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### POLICY, RESEARCH, AND ADAPTIVE MANAGEMENT IN AVIAN CONSERVATION

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RUTH ET AL. (2003) propose a science agenda to meet information needs for avian conservation, building on a vision for conservation under the North American Bird Conservation Initiative (NABCI) and conservation efforts that comprise NABCI (U.S. North American Bird Conservation Initiative Committee 2000). A close association between research and management is emphasized by the authors, especially concerning conservation planning and the use of ecological information in decision making. Left unanswered, however, are a number of interesting and important questions about exactly how scientific information is to be effectively communicated to decision makers, and how decision makers can be induced to use it for biologically informed and effective conservation. The need to address such issues was pointed out by a reviewer of Ruth et al. (2003). Thus, the objective here is to describe a framework for the interface of research and management in natural resource conservation. In what follows, I focus on the respective roles of decision makers and scientists in formulating and assessing natural resources policy.

*Background.*—Conservation of natural resources necessarily involves living systems and the environments that sustain them. However, by its very complexity the network of biological, environmental, and social components that influence living systems challenges our ability to understand and manage those systems effectively (Marzluff and Sallabanks 1998). Thus, ecosystems typically consist of large numbers of components, and large numbers of interactions among components. They are subject to a high

level of uncontrollable environmental variation, which affects biological processes and imposes constraints on decision making. Typically, most ecosystem components are only partially observable, and the processes controlling system dynamics are only partially understood. Management usually involves implementation of policies that are indirect, limited in scope, and often ambiguous. Decision making is broadly shared, geographically dispersed, and frequently contentious. Finally, management almost always involves multiple goals, which frequently are noneconomic and apparently incommensurate. Under such circumstances, protocols designed for stable, well-understood systems, with simple management objectives and limited decision options, simply do not apply (Holling 1995).

Despite those complications, it still is possible to describe an architecture for informed natural resource conservation. A key role is ascribed in this architecture to planning, and specifically to the articulation of goals and the identification of decisions pursuant to their achievement. Planning is recognized as a vehicle to guide conservation actions, and is seen in turn as being guided by resource assessment. A scenario for conservation thus describes decision making as an iterative process in which planning leads to interventions, the effects of which are recorded through monitoring, with the resulting data used in assessing effects on the resource, and that assessment used in turn to inform future planning. With some variations, planning efforts associated with NABCI describe avian conservation in these terms (e.g. Williams et al. 1999, Pashley et al. 2000, Brown et al. 2001).

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The remainder of this article uses this framework to focus on (1) conservation planning, as implemented through policy; (2) the potential for improved conservation as a result of learning; and (3) prospects for both conservation and learning through adaptive resource management. Below, decision making is described in terms of policy formulation, where the term "policy" is taken to mean a standing plan dictating actions pursuant to corporate goals (Bartol and Martin 1991). In the context of natural resource conservation, this suggests a prescription of resource-based actions supporting conservation goals.

*Policy and natural resource conservation.*—It seems obvious that the design of an effective resource policy must accommodate the realities of managing natural resources. For example, it must recognize the evolution of ecosystems as they respond to both management actions and environmental variation. Likewise, it must allow for the evolution of conservation goals in response to changing social and political conditions. It must accommodate political and environmental constraints on allowable interventions. Importantly, it must allow for a substantial amount of uncertainty as to the consequences of decision making. The latter point often is underemphasized, even though uncertainty about policy effects is ubiquitous in natural resources (Holling 1995). At least three manifestations of uncertainty can be recognized, attendant to (1) changes in the state of the natural-resource system, (2) changes in the natural environment and biological structures and processes influencing system dynamics, and (3) changes in the sociopolitical environment of the system. Ecosystem change is both natural and continuous, and occurs whether or not management actions are taken. The trick is to choose policies that adapt to those changes.

The difficulties of decision making under uncertainty are exacerbated by policy instruments that are only marginally effective in dealing with it. Thus, many approaches to policy formulation do not provide avenues by which scientific information can help shape policy (Ludwig 1994). Nor do they engender the necessary communication and information sharing among affected parties. Nor do they encourage negotiation and sharing of decision-making authority that can lead to acceptance of natural resource policy (Wondolleck et al. 1994).

Of course, other problems besides those associated with uncertainty can lead to failed policies. Policy failure can result from poorly conceived, ambiguous, or irrelevant conservation goals. Even with coherent goals, a policy can fail if it is only weakly connected to them. Policies fail because of a lack of understanding about the resource system itself, or the role of management in inducing system changes; or because of a lack of follow-up tracking of policy effects and implications; or because negotiations fail to include key parties or are handled poorly (Gray and Hay 1986).

