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PARTNERS IN FLIGHT MONITORING NEEDS ASSESSMENT SUMMARY

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INTRODUCTION

Bird monitoring, which involves repeated measurement of avian populations during one or more stages of species' life cycles, is widely recognized as a necessary component of successful conservation projects. All the State Wildlife Action Plans (http://www.wildlifeactionplans.org/), for example, call for monitoring programs to evaluate and support conservation actions. Currently, over one thousand bird monitoring programs are operating in the United States in a mostly uncoordinated patchwork that features redundant surveys for some (mostly common) species, and insufficient attention to others. Similarly, there has been little effort to share data, unify coverage, standardize protocols, or incorporate new and powerful techniques for managing and analyzing data until very recently. These shortcomings have hindered efforts to conserve the hundreds of Species of Greatest Conservation Need identified in State Wildlife Action Plans, USFWS Birds of Conservation Concern 2008 (http://library.fws.gov/Bird_Publications/BCC2008.pdf), Endangered Species Recovery Plans (http://ecos.fws.gov/tess_public/TESSWebpageRecovery?), Strategic Habitat Conservation Initiatives (National Ecological Assessment Team 2006), Partners in Flight (PIF) technical publications (http://www.partnersinflight.org/pubs/ts/), Joint Venture (http://www.fws.gov/birdhabitat/jointventures/index.shtm) plans, and other conservation initiatives. It was stressed numerous times during the McAllen workshop that monitoring needs are much greater in Latin America and the Caribbean than in the United States.

When conducted effectively, monitoring can: 1) quantify the current status or condition of bird populations in terms of occurrence, distribution, abundance, vital rates, and/or health, 2) measure trends, or changes in status, over time, 3) reveal effects of natural or human-induced changes in the environment, and 4) aid in the development and evaluation of conservation and management decisions. Monitoring can also bring to light conservation threats and remedies by providing new insight into the ecology of target species. The integration of bird monitoring, research, and management has helped stabilize or restore several high-profile species that were once imperiled or extirpated, including: Common Loon (*Gavia immer*), Atlantic Puffin (*Fratercula arctica*), American Black Duck (*Anas rubripes*), Bald Eagle (*Haliaeetus leucocephalus*), and Peregrine Falcon (*Falco peregrinus*). Information gained from bird monitoring is often used to plan, implement, and evaluate conservation activities. However, many monitoring programs have operated separately from the decision-making process, often without specified objectives or standardized methods. As threats to birds multiply and funds to address them fail to keep pace, the limits of monitoring in isolation have become increasingly evident.

Monitoring needs were identified through the PIF Needs Assessment at the 2008 International Partners In Flight Conference, and additional resources were evaluated for this document, including High Priority Needs for Range-wide Monitoring of North American Landbirds (Dunn et al. 2005), Opportunities for Improving Avian Monitoring (US NABCI 2007), A Framework for Coordinated Bird Monitoring in the Northeast (NECBM Partnership 2007), and The Northeast Bird Monitoring Handbook: 10 Steps to Successful Bird Conservation through Improved Monitoring (Lambert et al. 2008).

The following primary themes (priorities) were identified regarding the collection and use of monitoring data:

- Establish clear purposes for data collection
- Determine what monitoring products are needed and how they will be produced

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- Increase opportunities for cooperation among potential partners with complementary skills
- Assess the effectiveness of monitoring programs

This document is not intended as an exhaustive treatment of all bird monitoring but is rather a summary of high priority needs that are applicable to birds of any habitat. The importance ranking of these needs will vary, depending on circumstances. Addressing the following needs will better equip the PIF community to implement programs dedicated to conserving the remarkable variety of birds and their habitats.

ESTABLISH CLEAR PURPOSES FOR DATA COLLECTION

Collecting bird monitoring data can be expensive and time consuming. Further, bird monitoring data can be collected in various ways, some of which are more amenable to answering priority conservation questions than others. It is therefore paramount to define clear goals and specific objectives prior to the development of sampling designs or the collection of data.

