Scarlett, L. 2013. Collaborative adaptive management: challenges and opportunities. *Ecology and Society* **18**(3):26. http://dx.doi.org/10.5751/ES-05762-180326

Research, part of a Special Feature on Exploring Opportunities for Advancing Collaborative Adaptive Management (CAM): Integrating Experience and Practice

Collaborative Adaptive Management: Challenges and Opportunities

Lynn Scarlett [1]

ABSTRACT. Collaborative adaptive management merges three essential features of twenty-first century conservation and resource management—science, collaboration, and a focus on results. These features intersect in conservation and resource management contexts characterized by: (1) high degrees of uncertainty; (2) complexity resulting from multiple variables and non-linear interactions; (3) interconnectedness—among issues, across landscapes, and between people and place; and (4) persistent, possibly dramatic, change. In this context, many resource management decisions present communication challenges, information challenges, coordination challenges, and action challenges. Collaboration and adaptive management, in part, are responses to these challenges. Many resource management questions are technical and complex. But policies and project decisions have distributional effects and often involve trade-offs. These effects raise issues about the respective roles of scientists, technical experts, and the public; underscore the relevance of adaptive decision frameworks, and heighten the importance of collaborate decision making. This essay examines collaborative adaptive management in this context from the perspective of a decisionmaker.

Key Words: *adaptive management; collaboration; collaborative adaptive management; conservation; science and decision making*

INTRODUCTION

Uncertainty, complexity, and change characterize the settings in which conservation and natural resource management decisions unfold. These decision settings involve questions such as how much water should flow across vast areas to restore the Florida Everglades "River of Grass". Should dams be constructed or removed in the northwestern United States? How can the United States access traditional and renewable energy on land and offshore while sustaining wildlife and habitats? These questions involve matters of values, policy, and science.

Within this context, addressing conservation and resource management issues often requires coordinated actions across jurisdictional and ownership boundaries; ongoing learning; and a capacity to alter courses of action in response to new knowledge and dynamic conditions. With the engagement of multiple public-sector, nonprofit, and private-sector participants, conservation and resource management often "entails producing services with the public more than delivering services to the public" (Thomas 2012, p.86). This decision context has been accompanied by a broadening application and convergence of two decision processes—collaborative decision making and adaptive management.

This convergence reflects a response to perceived needs for a tighter intersection of science and decision making, greater pubic engagement in knowledge building and decision making, and improved decision outcomes. The aspirations for improved processes, public engagement, and outcomes confront both long-standing and emergent challenges. At the same time, the linking of collaboration with adaptive management presents some opportunities to address or moderate these challenges. I offer a former policy maker's perspective on the broadening application of collaborative adaptive management in conservation and resource management settings.

COLLABORATIVE DECISION MAKING

Kirsten Leong and others describe an evolution toward collaborative approaches to decision making in natural resource management and view this trend as reflecting the increasing complexity and 'wickedness' of resource management problems (Leong et al. 2009). They note that, "with wicked problems, the process of problem formulation and [the] resulting outcome often *[are]* the problem[s]. As such, negotiation over the way the problem is defined, or framed, plays an important role in identifying potential solutions and determining the relative success of management interventions" (Leong et al. 2009, p. 235). While varying in form, collaborative efforts generally involve "problem-setting, direction setting, and structuring" for implementation actions (Selin and Chavez 1995, p. 1).

Though there are many definitions of collaborative decision making, I use the term to refer to processes "in which autonomous or semi-autonomous actors interact through formal and informal negotiation, jointly creating rules and structures governing their relationships and ways to act or decide on the issues that brought them together" to achieve mutually beneficial interactions (Thomson et al. 2007, p. 25). The term is multidimensional, including structural elements (governance and administration), social capital (mutuality and norms), and agency (organizational autonomy) (Thomson et al. 2007).

[1]Resources for the Future

ADAPTIVE MANAGEMENT

Addressing complex conservation and resource management decisions, often involving uncertainties, requires more than public engagement; it requires scientific insights and information, and, in particular, the capacity to generate ongoing knowledge and adjust actions based on that learning. Over three decades ago, the concept of adaptive management surfaced in the writings of C. S. Holling (1978). But its evolution from concept to practice accelerated in the 1990s and gained significant traction with resource managers in the first decade of the twenty-first century. By 2007, for example, the U.S. Department of the Interior had created a management guide on adaptive management for federal agencies (U.S. Department of the Interior 2007, Williams et al. 2009) and, in 2008, the Department incorporated procedures for use of adaptive management into its National Environmental Policy Act regulations (Code of Federal Regulations 43 Part 46, October 15, 2008).

