A Summary of Current Thought on Avian Monitoring

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Abstract: A working group of the International Association of Fish and Wildlife Agencies' Science and Research Committee reviewed the rationale, design, and coordination of bird monitoring during 2004 to focus on the need for integration of information about bird status with budget, policy, and management decisions. "Rationale" promotes understanding of the role of monitoring in effective bird conservation and management, "design" of monitoring focuses on the effective and efficient use of monitoring resources, and "coordination" emphasizes the necessary infrastructure and resources for coordinated monitoring. Science-based management requires explicit objectives, management strategies and corresponding management actions, assessment, and periodic adjustment of management strategies. Distinctions between monitoring for status and trends versus monitoring to evaluate management have, however, become a source of debate among those responsible for bird monitoring. The bird conservation community should be concerned if these distinctions represent a fundamental philosophical disconnect among segments of the bird conservation community, which perpetuate "game" versus "nongame" distinctions. In the end, a continuum of monitoring approaches will need to be employed to increase our knowledge of resource impacts. The scale of monitoring coordination and infrastructure is dictated by the scale at which management is occurring. Clearly, efforts to advance all bird conservation will require greater integration of the essential roles of researchers, policy makers, and managers.

Key Words: birds, monitoring, management, coordination, evaluation

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This paper is a summary of a report by a working group of the International Association of Fish and Wildlife Agencies' (IAFWA) Science and Research Committee that was developed at the request of the U.S. Fish and Wildlife Service (USFWS) and the U.S. Geological Survey (USGS). The working group and the entire list of authors of this paper includes three state (Mace Hack, Jay Roberson, and Dale Humburg), three USFWS (Brad Andres, Hal Laskowski, and Mark Koneff), and three USGS representatives (Jon Bart, Jim Nichols, and Dave Otis), along with input from U.S. Forest Service (Beatrice Van Horne and Christina Vojta) and support from Ken Williams (USGS), Brian Millsap, Bob Ford, and Bob Blohm (USFWS), and Mike Hubbard (MDC). In large part, the text in this manuscript is taken verbatim from the

IAFWA report (Monitoring Avian Conservation: Rationale, Design, and Coordination) and follow-up evaluation from more than 50 individuals and groups throughout the bird conservation community. The manuscript is intended to summarize the report and the recommendations in an attempt to demonstrate the current state of and issues surrounding bird monitoring but is not intended to evaluate it.

Public investment in natural resource conservation has grown rapidly in recent years, along with the recognition of potential benefits in coordinating conservation activities. Increasingly, bird conservation is coordinated through organizations such as the North American Waterfowl Management Plan (NAWMP), Partners in Flight (PIF), the Waterbird Initiative, the Shorebird Initiative, and various game bird initiatives. The North American Bird Conservation Initiative (NABCI) provides a forum to facilitate integrated conservation, and the emerging State Comprehensive Wildlife Conservation Strategies provide important incentives for coordination.

Continued growth of bird conservation will require the integration of information about bird status with budget, policy, and management decisions. Unresolved technical and operational issues, administrative costs, and institutional requirements, however, have limited progress thus far. Close attention to rationale, design, and coordination will emphasize the need to focus monitoring efforts on evaluation of avian responses to conservation actions. The summary is presented in three parts based on the IAFWA report: 1) "Rationale" promotes understanding of the role of monitoring in effective bird conservation and management, 2) "Design" of monitoring focuses on the effective and efficient use of monitoring resources, and 3) "Coordination" emphasizes the necessary infrastructure and resources for coordinated monitoring.

Rationale—Integrating Science and Management

Science-based management refers broadly to iterative management processes involving: 1) specification of explicit objectives, 2) use of existing information to develop management strategies, 3) implementation of actions in accordance with these strategies, 4) assessment of the effect of actions taken, and 5) periodic adjustment of management strategies when necessary. Monitoring plays a critical role in science-based management by providing information for management decisions, evaluating those decisions through a comparison of results against prior beliefs, and increasing our understanding of the dynamics of managed species and habitats. Within the bird conservation community, the enhanced value of monitoring as part of an explicit decision-making framework is becoming widely accepted. Many national and international conservation strategies such as the NAWMP now promote an iterative cycle of conservation delivery that involves monitoring as an important component. More effective bird conservation will be achieved as monitoring is routinely considered as an integral part of the management process.

