A Publication of the U.S. NABCI Committee

Opportunities for Improving Avian Monitoring

U.S. North American Bird Conservation Initiative (NABCI) Monitoring Subcommittee

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Established in 1999, the U.S. North American Bird Conservation Initiative (NABCI) Committee is a coalition of government agencies, private organizations, and bird initiatives in the United States working to help partners across the continent meet their common bird conservation objectives by ensuring that organizations have the capacity to support and deliver integrated bird conservation on-the-ground.

Vision

Populations and habitats of North America's birds are protected, restored, and enhanced through coordinated efforts at international, national, regional, state, and local levels, guided by sound science and effective management.

Goal

To deliver the full spectrum of bird conservation through regionally based, biologically driven, landscape-oriented partnerships.

U.S. NABCI Committee

American Bird Conservancy
Association of Fish and Wildlife Agencies
Association of Joint Venture Management Boards
Bureau of Land Management
Ducks Unlimited, Inc.
Farm Service Agency
Migratory Shore and Upland Game Bird Working Group
National Audubon Society
National Flyway Council
Natural Resources Conservation Service
North American Waterfowl Management Plan
Partners in Flight
Resident Game Bird Working Group
The Nature Conservancy
U.S. Department of Defense
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Shorebird Conservation Plan
U.S. Forest Service
Waterbird Conservation for the Americas
Wildlife Management Institute

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Page iv: Long-billed dowitchers, Gary Kramer
Back Cover: Snowy egret chicks, John and Karen Hollingsworth
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Opportunities for Improving Avian Monitoring

U.S. North American Bird Conservation Initiative
Monitoring Subcommittee

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Horned puffin, Art Sowls

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Like the resource it seeks to protect,
wildlife conservation must be dynamic,
changing as conditions change,
seeking always to become more effective.

— Rachel Carson, 1907-1964

EXECUTIVE SUMMARY

Bird monitoring is a strategic activity that can be used to assess conservation status, ascertain and predict immediate or cumulative effects of habitat change, establish management and conservation priorities, and determine the effects of management so it can be adapted to meet its objectives. On the other hand, if it is ill-conceived, monitoring can waste funds, equipment, and personnel time. This report describes how current, disparate efforts to monitor avian populations could be improved to enhance efficiency and effectiveness. If recommendations in this report are implemented, our ability to understand and predict the effects of management and natural disturbance on birds would be substantially improved. This will require a commitment to include monitoring as an integral part of management and conservation practices, from project inception to periodic program review. Regular review should be rigorous enough to ensure that monitoring programs address the most critical needs and priorities, are based on consistent and valid methods, and provide secure and accessible data and syntheses.

American golden-plover, OW Johnson

We provide a number of recommendations for general consideration by the bird conservation community and a set of specific actions for implementation by the U.S. North American Bird Conservation Initiative (U.S. NABCI) Committee and Monitoring Subcommittee; all recommendations and actions address current challenges to our ability to achieve four monitoring goals. The first goal is to fully integrate monitoring into bird management and conservation practices and to ensure that monitoring is aligned with management and conservation priorities. When a monitoring program is initiated, the management or policy objectives should be explicit and coordinated among stakeholders, and the monitoring should be designed at an appropriate scale, scope, and intensity to address the objectives.

The second goal is to solve conservation or management problems effectively through coordinating monitoring efforts among organizations and integrating them across spatial scales. This will require both dedicated personnel and a will to work with other organizations.

The third goal is to increase the value of monitoring programs by improving statistical design. This requires not only defining the management or conservation role of the monitoring information and the appropriate target populations, but also the correct response variables and measurement techniques. Use of qualified statisticians in designing, implementing, and periodically reviewing programs will ensure high value of monitoring efforts.

Fourth, it is critical that monitoring data be maintained in secure and accessible data management systems. To accomplish this, agencies and organizations should adhere to a set of standards for data management and quality assurance and control that includes consideration of database content, data accessibility, and archiving in secure and accessible repositories. Database managers, GIS specialists, biologists, and data analysts should be involved at the outset of project development, and program reports and summaries provided routinely to the wider bird management and conservation community.

We realize that achieving these goals will take staff time and may require additional funding sources. Many improvements, however, can be made by making current programs more efficient, and adopting a practice that acknowledges that a proportion of all management and conservation investment should be allocated toward monitoring and evaluation. This does not mean that every local-scale project needs to spend a portion of their budget on monitoring and evaluation — but that at some appropriate scale, a portion of project resources will need to be spent to understand the state of the populations we are concerned about, judge how well our actions are meeting management and conservation objectives, and ensure that reliable and timely information is transmitted to decision makers.

We encourage the bird management and conservation community to carefully consider these recommendations. Successful implementation will require a willingness to undertake fundamental changes to the ways in which agencies, initiatives, and other organizations involved in bird conservation are accustomed to operating. We hope that the subsequent work plan developed for the Monitoring Subcommittee will demonstrate the commitment of the U.S. NABCI Committee for improving bird monitoring in the U.S. and, conceivably, beyond U.S. borders.

Lesser scaup, Lee Karney

INTRODUCTION

The past decade has seen a proliferation of initiatives for bird conservation, which include Partners in Flight, the U.S. Shorebird Conservation Plan, Waterbird Conservation for the Americas, the Northern Bobwhite Conservation Initiative, and other game bird initiatives. Following the North American Waterfowl Management Plan, developed in the mid-eighties, these initiatives have undertaken priority-setting and conservation planning efforts for bird groups at the continental scale and at numerous regional and local planning scales. Under the coordinating umbrella of the North American Bird Conservation Initiative (NABCI), these efforts have resulted in expanded partnerships for implementing conservation objectives within joint ventures, Bird Conservation Regions (BCRs), and other bird conservation partnerships that include participation by many federal and state wildlife resource agencies and non-governmental organizations.

Black-throated blue warbler, Steve Maslowksi

Information on the status of bird populations, from a wide variety of bird monitoring programs, has been critical to these conservation planning and implementation efforts. Many of these programs involve committed citizen participants in data collection. Additionally, the recent development of State Wildlife Action Plans affords the opportunity to fully engage states in integrating monitoring with management and conservation actions.

Monitoring and the subsequent act of evaluation are integral components of an iterative, science-based approach to bird management and conservation. The value of monitoring and evaluation is often judged by how well information is regularly integrated into decision-making for management or conservation. For example, monitoring information can significantly influence an array of management and conservation decisions, such as altering land management practices, determining species in highest need of management and conservation action, investing more resources to determine the causes of declining populations, identifying land units that will likely provide source populations, and regulating harvest of game birds. Technological advances have greatly influenced how, and at what rate, monitoring information can be incorporated into decision-making.

Monitoring information also enables evaluation of the effectiveness and efficiency of specific management or conservation actions, thus facilitating an adaptive management approach. Effectiveness and accountability require demonstrating not just that work has been done on a

certain number of acres or hectares, but that conservation investments have led to desired outcomes, such as enhancements to bird populations or other natural resources. Thus, the effectiveness of an action at a local scale is often measured by direct or indirect population performance and, therefore, needs to be pooled over regional, flyway, and range-wide scales to truly assess population-level success and to gain a broader context to understand local changes. Documenting outcomes of management and conservation investments improves accountability, leads to more confident decisions, and increases societal acceptance of decisions.

Common moorhen, Jim Rathert

Effective bird conservation requires monitoring information at a variety of spatial and temporal scales. Broad-scale monitoring provides a context for identification of priorities for more targeted monitoring that seeks to explain causes of population changes. Broad-scale monitoring also provides essential information for prioritizing species for conservation actions, directing the allocation of limited conservation resources, and identifying emerging conservation issues associated with changes in population levels. For example, monitoring information can shed light on how environmental changes, wrought by natural processes and human-induced actions, affect bird populations. Targeted monitoring programs are critical to assess the effectiveness of current management practices and answer questions that will affect the future management of natural resources. Holthausen et al. (2005) concluded that a combination of different monitoring approaches is needed to achieve valid outcomes for informed management and conservation.

Although current and past monitoring programs have provided critical information to bird management and conservation over the years, improvements are still needed. Incorporation of quality standards into monitoring programs, use of similar protocols for data collection, and coordination of monitoring among agencies, organizations, and initiatives have the potential to greatly improve results and outcomes, which will ultimately boost support for bird conservation. Moreover, greater sharing of monitoring and evaluation information among conservation partners is needed to increase knowledge about ecological systems and enhance decision-making.

Improvements for bird monitoring fall into four broad categories:

- improvements in effectiveness, better alignment of monitoring programs with clearly articulated management or conservation objectives and priorities;

- improvements in scope, increasing the number of species for which we can make more informed conservation or management decisions;
- improvements in utility, especially in the areas of statistical design and data management and accessibility; and
- improvements in coordination and efficiency, leading towards standardization and synergy among agencies and organizations and across spatial scales.

REPORT CONTEXT

The U.S. North American Bird Conservation Initiative (U.S. NABCI) Committee, a public-private coalition to improve the conservation of birds and their habitats in the United States, has taken a leadership role in the effort to coordinate monitoring. In general, the U.S. NABCI Committee is working to increase the effectiveness of existing and new bird conservation initiatives by enhancing coordination among them, and by fostering greater cooperation among the nations and peoples of the continent through actions of the NABCI Trinational Committee. Considering the importance of improving our understanding of bird population trends in relationship to habitat change and management, the U.S. NABCI Committee identified the need to coordinate bird monitoring efforts as one of their highest priorities at this time.

The U.S. NABCI Committee chartered a Monitoring Subcommittee to provide technical support to foster federal, state, non-governmental organization, and, eventually, international cooperation for effective monitoring of bird populations, and pertinent environmental conditions, and to develop methods to fully integrate monitoring into management and conservation decision-making. This task follows an initial report produced under the direction of the Association of Fish and Wildlife Agencies' (AFWA) Science and Research Committee (Coordinated Bird Monitoring Working Group of the Association of Fish and Wildlife Agencies 2004) and a report by the U.S. Forest Service (USFS) recommending strategies for monitoring terrestrial species (Holthausen 2005). Furthermore, the U.S. NABCI Committee charged their Monitoring Subcommittee to:

Long-billed curlew; Gary Kramer

- develop guidelines for monitoring, including protocols for data collection, accessibility, and analysis;

- find ways to integrate monitoring into science-based management and conservation practices;
- develop means to coordinate monitoring efforts across stakeholders where scale and question indicate a common goal;
- assess participant capacities to contribute to monitoring efforts (e.g., field observers, data entry, statistical analysis); and
- facilitate an assessment of current major monitoring efforts and make recommendations for continuation or change.

American black duck. Gary Nieminen

As background for discussion, members of the Monitoring Subcommittee drafted summaries from existing documents and polled their respective constituencies to generate a list of monitoring goals and objectives for each participating agency and bird initiative. The Subcommittee also considered general roles that agencies and non-governmental organizations play in bird monitoring (Appendix 1). From the background information presented in Appendix 1, similar objectives were grouped into broad themes that represent shared goals and objectives among U.S. NABCI partners (Appendix 2). Based on these goals and objectives, and on discussions among Monitoring Subcommittee members, four broad goals for improving the current state of bird monitoring in the U.S. were identified. We also conducted a brief overview of current continental and regional bird monitoring efforts, with examples from specific monitoring programs (Appendix 3). Although this is not a comprehensive review of all bird monitoring activities conducted in the U.S., it provides a general context of the type and extent of monitoring that is currently underway, and discusses the strengths and limitations of these efforts.