Definitions of adaptive management vary but generally invoke several consistent characteristics: (a) systematic processes; (b) for improving management practices; (c) through ongoing learning; (d) with a focus on outcomes; (e) assessed through monitoring and evaluation (Canter and Atkinson 2010). Variations in the definitions and practices of adaptive management typically center on the degree to which the systematic processes actively use experimentation to evaluate different policies and practices (Canter and Atkinson 2010; Office of Environmental Policy and Compliance 2008).

Despite increased attempts to structure conservation and resource management decisions within an adaptive management framework, cases of its successful application remain infrequent (Susskind et al. 2012). Many factors have limited its successful application, including, for example: (1) funding constraints; (2) institutional and legal constraints that limit the capacity to take risks and to alter courses of action despite emergence of new knowledge; (3) time constraints; and (4) insufficient coordination among scientists, stakeholders, and managers in development of the adaptive management plan and its implementation (Johnson and Williams 1999). The fourth constraint—insufficient coordination among scientists, stakeholders, and managers—has resulted in increased attention to ways to create and maintain ongoing dialogue among participants with relevant knowledge, interests, and decision-making influence. Out of this focus has emerged what is typically referred to as collaborative adaptive management.

SCIENCE AND DECISION MAKING

Before turning to collaborative adaptive management, its potential, and its challenges, it is useful to step back and examine general challenges of linking science and decision making. The interface of science and decision making in conservation and natural resource management contexts involves issues of:

- how problem sets are defined and priorities developed;
- how relevant information is identified and generated;
- how the science and decision-making discussion are conducted;
- how information is used, tested, validated, and augmented; and
- how decisions are adjusted as information evolves.

These are partly institutional and procedural questions. These questions arise from recognizing that many conservation and resource management decisions involve what Tijs van Maasakkers (2009) describes as distributional disputes. They involve debates about the distribution of funds and other benefits, the development of regulatory standards, and the siting and design of facilities (Susskind and Cruikshank 1987). To this list, one might add that such decisions involve debates about who uses natural resources, and how and for what purposes they are managed, which are questions that can also have significant distributional implications.

Framing of the problem and defining decision boundaries involve values, and such framing can introduce significant policy issues. “Is the relevant boundary for accumulating and applying information regarding infrastructure siting a backyard, a stream, a watershed, a continent, or a world? Through what processes might appropriate boundaries for a problem [be] set and decision focus be drawn? Answering these questions demands scientific insights. But these are as much questions of human communities, values, and social constructs as they are matters of scientific distinctions and categories” (Scarlett 2010, p. 895).

This observation points to the relevance of public engagement with technical experts and decision makers in framing environmental problems and defining decision boundaries. Beatrice Crona and John Parker (2011) describe two models of knowledge transfer—the engineering and the socio-organizational models. The engineering model essentially views transfer as one in which generators of knowledge and users of knowledge operate in separate contexts, with the focus and findings of research determined by the researcher and then communicated to others. The socio-organizational model emphasizes that knowledge and its potential relevance to users emerge within social settings through which issue framing occurs, goals are articulated, and information—both scientific and experiential—and options to address issues are developed, implemented, monitored, and adjusted. Others refer to this model as an analytic-deliberative approach to linking science and decision making (Stern and Fineberg 1996).