Increased emphasis on science-based management will require greater scientific accountability in decision-making about habitat conservation, harvest regulations, listing decisions under the Endangered Species Act, assignment of species conservation priorities, and a host of other issues. Monitoring in support of conservation de-

cisions will result in 1) increased confidence in policy decisions that allocate limited conservation dollars and program emphasis, 2) increased effectiveness of specific management methods, and 3) improved knowledge about ecological relationships.

An increased emphasis, however, on monitoring in a management context leads to distinctions between monitoring for status and trends versus monitoring to evaluate management and in turn becomes a source of debate among those responsible for bird monitoring. The extremes in views, captured in the terms (discussed below) "surveillance monitoring" and "management-based monitoring," create a false dichotomy across a broad range of monitoring efforts. The following definitions were developed in the IAFWA report and demonstrate the two extremes along a continuum of monitoring approaches.

Surveillance Monitoring

The role and contributions of large-scale, long-term monitoring efforts have been well documented (Bart 2005). Monitoring may be especially useful where little is known about a system of interest, in recognizing system dynamics, and identifying possible causes for concern that might prompt management action. One objective of monitoring in this situation might be to detect biologically significant declines over appropriate time scales. Many existing bird population surveys can be characterized as surveillance monitoring. They have provided 1) coarse-scale estimates of trends that represent useful information sources to establish bird conservation priorities, 2) information that can be useful for designing new, management-driven monitoring programs, and 3) a basis for formulating management hypotheses. Questions arise, however, about whether biological judgment, knowledge of habitat change, auxiliary information, and anecdotal evidence are sufficient to identify management needs, and thereby determine monitoring priorities. This argument highlights one of the differences of opinion within the monitoring community.

Management-based Monitoring

Monitoring in direct support of management relies on existing information and biological experience to identify relevant biological components to monitor, feasible management options to consider, and predicted responses to management. A focus on explicit management objectives and design of monitoring ensures an explicit link between actions and effects to improve future management (Yoccoz et al. 2001). Monitoring that is integrated into a decision-making process (e.g., adaptive management, research hypothesis testing, model development) can be considered "management-based" monitoring. In this context, monitoring data are used both for decision making and for comparison against predicted responses to better understand management impacts. Monitoring is integrated into a decision-making framework, so that the role and requirements of monitoring are unambiguous. Questions about management-based monitoring involve the spatial and temporal scales that are realistic to implement management-based approaches. One perspective is that "management-based" monitoring is primarily local, unique to specific sites, and thus, somewhat limited in large-scale utility and elucidates another element ripe for discussion.

Implications for Current Bird Monitoring Programs

Obviously, distinct categories of surveillance versus management-based monitoring represent endpoints of a gradient of monitoring possibilities. Alternative definitions (e.g., short-term versus long-term, local versus broad-scale, context versus cause and effect, decision-based versus activity-based, etc.) serve to further define the continuum but do little to resolve the debate as demonstrated above. The bird conservation community should be concerned if these distinctions represent more than a disconnect in the language of the debate. If this represents a fundamental philosophical disconnect among segments of the bird conservation community, which perpetuate "game" versus "nongame" distinctions, the vision for all bird conservation will be difficult to achieve. We face the challenge of developing a unifying vision, and distinctions based on traditional philosophical differences will serve only to polarize groups who should be conservation partners.

In the end, a continuum of monitoring approaches will need to be employed to increase our knowledge of resource impacts. Monitoring can be used in the context of: 1) an experimental study, 2) an observational study contrasting competing models of system response, 3) to more clearly define elements in biological models, 4) a retrospective assessment of management interventions, 5) an iterative cycle of planning, implementation, and evaluation, 6) an application of formal methods of Adaptive Resources Management, 7) to assess the status of a species of management concern. To be most relevant, monitoring should be designed expressly for the purpose of improving management by increasing our understanding of bird population dynamics and the effects of management actions. Regardless of the ongoing debate about surveillance and management-based monitoring, aspects of design and coordination must be considered in the foundation of a monitoring program for these data to be reliable and useful.

