in the East Asian–Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/International Wader Studies 17, Sydney, Australia, pp 158–160

Barzum J (1954) The indispensable amateur. Juilliard Rev 1:19–25

Beissinger SR, Walters JR, Catanzaro DG, Smith KG, Dunning Jr JB, Haig SM, Noon BR, Stith BM (2006) Modeling approaches in avian conservation and the role of field biologists. Ornithol Monogr 59

Bell S, Marzano M, Podjed D (2007) Inside monitoring: a comparison of bird monitoring groups in Slovenia and the United Kingdom. In: Lawrence A (ed) Taking stock of nature. Cambridge University Press, Cambridge (in press)

Bennun LA (2001) Long-term monitoring and the conservation of tropical wetlands: high ideals and harsh realities. Hydrobiologia 458:9–19

Bennun L, Matiku P, Mulwa R, Mwangi S, Buckley P (2005) Monitoring important bird areas in Africa: towards a sustainable and scaleable system. Biodiv Conserv 14:2575–2590

Bennun L, Burfield I, Fishpool L, Nagy S, Stattersfield A (2006) Monitoring important bird areas: a global framework. BirdLife International, Cambridge

Berry PM, Vanhinsbergh DV, Viles HA, Harrison PA, Pearson RG, Fuller RJ, Butt N, Miller F (2001) Impacts on terrestrial environments. In: Harrison PA, Berry PM, Dawson TE (eds) Climate change and nature conservation in Britain and Ireland: modelling natural resource responses to climate change (The MONARCH Project). UKCIP Technical Report, Oxford, pp 43–149

Berthold P (1995) Microevolution of migratory behaviour illustrated by the Blackcap (*Sylvia atricapilla*): 1993 Witherby Leture. Bird Study 42:89–100

Berthold P (2001) Bird migration: a general survey, 2nd edn. Oxford University Press, Oxford

Berthold P, Schlenker R (1975) Das "Mettnau-Reit-Illmitz-Programm" - ein langfristiges Vogelfangprogramm der Vogelwarte Radolfzell mit vielfältiger Fragestellung. Vogelwarte 28:97–123

Berthold P, Fliege G, Heine G, Querner U, Schlenker R (1991) Wegzug, Rastverhalten, Biometrie und Mauser von Kleinvögeln in Mitteleuropa. Vogelwarte 36:1–221

Berthold P, Helbig AJ, Mohr G, Querner U (1992) Rapid microevolution of migratory behaviour in a wild bird species. Nature 360:668–667

Berthold P, Kaiser A, Querner U, Schlenker R (1993) Analyse von Fangahlen im Hinblick auf die Bestandsentwicklung von

Kleinvögeln nach 20 jährigem Betrieb der Station Mettnau, Süddeutschland. J Ornithol 134:289–289
Besbeas P, Freeman SN (2006) Methods for joint inference from panel survey and demographic data. Ecology 87:1138–1145
Besbeas P, Freeman SN, Morgan BJT, Catchpole EA (2002) Integrating mark–recapture–recovery and census data to estimate animal abundance and demographic parameters. Biometrics 58:540–547
Besbeas P, Lebreton J-D, Morgan BJT (2003) The efficient integration of abundance and demographic data. Appl Stat 52:95–102
Besbeas P, Freeman SN, Morgan BJT (2005) The potential of integrated population modelling. Aust NZ J Stat 47:35–48
Bhattacharjee (2005) Citizen scientists supplement work of Cornell researchers. Science 308:1401–1402
Bhattarai T (2002) Process and methods for participatory M&E of biodiversity: a southern reconnaissance. Introduction to theme 3 of the PAMEB workshop: Processes, Methods and Tools. (Participatory assessment, monitoring and evaluation of biodiversity (PAMEB). Internet workshop 7–25 January 2002, and policy seminar 21 May 2002, convened by the Environmental Change Institute, University of Oxford. Available at: http://www.etfrn.org/etfrn/workshop/biodiversity/index.html)
Bibby CJ (2003) Fifty years of bird study. Bird Study 50:194–210
Bibby CJ (1999) Making the most of birds as environmental indicators. In: Adams NJ, Slotow RH (eds) Proc 22nd Int Ornithol Congr. Ostrich 70:81–88
Bildstein KL (2006) Migrating raptors of the world: their ecology and conservation. Cornell University Press, Ithaca
Blackburn TM, Gaston KJ (eds) (2003) Macroecology: concepts and consequences. Blackwell, Oxford
Blackshaw T, Long J (2005) What's the big idea? A critical exploration of the concept of social capital and its incorporation into leisure policy discourse. Leisure Stud 24:239–258
Boere GA, Galbraith CA, Stroud DA (eds) (2007) Waterbirds around the world. The Stationery Office, Edinburgh
Bonn A, Rodrigues ASL, Gaston KJ (2002) Threatened and endemic species: are they good indicators of patterns of biodiversity on a national scale? Ecol Lett 5:733–741
Boubier M (1932) L'Évolution de l'Ornithologie, new edn. Librairie Felix Alcan, Paris
Bourdieu P (1993, translated 1999) The weight of the world: social suffering in contemporary society. Polity, Cambridge
Brewer AD, Diamond AW, Woodsworth EJ, Collins BT, Dunn EH (2006) Canadian atlas of bird banding, vol 1: Doves, Cuckoos, and Hummingbirds through Passerines, 1921–1995, second edition. Canadian Wildlife Service Special Publication. Available online at: http://www.cws-scf.ec.gc.ca/publications/BBA-AOB/v1ed2
Brooke ML de, Davies NB (1987) Recent changes in host usage by Cuckoos (*Cuculus canorus*) in Britain. J Anim Ecol 56:873–883
Brooks SP, King R, Morgan BJT (2004) A Bayesian approach to combining animal abundance and demographic data. Anim Biodiv Conserv 27.1:515–529
Brossard D, Lewenstein B, Bonney R (2005) Scientific knowledge and attitude change: the impact of a citizen science project . Int J Sci Educ 27:1099–1121
Brown A, Grice P (2005) Birds in England. T&AD Poyser, London
Browne S, Vickery J, Chamberlain D (2000) Densities and population estimates of breeding Skylarks (*Alauda arvensis*) in Britain in 1997. Bird Study 47:52–65
Bruderer B (2001) Recent studies modifying current views of nocturnal bird migration in the Mediterranean. Avian Ecol Behav 7:11–25
Bub H (1991) Bird trapping and bird banding: a handbook for trapping methods all over the world. Cornell University Press, Ithaca
Buckland ST, Bell MV, Picozzi N (eds) (1990) The birds of North-East Scotland. North-East Scotland Bird Club, Aberdeen
Burton NHK, Armitage MJS, Musgrove AJ, Rehfisch MM (2002) Impacts of man-made landscape features on numbers of estuarine waterbirds at low tide. Environ Manage 30:857–864
Busse P, Kania W (1970) Operation Baltic 1961–1967 – working methods. Acta Ornithol 12:231–267
Busse P (2000) Bird station manual. SE European Bird Migration Network
Butcher GS (1990) Audubon Christmas bird counts. In: Sauer JR, Droege S (eds) Survey designs and statistical methods for the estimation of avian population trends, U.S. Fish and Wildlife Service. Biol Rep 90:5–13
Butcher GS, Niven DK, Sauer JR (2005) Using Christmas Bird Count data to assess population dynamics and trends of waterbirds. Am Birds 59:23–25
Bystrak D (1981) The North American Breeding Bird Survey. Stud Avian Biol 6:34–41
Böhning-Gaese K, Bauer H-G (1996) Changes in species abundance, distribution, and diversity in a Central European bird community. Conserv Biol 10:175–187
Bønløkke J, Madsen JJ, Thorup K, Rahbek C (2006) Dansk Trækfugleatlas. Rhodos International Science & Art Publ, Holtegaard
Cabeza M, Araújo MG, Wilson RJ, Thomas CD, Cowley MJR, Moilanel A (2004) Combining probabilities of occurrence with spatial reserve design. J App Ecol 41:252–262
Canadian Wildlife Service (2004) Results of the 2004 questionnaire for Canadian participants in the Breeding Bird Survey. Available at: http://www.cws-scf.ec.gc.ca/nwrc-cnrf/default.asp?lang=en&n=929AA800-1
Cardillo M (2002) The life-history basis of latitudinal diversity gradients: how do species traits vary from the poles to the equator? J Anim Ecol 71:79–88
Carey GJ, Chalmers ML, Diskin DA, Kennerley PR, Leader PJ, Leven M., Lewthwaite RW, Melville DS, Turnbull M, Young L (2001) The avifauna of Hong Kong. Hong Kong Bird Watching Society, Hong Kong
Cavé AJ (1983) Purple Heron survival and droughts in tropical West-Africa. Ardea 71:217–224
Chamberlain DE, Wilson AM, Browne SJ, Vickery JA (1999a) Effects of habitat type and management on the abundance of Skylarks in the breeding season. J App Ecol 36:856–970
Chamberlain DE, Wilson JD, Fuller RJ (1999b) A comparison of bird populations on organic and conventional farm system in southern Britain. Biol Conserv 88:307–320
Chamberlain DE, Vickery JA, Gough S (2000) Spatial and temporal distribution of breeding skylarks (A*lauda arvensis*) in relation to crop type in periods of population increase and decrease. Ardea 88:61–73
Chiang C-Y, Liu W-T (2005) Shorebird studies in Taiwan. In: Straw P (ed) Status and Conservation of Shorebirds in the East Asian-Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/International Wader Studies 17, Sydney, Australia, pp 143–146
Clarke WE (1912) Studies in bird migration, vols 1, 2. Gurney & Jackson, London
Collinson N, Sparks T (2005) Nature's calendar – 2004 results from the UK Phenology Network. Brit Wildl 16:251–256
Cooke WW (1888) Report on bird migration in the Mississippi Valley in the Years 1884 and 1885. US Department of Agriculture, Division of Economic Ornithology, Bull No 2
Cooper CB, Hochachka WM, Dhondt A (2005a) Latitudinal trends in within-year reoccupation of nest-boxes and their implications. J Avian Biol 36:31–39

