Monitoring Avian Conservation: Rationale, Design, and Coordination

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EXECUTIVE SUMMARY

Monitoring can play a key role in the continued growth of bird conservation, by providing the information needed to inform conservation decisions and evaluate their effectiveness. More effective monitoring can be ensured through coordination; however, unresolved technical and operational issues, administrative costs, and institutional requirements have limited progress thus far.

To assess opportunities and challenges in coordinated bird monitoring, the International Association of Fish and Wildlife Agencies (IAFWA) established a Coordinated Bird Monitoring Working Group under the Science and Research Committee to 1) identify key technical issues, approaches, and suggestions about the coordination of bird monitoring, 2) suggest a process for integrating and updating ideas from the avian conservation and research community; and 3) produce a report for the IAFWA Science and Research Committee with recommendations on technical aspects of coordinated bird monitoring. The working group report consists of three sections – **Rationale, Design, and Coordination** – which emphasize the need to focus monitoring efforts on evaluation of avian responses to conservation actions. The report recommendations are intended to serve as a springboard for the bird conservation community to develop a shared technical and administrative framework for coordinating bird monitoring.

The overall theme of the report is that monitoring and evaluation programs should be management-based, and predicated on an explicit agreement about the objectives of conservation actions. The working group recommends that monitoring be viewed as a component of a larger management or scientific process, recognizing that for management to be effective, it needs to be science-based. Likewise, for monitoring to be relevant, it should focus on specific objectives, desired outcomes, key hypotheses, and management treatments. Coordination of monitoring efforts across geographic, organizational, and political boundaries can increase survey efficiencies, ensure more reliable inferences at biologically meaningful spatial scales, pool resources, and help to meet continuing legal and regulatory challenges in bird conservation.

We distinguish between management-based and surveillance monitoring, as a way of contrasting the majority of existing monitoring approaches with a more purposeful approach that is needed to learn about managed systems and the effects of management actions. **Management-based monitoring** is in direct support of management, with monitoring data integrated directly into decision-making processes and used to better understand responses to decisions. **Surveillance monitoring** is appropriate when little is known about a system of interest, and monitoring efforts are used to track resource dynamics so as to identify possible causes of concern for resource conservation.

Effective and efficient monitoring design involves tailoring the effort to a scientific or a management process. Because specific recommendations about design are sensible only in the context of the scientific or management issues under consideration, guidance on design is necessarily general in nature. Design considerations include sampling across the temporal and geographic scale of the management or scientific issue, selection of sample units to provide the best opportunity for discriminating among competing hypotheses, and consideration of the precision and bias (e.g., detectability) of estimates.

When the scale of management and monitoring is large, coordination of effort often is critical for effective monitoring. However, it is important to recognize that coordination does not necessarily imply the use of the same estimation methods in all areas or by all participating groups, although in

most instances it will be advantageous. Rather than standardization of methods, large-scale designs should focus on meeting the inferential objectives of all participants. Nor does coordination mean that common management actions are required. It often is desirable to use different management actions (e.g., burning versus grazing) in different jurisdictions to achieve common management objectives. A shared management focus, rather than uniform management actions, should serve as the framework for the design and implementation of coordinated monitoring.

Effective coordination of monitoring will require new paradigms for cooperation and commitment. Requirements for coordination include shared goals, a spirit of cooperation among parties, and ongoing communication. Existing infrastructures [e.g., North American Bird Conservation Initiative (NABCI), North American Waterfowl Management Plan (NAWMP), Joint Ventures, Flyway System, IAFWA, etc.] provide a natural venue for identifying common management issues and developing cooperative monitoring programs. Through this infrastructure, shared resource objectives can be identified by policy makers, potential management actions can be selected by resource managers, and models of system response can be developed by researchers. A partnership of biologists, statisticians, managers, and decision-makers is needed to design effective monitoring programs.

Recommendations

The IAFWA Science and Research Committee and Bird Conservation Committee endorse a conceptual framework for coordinated bird monitoring 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) Management-based 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.

The IAFWA Bird Conservation Committee directs each working group to identify priority management issues for which cooperative monitoring programs should be developed. Each monitoring priority should identify:

1) **Explicit objective** – What is the resource management or policy decision that will be informed by the monitoring program?
2) **Scale** - Where will the management decision apply?
3) **Stakeholders** - Who else has the same management question or species focus? Who has a stake in answering the management question?
4) **Evaluation** - What information is needed to make an informed management or policy decision?