Design—Elements for Bird Monitoring

Monitoring purpose dictates design: The view of monitoring as a component of a larger scientific process has important implications for the design of monitoring programs. In the context of a scientific process, the purpose of monitoring is to discriminate among competing hypotheses about how a system works. Investigators frequently are interested in hypotheses about how factors influence system dynamics (for this discussion, "system" refers to avian populations or communities). On a broad level, hypotheses are developed that link state variables, such as population size, to factors of interest such as habitat quality. Factors influencing state variables are often beyond management control (e.g., rangeland conversion, global climate change). On a finer level, hypotheses may specify mechanistic relationships between factors of interest and the vital rates responsible for system dynamics. For example, the recognition of changes in bird population size can lead to hypotheses about factors affecting rates of survival, reproduction, and movement. An important principle of design is that the monitoring approach should follow directly from specification of competing hypotheses about system dynamics. Monitoring is focused on those

quantities (state variables, vital rates, hypothesized causal factors, covariates, etc.) that provide the maximum ability to discriminate among competing hypotheses.

In the management context, monitoring can play multiple roles. Monitoring in a scientific context, for example, involves efforts to discriminate among competing hypotheses about system response to management actions. For example, evaluating the response of grassland birds to burning may lead to a design that monitors the nest density of target bird species in relation to variations in burn timing and frequency.

Management decisions typically are state-specific, and optimal decisions depend on monitoring to determine the current system state. Here, the role of monitoring is to evaluate the effectiveness of management programs by asking how well the system state tracks management objectives. For example, managers along the Upper Mississippi River may be uncertain about water management regimes to produce food for target populations of migrating shorebirds; monitoring is used to amend drawdown timing to correspond to seasonal shorebird needs.

In each of these roles, the decisions faced by managers dictate the selection of appropriate measurements and monitoring designs. When imbedded in a management context, the monitoring of a system state like population size can be a valuable component of management. The view of monitoring as a component of a science-based, management process provides clear direction for the design of monitoring programs. The problem of design then becomes one of tailoring monitoring efforts specifically to a scientific or a management process.

Selection of Sample Units

Managers and scientists frequently are interested in making inferences about bird populations or communities that inhabit large portions of the landscape. However, a complete census of all possible sample units usually is impractical, even for small landscapes. Instead, a sample of spatial units should be selected in a manner that is most useful for the intended monitoring purpose, including replication as appropriate across the scale of the management or scientific question. Once the initial selection of samples is made, an additional question arises about how to sample space in subsequent years or seasons.

When focused on system responses to management actions and environmental factors, sample units should be selected to provide the best opportunity for discriminating among competing hypotheses about population dynamics. Usually, it is beneficial to identify survey strata, independently / randomly select sample units within strata, and allocate sampling effort to ensure discrimination among management uncertainties. A probability-based approach to sample allocation is always preferred. By identifying and then targeting particular strata for the purpose of model discrimination, some areas may not be included in any sample stratum. In such cases it may be desirable to include low-intensity sampling for non-target strata to generate estimates for an entire region or state. Finally, if model discrimination is to be based on changes in management actions over time, then stratification will not be needed for model discrimination, although it may still be useful for reducing estimator variances.

Survey Methods

Monitoring design also includes specification of the methods used to estimate the quantities of interest. Estimation of population size generally involves counting birds in a sample in a way that allows estimation of the probability of their detection or capture. The first component, the raw count, is often termed an index of abundance, and is assumed to represent the same fraction of the population at times or places being compared. Most existing monitoring programs fail to use methods that incorporate the second key component, detection or capture probability. Temporal changes in detectability or differential detectability among sampling units can result in severely biased comparisons and unreliable inferences.

