The Future of Water Resources Adaptive Management: Challenges and Overcoming Them

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Adaptive management is being increasingly embraced in water resource activities, not only in aquatic ecosystem restoration, but also in the operation of water resources infrastructure. The inherently complex and integrative nature of aquatic ecosystems presents a challenge to their management that requires a flexible and responsive approach. Uncertainty is a steadfast companion of aquatic management policies, and expecting the unexpected is part of the process, even when reliable data and models have been applied in decision making. With its focus on action, experimentation and organized learning while doing, adaptive management, in the ideal, promises more robust decisions, more effective designs, more efficient investments, more responsive operations, and, in the end, quicker achievement of goals.

Adaptive management has been explicitly adopted as a central organizational framework for restoration of large riverine, lacustrine and coastal ecosystems, including the Upper Mississippi, Missouri, Columbia and Colorado Rivers (Grand Canyon), the Everglades, the Sacramento-San Joaquin Bay Delta (CALFED), Lake Tahoe basin, Puget Sound and coastal Louisiana (National Research Council 2004). Moreover, other large restoration and management programs that have not explicitly embraced adaptive management, such as those for the Great Lakes and the Chesapeake Bay, have many of the components required for adaptive management and could benefit from application of its principles (Boesch 2006). Adaptive management approaches are also being applied in many other smaller scale restoration and water resource operations (e.g., in regulated water management). Models that are traditionally used to govern operations can be broadened to develop ecosystem response models (Walters et al. 2000) critical for adaptive management.

Decision makers are attracted to adaptive management because it can be used to overcome impediments arising from on uncertainties or because it allows the initiation of near-term steps while more difficult, longer-term steps are resolved (Gloss et al. 2005). However, adaptive management has been far more influential, so far, as a concept than as a practical means for water resources management. Progress in effective implementation of adaptive management has not lived up to its promise or appeal. Why is this so? If we believe that adaptive management is a powerful and effective approach, then what can be done to overcome these challenges?

Common Obstacles to Adaptive Management

Carl Walters (1997), reflecting on his long experience in attempting to apply adaptive management in riparian and coastal ecosystems, found among the most common obstacles the following: protracted modeling efforts that are plagued by difficulties in representation of cross-scale effects and the lack of data on key processes and their interactions; experimental policies seen as too costly or risky, particularly in relation to monitoring costs and risk to sensitive species; the self-interest of research and

management stakeholders in the status quo; and fundamental conflicts in values, which adaptive management cannot resolve. One or more of these obstacle and their associated challenges have been apparent in major ecosystem restoration efforts in which we have been involved:

- In the Everglades restoration, which is well supported by monitoring and assessment programs, all three obstacles are encountered. Hydrological and ecological models continue to be developed and refined in order to determine how to "get the water right," while more active adaptive management efforts to deconstruct artificial flow barriers are thwarted by concerns about risks to flooding of populated areas and endangered species.
- In coastal Louisiana restoration, stakeholder interests, including oyster growers and sportfishers, have limited the scale and operation of Mississippi River diversions undertaken to rebuild wetlands (Boesch 2006), although this may change as a result of the urgency of coastal restoration following the devastation of Hurricanes Katrina and Rita.
- In the Colorado River ecosystem of Grand Canyon National Park, several factors limit the range of options for flow regulation available to achieve restoration of physical habitats and meet the needs of native fish species. These include an interstate compact and an international treaty governing water transfers and the financial impacts of water releases from hydropower facilities. Despite new requirements for the operations of the Glen Canyon Dam put in place in the early 1990s sand bars and endangered humpback chub continued to show declines (Gloss et al. 2005). However, in 2002 adaptive management experimentation began, including controlled flooding under sediment enriched conditions and control of exotic fishes, and is providing solid guidance in this complex management setting.
- In the Lake Tahoe Basin, restoration has preceded the development of a structured adaptive management strategy. Reductions in the clarity of Lake Tahoe, combined with concerns about declining forest health, precipitated the Lake Tahoe Restoration Act (2000) and a concerted effort to restore Lake Tahoe and its watershed. While adaptive management is widely recognized as an appropriate and even necessary approach to achieving environmental restoration goals for Lake Tahoe (Manley et al. 2000), substantive progress in its implementation has been slow due to reticence on part of some agencies to participate. Continued commitment by supportive agencies, however, has resulted in the recent establishment of a consortium to improve the integration of science and management.

