Estimating bird population sizes and trends: what are the hard data, what are the unavoidable assumptions? A plea for good documentation

JOOST BROUWER[1], NEIL E. BAKER[2] & BERTRAND TROLLIET[3]

[1]Brouwer Envir. & Agric. Consultancy, Wildekamp 32, 6721 JD Bennekom, The Netherlands, tel. +31 318 413468, e-mail brouwbar@bos.nl; [2]Tanzania Bird Atlas, PO Box 9601, Moshi, Tanzania, tel: +255 27 2756771, e-mail kifufu@kilionline.com; [3]ONCFS, Chanteloup, F – 85340 L'Ile D'Olonne, France, tel. +33 2 5195 8686, e-mail b.trolliet@oncfs.gouv.fr

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Reliable population estimates and population trend estimates are key elements in wildlife management, conservation and research planning. They are also important for various legally binding international conventions. One would therefore expect that publications dealing with population estimates and trends would document in detail how such estimates are arrived at. Unfortunately that is often not the case. This detracts from the scientific validity of the estimates as well as their conservation value. A plea is made for good documentation of the process by which population size and trend estimates are determined. A standard for such documentation is proposed.

THE IMPORTANCE OF RELIABLE POPULATION ESTIMATES

Reliable population estimates are very important for wildlife management and conservation. Having at least two reliable population estimates is the best way to reliably calculate population trends. Population estimates and population trends are key elements in identifying priorities for conservation and also for research. Availability of such estimates is essential for putting into practice the Ramsar Convention, the Convention on Biological Diversity, the Convention on Migratory Species, the African–Eurasian Migratory Waterbird Agreement, and other regional agreements or programmes such as the agreement on the Conservation of Arctic Flora and Fauna (CAFF). The importance of population estimates is specifically reflected in criterion 6 of the Ramsar Convention: wetlands can be designated "wetlands of international importance" if they regularly hold 1% or more of a particular population of a species of waterbird (www.ramsar.org).

To demonstrate the degree of reliability of individual population estimates, it would be ideal to use a standardised method. In practise, we know, this is not always possible, but we think it is important to provide precise and exhaustive documentation of how individual estimates are arrived at. Good documentation is also an essential part of good science. Good science ideally implies repeatability on the basis of what is published. Repeating calculations, if not the original field observations, and arriving at the same conclusion, requires that one knows exactly what one's predecessor has done. And that is only possible if that predecessor has documented in detail what he or she has done to arrive at the stated conclusion or conclusions.

In the same vein, if one knows how a particular population estimate was reached, one can comment more easily and more precisely on the accuracy of the estimate. This will make improvement and updating of estimates more efficient. Underestimates and overestimates each hold their own dangers. Using well-documented population estimates, it will also be clearer whether a perceived population trend is due to actual changes in numbers, or to changes in the method of estimation. For management purposes there is a big difference between an increase in estimated population size due to increased survey effort in known or new areas of occurrence, and an increase due to successful conservation measures in areas of previous decline. One would surely want to know which is the real reason for a perceived increase. Conversely, it would be useful to know if an observed decline of a species in a particular region is due to an overall decline in numbers or to a shift in distribution to other areas, not yet properly censused by ornithologists. Such shifts in distribution could for example be caused by climate change, as postulated for e.g. the Ruff (Zöckler 2002) and Common Snipe (Gratto-Trevor 1996, Morozov 1998).

There are also legal aspects of population estimates to consider. It is quite possible that certain conservation measures, based on waterbird population estimates and leading to restrictions in land use, will one day be challenged in court. The challenger may argue that the 1% criterion used is invalid, because the population size is actually twice that what it is claimed to be. If conservationists cannot show precisely how the numbers they use were arrived at, they cannot even claim to be using best available information. Their case will be weakened accordingly. A detailed audit trail is essential if such cases are to be defended.

THE APPARENT LACK OF WELL-DOCUMENTED POPULATION ESTIMATES

Although what we have just said is valid for population and trend estimates for all bird species, and indeed also for other kinds of animals, we concentrate here on waterbirds, using

in particular examples relating to Africa. Waterbird populations are what we know most about, and Africa is the geographic area on which we can comment best.