Cooper CB, Hochachka WM, Butcher G, Dhondt AA (2005b) Seasonal and latitudinal trends in clutch size: thermal constraints during laying and incubation. Ecology 86:2018–2031

Crick HQP (1992a) Trends in the breeding performance of Golden Plover in Britain. BTO Research Report 76. BTO, Thetford

Crick HQP (1992b) A bird-habitat coding system for use in Britain and Ireland incorporating aspects of land-management and human activity. Bird Study 39:1–12

Crick HQP (1997) Long-term trends in corn bunting (*Miliaria calandra*) productivity in Britain. In: Donald PF, Aebischer NK (eds) The ecology and conservation of corn buntings (*Miliaria calandra*). JNCC, Peterborough, pp 52–64

Crick HQP, Sparks TH (1999) Climate change related to egg-laying trends. Nature 399:423–424

Crick HQP, Gibbons DW, Magrath RD (1993) Seasonal changes in clutch size in British birds. J Anim Ecol 62:263–273

Crick HQP, Dudley C, Glue DE, Thomson DL (1997) UK birds are laying eggs earlier. Nature 388:526

Crick HQP, Robinson RA, Appleton GF, Clark NA, Rickard AD (2002) Investigations into the decline of Starlings and House Sparrows in Great Britain. BTO Research Report 290. Defra, Bristol

Crick HQP, Baillie SR, Leech DI (2003) The UK Nest Record Scheme: its value for science and conservation: a review of its methodology, analytical procedures and uses. Bird Study 50:254–270

Crick HQP, Atkinson PA, Newson SE, Robinson RA, Snow L, Balmer DE, Chamberlain DE, Clark JA, Clark NA, Cranswick PA, Crombie R, Hughes B, Grantham MJ, Lee R, Musgrove A (2006) Avian influenza incursion analysis (through wild birds). BTO Research Report 448. BTO, Thetford

Dall'Antonia P, Spina F, Mantovani R (1996) Fenologia della migrazione di alcune specie di uccelli acquatici attraverso l'Italia. Richerche Biol Selvaggina 98:1–72

Danielsen F, Burgess ND, Balmford A, Fjeldså J, Andrianandrasana HT, Becker CD, Bennun L, Brashares JS, Jones JPG, Stuart-Hill G, Topp-Jorgensen E, Townsend WR, Uychiaoco AJ, Whitten T, Yonten D (2006) Monitoring matters: evaluating locally-based biodiversity monitoring in developing countries. Oryx 40:12–17

Darlington A (1951) The use of mobile observers in the study of patterns of migration. Brit Birds 44:152–159

Davidson N, Bryant D, Boere G (1999) Conservation uses of ringing data: flyway networks for waterbirds. In: Baillie SR, Wernham CV, Clark JA (eds) Proc JNCC/BTO Workshop Conserv Ringing Data. Ringing Migration (Suppl) 19:83–94

DeSante DF, Burton KM, Saracco JF, Walker BL (1995) Productivity indices and survival rate estimates from MAPS, a continent-wide programme of constant-effort mist-netting in North America. J Appl Stat 22:935–948

DeSante DF, O'Grady DR, Pyle P (1999) Measures of productivity and survival derived from standardized mist-netting are consistent with observed population changes. In: Baillie SR, North PM, Gosler AG (eds) Large-scale studies of marked Birds. Proc EURING97 Conf. Bird Study 46[Suppl]:S178–S188

DeSante DF, Nott MP, O'Grady DR (2001) Identifying the proximate demographic cause(s) of population change by modelling spatial variation in productivity, survivorship, and population trends. Ardea 89 (Spec Issue):185–208

DeSante DF, Saracco JF, O'Grady DR (2004) Methodological considerations of the Monitoring Avian Productivity and Survivorship (MAPS) Programme. Stud Avian Biol 29:28–46

Dhondt AA, Kast TL, Allen PE (2002) Geographical differences in seasonal clutch size variation in multi-brooded bird species. Ibis 144:646–651

Dhondt AA, Altizer S, Cooch EG, Davis AK, Dobson A, Driscoll MJL, Barry K, Hartup BK, Hawley DM, Hochachka WM, Hosseini PR, Jennelle CS, Kollias GV, Ley DH, Swarthout ECH, Sydenstricker KV (2005) Dynamics of a novel pathogen in an avian host: mycoplasmal conjunctivitis in house finches. Acta Trop 94:77–93

Dobinson HM (1962) Inland Observation Points: a new means of studying migration. Bird Migration 2:182–285

Dobinson HM (1963a) The Inland Observation Points: records from summer and autumn 1962. Bird Migration 2:272–276

Dobinson HM (1963b) The Inland Observation Points: February–May 1963. Bird Migration 2:325–328

Dobinson HM, Richards AJ (1964) The effects of the severe winter of 1962/63 on birds in Britain. Br Birds 57:373–434

Donald PF, Fuller RJ (1998) Ornithological atlas data: a review of uses and limitations. Bird Study 45:129–145

Donald PF, Sanderson FJ, Burfield IJ, van Bommel FPJ (2006) Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990–2000. Agric Ecosyst Environ 116:189–196

Drouin J-M, Bensaude-Vincent B (1996) Nature for the people. In: Jardine N, Secord JA, Spary EC (eds) Cultures of natural history. Cambridge University Press, Cambridge, pp 408–425

du Feu CR, McMeeking JM (2004) Relationship of juveniles captured in constant-effort netting and local abundance. Stud Avian Biol 29:57–62

Dunn EH (1993) Bird mortality from striking residential windows in winter. J Field Ornithol 64:302–309

Dunn EH (2005) Counting migrants to monitor bird populations: state of the Art. In Ralph CJ, Rich TD (eds) Bird conservation implementation and integration in the Americas: Proc 3rd Int Partners Flight Conf 2002, vols 651, 643; Asilomar, Gen Tech Rep PSW-GTR-191. Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Albany, pp 712–7

Dunn EH, Ralph CJ (2004) Use of mist nets as a tool for bird population monitoring. Stud Avian Biol 9:1–6

Dunn EH, Tessaglia DL (1994) Predation of birds at feeders in winter. J Field Ornithol 65:8–16

Dunn PO, Winkler DW (1999) Climate change has affected the breeding date of tree swallows throughout North America. Proc R Soc Lond B266:2487–2490

Dunn PO, Thusius KJ, Kimber K, Winkler DW (2000) Geographic and ecological variation in clutch size of Tree Swallows. Auk 117:215–221

Dunn EH, Hussell DJT, Adams RJ (2004a) An investigation of productivity indices derived from banding of fall migrants. Stud Avian Biol 29:92–96

Dunn EH, Hussell DJT, Francis CM, McCracken JD (2004b) A comparison of three count methods for monitoring songbird abundance during spring migration: capture, census, and estimated totals. Stud Avian Biol 29:16–122

Dunn EH, Francis CM, Blancher PJ, Drennan SR, Howe MA, Lepage D, Robbins CS, Rosenberg KV, Sauer JR, Smith KG (2005a) Enhancing the scientific value of the Christmas Bird Count. Auk 122:338–346

Dunn E H, Altman BL, Bart J, Beardmore CJ, Berlanga H, Blancher PJ, Butcher GS, Demarest DW, Dettmers R, Hunter WC, Iñigo-Elias EE, Panjabi AO, Pashley DN, Ralph CJ, Rich TD, Rosenberg KV, Rustay CM, Ruth JM, Will TC (2005b) High priority needs for range-wide monitoring of North American landbirds. Available at Partners in Flight Technical Series No. 2. Partners in Flight website: http://www.partnersinflight.org/pubs/ts/02-MonitoringNeeds.pdf

Dunn EH, Bart J, Collins BT, Craig B, Dale B, Downes CM, Francis CM, Woodley S, Zorn P (2006) Monitoring bird populations in small geographic areas. Canadian Wildlife Service, Ontario. Available at: http://www.cws-scf.ec.gc.ca