Although this is not a comprehensive review of all bird monitoring activities conducted in the U.S., it provides a general context of the type and extent of monitoring that is currently underway, and discusses the strengths and limitations of these efforts. Specific actions were also developed for the U.S. NABCI Committee and Monitoring Subcommittee to undertake. Detailed tasks, timelines, and partner responsibilities will be outlined in an annual work plan for the Monitoring Subcommittee.

GOALS, RECOMMENDATIONS, AND ACTIONS

Goal 1: Fully integrate monitoring into bird management and conservation practices and ensure that monitoring is aligned with management and conservation priorities.

Challenge: Monitoring programs are often not directly integrated into priority actions of regional, national, and continental bird conservation or management initiatives.

Challenge: Many management and conservation actions cannot be adequately evaluated because their effects on priority bird species have not been monitored.

Challenge: Management actions needed for some species have a high degree of uncertainty, and information is not sufficient to adequately determine population response.

If the bird management and conservation community values an iterative, science-based approach to their decision-making, then monitoring and evaluation must become integral components of their practice. Greater demand for fiscal resources, increased public involvement in management, and growing concerns about sustainability of species and ecosystems, all require a greater quantity and higher quality of natural resource information. The greater the uncertainty about how ecological drivers and environmental stressors influence avian population dynamics, the more monitoring and evaluation is needed to guide effective decision-making. Uncertainty is particularly an issue for species that travel long distances during their annual cycle.

Cassin's finch, Dave Menke

In current practice, monitoring data often do not directly contribute to decision-making or evaluation of management effects. To be most effective, monitoring must be implemented in the context of, and with direct relevance to, conservation actions. Generally referred to as adaptive management (Holling 1978, Walters 1986), the process of iterative, integrated decision-making is based on clear definition of management goals, integration of existing research and monitoring into predictive models, implementation of selected management actions, and monitoring to assess consequences of management. Adaptive Harvest Management (Williams et al. 1996, Johnson et al. 1997, Johnson and Williams 1999) provides an instructive model for incorporating monitoring information into decision-making for waterfowl management. Evaluating responses in bird populations to habitat changes is, however, more complex and requires a longer timeframe. For most migratory nongame bird species, a much less well-

developed infrastructure exists to evaluate monitoring priorities and to incorporate monitoring results into management decisions. Nonetheless, adaptive management provides a useful framework to purposefully and efficiently apply monitoring to conservation and policy decisions.

Green heron, Gary Kramer

Managers must also take advantage of information on bird populations obtained through long-term, regional, and continental programs because these data provide a broader spatial and temporal context for interpreting short-term outcomes of project monitoring (Holthausen et al. 2005). For many species, information amassed from existing monitoring efforts is insufficient to answer even the most fundamental questions regarding their status, which provides the basis for management and conservation decisions. For many shorebirds, seabirds, and secretive marshbirds, even the identification of species considered at risk cannot be accomplished because of the lack of adequate monitoring data in the context of management and conservation uncertainties. Lack of information on status and trends likewise impedes Partners in Flight's ability to reach their goal of "keeping common birds common."

Obtaining initial estimates of population status and trend is a high priority for the U.S. Fish and Wildlife Service, particularly for focal species and species considered for listing under the Endangered Species Act or the Convention on International Trade in Endangered Species. Assessing status and managing for species before they become listed is also a key goal of the State Wildlife Grants Program, State Wildlife Action Plans, and the U.S. Forest Service, which manages its extensive forests and rangelands to maintain biodiversity.

Future proposals for surveys should demonstrate relevance and utility to bird management and conservation. Effectively incorporating considerations of conservation objectives, scale, and stakeholders into monitoring programs will require much greater focus on why monitoring is needed, who will be involved, where conservation actions are occurring, and how new information will improve decision-making.

All agencies, organizations, and individuals engaged in bird management and conservation (e.g., administrators, biologists, land managers, and statisticians) should address the following fundamental issues and questions when developing monitoring programs.

Explicit objective: How will monitoring data inform the resource management or policy decision?

Response variable: What specific information is needed to make a more informed management or policy decision? Will information on abundance suffice or are data on vital rates required.

Precision: How confident do you need to be in the conclusions drawn from evaluation of the monitoring data?

Spatial scale and scope: Where will the management decision apply?

Stakeholders: Who else has the same management question or species focus? Who has a stake in answering the management question? How will information be integrated into their decision structure?

Recommendation 1.1: Establish a policy level expectation that monitoring will be explicitly acknowledged as an integral element of bird management and conservation.

Administrators, land managers, biologists, statisticians, and other stakeholders should establish active and ongoing collaborations when designing monitoring programs, defining uses of information, and evaluating utility of information in making management and conservation decisions.

Management, regulatory, and granting program administrators and managers should determine an appropriate and feasible allocation for monitoring and evaluation when budgeting for projects.

Rock sandpiper, USFWS

NABCI Action 1.1.1: Develop a Memorandum of Understanding, or other instrument, among U.S. NABCI partners to implement the action items from this report.

NABCI Action 1.1.2: Work with individual programs that can serve as successful examples by improving the integration of monitoring into their management and research projects.

Recommendation 1.2: Broaden the scope of current monitoring for species that are most at risk, and for which we have inadequate information to make effective management decisions.

NABCI Action 1.2.1: Synthesize information from the bird conservation initiatives to produce a comprehensive list of species most in need of new, enhanced, or different types of

monitoring information. Outline for the U.S. NABCI Committee how the results of new programs, or improvements in existing programs, can be actively integrated into management and conservation decisions at local and range-wide scales.

NABCI Action 1.2.2: Develop a process to complete the design of needed new or enhanced programs, according to the above determined priorities, and coordinate among NABCI partners for cost-effective implementation of new or expanded monitoring programs at the appropriate scales.

Goal 2: Coordinate monitoring programs among organizations and integrate them across spatial scales to solve conservation or management problems effectively.

Challenge: Monitoring programs are not sufficiently coordinated among organizations, resulting in unnecessary redundancies and inefficient use of funds.

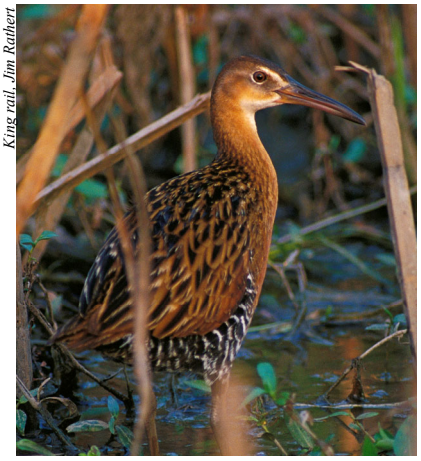
Challenge: Monitoring programs are not sufficiently integrated across spatial scales to effectively solve conservation or management problems.

Red-headed woodpecker, Dave Menke

We define "coordination" as the ability to align the various elements of monitoring programs (i.e. design, implementation, analysis, reporting, and evaluation) among stakeholders across appropriate spatial and temporal scales. Effective coordination among stakeholders requires identifying mutual information needs, developing collaborative approaches, leveraging fiscal resources, building information networks to report and share results, and identifying leadership. Although politically and logistically challenging, we argue that almost all local monitoring projects could provide more general and useful information if efforts were coordinated beyond the local scale.

Coordination among organizations is challenging because each organization initiates its own monitoring programs with funds it usually receives through its own budget process. Requests for monitoring funds are often made two to three years in advance, so availability of funds to partner organizations in any given year is unpredictable. However, adequate planning and coordination should lead to more efficient use of funds and enhance broader application of results. Rather than developing a single funding pool, clear definitions of roles and commitments could achieve collaborative results. Coordination could be achieved by designing a series of monitoring projects that all used the same design and same sampling protocol, while each contributing organization maintained control of its own funds.

A lack of long-term organizational commitment, including specifically appointed leadership positions, has hindered coordination of bird monitoring efforts. Commitment and leadership are required to successfully coordinate and align the various elements of a monitoring program among stakeholders at a variety of scales. Without it, collective monitoring efforts will fail.



King rail, Jim Rathert

The U.S. NABCI Committee endorsed BCRs, and Pelagic BCRs, as appropriate spatial, biological constructs to facilitate bird conservation planning, implementation, and evaluation within ecologically distinct regions with similar bird communities, habitats, and resource management issues. Therefore, the Monitoring Subcommittee recommends that BCRs are an appropriate spatial scale to serve as a starting point for assessing coordinated monitoring opportunities, particularly for non-harvested, breeding species. From the BCR, the spatial scale could be enlarged or reduced depending on the scale of priority management or conservation questions. Within each BCR, or other appropriate scale designation, representatives of existing organizational infrastructures (e.g., all-bird state conservation initiatives, flyway technical committees, joint ventures, regional bird initiative working groups) could meet to agree upon priority management questions and to improve coordination of existing monitoring programs. This is the approach used by flyway councils, which have effectively managed game birds at continental scales for more than 50 years. Regardless of the structure, an agency's or organization's commitment to lead the effort is crucial for success.

The scale of many current bird monitoring programs does not relate directly to the spatial extent of a specific management or conservation question. Moreover, local efforts are not well-coordinated and thus cannot contribute to larger scale programs. Developing effective and efficient coordinated bird monitoring programs, while simultaneously providing information to management and conservation decision-making at multiple spatial and temporal scales, is a challenge to the bird management and conservation community.

The U.S. NABCI Committee members have recognized the need for improved coordination, and several regional efforts to coordinate bird monitoring have been started. Completion of State Wildlife Action Plans, the development of state all-bird conservation initiatives, increased participation among agencies in broad conservation partnerships, and technological advances that facilitate shared data acquisition and management create opportunities for increased coordination.

Recommendation 2: Take specific steps to increase the appropriate coordination of monitoring programs.

Administrators, land managers, biologists, statisticians, and other stakeholders should support ongoing coordination efforts and develop an enhanced, integrated approach to bird monitoring that addresses relevant conservation or management issues.

Monitoring practitioners should use the criteria presented in Appendix 4 to assess how well existing monitoring programs meet their current conservation needs and communicate results to appropriate stakeholders.

As a preliminary step to assess the potential for coordination, practitioners should be encouraged to incorporate their monitoring information into readily available data and metadata clearinghouses such as the Natural Resource Monitoring Partnership (NRMP), Avian Knowledge Network (AKN), and the National Biological Information Infrastructure (NBII).

NABCI Action 2.1: With information technology partners, produce a brief description of data and metadata clearinghouses that will be most useful to bird management and conservation partners.

NABCI Action 2.2: Work with partners to determine how well existing monitoring programs are meeting current management and conservation needs at regional and continental scales.

NABCI Action 2.3: Communicate examples of successful monitoring partnerships to the bird management and conservation community.

Townsend's warbler. Steve Matsuoka

Goal 3: Increase the value of monitoring information by improving statistical design.

Challenge: The value of many monitoring efforts is often limited by design shortcomings.

