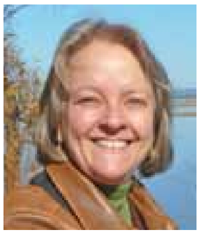
Defensible Decision Making

HARNESSING THE POWER OF ADAPTIVE RESOURCE MANAGEMENT

By Melinda Knutson, Ph.D., Harold Laskowski, Clinton Moore, Ph.D., Eric Lonsdorf, Ph.D., Socheata Lor, Ph.D., and Lori Stevenson



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Many wildlife species—from red knots to marsh rabbits to grassland nesting birds—seem to be losing the conservation battle while the managers responsible for saving them face mounting obstacles. The public demands a voice in natural resource decisions, but has competing goals. How can a manager conserve species, address public needs, and achieve agency objectives while adhering to budgetary, legal, and policy constraints?

To juggle these competing goals, resource managers need to plan carefully, make smart decisions, and be transparent about how decisions are made. Fortunately, there's a decision-making tool that holds great promise: Adaptive resource management (ARM) helps managers devise and test strategies to restore habitats for a host of wildlife species.

Because ARM holds such promise—yet remains relatively misunderstood—the U.S. Department of the Interior (DOI) will issue a new handbook next spring containing case studies and guidelines for managers about how to effectively implement adaptive resource management programs (Williams *et al.* in review). The handbook complements an earlier DOI publication about the potential of ARM to improve the quality of land management and the transparency of decision making (Williams *et al.* 2007, revised 2009). In addition, the U.S. Geological Survey (USGS) and the U.S. Fish and Wildlife Service (FWS) are now engaged in more than a dozen case studies that show how ARM can address problems arising at multiple geographic scales (Moore *et al.* in press). These studies range from the use of fire in salt marshes at a single refuge to managing wetland impoundments in the Northeast and Midwestern U.S. What follows explores how ARM evolved and draws upon the lessons learned from these ongoing case studies.

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Born in the Business World

Adaptive resource management has its roots in the structured decision making (SDM) tools employed for decades by corporations seeking to maximize profit and minimize business risks (Keeney 1992). Eventually ARM evolved as a form of SDM specifically for fisheries management and then waterfowl population management (Walters 1986, Nichols *et al.* 1995). Today ARM is used to manage a variety of risks to species across a range of habitat types.

The ARM approach may be used when there is uncertainty about the outcome of resource management decisions that are repeated, either in one place over time, or in different locations. For example, grassland managers make annual decisions about whether to mow, graze, or burn a particular site to benefit upland birds, just as wetlands managers may annually raise or lower water levels to benefit waterfowl. Even a one-time decision, such as dam removal, is suitable for ARM because similar decisions may be considered at multiple other locations.

By combining a standardized approach to monitoring outcomes with modeling, ARM helps optimize habitat quality for wildlife. Managers can learn from each site and then apply that knowledge the next time in a similar situation. "One of the biggest benefits of ARM," says Frank Durbian, assistant refuge manager at the FWS Morris Wetland Management District in Minnesota, "is that it provides a framework for several land managers or agencies who share a common resource management problem to work together to resolve it."

Managers with USGS and FWS, for example, are using ARM on a grassland management project that involves more than 120 management units on

19 wildlife refuges across four states in the prairie pothole region. "ARM makes efficient use of individual efforts toward a shared goal of improved management," says Bridgette Flanders-Wanner, an FWS wildlife biologist involved in the effort. Before managers can effectively apply ARM, however, they need to understand the following steps.

1. Define the Problem

A problem can't be solved unless it is clearly defined and understood by all involved. What is the geographic and temporal scope of the problem? What are the key decisions that face the manager? Are decisions repeated in time or in space? What information would help a manager make better decisions? What are the key uncertainties that make the problem difficult to address? Answers to such questions help define the decision problem.

In natural resource management, decisions typically reflect an underlying school of thought about how a natural system will respond to a particular action. Even if two managers agree on a resource objective, they may have different ideas about how to reach it. These competing models describe different ways that the resource might respond to management—a situation termed "structural uncertainty." ARM uses monitoring data to indicate which school of thought or model is best supported by the actual outcomes of management actions.

Environmental variation creates another form of uncertainty. Weather conditions vary, and no two management units are exactly the same. Even farmers planting corn and soybeans on the same farm year after year do not get the same annual crop yields. Managers of natural areas also experience variation in management outcomes, especially if the action and outcome are separated by many years. Climate change will increase environmental variation (Nichols *et al*. in press, Knutson and Heglund in press), and most such variation is resistant to direct control by the manager. ARM accommodates this uncertainty.