Dybbro T (1976) De danske ynglefugles udbredelse: Resultaterne af Atlas-projektet, kortlægningen af Danmarks ynglefugle 1971–1974. Dansk Ornitologisk Forening, Copenhagen

Ealey D, Dale B, Dickson R, Park J (1994) Hey buddy, can you spare the time? Motivation and the Breeding Bird Survey participant in Alberta. Alberta Nat 24:65–69

Edelstam C (1972) The visible migration of birds at Ottenby, Sweden. Vår Fågelvärld Suppl 7

Elkins N (2004) Weather and bird behaviour. T&D Poyser, London

Ellis R, Waterton C (2004) Environmental citizenship in the making: the participation of volunteer naturalists in UK biological recording and biodiversity policy. Sci Public Policy 31:1–11

Ellis R, Waterton C (2005) Caught between the cartographic and the ethnographic imagination: the whereabouts of amateurs professionals and nature in knowing biodiversity. Environ Plan D Soc Space 23:673–693

Elton C (1935) A reconnaissance of woodland bird communities in England and Wales. J Anim Ecol 4:127–136

Estrada J, Pedrocchi V, Brotons L, Herrando S (eds) (2004) Atles dels ocells nidificants de Catalunya 1999–2002. Lynx Edicions, Barcelona

Etheridge B, Holling M, Thompson DBA, Riley HT (eds) (2006) Scottish Raptor Monitoring Scheme Report 2004. Scottish Ornithologists' Club, Aberlady

Evans KL, Duncan RP, Blackburn TM, Crick HQP (2005a) Investigating geographic variation in clutch size using a natural experiment. Funct Ecol 19:616–624

Evans KL, Greenwood JJD, Gaston KJ (2005b) Relative contribution of abundant and rare species to species–energy relationships. Biol Lett 1:87–90

Evans KL, Jackson SF, Greenwood JJD, Gaston KJ (2006a) Species traits and the form of individual species–energy relationships. Proc R Soc B 273:1779–1787

Evans KL, Rodrigues ASL, Chown SL, Gaston KJ (2006b) Protected areas and regional avain species richness in South Africa. Biol Lett 2:184–188

Faanes CA, Bystrak D (1981) The role of observer bias in the North American Breeding Bird Survey. Stud Avian Biol 6:353–359

Fernandez JM, Gainzarain JA (2004) Deriving avian population trends from atlas data in Spain: opportunities and biases at a regional scale. Bird Census News 17:5–22

Fiedler W (2001) Vogelwarte Rossitten – Ornithology on the Courish Spit between 1901 and 1944. Avian Ecol Behav 7:3–9

Fiedler W (2003) Recent changes in migratory behaviour of birds: a compilation of field observations and ringing data. In: Berthold P, Gwinner E, Sonnenschein E (eds) Avian migration. Springer, Berlin, pp 21–38

Finnegan R (ed) (2005a) Participating in the Knowledge Society: researchers beyond the University walls. Palgrave Macmillan, Basingstoke

Finnegan R (2005b) Introduction: looking beyond the walls. In: Finnegan R (ed) Participating in the knowledge society: researchers beyond the University walls. Palgrave Macmillan, Basingstoke, pp 1–19

Fisher J, Hinde RA (1949) The opening of milk bottles by birds. Br Birds 42:347–357

Forchhammer MC, Post E, Stenseth NC (1998) Breeding phenology and climate. Nature 391:29–30

Fransson T, Pettersson J (2001) Swedish bird ringing atlas, vol 1. Naturhistoriska Riksmuseet and Sveriges Ornithologiska Förening, Stockholm

Fraser P (1997) How many rarities are we missing? Weekend bias and length of stay revisited. Br Birds 90:94–101

Freeman SN, Crick HQP (2003) The decline of the Spotted Flycatcher (*Muscicapa striata*) in the UK: an integrated population model. Ibis 145:400–412

Freeman SN, Noble DG, Newson SE, Baillie SR (2007) Modelling population changes using data from different surveys: the Common Bird Census and the Breeding Bird Survey. Bird Study 54:61–72

Fryer JCF (1939) The destruction of buds of trees and shrubs by birds. Br Birds 33:90–94

Fuller RJ, Crick HQP (1992) Broad-scale patterns in geographical and habitat distribution of migrant and resident passerines in Britain and Ireland. Ibis 134(Suppl):14–20

Fuller RJ, Lloyd D (1981) The distribution and habitats of wintering Golden Plovers in Britain 1977–1978. Bird Study 28:169–185

Fuller RJ, Gregory RD, Gibbons DW, Marchant JH, Wilson JD, Baillie SR, Carter N (1995) Population declines and range contractions among lowland farmland birds in Britain. Conserv Biol 9:1425–1441

Fuller RJ, Chamberlain DE, Burton NHK, Gough SJ (2001) Distributions of birds in lowland agricultural landscapes of England and Wales: how distinctive are bird communities of hedgerows and woodland? Agric Ecosys Environ 84:79–92

Fuller RJ, Norton LR, Feber RE, Johnson PJ, Chamberlain DE, Joys AC, Mathews F, Stuart RC, Townsend MC, Manley WJ, Wolfe MS, Macdonald DW, Firbank LG (2005) Benefits of organic farming to biodiversity vary among taxa. Biol Lett 1:431–34

Furness RW, Greenwood JJD (eds) (1993) Birds as monitors of environmental change. Chapman & Hall, London

Gaston KJ, Blackburn TM (2000) Pattern and process in macroecology. Blackwell, Oxford

Gaston KJ, Blackburn TM, Greenwood JJD, Gregory RD, Quinn RM, Lawton JH (2000) Abundance–occupancy relationships. J Appl Ecol 37:39–59

Gaston KJ, Rodrigues ASL, van Rensburg BJ, Koleff P, Chown SL (2001) Complementary representation and zones of ecological transition. Ecol Lett 4:4–9

Gates S, Donald PF (2000) Local extinction of British farmland birds and the prediction of further loss. J App Ecol 37:806–820

Gibbons DW, Gates S (1994) Hypothesis testing with ornithological atlas data: two case-studies. In: Hagemeijer EJM, Verstrael TJ (eds) Bird numbers 1992. Distribution, monitoring and ecological aspects. Proc 12th Int Conference IBCC EOAC. Statistics Netherlands, Voorburg/Heerlen & SOVON, Beek-Ubbergen, pp 39–48

Gibbons DW, Reid JB, Chapman RA (eds) (1993) The New Atlas of breeding birds in Britain and Ireland: 1988–1991. T&AD Poyser, London

Gibbons DW, Donald PF, Bauer H-G, Fornasari L, Dawson IK (2007) Mapping avian distributions: the evolution of bird atlases. Bird Stud 54

Gillett S, Lawrence A (2003) Why involve volunteers in biodiversity monitoring? Summary of the BioWatch UK Workshop, 20 October 2003. Available at: http://www.eci.ox.ac.uk/research/humaneco/biowatch.php

Gillings S (2001) Factors affecting the distribution of skylarks (*Alauda arvensis*) wintering in Britain and Ireland during the early 1980s. In: Donald PF, Vickery JA (eds) The ecology and conservation of Skylarks *Alauda arvensis*: Proc Conf University Southampton. RSPB, Sandy, pp 115–128

Gillings S, Fuller RJ (2001) Habitat selection by Skylarks (*Alauda arvensis*) wintering in Britain in 1997/98. Bird Study 48:293–307

Gillings S, Newson SE, Noble DG, Vickery JA (2005) Winter availability of cereal stubbles attracts declining farmland birds and positively influences breeding population trends. Proc R Soc 272:733–739

Ginn HB, Melville DS (1983) Moult in birds. BTO, Tring

Glazer AN (2001) Natural reserves and preserves. In: Leven SA (ed) Encyclopedia of biodiversity, vol 4. Academic, San Diego, pp 317–327

Glue DE (1974) Food of the Barn Owl in Britain and Ireland. Bird Study 21:200–210

Goodwin P (1998) 'Hired hands' or 'local voice': understandings and experience of local participation in conservation. Trans Inst Br Geogr 2:481–491

Gough GA, Sauer JR, Iliff M (1998) Patuxent bird identification Infocenter Version 97.1 Patuxent Wildlife Research Center, Laurel, MD. Available at:http://www.mbr-pwrc.usgs.gov/id/framlst/infocenter.html

Green PT, Gill FB (2004–05) Think Local, Act Global. Am Birds 59:10–12

Greenwood JJD, Baillie SR (1991) Effects of density-dependence and weather on population changes of English passerines using a non-experimental paradigm. Ibis 133[Suppl]:121–133

Greenwood JJD, Carter N (2003) Organisation eines nationalen Vogelmonitorings durch den British Trust for Ornithology – Erfahrungsbericht aus Groβbritannien. In: Berichte des Landesamtes für umweltschutz Sachsen-Anhalt. Sonderheft 1/2003: 14–26