Although federal agencies and Joint Ventures will continue to be leaders in defining monitoring goals and objectives at the national and regional scale and facilitating the coordination of local scale bird monitoring programs, there are valuable new partners evolving in the monitoring community (e.g., Avian Knowledge Network, eBird, and regional bird observatories). Increased capacity in terms of dedicated personnel, time, and expertise were highlighted as necessary for more effective monitoring leadership at the regional scale, especially for species thought or known to be declining across their range.

Private Lands Programs

In McAllen, many priority monitoring goals and objectives were identified. In particular, participants of a session dedicated to the application of Farm Bill programs on private lands made several suggestions associated with setting measurable bird population targets to evaluate the success of the Farm Bill and other government programs at maintaining or increasing bird population sizes. Many management and conservation actions cannot be adequately evaluated because their effects on priority bird species have not been monitored. Similar needs were expressed for monitoring population changes on private lands in general. For example, ponderosa pine-dependent species were identified as a group in need of revised public lands management plans and increased monitoring of their effectiveness.

Cage Bird Trade

A lack of knowledge of the impacts of wildlife trade on bird populations was also a cause for concern. There is therefore a need for monitoring the population status of species captured for the bird trade. One possible outcome of having such knowledge would be the calculation of sustainable harvest levels that could be used for setting quotas. In cases where nations choose to do so, monitoring data are needed on the status of traded bird species in order to set sustainable quotas.

Indicators of Ecosystem Integrity

Another expressed need was for bird monitoring data that are compatible with indices of ecosystem integrity at the local, regional, and continental scales. If relationships among indices of ecosystem integrity and populations of bird species can be established, then bird monitoring could provide more information about the capacity of ecosystems to renew themselves and continually supply resources and essential services. Several recent papers were identified as providing a basis for selecting focal species as indicators of at ecological integrity at various scales of interest (e.g., Canterbury et al. 2000, O'Connell et al. 2000, Bryce et al. 2002, Carignan and Villard 2002, Lussier et al. 2006, Mattsson and Cooper 2006, Howe et al. 2007, O'Connell et al. 2007).

High-Priority Species

Similarly, data collection protocols and survey designs are needed that target species of greatest conservation concern. The session on the Ivory-Billed Woodpecker (*Campephilus principalis*) highlighted this need for region-wide efforts to locate elusive and rare species. Other rare species in need of targeted surveys include cavity nesters such as Flammulated Owl (*Otus flammeolus*) , secretive marshbirds, shorebirds, inland colonial waterbirds, early season nesters, and nocturnal species (owls and nightjars) not typically sampled by point count protocols. Species with very specialized habitats (e.g., Black Swifts (*Cypseloides niger*) associated with waterfalls) are also strong candidates for targeted monitoring programs.

Climate Change

Assessing the effects of climate change on bird populations is increasingly a goal of monitoring programs. However, the temporal and spatial scales of these effects require broad coordination of monitoring programs. Climate change therefore provides impetus and opportunity to standardize protocols and consolidate output from multiple programs for a single unifying purpose. Given that federal and state resources are increasingly directed towards measuring and monitoring climate change, bird monitoring program leaders should consider how their data can be used within a cooperative framework to monitor such change.

The National Phenology Network is one example of how coordinated efforts to identify changes in bird phenology (timing of life history events) provide data that may be used to monitor the effects of climate change. While knowledge of how climate change affects bird populations is of high priority, efforts to better understand and mitigate its impacts should complement (and not substitute) for greater awareness and understanding of the many other stressors to bird populations (e.g., habitat loss and degradation, fragmentation, urban sprawl, heavy metal poisoning, feral cat pressure).

Renewable Energy

The renewable energy market is expected to increasingly pose a threat to bird populations as native forests, shrublands, and grasslands are converted to corn, switchgrass, and other forms of cellulosic energy. Similar threats are looming from the anticipated explosion in wind farm development and associated electricity transmission infrastructure. For example, there is available information on wind farm effects on the behaviors, breeding populations, and wintering populations for some grouse species, for some boreal songbirds, and for a few shrub-steppe birds, but there is almost no information on effects to passerines in grasslands and tundra and little knowledge of why reductions in abundance occur (Do birds avoid exotics, roads, noise, vertical structures? Is productivity affected?). Future coordinated bird monitoring with the goals of identifying areas of high risk (e.g., migration pathways and sensitive breeding populations) should be implemented, as this knowledge is essential for the prioritization of lands that are converted to renewable energy production. Monitoring of bird population responses to different types and ages of linear features (e.g., width, type, time of disturbance, vegetation regeneration rates) and vertical structure also need to be conducted on a biome specific basis for various species and species groups. Mandatory monitoring with sufficient statistical power should be implemented to determine the effectiveness of regulations, habitat restoration, easement and enhancement project practices, and mitigation.