Pending endorsement by IAFWA, the working group forwards this report and recommendations to the directors of FWS, USGS, and NABCI (and ultimately, for dissemination to other federal agencies with resource management and monitoring responsibilities).

INTRODUCTION

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.

Monitoring can play a key role in supporting the continued growth of these and other bird conservation efforts by providing the information needed to inform decisions and evaluate their effectiveness. The value of coordination is especially apparent in bird monitoring, where economies of scale and effort can be realized and more useful monitoring products can be developed through coordination. Considerable effort already has been expended in trying to describe what coordinated bird monitoring might entail. However, unresolved technical and operational issues, administrative costs, and institutional requirements have limited our progress thus far.

To assess opportunities and challenges in coordinated bird monitoring, the International Association of Fish and Wildlife Agencies (IAFWA) established a Coordinated Bird Monitoring Working Group under the IAFWA Science and Research Committee in coordination with the U.S. Fish and Wildlife Service (FWS) and U.S. Geological Survey (USGS). Building on work in progress in the avian conservation community, the working group was asked to: 1) identify key technical issues, approaches, and suggestions about the coordination of bird monitoring, as a basis for comprehensive discussion in the bird conservation and research community; 2) suggest a process for integrating and updating ideas from the avian conservation and research community; and 3) produce a report for the IAFWA Science and Research Committee with recommendations on technical aspects of coordinated bird monitoring. The group was to complete its review during summer 2004 and report findings back to the IAFWA Science and Research Committee and the Bird Conservation Committee at the annual IAFWA meeting in September 2004, and to the North American Bird Conservation Initiative (NABCI) thereafter. They also were asked for recommendations on communicating findings to the broader conservation community. Nine biologists with technical backgrounds, based on their biological and quantitative focus and their associations with the national bird conservation initiatives, were selected for the working group.

The group adopted a number of guidelines in its deliberations:

* To the extent possible, monitoring issues were to be developed in terms of existing agency infrastructure. In restructuring and/or expanding monitoring activities, agencies can economize and benefit from the use of existing administrative and operational functions.

* Deliberations were to be framed in terms of cost constraints, and the need to have efficient monitoring designs. Under current budgetary circumstances, it was felt that additional funding for monitoring would be forthcoming only if efforts are efficiently designed.

* To the extent possible, consensus was to be reached on the report and its recommendations. Group recommendations were expected to have more weight if offered as consensus (or near-consensus) positions.

The report contains three sections: 1) a **Rationale** for management-based monitoring and coordination, which promotes understanding of the role of monitoring in effective bird management; 2) the **Design** of monitoring efforts which focus on the effective and efficient use of monitoring resources; and 3) **Coordination** of monitoring programs that emphasize the necessary infrastructure and resources for coordinated monitoring. In addition to these sections, a glossary is provided that defines some of the terms in the report. Finally, answers are provided for some frequently asked questions about the report and its conclusions.

In the report we recommend a focus on the monitoring of avian responses to conservation actions. This goes beyond coordination per se. We emphasize monitoring as an integral component of natural resources management, with monitoring activities tied closely to the management process itself.

Recommendations from the working group are intended to:

1) Generate institutional support for an emphasis on management-based monitoring;

2) Encourage recognition that well-designed monitoring programs will lead to better management decisions and conservation actions that benefit birds;

3) Stimulate improved coordination of monitoring objectives and activities across geographic and organizational boundaries; and

4) Serve as a springboard for the bird conservation community to develop a shared technical and administrative framework for coordinating bird 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 (e.g., establishment of hunting season frameworks based on duck population size), evaluating those decisions through a comparison of results against prior beliefs (e.g., predicted vs. observed response of vegetation to a water management regime), and increasing understanding of the dynamics of managed systems (e.g., effect of uncontrollable factors such as weather on habitat condition and population response).

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.

Frequently, however, monitoring programs have been developed with little consideration of management needs, based on a presumption that monitoring is inherently worthwhile and that general survey data will be useful in addressing future management questions. Such a presumption is unsupportable in an emerging political and social climate that demands proof of return on bird conservation investments.

Increased emphasis on performance-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. Thus, the overall goal of coordinated bird monitoring is to foster monitoring and evaluation programs that are science and management-based, and predicated on explicit agreement about the objectives of conservation actions. Purposeful monitoring should lead to improved policy and management decisions about bird conservation through:

1) Increased confidence in policy decisions that allocate limited conservation dollars and program emphasis (e.g., budgets for conservation of breeding versus wintering habitat).
2) Increased effectiveness of specific management methods (e.g., role of fire versus mechanical disturbance regimes in habitat management).
3) Improved knowledge about ecological relationships (e.g., relative role of harvest versus habitat management).