For waterbirds, we have certainly come a long way since the first Ramsar meeting and the inception of the 1% criterion in 1971. Witness the publication of three editions of *Waterbird Population Estimates* (WPE) (Rose & Scott 1994, 1997, Wetlands International 2002), and the progress made from one edition of WPE to the next. However, overview publications like WPE can be no better than the source documents on which they rely so heavily. Individually these documents often deal with only (part of) one or a few populations in a limited part of the world. But together they provide much of the information used to compile world- or continent-wide overviews. In some such source publications, population estimates are indeed very well documented. A case in point is the article by Kirby (1995) on winter population estimates for selected waterfowl species in Britain. Kirby made clear his assumption that all important sites for each species were known, included provisions for sites not visited during a particular count, and quoted wetland surveys to support his assumption that the regions counted contained representative samples of the different relevant wetland types in Britain. Zwarts (1988) provides another, if simpler, example: he extrapolated linearly his wader counts from a small counted area of mudflats on the coast of Guinea-Bissau to a much larger area of what was presumed to be the same habitat.

In many other cases, clarity about how particular population estimates are arrived at is unfortunately rather lacking. All too often the jump from total number counted to population estimate is made with no or a very incomplete explanation (e.g. USFWS & CWS 1988). Better documented, but underestimations by an unknown factor, are the cases where summed count totals are presented as population estimates (e.g. Summers *et al.* 1987, for southern and eastern Africa and western Asia): it is only very rarely that every single individual of a population is actually seen and counted during waterbird surveys, wherever they take place. Meininger *et al.* (1995) also directly use count totals from mid-winter counts as national population estimates, but specifically mention that it is assumed that all the most important areas had been adequately counted. Pirot *et al.* (1989) and Smit & Piersma (1989), on the other hand, do give actual population estimates, and refer to certain extrapolation methods, but give insufficient information for their calculations to be checked, corrected or adapted. Scott & Rose (1996) also give fairly detailed population estimates for a number of Anatidae species, but do not refer to basic data nor do they give details of calculation procedures.

We want to point out that lack of clarity about its origin says nothing about the quality of a population or trend estimate itself. Those people we know that are involved in compiling such estimates are very able, very dedicated, and hard working to a degree way above what donors have any right to expect. However, for the reasons stated in the introduction, we feel that it is regrettable that there is very often a lack of transparency about the derivation of the numbers presented, even in publications that are mostly concerned with population estimates such as WPE, Tucker & Heath (1994) and BirdLife International/EBCC (2000), and also in *Handbook of the Birds of the World* (del Hoyo *et al.* 1992, 1996, and other volumes). And when there *is* a clear reference for the source of a population or trend estimate in these overview publications, it too often turns out that quoters are being quoted, and not the original source or sources.

This "quoting of quoters" is not entirely satisfactory for a number of reasons. Firstly, the basis for a particular population estimate can become very unclear. Secondly, what one thinks is an estimate from year X may in fact be an estimate from more than ten years earlier. Thirdly, the people who did the original work do not get credit for it anymore. And fourthly, when A is quoted by B is quoted by C etc., quite tentative figures can start leading their own life, with the assumptions made by A becoming lost along the way. This is especially true when unpublished or internal discussion documents, often difficult to obtain, are quoted as the source for a population estimate or for a critical comment. To illustrate this we give examples for the Cape Teal *Anas capensis* and the Crested Coot *Fulica cristata*, if we may be so bold as to also include non-wader examples that we happen to be familiar with.

Cape Teal

In the case of the Cape Teal, Scott & Rose (1996) gave the population size for Eastern and north-central Africa as 100,000–250,000, but without any references to how this figure was arrived at. They referenced Urban & Brown (1971) in using such terms as "common to abundant" in Ethiopia, and followed Brown et al. (1982) in mapping the range. A literature review of the status of the species (Baker in press) gives details from original references for all range states. There is no suggestion from any source that the total for this population exceeds 10,000 birds, with most probably less than 500 in Ethiopia. Clearly the term "common to abundant" mentioned above is highly subjective. The range map in Scott & Rose includes some 90% of the Sudan yet there has only ever been a single record from this country and that was more than 80 years ago (Lynes 1925). The whole of Uganda is included within the species range but no records at all have been traced for this well documented country. The range map in Wetlands International (2002), made available from del Hoyo et al. (1992), has the same errors.

Crested Coot

For the sub-Saharan population of the Crested Coot, Wetlands International (2002), following Dodman (in review 2002), estimate population size as "D", 100,000–1,000,000, referring to Fishpool & Evans (2001) as the source. Fishpool & Evans were indeed new in setting a 1% threshold of 5,000, but indicated that they based that on the estimate of population size D given by Rose & Scott (1997), who referred to Rose & Scott (1994), who in turn referred to "unpublished data summarised for this report from a variety of literature sources". So the population estimate for the Crested Coot is nine years old, not two, is made by Rose and Scott and not by Fishpool and Evans (although no doubt supported by the latter), and is not supported by published data (while the data that Rose and Scott did use will be even older than 1994). For such a rough estimate this is perhaps less important, but still.