Other Sources Of Mortality

Other structures, especially those made of glass and lit at night, also pose risks to birds. Regionally coordinated monitoring will help partners determine whether these risks vary across the continent. For example, is the issue of nocturnal migrant birds flying into lit skyscrapers as detrimental in the West as it is in the East? The answer to this and related regional questions could help direct conservation efforts (e.g. targeted outreach or light reduction programs) where they are most needed.

More monitoring of the effects of free-ranging domestic and feral cats on birds is also needed. Areas such as Texas, where there are many feral cat colonies but apparently no studies on their effects on birds, should be targeted as monitoring priorities. Survey designs should consider Before-After Control-Impact designs – before and after cat removal, and in areas with and without cats.

Bird monitoring at birding trail sites would be useful for exploring whether increased usage of sites by birders leads to conservation concerns. This information could then be used to provide guidance on best practices of site selection and development, to minimize potential impacts.

Nonbreeding Season

Additional monitoring is needed in Central and South America for many reasons. Vegetation communities of particular interest include highlands, pine oak forests, and mangrove swamps. Of great need is a better understanding of overwinter survivorship that may vary over time and space for many species. Greater funding and regional cooperation is therefore needed for projects such as Monitoreo de Sobrevivencia Invernal (MoSI; English—Monitoring Overwintering Survival) to establish and maintain a large network of monitoring stations. In addition, many existing data sets that could also be used for analyses in Central and South America were collected from researchers based outside these areas and are dispersed around the world. Data should be provided for storage in their home countries.

Greater coordination among existing conservation networks (e.g., El Grupo Cerúleo) is especially needed in the wintering grounds, but this need is relevant everywhere. Full-time, regional coordinators are needed to improve efficiencies among monitoring programs, define specific needs and advance regional monitoring data acquisition, and provide opportunities for collaboration among agencies and organizations and across spatial scales.

DETERMINE WHAT MONITORING PRODUCTS ARE NEEDED AND HOW THEY WILL BE PRODUCED

There are countless ways to monitor bird populations. Some are more useful than others, and utility is not always dependent on goals. Deficiencies in the design and implementation of monitoring protocols and survey designs can stymie even the best-intentioned and well-funded programs. Bird monitoring needs therefore include the identification of dependable measures of population status, efficient monitoring protocols that permit the quantification and adjustment of errors and biases, and user-friendly analysis tools.

Most bird monitoring programs implicitly consider the life history of target populations in the development of field protocols. However, few explicitly describe the known or hypothesized relationships among life history traits, populations, habitat characteristics, and real or potential stressors. Detailing these relationships using conceptual models during the design of a monitoring strategy can help identify what response variables and covariates to measure. A conceptual model, or "a hypothesis regarding the expected response of a species or species group to changes in environmental conditions and/or management" (Vesely et al. 2006), includes written descriptions and/or diagrams to depict cause-and-effect relationships among ecosystem elements, natural processes, and anthropogenic stressors.

Monitoring programs that build and test alternative conceptual models are better equipped to determine the importance of individual conservation activities. Therefore, more emphasis is needed on using conceptual models during the design of monitoring programs, and evaluating system models after data have been collected. Conceptual models may be created through hand drawings or flowchart tools available in most office software packages, or by using systems modeling (e.g., Stella) and workflow software (e.g., Kepler).