If there are many reasons for policy failure, so is there a range of possible results. For example, policies can simply be ignored; or the goals underlying the policies can be discredited; or the planning process itself can be circumvented. The net result is *ad hoc*, often ineffective, sometimes even counterproductive policy, which often is disconnected from any effective action (Hayes 1985). Given the accelerating loss of biodiversity and other conservation values, we can ill afford such consequences.

The robust history of failure in conservation policy, and the rather pallid record of success (Ludwig et al. 1993), suggests that we should look for different approaches. The question is then raised, How can we formulate and implement policies that are effective in promoting conservation?

*Adaptive resource management (ARM).*—A promising approach in resource conservation is adaptive resource management (Holling 1978, Walters 1986), defined variously but taken here to mean "resource management under uncertainty, with a focus on the reduction of that uncertainty" (Williams and Johnson 1995). An adaptive approach to management is especially appropriate for iterative decision making under high levels of system uncertainty, as often characterizes natural resource management. By "adaptation" is meant the adjustment of management strategy based on an improved understanding of the enterprise or a perceived change in its environment. In general, managing adaptively involves a dual focus on (1) achieving enterprise goals, and (2) attaining knowledge about the enterprise pursuant to those goals. Adaptive resource management is simply the application of adaptive management to renewable natural-resource systems, specifically biotic resource systems.

It is the incorporation of uncertainty that distinguishes ARM from other management approaches (Lancia et al. 1996). Uncertainty is expressed by an explicit acknowledgment of the lack of understanding about resource status and processes, coupled with a focus on improving management through enhanced understanding. Biological structure and function are emphasized (Marzluff et al. 2000), recognizing that biological systems are only partially understood, and there is value in tracking what one learns about them as they are managed.

The phrase “adaptive management” was used by Holling (1978) to address intrinsic uncertainties in environmental management, and simultaneously was advocated by Walters and Hilborn (1978) as a way to discriminate among competing models in an effort to reduce uncertainty. However, the concept of “learning by doing” (Walters and Holling 1990) has been espoused for many years in many forums, often in terms of “management by experiment” (Mcnab 1983) or “system probing” (Walters 1986). One of the earliest and clearest expressions of such an approach was by Beverton and Holt (1957) in their recognition of fisheries management as a dual control problem (Stengel 1994). In recent years, ARM has borrowed extensively from systems engineering (Williams et al. 2002), and by now its application to avian conservation is seen in terms of integrated planning, monitoring, and resource assessment (Marzluff and Sallabanks 1998, Williams et al. 1999, Marzluff et al. 2000).

There are several implications of managing so as to reduce uncertainty. First, uncertainty is recognized as a factor in assessing management options and is factored into the objectives of management. That differs from some traditional approaches where policy is determined by individuals representing only one or a few perspectives, often based on an assumed, but typically unverified, response of the resource system. Second, acquisition of data is incorporated directly into the goals of management, and used to guide decision making. Thus, monitoring programs are designed (or redesigned) to facilitate the reduction of uncertainty, in rather sharp contrast to the all-too-common practice of monitoring for its own sake (Holling 1995). Finally, management and research are integrated into a common enterprise, whereby research supports management with information about system

structure and function, and management supports research with interventions designed to be useful in investigating the resource system. This linkage between research and management offers great promise in ensuring that conservation policies are science-based, and thus more likely to be effective.

Policies arise naturally in the course of managing adaptively. By design they are prescriptive, in that management actions are prescribed at each point in time given the current state of the resource system. Also by design, they are responsive to both conservation objectives and information needs. Importantly, the dual pursuit of understanding and conservation objectives requires collaboration among researchers and managers in both the formulation of natural resource policy and its implementation over time. That requirement increases substantially the chances that conservation policies will be effective over the long-term.

*Information requirements for biologically informed management.*—Continuous tracking, assessment, and feedback to decision makers impose substantial burdens on monitoring and research. In the context of ARM, sequential updating of four information components is required, the first being knowledge about the status of the natural-resource system. The state of the system and its processes must be tracked via monitoring programs so as to produce the necessary information for estimating population sizes, vital rates, and other relevant system features (Pollock et al. 2002).

A second component focuses on knowledge about the operational milieu, or “system environment”, of the natural-resource system. For a given resource system, that environment might include structural features such as land-use and land-cover patterns; or ambient features such as temperature, solar radiation, and hydrologic conditions; or sociopolitical features that limit policy options and acceptable system responses. The system environment influences and constrains the biological processes that drive ecosystem change through time (Williams et al. 2002). Tracking of environmental change is therefore necessary to calibrate models of those processes.

Also required are anticipated responses of the natural-resource system to management interventions. That typically involves use of

predictive models, specifically dynamic models (Williams and Nichols 1990). Modeling lends itself naturally to the capture of uncertainty about the effects of management through the use of multiple models incorporating different hypotheses about system response (Williams et al. 2002). Characterizing alternative responses to management with models allows scientific investigation to be built directly into the process of management.