We want to emphasise that we say all this not to denigrate the value of (sections of) key publications such as *Waterbird Population Estimates*, *Important Bird Areas of Africa* or *Handbook of the Birds of the World*. We know how much good work has gone into such publications. All we want to do is put their value in perspective so that in due course that value can perhaps be increased even further. For WPE,

Tucker & Heath (1994), BirdLife International/EBCC (2000) and similar publications, it would for instance be good if there were, on the world-wide web at least, a background document showing precisely how the totals presented in the final publication were arrived at. We expect that the various compilers would love to have the time and money to do so.

SUGGESTIONS FOR MAKING THE RELIABILITY OF POPULATION ESTIMATES MORE CLEAR

What information should be included in order to make the origin and reliability of published population estimates more explicit? We would argue that complete openness is the only answer. It needs to be made quite clear what figures are estimates or partial estimates, based exclusively on hard data, and how they were derived; what figures are less precise guesstimates, and how were they derived; and what figures are guesses, based on more tentative assumptions. In order to achieve this we propose a standard for documenting population estimates. We strongly feel that such a standard should be used in all scientific publications of which one or more population size and/or trend estimate forms an important part, be they reports, scientific journals or books. This would of course include the *Bulletin* and other publications of the Wader Study Group. In such publications one should first

1. list the actual count totals for each survey site and the dates of survey; in addition one should discuss the reliability of those totals as well as the representativity of the surveyed sites for the larger area (entire site, (part of) country, region, etc.) for which extrapolations may be made.

Then

2. give the formula used to calculate the estimated total and/or density for each site, and the resulting numbers.

In explanatory notes, the size of each multiplier, and the underlying assumptions, should be explained. At a minimum each formula will include the actual count total (or totals), the size of the surveyed sample area (or areas) within the site, and the size of the site to which the actual count totals are extrapolated. Each formula may also include possible sources of error such as listed by Van der Kam *et al.* (1999): incomplete counts, incorrect (or imprecise) estimates of numbers, misidentification of species, and incorrect estimates of the size of the sample areas surveyed. It can also include multiplication factors related to visibility of a particular species, to prevalence of certain wetland types, and to prevalence of individual habitat types within wetlands (cf. Brouwer & Mullié 2001). Estimated totals and densities for areas can often be given as ranges. If these ranges can be replaced by statistical confidence intervals, so much the better.

For each population or subpopulation one should then

3. give the formula used to calculate the total for that (sub)population, and the resulting number.

The formula will need to include the estimated totals for individual sites, the size of those sites, and the area within the distribution of the (sub)population that is covered by similar sites. Different sites may represent different wetland types, in which case they should be treated separately within the formula. The size of each multiplier and the underlying assumptions should be explained for each formula, too. Formulae can differ for different species-habitat combinations.

Authors should be encouraged to detail bias and sources of error. In addition they could add an evaluation of the accuracy of the estimate. This could be expressed as the likelihood of the estimate being correct; as an estimate of the Coefficient of Variability (the standard deviation of the estimate divided by its mean); or as a different statistical confidence interval. With many populations showing more or less cyclical variations in size, population estimates should of course preferably specify that variation, or at least give the average population size over several years, instead of referring to an individual year.

In some cases, however, it may be wiser not to give a population estimate at all, but to only give a count total, which can serve as a minimum population estimate. This may be the case when a species is known to congregate in only few, large groups, which can easily be missed, or hit, during a survey, making extrapolation difficult. When too little is known of the occurrence of suitable habitat for a species, or when only small parts of huge wetlands are sampled, it may also be better to make no attempt to extrapolate and just mention count totals (*and then call them count totals*!).

Special care must, of course, be taken where individuals from more than one population may occur.

EXAMPLES OF THE PROVISION OF INFORMATION SIMILAR TO THAT PROPOSED IN THE STANDARD

In addition to Kirby (1995) and Zwarts (1988), there are a number of other papers that already go at least part of the way towards the goal of clear documentation of the origin of (national) waterbird population estimates. Meltofte *et al.* (1994) provided good documentation of how their comparative population estimates were derived for the entire Wadden Sea region. Similarly, Hälterlein *et al.* (2000) provided details of how they estimated population sizes for most waterbird species during their assessment of the German Wadden Sea coast. Going back to tropical Africa, another example is provided by Baker (1996). As it concerns Africa, we again provide a bit more detail.

Based on a nationwide waterbird count in 1995, Baker estimated the size of the Tanzanian populations of a number of species of waterbird. The method used to estimate *(the word guesstimate was used in many cases)* each population was clearly spelled out, and different methods were used for different species / habitat combinations. It was, for instance, quite easy to extrapolate along lengths of river, with a sample size of hundreds of km of river. It was rather more difficult extrapolating for small wetlands, the number and types of which in Tanzania are simply not known. Where huge wetlands were concerned, which were very incompletely sampled, it was considered preferable not to extrapolate. Instead only the total numbers counted were given, and called count totals that give an indication of the minimum population size. All the original count data from each site were included in this report.