1.0 INCREASING MANAGEMENT AND MONITORING EFFICIENCY – WHY COORDINATE MONITORING?

Biologically meaningful management often encompasses several political and/or organizational (agency) boundaries. In such cases there is a clear need for coordination among agencies with similar objectives and/or interests.

In particular, efficient and effective monitoring necessitates the specification of the spatial extent of the intended management outcomes. This allows 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.

We acknowledge the challenges in identifying objectives, implementing bird surveys, and sharing data. However, the long-term benefits from better informed avian conservation far exceed the additional cost of coordination.

<u>An example</u>**:** Consider the problem of evaluating the effects of disturbance regimes on breeding success of grassland species. Most agencies invest in grassland management using a variety of tools (e.g., burning and grazing), and each is interested in knowing whether the investment is effective and justified. Although each agency may initially focus on local efforts, it makes biological sense to frame this question at the larger, ecoregional scale and to consider the added inferential power of evaluation of multiple, similar projects. Identification of common objectives (e.g., nest density of selected species) is essential for coordination of management (though not necessarily monitoring). Agreement on the suite of management techniques evaluated (e.g., limited combination of burning or grazing) also may be needed to avoid confounding the interpretations of subsequent monitoring results. Careful consideration of how management treatments can be used to inform management objectives must precede implementation of management actions. The benefits from mutual discussions about expected management outcomes will outweigh the limited loss of management flexibility. Stronger and more reliable inferences about effects of management on biologically meaningful scales will result from the larger, coordinated effort. In addition, concurrent monitoring of biological response and local environmental factors (e.g., seasonal temperature, precipitation, habitat conditions, etc.) will increase ecological understanding.

2.0 CONTRASTING MONITORING APPROACHES IN A MANAGEMENT CONTEXT

A continuum of monitoring approaches can be employed to increase our knowledge of resource impacts. Monitoring can be used in the context of an experimental study, or an observational study contrasting competing models of system response, or to more clearly define elements in biological models, or a retrospective assessment of management interventions, or an iterative cycle of planning, implementation, and evaluation, or an application of formal methods of Adaptive Resources Management. In all of these cases, monitoring is designed expressly for the purpose of improving management by increasing our understanding of bird population dynamics and the effects of management actions.

We distinguish here between management-based and surveillance monitoring, as a way of contrasting the majority of existing monitoring approaches with the more purposeful approach needed to learn about managed systems and the effects of management actions.

2.1 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 hypotheses about biological responses. Monitoring that is integrated into a decision-making process (e.g., adaptive management, research hypothesis testing, model development) is considered management-based monitoring. Monitoring data are used both for decision making and for comparison against predicted responses to better understand management impacts. Monitoring design is determined by management objective(s), available management actions, and predicted responses to management. Monitoring is integrated into a decision-making framework, so that the role and requirements of monitoring are unambiguous.

2.2 Surveillance monitoring

Where little is known about a system of interest, monitoring may be useful 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. In the context of bird conservation, surveillance monitoring often focuses on population status and trends, and is largely uninfluenced by specific management needs or questions.

We acknowledge the utility of surveillance monitoring where managers cannot recognize which biological attributes and environmental/habitat factors to monitor to best inform conservation. In most instances, however, biological judgment, knowledge of habitat change, auxiliary information, and anecdotal evidence can be used to identify management needs, and thereby determine monitoring priorities. In this context, general disagreement among experts over what the anecdotal information means can become the focus for monitoring design. There are few situations in which we know so little that omnibus, exploratory surveillance is the preferred alternative. Even for little-known species, hypotheses often can be developed based on ecological theory, and used to structure a monitoring effort that includes covariates, contrasts, and other useful features that can be helpful when and if attention is warranted.

3.0 Implications for current bird monitoring programs

We recognize that many bird population surveys can be characterized as surveillance monitoring. Although these surveys were not designed to address specific management issues, they have provided 1) coarse-scale estimates of trend that represent a useful information source 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.

When surveillance surveys are used for management, the objectives for management should be explicitly identified, and monitoring objectives and design should be reconsidered. Future resources directed at surveillance surveys should be targeted at improved statistical reliability (specifically, to reduce bias – e.g., detectability) and greater survey efficiency. In most cases, survey designs should be expanded to collect auxiliary information (e.g., habitat conditions/treatments, precipitation, etc.) that enable testing of management hypotheses.

