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# Developing a general conceptual framework for avian conservation science

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Avian conservation science in North America has produced a variety of monitoring programs designed to provide information on population status of birds. Waterfowl surveys provide population estimates for breeding ducks over most of the continent, the North American Breeding Bird Survey (BBS) provides indexes to population change for >400 breeding bird species, and many other surveys exist that index bird populations at a variety of scales and seasons. However, many fundamental questions about bird population change remain unanswered. I suggest that analyses of monitoring data provide limited understanding of causes of population change, and that the declining species paradigm (Caughley 1994) is sometimes an inefficient approach to increasing our understanding of causes of population change. In North America, the North American Bird Conservation Initiative (NABCI) provides an opportunity to implement alternative approaches that use management, modeling of population responses to management, and monitoring in combination to increase our understanding of bird populations. In adaptive resources management, modeling provides predictions about consequences of management, and monitoring data allow us to assess the population consequences of management. In this framework, alternative hypotheses about response of populations to management can be evaluated by formulating a series of models with differing structure, and management and monitoring provide information about which model best predicts population response.

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## 1. Introduction

The North American Bird Conservation Initiative (NABCI) is a collaboration among bird management plans in North America (For more information, see their website at http://www.nabci.org/cec/about_frame.htm). It includes a variety of partnerships, including government and private organizations, and is international in scope. Because it incorporates existing conservation activities such as Partners in Flight the North American Waterfowl Management Plan, the Shorebird Management Plan, and the Waterbird Management Plan, an enormous amount of effort is devoted to discussion of development of monitoring, management, and research activities for birds. Avian research efforts associated with NABCI focuses on 5 primary topics: monitoring, integrated modeling/analysis, decision support, adaptive management, and information management (http://www.pwrc.usgs.gov/nacwcp/nabcidr.pdf). NABCI provides a unique opportunity to consider the relative role of these activities in increasing our understanding of the causes of bird population change.

## 2. Monitoring

### 2.1. History

Monitoring has long been a primary focus of bird management. Documenting changes in populations over space and time is fundamental to any conservation or management activity, and the notion of tracking population response to management is well established. Caughley (1994) described 2 models for conservation. The "endangered species" paradigm is applied to small populations at risk of extinction. For these species, genetics concerns are important considerations, and population dynamics modeling such as population viability analyses are often conducted. The "declining species" paradigm is the alternative strategy of monitoring populations to identify species that are declining in population, and then conducting research to identify causes. Migratory bird conservation activities in North America historically have relied upon of the declining species paradigm, in that effort is first directed in developing monitoring to identify population declines. Once these changes are identified, conservation actions are developed to prevent species from further declines (USFWS 2000).

### 2.2. Shortcomings

Unfortunately, research does not always provide coherent answers to managers. A variety of North American species have shown long-term population declines, but the causes of these declines remain obscure even though many research studies have attempted to identify causes. Examples of these taxa with uncertain causal factors for declines include Black Ducks *Anas rubripes*, *e.g*. The Black Duck Joint Venture Strategic Plan (http://www.pwrc.nbs.gov/bdjv/bdjvstpl.htm), Neotropical migrant birds, and grassland-breeding birds (*e.g*. Peterjohn & Sauer 1999). Many important questions are still unresolved for most species, including such fundamental questions as:

1. Relative importance of wintering ground and breeding ground in influencing population change.
2. Relative influence of environmental features on survival and productivity.
3. Influence of harvest on bird populations.
4. Influence of local habitat management on bird populations.
5. Influence of habitat management at a landscape scale on bird populations.

These questions are still controversial for several reasons. The scale of some questions is beyond our current resources or tools. Banding is an insufficient tool for addressing many demographic issues and other complicated questions of movement rates among breeding and wintering sites of migratory birds. Often, the scale of experiments is local, and extrapolation to regional populations is uncertain. Estimation of survival rates from radio-tagged birds and local productivity analyses are examples of local studies that are often difficult to extrapolate to a regional scale. Coordinated experiments with appropriate sampling frames that provide inference to regions using these intensive tools are still very rare. Models of bird-habitat relationships are similarly limited in scale. Generally, to evaluate regional-scale hypotheses, we rely on association analyses where 'treatments' (*e.g.* habitat manipulations, harvest regulations) are not

experimentally applied. Unfortunately, it is generally difficult to establish causality in these association analyses.

