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ADAPTIVE MANAGEMENT: BACKGROUND FOR STAKEHOLDERS IN THE MISSOURI RIVER RECOVERY PROGRAM

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Introduction

Since adaptive ecosystem management was described,[1] the need for such a process has been widely recognized by restoration ecologists and managers. In the United States, for example, the National Research Council (NRC) has recommended that ecological restoration projects be designed and executed according to the principles of adaptive planning and management.[2] The NRC report highlights the fact that inflexible restoration goals and plans are unlikely to succeed given that knowledge of natural and social systems is imperfect. As the restoration ecologist John Cairns, Jr., stated: "*whatever restoration measures we take, the outcome is highly uncertain.*"[3] The reliable existence of such uncertainty means that plans for ecological restoration may need to be modified as technical knowledge improves, as social preferences change, or as laws and regulations mandate. Adaptive management is designed for situations in which critical decisions must be made despite the existence of uncertainties, even changing ecosystems.

Piping plover *(Charadrius melodus)* and chick.
Photo: U.S. Army Corps of Engineers.

Pallid sturgeon fry.
Photo: U.S. Fish and Wildlife Service.

The definitions of adaptive management available in the published literature are somewhat varied, but generally reflect the principles contained in the following definition: A process for testing hypotheses through management experiments in natural systems, collecting and interpreting new information, and making changes based on monitoring information to improve the management of ecosystems.[4]

As this definition suggests, it is useful to think of adaptive management as a restoration planning process that allows managers, researchers and stakeholders to learn from experience. Most ecosystems take many years to recover, and careful planning makes it possible to learn during this time period. Learning occurs through comparison of initial conceptions about the ecosystem to measured effects of management actions, particularly actions that are experimentally designed. The application of this learning in later stages of adaptive management programs can produce outcomes that are substantially improved over implementation based on initial knowledge alone.

Oftentimes, a defined goal such as the recovery of Pallid sturgeon *(Scaphirhynchus albus)* populations provides the impetus for a restoration planning process. Adaptive management is a tool that allows all stakeholders to work toward this goal while recognizing that ecosystems are complex, recovery times may be long and management actions are uncertain. Both scientific information and the value systems of stakeholders are incorporated in the process. Because of this promise, adaptive management "has become the paradigm for the management of large, complex, human-dominated systems."[5]

Components of Adaptive Management

The U.S. Department of the Interior has provided a handbook for federal agencies that helps to standardize the adaptive management process, available at the following URL:[6] http://www.doi.gov/initiatives/AdaptiveManagement/documents.html

The handbook describes a setup phase followed by an iterative phase or "an ongoing cycle of learning about system structure and function and managing based on what is learned." The Missouri River Recovery Program adheres to the nine adaptive management steps outlined in this handbook:

Setup Phase

- Stakeholder involvement
- Management objectives
- Potential management actions
- Predictive models
- Monitoring plans

Iterative Phase

- Decision making
- Follow-up monitoring
- Assessment
- Iteration

In brief, the setup phase produces three components: a clear goal statement, a conceptual model and a decision framework.[7]

Once the goal is defined, the conceptual model can be used both as a communication tool and as a baseline for predicting the effects of management actions. Model outputs are incorporated in the initial design of management actions, the results of which can then be compared to the model to improve it. The model should therefore be viewed as a work in progress, subject itself to the adaptive learning process.[8] In actual practice, it is often necessary for key aspects of the ecosystem such as species-habitat relationships, and in some cases aspects of the socioeconomic system, to be modeled numerically as well.[9]

Monitoring data can be incorporated to refine the numerical models, and the outputs of both conceptual and numerical models can be incorporated in the decision process. Decisions rely on the measurement or modeling of defined performance metrics such as population size. Criteria or thresholds for decisions may be set which, if met, trigger specific decisions in response or indicate that an objective is met.

Applications of Adaptive Management

The principles of adaptive management are used in aquatic and terrestrial ecosystems throughout the country, for both individual ecological restoration projects and large programs. One example of an individual project is the Elk River marsh in Washington State.[10] There, managers applied the collective scientific knowledge about the ecosystem to predict outcomes of plant species composition

Constructing shallow-water habitat on the Missouri River.
Photo: U.S. Army Corps of Engineers.

Upper Missouri River emergent sandbar habitat prior to vegetation removal.
Photo: U.S. Army Corps of Engineers.

Emergent sandbar habitat data collection.
Photo: U.S. Army Corps of Engineers.