In the same vein, the count totals in the annual reports of the African Waterbird Census are enormously influenced by annual differences in survey effort, both within and between countries. If such differences are not quantified, it is very difficult to conclude trends from the available data. In a sec-

ond example for Africa, Brouwer & Mullié (2001) have tried to overcome this.

Based on annual surveys from 1994–1997 at about seventy-five wetland sites in Niger, Brouwer & Mullié (2001) presented actual count totals as well as average, minimum and maximum national population estimates for all of Niger (more than 1000 isolated wetlands plus 550 km of river) for the middle of the dry season (January–February) over the survey period. They also showed how they arrived at those estimates using a method that includes (a) separating isolated wetlands from irrigated floodplains and from sections of the river Niger; (b) separating open areas from vegetated areas at each site; (c) estimating the percentage cover that was achieved for each type of habitat at each site; (d) estimating the proportion surveyed of each of these three types of wetland, as part of the total areas present in the country; (e) taking into account relative visibility of each species (e.g. very high for cranes, relatively low for Wood Sandpipers Tringa glareola); (f) using all this information to extrapolate the actual numbers counted to an estimate of total numbers present in Niger at each time of counting, for each species. The authors fully acknowledged that their calculations were not perfect, and suggested ways of improving them. To their comments can be added the necessity to deal with the problem of certain species occurring in relatively few, large concentrations, either always at the same site or now here, then there.

We understand that Stroud *et al.* (in review 2002) will also to a considerable degree meet the standard here proposed. That would be excellent. The information in Stroud *et al.* can then of course be included in the final version of the Wader Atlas as well.

ADDITIONAL REMARKS

Although our examples are mostly from wintering areas, it will be clear that, for estimates from breeding areas or from hunting bags, the requirement of good documentation is exactly the same. Only the calculation methods will differ, and we certainly do not pretend to provide all the answers here: we just want to start a discussion that we hope will lead to better documentation of waterbird population and trend estimates.

We also add that any extrapolations, be they in breeding areas or in wintering areas, and however well documented, should preferably only take place with the assistance of people who have good first hand knowledge of the areas concerned. It is very tempting to use only one's limited knowledge of an area for extrapolations, but that way of working is potentially a major trap. A case in point is the population estimate for the Crowned Plover *Vanellus coronatus* in East Africa. Various draft documents by people who did not know the area well gave an estimate of 10,000–40,000 birds. A relatively simple calculation suggested a population well in excess of 200,000, and probably more than 300,000, based on data from the Tanzania Atlas database and assuming a maximum of only 2,000 birds per half degree square (roughly 2,500 km^2). The example illustrates that more accurate estimates are possible from already collected data, especially if good local knowledge is recognised

The temptation to extrapolate to unknown areas is nowadays even greater because of the existence of remote sensing images and Geographic Information Systems. With these tools one is easily seduced into thinking that one can extrapolate from small sample sites to huge areas within the total range of the species, and even well beyond one's own part of the world to the entire remainder of the planet. But good ground truthing remains essential, and that can only be done by people who are, or have been, on the spot.

CONCLUSIONS

We realise that it is not always possible to make population estimates in the ideal way. We definitely do not want to discourage anybody from providing only approximate estimates, when circumstances do not allow for anything better: for so many populations there is still hardly any size and/or trend information at all. All we plead for is precise and detailed documentation when estimates are given, so that it is clear how good the estimates are and what information is required to improve them.

We also realise that all this detailed documentation, and involving all those extra people, requires a lot of extra effort from all concerned: counters, reporters, analysers, editors and referees. The effort required is still greater because very many existing population estimates do not meet these standards. However, and we repeat this, in our opinion exhaustive documentation of the derivation of population estimates and trends is the only way to produce population estimates and trends of recognisable reliability, which are so important for setting conservation and research priorities. Exhaustive documentation is also essential for accurate evaluation of perceived population trends, be they declining, stable, or increasing. It is essential as well for efficient implementation of various international conventions, not least the Ramsar Convention. It is also necessary for being well armed against possible legal challenges to certain conservation decisions made under those conventions. And finally, and not the least important for a scientific organisation like the Wader Study Group: good documentation is an essential part of good science.

For the sake of our own credibility, we must travel down this road of exhaustive documentation. And we must do what we can as individuals to help compilers of other major population estimate publications do the same, including helping them find funding if necessary.

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