Monitoring information must be credible and meet fundamental statistical survey requirements, such as providing inference for the entire population of interest and appropriately estimating or controlling for detection of animals during sampling. Poor or impractical statistical designs are often a consequence of limited input from administrators, biologists, or statisticians during the collaborative process of establishing a monitoring

program. Biologists define biologically meaningful attributes to be sampled, sample sites, timing of sampling, and constraints on detection of the sampled attributes. Statisticians provide the quantitative components to permit inference within the goals and biological constraints, defining sampling frameworks that allow for selection of sample sites, additional sampling needed to address detectability issues, and predicting the number of samples required to attain the goals. They also contribute to analysis and communication of results. For bird surveys, specific design issues are listed below.

Arctic tern. Tim Bowman

Defining how monitoring will inform management and conservation. Explicit statements of management goals and information needs are critical to designing monitoring programs that inform management. The increasing use of models in management is clarifying information needed from monitoring, because models contain precisely defined population variables, time periods, and geographic scopes. The statistical designs of monitoring programs are a natural consequence of the information needs; the response variable, temporal and spatial scopes of inference, needed precision, and analysis method are all based on the needs. Identification and measurement of relevant explanatory variables are critical for integrating bird counting with management and conservation decision-making. The investment in monitoring programs must be cost-effective and relate to the value that information provides to management and conservation decision-making.

Defining target populations. The sampled population must represent the population about which managers or conservationists are interested in making inferences. Improvements in many surveys can be, and are being, made to ensure that the sample is representative of the population of interest. Without such improvements, it is often difficult to draw inferences from the survey to the unsampled portions of the population.

Determining the appropriate response variable. It is important to define the proper response variable in the context of what question the information will answer. The scale and context of the management or conservation question will dictate the type of response variable required (e.g., site occupancy, abundance, or vital rates). Measuring vital rates is often the most direct method to evaluate on-the-ground management actions. For abundance and occupancy responses, estimation of detection rates to test assumptions of detectability across space and time is desirable.

Specification of appropriate analysis methods. Many monitoring programs are designed and implemented without any clear notion of how the data will be analyzed. Designing monitoring programs based on clear statements of objectives allows for an exact specification of the procedure to be used in the analysis and provides a clear framework for evaluating the survey design. Understanding which analytical procedures will be used is fundamental to any design, which is critical for the consideration of statistical power or predicted precision of results.

Periodic review. Programs should be periodically assessed for the value of the information to management and conservation decision-making, and design shortcomings should be modified to better meet information needs.

Northern shoveler, Dave Menke

Coordination. Coordination of large-scale survey methods will greatly enhance the value of the information generated by the surveys. Evaluation of replicated management activities among regions requires consistent monitoring designs and implementation. Aggregating information over regions also requires monitoring designs that provide reliable information. Surveys conducted at local scales that do not have appropriate sampling frames or detectability estimation procedures cannot be credibly aggregated to provide regional estimates.

Recommendation 3: Every monitoring program should be designed and periodically reviewed in consultation with input from administrators, managers, and statisticians familiar with bird conservation and survey design.

Monitoring practitioners should develop and adhere to design standards that allow for strong inferences about the target population and permit aggregation of data across temporal and geographic scales. They should implement a process to review and modify all aspects of survey design and implementation to better meet current information needs. Statisticians advising on the design of monitoring programs should be knowledgeable about relevant practices and guidelines developed at the national or continental level, including statistical issues where consensus is lacking.

NABCI Action 3.1: Identify survey design and analysis issues where consensus is lacking and develop procedures to increase consistency and effectiveness.

NABCI Action 3.2: Develop and sponsor symposia and seminars for interaction and development of professional statisticians.

Goal 4: Maintain bird population monitoring data in modern data management systems. Recognizing legal, institutional, proprietary, and other constraints, provide greater availability of raw data, associated metadata, and summary data for bird monitoring programs.

> *Challenge:* A large proportion of existing monitoring data is either unavailable or insufficient to aid decision-making for bird management and conservation.

Management of monitoring data is an important but frequently overlooked aspect of bird population monitoring. Discussions of bird population monitoring frequently revolve around setting objectives and developing appropriate survey designs and protocols, but issues associated with managing and accessing information are also important. Even if a monitoring program is well designed using state-of-the-art survey protocols, the program cannot meet its objectives if its data are not readily accessible to users.

Bird population monitoring data are currently managed through the haphazard creation of data management systems. Some monitoring efforts devote resources towards centralizing data management processes, but frequently, data management is the responsibility of local or regional programs with little or no coordination among them. The Breeding Bird Survey (BBS) serves as an example of a monitoring program with well-managed, current data that are easily accessed over the Internet as both raw data and summarized results. At the other extreme, some monitoring programs have data in a combination of hard copy and electronic formats that are inaccessible to users. A spectrum of data management systems exists between these extremes, producing data of variable quality and availability.

Snow bunting, USFWS

Current inadequacies involve all aspects of managing data, including quality control, security of data systems, metadata creation, and accessibility to raw data and summarized reports. Accessibility involves the timeliness of data processing, ability to download raw data in user-friendly formats, and production of timely summaries. Archiving "legacy" data is becoming increasingly important to avoid losing baseline data of value for future comparative studies. Developing accessible permanent archival repositories of monitoring information requires greater attention. Additional issues related to managing bird population monitoring data are discussed in Appendix 5.

A coordinated and collaborative approach to data management will use resources more efficiently and create uniform and readily accessible data to support decision-making. Developing and using common data management systems would greatly benefit bird management and conservation. These common data systems should be standardized and readily accessible, while reducing the resources necessary to manage data, allowing more resources to be allocated for data collection. Monitoring data must be web-accessible to enhance data entry, data sharing, and timely use for bird management and conservation. Developing and maintaining web-based data entry and retrieval pages can be costly, especially given the need to constantly improve these systems to meet the demands of changing technologies. Creating funding sources to support these activities would improve the quality and comparability of bird population monitoring data. Partners in the Avian Knowledge Network and Natural Resource Monitoring Partnership are working to provide collaborative solutions to some of these data management problems.

Red phalarope, Dave Menke

Data comparability may not be readily apparent to users unfamiliar with each monitoring program. Unless users understand how, when, and why data were collected, they may not be able to assess whether data from multiple surveys are comparable. Metadata allows users to make this determination, so access to the metadata record is as important as access to raw data. Keeping metadata current is important to reflect changes within a program. Metadata involves both geographic and data components, and developing complete metadata records for both components should be required of all bird population monitoring data management systems.

Recommendations to address these inadequacies are described below. Though essential, it will be challenging to alter existing approaches for managing monitoring data. Data management requirements should be identified as monitoring programs are developed and revamped. Database managers, biologists, and GIS specialists should be involved at initial stages of project development to define these requirements. Sufficient resources should be dedicated for proper maintenance and timely availability.

Data management is integral to the successful management and conservation of bird populations. A substantial commitment to improve current data management practices is necessary to fully realize the potential of bird population monitoring programs.

Recommendation 4: Develop a comprehensive plan for integrating and managing bird population monitoring data.

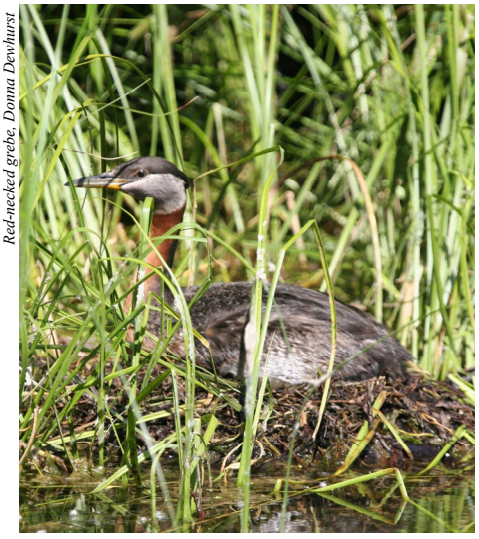
Database managers, GIS specialists, and data analysts should be involved at the outset of monitoring program development to ensure that collected data will be maintained and readily accessible in formats that expedite analysis and summarization of results.

Appropriate metadata should be created and readily available for all monitoring data sets through coordination with ongoing efforts to develop metadata for bird population monitoring programs.

Program reports and summaries should be routinely available in the peer-reviewed literature or accessible over the Internet in a timely manner. Results should be communicated to relevant project managers and administrators.

NABCI Action 4.1: Develop a set of standards for data management, quality assurance and control, content, data accessibility, and archiving that apply to bird population monitoring programs.

NABCI Action 4.2: Improve coordination and efficiency of data management efforts by providing centralized data repositories that are readily accessible by the monitoring community, analyze "gaps" in current data management systems to identify additional data repositories that need to be developed, and identify resources necessary to develop and maintain these coordinated data management efforts.



Red-necked grebe, Donna Dewhurst

CONCLUSIONS

This report presents the Monitoring Subcommittee's progress on the tasks assigned by the U.S. NABCI Committee and offers a concise set of agreed upon goals, recommendations, and actions. The Monitoring Subcommittee's intent is to insure that monitoring is included as a feasible and integral portion of the costs of management and conservation projects, and that all monitoring efforts are based on consistent and valid methods and produce useful information in an efficient manner. In addition, ongoing international and regional efforts to coordinate bird monitoring are in need of guidance and support.

We have provided a number of recommendations for general consideration by all monitoring program stakeholders and specific actions for the U.S. NABCI Committee and Monitoring Subcommittee. We encourage the bird management and conservation community to carefully consider these recommendations; successful implementation will require a broad coalition of committed partners. We hope that the work plan developed for the Monitoring Subcommittee will demonstrate the commitment of U.S. NABCI Committee members for improving bird monitoring in the U.S. and, conceivably, beyond U.S. borders.

Implementing these recommendations may require a change in the way agencies, organizations, and initiatives operate their monitoring programs. First, we must carefully attend to information quality, statistical design, and data management. Monitoring efforts are most effective when they are of sufficient quality and appropriate design to address management and conservation needs. Second, we can achieve considerably more value from a monitoring investment if potential cooperators and information users are considered across a reasonably broad spatial scale. Finally, we need to develop a business practice where monitoring is integral to evaluating whether or not we are meeting our bird management and conservation objectives. Monitoring should not be considered an opportunistic afterthought to management and conservation projects.

We realize that achieving these goals will take staff time and may require additional funding sources. Many improvements, however, can be made by making current programs more efficient, and adopting a practice that acknowledges that a proportion of all management and conservation investment should be allocated toward monitoring and evaluation. This does not mean that every local-scale project needs to spend a portion of their budget on monitoring and evaluation — but that at some appropriate scale, a portion of project resources will need to be spent on understanding the state of the populations we are concerned about, judging how well our actions are meeting management and conservation objectives, and ensuring reliable and timely information is transmitted to decision makers.

Black-legged kittiwake. Vernon Byrd

APPENDIX 1. ROLES, RESPONSIBILITES, GOALS, OBJECTIVES, AND PRIORITES FOR BIRD MONITORING

Generalized Roles and Responsibilities of Government Agencies, Non-governmental Organizations, and Partnership Initiatives in Bird Monitoring

Broad participation and shared conservation goals will be essential for integrated bird monitoring to be supported as an integral part of bird conservation. Numerous agencies and organizations are already involved in the development and implementation of bird monitoring programs, which operate at a variety of scales. Lack of coordination, however, often results in duplication of roles and responsibilities, especially at larger scales. Improving the effectiveness and efficiency of bird monitoring does not necessarily require increased capacity or expertise within all agencies and organizations. Rather, the recognition of lead roles and responsibilities and sharing of distributed expertise through coordinated regional partnerships will be essential for achieving the goals of this report. Below we suggest lead roles and responsibilities based on legal mandates and missions of partners within the bird-monitoring community:

U.S. Fish and Wildlife Service Migratory Bird Program is legally mandated to take the lead on monitoring for migratory and endangered species. It therefore will play a major role in all aspects of monitoring, including identification of management issues, funding support for monitoring, and design and implementation of specific programs.

