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OVERVIEW

MONITORING THE ABUNDANCE OF BIRD POPULATIONS

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Large-scale, long-term programs to monitor bird abundance have provided the foundation for many of our most successful programs to study and conserve bird populations (Brown et al. 2001, Williams et al. 2002, Kushlan et al. 2002, Rich et al. 2004, U.S. Fish and Wildlife Service 2004). Those programs help identify species at risk and limiting factors, suggest and help evaluate management approaches, and document recovery at the regional and rangewide scale. It is difficult to think of a major wildlife issue for which monitoring has not provided essential information. Yet despite the critical role of bird monitoring programs, many of them are poorly designed and coordinated, and many improvements could be made at relatively low cost.

In a welcome addition to the bird-monitoring literature, Conway and Gibbs (2005) describe improved methods for surveying secretive marsh birds. Their study is notable because it is based on >16,000 point counts contributed, at the authors' request, by 15 cooperators working on 12 species in 10 states. Only by recruiting collaborators (they wrote to more than 100 authors) could Conway and Gibbs have compiled such a large and spatially extensive database on that relatively unknown group of birds. Their specific question was whether secretive marsh birds are best monitored by broadcasting calls, listening passively, or doing both. Most of their collaborators used both methods, so Conway and Gibbs (2005) used differences in numbers recorded during passive and active periods, thereby excluding extraneous sources of variation such as site, observer, and weather. They also adjusted results to enable comparison of numbers that would have been recorded with periods of equal duration. They compared number recorded per period, the coefficient of variation (CV) of that number (the appropriate measure for examining precision), and the proportion of sites at which each species was recorded.

Conway and Gibbs (2005) found that broadcasting calls and songs increased the mean number of responses and the proportion of sites with a response and decreased the CVs, albeit only slightly. They point out that broadcasting some species' calls may reduce the frequency of calling by other species and, therefore, recommend that surveyors employ both a passive period and a period during which calls are broadcast. They conclude by recommending that the removal (Farnsworth et al. 2002) or double- observer (Nichols et al. 2000) methods be used, but they note, appropriately, that those methods estimate a "component of detectability," not overall detectability. Their study thus provides a solid foundation for completing the continental monitoring program for secretive marsh birds, a task that the waterbirds initiative has undertaken (Ribic et al. 1999) and that will probably be complete in less than a year.

Conway and Gibbs's (2005) study is part of a large effort to improve monitoring programs for waterbirds, shorebirds, and landbirds, particularly programs that monitor abundance at a large spatial scale. The effort is being carried out by several dozen managers and researchers working at the state, regional, and continental scales and includes both new methods and new programs. On the basis of progress during the past few years, we can now envision an interlocking series of programs to monitor birds, using state-of-the-art techniques, which will provide a far better foundation for studying and conserving bird populations than we have had in the past. Here I describe recent progress and the vision for bird monitoring that many of us share.

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Recent Progress

Number of Existing Programs

A review is being conducted by the Partners in Flight (PIF) Monitoring Working Group, building on earlier work by Moser (2000), of existing programs whose goal is to collect long-term data on abundance of nongame birds. Information on goals and methods, sponsors, duration, and geographic scope of the programs is being collected. Descriptions are being posted on a North American Bird Monitoring Projects Database website (see Acknowledgments). Most programs of this sort are probably conducted by states and provinces, and most of them have not yet provided descriptions of their programs. Nonetheless, descriptions have already been compiled for 251 programs in Canada and the United States. Extrapolating from that list and our knowledge of other programs not yet in the database, we estimate that the number of programs for landbirds in the breeding season, the number of migration monitoring stations, and the number of surveys of aquatic areas (e.g. on National Wildlife Refuges) almost certainly each exceed 500, and that several hundred surveys of colonies are conducted on a regular, though often not annual, basis. The number of independent programs conducted to gather long-term data on bird abundance in Canada and the United States may thus be as high as 2,000, and almost certainly exceeds 1,000.