2. Set Tiers of Objectives

The next step in ARM is to define the principal management objectives, or the desired future condition of the resource—a surprisingly difficult task. Setting clear management objectives and outcomes requires clarifying what is valued by individuals, organizations, or government agencies (Keeney 1992). Goals for public land and water are defined by laws, policies, and the public. Because of competing objectives, trade-offs may be inevitable. Under ARM, the desired future condition of the resource is called the "fundamental objective." The fundamental objective for a grassland management unit might be to support populations of grassland birds. This objective drives the rest of the process, including identifying management options and selecting the monitoring metrics. Given its broad scope, however, the fundamental objective may be difficult to measure at the scale of a management unit. This is why ARM requires setting "means objectives," more specific targets or goals that support

Credit: Shawn May/USFWS

At Edwin Lake near Beaulieu, Minnesota, sediment removal leaves a patch of land stripped bare at the start of a cooperative wetland restoration study using adaptive resource management. After reflooding to restore hydrology, native grasses and plants began to thrive at the site (below). The presence of natives such as swamp milkweed provides valuable habitat for butterflies and other pollinators, and indicates a successful restoration.

Credit: Shawn May/USFWS

the fundamental objective and that can more easily be measured. In the grassland example, then, means objectives include maximizing habitat quality for birds by maximizing native plant diversity and minimizing invasives. Means objectives help managers select the best attributes of the resource to monitor.

3. Assess Management Alternatives

Once managers are clear about what they hope to achieve, they can consider management options, thinking creatively to find the best alternatives. Thinking outside the box may result in a novel, perhaps superior, management alternative. Clearly there can be numerous variations on a single management action. An herbicide, for example, can be applied in different seasons at different concentrations to all or part of a management unit and in combination with different types of actions (such as mowing). To help managers sort through the alternatives, ARM requires that all feasible management actions be grouped into related subsets. These sets should span a wide range of options (including "do nothing" and "business as usual") that could result in measurable differences in ecosystem response. The goal of ARM is to learn which set of actions best achieves the objectives.

4. Consider Alternative Models

Models help managers assess the consequences of different management actions and the trade-offs among competing objectives. In ARM, modeling provides a transparent form of accounting that links management actions with two or more possible outcomes. The nature of the decision problem determines what type of model should be used, and model complexity increases with the number of competing objectives, possible outcomes, geographic extent, and time frame. ARM is especially useful if there are multiple stakeholders with widely differing objectives, if high risks are associated with the 'wrong' decision, or if costly monitoring is involved.

Effective use of ARM requires at least two competing models that link decisions with outcomes. Observed monitoring data (actual outcomes) can be compared against the predictions of each competing model, and the model with the better prediction then gains greater influence in the next decision (Kendall 2001). This repetitive learning process reveals the management alternative that best meets the objectives.

Despite its value, the role of modeling in ARM is often misunderstood. For some managers, "model" is synonymous with complex computer programs, high cost, and sometimes irrelevant information. Most ecological or population models are designed to elucidate ecological relationships, test theories, and learn how natural systems function, but an ecological model by itself does not necessarily lead to better decision making. In contrast, models that support ARM help evaluate the effectiveness of management decisions based on achievement of objectives. The models of highest value for decision making are often based on the experiences of the managers and serve to clarify the assumptions managers have been using.

In our experience, managers discover that models are powerful tools, not only for helping make smarter, more transparent decisions, but also for explaining and defending those decisions. "Models help managers get more information out of their data collection efforts," says Durbian, "but the models have to be simple enough that the managers can understand and use them after the development phase is over."