U.S. Geological Survey similarly provides science support for monitoring of all bird species, in particular taking the lead in statistical design of protocols, analysis of monitoring data, development of data-management systems, and evaluation of monitoring programs across agencies and organizations.

U.S.D.A. Forest Service, National Wildlife Refuges and other federal land management agencies play a major role in identifying broad-scale management issues, implementing monitoring programs to address these issues, and incorporating monitoring results into the decision-making process.

State wildlife agencies have legal responsibility for monitoring upland game birds and play a key role in identifying regional and local management issues and implementing bird monitoring programs within their jurisdictions. Many states lack sufficient capacity to implement the full range of monitoring programs for all birds, especially in the areas of statistical design and analysis and database management. States will benefit most, therefore, from regional coordination, taking advantage of shared expertise, as well as from partnerships with federal agencies and non-governmental organizations (NGOs).

Many NGOs include in their missions the design, coordination, and implementation of bird monitoring programs, often at the regional or national scale. Although often dependent on federal or state agency funding, these NGOs have the ability to leverage funding through effective use of trained and competent volunteers, intern programs, ties with academic universities, and supplemental private funding. Such collaboration among agencies and NGOs increases overall capacity and cost-effectiveness of monitoring, especially of nongame species.

Joint Ventures (JVs) provide the framework for coordinating monitoring programs and for integrating monitoring into management and conservation actions at the Bird Conservation Region and larger scales. JVs could play an increasing role in generating funding for large-scale monitoring in support of management and in providing science support for regional monitoring programs.

Flyway councils also provide a framework for support and coordination of monitoring of migratory species, primarily waterfowl. An expanded role for flyways could include other hunted, but poorly monitored, species such as secretive marshbirds and some shorebirds.

Bird conservation initiatives associated with the North American Bird Conservation Initiative maintain primary responsibility for identifying priorities for monitoring species at the continental scale, including filling gaps in monitoring for high concern species and identifying overarching management and conservation issues that can be addressed through improved bird monitoring programs. Initiatives will also track the effectiveness of bird monitoring programs in meeting continental population objectives, and will play a key role in the coordination of regional monitoring programs.

Agency/Initiative Goals, Objectives, and Priorities for Bird Monitoring

The following accounts were provided by each agency and bird initiative to summarize their individual goals and objectives for monitoring. Some monitoring goals are specific to agency mandates and policies and were not necessarily developed to meet bird conservation objectives. These differing perspectives and priorities, however, serve as a necessary basis for understanding the roles of various partners in coordinating bird monitoring programs to benefit bird conservation. By no means is this a comprehensive review of all agencies and organizations engaged in bird management and conservation in North America or the U.S.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) has the legal mandate and trust responsibility, established through more than 25 primary conventions, treaties, and laws, to maintain healthy migratory bird populations for the benefit of the American public. The USFWS has four principal goals that support this core mission: 1) conserve, protect, restore, and enhance fish, wildlife, and plant populations entrusted to our care, 2) conserve an ecologically diverse network of lands and waters — of various ownerships — providing habitats for fish, wildlife, and plant resources, 3) provide opportunities to the public to enjoy, understand, and participate in the use and conservation of fish and wildlife resources, 4) support and strengthen partnerships with tribal, state, and local governments and others in their efforts to conserve and enjoy fish, wildlife, plants and their habitats. Bird monitoring information assists USFWS programs in meeting their legal mandates in the following ways.

Determine status of migratory birds and the need to list any bird species as threatened or endangered. For decades, the USFWS has used monitoring information from spring waterfowl surveys to assess population status and set, in conjunction with the states, migratory bird harvest regulations. These data are also used to assess progress toward population objectives defined in the North American Waterfowl Management Plan, which include model-based approaches for assessing effects of environmental factors. The Service coordinates similar surveys for American woodcock and mourning doves, and Service biologists have conducted a variety of aerial surveys to determine population status of migratory game birds (e.g., Sandhill cranes, trumpeter swans, seaducks). Many monitoring projects for nongame migratory birds are at the stage of providing initial estimates of population status, particularly for shorebirds, waterbirds, and secretive marshbirds. The Service Migratory Bird Program has identified a set of focal species to initiate assessments in 2006 and beyond. Monitoring information on population status and trend are incorporated into decisions regarding listing of species under the Endangered Species Act (ESA) or the Convention on International Trade in Endangered Species (CITES).

Understand the effects that environmental factors have on migratory bird population dynamics. Concurrent monitoring of environmental factors is useful to help understand what drives bird population dynamics. For example, pond counts conducted in the prairie parkland region, in conjunction with aerial waterfowl counts, have helped elucidate relationships between the environment and duck population dynamics that are fundamental to waterfowl harvest regulation and habitat conservation planning.

Regulate and manage take of migratory and threatened/endangered birds. To determine the effectiveness of harvest regulations, the Service monitors the harvest of migratory game birds, including subsistence harvest of non-waterfowl. Take associated with permits for religious observances, falconry, and Bald Eagle de-listing will require monitoring programs, and the efficacy of long-line fishery deterrent streamers on reducing seabird by-catch is being evaluated. Data management tools have been developed to annually assess the number of permits issued for migratory bird species. Law enforcement monitors adherence to hunting regulations or violations of the Migratory Bird Treaty Act, ESA, CITES, or Bald and Golden Eagle Protection Act.

Evaluate the recovery of listed bird species. The USFWS uses monitoring information to evaluate the success of endangered species recovery plans. Monitoring has included, for example, singing male counts, pair counts, and indicators of reproductive success. For some species like the Kirtland's warbler, parasitism rates have been monitored to judge the effectiveness of brown-headed cowbird trapping.

Set spatially explicit management and conservation priorities. Monitoring information at local sites helps managers determine proper management and conservation priorities. In some areas of the country, bird monitoring information is being incorporated into landscape models that prioritize areas for protection, enhancement or restoration, which extends beyond USFWS lands. Particularly in Joint Ventures, monitoring systems have been used to develop and evaluate these predictive models.

Assess effectiveness of projects implemented on lands owned by the USFWS or influenced by USFWS grants, programs, or policies. The National Wildlife Refuge System (NWRS) uses monitoring information to evaluate the effectiveness, and sometimes efficiency, of a variety of management and conservation interventions — the response, for example, of marine bird productivity to removal of exotic predators, grassland bird nest density to periodic burning, migrant shorebird numbers to water level manipulations. In the latter example, monitoring was designed to include numerous NWRs in the northeastern U.S. In most instances, however, monitoring is implemented to provide information to the immediate NWR manager. For Joint Ventures, Partners for Fish and Wildlife, and other programs, evaluation of project effectiveness extends beyond USFWS-owned lands.

Report efficiency of base funding and grant programs. Efficiency of delivering habitat has been traditionally reported in number of acres protected, enhanced, or restored and dollars leveraged by USFWS grant programs in conjunction with private, state, or federal landowners. The USFWS will be increasingly challenged to link projects with positive responses in trust resource bird populations. Beyond biological accomplishments, grants for migratory bird projects are audited for adherence to stated objectives and legal constraints.

Determine how the American public uses and enjoys birds and USFWS lands. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation has been conducted about every five years since 1955. It provides information on the number of participants in fishing, hunting, and wildlife watching (i.e., observing, photographing, and feeding wildlife), and the amount of time and money spent on these activities. The Survey is one of the Nation's most important wildlife recreation databases. It is the only source of comprehensive information on participation and expenditures that is comparable on a state-by-state basis. It is used for estimating the economic impact of wildlife-related recreation for each state; for estimating the value of wildlife resources lost due to pollution or disease, such as whirling disease in fish; for use in critical habitat analysis of threatened species; and for preparing environmental impact statements, budgets, and legislative proposals.

U.S.D.A. Forest Service

Forest Service national policy and guidelines do not provide specific goals or objectives related to bird monitoring, but they do provide general goals related to all forms of natural resource monitoring, and also offer insights into the types of data considered of value to the Forest Service. Some of the underlying themes of various goal statements are that monitoring should:

- produce highly credible data,
- provide useful information for management decision,
- provide useful information to stakeholders, and
- demonstrate collaboration with partners.

Specific goals and objectives for monitoring are generally contained within the specific Land and Resource Management Plan (LRMP) for each planning unit (i.e., one or more national forests or grasslands). Goals and objectives for monitoring specific bird species are contained in recovery plans or biological opinions for federally listed species, and are sometime reiterated in LRMPs.

The goal statement from the Forest Service Framework for Inventory and Monitoring (2000) is as follows: "Forest Service leadership is committed to using state-of-the-art methods and a systems approach to provide highly credible data and information to meet a wide range of customer business needs in collaboration with our land management partners."

Accompanying principles elaborate on this vision:

- utilize a systems approach to inventory and monitoring that adopts a holistic view, recognizes complexity and interactions, and accounts for the dynamic nature and finite capacities of ecosystems;
- inventory and monitoring are done with the clear purpose of meeting the agency business requirements (at all scales and organizational levels) as determined by the needs of our varied customers and partners;
- inventory and monitoring are conducted in coordination, cooperation, and collaboration among Forest Service program areas and organizational units and with partners and customers;
- inventory and monitoring methods and results are scientifically credible and meet rigorous quality assurance and quality control standards; and
- leadership clearly defines the structure for implementing the Framework, provides the resources needed to accomplish the tasks, and is held and holds others accountable for the success of inventory and monitoring programs.

Many national forests are still operating under the 1982 planning regulation (36 CFR Part 219), where monitoring language for Management Indicator Species is explicitly stated in Section 219.19(a)7: "Population trends of the management indicator species will be monitored and relationships to habitat changes determined."

The 2004 planning rule provides only general direction for monitoring and removes the requirement to monitor management indicator species (36CFR Part 219.6(3)(b)(2)).

The plan-monitoring program shall provide for:

- monitoring to determine whether plan implementation is achieving multiple use objectives,
- monitoring to determine the effects of the various resource management activities within the plan area on the productivity of the land,

- monitoring of the degree to which on-the-ground management is maintaining or making progress toward the desired conditions and objectives for the plan, and
- adjustment of the monitoring program as appropriate to account for unanticipated changes in conditions.

A Forest Service Handbook was prepared in 2005 to interpret and implement the 2004 planning rule (FSM 1909.13 from Land Management Planning Handbook). When developing the monitoring program, the Responsible Official shall:

- involve the public in designing the monitoring program (36 CFR 219.9(a)),
- consider multi-agency approaches,
- design the monitoring program to form the basis for continual improvement,
- design monitoring and the evaluation of monitoring results to take into account the best available science (FSM 1921.8), and
- focus on resource areas where human influence is likely to cause a change over time.

U.S. Geological Survey

Migratory bird monitoring is a critical component of the USGS Biological Resources and Monitoring Subactivity (BRM). BRM has seven research programs all of which have monitoring wildlife species as part of some aspect of their priorities. The BRM USGS Status and Trends Program is specifically designed to focus on monitoring and assessment. The Program's broad-based goal and details of specific strategies for migratory birds are listed below.