Greenwood JJD, Robinson RA (2006) Principles of sampling. In: Sutherland WJ (ed) Ecological census techniques, 2nd edn. Cambridge University Press, Cambridge, pp 11–86

Greenwood JJD, Crick HQP, Bainbridge IP (2003) Numbers and international importance of raptors and owls in Britain and Ireland. In: Thompson DBA, Redpath SM, Fielding AH, Marquiss Galbraith CA (eds) Birds of prey in a changing environment. The Stationery Office, Edinburgh, pp 25–49

Gregory RD, Baillie SR (1998) Large-scale habitat use of some declining British birds. J App Ecol 35:785–799

Gregory RD, Greenwood JJD, Hagemeijer EJM (1998) The EBCC Atlas of European breeding birds: a contribution to science and conservation. Biol Cons Fauna 102:38–49

Grice PV, Radley GP, Smallshire D, Green MR (2007) Conserving England's arable biodiversity through agri-environment schemes and other environmental policies: a brief history. In: Boatman N, Bradbury R, Critchely N, Holland J, Marshall J, Ogilvy S (eds) Aspects of Applied Biology, vol 81. Delivering Arable Biodiversity. Association of Applied Biologists, Wellesbourne, pp 7–22

Griffioen PA, Clarke MF (2002) Large-scale bird-movement patterns evident in eastern Australian atlas data. Emu 102:99–125

Hagemeijer EJM, Blair (eds) (1997) The EBCC atlas of European breeding birds: their distribution and abundance. T&AD Poyser, London

Hagen JM, Lloyd-Evans TL, Atwood JL (1991) The relationship between latitude and the timing of spring migration in North American landbirds. Ornis Scand 22:129–136

Hamel PB, Riley CM, Hunter WC, Woodrey MS (2005) Monitoring bird migration in the Caribbean Basin: multi-national cooperation can close the loop. In: Ralph CJ, Rich TD (eds) Bird Conservation Implementation Integration in the Americas: Proc 3rd Int Partners in Flight Conf 2002, vols 651, 643. Gen. Tech. Rep. PSW-GTR-191. Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Albany, CA, pp 729–733

Hames RS, Rosenberg KV, Lowe JD, Dhondt AA (2001) Site reoccupation in fragmented landscapes: testing predictions of metapopulation theory. J Anim Ecol 70:182–190

Hansen P (1985) Geographic song variation in the Yellowhammer (*Emberiza citrinella*). Nat Jutlandica 21:209–219

Hardey J, Crick HQP, Wernham CV, Riley HT, Etheridge B, Thompson DBA (2006) Raptors: a field guide to survey and monitoring. The Stationery Office, Edinburgh

Harrison JA, Allan DG, Underhill LG, Herremans M, Tree AJ, Parker V, Brown CJ (eds) (1997) The atlas of Southern African Birds; Bird Life South Africa, Johannesburg

den Held JJD (1981) Population changes in the Purple Heron in relation to drought in the wintering area. Ardea 69:185–191

Henderson IG, Peach WJ, Baillie SR (1993) The hunting of Snipe and Woodcock in Europe: a ringing recovery analysis. BTO Research Report No 115. BTO, Thetford

Henderson IG, Cooper J, Fuller RJ, Vickery J (2000) The relative abundance of birds on set-aside and neighbouring fields in summer. J Appl Ecol 37:335–347

Henderson IG, Vickery JA, Carter N (2004) The use of winter bird crops by farmland birds in lowland England. Biol Conserv 118:21–32

Hengeveld R (1988) Mechanisms of biological invasions. J Biogeog 15:819–282

Hibbert-Ware A (1937–1938) Report of the Little Owl food enquiry 1936–37. Br Birds 31:162–187, 205–229, 249–264

Hinde RA (1951) Further report on the inland migration of Waders and Terns. Br Birds 44:329–346

Hinde RA, Fisher J (1951) Further observations on the opening of milk bottles by birds. Br Birds 44:393–396

Hinde RA, Harrison JG (1949) Inland migration of Waders and Terns. Br Birds 42:308–319

Hochachka WM, Dhondt AA (2000) Density-dependent decline of host abundance resulting from a new infectious disease. Proc Nat Acad Sci USA 97:5303–5306

Hodson NL, Snow DW (1965) The road deaths inquiry, 1960–61. Bird Study 12:90–98

Hudson R (1965) The spread of the Collared Dove in Britain and Ireland. Br Birds 58:105–139

Hudson R (1972) Collared Doves in Britain and Ireland during 1965–70. Br Birds 65:139–155

Huin N, Sparks TH (1998) Arrival and progression of the Swallow (*Hirundo rustica*) through Britain. Bird Study 45:361–370

Huin N, Sparks TH (2000) Spring arrival patterns of the Cuckoo (*Cuculus canorus*), Nightingale (*Luscinia megarhynchos*) and Spotted Flycatcher (*Muscicapa striata*) in Britain. Bird Study 47:22–31

Hurrel HG (1948) Simultaneous watch for migrant Swifts, May 11th 1947. Br Birds 41:138–145

Hussell DJT (2004) Determining productivity indices from age composition of migrants captured for banding: problems and possible solutions. Stud Avian Biol 29:82–91

Hussell D (1997) Monitoring migrants to detect changes in populations of birds breeding in Canada: present status and future prospects. In: Dunn EH, Cadman MD, Falls JB (eds) Monitoring bird populations: the Canadian experience. Canadian Wildlife Service Occasional Paper 95:43–48

Huxley JS (1959) The British contribution to our knowledge of the living bird. Ibis 101:103–106

Jackson SF, Austin GE, Armitage MJS (2006) Surveying waterbirds away from major waterbodies: implications for waterbird population estimates in Great Britain. Bird Study 53:105–111

Jahn AE, Levey DJ, Smith KG (2004) Reflections across hemispheres: a system-wide approach to New World bird migration. Auk 121:1005–1013

Janzen DH (2004) Setting up biodiversity for conservation through non-damaging use: participation by parataxonomists. J App Ecol 41:181–187

Jardine N, Secord JA, Spary EC (eds) (1996) Cultures of natural history. Cambridge University Press, Cambridge

Jeffrey DW (2001) The roles of environmental non-governmental organizations in the twenty-first century. Biol Environ Proc R Irish Acad 101B:151–156

Jiguet F, Godet L (2004) BBS in protected areas: comparing predicted and measured values as a tool to assess general protection efficiency for common species. In: Bird Numbers 2004: monitoring in a changing Europe. Proc 16th Int Conf EBCC. Kayseri, Turkey

Jiguet F, Julliard R (2006) Inferences from common species communities for selecting conservation areas. Biodiv Conserv 15:799–815

Jiguet F, Julliard R, Couvet D, Petiau A (2005) Modeling spatial trends in estimated species richness using breeding bird survey data: a valuable tool in biodiversity assessment. Biodiv Conserv 14:3305–3324

Jiguet F, Julliard R, Thomas CD, Dehorter O, Newson SE, Couvet D (2006) Thermal range predicts bird population resilience to extreme high temperatures. Ecol Lett 9:1321–1330

Johnson NK (1994) Pioneering and natural expansion of breeding distributions in western North American birds. In: Jehl JR, Johnson NK (eds) A century of avifaunal change in western North America. Cooper Ornithological Society, pp 27–44

Jonkel GM (1978) The Bird Banding Laboratory and encouragement of amateur ornithologists. In: McCrimmon Jr DA, Sprunt A (eds) Proc Conf Amateur North Am Ornithol. National Audubon Society and Cornell Laboratory of Ornithology, Ithaca, pp 45–46

Kaiser A, Berthold P (2004) A European example of standardized mist netting in population studies of birds. Stud Avian Biol 29:75–81

Kanyamibwa S, Schierer A, Pradel R, Lebreton JD (1990) Changes in adult annual survival rates in a western European population of the White Stork (*Ciconia ciconia*). Ibis 132:27–35

Karr J (1981) Surveying birds in the tropics. Stud Avian Biol 6:548–553

Kawachi I, Kennedy B., Lochner K, Prothrow-Stith D (1997) Social capital, income inequality and mortality. Am J Public Health 87:1491–1498

Kew A (1999) A history of the Wash Wader Ringing Group. Wash Wader Ringing Group 1997–1998 Report, pp 12–28

Krajik K (2003) In search of the Ivory Gull. Science 301:1840–1841

Krasny ME, Bonney T (2005) Environmental education through citizen science and participatory action research: the Cornell Laboratory of Ornithology and Garden Mosaics examples. In: Mappin M, Johnson EA (eds) Environmental education or advocacy: perspectives of ecology and education in environmental education. Cambridge University Press, Cambridge, pp 292–319

Lack D (1943) The age of the blackbird. Br Birds 36:166–175

Lack P (1986) The atlas of wintering birds in Britain and Ireland. T&AD Poyser, Calton

Lack D, Venables LSV (1939) The habitat distribution of British woodland birds. J Anim Ecol 8:39–70