Lastly, learning requires tracking of uncertainty about responses to management. Learning occurs through a comparison of model-based predictions against data-based responses, as recorded through monitoring. It is by means of those comparisons that accumulating information can be used to recognize the most appropriate model of resource dynamics, and thus to confirm the hypotheses associated with it (Williams 2001).

It is interesting to note the remarkable correspondence between the information needs of ARM and the science needs presented by Ruth et al. (2003) in their research agenda. For example, many of the investigations identified in Ruth et al. (2003) focus on ecological processes, environmental factors, and linkages between the two that are required for process modeling. The authors document a need for improved methods of monitoring populations and habitats at appropriate spatiotemporal scales. They also emphasize a need for further development of ecological models, for both scientific and management purposes. Finally, they highlight a need for better decision support systems, and for mechanisms to facilitate sharing of information among scientists, managers, and policy makers.

On reflection, the correspondence between science information needs and management information needs is reasonable, and should be expected. After all, Ruth et al. (2003) acknowledge at several points the importance of providing information that is useful for conserving and managing avian populations. Indeed, the workshop from which their paper emanated was entitled "Science for Avian Conservation: Understanding, Modeling, and Applying Ecological Relationships" (U.S. Geological Survey 2000). Still, it is reassuring to see a science agenda that is so well adapted to policy formulation and implementation under ARM.

## DISCUSSION

An important factor contributing to the failure to produce effective policy is an absence of mechanisms for handling uncertainty (or disagreement) about biological responses to policy (Ludwig et al. 1993). Consequently, policy formulation often lacks buy-in by key players, and thus is unnecessarily contentious and suffers an increased chance that the policy will be ineffective. By recognizing uncertainty in projected management effects, an adaptive approach to conservation mitigates that deficiency. Indeed, one of the most important strengths of ARM is the creation of a framework for embracing uncertainty (Walters 1986), by incorporating it directly into a decision-making process along with the necessary monitoring and feedback for its resolution. It is through an integrated process of planning, monitoring, and assessment that adaptive policies can be responsive to conservation objectives, while simultaneously providing information to improve conservation in the future.

Many investigators have pointed out the crucial role played by policy makers and their institutions in the implementation of ARM (Gunderson et al. 1995, Walters 1997, Johnson and Williams 1999). Thus, for adaptive resource management to be successful, policy makers must recognize (and commit to) the monitoring of resources and their responses to management interventions. Such a commitment is not insignificant, given the fiscal demands involved in large scale, long-term monitoring. In addition, an institutional framework for decision making must be established that allows for the expression of uncertainty and disagreement, through processes that accommodate differences of opinion about management effects. The role of research in enhancing our understanding of biological processes must be recognized and endorsed. Finally and most importantly, cooperative management is required, wherein the involved parties are included in the decision-making process, and values shared by them are incorporated in the management objectives that drive policy formulation (Lee 1993, Westley 1995).

Clearly, there are substantial impediments to adaptive management—some technical, some operational, some institutional. Indeed, recent reviews (McLain and Lee 1996, Walters 1997)



indicate that few fully adaptive approaches to resource management have extended beyond the planning phase, not least because the approach involves complex concepts and methodologies, high biological and social dimensions, sometimes strong institutional resistance, and substantial data requirements (Johnson and Williams 1999).

Despite those impediments, the advantages of an adaptive approach recommend it for long-term management of many natural resources. Beyond the obvious benefits accruing to informed policies based on explicit conservation objectives, an adaptive approach effectively links data and decisions by integrating monitoring, assessment, and decision making in a coherent framework. By encouraging collaboration between managers and researchers on issues of joint importance, both groups can benefit materially from this framework. The explicitness required by an adaptive approach helps decision makers to focus attention on important biological and social issues, and ensures greater accountability in decision making. Acceptance of uncertainty, combined with more rigorous and focused assessments, facilitates the challenge to dogma and traditional beliefs (Johnson and Williams 1999).

Of special relevance here is the applicability (or lack thereof) of policy approaches to the conservation of long-distance migrants like many bird species. Given the less-than-exemplary record of success that many conventional alternatives to ARM have enjoyed, one must question the viability and effectiveness of those alternatives when operating at scales that are appropriate and even necessary for avian conservation. On the other hand, ARM applies naturally in situations involving large expanses of habitat with ecological and social dimensions that sometimes transcend regional and even national boundaries. Under those circumstances, the advantages of shared decision making and collaboration, pursuant to biologically informed conservation, are both obvious and substantial. By contributing jointly to avian science and conservation, the agenda described by Ruth et al. (2003) both promotes and enhances those advantages.

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