GOAL: Collect, manage, archive, and share critical, high-quality monitoring data, in cooperation with our partners, to enable a determination of the status and trends of biological resources.

Incorporate measurement of detection probability into survey design. Interpretation of results from the BBS or any other survey will be significantly enhanced, if methods to measure detection probability can be incorporated into the survey protocol.

Provide high-quality bird banding services to partners. Banding is essential for developing harvest management models for waterfowl, tracking individual bird histories in many kinds of research studies, and as a tool in environmental education. Because the services must be efficient, the BBL needs sufficient operational support.

Increase the number of species effectively monitored by long-term surveys. Effective long-term monitoring of all bird species in the U.S. is a stated goal of Partners in Flight, the U.S. Shorebird Conservation Plan, the North American Waterbird Conservation Plan, and the North American Waterfowl Management Plan.

Expand the geographic scope of existing surveys. Because most bird conservation programs have a species focus, or measure effectiveness of habitat management actions in terms of response of species, designs of long-term surveys should, when possible, allow for population inferences across the entire ranges of species.

Improve bird population database infrastructure and data delivery to partners. Status and trends surveys are most valuable to resource management partners when their databases are actively managed relational databases, delivered as part of either a centralized or distributed network electronically accessible through a single web portal.

Increase efforts to incorporate measurement of potential causative factors into population surveys. The value of surveys is greatly enhanced when data on habitat, or other factors likely to be causing the observed changes, are collected along with the population data itself.

Association of Fish and Wildlife Agencies (States)

Goals and objectives for bird monitoring that are the responsibility of the Association of Fish and Wildlife Agencies (AFWA) and member state and provincial agencies are reflected in the AFWA strategic plan (AFWA 2006) goals of the Bird Conservation Committee (Bird Conservation Committee of AFWA 2006), State Wildlife Action Plans, and individual state agency missions and goals. Integrating efforts across agency boundaries will promote sound resource management and strengthen federal, state, provincial, territorial, and private cooperation in conserving fish and wildlife and their habitats in the public interest. Coordinated monitoring must protect state authority and support provincial and territorial authority for wildlife conservation.

Critical issues affecting states, provinces, and territories include 1) adequate funding to support wildlife conservation, 2) an adequate habitat base to sustain fish and wildlife populations and those physical, chemical, biological and social factors that directly impact wildlife resources, 3) public and political support and coordination necessary to fulfill our mission, and 4) efficient and effective internal operations and business systems to maximize benefits to the wildlife resources and the public

The specific focus on bird conservation varies considerably across geographies and within states. The recently completed State Wildlife Action Plans provide lists of species of greatest conservation need that will guide much of the monitoring the states participate in and conduct in the future. State species of concern lists will also guide monitoring.

Monitoring priorities include the following:

- assess or evaluate management and/or conservation actions (e.g., habitat management),
- develop management and conservation actions,
- trend information for management of species (e.g., harvest),
- prioritize species for management and conservation,
- maintain diversity,
- evaluate how well an agency is meeting it objectives,
- determine information gaps, and
- understanding stakeholder activity, attitudes, and desires.

Priorities among agencies for bird monitoring and conservation will require integrated programs, communication, regulation, policy, and legislation.

Interagency working relationships. To cultivate relationships and mutual understanding among those officially engaged in the conservation of our natural resources, and especially to coordinate the efforts of public administrative agencies responsible for the protection, preservation and management of the fish, wildlife, forests, waters and soils of North America.

Information transfer. To distribute literature and, by other available means, to develop a more general public understanding and appreciation of the economic and ethical importance of conserving the forests, waters and soils, and of managing wisely our fish and wildlife as part of natural and managed ecosystems, and as a source of recreation and food for our citizens.

Natural resources management and restoration. To promote fish and wildlife management, and to investigate and advise with respect to the introduction of new species and varieties of fish and wildlife.

Natural resources legislation. To create and foster a healthy public sentiment in favor of better laws for protection of natural resources; to assist in the enactment of laws for the adequate protection and management of said natural resources; to obtain as far as possible uniformity in same; and to correct irregularities and inconsistencies in existing laws.

Natural resources regulations. To assist the duly constituted authorities in enforcing laws for the protection of natural resources, including fish and wildlife and their habitat.

Natural resources litigation. Generally, to take all such legal and other proper actions as will further the cause of maintaining an adequate supply of fish and wildlife and other natural resources.

Partners in Flight

The following are the continental goals and objectives for bird monitoring to meet the objectives of the North American Landbird Conservation Plan (Rich et al. 2004). Details of trend monitoring needs for landbirds, including priorities for filling in trend monitoring gaps and suggestions for new and expanded trend monitoring programs, are provided in Dunn et al. (2005a).

Continental Goals and Objectives for Bird Monitoring

Goal I: To detect and assess significant population declines in any native North American bird species.

> Objective 1: Assess monitoring status of 448+ landbird species, with ability to detect a 50 percent population decline within a 30-year period.
>
> Objective 2: Identify species (or groups) not adequately monitored to meet objective 1.
>
> Objective 3: Identify specific program improvements or new monitoring programs that can address species identified under objective 2.
>
> Objective 4: Prioritize continental monitoring needs – which new or improved programs are needed (where) to address monitoring status of highest concern species?

Goal II: To inform sound policies and prioritize actions by land management agencies that affect native bird populations, especially species of conservation concern.

> Objective 1: Identify overarching management issues (e.g., policy, land use) of greatest importance to bird populations in the North American Landbird Conservation Plan.
>
> Objective 2: Incorporate monitoring needs for priority bird species into agency management plans – to address overarching issues.
>
> Objective 3: Coordinate bird monitoring programs across agencies and organizations to increase efficiency, reduce redundancy, and therefore increase overall capacity to effectively monitor species of highest concern.

Goal III: To investigate causes of population change in species of interest

Objective 1: Conduct demographic monitoring to determine whether population change is driven primarily by reproduction or survival.

Objective 2: Communicate monitoring results to research community to encourage more detailed research into causes of population changes of interest.

Goal IV: To evaluate success of conservation planning and actions – are bird populations responding and improving?

Objective 1: Measure direct response to local management actions

Objective 2: Detect regional response to management at local scales

Objective 3: Link regional and local monitoring with continental population objectives.

North American Waterfowl Management Plan (NAWMP Plan Committee 2004)

Scaup population management. Greater and lesser scaup have not traditionally been distinguished separately in continental waterfowl breeding population surveys due to difficulties in distinguishing these species from the air. The combined continental scaup population estimate has been declining since the 1970s and concern over the status of these species has led recently to harvest restrictions. Lack of species-specific estimates of abundance and trend also hamper efforts to understand the causes of population changes and set meaningful conservation objectives.

Conservation Objective: Develop sustainable species-specific harvest strategies and regional habitat conservation strategies for greater and lesser scaup.

Management Actions: Harvest regulations, regional habitat conservation objectives and strategies stepped down from continental population objectives, environmental policies that address population stressors such as contaminants.

Management Uncertainties: Species specific population trajectories and spatial patterns of population change are currently unknown due to survey limitations. Agents causing population change and the timing and scale at which these processes operate are also unknown.

Monitoring: Monitor continental breeding population of both species utilizing a combination of aerial and ground based methods. Adjust timing of breeding surveys to coincide with scaup nesting phenology. Monitor environmental and weather factors thought to impact scaup breeding propensity and success. Evaluate the feasibility of winter surveys to monitor scaup winter concentration areas, possibly in conjunction with statistically rigorous sea duck surveys. Monitor environmental parameters including contaminants and offshore human activities (e.g., fisheries and by-catch, shipping, pollution) along with weather to assess possible effects on scaup populations.

Stakeholders: State and federal conservation agency managers and administrators, NAWMP Habitat Joint Ventures.

Mottled duck population management. No systematic and comprehensive surveys of the mottled duck breeding range currently exist. Breeding surveys are conducted annually on NWRs along the Texas Gulf Coast and suggest Western Gulf Coast mottled ducks breeding in Texas have declined recently. A statistically rigorous breeding population survey does exist for Florida mottled ducks. Mid-winter surveys are not considered adequate to assess the status of this species or to develop effective harvest strategies or conservation plans.

Conservation Objective: Develop sustainable species-specific harvest strategies and regional habitat conservation strategies for Western Gulf Coast mottled ducks.

Management Actions: Harvest regulations, regional habitat conservation objectives and strategies stepped down from continental population objectives, conservation policies that address potential population stressors such as alligator predation.

Management Uncertainties: Range-wide population trajectories and spatial patterns of population change are currently unknown due to limitations of breeding survey coverage. Agents causing population change and the timing and scale at which these processes operate are also unknown.

Monitoring: Develop a range-wide breeding population survey for Western Gulf Coast mottled ducks to determine if declines on Texas coastal NWRs are representative of population-wide trajectories. Monitor environmental, weather, and other (e.g., predation) factors thought to impact mottled duck breeding success.

Stakeholders: State and federal conservation agency managers and administrators, the Gulf Coast Joint Venture.

Sea duck population management. Many sea duck species have not traditionally been adequately monitored through continental waterfowl breeding population surveys because large portions of some species northern breeding ranges lie outside surveyed areas and because of the cost and specialized equipment requirements of operating in arctic regions. Traditional winter surveys do not include offshore habitats utilized by some species. Available population estimates of scoters, long-tailed ducks, and some eider populations have declined over recent decades.

Conservation Objective: Develop sustainable species-specific harvest strategies and regional habitat conservation strategies for sea ducks, especially scoters, long-tailed ducks, and eiders, not adequately monitored through traditional breeding and wintering surveys.

Management Actions: Harvest regulations, regional habitat conservation objectives and strategies stepped down from continental population objectives, environmental policies that address potential population stressors such as contaminants, fisheries by-catch, and offshore development in wintering areas (e.g., sand mining for beach nourishment, wind power development).

Management Uncertainties: Species specific population trajectories and spatial patterns of population change are currently unknown due to survey limitations. Agents causing population change, and the timing and scale at which these processes operate, are also unknown.

Monitoring: The Sea Duck Joint Venture of the NAWMP has identified priority breeding and wintering surveys for populations of sea ducks recognized by the NAWMP. Monitor species-specific breeding populations of certain arctic breeding sea ducks possibly in conjunction with surveys of arctic nesting geese.. Adjust timing of breeding surveys to coincide with sea duck nesting phenology. Monitor environmental and weather factors thought to impact sea duck breeding propensity and success. Evaluate the feasibility of winter surveys to monitor sea duck winter concentration areas, possibly in conjunction with statistically rigorous diving duck (e.g., scaup) surveys. Monitor environmental parameters including contaminants and offshore human activities (e.g., fisheries and by-catch, shipping, pollution) along with weather to assess possible effects on sea duck populations.

Stakeholders: State and federal conservation agency managers and administrators, the Sea Duck Joint Venture, and NAWMP Habitat Joint Ventures.

Population-scale, multi-regional conservation planning. The NAWMP is predicated on the assumption that the cumulative effects of regional conservation actions implemented or directed (e.g., conservation programs or policies such as the CRP or WRP programs) through joint ventures will result in range-wide habitat conditions suitable for attainment of NAWMP continental population objectives. A challenging aspect of conservation planning for migratory waterfowl is accounting for cross-seasonal effects of regional habitat and weather conditions on duck populations. Knowledge of the effects of regional conditions on intra-seasonal movements, migration timing and patterns, body condition, survival, and settling patterns would assist in development of regional conservation strategies that account for cross-seasonal influences on population abundance and demography. Comprehensive, large-scale monitoring programs for the mallard already exist and similarities to other dabbling species in habitat requirements and migratory behavior make the mallard a good candidate for investigation.