Latour B (1987) Science in action. Harvard University Press, Cambridge

Lawrence A (2006) "No Personal Motive?" volunteers, biodiversity, and the false dichotomies of participation. Ethics Place Environ 9:279–298

Lawrence A (2005) Reluctant citizens? The disjuncture between participatory biological monitoring and environmental governance. Paper presented at the Int Sociol Assoc Conf "Environment, Knowledge and Democracy". Available at: http://www.eci.ox.ac.uk/research/humaneco/downloads/lawrence_marseille.pdf

Lawrence A, Turnhout E (2005) Personal meaning in the public space: the bureaucratization of biodiversity data in the UK and the Netherlands. Paper presented at the RGS-IBG annual conference, London. Available at: http://www.eci.ox.ac.uk/research/humaneco/downloads/lawrenceturnhout_2005.pdf

Leach EP (1945) British recoveries of birds ringed abroad. Br Birds 38:222–227

Leach IH (1981) Wintering blackcaps in Britain and Ireland. Bird Study 28:5–14

Leadbeater C, Miller P (2004) The Pro-Am revolution: how enthusiasts are changing our economy and society. Demos, London

Lebreton J-D (2001) The use of bird rings in the study of survival. Ardea 89 (Spec Issue):85–100

Lehikoinen E, Sparks TH, Zalakevicius M (2004) Arrival and departure dates. In: Møller AP, Fiedler W, Berthold P (eds) Advances in ecological research, vol 35. Elsevier, Amsterdam, pp 1–31

Lennon JJ, Koleff P, Greenwood JJD, Gaston KJ (2004) Contribution of rarity and commonness to patterns of species richness. Ecol Lett 7:81–87

Lewington I (2006) A Caspian Gull in Oxfordshire and Ireland. Bird World 19:118–119

Licheri D, Spina F (2002) Biodiversità dell'aviafauna Italiana: variabilità morfologica nei Passeriformi (parte II: Alaudidae-Sylviidae). Biol Cons Fauna 112:1–205

Licheri D, Spina F (2005) Biodiversità dell'aviafauna italiana: variabilità morfologica nei non-Passeriformi. Biol Cons Fauna 114:1–192

Liechti F (2001) Calibrating the moon-watching method – chances and limits. Avian Ecol Behav 7:27–40

Liechti F, Bruderer B, Paproth H (1995) Quantification of nocturnal bird migration by moon-watching: comparison with radar and infrared observations. J Field Ornithol 66:457–468

Liechti F, Peter D, Lardelli R, Bruderer B (1996a) Herbstlichen Vogelzug im Alpenraum nach Mondbeobochtungun—Topographie und Wind beeinflussen den Zugverlauf. Der Ornithologische Beobachter 93:131–152

Liechti F, Peter D, Lardelli R., Bruderer B (1996b) Die Alpen, ein Hindernis im nächtlichen Breitfrontzug – eine grossräumige Übersicht nach Mondbeobachtungen. J Ornithol 137:337–356

Lincoln FC (1933) Bird banding. In: Fifty Years' progress of American Ornithology 1988–1933. American Ornithological Union, New York

Link WA, Sauer JR (1999) On the importance of controlling for effort in analysis of count survey data: modelling population change from Christmas Bird Count data. In: Helbig AJ, Flade M (eds) Bird numbers 1998: where monitoring and ecological research meet. Proc 14th Int Conf Eur Bird Census Council (EWBCC). Vogelwelt 120[Suppl]:119–124

Link WA, Sauer JR, Niven DK (2006) A hierarchical model for regional analysis of population change using Christmas Bird Count data, with application to the American Black Duck. Condor 108:13–24

Lord J, Munns DJ (eds) (1970) Atlas of breeding birds of the West Midlands. Collins, London

Lowery GH, Newman RJ (1966) A continent-wide view of bird migration on four nights in October. Auk 83:547–586

Macdonald JE (1962) Mortality in wild birds with some observations on weights. Bird Study 9:147–167

Mammen U (2003) No chance of European monitoring of raptors and owls? Ornis Hung 12–13:1–2

Mammen U, Stubbe M (1999) Monitoring of raptors and owls in Europe: a review of the first 10 years. In: Helbig AJ, Flade M (eds) Bird numbers 1998: where monitoring and ecological research meet. Proc 14th Int Conf Eur Bird Census Council (EWBCC). Vogelwelt 120[Suppl]:75–78

Marchant JH, Hudson R, Carter SP, Whittington P (1990) Population trends in British breeding birds. BTO, Tring

Marchant JH, Freeman SN, Crick HP, Beaven LP (2004) The BTO Heronries Census of England & Wales 1928–2000. Ibis 146:323–334

Marples BJ (1934) The wintering Starling roosts of Great Britain 1932–1933. J Anim Ecol 3:187–203

Martin TE (1996) Life history evolution in tropical and south temperate birds: what do we really know? J Avian Biol 27:263–272

Martin GJ, Agama AL, Beaman JH, Nais J (2002) Projek Etnobotani Kinabulu: the making of a Dusun Ethnoflora (Sabah, Malaysia). People and Plants Working Paper 9, UNESCO
Martin TE, Martin PR, Olson CR, Heidinger BJ, Fontaine JJ (2000) Parental care and clutch sizes in North and South American birds. Science 287:1582–1485
Mayer-Gross H, Crick HQP, Greenwood JJD (1997) The effect of observers visiting the nests of passerines: an experimental study. Bird Study 44:53–65
Mayfield HF (1961) Nesting success calculated from exposure. Wilson Bull 73:255–261
Mayfield HF (1975) Suggestions for calculating nest success. Wilson Bull 87:456–466
Mayfield HF (1978) Suggestions for organisers. In: McCrimmon Jr DA, Sprunt A (eds) The Amateur and North American Ornithology: Proc Conf. National Audubon Society/Cornell Laboratory of Ornithology, Ithaca
Mayfield HF (1979) The amateur in ornithology. Auk 96:168–171
Mayr E (1963) The role of ornithological research in biology. In: Sibley CG (ed) Proc 12th Int Ornithol Congr. American Ornithologists' Union, Baton Rouge, pp 27–38
McCarty K, Bildstein KL (2005) Using Autumn Hawk Watch to track raptor migration and to monitor populations of North American birds of prey. In: Ralph CJ, Rich TD (eds) Bird conservation implementation and integration in the Americas: Proc 3rd Int Partners in Flight Conference 2002. Gen. Tech. Rep. PSW-GTR-191. Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Albany, CA, 651, 643, pp 718–725
McCrimmon Jr DA, Sprunt A (eds) (1978) The amateur and North American Ornithology: proceedings of a conference. National Audubon Society/Cornell Laboratory of Ornithology, Ithaca
McCulloch MN, Tucker GM, Baillie SR (1992) The hunting of migratory birds in Europe: a ringing recovery analysis. Ibis 134[Suppl]:55–65
McLaren MA, Cadman MD (1999) Can novice volunteers provide credible data for bird surveys requiring song identification? J Field Ornithol 70:481–490
Meyberg B-U, Matthes J, Meyberg C (2002) Satellite-tracked Lesser Spotted Eagle avoids crossing water at the Gulf of Suez. Br Birds 95:372–376
Michel N, DeSante DF, Kaschube DR, Nott MP (2006) The Monitoring Avian Productivity and Survivorship (MAPS) Program annual reports, 1989–2003. NBII/MAPS Avian Demographics Query Interface. Available at: http://www.birdpop.org/nbii/NBIIHome.asp
Milton D, Minton C, Gosbell K (2005) Are populations of migratory shorebirds in the East Asian Australasian flyway at risk of decline? In: Straw P (ed) Status and conservation of shorebirds in the East Asian-Australasian flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/ International Wader Studies 17, Sydney, Australia, pp 153–157
Mims FM III (1999) Amateur science—strong tradition, bright future. Science 284:55–56
Minton C (1999) My memories of the early years. Wash Wader Ringing Group 1997–1998 Report, pp 5–11
Minton C (2005) What have we learned from banding and flagging waders in Australia? In: Straw P (ed) Status and conservation of shorebirds in the East Asian-Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/ International Wader Studies 17, Sydney, Australia, pp 117–142
Minton C, Jessop R, Collins P, Gosbell K (2005) Monitoring shorebird breeding productivity by the percentage of first year birds in populations in S.E. Australian non-breeding areas. In: Straw P (ed) Status and conservation of shorebirds in the East Asian-Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/International Wader Studies 17, Sydney, Australia, pp 73–85
Miskelly C, Empson R, Wright K (2005) Forest birds recolonising Wellington. Notornis 52:21–26
Mitchell PI, Newton SF, Ratcliffe N, Dunn TE (2004) Seabird Populations of Britain and Ireland. T&AD Poyser, London
Mortensen HCC (1950) Studies in bird migration. Jespersen P, Tåning AV (eds) Being the collected papers of HCC Mortensen 1856–1921. Munksgaard, Copenhagen
Moss D, Joys AC, Clark JA, Kirby A, Smith A, Baines D, Crick HQP (2005) Timing of breeding of Moorland Birds. BTO Research Report No. 362. BTO, Thetford
Mouritsen H (2001) Ringing recoveries contain hidden information about orientation mechanisms. Ardea 89 (Spec Issue):31–42
Nelson JB (2002) The Atlantic gannet. Fenix Books, Great Yarmouth
Newson S, Marchant J (2006) RAS comes of age. BTO News 265: 10–11
Newton A (1896) A dictionary of birds. A&C Black, London
Newton I (2003) Geographical patterns in bird migration. In: Berthold P, Gwinner E, Sonnenschein E (eds) Avian migration. Springer, Berlin pp 211–224
Nicholson EM (1959) The British approach to ornithology. Ibis 101:39–43
Nicholson EM (1970) The environmental revolution: a guide for the new masters of the World. Hodder & Stoughton, London
Nicholson EM (1978) The role of organisation in field ornithology: some notes based upon the BTO's experience. In: McCrimmon Jr DA, Sprunt A (eds) The Amateur and North American Ornithology: Proc Conf. National Audubon Society/Cornell Laboratory of Ornithology, Ithaca, pp 72–74
Norris CA (1944) Summary of a report on the distribution and status of the Corn-Crake (*Crex crex*). Br Birds 38:142–148, 162–168
Novak E (1971) The range expansion of animals and its causes. Zeszyty Naukowe 3:1–255
Nowakowski JK (2003) Catch numbers at ringing stations is a reflection of bird migration intensity, as exemplified by autumn movements of the Great Tit. Ring 25:3–15
Nur N, Geupel GR (1993) Evaluation of mist-netting, nest-searching and other methods for monitoring demographic processes in landbird populations. In: Finch DM, Stangel PW (eds) Status and management of neotropical migratory birds. Gen Tech Rep RM-229. Rocky Mountain Forest and Range Experiment Station, US Department of Agriculture, Forest Service, Fort Collins, pp 237–244
O'Connor RJ (1980a) Population regulation in the Yellowhammer (*Emberiza citrinella*) in Britain. In: Oelke H (ed) Bird census work and nature conservation. Dachverbandes Deutscher Avifaunisten, Göttingen, pp 190–200
O'Connor RJ (1980b) Pattern and process in Great Tit (*Parus major*) populations in Britain. Ardea 68:165–183
O'Connor RJ (1981) The influence of observer and analyst efficiency in mapping method censuses. Stud Avian Biol 6:372–376
O'Connor RJ (1985) Behavioural regulation of bird populations: a review of habitat use in relation to migration and residence. In: Sibly RM, Smith RH (eds) Behavioural ecology. Ecological consequences and adaptive behaviour. Blackwell, Oxford pp 105–142
O'Connor RJ (1986) Dynamical aspects of habitat use. In: Verner J, Morrison ML, Ralph CJ (eds) Wildlife zoo: modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, pp 235–240
O'Connor RJ, Shrubb M (1986) Farming and birds. Cambridge University Press, Cambridge
O'Connor RJ, Fuller RJ (1985) Bird population responses to habitat. In: Taylor K, Fuller RJ, Lack PC (eds) Bird census and atlas studies. British Trust for Ornithology, Tring, pp 197–211