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.

DESIGN - Elements for bird monitoring

1.0 MONITORING PURPOSE DICTATES DESIGN

The view of monitoring as a component of a larger management or 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. The first is analogous to monitoring in a scientific context, and 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.

Another role of management-based monitoring focuses on determining system state. Management decisions typically are state-specific, and optimal decisions depend on the current system state. For example, quail hunting regulations may be contingent on estimates of the current population size. In that context, the role of management-based monitoring is to evaluate the effectiveness of management programs by asking how well the system state tracks management objectives. In another example, managers along the Upper Mississippi River may be uncertain about water management regimes to produce food for target populations of migrating shorebirds.

In each of these roles, the decisions faced by managers should 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. On the other hand, monitoring outside the context of a clear management-decision framework can be quite inefficient, and thus less likely to be effective or politically supported.

The view of monitoring as a component of a science-based, management process provides clearer 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. Because specific recommendations are sensible only in the context of the scientific or management issues under consideration, overall guidance on design must necessarily be general in nature.

The perspective of monitoring as imbedded in management and/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 of a particular species. In such a situation, questions about the effects of management are likely to be similar for the different agencies (e.g., how does controlled flooding impact habitat quality for migrating shorebirds and waterfowl?). State variables such as population size can be viewed as regional variables across state boundaries when movement among locations is frequent; or, as in the above example, when annual migratory population sizes are regionally predictable but unpredictable at any single site. 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.

In many cases, surveillance monitoring has been the default approach for monitoring bird populations. As suggested in the preceding section, surveillance monitoring should be designed with *a priori* management hypotheses in mind so that, in addition to information on system state, some insights can be gained into possible causes of system response. For example, monitoring of variation in habitat structure concurrent with variation in bird population parameters could be considered where natural or anthropogenic changes (including management) are believed to influence avian populations. Information gained through well-designed surveillance programs could eventually lead to development of more directed, management-based monitoring programs (e.g., several years of surveillance monitoring have revealed alarming declines in long-billed curlew breeding populations in part of their range, leading to more focused monitoring of breeding success in relation to land use variation). For many systems, however, currently available information is adequate to integrate monitoring efforts directly into the management process.

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. With minimum coordination effort, management-based monitoring conducted in a region can contribute to broader surveillance objectives. To use the above example, monitoring of the breeding success of curlews across differently managed habitats could provide general information on changes in range-wide population size over time. Indeed, contributions to surveillance efforts likely would be a frequent by-product of coordinated, management-based monitoring programs.

2.0 DESIGN RECOMMENDATIONS

2.1 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. Often it is beneficial to identify survey strata and select sample units independently within each stratum. The allocation of sample units to strata typically is based on an objective of model discrimination, or else on some target level of estimator precision. Larger numbers of units are assigned to strata that are most useful for discrimination, or to strata that are predicted to be most different from each other with respect to potentially explanatory covariates. Within strata, sample units should be allocated randomly, or at least in a way that does not favor or avoid areas thought to systematically influence population dynamics. A probability-based approach to sample allocation is always preferred. By 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, as in the above example of harvest, then stratification will not be needed for model discrimination, although it may still be useful for reducing estimator variances.

As an example, a design to estimate breeding success and subsequent population growth of least terns nesting on isolated versus accreted sand islands should concentrate sample units in these two primary breeding habitats. If terns also breed infrequently in a third habitat type (e.g., river banks), a minimal amount of effort could be expended there, but most of the sampling effort would be directed toward assessing the relative value of sand islands. A second example involves grassland plant diversity, which may be maintained by either periodic burning or grazing. Each management practice is hypothesized to influence the abundance of several grassland birds. A good design would divide potential management areas into groups that receive each of these management practices in a consistent manner (e.g., replicates of each treatment would be assigned randomly to potential management units), with a temporal scale for the monitoring that is tied to bird response (e.g., over several seasons).

2.2 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 detectabilty 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, based on 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, we recommend numerical experiments with prospective methods of analysis 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.

3.0 INTEGRATION OF MONITORING AND MANAGEMENT

Because we emphasize monitoring as a component of a larger management process, we believe that a cadre of biologists, statisticians, managers, and decision-makers is needed to contribute to the effective design of monitoring programs. Thus, resource objectives can be identified by policy makers, potential management actions can be selected by resource managers, and models of system response and monitoring design can be developed 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. As emphasized above, the monitoring design should include considerations for estimating both the relevant state variables for the purpose of making decisions, and the state variables and vital rates to be used in discriminating among competing management hypotheses. The procedures for discriminating among models should be identified *a priori*, as they may be relevant to the design.