Conservation Objective: Develop coordinated regional habitat conservation strategies for mallards (and possibly other species of interest, e.g., northern pintail) that account for cross-seasonal influences of habitat and weather conditions.

Management Actions: Regional habitat conservation objectives and strategies stepped down from continental population objectives that are sensitive to heterogeneity and stochasticity in regional habitat and weather conditions.

Management Uncertainties: The effects of within season and annual variation in habitat availability and quality and weather conditions on within season movements, migration, body condition, survival and settling patterns of ducks are poorly understood.

Monitoring: Conduct a coordinated, large-scale satellite and conventional telemetry study of mid-continent mallards (and possibly other species of interest) in conjunction with traditional banding, population, and harvest surveys to track within season and annual movement patterns, monitor body condition, and estimate survival rates. Monitor weather, habitat, and other environmental parameters in key habitat regions to assess the effects of environmental variability on mallard movements, body condition, survival, and settling.

Stakeholders: State and federal conservation agency managers and administrators, NAWMP Habitat Joint Ventures.

Duck production in the prairie parkland region**.** Information on annual duck production from the prairie-parkland region provides important verification of predictions made during the process of establishing annual hunting regulations, predictions made without knowledge of changes in habitat conditions that occur between spring breeding surveys and early summer. Species-specific indices of production, as well as spatial and temporal pattern in these indices, are also critical to validating the predictions of models used in habitat conservation planning in the prairie parkland region and in refining these models. Budget constraints in the FWS forced the cancellation of the long-standing Waterfowl Production and Habitat Survey, which was conducted every July. This survey has not been conducted since 2003. Prior to the cancellation of this survey, it had come under scrutiny because it lacked methods to estimate detection rates, did not provide species-specific indices, and did not provide insight into season-long production.

Conservation Objective: Validate and refine models to predict prairie parkland duck production at local and regional scales in order to establish effective harvest regulations and develop appropriate habitat conservation strategies.

Management Actions: Harvest regulations, regional habitat conservation objectives and strategies stepped down from continental population objectives, land use policies such as the CRP.

Management Uncertainties: Local and regional duck production and the relationship of production to landscape attributes, weather conditions, and population size.

Monitoring: Develop improved procedures to monitoring duck production from the prairie parkland region. These methods should result in species-specific indices to production that can be summarized at local and regional scales and can be related to landscape attributes, breeding population estimates, and weather conditions. The FWS and CWS have recently begun to explore a variety of ground-based and aerial survey methods to assess production, and these efforts should continue in a coordinated fashion.

Stakeholders: State and federal conservation agency managers and administrators, NAWMP Habitat Joint Ventures, HAPET Offices.

Waterbird Conservation for the Americas

Population monitoring programs support two major goals of the Waterbird Conservation for the Americas: North American Waterbird Conservation Plan, Version 1 (Kushlan et al. 2002.) Data collected by these programs are integral for achieving the species and population goal of ensuring "sustainable distributions, diversity, and abundance of waterbird species throughout each of their historical or naturally expanding ranges in the lands and waters of North America, Central America, and the Caribbean." Monitoring information also identifies locations receiving significant use by waterbirds, helping to meet the habitat goal "to protect, restore and manage sufficient high quality habitat and key sites for waterbirds throughout the year to meet species and population goals."

Effective monitoring to meet these goals requires surveillance and management-based approaches combined with information on demographic parameters and environmental covariates, carefully crafted to obtain data at appropriate geographic and temporal scales. This multi-dimensional approach fosters collaboration among agencies and individuals concerned about waterbirds, resulting in efficient use of limited resources, better informed management decisions, and broad support for conservation actions.

Monitoring information will meet the objectives of the Waterbird Initiative by:

- establishing population status and trends for all waterbirds in North America, Central America, and the Caribbean,
- defining sustainable population goals for all species at regional and continental scales,
- identifying key marine, coastal, and freshwater habitats for breeding, wintering, migrating, roosting, and foraging waterbirds,
- increasing our understanding of waterbird habitat requirements and how habitat management activities can be improved to benefit their populations,
- collecting data on demographic parameters for some species to identify factors responsible for population changes, and
- identifying significant threats to waterbird populations and habitat quality in order to take appropriate conservation actions.

U.S. Shorebird Conservation Plan

At a regional scale, the goal of the plan is to ensure that adequate quantity and quality of habitat is identified and maintained to support the different shorebirds that breed in, winter in, and migrate through each region. At a national scale, the goal is to stabilize populations of all shorebird species

known or suspected of being in decline due to limiting factors occurring within the U.S., while ensuring that common species are also protected from future threats. At a hemispheric scale, the goal is to restore and maintain the populations of all shorebird species in the Western Hemisphere through cooperative international effort.

Monitoring goals of the U.S. Shorebird Conservation Plan (Brown et al. 2001), catalyzed in the Program for Regional and International Shorebirds Monitoring (PRISM; see <http://www.fws.gov/shorebirdplan/USShorebird/CommitteeReports.htm>) are presented below.

- *Conduct statistically valid monitoring of long-term, species-specific population trends*. This goal is critical to determining the status of existing populations, and the long term effects of large scale conservation activities.

- *Provide more precise estimates of population size for shorebird species*. This goal allows for conservation planning at a variety of scales, based on accurate information about species distribution and status.

- *Monitor shorebird use of major staging areas, migration pathways, and wintering areas.* This goal supports management activities targeted to specific life history states of shorebirds, helps identify key areas for shorebird conservation, and helps measure the success of local conservation activities.

- *Ensure that shorebird population information is effectively integrated into national bird conservation planning and implementation.* This goal supports the appropriate use of monitoring data in design and evaluation of conservation activities, and encourages communication between diverse wildlife research, monitoring, and management agencies and organizations.

Objectives to achieve these national monitoring goals are detailed in the Shorebird Plan. Few shorebird species are monitored adequately at this time, and despite their widespread distribution, information regarding many shorebird species is lacking. The PRISM was developed to address all of the monitoring goals of the Plan.

APPENDIX 2. GOALS AND OBJECTIVES FOR BIRD MONITORING

Based on the stated monitoring goals and objectives of each agency and bird initiative (see Appendix 1), several common themes emerged that reflect shared priorities across the bird conservation community. Listed below are the goal statements of each NABCI partner that fall within these broad themes. Note that some broad goals of bird monitoring, such as determining causes of population declines or assessing human dimensions, remain beyond the scope of the present report.

DETERMINE STATUS AND TRENDS OF POPULATIONS

- Detect and assess significant population declines in any native North American (landbird) species (PIF)
- Conduct statistically valid monitoring of long-term, species-specific population trends (SB)
- Establish population status and trends for all waterbirds in North America, Central America, and Caribbean (WB)
- Track changes in waterfowl abundance and habitat to enable assessment of status and the development of abundance objectives (NAWMP)
- Determine the status of migratory birds and the need to list any bird species as threatened or endangered (USFWS)
- Collect, manage, archive, and share critical, high-quality monitoring data to enable a determination of the status and trends of biological resources (USGS)
- Document trends for management of species (e.g., harvest) (AFWA)
- Document trends of the management indicator species and determine relationships to habitat changes (USFS)

INFORM MANAGEMENT AND POLICIES TO ACHIEVE CONSERVATION

- Inform sound policies and prioritize actions by land-management agencies that affect native bird populations (PIF)
- Ensure that shorebird population information is effectively integrated into national bird conservation planning and implementation (SB)
- Increase understanding of waterbird habitat requirements and how habitat management can be improved to benefit populations (WB)
- Identify significant threats to waterbird populations and habitat quality in order to take appropriate conservation actions (WB)
- Inform adaptive management decisions based upon waterfowl population trends and habitat status (NAWMP)
- Regulate and manage the take of migratory birds (USFWS)
- Develop management and conservation actions (AFWA)
- Determine whether plan implementation is achieving multiple use objectives (USFS)

DETERMINE CAUSES OF POPULATION CHANGE

- Investigate causes of population change and conduct demographic monitoring (PIF)
- Collect data on demographic parameters to identify factors responsible for population change (WB)
- Improve methods to monitor habitat carrying capacity, vital rates and harvest rates to better understand mechanisms— causing changes in abundance (NAWMP)
- Understand the effects that environmental factors have on bird population dynamics (USFWS)
- Increase efforts to incorporate measurement of potential causative factors into population surveys (USGS)

EVALUATE CONSERVATION EFFORTS

- Evaluate conservation planning and actions (i.e., are bird populations responding and improving?) (PIF)
- Test assumptions underlying habitat conservation objectives, and evaluate conservation actions, seek cohesion of population objectives with adaptive harvest management
- Evaluate the recovery of listed bird species (USFWS)

EVALUATE CONSERVATION EFFORTS (continued)

- Assess effectiveness of projects implemented on lands owned by the USFWS or influenced by USFWS grants, programs, or policies (USFWS)
- Determine Program efficiency and effectiveness (USFWS)
- Assess or evaluate management and/or conservation actions (e.g. habitat management) (AFWA)
- Evaluate agency objectives (AFWA)
- Determine information gaps (AFWA)
- Determine the effects of the resource management activities within the plan area (USFS)

SET POPULATION OBJECTIVES AND SPECIES/MANAGEMENT PRIORITIES

- Provide more precise estimates of population size for shorebird species (SB)
- Define sustainable population goals for all species at regional and continental scales (WB, PIF)
- Provide science-based biological foundation to address Joint Venture (JV) management needs.
- Set spatially explicit management and conservation priorities by habitat and species (USFWS)
- Prioritize species for management and conservation (AFWA)
- Establish goals and measure progress in recovery plans or biological opinions for federally listed species, (USFS)
- Improve capability to assess population status and trend for poorly monitored waterfowl species to enable development of explicit, internationally recognized population objectives (NAWMP)

INFORM CONSERVATION DESIGN

- Monitor shorebird use of major staging areas, migration pathways, and wintering areas (SB)
- Identifying key marine, coastal, and freshwater habitats for breeding, wintering, migrating, roosting, and foraging waterbirds (WB)
- Disseminate scientific conservation techniques/information to influence conservation/agricultural land use.
- Set goals and objectives for monitoring within the specific Land and Resource Management Plan (LRMP) for each planning unit (i.e., one or more national forests or grasslands) (USFS)
- Set spatially explicit management and conservation priorities (NAWMP, USFWS, PIF)

ASSESS HUMAN DIMENSIONS

- Conduct hunter and harvest surveys to assess hunter attitudes and preferences (USFWS)
- Determine how the American public uses and enjoys birds and USFWS lands (USFWS)
- Understand stakeholder activity, attitudes, and desires (AFWA)
- Measure performance at all scales and organizational levels as determined by the needs of our varied customers and partners (USFS)

Key to Abbreviations

PIF = Partners in Flight

SB = U.S. Shorebird Conservation Plan

WB = North American Waterbird Conservation Plan

NAWMP = North American Waterfowl Management Plan

AFWA = Association of Fish and Wildlife Agencies

USFWS = U.S. Fish and Wildlife Service

USFS = U.S. Forest Service

USGS = U.S. Geological Survey

APPENDIX 3. BRIEF OVERVIEW OF CURRENT MONITORING PROGRAMS

The U.S. NABCI Monitoring Subcommittee plans to support an evaluation of existing monitoring programs that are continental, national, or regional in scope, in order to identify opportunities to increase efficiency and improve standardization. Here we briefly summarize our knowledge of a few existing bird monitoring programs and how they currently contribute to bird conservation. This overview is based on monitoring reports from each of the bird initiatives, on recent overviews published by Bart et al. (2004) and Bart (2005), and on publications related to specific monitoring programs. By no means does this represent an exhaustive review of all monitoring programs in the U.S.