O'Connor RJ, Dunn EH, Johnson DH, Jones SL, Petit D, Pollock K, Smith CR, Trap JL, Welling W (2001) A programmatic review of the North American Breeding Bird Survey (online). Available at: http://www.mp2-wrc.usgs.gov/bbs/index/htm

Oatley TB (1996) Bird ringing in Southern Africa. EURING Newsl 1:24–26

Offer A (2006) The challenge of affluence. Oxford University Press, Oxford

Palmer TS (1917) In Memoriam: Wells Woodbridge Cooke. Auk 34:119–132

Paradis E, Baillie SR, Sutherland WJ, Gregory R (1998) Patterns of natal and breeding dispersal in birds. J Anim Ecol 67:518–536

Paradis E, Baillie SR, Sutherland WJ, Gregory R (1999) Dispersal and spatial scale affect synchrony in spatial population dynamics. Ecol Lett 2:114–120

Pashby BS (1985) John Cordeaux: Ornithologist. Spurn Bird Observatory

Peach WJ, Baillie SR (2004) Estimating adult survival rates from between-year recaptures in the British Trust for Ornithology Constant Effort Sites scheme. Stud Avian Biol 29:71–74

Peach WJ, Buckland ST, Baillie SR (1990) Estimating survival rates using mark-recapture data from multiple ringing sites. Ring 13:87–102

Peach WJ, Baillie SR, Underhill L (1991) Survival of British Sedge Warblers (*Acrocephalus schoenobaenus*) in relation to west African rainfall. Ibis 133:300–305

Peach WJ, Siriwardena GM, Gregory RD (1999) Long-term changes in over-winter survival rates explain the decline of reed buntings (*Emberiza schoeniclus*) in Britain. J Appl Ecol 36:798–811

Peach WJ, Baillie SR, Buckland ST (2004) Current practices in the British Trust for Ornithology Constant Effort Sites Scheme and comparisons of temporal changes in mist-net captures with changes in spot-mapping counts at the extensive scale. Stud Avian Biol 29:46–56

Pettersson MLR (1959) Diffusion of a new habit among Greenfinches. Nature 184:649

Pettersson MLR (1961) The nature and spread of *Daphne*-eating in the Greenfinch and the spread of some other habits. Anim Behav 9:114

Piha M, London E, Pakkala T, Tiainen J (2004) Linking habitat changes and weather conditions to population dynamics—a case study of the skylark (*Alauda arvensis*) In: Bird Numbers 2004: monitoring in a changing Europe. Proceedings of the 16th international conference of the EBCC, 6–11 September 2004, Kayseri, Turkey (in press)

Potts GR (1967) Urban Starling roosts in the British Isles. Bird Study 14:25–42

Potts GR (1986) The partridge: pesticides, predation and conservation. Collins, London

Preuss NO (2001) Hans Christian Cornelius Mortensen: aspects of his life and of the history of bird ringing. Ardea 89(Spec Issue):1–6

Price J, Droege S, Price A (1995) The summer atlas of North American Birds. Academic, London

Putman RD (2000) Bowling alone: the collapse and revival of American community. Simon & Schuster, New York

Rahbek C (2004) Use of large quantitative distribution databases in macroecology and conservation research. In: Bird numbers 2004: monitoring in a changing Europe. Proceedings of the 16th international conference of the EBCC, 6–11 September 2004, Kayseri, Turkey (in press)

Ralph CJ, Hollinger KY, Miller SL (2004) Monitoring productivity with multiple mist-net stations. Stud Avian Biol 29:12–20

Ralph CJ, Rich TD (eds) (2005) Bird conservation implementation and integration in the Americas. Proceedings of the third international partners in flight conference 2002, March 20–24, vols 651, 643; Asilomar, Gen. Tech. Rep. PSW-GTR-191. Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture

Ratcliffe D (1993) The Peregrine Falcon. T&AD Poyser, London

Rees E (2006) Bewick's Swan. T&AD Poyser, London

Rees G, Pond K (1995) Marine litter monitoring programmes: a review of methods with special reference to national survey. Mar Pollut Bull 30:103–108

Rehfisch MM, Holloway SJ, Yates MG, Clarke RT, Austin G, Clark NA, Durrell SEA le V dit, Eastwood JA, Goss-Custard JD, Swetnam RD, West JR (1999) Predicting the effect of habitat change on waterfowl communities: a novel empirical approach. In: Goss-Custard J, Rufine R, Luis A (eds) Predicting habitat loss. HMSO, London pp 116–126

Rehfisch MM, Austin GE, Clark NA, Clarke RT, Holloway SJ, Yates MG, Durrell SEA le V dit, Eastwood JA, Goss-Custard JD, Swetnam RD, West JR (2000) Predicting densities of wintering Redshank (*Tringa tetanus*) from estuary characteristics: a method for assessing the likely impact of habitat change. Acta Ornithol 35:25–32

van Rensburg BJ, Chown SL, Gaston KJ (2002) Species richness, environmental correlates, and spatial scale: a test using South African birds. Am Nat 159:566–577

van Rensburg BJ, Erasmus BFN, van Jaarsveld AS, Gaston KJ, Chown SL (2004) Conservation during times of change: correlations between birds, climate and people in South Africa. S Afr J Sci 100:266–272

Rich TD, Beardmore CH, Berlanga H, Blancher PJ, Bradstreet MSW, Butcher GS, Demarest DW, Dunn EH, Hunter WC, Inigo-Elias EE, Kennedy JA, Martell AM, Punjabi AO, Pashley DN, Rosenberg KV, Rustay CM, Wendt JS, Will TC (2004) Partners in flight North American Landbird Conservation Plan. Cornell Laboratory of Ornithology, Ithaca. Partners in Flight website. Available at: http://www.partnersinflight.org/cont_plan/ (version March 2005)

Robbins CS, Droege S, Sauer JR (1989) Monitoring bird populations with Breeding Bird Survey and atlas data. Ann Zool Fennici 26:297–304

