Research and Management Viewpoint

ENHANCING THE VALUE OF THE BREEDING BIRD SURVEY: REPLY TO SAUER ET AL. (2005)

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Abstract: Bart et al (2004*a*) proposed several approaches for enhancing the considerable value of the Breeding Bird Survey (BBS). Sauer et al. (2005) critiqued some of these approaches, and emphasized alternative goals for the survey. We agree with many of the suggestions of Sauer et al. (2005); notably that multispecies, large-scale surveys such as the BBS are most valuable for bird conservation if they achieve multiple objectives. Nevertheless, we strongly assert that estimation of long-term trends is of fundamental importance for identifying important conservation issues and determining which species represent priorities for conservation efforts, as has been repeatedly demonstrated in the past. We are confident that our recommendations for enhancing the ability of the BBS to detect trends—reducing bias, explicitly recognizing that all bias cannot be eliminated, and increasing sample size in poorly covered areas—can only enhance, and not detract from, the value of the BBS for other purposes.

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The North American Breeding Bird Survey (BBS) was formally launched in 1966, under the leadership of Chandler Robbins, in recognition of the lack of quantitative data on the status of most bird populations in North America (Peterjohn 1994). In the early 1960s, widespread use of organochlorines and other pesticides had significant environmental impacts and triggered growing concerns. Effects on some raptors were so dramatic that they could be readily detected without quantitative surveys—such as the near extirpation of peregrines (*Falco peregrinus*) and ospreys (*Pandion haliaetus*) in eastern North America. However, conservation action is more effective before populations reach a crisis situation, and anecdotal information is not sufficient to detect more modest changes in bird species. The data gathered by the BBS since its inception have been extensively used in research and conservation planning, are at the core of major planning documents (e.g., Rich et al. 2004), and have been incorporated into hundreds of scientific papers and government reports.

Nevertheless, there are some concerns about interpretation of data from the BBS. Surveys are restricted to roadsides; detection rates are unknown and may vary among observers, habitats or years; and routes are unevenly distributed across the survey area in the continental United States and southern Canada. Although trend estimates from the survey are very precise for some species, they are imprecise for others (Sauer et al. 2002).

We proposed quantitative objectives for assessing whether a species is adequately monitored by surveys such as the BBS, and we suggested a means for dealing with bias when it is unknown, but limits for it can be estimated (Bart et al. 2004*a*). We then used this approach to identify ways that the BBS could be improved to enhance its power for trend estimation and to increase the number of species that would be adequately monitored. Our major conclusions were that reducing bias was the most effective way of enhancing the effectiveness of the survey, but that even if bias could be reduced to a relatively low level, increased survey coverage was needed in some regions of North America.

Sauer et al. (2005) challenged 3 components of our analysis: our focus on long-term trends as an appropriate objective of bird population monitoring; our approach for dealing with bias; and the details of our power analyses. We shall treat each of these in turn, and show that not only do our fundamental recommendations remain unchanged by our reassessment, but that they are, in fact, largely compatible with those of Sauer et al. (2005).

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RESPONSES TO CRITIQUE

Objectives for Bird Population Surveys

We agree with Sauer et al. (2005) that trend estimation is only one of many potential uses of large-scale survey data, and did not intend to imply otherwise. However, unlike Sauer et al. (2005), we believe that range-wide trend estimates derived from monitoring programs such as the BBS have been, and will continue to be for the foreseeable future, an important part of bird conservation planning. Population trend estimates are a key element of priority ranking used by Partners in Flight (Rich et al. 2004), and are an important component of the global conservation ranks used in assessing the status of animals worldwide (IUCN 2001).

Sauer et al. (2005) suggest that monitoring should be focused on species of conservation priority, but it is only through widespread monitoring programs such as the BBS that one can identify which species are of conservation concern in the first place and give early warning of impending losses. Greenwood (2003) outlined how survey data from breeding bird surveys in the United Kingdom have contributed to conservation success: declines in farmland birds detected through population monitoring led to public awareness of the problem; complementary surveys of reproductive success and survival helped to identify probable causes; and the result was substantial changes in policies affecting management of agricultural land. Had monitoring in the U.K. been focused only on species of conservation concern 20 years ago, the crisis in farmland birds might not have been detected in time to affect policy.