In bird conservation, other agencies or groups may be involved in similar management efforts for the same species. In this case, coordinated monitoring may consist of an integrated or joint design involving all interested groups. The value added by coordination includes increased inferential power, incorporation of a broader range of environmental variability, and possible economies of scale (e.g., a single statistical consultant may work on the entire program; joint workshops may be held to train field personnel).

It is important to note 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.

Coordination involves other practical and organizational issues as well, and these are covered in the last section of this report. As a general recommendation, participants in a coordinated monitoring program should develop, at the outset, the methods and infrastructure to manage, share, and analyze data to report results to all partners. Expectations of program participants should be specified *a priori* and agreed to by all parties. Full programmatic costs should be estimated, so that sufficient resources can be committed prior to survey initiation, to ensure that useful results are obtained. We recommend that monitoring program designs 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.

COORDINATION

Coordinated monitoring can help ensure that resources allocated to bird conservation will produce population benefits and increased knowledge, with the ultimate result of increased confidence in management and policy decisions. However, identifying the infrastructure and processes to facilitate management and monitoring is a key challenge facing bird conservation. The Flyways, Joint Ventures, and Bird Conservation Regions are essential components of the administrative structure that is necessary for coordinated management and monitoring.

Here we define "coordination" as the alignment of activities among stakeholders to combine resources, share costs, and address issues of common concern. Examples include coordinated conservation actions (e.g., harvest management), the pooling of fiscal resources by multiple partners for habitat restoration; and the combined efforts among organizations to collect field data as part of a comprehensive 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. In the past, many management questions were 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 supported – often suffered. Although coordination across political or organizational lines is not a prerequisite of science-based management, coordination of monitoring to address common management needs will improve monitoring efficiencies. When monitoring is coordinated across taxonomic divisions and geographic, political, or organizational jurisdictions, increased inferential strength and more broadly applicable information should be the result.

1.0 COORDINATION AND THE MANAGEMENT PROCESS

Science-based management was defined earlier as an iterative process 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. Clearly, coordination across political or organizational lines can be beneficial throughout this process through 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 of management and monitoring requires management objectives that are shared by stakeholders. However, different management actions (e.g., burning versus grazing) may be used in different jurisdictions to achieve common management objectives (e.g., increased nesting density of grassland birds). Likewise, coordination of monitoring does not necessarily mean uniform management actions. It is the evaluation of management uncertainties (e.g., influence of early successional management through burning, grazing, disking, chemical treatment, etc.), not standardization of management interventions, which motivates coordinated monitoring.

2.0 SUPPORTING INFRASTRUCTURE

Infrastructure to support the coordination of management and monitoring for bird conservation currently resides with the North American Bird Conservation Initiative (NABCI) and its member national/ international conservation initiatives (e.g., Partners in Flight, North American Waterfowl Management Plan-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. Though there are significant gaps in financial and personnel resources that limit the effectiveness of the existing coordination infrastructure, central elements are in place to facilitate cooperation in management and monitoring.

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 committees (e.g., the International NAWMP Committee) 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 that are 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.

3.0 COORDINATED MONITORING AS A COMPONENT OF SCIENCE-BASED MANAGEMENT

When common management needs that can be addressed through monitoring are identified (e.g., the resolution of management uncertainties), a multi-disciplinary team with in-depth knowledge of the management issues, technical capabilities in modeling and survey design, and appropriate administrative authority 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.

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

4.0 Coordination of surveillance programs

There is a need to review, and in many cases consolidate, established surveys. For example, numerous omnibus, multi-species surveys occur each year in North America, but at present they are fragmented, and most of the data collected are not incorporated into long-term databases. A review is needed to clarify which management issues can be addressed by these surveys, what methods are most appropriate, and what auxiliary information (e.g., habitat, weather) might be necessary to address specific management problems. If management utility is demonstrated, similar surveys should be consolidated into more cohesive programs. Surveys for which management utility can no longer be demonstrated become candidates for termination of support. Consolidation should ensure efficient data management and access to the technical expertise needed to ensure timely design, quality control, analysis, reporting and dissemination of results.

RECOMMENDATIONS

The IAFWA Science and Research Committee and Bird Conservation Committee endorse a conceptual framework for coordinated bird monitoring 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) Management-based 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.