Nest of Interior least tern *(Sternula antillarum)*.
Photo: U.S. Army Corps of Engineers.

Piping plover nest.
Photo: U.S. Army Corps of Engineers.

Sandbar on the Missouri River. *Photo: U.S. Army Corps of Engineers.*

during the setup phase. Scientists compared conditions at a reference site where no management change had occurred to the restoration site during the iterative phase. Actual results, measured by monitoring data, were compared to the predicted trajectory of ecological restoration with modeling tools such as a "system-development matrix."[11] During the period of recovery, differences from predictions identified by monitoring allowed scientists to improve their understanding of the system and managers and stakeholders to alter their expectations or implement adjustments. A similarity index showed that composition at the restoration site converged on that of the reference site over time. This learning process improves the likelihood that the goal of ecosystem recovery will be met in this and other projects, and in larger programs in similar ecosystems.

Typical of large rivers, the Colorado River ecosystem directly affects many federal and state jurisdictions and other stakeholders, so its management requires a complex adaptive program. In fact, the 1996 Record of Decision on operation of the Glen Canyon Dam established an Adaptive Management Work Group (AMWG) that included 27 stakeholders to address the many remaining uncertainties in scientific understanding of relationships between physical factors such as river flow and biological elements including fish and birds. Given this complex social and natural environment, the AMWG undertook several widely accepted adaptive management steps: the group developed a vision, agreed on goals and objectives, saw to it that existing scientific knowledge was synthesized in a conceptual model of the ecosystem, evaluated monitoring protocols, and established processes for data management and information sharing.[12]

Missouri River

Like the Colorado River, the Missouri affects the people and economies of many states, and the scientific understanding of the river's biological and physical processes will need to be augmented during ecosystem restoration for recovery of endangered species to occur. The upriver boundary of the Missouri River Recovery Program (MRRP) is in Montana and the program extends downstream to St. Louis. Management actions within the MRRP are being implemented in response to a Biological Opinion,[13] the Bank Stabilization and Navigation Program (Mitigation), and the 2007 Water Resources Development Act (WRDA). The Opinion addresses how river operations impact populations of two avian and one fish species listed under the Endangered Species Act: the Interior least tern, the piping plover, and the pallid sturgeon. The purpose of the Missouri River Fish and Wildlife Mitigation Project is to restore 166,750 acres of habitat in the Lower Missouri River.

Like the Colorado River program, a stakeholder group called the Missouri River Recovery Implementation Committee (MRRIC) has been established to provide input to the MRRP. Decisions are made at multiple levels in the MRRP including the inter-agency Cooperating for Recovery (CORE) Team.

Nesting Interior least tern.
Photo: U.S. Army Corps of Engineers.

Adaptive Management and the Corps of Engineers[14]

In 1995, a Corps circular entitled "Ecosystem Restoration in the Civil Works Program" (No. 1105-2-210) recommended adaptive management when uncertainties could threaten achievement of restoration project objectives, and emphasized the critical role of monitoring after implementation of management actions:

"At the heart of adaptive management, and the cornerstone for its success, is a carefully designed monitoring program that begins during construction and continues for a specific period after the project has been completed…Improving the knowledge base regarding a particular restoration approach or ecosystem component is a significant subset of the overall goal of adaptive management" (Department of the Army 1995).

Reports by Corps' research arms—the Institute for Water Resources (IWR) and Waterways Experiment Station (WES)—have detailed the incorporation of adaptive management principles within Corps ecosystem restoration planning. The Corps' Engineering Research and Development Center (ERDC) has produced guidance on the use of conceptual models in ecosystem restoration, environmental planning, and operations. The National Research Council called on the Corps to use adaptive management in its river basin planning in 2002. Since then, the Corps' Environmental Advisory Board (EAB) has recommended to the Chief of Engineers a focus on adaptive management and ecosystem restoration.

The goal statement of the MRRP envisions "a sustainable ecosystem supporting thriving populations of native species while providing for current social values." Within this program, the adaptive management strategy being developed is two-phased: Phase I involves the application of adaptive management principles to ongoing actions within the MRRP (project level). An example of Phase I is the Emergent Sandbar Habitat (ESH) Adaptive Management Plan, which has the aim of restoring and sustaining habitats, species, and ecosystem functions, while balancing social, economic, and cultural values. Phase II is the development of system-level adaptive management for the long-term planning process: e.g., the Missouri River Ecosystem Restoration Plan and Environmental Impact Statement.