There are numerous methods available for estimating bird abundance or density, and the key to successful design is to select the most reasonable approach based on logistics and biological considerations. Point counts are frequently used in avian monitoring programs, and several methods exist for estimating detection probability: distance sampling, multiple observers, time at detection (temporal removal) models, and multiple-visit models. Double-sampling approaches have been used to adjust counts from aerial waterfowl surveys and ground counts of breeding shorebirds. There are subtle differences among these methods in the exact quantities being estimated, but they all represent a substantial improvement over index methods based on raw counts alone. Estimation of avian abundance is an active topic of research and is a positive development for avian monitoring programs. In most cases, assumptions about the relationship between the index value and population size are difficult to defend, and formal incorporation of detection and capture probability estimation into monitoring programs is strongly advised.

Design decisions do not end with selection of sample methods and sample locations. The precision of estimates produced from monitoring data is an important quantity that influences our ability to make good management decisions and to discriminate among competing hypotheses. Desired levels of precision will vary depending on the management situation, the number of sample units selected (replication), amount of survey effort expended on each unit, and estimation method. The design will involve tradeoffs between the number of survey sample units and the effort expended on each unit. These allocation decisions are typically design-specific and defy general recommendations. It is useful to explore them using numerical methods (simulations or large-sample approximations), so as to develop a design that is tailored to the specific scientific or management program. As a practical matter, numerical experiments with prospective methods of analysis should be employed before initiating a monitoring program. This approach deviates substantially from the more typical tendency to initiate monitoring without a clear idea of how the resulting data are to be analyzed and used.

Coordination: Increasing Management and Monitoring Efficiency

Coordination can be defined as the alignment of activities among stakeholders to combine resources, share costs, and address issues of common concern. Con-

servation examples include coordinated management actions (e.g., harvest management), pooling of fiscal resources by multiple partners for habitat restoration, and collaborative efforts to collect field data as part of a monitoring program. Requirements for coordination include shared goals, a spirit of cooperation among parties, and ongoing communication.

The purpose of coordination is to efficiently address management issues that are common to multiple conservation agencies and organizations. Often, management questions have been dealt with by stakeholders in isolation, even though they shared common management concerns. As a result, the efficiency and utility of monitoring—and thus the management efforts it supports—often suffer as well. Although coordination across political or organizational lines is not a prerequisite of science-based management, coordinating monitoring at the scale of the management issue will increase monitoring efficiency. When monitoring is coordinated across taxonomic divisions and geographic, political, or organizational jurisdictions, increased inferential strength and more broadly applicable information result. Although the challenges of coordinating objectives, survey methods, and data sharing are daunting, coordinated avian conservation and monitoring allow partners to:

1) Sharpen the focus on specific objectives, desired outcomes, key hypotheses, and potential management treatments among agencies with management objectives that involve the same species or communities.

2) Pool staff and financial resources to increase efficiencies of scale and economy of monitoring effort.

3) Make reliable inferences at more biologically meaningful spatial scales. Based on compatible implementation protocols and shared objectives, the results from a number of local sites can be "scaled-up" to produce reliable information about the effects of management activities.

4) Meet continuing legal and regulatory challenges in bird conservation. Requirements for reliable documentation and evidence of the effects of management activities will continue to grow for the foreseeable future.

When management encompasses several political and/or organizational (agency) boundaries, the need for coordination among agencies with similar objectives and/or interests is clear. However, effective coordination of monitoring will require new paradigms for cooperation among state and federal natural resource agencies, NGOs, and others. Achievement of management goals will depend on long-term commitments from these groups to ensure that: 1) population objectives and management alternatives are agreed on, 2) management questions or disputes are identified, 3) appropriate monitoring protocols are developed and implemented, 4) database management, analysis, and reporting responsibilities are clear, 5) technical support is widely available, and 6) common decision-making frameworks are developed.

The perspective of monitoring as imbedded in management or scientific inquiry has implications for the coordination of bird monitoring. Just as monitoring designs should be tailored to the objectives of a larger management or scientific process, coordination across resource organizations should match the scale of the question

being addressed. We can easily envision regional issues in which several state agencies are independently managing habitat for a particular species; yet evaluation often has been limited even though questions about the effects of management are similar. With minimum coordination effort, monitoring conducted in a region can contribute to broader monitoring objectives. For example, population size can be viewed as a regional variable across political boundaries when movement among locations is frequent. Alternatively, populations may be sufficiently independent to be considered replicates, and thus can be used to increase the inferential power of the collective effort. In both situations, coordination of design is useful for discriminating among competing management hypotheses, and for monitoring system state for the purpose of making periodic management decisions.