That large number of programs is a concern, for several reasons. Only a small fraction of the data collected is deposited in long-term databases. C. J. Ralph (pers. comm.) estimates that more than 1 million point counts are collected annually but that <10% of those data are stored in permanent repositories. Many of the programs do not last more than 10 years, and Ralph suggests that the half-life for "orphaned" data sets is only 5–8 years, which indicates how quickly the data collected in temporary programs are lost when not archived. But even if the data are archived, their use in estimating long-term trends is questionable. For example, few programs use well-defined sampling plans to select survey locations, so extrapolating to larger regions using their data is difficult. Thus, because most of the data collected are lost, and because of questions about methods, most of the programs contribute little to estimating continental trends. Certainly they may achieve other goals, but they would be much more useful if they were part of a comprehensive strategy involving clear goals, well-defined sampling plans, accepted counting methods, permanent storage of data, and regular reports.

Initiative-based Monitoring Programs

Partners In Flight was founded in 1990 on the basis of reports that Neotropical migrants were declining (National Fish and Wildlife Foundation 1990). Their "PIF North American Landbird Conservation Plan," including recommendations on monitoring, was published in 2004 (Rich et al. 2004). Canada and the United States published separate shorebird conservation plans (Brown et al. 2001; Donaldson et al. 2001), and a single group was then formed to work on shorebird monitoring programs. The remaining nongame species are covered by the waterbird initiative. Their "Waterbird Conservation for the Americas" (Kushlan et al. 2002) covers both North America and South America and includes monitoring goals. A separate report (Steinkamp et al. 2000) provides detailed advice on methods for surveying selected waterbirds.

The need for better coordination among bird surveys has been recognized in the conservation plans produced by the bird initiatives, and much progress has been made in the past five years. The greatest emphasis has been placed on the long-term, large-scale, multispecies surveys to monitor abundance. The shorebird initiative started the Program for Regional and International Shorebird Monitoring (PRISM), a cooperative effort between Canada and the United States (Skagen et al. 2004). Having adopted an accuracy target for trend estimation, PRISM is organizing surveys on the breeding, migration, and wintering grounds to achieve that target.

The PRISM collaborators have designed a large project to estimate population sizes of shorebirds in the Arctic. It uses double sampling and habitat-based models (Bart and Earnst 2002), and has been tested widely across the Arctic. Significant efforts to develop shorebird surveys in the boreal region are beginning and will continue for at least the next two years. Less work has been completed on temperate-breeding shorebird species, but the PRISM accuracy target appears to be met for Piping Plovers (*Charadrius melodus*) and American Woodcock (*Scolopax minor*) and may be met for five other species that are frequently recorded on the Breeding Bird Survey (BBS), though more work is needed to assess potential bias. In 2004, a two-year study of Long-billed Curlews was initiated (*Numenius americanus*; see Acknowledgments). The results will achieve the PRISM trend-monitoring target and provide information on habitat relationships and conservation priorities for that species. A comprehensive plan is needed for monitoring eight other temperate-nesting species.

Migrating shorebirds have been monitored in North America since the mid-1970s by the International Shorebird Survey (Brown et al. 2001) and the Maritimes Shorebird Survey (Morrison et al. 1994, 2001). Although data from those programs have proved useful in estimating trends (Howe et al. 1989; Morrison et al. 1994, 2001), neither program was initiated as a long-term monitoring program and neither employs a well-defined sampling frame or documented survey methods. Investigators in the PRISM effort have addressed those issues by developing procedures for identifying important sites and regions for migrant shorebirds and detailed procedures for describing sites and how to survey them (Skagen et al. 2004).

Less work has been carried out on shorebird wintering grounds, but extensive aerial surveys were conducted in South America during the mid-1980s by Morrison and Ross (1989), with additional work in Panama in the early 1990s (Morrison et al. 1998). Several surveys for single species have been conducted, including a recent one for American Oystercatchers (*Haematopus palliatus*), undertaken as part of PRISM by Brown et al. (2005).