Continental, multiple species monitoring programs

Program descriptions

This section describes three large scale monitoring programs: the Breeding Bird Survey (BBS), the Waterfowl Breeding Population and Habitat Survey, and the North American Monitoring Avian Productivity and Survivorship (MAPS) program. Generally speaking, the goals of these programs are to obtain and disseminate information on bird abundance and trends (and in the case of MAPS, to provide productivity and survivorship information), to make informed management decisions, identify species most in need of conservation attention, and identify research needs. All three programs use consistent survey methods that can be undertaken at a fairly reasonable cost, and all maintain central data repositories from which data analyses can be performed at a variety of spatial scales. Canada and Mexico collaborate on the BBS and Waterfowl surveys, and Canada, also collaborates on the MAPS program.

The Breeding Bird Survey began with 600 routes in 1966 and has expanded to over 4,400 routes, with approximately 2,900 routes surveyed annually (see <http://www.pwrc.usgs.gov/bbs/bbsnews/Memos/>). It was initiated by the U.S. Fish and Wildlife Service and was transferred to U.S. Geological Survey in 1993. The Waterfowl Breeding Population and Habitat Survey is an annual May survey that has been in place since 1955, and covers the prairie pothole region, boreal forests, and tundra habitats from South Dakota to Alaska. During the 1990s, this survey was expanded to include waterfowl breeding habitats in eastern North America. It is coordinated by the USFWS Division of Migratory Bird Management. The MAPS program was established in 1989 by the Institute for Bird Populations (IBP) and has been continuously growing in the number of stations and spatial coverage. Currently there are over 500 stations in the United States and Canada, using a field protocol that was standardized in 1991 (Desante and Nott 2000, DeSante pers. comm.).

The BBS and Waterfowl Survey programs are remarkable in their long-term stability, the development and maintenance of centralized data repositories, and the use of qualified biometricians for data analysis. For decades, the Waterfowl Breeding Population and Habitat Survey has been the primary source of population information for setting waterfowl management objectives. Data from the Breeding Bird Survey has influenced management actions and sparked research questions, particularly since the mid-90's when the data and analysis tools were made available on the Patuxent Wildlife Research Center website. Because of its shorter history, MAPS does not yet have a long-term database, but it has a centralized data repository, housed at IBP, and employs qualified biometricians for the analyses that have emerged from the first 15 years of standardized data collection.

Program limitations

Continental programs have limitations that primarily stem from the need to keep costs of these vast programs manageable. Many species are not adequately sampled because the short duration of the survey period does not coincide with their breeding phenology. For example, the Waterfowl Breeding Population and Habitat Survey is not optimally timed for most diving ducks (NAWMP Plan Committee 2004).

Several woodpeckers and a number of desert species are poorly sampled by the BBS because their breeding activity takes place prior to the survey period (Dunn et al. 2005a).

Other species are not adequately sampled because the survey areas do not include sufficient representation of their breeding range. The core breeding ranges of approximately half of the sea ducks are not adequately covered by the Waterfowl Breeding Population and Habitat Survey (NAWMP Plan Committee 2004). Of the landbirds, 167 species are not adequately monitored because more than one-third of their ranges are within the northern boreal regions (Bart et al. 2004). Breeding Bird Survey routes also are not adequate for most species that breed at high elevations (or have clumped/disjunct distributions). MAPS was primarily designed for a limited number of landbirds, although this number could increase with expansion of the program into more habitats.

All three programs have limitations related to sampling approaches. Methods to estimate detection probabilities are only partially incorporated into the Waterfowl Breeding Population and Habitat Survey, and such methods are not a part of the BBS sampling design. Unlike these programs, MAPS uses constant-effort mist-netting that enables field personnel to mark individuals so that abundance can be estimated from modified Cormack-Jolly-Seber mark-recapture models (DeSante and Nott 2000). The disadvantage to this approach is that extensive expertise is required to conduct mist netting, band individuals, and accurately separate birds into age categories.

The extensive nature of the BBS and Waterfowl Survey makes it difficult to collect habitat data that could be meaningfully correlated with annual abundance and multi-year trends. Different vegetation types are used as habitat across a species' range, and each of these vegetation types undergoes regional or local changes in quality or quantity. In spite of these shortcomings, these programs provide value in the context of their initial objective of providing abundance and trend information over broad spatial extents (Bart et al. 2004, Bart 2005).

MAPS has begun to incorporate habitat information by using landscape metrics within a 4 km radius of the mist-netting stations, and this appears to be a useful characterization for the targeted species that have been evaluated (DeSante and Nott 2000). Additionally, MAPS data have been successfully used to correlate forest management actions with bird productivity, demographics, and abundance (Nott et al. 2003, 2005). However, habitat information requires additional data collection and funding beyond the core MAPS program, so it is not always obtained.

The Waterfowl Breeding Population and Habitat Survey provides reliable estimates for seven species of dabbling ducks (NAWMP Plan Committee 2004), and the BBS adequately monitors 153 of the 448 species of landbirds that regularly breed in North America (Dunn et al. 2005a). The utility of the Waterfowl Breeding Population and Habitat Survey could be increased for diving ducks and sea ducks by expanding the temporal and spatial extent of this program (NAWMP Plan Committee 2004). Similarly, the number of adequately monitored landbirds could be increased to approximately 237 species, which represents 53 percent of all landbirds and 80 percent of landbirds for which the BBS is an appropriate monitoring method, if recommendations for expanding and improving the BBS are adopted (Bart et al. 2005, Dunn et al. 2005a).

There are no continental programs in place that adequately monitor several groups of species, including colonial waterbirds, secretive marshbirds, nearly all of the shorebirds, and approximately half of the landbirds. The Christmas Bird Count has some utility in assessing long-term trends of some species, especially those that exhibit obvious range expansions and contractions, and those with large wintering populations within the continental U.S. (Dunn et al. 2005b). Additionally, the eBird program, an on-line database sponsored by the Cornell Lab of Ornithology, enables all citizens to record and retrieve bird observations, and could become a useful tool for observing changes in abundance and distribution of certain bird species.

There is a shared desire under most bird initiatives to increase the proportion of bird species that are monitored under continental programs and to increase the adequacy of the monitoring effort for those that are marginally included. As new programs are initiated, the development of fully accessible databases should also be advanced (Bart 2005).

Multiple species programs at the regional and multi-state or provincial scale

A number of multiple species bird monitoring programs are coordinated at the regional, multi-state, or provincial scale. Each program is characterized by one or more standard field protocols for a group of species, but these protocols frequently vary by region. As with the continental programs, the primary objective is to estimate abundance and trend for a suite of species. In some cases, the data are aggregated across a nation or continent, and in other cases the data are managed and reported at a state, multi-state, or provincial scale.

The Midwinter Waterfowl Inventory. This survey, conducted annually in early January since the mid-1940's, is an example of a long-standing, continent-wide survey in which the field protocols vary by state and province (NAWMP Plan Committee 2004). The objective is to obtain a complete census of all waterfowl within a prescribed survey area using a detection method that is considered the best and most practical for a specific area. Although the Midwinter Waterfowl Inventory provides information on many species that are not adequately monitored during the breeding season, the ability to aggregate data and estimate trends is hampered by regional differences in field methods (Eggeman and Johnson 1989). Moreover, it is generally not possible to make inferences about state and regional populations because of the manner in which survey areas are selected, annual differences in survey efforts, and other factors. Despite these limitations, this survey remains the only source of status information for several harvested waterfowl species, including brant and tundra swans.

Colonial waterbird surveys. Several surveys have been conducted since the early 1970s by various federal and state agencies and private organizations (Moser and Jones 2000, Kushlan et al. 2002). Included in this suite of multiple species programs are those that target freshwater wading birds and others that focus on seabirds. These surveys provide the only long-term data for the majority of species in these groups, but the data have limited application due to methodological shortcomings and differences in methodology across regions. Although the need to improve and standardize survey methods is well recognized, many regions are hesitant to abandon current methods that have yielded decades of data. The Waterbird Monitoring Partnership provides a web-accessible database of data from individual waterbird surveys, but because of differences in survey methods, the data are not collated.

Shorebird surveys. The current monitoring situation for shorebirds is similar to that of waterbirds, in that the various programs are regional in scope and use different methodologies. The International Shorebird Survey, Maritimes Shorebird Survey, Western Shorebird Survey, British Columbia Coastal Waterbird Survey, and South Atlantic Migratory Bird Initiative are all migration surveys that use different methods with different sets of strengths and shortcomings. A few shorebird species are also monitored under the BBS and Christmas Bird Count programs. The Program for Regional and International Shorebird Monitoring (PRISM) (Bart et al. 2002) summarizes the current level of monitoring provided for 74 species, subspecies, or distinct populations of shorebirds in Canada and the U.S., under existing programs. Many shorebirds breed in the arctic and boreal regions and are currently inadequately monitored, and for these, PRISM recommends double sampling, with rapid surveys on numerous, randomly selected plots, and intensive work on a subset of these plots to obtain detection rates on the rapid surveys. Arctic surveys that use double sampling have already been established in some areas. The breeding ranges of 17 shorebird species are within the central, temperate regions of North America, but currently only 6 of these are adequately monitored through existing programs. Winter surveys in Central and South America at major shorebird concentration areas are needed for populations of many North American shorebirds.

Raptor migration. In 2003, the Hawk Migration Association North America (HMANA), Hawk Mountain Sanctuary Association, and HawkWatch International formed the Raptor Population Index (RPI) Partnership to develop a common set of indices for estimating raptor populations and trends at spring and fall migration sites in Canada, the U.S., and Mexico. Since its establishment, RPI has developed and distributed a standardized protocol for the collection of raptor migration counts. It has created a web-based data management system <http://www.hawkcount.org>, managed by HMANA, for raptor migration counts, and enlisted the participation of more than 160 hawk watch sites. The data management system stores metadata and daily or hourly migration counts for each of the participating hawk watches. In 2005, HMANA hired a full-time project director and part-time data manager for RPI assisted by a challenge grant from the National Fish and Wildlife Foundation. Since January 2005, RPI has generated population index and trend information for 19 participating autumn hawk-watch sites in eastern and western North America, and analyses are underway for additional suites of spring hawk watches in North America and autumn hawk watches in Central America. These analyses facilitate examination of population trends on local, regional, and continental scales for 21 species of migratory raptors. Trend analyses are presented on a newly developed RPI website <http://www.rpi-project.org> which eventually will provide bi-annual updates of raptor trends from sites across the continent. Further development of the network and methods will allow monitoring of additional species of raptors and increased geographic coverage.