Overcoming Adaptive Management Challenges

Overcoming the multiple challenges that have hindered adaptive management of water resources requires strong and relentless focus on a number of critical requirements:

1. Rely, but do not over-rely on quantitative models. Adaptive management must be based on one or more models of how the system works and responds to

management action, but it recognizes that models will likely be inaccurate if not wrong. There is a false hubris that with more input data and improved deterministic models we can accurately predict outcomes. Protracted efforts to get the models right can delay action to "get the water right." But, at some point, one can only build confidence by taking action and comparing outcomes with modeled expectations. Such an approach can provide a solid foundation for subsequent planning, while identifying uncertainties in a way that helps managers address risks associated with policy choices.

2. Sustain and strategically focus monitoring to address questions critical to adaptive decision making. As Walters (1997) points out, most monitoring programs focus on "doing the thing right" (more precise or local measurements) rather than "doing the right thing." Explicit, well-crafted experimental design is critical to effective adaptive management and requires identification of sensitive indicators and thresholds of response. Monitoring strategically designed to address key questions is more likely to be viewed as pivotal to decision making and, thus, to be sustained.

3. Provide integrated assessments designed to inform adaptive decision making on a timely basis. Periodic assessments that include analysis and interpretation of the results of monitoring and ongoing research and modeling are critical to adaptive management. These must be conducted on a timely basis, consistent with decision-making cycles, and must integrate across sectors of ecosystem response and societal concerns, not just present lists of unconnected indicators. Frequent and ongoing dialog between managers and scientists fosters evaluation of knowledge through ongoing assessments and identification of milestones in learning, which can better link monitoring efforts to experimentation.

4. Develop and exercise effective linkages among planning, assessment and decision-making functions. Adaptive management can also fail because of deficiencies in the linkages among planning (e.g., modeling, design and sequencing activities), assessment of outcomes and subsequent adaptive decision making. To make these linkages effective, a common vision of how adaptive management should work and clear communication of expectations, results and uncertainties are required. If managers clearly identify expected outcomes, then scientists have a better chance to determine whether these objectives are attainable and measurable and to identify options for achieving the desired outcomes.

5. Expand the capacity for adaptive management at all levels. There are critical shortages of practitioners in all sectors—researchers, modelers, those engaged in monitoring, decision and policy makers—who are knowledgeable about the adaptive management process beyond a superficial understanding of its appeal. Given the proliferation of adaptive management in aquatic ecosystem and resource management, much more attention is required on training and building institutional capacity for its practice. Of particular importance is the

development of academic and continuing education programs that strive to educate current and future scientists and managers in the practice of stakeholder-based adaptive management in a variety of ecosystem settings.

6. Effectively engage stakeholders. Adaptive management is often hindered by skeptical stakeholders who are unprepared to take risks and do not value "learning" as much as the protection of their own interests. Some may see it as a ploy to avoid or delay what they believe needs to be done. Most practitioners recognize that it is most effective to engage stakeholders at the beginning and throughout the adaptive management process, thus the concept of collaborative adaptive management has emerged. Although science can assist managers in the evaluation of policy alternatives and identification of options for achieving resource objectives, scientists cannot provide resolution for the value-based tradeoffs that must often be resolved within the complex weave of physical, biological and social settings associated with water resources.

Conclusion

Adaptive management is not for the faint of heart. It requires a substantial investment of human and financial capital in order to surmount the sizable challenges it must confront. It requires sharing commodities among individuals, institutions, and entities that are highly coveted: funds, time, and prerogatives. But, where high uncertainty and great risk coexist adaptive management can provide an effective path forward. Adaptive management offers a process by which risks can be understood, shared and reduced. As water resources become more limited and valuable, adaptive management is likely to become increasingly invoked. It will be effective to the degree to which the challenges we identify are effectively overcome.

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