Several major programs monitor landbirds; chief among them is the BBS (Sauer et al. 2001). A great deal of work has been done in evaluating the BBS (O'Connor et al. 2000). Many of the recommendations have been implemented, though additional resources are needed to implement some of the most important ones. Partners In Flight has adopted the accuracy target proposed by PRISM. Rich et al. (2004) discuss how well the target is being achieved, and a more detailed analysis has been conducted for Canada (E. H. Dunn unpubl. data). Recommendations have also been made for a Canada–United States program of breeding-season surveys, and the number of BBS, or other similar, survey routes needed in each province and state to implement the program has been calculated (Bart et al. 2004). Some states (e.g. Nevada, Idaho, New Jersey) are implementing those recommendations. A network of 22 migration monitoring stations for landbirds was created in Canada during the past decade. A separate network of raptor migration stations has also been created (Raptor Population Index; see Acknowledgments), and a comprehensive migration monitoring program for other landbirds is being developed (C. J. Ralph pers. comm.) A detailed summary of continental-scale monitoring needs and priorities for landbirds has been prepared by the PIF Science Committee.

Less work at the continental scale has been done by the waterbirds initiative, which, to date, has focused its efforts more at the regional level. Seabird colonies are well surveyed in many regions of North America; periodic surveys of gull, tern, and long-legged wader colonies are made in many regions, and a few regional surveys are made for other species (e.g. loons, grebes). Little has been done toward developing rangewide or continental programs to integrate regional information. However, a continental program is being developed for secretive marsh birds, and programs for other groups will probably be organized during the next several years.

All-bird Monitoring Programs

Mike Carter and the Rocky Mountain Bird Observatory carried out pioneering work during the 1990s on ways to survey all birds in a region. Their approach included random selection of survey routes (for landbirds), estimation of detection ratios, and integration of field work on different bird groups (e.g. landbird surveys in early morning, surveys of wetlands by the same people later in the day). Programs to monitor all aquatic species have been carried out at the Great Salt Lake, in British Columbia, and in Alaska, among other locations. Comprehensive landbird monitoring programs are conducted by many groups, for example, the U.S. Forest Service (nine separate regional programs; C. Vojta pers. comm.), PRBO Conservation Science, the Great Basin Bird Observatory, and the Klamath Bird Observatory. The work of Richard Hutto and colleagues (Hutto and Young 2002) is a particularly good example of combining long-term and short-term projects, and regularly communicating relevant results to managers.

During the past five years, the nongame initiatives, particularly in the western United States under the auspices of PIF, have collaborated on a "Coordinated Bird Monitoring" (CBM) approach for conducting comprehensive surveys (Bart and Ralph 2004). Coordinated Bird Monitoring plans have been completed for Nevada and Idaho; are underway in Montana, Utah, Colorado, New Jersey, and Wisconsin; and are under consideration in several other states. The Intermountain West Joint Venture and the Department of Defense have also recently decided to prepare CBM plans, and the North American Bird Conservation Initiative (NABCI), a consortium of federal, state, and private bird conservation organizations, is investigating ways to enhance CBM.

Summary

An enormous amount of work is being done annually in Canada and the United States to survey birds. It seems likely, in fact, that more than enough effort is being expended on monitoring birds, and that some of those resources could usefully be redirected to other, usually short-term, work such as identifying causes of declines, deciding which areas should have highest priority for acquisition or restoration, and designing or evaluating management programs. But as noted above, continuation of broadscale monitoring is important, and many improvements in the current situation are needed, some of which will require new resources, particularly to improve coordination so that data are not lost and to fill gaps in current coverage. A comprehensive assessment is thus needed of long-term, large-scale programs to monitor bird populations in Canada and the United States. Below, I describe opportunities for increasing the efficiency of those programs through improved coordination and implementation of new methods.