### 2.3. The debate

This uncertainty on causes of observed population changes has led to introspection about the process of management and the role of managers and researchers in bird conservation. Subtle differences of opinion exist about how information is acquired and used, and whether monitoring should provide general information on population status or be an active tool with specific goals. Tools such as decision support systems and geographic information systems provide new opportunities for managers to make monitoring an explicit part of management, with clearly defined goals. These tools also provide the opportunity to use models to predict consequences of management on bird populations, and provide new goals for monitoring in evaluating predictions from models. NABCI provides an opportunity for researchers and monitoring specialists to evaluate their role in increasing our understanding of bird population dynamics.

### 2.4. Limitations of the declining species paradigm

This paradigm is the prevailing idea for much of bird conservation. In the declining species paradigm, bird conservation has 2 phases: observation of population change, and then research into causes of declines. Unfortunately, this approach is inefficient, as observing declines does not lead to understanding of causes of declines. Because observation of declines tends to trigger simultaneously both management and research, it encourages action to mitigate problems at the same time as research is in progress. It justifies monitoring for monitoring's sake, rather than considering it as part of management. When evaluation of causes is distinct from management, there is no impetus to think in an integrated manner about the roles of research, monitoring and management.

Management of populations is extremely difficult when decisions must be made based only on monitoring data. For example, it is impossible to interpret the biological significance of most population declines estimated from monitoring programs. Often, arbitrary population changes are set as standards, and estimated population changes that exceed these thresholds are considered for additional management and research. However, without additional information on the context of the population change estimates, most of these thresholds are meaningless. Occasionally, causes of population change are obvious, and can be evaluated by association analyses of monitoring data. Often, however, changes are subtle rather than obvious, and managers cannot determine the context for the observed population change.

This lack of generally accepted standards for defining population declines is a complication in any species prioritization process (*e.g.* Carter *et al.* 2000).

An additional complication associated with migratory bird conservation is that, in the past, managers have not received clearly defined management options, and their ability to predict the consequences of their management has been poor. Management options have been limited, and in North America the emphasis on management of harvested species reflects

the notion that for these species an obvious management tool exists. For land managers at local and regional scales, the management options for migratory birds have been even more limited, because little information exists on management of habitats for migratory birds. Local management has relied on simple bird habitat models that generally are not based on experimental studies of the relationships of population change and habitat change. Defining management options and implementing reasonable monitoring systems at these scales is a fairly recent innovation.

## 3. Escaping the declining species paradigm

### 3.1. Defining scales and systems for management

NABCI has concentrated conservation efforts on habitat management at local and regional geographic scales. In particular, Bird Conservation Regions (BCRs, Fig. 1) have been developed to provide a common geographic framework for conservation in North America. Within these regions, management plans define priority species and plan conservation activities. Clearly, conservation activities include management of habitats to modify suitability for priority species. This definition of spatial scales and areas of conservation interest is accompanied by development of geographic information that can be used by managers to assess available habitats. These tools permit emphasis by managers on systems and scales of interest and on options for management that can be rigorously defined in terms of geographic models. Local land managers can evaluate the consequences of changing land use on parts of their areas, and regional landscape managers can evaluate changing land-use patterns at the regional scale.

### 3.2. New information sources help in decision support

Remote-sensed data and geographic information systems provide a variety of new tools to describe habitats and bird populations for local and regional management. Managers can use these tools to define habitats in areas to be managed, developed predictive models in the geographic context, and to describe alternative management scenarios. These decision support tools can be used provide quantitative information on local and regional landscapes and habitats, but only recently have managers begun to gain access to these sophisticated tools. A great deal of additional work is needed to develop tools that allow managers to use decision support tools effectively in management.