Error and Bias

Bird monitoring is subject to multiple sources of error and bias. If these are controlled, results may better inform management and conservation decisions. Classification errors arise when observers misidentify birds or use mistaken field codes when rushed to record observations during a fast-paced count. Measurement errors can stem from double-counting an individual bird, assuming two or more birds are the same individual, failing to detect a bird that is quiet or otherwise undetectable, or failing to detect an observable bird due to inattention or hearing failure. Characteristics of a site, such as a dense understory or a noisy stream, may also introduce sampling bias, in which some members of the population (e.g., highly visible and loud birds) are more likely to be detected than others. Bias may also arise from survey conditions that affect bird activity and/or one's ability to detect the activity, such as time of year, time of day, or weather. The importance of rigorous training designed to identify and minimize such sources of bias and error in applying monitoring protocols cannot be overemphasized, and yet many monitoring programs have only minimal training components, or forego them altogether.

Fortunately, the science of bird monitoring is rapidly evolving, producing new techniques to quantify and adjust for variable detection rates. Options include repeated counts (Kery et al. 2005), time-of-removal methods (Farnsworth et al. 2002), time-of-detection methods (Alldredge et al. 2007), distance sampling (Rosenstock et al. 2002), double-observer (Nichols et al. 2000), double-sampling (Collins 2007), and hybrid approaches (e.g., Farnsworth et al. 2005). Repeated presence-absence surveys can be used to estimate occupancy or abundance with methods that include measures of detectability (Royle and Nichols 2003, McKenzie et al. 2006). Because the options are varied and complex, there is need for intuitive training guides and workshops targeted to broad audiences. Funding for workshops and travel stipends for participants are needed to overcome logistic hurdles that increasingly include travel restrictions.

COARSE VERSUS PRECISE RELATIONSHIPS

Recent studies have also shown that large datasets, including those compiled from multiple sources and sampling protocols, can be useful for quantifying relationships and trends (e.g., LaDreau et al. 2007, Bonter and Harvey 2008, Kelling et al. in press). If the objective of the monitoring program does not require spatially, temporally, or thematically precise information, then time may be better spent finding and archiving existing datasets instead of developing sophisticated sampling designs and survey protocols.

When monitoring objectives require precise information, then it is best to minimize bias and error during data collection and entry, regardless of whether these problems can be modeled using monitoring data. Strong collaboration among statisticians and bird monitoring leaders is needed to develop standardized protocols that can be understood and implemented on the ground. Modular protocols that permit the exclusion of components based on project constraints will ease their integration into monitoring programs. For example, budgetary and logistical constraints need to be considered in order to avoid problems that could arise from impractical sampling schemes, cumbersome field methods, or analysis procedures that exceed the technical or financial resources of the monitoring organizations.

Other Monitoring Standards

In addition to protocols to monitor bird species occurrences, densities and population rates, standardized protocols are also needed for obtaining permits to collect feathers and blood. This need includes methods to store feathers, blood, and "partial specimens," as well as for an accessible database for storing all collected information. There is also a need for better coordination of blood and feathers collection in countries outside the U.S. and Canada, including increased capacity to analyze and store samples within wintering-grounds countries and ability to share data in internationally accessible databases.

Consistent techniques for morphological measurements need to be developed and shared widely throughout the Western Hemisphere. Tarsus, for example, is one of the most difficult measurements to make but one of the most important. Similarly, molt is also often overlooked in mist-netting or monitoring. While much data on non-breeding biology and natural history already exist in museums, people's natural history notebooks and in the literature, this information still needs to be harnessed and organized and entered into a single database.

Tools and Training

More tools and training are also needed for analyzing data. Beyond the capabilities at national-level institutions like U.S. Geological Survey, data storage and distribution networks such as the Avian Knowledge Network (http://www.avianknowledge.net) are making great strides towards fulfilling this need, but more sophisticated tools that model errors and biases are still out of reach for most ornithologists. Web-based "black box" tools that can accept preformatted data, run various analyses, and output intuitive reports are needed. Not only would such tools help address the constant need for technical training to analyze data and interpret results, but the standardized presentation of outputs and their interpretations would also help bridge the growing knowledge gap between monitoring program designers and the majority of natural resource managers who do not have advanced statistical expertise.