Improved Coordination

Coordination should occur at the scale of the management issues being addressed. For example, efforts to identify species at risk should be coordinated at the rangewide scale, which for multispecies programs means the continental scale. When independent programs are carried out at a smaller scale, it is usually difficult to collect and analyze results; hence, managers do not obtain the rangewide perspective needed to determine whether species really are at risk. Thus, a decline observed in one state or region may reflect declining conditions in that area, but may also reflect a range shift caused by climate change. The former situation might indicate a need for work within the state to conserve the species, whereas the latter probably would not. As noted above, coordination at present falls far short of the optimal level, even acknowledging that coordination is expensive and is only warranted when benefits exceed costs. Progress is being made, however, and opportunities exist to establish a more appropriate level of coordination, particularly in the following five areas.

State Programs

All 50 states are preparing comprehensive wildlife conservation strategies that will guide conservation activities by all stakeholders within their borders. The U.S. Fish and Wildlife Service, Division of Federal Aid, will review and approve the strategies as part of their process for approving federal aid to states. Federal Aid has published guidelines for preparation of the strategies. Monitoring is one of nine required sections and is to include a "system to monitor Plan-Strategy implementation and the status of trends of wildlife and habitat" (Organization of Fish and Wildlife Information Managers 2004). The strategies, which are to be completed by 1 October 2005, provide an unprecedented opportunity to improve coordination of monitoring work within state borders. The strategies also provide the states a convenient vehicle for committing to support continental programs. First, however, the bird initiatives must work together, ideally under the auspices of NABCI, to propose needed continental programs. Otherwise, the state efforts will be fragmented and will not "add up" to continent-wide estimates of trends and other parameters.

Integrating Data Sets

As noted above, long-term trends in bird abundance are estimated in many programs. Even if those programs are consolidated, most species will still be monitored by more than one program. Combining trend estimates is generally straightforward statistically. If the trend estimates are both rangewide in scope, then the overall estimate is just the average of the program-specific estimates, perhaps with estimates weighted inversely to variances. If the estimates are from different parts of the range (e.g. the boreal region and south of the boreal), then the two areas should be regarded as strata, and an overall estimate can be obtained using formulas for stratified sampling. If the detection rates are believed to be different, then estimates of the rates (or more specifically of the ratio of rates) should be incorporated into the stratum-specific estimates. Occasionally, it may be useful to combine data at the level of the site (e.g. BBS route) rather than at the level of the estimate. This is also straightforward using standard route regression approaches (Geissler and Noon 1981). A separate trend estimate is made at each site, and then the estimates are combined using weights to acknowledge different densities.

Given the relative ease with which estimates can be combined, it is puzzling that so little effort has been made, in designing regional programs, to make use of all programs. Few regional landbird programs have been designed to use data from the BBS as well as their own data (though the Nevada Bird Count, coordinated by the Great Basin Bird Survey, is an exception). Land-based waterbird surveys are usually designed independently of aerial surveys that may occur at the same time, and different aerial surveys of the same region are sometimes carried out as independent, rather than coordinated, efforts. Program managers should realize that plans for integrating data sets need to be made in the design—not the analysis—phase.