Landbird surveys. Several regional monitoring programs for landbirds have been in place for several years, either using point counts or MAPS. Examples are the Northern Rockies Landbird Monitoring Program (12 years,), Monitoring Colorado Birds (7 years), Songbird monitoring in the Great Lakes Region (14 years), Landbird Monitoring for the Klamath-Siskiyou Bioregion (14 years), Southern Region Neotropical Migrants and Resident Landbird Monitoring (8 years), and Nevada Bird Count (4 years). Most programs provide web-accessible data summaries and some provide access to raw data. Each of these programs uses different sampling designs, so data and programs will likely remain at the regional scale, but all programs have contributed information to numerous management decisions within their respective regions. The information includes short-term trend data (< 20 years to date) and improvement of regional bird-habitat relationships models.

A national monitoring protocol to measure the response of landbirds and northern bobwhite quail to USDA-FSA CRP-479 conservation practice 33, habitat buffers for upland wildlife, was implemented in summer 2006. The Southeast Quail Study Group developed a multi-stage sampling framework for monitoring CP-33 that insures consistency in data collection among states and facilitates statically valid measures of effectiveness of the practice regionally and nationally.

The Birds and Burns Network is a regional program that examines fire effects on populations and habitats of wildlife in ponderosa pine forests (Saab and Powell 2005). The targeted species are cavity-nesters and songbirds. For prescribed fire effects, the Network uses a Before, After, Control, Impact (BACI) design with replication at 9 locations in 8 western states, including locations on National Forests, National Parks, and state and private lands. Additional monitoring is carried out at wildfires in 4 states, to compare prescribed fire and wildfire effects.

Seabird monitoring. The North Pacific Seabird Colony Database is a computerized, GIS-based database <http://alaska.fws.gov/mbsp/mbm/northpacificseabirds/colonies/>. It contains the locations and names of all Alaska's seabird breeding colonies, the species of birds that nest in each colony, and the numbers of each species. Systematic surveys of seabird abundance have been ongoing in Alaska for decades. The North Pacific Pelagic Seabird Database (NPPSD) project has collected data from researchers in Canada, Russia, and the U.S. (1972-2003). Currently work is being done to integrate these different datasets into a single database that will be available over the internet through an Arc/IMS (Internet Map Server) interface. The NPPSD will be an ongoing project that will serve as a repository and server for future pelagic survey data from the North Pacific. The Pacific Seabird group is currently developing a

comprehensive database for seabird monitoring results from throughout the North Pacific. Though not yet available for general release, the Pacific Seabird Monitoring Database includes more than 11,000 observations, each representing an annual measure of some population parameter (e.g., numbers, productivity, survival, breeding chronology, or other) for a given species, location, and year. Those observations comprise about 1,800 time series spanning 1 to 37 years since studies were initiated. Some quantity of information is available on 54 species breeding in 190 locations. A draft version of the database is now undergoing review and error-checking by cooperators; wider distribution via the Internet is anticipated within 1-2 years.

Range-wide, single species programs

Single-species monitoring programs are needed for obtaining long-term trends on species that are rare or are restricted to a specific habitat or locality. An estimated 10-15 percent of all birds that breed in North America fall into this category, but this estimate is rough because only Partners in Flight has published a detailed evaluation. This evaluation recommends single-species programs for 33 landbirds that represent 7 percent of the 448 landbird species that regularly breed in Canada and the U.S. (Dunn et al. 2005a). Of these, 10 species currently have single species, range-wide monitoring programs in place. Many of these species are federally listed, and the monitoring programs are part of the species' recovery plan.

The U.S. Fish and Wildlife Service Division of Migratory Birds and the Canadian Wildlife Service coordinate two single species monitoring programs: the Mourning Dove Call-Count Survey and the Woodcock Singing-Ground Survey. Both surveys provide one source of information considered in the establishment of annual hunting regulations for these species.

Most species with single-species monitoring needs do not have monitoring programs with a consistent protocol across the range of the species. Commonly, different jurisdictions carry out sporadic monitoring with very little consistency in field methods and little to no inclusion of a sampling design. The data have short half-lives, rarely lasting longer than the tenure of the biologist who established the program. Analysis of data is extremely rare and fraught with statistical shortcomings.

APPENDIX 4. EVALUATION CRITERIA

The U.S. NABCI Monitoring Subcommittee intends to assess the current state of bird population monitoring in the United States. In doing so, the Subcommittee will review the hundreds of programs throughout the country with the following criteria in mind:

Rationale:

- Clearly articulated survey objectives provide management and conservation context.

Design:

- Explicitly defined geographic scope and spatial sampling unit.
- Taxa and inferential populations are defined.
- Primary response variables and environmental covariates.
- Survey protocols (sampling frame, procedures, precision and bias).
- Appropriate analytical procedures.
- Long-term data storage and access, preferably in a central facility.

Coordination

- Clearly defined responsibilities across geographic coverage.
- Training programs.
- Accessible reports, data, and metadata.

APPENDIX 5. DATA MANAGEMENT SYSTEMS

Defining objectives of data management systems

Just as most monitoring programs are developed to meet specific objectives, data management systems should be established to meet objectives related to these programs. Most data systems are designed with little consideration of how one system may interact with others. Finding the proper balance between programmatic objectives and the objectives of a larger "network" of databases can be problematic, especially when these objectives are conflicting.

Approaches for resolving this problem: Data managers should describe the objectives of each data management system so that the intended uses and audiences are clearly identified. When data bases are posted on the Internet, the objectives should be evident on the primary entry page into the website, not buried in the metadata.

Resources needed: Defining objectives for data management systems is an educational process for biologists and data managers. A group of data management experts from the bird conservation and bioinformatics communities should convene to develop recommendations to address this issue, preferably concurrent with a review of the status of existing databases and how these databases could be coalesced into coordinated data management systems.

Taxonomic issues

Avian taxonomy is constantly changing. For data collected over decades, the taxonomic treatment of a single species can change multiple times. Keeping databases current with every taxonomic change and updating historic data to meet new taxonomic treatments can be costly. Most users do not want to become taxonomic experts in order to interpret data sets. Hence, taxonomic treatments must be transparent or major problems can occur. Three somewhat related issues are identified below.

Inconsistent taxonomies used across databases: Some problems here include using non-standard taxonomies (i.e., not following the American Ornithologists' Union within its geographic area of coverage), use of conflicting taxonomies in regions where a "standard" taxonomy does not exist (i.e., in South America), and maintaining data at different taxonomic levels (i.e. storing data at subspecific level in some databases but not in others).

Use of outdated taxonomy: Interpreting data stored using outdated taxonomic treatments can be problematic, especially if recent data collected using a different and newer taxonomy is also stored in the same database.

Inconsistent updating of existing records*:* Such inconsistency results in major data interpretation issues, especially for species whose taxonomic status has been modified multiple times.

Approaches for resolving this problem: At a minimum, data managers should be consistent in their taxonomic treatment of species. Adopting new taxonomic treatments requires updating existing data in accordance with these new treatments. This problem can be addressed by developing a query tool that describes recent taxonomic changes that have occurred for each species and allowing the user to define the specific taxonomic treatments that meet their needs. This query tool can then search databases and retrieve data stored using different taxonomic systems. Such a query tool could be developed based on the AVIBASE search tool developed by Dennis LePage at Bird Studies Canada and available at <http://www.bsc-eoc.org/avibase/>.

Resources needed: Funding is required to develop this query tool, whether it is based on AVIBASE or some other application that provides synonyms for current bird nomenclature. A group of data managers and taxonomists may need to develop the requirements for this query tool. Funding would be needed to create the tool.

Maintenance of "distributed" data management systems

Once distributed data management systems are established, they require maintenance in order to function properly. Maintenance is normally conducted at the level of individual databases, causing these costs to be borne by each monitoring program. Some long-term database maintenance issues include:

Maintaining functionality when local databases are updated: Database modifications are necessary for all systems, especially programs that are fairly new and the data management objectives are not yet well established. Both the database structure and the data collected can change. As these systems change, the process linking distributed databases must be modified to keep the system functioning properly.

Reliable access to data sources: Local database servers must be online to be accessed by the distributed system. If servers are frequently unavailable, those datasets are not available for use in the system.

Security issues and access to data: Data security is an ongoing concern and security requirements are constantly changing to meet the challenges posed by new threats. Major changes to security requirements can affect the operations of the entire system and potentially require major maintenance expenses if the entire network is to remain functional.

Approaches for resolving this problem: Maintaining a distributed network of data management systems requires funding on an annual basis. Requiring each system to devote resources towards maintaining their component of this network is not viable given the limited resources available for data management. This approach would eventually result in a network composed of systems receiving substantial organizational support. Given the complexity of network security issues, systems within this distributed network require considerable support from network administrators to circumvent problems as they arise.

Resources needed: Reliable long-term funding sources are required to maintain the functionality of any distributed network of bird population monitoring databases. For important data management systems having minimal organizational support, system administrators may have to provide maintenance and security functions needed to keep the entire network accessible.

Other components required for a fully functional distributed data management system include developing data exchange schemas, applying new technologies to harvest data across the distributed resources as they become available, integrating data across monitoring projects, and acquiring access to data sets and the rights to use data for specific purposes. Some of these components require cooperation from program and database managers, while other aspects, such as developing schemas and applying data harvest technologies, require additional funding.

Balancing the need for "centralized" vs. "distributed" databases

There are advantages and disadvantages to both types of data management systems. Centralized systems offer economic efficiency because of reduced hardware and software costs. Distributed systems are more expensive to maintain but offer greater control to program managers. Finding the proper balance to achieve economic efficiency yet retain programmatic control over data is the challenge, and this balance may shift as new technologies emerge. In any case, this issue must be resolved by consensus among system cooperators, facilitators, and administrators. Reducing data management costs should be a goal because those resources can then be shifted to data collection and on-the-ground conservation.

Approaches for resolving this problem: This issue raises the question of how many database systems are necessary to maintain data from bird population monitoring programs. This question may not be answerable today, but the number of database systems should be finite. The number of databases will be larger than the number of database systems, recognizing that multiple agencies/organizations may want to maintain similar database systems that meet their specific information needs while also benefiting the entire bird conservation community.

Resources needed: The U.S. NABCI Committee should play a lead role in facilitating these discussions, recognizing that it cannot dictate solutions, but would attempt to improve coordination among agencies and organizations involved in managing bird population monitoring data sets and improve the efficiency of data management operations. Important issues are control of data and the desire to maintain data resources locally, as compared with the increased efficiency, standardization, and persistence of centralized systems. New technologies are blurring some distinctions between these types of data management systems. But data management at any level can be expensive and reduce funding available for conservation purposes. Hence, economies gained from the use of centralized systems results in more resources available for conservation activities.

Permanent archives for monitoring data sets

The persistence of bird population monitoring data sets and their availability over time is becoming an increasingly important issue. Some monitoring data have disappeared when scientists retire or change

jobs. Even for programs with organizational support, data sets have disappeared following the termination of monitoring programs or when budgetary limitations reduce the funding available to maintain data management systems. Other problems include storing data on archaic hardware or on proprietary data management systems no longer supported by their manufacturers. For all of these situations, the net result is that important bird population data sets may become inaccessible to users.

Approaches for resolving this problem: Permanent data archives to store and maintain bird population data sets are needed so that important information resources are not lost. These archives must be readily accessible for long-term use.

Resources needed: Organizations willing to perform this role need to be identified. Funding will be needed to support archival processes and the long-term maintenance of data sets, including their periodic transfer to current data storage hardware/software so that they remain accessible to the user community.

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