Robbins CS, Stallcup RW (1981) Problems in separating species with similar habits and vocalizations. Stud Avian Biol 6:360–365

Robinson RA (2005) BirdFacts: species profiles of birds occurring in Britain and Ireland. BTO Research Report 407. BTO, Thetford. Available at: http://www.bto.org/birdfacts

Robinson RA, Learmonth JA, Hutson AM, Macleod CD, Sparks TH, Leech DI, Pierce GJ, Rehfisch MM, Crick HQP (2005) Climate change and migratory species. BTO Research Report No 414. BTO, Defra, London

Robinson R, Newson S, Marchant J (2006) RAS comes of age. BTO News 265:10–11

Rodewald AD (2004) Nest-searching cues and studies of nest-site selection and nesting success. J Field Ornithol 75:31–39

Rogers DI, Rogers KG, Barter MA (2005) Measuring recruitment of shorebirds with telescopes: a pilot study of age proportions on Australian non-breeding grounds. In Straw P (ed) Status and conservation of shorebirds in the East Asian-Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/International Wader Studies 17, Sydney, Australia, pp 63–72

Root T (1988) Atlas of wintering North American Birds: an analysis of Christmas Bird Count data. University of Chicago Press, Chicago

Root T, Alpert P (1994) Volunteers and the NBS. Science 263:1205

Rosenberg DK, DeSante DF, McKelvey KS, Hines JE (1999) Monitoring survival rates of Swainson's Thrush (*Catharus ustulatus*) at multiple spatial scales. In: Baillie SR, North PM, Gosler AG (eds) Large-scale studies of marked Birds. Proc EURING97 Conf. Bird Study 46[Suppl]:S198–208

Rubolini D (2000) Strategie di migrazione della Rondine *Hirundo rustica* in Europa. Testi di laurea, University of Pavia
Rubolini D, Massi A, Spina F (2004) Replacement of body feathers is associated with low pre-migratory energy stores in a long-distance migratory bird, the barn swallow (*Hirundo rustica*). J Zool Lond 258:441–447
Rubolini D, Pastor AG, Pilastro A, Spina F (2002) Ecological barriers shaping fuel stores in barn swallows (*Hirundo rustica*) following the central and western Mediterranean flyways. J Avian Biol 33:15–22
Rudebeck G (1950) Studies on bird migration. Vår Fågelvärld, Suppl 1
Rushton SP, Ormerod SJ, Kerby G (2004) New paradigms for modelling species distributions? J Appl Ecol 41:193–200
Salmon JD (1834) The accumulation of all possible information respecting the habits of the rock birds in Britain, by the cooperative agency of naturalists residing near headlands on the coasts. Mag Nat Hist 7:573
Sauer JR, Hines JE, Fallon J (2005) The North American breeding bird survey, results and analysis 1966–2005. Version 6.2.2006. USGS Patuxent Wildlife Research Center, Laurel, MD. http://www.mbr-pwrc.usgs.gov/bbs/
Sauer JR, Link WA (1999) Regional analysis of population trajectories from North American breeding bird survey. In: Helbig AJ, Flade M (eds) Bird numbers 1998: where monitoring and ecological research meet. Proceedings of the 14th international conference of the European Bird Census Council (EBCC) in Cottbus (Brandenburg), Germany, 23–31 March 1998. Vogelwelt 120(Suppl):31–38
Saurola P (2001) The Finnish ringing scheme. EURING Newsl 3:66–69
Schaub M, Jenni L (2000a) Fuel deposition of three passerine bird species along the migration route. Oecologia 122:306–317
Schaub M, Jenni L (2000b) Body mass of six long-distance migrant passerine species along the autumn migration route. J Ornithol 141:441–460
Schaub M, Jenni L (2001a) Variation of fuelling rates among sites, days and individuals in migrating passerine birds. Funct Ecol 15:584–594
Schaub M, Jenni L (2001b) Stopover durations of three warbler species along their autumn migration route. Oecologia 128:217–227
Schmid H, Luder R, Naef-Daenzer B, Graf R, Zbinden N (1998) Atlas des oiseaux nicheurs de Suisse. Distribution des oiseaux nicheurs en Suisse et au Liechtenstein en 1933–1996. Station Ornithologique Suisse, Sempach
Schroeder HW (2000) The restoration experience: volunteers' motives, values, and concepts of nature. In: Gobster PH, Bruce HR (eds) Restoring nature: perspectives from the social sciences and humanities. Island Press, Washington D.C., pp 247–264
Schulz H (1999) Weiβstorch im Aufwind?—White storks on the up? Proceedings of the International Symposium on the White Stork, Hamburg 1996. Naturschutzbund Deutschland, Bonn
Schüz E, Weigold H (1931) Atlas des Vogelzuges. R Friedländer & Sohn, Berlin
Secord JA (1996) The crisis of nature. In: Jardine N, Secord JA, Spary EC (eds) Cultures of natural history. Cambridge University Press, Cambridge, pp 447–459
Sekercioglu CH (2002) Impacts of birdwatching on human and avian communities. Environ Conserv 29:282–289
Sere D (2001) 75 years of the bird ringing scheme Ljubljana. EURING Newsl 3:70–71
Shaffer TL (2004) A unified approach to analyzing nest success. Auk 121:526–540
Shaffer TL, Thompson FR III (2007) Making meaningful estimates of nest survival with model-based methods. Stud Avian Biol 34:84–95
Sharrock JTR (ed) (1976) The atlas of breeding birds in Britain and Ireland. T&AD Poyser, Calton
Sheil D, Lawrence A (2004) Tropical biologists, local people and conservation: new opportunities for collaboration. TREE 19:634–638
Shore RF, Walker LA, Turk A, Wienburg CL, Wright J, Murk A, Wanless S (2006) Wildlife and pollution: 2003/04 Annual report. JNCC Report No. 391. Joint Nature Conservation Committee, Peterborough
Shukuroglou P, McCarthy MA (2006) Modelling the occurrence of rainbow lorikeets (*Trichoglossus haematodus*) in Melbourne. Austral Ecol 31:240–253.
Siriwardena GM, Baillie SR, Wilson JD (1998) Temporal variation in the survival rates of some British farmland passerines with respect to their population trends on farmland. Bird Study 45:276–292
Siriwardena GM, Baillie SR, Wilson JD (1999) Temporal variation in the annual survival rates of six granivorous birds with contrasting population trends. Ibis 141:621–636
Siriwardena GM, Baillie SR, Crick HQP, Wilson JD (2000a) The importance of variation in the breeding performance of seed-eating birds in determining their population trends on farmland. J Appl Ecol 7:128–148
Siriwardena GM, Crick HQP, Baillie SR, Wilson JD (2000b) Agricultural land-use and the spatial distribution of granivorous lowland farmland birds. Ecography 23:702–719
Siriwardena GM, Freeman SN, Crick HQP (2001) The decline of the Bullfinch (*P. pyrrhula*) in Britain: is the mechanism known? Acta Ornithol 36:143–152
Sitters HP, Fuller RJ, Hoblyn RA, Wright MT, Cowie N, Bowden CGR (1996) The Woodlark (*Lullula arborea*) in Britain: population trends, distribution and habitat occupancy. Bird Study 43:172–187
Snow DW, Perrins CM (eds) (1998) The birds of the Western Palearctic (2 vols). Oxford University Press, Oxford
Southern HN (1962) Survey of Bridled Guillemots 1959–1960. Proc Zool Soc Lond 138:455–472
Sparks T, Collinson N (2006) The UK Phenology Network – some highlights from 2005. Br Wildl 17:237–241
Sparks TH, Crick HQP, Dunn PO, Sokolov LV (2003) Birds. In: Schwartz MD (ed) Phenology: an integrative environmental science. Kluwer, Dordrecht, pp 421–436
Sparks TH, Roberts DR, Crick HQP (2001) What is the value of first arrival dates of spring migrants in phenology? Avian Ecol Behav 7:75–85
Spencer R, Gush G (1973) Siskins feeding in gardens. Br Birds 66:91–99
Spina F (2001) EURING Swallow Project: third newsletter years 1999–2000. EURING Newsl 3:29–34
Spina F, Licheri D (2003) Biodiversità dell'aviafauna Italiana: variabilità morfologica nei Passeriforia (parte III: Muscicapidae-Emberizidae). Biol Cons Fauna 113:1–77
Spina F, Pilastro A (1996) European ringing scheme: who's who. EURING Newsl 1:2–12
Spina F, Pilastro A (1998) Ecological, morphological and conservation aspects of spring songbird migration across the Mediterranean. Biol Cons Fauna 102:63–71
Spina F, Massi A, Montemaggiori A, Baccetti N (1993) Spring migration across central Mediterranean: general results from the "Progetto Piccolle Isole". Die Vogelwarte 37(Sonderheft): 1–94
Spina F, Cardinale M, Macchio S (2001) Biodiversità dell'aviafauna Italiana: variabilità morfologica nei Passeriformi (parte I). Biol Cons Fauna 107:1–79
Stebbins RA (1992) Amateurs, professionals and serious leisure. McGill-Queens University Press, Montreal & Kingston