Data Management

One of the most difficult challenges facing the bird (or any other) monitoring community is how to ensure that that the data collected are archived in long-term data repositories. Great progress has been made during the past decade with centralized data repositories, particularly at the U.S. Geological Survey (USGS) Patuxent Wildlife Research Center, but many groups need, or at least want, to maintain their own data, and that has been a serious obstacle to establishing comprehensive databases. Recently, a group of specialists, led by Steve Kelling at the Cornell University Laboratory of Ornithology, has developed a new approach, based on work in the museums (Kaiser 1999), which promises to accommodate the need for both distributed databases and comprehensive analyses. The approach involves agreeing, for any given analysis (e.g. estimating trend in bird abundance), on a core set of variables, such as location, date, time, descriptors of the sample unit (e.g. stratum number, number of the primary sampling unit), and numbers of birds recorded by species and perhaps cohort. At least one repository that will accept and serve data from anywhere, via the Internet, must be established so that all participants have a place to which they can submit data. Groups that want to maintain their own data do so, but they prepare scripts, accessible on the Internet, which, when activated, query their database and produce the core set of variables. Those queries include filters, so that users can obtain, for example, all records from a given state, period, and range of elevations. At least one analysis program is also prepared and posted on a website. All interested groups can contribute extensions for existing programs or new, comprehensive analysis programs. A user activates the system by calling one of the analysis programs, from any remote terminal, and defining her query. The program then reaches out across the Internet to all the data providers, extracts the data meeting the query specifications, combines it into one or more comprehensive files, and returns it to the analysis program. Analyses requested by the user are carried out there, and results, optionally including all the underlying data, are returned to the user. More information on this project, called Avian Knowledge Network, is available online (see Acknowledgments).

That approach has several advantages. All participants can contribute their data easily to a central repository. Groups that want to maintain control of their own data do so, and can employ whatever information and database structure they wish. Such groups also control what information is released, so that sensitive information is protected. Finally, users are offered a comprehensive and steadily expanding set of analytic tools. This "avian knowledge network" offers, for the first time, a vision of how bird-monitoring data can be managed in a manner that addresses the concerns of all stakeholders. Evaluation, refinement, and endorsement of the approach is needed by the bird initiatives and by all the major organizations involved in bird monitoring. Developing a demonstration project, perhaps involving four to six data providers, might be an effective way to publicize the approach and begin generating support for it.

Citizen Science

Many organizations recruit volunteers to carry out bird-monitoring projects. Among many examples that could be cited are various federal agencies, the Cornell University Laboratory of Ornithology, Bird Studies Canada, PRBO Conservation Science, and the Manomet Center for Conservation Sciences. Observers vary in expertise, and questions are sometimes raised about the use of information collected by less-skilled observers. The answer, however, is that no monitoring program is perfect and none is useless, so the information collected in nearly any program contributes to our understanding of bird populations. Even anecdotal reports by birders can provide useful information. For example, a report in *Science* (Krajick 2003) credits incidental observations by birders on both coasts of North America for helping identify causes of apparent large declines in Ivory Gulls (*Pagophila eburnea*). Similarly, Breeding Bird Atlases have increased our knowledge of bird distribution, and many Atlas programs now include standardized counts that yield measures of abundance and further increase the value of those projects.

Many opportunities exist to improve volunteer-based programs, and much work is being done in that arena. Two areas receiving special emphasis are design of short-term investigations and training for participants. Another area that warrants attention is strengthening partnerships between states, which receive federal funding but need nonfederal match, and groups that recruit volunteers whose time can be used for the needed match. Establishing standards and accounting systems to record volunteers' time and receive credit for it from the Division of Federal Aid will encourage states to participate in the large-scale monitoring programs and could be very helpful in gaining support for those programs.

A North American Coordinated Bird Monitoring Plan

A logical next step in improving coordination among bird-monitoring programs is to develop a comprehensive program that integrates the initiative-specific programs. Integration does not mean that surveyors necessarily record all species on a given survey, but rather that opportunities be used for increasing efficiency through improved coordination. Opportunities include a single directory of existing programs; common goals (e.g. accuracy targets) where appropriate, and published rationales explaining why some goals differ; communication between initiatives about surveys on which additional species should be recorded; shared procedures for data management; and coordinated fund-raising efforts and reporting procedures. The PRISM Arctic surveys illustrate the benefits that may result from communication between initiatives. Those surveys are carried out in some of the remotest parts of North America, places where biologists have never conducted ground-based surveys. Initially, the surveys focused only on shorebirds. Other species were also recorded as encountered, but little use was made of the data. Recently, Canadians involved with those surveys have met with representatives from the other initiatives and developed procedures specifically for landbirds and waterbirds. As a result, information is being provided on those groups, which the landbird and waterbird initiatives would not have been able to collect on their own because of high costs.