Sauer et al. (2005) suggest that trend detection may occur too late for effective management. This could be the case if the survey had insufficient power to detect trends in a timely manner. We proposed that surveys be designed to detect a 50% decline over 20 years. This value probably exceeds most natural fluctuations in populations, but is unlikely to represent an irrecoverable state, at least for species not already at critically low numbers (most rare species are not, in any case, well monitored by general purpose surveys such as the BBS). As we noted in Bart et al. (2004*a*), a survey that can detect a 50% decline over 20 years will also be able to detect larger changes over shorter time periods. Many of the current priorities for landbird conservation efforts, from individual species such as the cerulean warbler (*Dendroica cerulea*; Robbins et al. 1992) to guilds of species such as grassland birds (Brennan and Kuvleskey 2005), were identified on the basis of trends in BBS data of similar magnitude to those that we suggest the BBS should be able to detect.

Sauer et al. (2005) emphasized that waterfowl management has been based "on information about population size, not trend." This may be true for harvest management of selected waterfowl species, particularly for the mid-continent population of mallards (*Anas platyrhynchos*). However, even for waterfowl, many other management concerns and actions have been based on the identification of trends. For example, concern about low productivity in northern pintails (*Anas acuta*) was prompted by long-term declines in pintail populations (Hebert and Wassenaar 2005). Concern about damage to arctic ecosystems by snow geese (*Chen caerulescens*), and subsequent decisions to control populations, arose partly on the basis of increasing trends in the mid-winter inventory count (Cooke et al. 2000), which is widely recognized as an index rather than a reliable population estimate. Population objectives for the North American waterfowl management plan are based on mean population sizes during an arbitrary time period, the 1970s (NAWMP 1998). Progress towards these objectives could be measured based on estimates of population trajectory since that time period, even without estimates of actual population size. Although some management activities, such as determining an acceptable harvest level, clearly benefit from reliable population estimates, many other actions and thresholds can equivalently be based on percentage change in the population from a base year.

We agree that reliable estimates of population size are useful for decision making and management. The estimates for landbirds in Rich et al. (2004) certainly facilitate public understanding of objectives. However, these estimates were based on means over many years, using various sources to estimate detection probability. Many estimates were very imprecise and had uncertainties >50%. Some were likely only within an order of magnitude of the actual population size. It remains to be demonstrated whether population estimates that are sufficiently precise to serve as management goals can be obtained for the majority of bird species in North America, and whether doing so through the BBS would be either feasible or cost-effective. Even for waterfowl, it is worth noting that population estimates for many species are potentially biased because surveys do not cover the whole breeding range, and visibility correction factors have often been extrapolated across years (Smith 1995).

Sauer et al. (2005) also criticize our focus on long-term trends, noting that this entails a loss of much of the information about year-to-year change that is represented by a population trajectory (despite the fact that their own reporting of results for the BBS has focused largely on trends [e.g., Sauer et al. 2002]). We agree that trajectories can provide much additional information for understanding population dynamics. On the other hand, a long-term trend provides a useful summary statistic of the population trajectory, and is more likely to reflect a population change of conservation concern, rather than a change due to natural cycles or short-term fluctuations in population numbers.

With respect to scale, we recommended that the survey should, as a minimum, be able to detect changes over a geographic scale equivalent to about one third of the overall survey area in the continental United States and southern Canada (Bart et al. 2004*a*). Sauer et al. (2005) note that much management activity is likely to take place at the scale of a Bird Conservation Region (BCR) and suggest that monitoring targets may better be scaled to that level. We agree that monitoring at the scale of individual BCRs is important to evaluate and guide management actions within the BCR. However, depending on the particular management actions, the BBS may or may not be the most appropriate survey method at this scale. It would not be cost effective to design a survey that provides precise trend estimates for all species at all scales. Achieving the precision targets that we recommend at a national level within each BCR would require a much larger increase in sampling intensity than we propose. At smaller scales, we agree with Sauer et al. (2005) that the monitoring should be specifically tailored to the management actions, ideally in an adaptive management framework.

Monitoring over broad geographic scales also provides a context for evaluating local or regional population change, in addition to providing key information for setting conservation priorities as outlined above. Most bird species in North America are migratory and only spend part of their life cycle in any particular BCR. Factors limiting their populations may occur well away from a BCR where management activities are being planned. The response of species to management actions in a particular BCR can best be evaluated through comparison with population changes at a larger scale. The BBS, with its information on trends at large geographical scales, is ideally suited to provide that context.

Dealing with Bias

Estimates of population trajectories or trends based on an index count, such as the BBS, will be biased if a relationship between the count and population size changes over time, or if bird population changes in the area being surveyed are not representative of changes in the area of interest. As noted both by Bart et al. (2004a) and Sauer et al. (2005), both components of bias are of potential concern in the BBS: detection rates may vary across space or time, and bird population changes along roadsides (which are sampled by the BBS) may not be representative of those across the whole landscape.