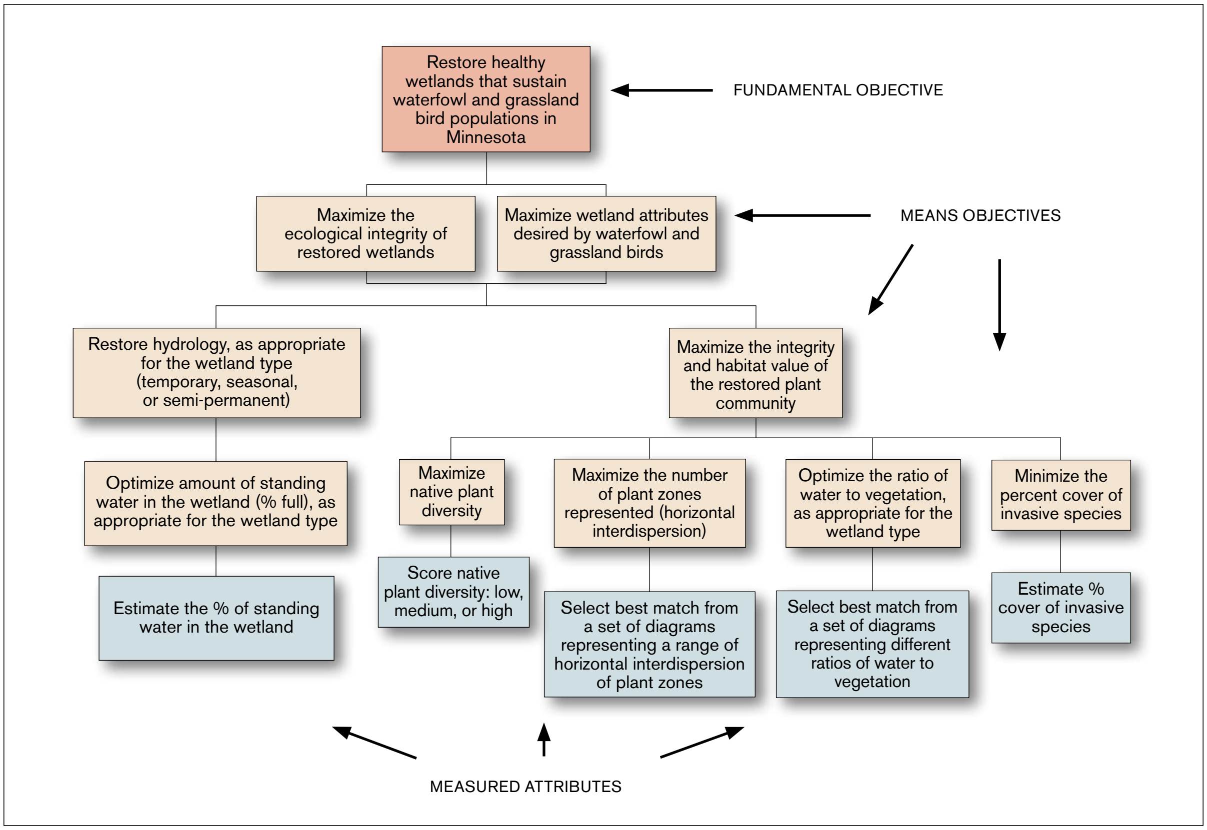
5. Monitor and Adapt

Monitoring is essential to success. If ARM fails, it is likely due to a lack of resources devoted to monitoring (Walters 2007). A key feature of ARM is that the monitored attributes are directly related to the hierarchy of objectives established by the manager. This hierarchy helps managers clarify how the monitoring data will be used to evaluate achievement of the objectives. If there is a weak relationship among these elements, it will be difficult to interpret the monitoring data and learn whether or not the management objectives were met.

This strong tie between what is monitored and the management objectives differentiates ARM from surveillance monitoring (Nichols and Williams 2006). The latter focuses on ascertaining a trend in an attribute over time, and management may or may not effect changes in the monitored attribute. In ARM, monitoring helps the manager learn over time which approach is best supported by the data and which management practices best meet the management objectives.

A Wetlands Case Study

In Minnesota's prairie pothole region, habitat managers are using adaptive resource management to assess two different approaches to restoring degraded wetlands basins. The program, launched in January 2008, is a partnership



ARM Objectives Hierarchy
An ARM objectives hierarchy for wetlands restoration shows relationships among the "fundamental objective" (or desired outcome), the "means objectives" (targets or goals that support the fundamental objective), and "measured attributes" (features that can be monitored to assess whether objectives are being met).

among the U.S. Fish and Wildlife Service (FWS) Partners for Fish and Wildlife Program (PFWP), the Minnesota Department of Natural Resources, and the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

When restoring wetlands, managers typically either reflood the land to restore hydrology or remove sediments first and then re-flood. Prior to 2008, only one or two FWS offices did sediment removal. Results were generally positive, but sporadic monitoring left it unclear whether sediment removal yielded a higher quality wetland, primarily because it takes five to 10 years to see the full restoration outcome. So the question in this ARM project is: Will the quality of a restored wetland justify the extra cost of sediment removal?