Coordination of large-scale survey methods will be essential to ensure compatibility and consistency of data, and coordination of archiving and reporting information will enhance utility. Integrated design involving all interested groups adds value through increased inferential power, incorporation of a broader range of environmental variability, and possible economies of scale. It is important to note, however, that coordination does not necessarily imply the use of the same parameter estimation methods in all areas or by all participating groups, although in most instances it will be advantageous. The key design issue is not standardization per se, but instead is a focus on meeting the inferential objectives of all participants. Likewise, complete standardization of protocols is not necessarily required for coordinated monitoring. There must be agreement, however, about specific management objectives and the temporal and spatial scales at which management processes operate. Agreement on these issues is critical in determining key stakeholders, appropriate state variables, and an efficient monitoring design.

Clearly, coordination across political or organizational lines can be beneficial throughout this process through the development of common objectives and management strategies, joint identification of key management uncertainties, and cooperative development of hypotheses and the monitoring and assessment procedures. Effective coordination of monitoring programs is predicated on the coordination of management at multiple scales. The scale of monitoring coordination is dictated by the scale at which management is occurring.

Coordination involves other practical and organizational issues as well. As a general recommendation, partners should agree, at the outset, on the methods and infrastructure to manage, share, and analyze data to report results to all partners. Full programmatic costs should be estimated, so that sufficient resources can be committed prior to survey initiation, to ensure that useful results are obtained. Monitoring program designs also should include plans for periodic evaluation of program objectives and operations. This is important for any monitoring program, but assumes special relevance in programs coordinated across numerous organizations or regions.

Identifying the infrastructure and processes to facilitate management and monitoring is a key challenge facing bird conservation. A common monitoring infrastructure at the scale of the management objective will be necessary to ensure evaluation of bird conservation. The overall infrastructure to support the coordination of man-

agement and monitoring currently resides with the NABCI and its member national/international conservation initiatives (e.g., Partners in Flight, NAWMP), Joint Venture and Bird Conservation Region partnerships, IAFWA and its committees, and the administrative Flyway System. The coordination of conservation activities is explicitly recognized as a primary purpose of these structures.

At a continental scale, NABCI exists to coordinate habitat conservation by integrating conservation objectives, priorities, and delivery programs of individual, taxonomically-focused bird conservation initiatives. IAFWA committees provide another venue for broad-scale coordination of activities. In collaboration with the Flyway System and principal federal agencies, the oversight groups of the major bird conservation initiatives coordinate the establishment of range-wide conservation objectives, and large-scale evaluation programs. The Flyway System and federal regulatory agencies provide the necessary structure for coordination of population management actions.

At regional scales, Joint Ventures and Bird Conservation Regions are geographically-focused partnerships that have developed regional objectives related to continental bird conservation goals. These existing bird conservation partnerships currently are developing and implementing habitat management strategies as well as monitoring and assessment processes to evaluate these strategies. To meet a need for cross-taxa coordination and integration, the Joint Ventures have assumed regional responsibilities for implementing conservation strategies of all major bird initiatives.

From the perspective of coordinated monitoring, the technical committees and management boards of Joint Ventures provide a natural venue for identifying common regional management issues and developing cooperative monitoring programs. Larger-scale infrastructure (e.g. international committees) within the bird initiatives could facilitate identification of coordination needs and opportunities among the Joint Ventures. Although coordination efforts by the Joint Ventures may not engage all stakeholders, they are key components of the basic infrastructure needed to coordinate management and monitoring for bird habitat conservation.