The IAFWA Bird Conservation Committee directs each working group to identify priority management issues for which cooperative monitoring programs should be developed. Each monitoring priority should identify:

1) **Explicit objective** – What is the resource management or policy decision that will be informed by the monitoring program?
2) **Scale** - Where will the management decision apply?
3) **Stakeholders** - Who else has the same management question or species focus? Who has a stake in answering the management question?
4) **Evaluation** - What information is needed to make an informed management or policy decision?

Pending endorsement by IAFWA, the working group forwards this report and recommendations to the directors of FWS, USGS, and NABCI (and ultimately, for dissemination to other federal agencies with resource management and monitoring responsibilities).

Coordinated Bird Monitoring Working Group – IAFWA

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Appendix A: GLOSSARY

Adaptive Resources Management (ARM)

At its core Adaptive Resources Management consists of learning by doing, and then adapting based on what is learned. That is, one learns how a resource system functions by managing it (learning by doing), and then applies that learning so as to manage the resource system more effectively (adapting based on what's learned). Implied in this scenario is uncertainty about how the system works, and specifically how it responds to management and why. The idea is to reduce that uncertainty through the process of management itself, with the salutary consequence of improving management through time. Requirements for ARM include 1) decision making pursuant to both management goals and understanding; 2) the tracking of responses to decisions through the monitoring of resource status and processes; and 3) analysis/assessment, with the intent of informing future management through improved understanding. By its nature, the emphasis in ARM is on management, with science imbedded in the management process through monitoring and assessment. A key challenge is to ensure an enduring institutional commitment to monitoring and assessment, so as to allow learning and adaptation to occur over time.

Bias

Bias is a systematic difference between a biological attribute and the data-based estimate used to represent it. More formally, bias is the difference between the expected or average value of an estimator of a parameter and the value of the parameter itself. Though bias can arise in many ways, two of the most common in biology are 1) a mismatch between the sampled and target populations, as when the choice of sample sites is restricted to sites that are the most easily accessible; and 2) a failure to account for detectability when estimating population status and vital rates.

Coordination

Coordination is the alignment of activities among stakeholders so as to combine resources, share costs, and address issues of common concern. Examples include coordinated conservation actions (e.g., harvest management); the pooling of fiscal resources by multiple partners for habitat restoration; and the joint collection of field data as part of a comprehensive monitoring program. Requirements for coordination include shared goals, a spirit of cooperation among parties, and ongoing communication.

Detectability

Detectability is the extent to which organisms at a sample location are recorded in the sample data. More formally, detectability is the probability that an organism at a sample site is actually observed in the sample. Detectability can range from 0 for small, highly secretive species, to 1 for large, colorful, showy species. Factors influencing detectability include weather conditions, habitat structure, and differences in individual observers.

Estimation

Estimation is the aggregation of field data into measures of biological attributes. Examples include the use of a sample mean based on field data to estimate population density; the use of sample variance to estimate variation in organism size; and the use of a sample correlation coefficient to estimate the correlation between size and weight. For any biological attribute, multiple estimators are always available, and the choice of which particular estimator to use often is based on such features as estimator bias, precision, and statistical efficiency.

Hypothesis

A hypothesis is a suggested but unconfirmed explanation of observed patterns. An example is a hypothesized linear relationship between harvest and survival rate. Another is a hypothesis of seasonal temperature extremes as determinants of the geographic distribution of species. Hypotheses often can be expressed in terms of parameter values or mathematical relationships, which can be incorporated into a statistical framework and tested by comparison against field data.

Management

Management is defined as decisions and follow-up actions by resource managers to achieve some predefined objective(s). Examples include decisions about which land parcels to conserve, which actions to take to restore wetland habitats, which agricultural practices to use to enhance songbird recruitment, and which regulations to select to balance sport harvest with long-term population vitality. For purposes of this report, management is distinguished from the scientific investigation of causes, evaluation of management actions, and biological monitoring.

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 hypotheses about biological responses to management to evaluate. Monitoring data are used both for decision-making and for comparison against predicted responses so as to better understand management impacts. Monitoring designs are determined by management objectives. Monitoring that is integrated into a decision-making process (e.g., adaptive management, research hypothesis testing, model development) is considered management-based monitoring. Integrated within a decision-making framework, the roles and requirements of monitoring programs are unambiguous.