INCREASE OPPORTUNITIES FOR COOPERATION AMONG POTENTIAL PARTNERS WITH COMPLEMENTARY SKILLS

Each monitoring program should also define partner roles at the outset with respect to funding, survey design, implementation, data management, analysis, reporting, as well as the development and delivery of tools to support conservation decisions. Hence, diverse and well defined partnerships are needed to combine technical expertise in project management, ecology and behavior of the target species, field methods, statistical methods, geographic information systems, data management, and reporting. While large partnerships run a risk of conflict and stagnation, well coordinated partnerships can strengthen monitoring by aligning equipment, staff, historical data, financial resources, analytical tools, and management influence behind common conservation purposes.

Data Managers

Data managers are needed to organize and distribute primary data collected in the field and derived data that are produced through statistical summaries, data transformations, and analysis procedures. The Avian Knowledge Network (http://www.avianknowledge.net) has been very successful in fulfilling this need for large datasets, but much work is still needed to collect, organize, and integrate smaller datasets. Data management should be considered at the earliest stages of program development, not after the data are being collected. Incentives are therefore needed to better integrate data management into the planning and development of bird monitoring programs.

Metadata

Formal metadata describing the "who", "what", "where", "when" and "how" of data collection are lacking for most datasets. This deficiency can relegate powerful datasets to obscurity, limit their ability to be integrated with other datasets, lead to the misuse of data, and consume the time of data curators who are tasked with the detective work of discovering these essential details. Hence, there is a proactive need for simple tools to describe bird conservation projects and their datasets so that their qualities can be recorded by project leaders, regardless of their technical expertise, in standard formats and stored in publicly accessible metadata repositories such as AKN and NBII (http://www.nbii.gov) in perpetuity. There is also a retroactive need to compile and describe historical datasets so that they are not lost or misused. Initial steps to proper metadata creation for historical datasets could include "calls for information" through professional forums such as discussion email lists. If datasets were first identified and classified into broad categories (e.g., point counts, nest monitoring), this could provide a starting point for finer details of the metadata to be found and documented by outside parties interested in using the data.

Maps

Maps have become a central component of many monitoring projects. They are used to stratify areas for survey designs, coordinate field crews, describe environmental variables used in habitat analysis and predictive modeling, and for many other purposes. These advances come with the challenge of staying updated on software, which are increasingly powerful but also increasingly complicated to use. There is therefore a need for cooperation with partners whose mission is to stay updated with mapping software changes; create GIS data libraries that are easy to access, search, and download by the general public; and create new maps that have functional relevance to the distribution and status of birds and their habitats. In particular, new maps derived from Forest Inventory and Assessment data were identified as having great potential for predicting bird populations. There is also a burgeoning need and opportunity to serve GIS data within and alongside of user-friendly web-based mapping interfaces (e.g. Google Earth) that are accessible to all potential users.

Habitat Variables

While increasing scrutiny of bird monitoring data is resulting in better coordinated bird data collection activities that have greater statistically power, little has been done to coordinate the collection of habitat variables. Further, little to no thought has been given to how bird monitoring programs can contribute to improvements in GIS layers used for landscape analysis and predictions of bird populations. There is great potential for bird surveyors, who have already committed the time and expense to sample a location, to collect vegetation data that can be used to ground-truth satellite images and aerial photography used to classify land cover maps, that in turn can be used to describe and predict changes in bird population trends. Collaboration among bird monitoring leaders and image analysts also has strong potential to improve the accuracy and relevance of maps for bird conservation. However, attention is needed to identify scales of data collection that are both relevant to birds and representative of image and map pixels - measured variables should be relevant to birds and have qualities that allow them to be discriminated spectrally and/or texturally in images.

Non-traditional Partners Needed

The Partners in Flight community also needs to identify even more unlikely alliances that could address data needs. Potential partners include pet food industries, humane societies, green building associations, municipalities, energy companies, academia, and others. Mist-netting demonstrations could also be used to educate the public on citizen scientist monitoring programs such as eBird. Citizen scientist programs that target birding tour companies should also be implemented to provide simple and fast tools for experienced guides to contribute to cooperative data sets and engage the public. However, there is also a need to ensure that ecotourism companies using conservation areas also follow ethical guidelines and pay for habitat services.