### 3.3. New notions on use of management as a tool for increasing understanding of systems

Our limited understanding of causal factors influencing population change, and our limited abilities to develop appropriate experiments to evaluate factors influencing bird populations, have led to the idea that management often provides our best tool for learning about factors influencing population change. Historically, monitoring and management of harvested species such as waterfowl has provided data used in association analyses. Unfortunately, these association analyses only provide

weak evidence of causes of population change. Adaptive management is an alternative approach that provides a coherent framework for assessing causality.

Adaptive management is a model-based approach to management that acknowledges uncertainty in our understanding of how management influences populations. In adaptive management, models are used to predict outcomes of management and to choose an appropriate management strategy. Management then occurs, and monitoring is used to assess the results of management. Monitoring results are compared to predictions of the models, and model selection for use in prediction is updated to reflect the new information on how management influenced the population. Later

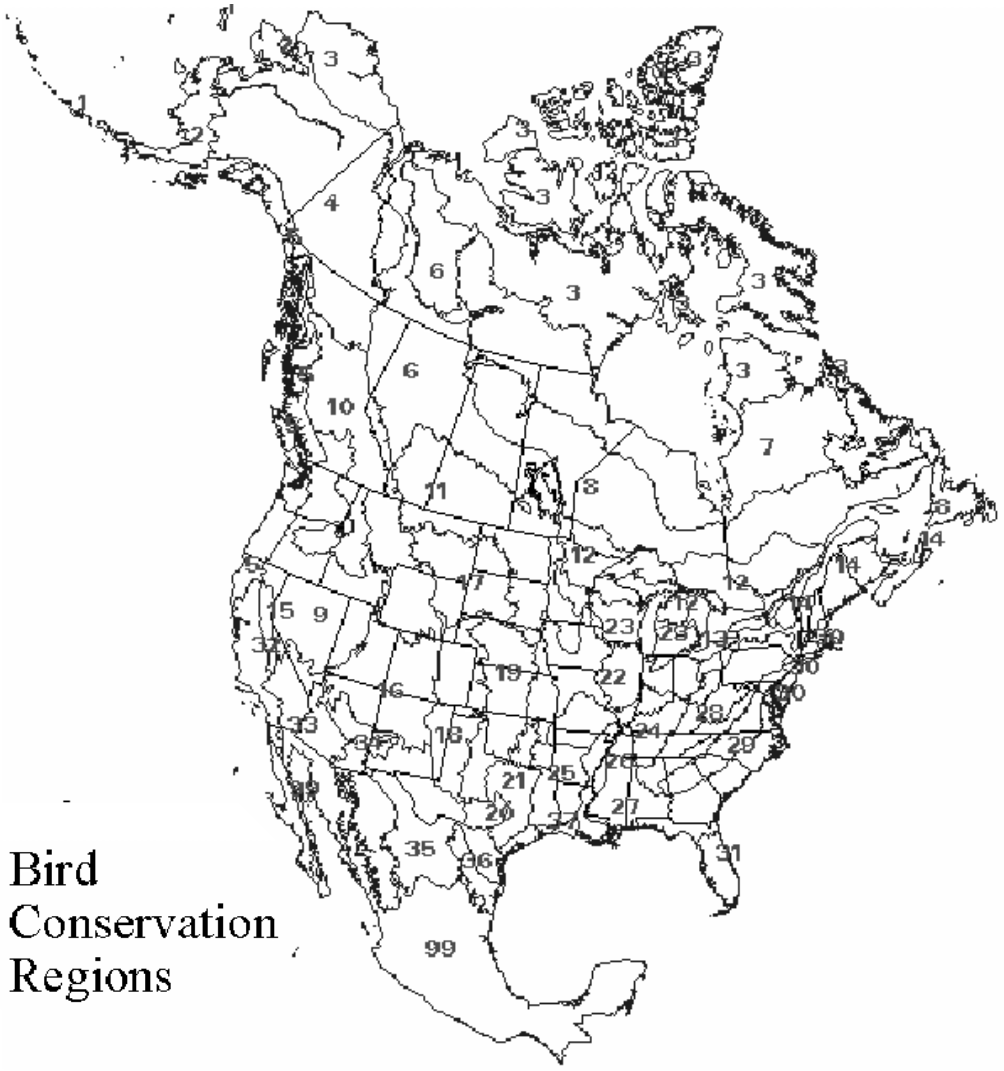


Fig. 1. Map of Bird Conservation Regions, as defined by the North American Bird Conservation Initiative (R. Johnson, United States Fish and Wildlife Service *pers comm*).