Stokes P, Havas M, Brydges T (1990) Public participation and volunteer help in monitoring programs: an assessment. Environ Monit Assess 15:225–229

Storch D, Šizling AL, Gaston KJ (2003) Geometry of the species-area relationship in central European birds: testing the mechanism. J Anim Ecol 72:509–519

Straw P (ed) (2005) Status and conservation of shorebirds in the East Asian-Australasian Flyway: Proc Australasian Shorebirds Conf. Wetlands International Global Series 18/International Wader Studies 17, Sydney, Australia

Stresemann E (1975) Ornithology from Aristotle to the present. Harvard University Press, Cambridge

Stroud DA (2004) Monitoring rare birds: 30 years of the UK's rare breeding birds panel. In: Bird numbers 2004: monitoring in a changing europe. Proc 16th Int Conf EBCC Kayseri, Turkey

Stubbe M, Mammen U, Gedeon K (1996) Das Monitoring-Programm Greifvögel und Eulen Europas. Vogelwelt 117:261–267

Sultana J (1998) The Valetta ringing scheme. EURING Newsl 2:43

Summers-Smith JD (1963) The house sparrow. Collins, London

Summers-Smith JD (1988) The sparrows. T&AD Poyser, Calton

Summers-Smith JD (1995) The tree sparrow. J. Denis Summers-Smith, Guisborough

Surmacki A (2005) What do data from birdwatchers notepads tell us? The case of the Bearded Tit (*Panurus biarmicus*) occurrence in Western Poland. Ring 27:79–85

Svensson S (2000) European bird monitoring: geographical scales and sampling strategies. Ring 22:1–23

Symonds MRE, Johnson CN (2006) Range size–abundance relationships in Australian passerines. Global Ecol Biogeogr 15:143–152

Tautin J, Metras L (1998) The North American banding program. EURING Newsl 2:44–46

Tautin J, Metras L, Smith G (1999) Large-scale studies of marked birds in North America. In: Baillie SR, North PM, Gosler AG (eds) Large-scale studies of marked Birds. Proc EURING97 Conference. Bird Study[Suppl]: 46:s271–s278

Thomas CD, Lennon JJ (1999) Birds extend their ranges northwards. Nature 399:213

Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, de Siqueira MF, Grainger A, Hannah L, Hughes L, Huntley B, van Jaarsveld AS, Midgley GF, Miles L, Ortega-Huerta MA, Peterson AT, Phillips OL, Williams SE (2004) Extinction risk from climate change. Nature 427:145–148

Thomson AL (1926) Problems of bird-migration. HF, G Witherby, London

Tinbergen N (1959) Recent British contributions to scientific ornithology. Ibis 101:126–131

Titmuss RM (1970) The gift relationship: from human blood to social policy. Allen & Unwin, London

van Turnhout C, Willems F, Plate C, van Strien A, Teunissen W, van Dijk A, Foppen R (2007) Monitoring common and scarce breeding birds in the Netherlands: applying a post-hoc stratification and weighting procedure to obtain less biased population trends (in press)

Underhill L, Gibbons D (2002) Mapping and monitoring bird populations: their conservation uses. In: Norris K, Pain DJ (eds) Conserving bird biodiversity: general principles and their application. Cambridge University Press, Cambridge, pp 34–60

Urfi AJ, Sen M, Kalam A, Meganathan T (2005) Counting birds in India: methodologies and trends. Curr Sci 89:1997–2003

Venier LA, Pearce J, McKee JE, McKenney DW, Niemi GJ (2004) Climate and satellite-derived land cover for predicting breeding bird distribution in the Great Lakes Basin. J Biogeogr 31:315–331

Vickery JA, Bradbury RB, Henderson IG, Eaton MA, Grice PV (2004) The role of agri-environment schemes and farm management practices in reversing the decline of farmland birds in England. Biol Conserv 119:19–39

Vikström T (2004) The Danish IBA Caretaker Project. In: Bird numbers 2004: monitoring in a changing Europe. Proc 16th Int Conf EBCC, Kayseri, Turkey

Voříšek P, Marchant JH (2003) Review of large-scale generic population monitoring schemes in Europe. Bird Census News 16:14–30

Vuilleumier F (2003) Neotropical ornithology: then and now. Auk 120:577–590

WIWO (1999) Between Taimyr and Table Mountain: Forward Plan 1999–2003. WIWO, Zeist

Warburton J, Crosier T (2001) Are we too busy to volunteer? The relationship between time and volunteering using the 1997 ABS time use data. Austral J Soc Issues 36:295–314

Warburton J, Dyer M (2004) Older volunteers participating in a university research registry: helping others my age. Educ Gerontol 30:367–381. 1

Warburton J, Gooch M (2007) Stewardship volunteering: the generative response. Local Environ 12:43–55

Warburton J, Marshall S, Warburton K, Gooch M (2005) Information-related constraints on the effectiveness of environmental volunteers: a case study. Austral J Volunt 10:24–31

Wernham C, Toms M, Marchant J, Clark J, Siriwardena G, Baillie S (eds) (2002) The migration atlas: movements of the birds of Britain and Ireland. T&AD Poyser, London

Wessels KJ, Reyers B, van Jaarsveld AS (2000) Incorporating land cover information into regional biodiversity assessments in South Africa. Anim Conserv 3:67–69

Weston MA, Paton S (2002) A survey of Victorian Hooded plover counters. Stilt 42:30–31

Weston M, Fendley M, Jewell R, Satchell M, Tzaros C (2003) Volunteers in bird conservation: insights from the Australian Threatened Bird Network. Ecol Manage Restor 4:205–211

Weston MA, Silcocks A, Tzaros C, Ingwersen D (2006) A survey of contributors to an Australian bird atlassing project: demography, skills and motivation. Austral J Volunt 11:51–58

Wetlands International (2007) Waterbird population estimates, 4th edn. Wetlands International, Wageningen

Whittingham MJ, Krebs JR, Swetnam RD, Vickery JA, Wilson JD, Freckleton RP (2007) Should conservation strategies consider spatial generality? Farmland birds show regional not national patterns of habitat association. Ecol Lett 10:25–35

Williams P (2001) Complementarity. In: Leven SA (ed) Encyclopedia of biodiversity, vol 1. Academic, San Diego, pp 813–829

Williams PH, Gibbons D, Margules C, Rebelo A, Humphries C, Pressey RL (1996) A comparison of richness hotspots, rarity hotspots, and complementary areas for conserving diversity of British birds. Conserv Biol 10:155–174

Williamson K (1969) Habitat preferences of the Wren on English farmland. Bird Study 16:53–59

Williamson K, Batten L (1977) Ecological implications of the Common Birds Census. Polish Ecol Stud 3:237–244

Wilsdon J, Willis R (2004) See-through science: why public engagement needs to move upstream. Demos, London

Wilson AM, Vickery JA, Browne SJ (2001) Numbers and distribution of Northern Lapwings (*Vanellus vanellus*) breeding in England and Wales in 1998. Bird Study 48:2–17

Wilson AM, Henderson ACB, Fuller RJ (2002) Status of the Nightingale (*Luscinia megarhynchos*) in Britain at the end of the 20th Century with particular reference to climate change. Bird Study 49:193–204

Yeatman L (ed) (1976) Atlas des Oiseaux Nicheurs de France de 1970 à 1975. Ministère de la Qualité de a Vie, Environnement Direction de la Protection de la Nature, Paris

Yunick RP, Pantle RJ (1978) Amateurs and bird banding organisations. In: McCrimmon Jr DA, Sprunt A (eds) Proc Conf Amateur North Am Ornithol. National Audubon Society and Cornell Laboratory of Ornithology, Ithaca, pp 56–57

Zafar ul-Islam M, Rahmani AR (2004) Important bird areas in India: priority sites for conservation. Bombay Natural History Society, Mumbai

Zehtindjiev P, Liechti F (2003) A quantitative estimate of the spatial and temporal distribution of nocturnal bird migration in south-eastern Europe – a coordinated moon-watching study. Avian Sci 3:37–45

Zink G (1973) Der Zug europäischer Singvögel: ein Atlas der Wiederfunde beringter Vögel. Lfg 1. Aula-Verlag, Wiesbaden

Zink G (1975) Der Zug europäischer Singvögel: ein Atlas der Wiederfunde beringter Vögel. Lfg 2. Aula-Verlag, Wiesbaden

Zink G (1981) Der Zug europäischer Singvögel: ein Atlas der Wiederfunde beringter Vögel. Lfg 3. Aula-Verlag, Wiesbaden

Zink G (1985) Der Zug europäischer Singvögel: ein Atlas der Wiederfunde beringter Vögel. Lfg 4. Aula-Verlag, Wiesbaden

Zink G, Bairlein F (1995) Der Zug europäischer Singvögel: ein Atlas der Wiederfunde beringter Vögel. vol 3, Aula-Verlag, Wiesbaden