ASSESS THE EFFECTIVENESS OF MONITORING PROGRAMS

There is a need to develop a list of objective questions that will help managers assess their own monitoring programs based on the recommendations in this document and others, such as Opportunities for Improving Avian Monitoring (US NABCI 2007). This effort should result in monitoring program report cards to aid in self-evaluation by biologists and managers. Regular reviews of monitoring programs are needed to identify specific failings, and opportunities to improve monitoring programs and advance the goals of both local and regional monitoring programs. The outcomes of these reviews should be summarized to determine how financial support for monitoring should be distributed across institutions and spatial scales.

NEXT STEPS

Based on the monitoring needs expressed during the McAllen sessions and other documents, we make the following recommendations for improving the efficacy, utility, and effectiveness of monitoring programs:

Building Capacity

- Increase the capacity of Joint Ventures to provide more effective monitoring leadership at the regional scale, especially for species thought or known to be declining across their range.
- Full-time, regional and national coordinators are needed to improve efficiencies among monitoring programs, define and advance regional monitoring data acquisition needs, and provide opportunities for collaboration among agencies and organizations and across spatial scales.
- Establish more data collection alliances with private partners including ecotourism companies, pet food industries, humane societies, green building associations, municipalities, and energy companies.
- Establish and maintain a large network of monitoring stations in Central and South America to better understand spatial and temporal variation in of overwinter survivorship for many species.
- Establish intuitive training guides and workshops on new techniques for quantifying and adjusting for biases and variable detection rates among people, species, and locations.
- Establish well defined partnerships to combine technical expertise in project management, ecology and behavior of target species, field methods, statistical methods, geographic information systems, data management, and reporting.

Setting Objectives

- Set measurable bird population targets to evaluate the success of the Farm Bill and other government programs at maintaining or increasing bird population sizes on private lands.
- Increase monitoring of species captured for trade so that their population status can be assessed for the calculation of sustainable harvest levels for setting quotas.
- Increase the collection of bird monitoring data that are compatible with indices of ecosystem integrity at the local, regional, and continental scales to provide information about the capacity of ecosystems to renew themselves and continually supply resources and essential services.
- Establish dependable population status measures.

Identifying Limiting Factors

- Assess the effects of climate change to improve the understanding of this one, among many, stressors to bird populations
- Identify areas of high risk from new energy infrastructure to bird populations throughout their life cycle, including migration, with sufficient statistical power to determine the effectiveness of regulations, practices, and mitigation.
- Implement a nationally coordinated monitoring program to assess variation in the risks of structures, especially those made of glass, to birds across the continent.
- Assess the effects of feral and domesticated cats on bird populations, including surveys with Before-After Control-Impact designs – before and after cat removal.
- Assess impacts of increased usage of birding sites by birders to provide guidance on best practices of site selection and development.

Improving Data Management

- Establish data management and integration as a core component of the planning and development of bird monitoring programs.
- Provide better access to data collected in Central and South America to the people in the countries in which the data were collected.
- Create centralized GIS data libraries that are easy to access, search, and download

Improve Design of Monitoring Programs

- Develop a list of objective questions to aid biologists and managers in evaluating their monitoring program's effectiveness in advancing local and regional monitoring goals.
- Emphasize the need for conceptual models during the design of monitoring programs and evaluate those models after data have been collected.
- Establish efficient monitoring protocols that permit the quantification and adjustment of errors and biases, and

incorporate these protocols into new and existing programs like the Breeding Bird Survey, especially into Mexico and Central America.

- Establish habitat data collection protocols that measure variables at scales that are both relevant to birds and representative of image and map pixels.
- Establish standardized protocols for obtaining permits to collect feathers and blood, and establish one or more information nodes for organizing and accessing samples.
- Establish standard techniques for morphological measurements and consolidate existing morphological data into a single database.

IMPROVING ANALYTICAL TOOLS [2ND LEVEL]

- Establish user friendly data analysis tools, including web-based "black box" tools that can accept preformatted data, run various analyses, and output intuitive reports.
- Develop simple tools for collecting project metadata in standard formats and store them in publicly accessible metadata repositories such as AKN and NBII (http://www.nbii.gov) in perpetuity.
- Create new maps that have functional relevance to the distribution and status of bird species.

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