An effort is underway to produce a North American Coordinated Bird Monitoring Plan that will present a comprehensive vision for bird monitoring in North America (Bart and Ralph 2004). It is based on work by the Western Working Group of PIF, the PIF Science Committee, PRISM, and work on nongame birds in several states. The first version will cover landbirds, shorebirds, and some waterbirds and will be restricted to programs in Canada and the United States. It will describe monitoring goals and strategies for achieving them with suggested roles at the national, regional, and local levels. Recommended procedures for data management and reporting will be included, as well as suggestions for designing short-term monitoring programs and selecting survey methods.

Methodology

Large-scale, Habitat-based Sampling Plans

Most large-scale bird-monitoring programs either do not use habitat in selecting survey locations (e.g. BBS, aerial surveys) or do not use a well-defined sampling plan to select sites (e.g. ISS, MSS), or use neither (e.g. migration monitoring sites, Christmas Bird Counts). Disregarding habitat in site selection means that rare habitats receive little sampling effort. For example, in many parts of the country, riparian habitat, canyons, and high-elevation areas are not well sampled by the BBS, even though each habitat has obligate species of interest. Not using a well-defined sampling plan means that extrapolation to large areas is difficult, because sampling is not based on statistical methodology.

Incorporating habitat into site selection plans, however, is difficult and has rarely been accomplished, though participants in PRISM are making a serious effort. The major difficulties appear to be (1) obtaining relevant and accurate large-scale information about landcover and other variables useful in delineating strata (e.g. elevation), (2) consolidating detailed GIS information into stratum maps (i.e. minimum mapping units on GIS layers are usually much too small to be used as strata), (3) delineating second- and third-stage strata or sampling units so that their borders follow natural borders, (4) selecting survey locations in irregularly shaped patches, and (5) using habitat information to extrapolate counts across the region in a manner that acknowledges the complex sampling design. Most of those issues have been addressed in recent PRISM documents (available from the author), but much work remains to resolve the problems.

Estimation of Detection Ratios

Estimation of the ratio (expected survey result)/(number of birds "present"), needed to convert indices to estimates of density, continues to be difficult and contentious (Anderson 2002, Hutto and Young 2002). Much work has been done in the past decade on methods for estimating the numerator, but we are far from consensus (Thompson 2002). Less attention has been given to how the denominator should be defined, but that step is important, because the answer is often not obvious yet it defines the parameter we are trying to estimate. At present, many managers and biologists worry that no matter what method they use, their results may be challenged (e.g. in court). Accepted guidelines are thus needed for selecting and applying bird survey methods. The bird initiatives are probably an appropriate group to develop such guidelines.

Upper Limits on Bias

Standard statistical methods assume that bias is zero; and in that case, calculation of precision provides a sound basis for accuracy estimation. In bird surveys, however, bias (broadly defined as errors other than sampling error) is often non-negligible. Furthermore, any use of sample results to make inferences about populations requires an assumption about bias. For example, without an upper limit on bias, any difference observed between two populations might be due to differences in detection ratios (one source of bias). On the other hand, establishing upper limits for bias is usually difficult and subjective, because the sample data rarely provide much basis for quantitative estimates of bias. Instead, the estimates must be based on other information, including professional judgment. If the sampled population and population of interest are identical, and unbiased estimates of detection ratios are obtained, then bias is essentially zero (a small statistical bias may remain). Usually, however, detection ratios cannot be estimated without bias; and in most surveys, the sampled population and population of interest are not identical. In such cases, detailed assessment of potential bias is needed as part of the analysis. That issue warrants more attention by authors, reviewers, and editors. One of the benefits of requiring such assessments would be helping investigators recognize that shifting some of their resources away from accumulating sample size and toward reducing potential bias will often lead to increased accuracy.