management subsequently uses the updated models for prediction and selection of the best management action. This approach is used in harvest management of selected species in North America (Williams & Johnson 1999). It provides a coherent framework for defining management goals, organizing research information into models, and applying the results to subsequent management decisions; monitoring is then implemented to assess the species population response to management.

### 3.4. Developing models of systems of interest

Adaptive management requires an ability to predict the consequences of management. This requires us to formalize our understanding of the system by developing predictive models about how management will influence population change. Models are supposed to explain essential elements of the system, incorporating both our knowledge of the system and the uncertainties associated with our knowledge. Although managers use many types of models at present, much of the present modeling is based on qualitative information that does not provide specificity for management. Now, new opportunities exist for development of quantitative models, because definitions of goals and scales of management provide an explicit context for developing models to describe the effects of management on birds. Furthermore, decision support tools provide additional structure by providing information on relevant habitat and environmental covariates for management.

### 3.5. Making models

To make a model, one must formally define the physical boundaries of the system. For bird conservation in North America, systems are frequently defined in terms of areas such as:

1. Refuges and surrounding landscapes.
2. National Parks.
3. Bird Conservation Regions.

For the system, it is necessary to define the state variables, the variables that are to be modeled (*e.g.* population size). It is essential to include in the model:

a. Exogenous variables: *i.e.* factors that influence population change but which cannot be controlled, such as weather and water levels.
b. Control variables; *i.e.* factors that influence population change that can be managed, such as harvest and habitat.

Finally, a transition equation must be developed that defines how variables interact over time to influence population change. Often, a transition equation is not known exactly, but we can define alternative possibilities in a series of models. In all modeling efforts, it is important to incorporate uncertainty of the estimates of these factors.

Modeling is an obvious component of any management of populations, and all migratory bird conservation fits implicitly into a system that could be modeled. Experimental work plays a large part in the development of models, model structure and it is also crucial in the estimation of components. Systems are never completely understood, but this uncertainty is implicit in both modeling and management. Our models change, either as knowledge expands through experimentation or

upon examination of management results. Management actions followed by evaluation is the only possible method of increasing our understanding of many of our systems. Consequently, ties to management must be explicit in models.

## 4. The role of monitoring in adaptive management

Monitoring has a critical role in adaptive management in that it allows us to assess system status in the context of a model, providing a basis for assessing results of management. This role is fundamentally different from monitoring's role in the declining species paradigm, where often observation of pattern becomes disconnected from understanding of causes. Of course, the traditional roles of monitoring programs remain relevant in documenting patterns of bird population change and in bringing public attention to bird populations. However, it is important to recognize that monitoring data are not sufficient to address critical questions about causes of population change, and we presently rely too much on association analyses as surrogates for research.

### 4.1. Framework for avian conservation?

NABCI provides a possibility for getting away from the declining species paradigm, in which perception of interval-specific change drives management actions and in which qualitative notions of bird-habitat (or bird-harvest) associations are used to make management decisions. To develop a new framework for avian conservation, the essential requirements are:

1. Collaboration with managers in understanding:
   a. Systems of interest.
   b. Available (and needed) information.
   c. Management options.
2. Integration of information on systems through model development.
3. Experimental work to help us understand systems.
4. Development of alternative models when controversy exists about the effects of management.
5. Use of management as source of information on the validity of models through the use of adaptive management. Monitoring has a very focused role in assessing change in system status associated with management and hence in evaluating model predictions.

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