Sampling unit

A sampling unit is the basic unit on which field data are collected. Examples of sample units include parcels of land (e.g., quadrats, plots) on which vegetative cover is recorded; transects along which organisms are observed; point locations at which bird calls are recorded; and individual organisms on which physiological measurements are taken. Sampling units are (or should be) randomly selected from a larger universe of potential sampling units according to a sampling design. The data recorded on sampling units are used to produce estimates of population parameters.

Scale

Scale is the extent of an effort that is implemented within some gradient of potential coverage. Examples include spatial scale, as in the geographic extent of a monitoring effort; temporal scale, as in the temporal scope of a monitoring effort; taxonomic scale, as in the diversity of species recorded in a survey; and organizational scale, as in the organizational breadth of partnerships (e.g., states, federal agencies, NGOs) involved in a monitoring effort. In this context, "broad-scale" means extensive coverage over the gradient of interest.

Scale-dependence

Scale-dependence is the sensitivity of an attribute to the scale at which it is viewed or measured. An example is the measurement of species richness, which increases with expanding geographic scale. Another is the relationship between habitat structure and nesting success, which often can be seen at small but not large geographic scales. Yet another is trend, which can change from positive to negative and back to positive with expanding temporal scale.

Science-based management

Science-based management refers broadly to iterative management processes that involve: 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.

Stakeholders

Stakeholders are represented by individuals and organizations with a vested interest in a shared enterprise. Their interests can include 1) an expectation of received benefit; 2) a perceived threat; 3) a prior investment in time and resources; or 4) values shared with others associated with the enterprise. The active engagement of stakeholders is generally recognized as a necessary condition for successful implementation of a management strategy.

Appendix B: FREQUENTLY ASKED QUESTIONS

1. How do we know about the status of a continental population?
    a. We are not recommending that continental-scale surveillance programs be ended; only that they be reviewed.
    b. Even with management-based monitoring, if you follow the design principles in this report, estimates of abundance and trend can emerge as by-products.
    c. We question the usefulness of this information alone in establishing management priorities or strategies. In most instances, biological judgment, knowledge of habitat change, auxiliary information, and anecdotal evidence are sufficient to set management and hence, monitoring priorities

2. How would agencies, refuges, national parks etc. restructure programs?
    a. This is a decentralized approach; not a top down approach.
    b. The scale of the management decisions determines the scale of administration and coordination.
    c. Look within your own infrastructure to see how you would accomplish coordination.

3. What is it going to cost?
    a. The cost of monitoring needs to be integrated into the resources (budgets, personnel, equipment, etc.) dedicated to bird conservation.
    b. In the long term, it will cost less because of the economy of scale of coordination; the termination of programs that are inefficient; and the additional information gained from a coordinated monitoring program.
    c. Redirection of existing resources is a key first step to supporting monitoring.

4. What does this mean for the Breeding Bird Survey (BBS) and similar programs?
    a. We are not recommending that continental programs be ended; only that they be reviewed.
    b. Consider each management decision to determine what monitoring program best suits your needs. In this context, evaluate the utility of incorporating collection of appropriate management-based co-variate data in conjunction with bird population data in existing surveys as a means of increasing their utility in rendering useful information.

5. When do you intend to ask other groups to participate? How do I get my voice into this process?
    a. The report is a springboard and framework for discussion by the larger conservation community.
    b. Get involved through JVs, IAFWA, NABCI, etc.

6. What if a partner doesn't agree with the report? How do we discuss those differences?
    a. NABCI national committee

7. How do we set priorities in the absence of a continental level monitoring program?

    a. We are not recommending that continental programs be ended; only that they be reviewed.
    b. We question the need for a continental population estimate in order to set priorities.
8. We already know what management is effective. Why do we have to evaluate everything?
    a. In some instances we don't need to evaluate.
    b. Increasingly, we need to document and justify our decisions to satisfy legal requirements and to convince policymakers our management is working.
    c. Monitoring can help choose among management scenarios.

9. Where is my cookbook? Who will write the cookbook?
    a. Tailor your monitoring program to the management decision because a cookbook approach will not be successful.
    b. Use a general set of principles (a toolbox) and apply the principles to your individual monitoring program.

10. Who provides the technical expertise?
    a. In many places the technical expertise along with the means of coordination are not in place, available, and/or supported. This is one of the challenges. However, pooling the resources we do have through coordination is perhaps the most effective way of dealing with the lack of support until more resources become available.