Ideally, a survey would be designed such that it is unbiased, or at least bias is so small as to be negligible. One of our major recommendations was to find ways to minimize all sources of bias. However, we doubt that it will ever be possible to eliminate bias altogether. Methods for estimating detection probabilities (summarized by Bart et al. 2004*a*) remain untested at an operational scale, and are unlikely to remove all bias. Practical methods for including off-road strata within the BBS have yet to be developed in most parts of North America.

Three strategies are available for dealing with any bias that exists now or that would remain after improvements in the survey. One is to assume that bias is negligible, and effectively ignore it. A second is to assume that any form of bias completely undermines the survey, and ignore the survey. A third is to estimate upper limits on potential bias, and to consider its potential effects when reporting results. The last of these alternatives seems the best choice. If observed changes in a population index are much larger than any potential bias, then we can be reasonably confident that the underlying population really has changed, even if the survey is not perfect. Conversely, if changes are small, such that known sources of bias could represent a major component of that change, then we would not be confident that observed changes represent changes in the underlying population.

Sauer et al. (2005) dismissed our approach for dealing with bias on the basis that we have few data for estimating its potential magnitude—a fact that we clearly acknowledged in our paper.

Sauer et al. (2005) imply that if the magnitude of potential bias can be estimated, then it can be eliminated. This is not necessarily the case. For example, off-road sampling in a subset of areas could be used to estimate the magnitude and direction of differences between trends in roadside and off-road habitats. If we had a sufficiently large random sample, then we could adjust trend estimates accordingly, taking into account the precision of the correction factor, thus eliminating this source of bias, as implied by Sauer et al. (2005). However, obtaining an adequate, random, offroad sample throughout the range of the BBS may not be practical, due to costs or limited access to private property. If the magnitude or direction of differences between roadside and off-road varies regionally and among species, as seems likely, then extrapolating from sampled areas to regions where only roadside sampling is possible would not eliminate bias. Nevertheless, estimates of the magnitude of differences between roadside and offroad areas from sampled areas can be used to estimate limits for potential bias.

We agree with Sauer et al. (2005) that a major priority for the BBS is to find ways to minimize bias in the survey. The difference is that we believe it is also possible to estimate the approximate maximum value of bias (which we termed potential bias), even if it cannot be eliminated, and hence to incorporate this component of uncertainty into the estimation procedure. Trend estimates should be presented with an estimate of uncertainty considering both sampling error and estimated potential bias. Bart et al. (2004*a*) outlined one approach for doing this. Other approaches may be possible within the context of the hierarchical modeling proposed by Link and Sauer (2002). Sauer et al. (2002) provide information on the credibility of individual trends based on sampling issues (number of routes, number of birds detected, and standard error). Estimates of potential bias, and its magnitude relative to observed trends, could also be incorporated into these indicators.

Sauer et al. (2005) imply that our approach may undermine the credibility of the BBS. We believe that quite the opposite is true. The credibility of the survey is far more likely to be at risk if we naively assume that all sources of bias can be eliminated, and fail to consider the consequences of any bias that may remain.

Assessing Future Sample Sizes

Power analysis, such as that used by Bart et al. (2004*a*), is always an approximation, as it requires making assumptions about future analysis methods, and uses estimates of past variance to predict future variance. This is particularly challenging in the case of large-scale surveys, such as the BBS, for which increasingly complex analysis methods are continually being developed to deal with complexities in the survey. In fact, the most recently proposed hierarchical models (Link and Sauer 2002) are sufficiently computer intensive that they have not yet been implemented on an operational basis.

Sauer et al. (2005) criticized our analyses on the basis that we used inappropriate statistical models. In fact, the power analyses of Bart et al. (2004*a*) were based on the standard errors derived from the most recent analyses that were publicly available at the time of our analysis (Sauer et al. 2002—note that we accidentally cited this as 2001 in our original paper). Although we believe there may be more efficient and more appropriate ways to deal with observer effects than including every observer as a covariate (see McCulloch et al. 1997, Bart et al. 2004*b*), we did not use these alternative methods because we wanted to ensure that our analyses were consistent with the publicly available results, as well as those that are currently used for conservation initiatives such as Partners in Flight (e.g., Rich et al. 2004).

We did use the methods of Bart et al. (2003) to explore the potential bias associated with incomplete geographic coverage, in part because the computer programs used to implement the statistical models of Sauer et al. (2002) were not readily available for us to use. The analyses using the alternative methods were concerned only with estimating the potential magnitude of one component of bias (geographic variation), and would have been relatively unaffected by whether or not observers were included as covariates.