In the ARM objectives hierarchy (see diagram above), the "fundamental objective" for this project is to restore healthy wetlands to sustain waterfowl and grassland bird populations. The "means objectives" include restoring appropriate hydrology, maximizing the integrity of the restored plant community, and maximizing wetland features that attract waterfowl and grassland birds.

Managers designed monitoring methods to estimate the attributes associated with these means objectives. They also developed a set of models to make different predictions about the two possible responses to sediment removal prior to re-flooding, (i.e., either it results in a higher quality wetland or it doesn't). To test these differing views, some restorations in the project include sediment excavation and some do not.

A pre-assessment of each site, including a series of questions regarding the site's hydrology and soil type, helps managers determine its potential for restoration. Managers can then decide which sites will or will not receive excavation. At excavation sites, biologists use soil cores to decide how much sediment should be removed—from inches to several feet—following a protocol designed by NRCS soil scientists.

The same monitoring protocols are used whether the treatment involves only hydrology restoration or also includes sediment removal. Vegetative community evaluations, for example, are based on species diversity, invasive species, and community structure. Monitoring also evaluates the expected hydrology for the wetland type. Monitoring occurs pre-restoration, and post-restoration in years one through four, six, and eight. As monitoring data from each site comes in, the "degree of belief" or weight assigned to each model will be updated, with the model that best predicts the actual outcomes receiving the highest weight.

Since this project began, managers have enrolled approximately 36 wetland basins totaling more than 160 acres. Though it's too early to report with confidence which treatment is most successful, plant communities in the basins that had sediment removed appear to have a greater diversity of plants, especially submerged plants in the open-water areas.

Credit: Scott Kahan/USFWS

Shawn May (right), a biologist with the FWS Detroit Lakes Wetland Management District, talks with private landowner Vern Danielson (left) and bulldozer operator Randy Anderson about how deep to dig when removing sediment from a degraded wetland on Danielson's land. May is cooperating with other land managers on an ARM project to assess the benefits of sediment excavation and other practices at multiple sites.

As an ARM project progresses, the selection of actions and updating of models can be straightforward and relatively easy to implement in a management setting. Backed by data and measurable results, adaptive management of Minnesota's wetlands will provide guidance for future restorations in the prairie potholes.

A New Paradigm

Managers inexperienced with ARM may benefit from focused workshops run by facilitators familiar with ARM and skilled in human dimensions. The FWS National Conservation Training Center (NCTC) offers classes and workshops in ARM and provides summaries of case studies that have addressed diverse decision problems. Such workshops can help stakeholders clarify their goals, set fundamental and means objectives, select management options, define successful outcomes, and establish monitoring metrics. Facilitators are analogous to midwives attending births: You might get the job done without them, but their skills are likely to improve the outcome.

Adaptive resource management is proving more effective than an unstructured trial-and-error approach, which tends to focus primarily on management options or monitoring and not on management objectives. Yet ARM can entail a significant amount of time and effort, and it's not a panacea capable of resolving all resource management problems. Land managers, who make hundreds of decisions in a year, cannot think deeply about every decision; they must be strategic in deciding when to use ARM versus continuing to manage under uncertainty.

The ARM approach represents a paradigm shift in the practice of natural resources management. In the face of climate change, endangered and invasive species, habitat fragmentation, and public demands for more transparency, ARM is needed now more than ever before. One of the keys to success is a motivated and effective leader to oversee the project, keep others motivated, and ensure that documentation, data management, and data interpretation are carried through, even when there are staff changes.

If natural resource managers are going to improve future decisions by learning from decisions made today, they must put in place an accounting system to keep track of what decisions are made, when, and why. They must also regularly summarize the monitoring information in a way that can be interpreted by present and future managers. By doing so, ecological systems such as forests, wetlands, or grasslands—which can take years or even decades to fully respond to management actions—have the greatest chance of surviving today's challenges. ■

This article has been reviewed by subject-matter experts in USGS.

For a complete bibliography and to learn more about ARM and its application, go to *www.wildlife.org*.

Adaptive Resource Management

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Additional Resources

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Additional DOI Documents on Adaptive Management

DOI's Adaptive Management Technical Guide

Case study: The Five Rivers Landscape Management Project, designed for 32,000 acres of productive Siuslaw

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