Advances in Technology

Exciting work on new recording devices is being carried out in several laboratories around the world. Radar methods for monitoring bird migration have been developed during the past two decades, particularly by Sydney

Gauthreaux and coworkers (Gauthreaux and Belser 2003). Efforts are now beginning to implement those methods in large-scale programs. Work is progressing on identification of species by their nocturnal flight calls (S. Kelling pers. comm.). Migration monitoring by radar and by flight calls will permit detection of migration pathways and of change in those pathways, and will provide an independent index to trends in abundance. Recording devices, at fixed stations or mounted on balloons, have recently been used to search for rare species during the breeding season (K. Fristrup pers. comm.). Microphone arrays are being used in Canada to survey remote areas (Hobson et al. 2002), and new engineering approaches, which will permit accurate location and individual identification, are being developed in the United States (K. Fristrup pers. comm.). Those methods, if successful, will solve the problem of estimating number of birds "present" at a subsample of survey stations, because the number of birds in a plot can be defined as the number of singing location centroids within the plot. Those approaches will thus help solve two quite different problems: how to survey inaccessible areas and how to estimate detection ratios. Programs based on radar, nocturnal flight calls, and microphone arrays will have their own sources of potential bias; but in many cases, the errors will be independent of the errors in current methods that are based on human observers. Confidence will be higher when two or more, quite different, methods produce similar trend estimates.

Multiprogram Power Analysis

As noted above, progress is being made in developing continental monitoring programs for particular birds, times, and areas. Many species are well surveyed by more than one of those programs. For example, in the near future, many landbirds will be surveyed on their breeding grounds in the boreal or Arctic regions, at migration stations, and on their wintering grounds. In designing those programs, and particularly in deciding how much effort to invest in each program, we need estimates of the overall power to detect trends using all sources of data. The assessment should permit specification of how resources will be distributed among programs, what level of accuracy (including estimation of potential bias) will result, and what the overall power to detect specified trends will be. The statistical machinery needed for such an exercise is not difficult to create, but numerous estimates of likely sample sizes and trend accuracies are needed for each species. A process for developing the estimates is also needed that will result in a clear majority of bird-monitoring specialists endorsing the final estimates and proposed comprehensive plan. We can expect managers to support such a plan financially only if that level of consensus is achieved. Here again, the bird initiatives are probably the logical group to carry out the assessment.

Summary and Conclusions

Above, I have described recent and forthcoming advances in large-scale programs to monitor the abundance of birds; I will close by mentioning two related topics on which progress is also needed. Demographic rates are clearly needed to develop management actions and conservation programs and to evaluate the effectiveness of those actions and programs when implemented (DeSante 1995, DeSante and Rosenberg 1998). The Monitoring Avian Productivity and Survivorship program (MAPS; DeSante et al. 1995, 2001, 2004; DeSante and O'Grady 2000), established in 1989 and now with ~500 stations operated annually, is currently the only continent-wide program in North America providing demographic information on nongame birds. Regional productivity indices and survival-rate estimates from MAPS are available online (see Acknowledgments). Bird Studies Canada has recently established Project NestWatch to collect information on nesting success, and the Laboratory of Ornithology plans to revitalize its Nest Record Card Program (S. Kelling pers. comm.). Those programs, and others providing demographic information, are important, because without them managers would be forced to equate density with habitat quality, an assumption that is often incorrect (Van Horne 1983, Purcell and Verner 1998).

A second area for increased attention from the bird-monitoring community is integrating bird-monitoring programs with ecological monitoring programs. Although most bird monitoring will continue to be conducted as an independent effort, rich opportunities also exist for working with others who collect general ecological information. Organizers of arctic

PRISM in Canada recently decided to expand their all-bird surveys by working with specialists in ecological monitoring. Integration of bird-abundance monitoring with demographic monitoring programs, and with ecological monitoring, are two of the interesting ways in which bird monitoring will develop during the next five to ten years.

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