Challenges for All Bird Conservation

Despite the value of monitoring as a component of science-based management and the obvious value of coordinating design and implementation, efforts to integrate stakeholders often have been limited. At the risk of adding to exclusive distinctions, stakeholders who share responsibility for bird conservation largely remain disconnected in roles and objectives for bird conservation and bird monitoring:

- Those responsible for assessing the status and trends of birds who are advocating for the resources to do so
- Those responsible for allocating budgets for bird conservation who are not always convinced of the relevance of monitoring
- Those who “just want to put habitat on the ground” often view monitoring as a distraction that diverts budgets from the real conservation objective

Clearly, efforts to advance all bird conservation will require greater integration of the essential roles of researchers, policy makers, and managers. Resource objectives should be identified primarily by policy makers, potential management actions selected by managers, and the primary responsibility for developing models of system response and monitoring design are shared by researchers. Armed with the prerequisites of management objectives, potential management actions, and models, scientists and managers can jointly develop specific monitoring designs, including the two critical issues of spatial sampling and the appropriate estimation methods.

Once common management objectives are identified, a multi-disciplinary team of stakeholders should be assembled to:

1) Identify the key information needed to address the management issue and the scale at which the information is required.

2) Identify an appropriate monitoring design. It may be useful at this stage to review existing monitoring programs to determine if they can be useful, or can be augmented to become useful

3) Identify required resources and stakeholder roles in implementation

4) Develop protocols to manage, and make accessible, the resulting monitoring databases.

5) Develop reporting or publication procedures.

6) Develop explicit feedback mechanisms to ensure that the monitoring data are useful for management, and that continuation of the monitoring program is advisable.

A conceptual framework for bird monitoring would be based on the following principles:

1) Monitoring is a key component of science-based management.

2) Science-based management in turn requires a) specification of explicit objectives, b) use of existing information to develop management strategies, c) implementation of actions in accordance with these strategies, d) assessment of the effect of actions taken, and e) periodic adjustment of management strategies.

3) Monitoring is in direct support of, and actively integrated into, resource decision-making

4) Bird monitoring should be designed and coordinated at the scale of bird conservation programs and existing infrastructure.

A key remaining uncertainty involves the question “Where do we start?” Our tendency has been to begin by recommending evaluation of existing monitoring programs or with a list of priority species to monitor. Certainly, this is appropriate for existing management programs for high profile species and for some established monitoring programs (e.g., BBS, bird banding, waterfowl surveys). Here, a review of existing programs assumes that agreement on management objectives is in place and the infrastructure for delivery of management and monitoring already exist. Key steps would include engaging a team with broad representation across bird conser-

vation initiatives, emphasis on improving and adapting established surveys (as well as deletion of some elements), considerations for the scale of species and landscape conditions, and a focus on details of data sharing and availability. In the future, institutional support that ensures funding, expertise, collaboration among agencies, and ongoing evaluation of monitoring will be necessary to ensure continuation of established monitoring efforts.

In light of limited resources for monitoring and the need to ensure a relevant focus on the information needed to efficiently allocate bird conservation dollars, an increased emphasis on management-based monitoring is appropriate; however, this is not to say that other types of monitoring along the monitoring continuum should be ended. As State Wildlife Strategies are developed, for example, front-loaded attention to monitoring will ensure integrated evaluation of conservation progress. Here, initial emphasis should be less on which species to monitor and more on explicit recognition of conservation goals, scale of management, partnerships, and the specific information needed for confident management decisions by addressing the following:

- *Explicit objective*—What is the resource management or policy decision that will be informed by the monitoring program?
- *Scale*—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?
- *Evaluation*—What specific information is needed to make an informed management or policy decision?

Monitoring can play a key role in supporting the continued growth of bird conservation efforts by providing the information needed to inform conservation and management decisions and evaluate their effectiveness. To be most effective, however, monitoring must be integrated as a component of a larger management or scientific process. Likewise, for monitoring to be most relevant, it should focus on specific objectives, desired outcomes, key hypotheses, and management treatments. For monitoring to be most efficient, it needs to be coordinated across geographic, organizational, and political boundaries to ensure more reliable inferences at biologically meaningful spatial scales, pool resources, and help to meet continuing legal and regulatory challenges in bird conservation.

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