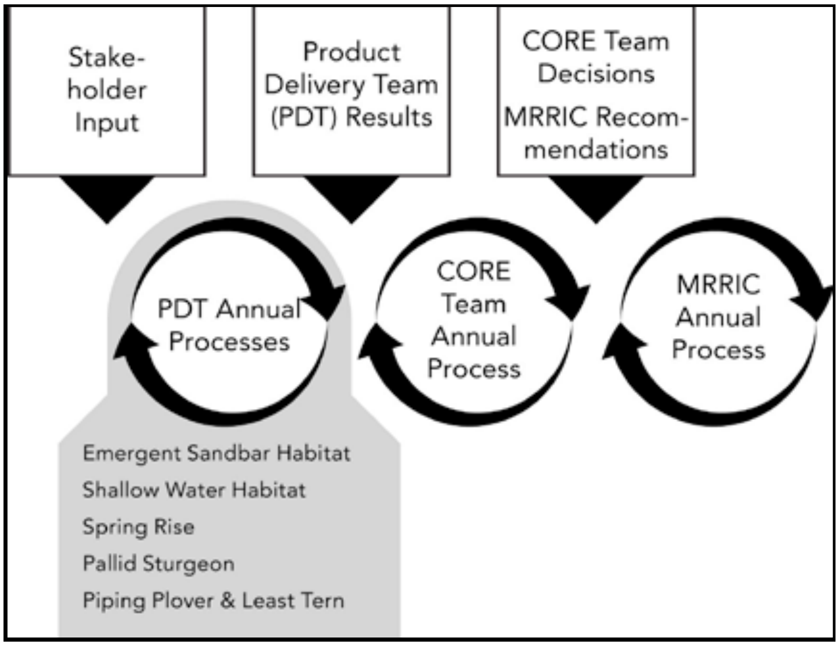
Inserting data storage and telemetry tags into sturgeon to track and monitor environmental conditions.
Photo: U.S. Geological Survey.

Challenges to Implementation of Adaptive Management

The topic of adaptive management is still actively discussed at professional conferences in the field of ecological restoration such as the National Conference on Ecosystem Restoration (NCER) (Kansas City, Missouri, April 2007) and Restore America's Estuaries (Providence, Rhode Island, October 2008). Follow-up sessions focusing on adaptive management are being planned for NCER 2009 in Los Angeles, indicating that the process is still being vetted by the scientific community through specific projects and programs nationwide.

While some such sessions have suggested updates to the concept and practice, others have demonstrated significant challenges to on-the-ground implementation of adaptive management principles.[15] Perhaps the primary challenges raised concern long-term commitment to ecosystem monitoring, data analysis, and adherence to a decision framework that incorporates scientifically based thresholds for change in management actions. This is the "iterative phase" of adaptive management and it may take decades. However, most agencies are subject to much shorter fiscal cycles that rarely mirror scientific recommendations for monitoring ecosystem development following management actions.

Additionally, the costs of adaptive management may be high because quality data collection and management are labor-intensive activities. Some exceedingly complicated planned adaptive management programs have been determined to be prohibitively expensive prior to implementation. Committing funds to experimental management actions is sometimes perceived as a risk.



The MRRP adaptive management process. Input from the States, the Tribes, and the public is included at multiple points.

However, these costs should be weighed against the costs of failure to achieve restoration and recovery goals if an adaptive management approach is not used. Adopting the simplest effective adaptive management approach is beneficial both for costs and communication. Adaptive management provides a form of structured learning that increases the long-term benefits of critical management decisions that must be taken in the short term.

In general, successful long-term monitoring programs secure commitment from the agencies and other partners in restoration to monitor specific metrics for specific time periods using agreed-upon protocols.[16] The meaningful long-term involvement of agencies and stakeholders in the planning and adaptive management process may be difficult to secure yet it is critical to success.

Conclusion

Adaptively managing restoration projects and programs allows managers, researchers and stakeholders to address the uncertainties inherent in scientific understandings of complex ecosystems. By evaluating what has been learned at each step, and identifying how system components are working together, managers have a better chance of responding to change with actions that will ultimately benefit the ecosystem and human community. After the setup phase, the long-term iterative phase is a collaborative process that continually informs decision-makers of changing conditions, both natural and social. Adaptive management is an evolving framework and an important tool for restoring species and ecosystems in light of social and economic interests in river basins.

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