11. If we are advocating a shift to management-based monitoring, how is this type of monitoring going to inform future problems, especially those requiring long-term data?
    a. Even with management based monitoring, if you follow the design principles then estimates of abundance and trend can emerge as by products.

12. Give us an example of how this works for nongame species?
    a. Shorebird management on National Wildlife Refuges – 13 refuges coordinated on shorebird management and used the data from the monitoring program to set priorities and develop management decisions.
    b. If monitoring is management-based and the management decision will affect forest dwelling bird species then monitoring should be tailored to detect state changes in target forest-dwelling bird species.
    c. Longleaf pine – Henslow's sparrow and northern bobwhite may respond similarly to understory management practices, and might both be incorporated in a monitoring program to assess the effectiveness of a management strategy in this community.

13. Doesn't management-based monitoring and coordination apply across all taxonomic groups? Who is coordinating that? What about systems monitoring?
    a. Depending upon scale of the management decisions, it might be appropriate to manage for a system. In these cases, birds might not be the only taxonomic groups of interest, but the principles espoused in this report should still apply.

14. How is this different from Coordinated Bird Monitoring (CBM) in the North American Bird Conservation Initiative (NABCI) Monitoring Working Group?
    a. This committee was given a charge by the USFWS, USGS, and IAFWA representing the state agencies. On the other hand, NABCI doesn't have legislative authority.

15. What is the role of citizen science?

    a. Citizens are viewed as stakeholders who will contribute to monitoring depending on the needs of the tailored monitoring program.

16. What is the next step?
    a. We invite broader discussions.
    b. What about another committee with broader recommendations? What about this group as the core of the NABCI Monitoring Working Group?
    c. Recommend asking NABCI to do what?
        i. Policy review within US and Mexico, Canada
    d. Ask IAFWA Science and Research committee to do what?
        i. Share with BCC and working groups
        ii. Share with NABCI with these recommendations
            1. Policy review within US, Mexico, Canada
            2. Carry report to the organizations of NABCI and provide feedback.
        iii. Technical Review?

17. What does management-based monitoring have to do with coordination?
    a. The Committee made a decision to focus on the foundation of monitoring in addition to the role of coordination in monitoring.
    b. Coordination is performed at the scale of the management decision.

18. Why do we want to coordinate?
    a. To manage more effectively; therefore, stepping back and ensuring that the management process makes sense.
    b. Effective coordination will increase the amount of information obtained, and the scope and scale of inference that can appropriately be drawn from that information.

19. Following the example of the North American Waterfowl Management Plan, how can we develop population objectives without continental numbers? What about a migratory stop over area?
    a. Data are (should be) collected at a large scale because the management decision is at that scale.
    b. The scale of monitoring should correspond to the scale of the management decision.
    c. Pragmatically, are continental numbers the best way to use our monitoring resources?
    d. Trade-offs need to be considered.

20. Are you suggesting that the monitoring of the North American Plan is not appropriate when you say that the scale of monitoring is at the scale of the management? (North American Plan manages locally but monitors at the continental level)
    a. Management is not local because hundreds of projects are being done locally but aggregated up.

21. Is management/science-based monitoring Adaptive Resources Management (ARM)?
    a. It is not just ARM; a number of approaches to "learning by doing" or otherwise structuring the process of management evaluation can be utilized.

22. What are the key attributes of omnibus surveillance monitoring?

a. Represents a cost-effective way to collect status and trend information for a large number of species over large areas
b. Strengths
    i. Produces indicators (but not estimates) of status and trend
    ii. Sometimes can identify species of potential concern
    iii. Sometimes helpful in generating hypotheses about status and trend
c. Limitations
    i. Cannot provide efficient parameter estimates, even of status and trend
    ii. Neither confirms or disconfirms hypotheses as to causes of trends
    iii. Limited usefulness for conservation decision making
d. Is both economical and uneconomical
    i. Economical because lots of data can be generated at low cost
    ii. Uneconomical because the data typically are of limited inferential value for confirming biological patterns and their causes

23. What are the key attributes of management-based monitoring?
    a. Is embedded in management, with data integrated into decision-making and used to understand responses to decisions
    b. Can produce statistically reliable estimates of biological attributes
    c. Useful for statistical confirmation/disconfirmation of hypotheses about the causes of biological patterns
    d. Can be used as a basis for conservation decision making
    e. Uneconomical because the sharp focus on particular attributes in a specific management context obviates the low-cost collection of data on large numbers of attributes
    f. Economical because monitoring can be designed to maximize information content at minimum cost for a specific monitoring objective