Our analyses indicated that, if potential bias was as high as our initial estimates, then an enormous increase in sample size would be required to achieve our monitoring objectives. As such, our major recommendation, which matches that of Sauer et al. (2005), was that methods were needed to measure and reduce potential sources of bias in the BBS. However, we doubt that bias can ever be completely eliminated. Therefore, assuming a modest level of bias, we recommended a 40% increase in sample size, concentrated in selected states and provinces that currently have relatively sparse coverage. While there may be uncertainty as to the exact number of routes required, increased coverage in regions that are currently rather sparsely sampled can only lead to improvements in the survey. We find it hard to see how our recommendations could "threaten the future" of BBS (Sauer et al. 2005).

DISCUSSION

Sauer et al. (2005) express concern that the BBS may be losing credibility, and cite as an example concerns expressed in the Federal Register (67[205]) about the suitability of the BBS for making listing determinations for bird species associated with mature forest, such as the cerulean warbler. In point of fact, as we noted above, BBS data were instrumental in determining that the cerulean warbler may be a species of concern (Robbins et al. 1992). Also despite some reservations, the major recommendation of the ruling on the cerulean warbler in the Federal Register (67[205]) was that there was still sufficient concern about the species to justify moving to the next stage of evaluation: preparation of a Status Assessment to determine whether protection under the Endangered Species Act is warranted. This is a good example of a broad-scale survey highlighting the need for additional, more targeted research to determine appropriate management actions.

We believe that trend information alone will rarely be sufficient to make listing determinations, regardless of how well designed the survey may be. As with the IUCN criteria for red-listing (IUCN 2001), additional factors such as absolute population size, distribution, threats, and demographic characteristics must all be considered. In the United Kingdom, breeding bird surveys are complemented by constant-effort site monitoring and the maintenance of nest records that provide information on changes in demographic parameters such as survival rates and productivity (Baillie 1990). Such complementary information can help to differentiate problems on the wintering grounds from problems in the breeding areas and was important in identifying recent changes to farming practices as a negative influence on farmland bird populations in the United Kingdom (Greenwood 2003). In North America, for many waterfowl species, extensive banding programs and productivity surveys provide information on demographic parameters that complement population surveys and aid in developing management models (e.g., Williams and Johnson 1995, Cooke et al. 2000). For songbirds, limited programs have been developed to monitor survival and productivity, such as the Monitoring Avian Productivity and Survival (MAPS) Program (DeSante et al. 1999), but most species and most regions are not yet well monitored.

Even if adequate demographic surveys can be developed in North America, surveys assessing trends in population numbers, such as the BBS, are needed to provide context for understanding changes in other parameters. In the absence of demographic monitoring, the BBS will continue to play a critical role in identifying species of potential concern for which more intensive research may be required.

Sauer et al. (2005) advocate changes to BBS other than our recommended increase in coverage: integration of BBS data into regional management planning, judicious changes to design and protocol, and development of new methods for analyzing BBS data, including such approaches as assessing abundance of species in specific habitats (Thogmartin et al. 2004). We see no conflict between those recommendations and ours, and we share a common goal in wanting to improve this valuable survey.

MANAGEMENT IMPLICATIONS

We agree with Sauer et al. (2005) that the most important step required to improve the BBS and related large-scale, multispecies surveys is to quantify and reduce potential sources of bias, including bias arising from variable detection probabilities and bias due to an incomplete sampling frame (roadsides). Although several methods have been proposed to address these problems, further research is required to determine which, if any, will prove effective and cost-efficient in an operational context. Although it is highly unlikely that all sources of bias can be eliminated, the credibility of the survey can be maintained if estimates of potential remaining bias are explicitly incorporated into any presentation of results from the survey, whether the presenters use our approach (Bart et al. 2004*a*) or some alternative.

We also agree with Sauer et al. (2005) that management actions at regional scales, such as BCRs, should be based on explicit objectives and population models, and should be integrated with appropriate monitoring programs. Depending upon the objectives, this monitoring may or may not be based on the BBS. Such management goals are likely to vary among regions and, until explicit models have been developed, it is unclear how they may contribute to future planning for the BBS.

Nevertheless, long-term population monitoring across the range of a species remains important for assessing the status of species, identifying conservation priorities, and placing regional population change into context. Even if bias can be largely eliminated from the BBS, it is clear that some parts of the survey region are better surveyed than others. Enhancing coverage in undersampled areas, as recommended by Bart et al. (2004*a*), will allow the BBS to provide reliable status information on substantially more species than at present, and can only benefit other uses of BBS data.

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