Research on the sociology of science, cognition, and related fields has focused increasingly on socio-organizational models in the context of decision making on environmental issues. In part, this focus arises from the recognition that many environmental problems are complex and involve the intersection of scientific considerations with individual, community, and broad social values and behaviors. For example, reflecting on U.S. Forest Service planning practices in the 1990s, a forest service commentator noted that experts such as agency officials cannot simply sum up available technical and scientific research to develop the "right" answers to forest management questions (Iverson 1999). The commentator noted that policy making is both complex and politically wicked and that these are not the same qualities (Iverson 1999). Complexity refers to multiple, interconnected ecosystem variables and often nonlinear processes relevant to understanding ecosystem and natural resources dynamics. The politically wicked nature of many environmental problems refers to the fundamental interplay of human values and behaviors with environmental conditions such that decisions to manage or alter these conditions potentially involve priority setting and value trade-offs. These wicked problems "cannot be solved by any multistep planning process designed to 'collect more data, build bigger models, and crunch more numbers . . . [expecting that] surely the right answer would be forthcoming'" (Allen and Gould 1986, p. 22). Such efforts reflect "a naïve hope that science can eliminate politics" (Allen and Gould 1986, p. 22).

Substantial empirical research validates the importance of three attributes of effective linkage of science with decision making—credibility, relevance, and legitimacy (Cash et al. 2003, Committee on Analysis of Global Change Assessments 2007, Panel on Strategies and Methods for Climate-Related Decision Support 2009). Credibility refers to the extent to which the science is perceived to meet technical standards; relevance refers to users' perceptions of its appropriateness for addressing their information needs; and legitimacy relates to perceptions that the processes for generating and using the information are procedurally fair. The importance of credibility, relevance, and legitimacy has turned attention to the role of collaborative processes in bringing together scientists, stakeholders, and decisions makers. For example, Larry Susskind refers to collaborative processes in which participants "engage with other members of a community to jointly learn and work out how to generate improvements in the face of conflict, changing conditions, and conflicting sources of information" (Susskind 2010, p. 369).

A 2006 report of the United States' National Research Council identifies six principles for programs attempting to better link science and decisions (Committee on Independent Scientific Review of Everglades Restoration Progress 2006). These include defining the problem with users, defining clear project goals and accountability, using boundary-spanning organizations, placing work in a decision chain, experimenting with and incentivizing innovation in program management, and ensuring continuity and flexibility (Stern and Brewer 2006). Others have underscored the importance of engagement among scientists, stakeholders, and decision makers early in the process to enhance the prospects that scientific products will be perceived as relevant to stakeholders' and decision makers' needs and will increase perceptions of legitimacy. Empirical research affirms that early involvement of intended users may correlate with a greater linking of science to decisions after project completion (Matso 2012). Architects of collaborative adaptive management processes, at least implicitly, attempt to achieve such early and ongoing involvement by scientists and decision makers.

COLLABORATIVE ADAPTIVE MANAGEMENT

In part to address limitations identified in early-generation adaptive management processes, some conservation and ecosystem restoration managers have designed adaptive management as more collaborative, iterative processes that engage scientists, stakeholders, and decision makers. The Collaborative Adaptive Management Network defines collaborative adaptive management as:

> . . . a systematic management paradigm that assumes natural resource management policies and actions are not static, but are adjusted based on the combination of new scientific and socioeconomic information. Management is improved through learning from actions taken on the ecosystem being affected. A collaborative adaptive management approach incorporates and links knowledge and credible science with the experience and values of stakeholders and managers for more effective management decision-making. (Sims and Pratt Miles 2011).

For example, in Colorado, Wyoming, and Nebraska, participants in the Platte River Recovery Implementation Plan, a basin-wide initiative that includes federal and state agencies, local landowners, the agricultural community, and others, developed a collaborative adaptive management process to enhance knowledge in a context of stakeholder and decision-maker disagreements and scientific uncertainties while using the process itself to help set goals, select action options, and develop new information on the effectiveness of actions. A central element of this planning effort includes development of a "depletion plan" to mitigate, offset, or prevent new depletion to the river's target flows (Platte River Recovery Implementation Plan 2012).

Significant disagreements have divided participants regarding what the at-risk species need in terms of water management for their protection. To move beyond disagreements, the program uses a collaborative adaptive management framework. Participants agree to certain goals and actions but then monitor and evaluate program benefits based on emerging information. The process has provided a way to transcend data disagreements and move to action. In effect, the collaborative adaptive management approach frames conflicts "not as a legal violation but as a divergence of interests and a competition of interests among parties. The goal of the process is to find a way to meet the interests of the parties, rather than just to meet the needs of the law" (Brown 1993).

In effect, collaborative adaptive management merges three essential features of twenty-first century conservation and resource management—science, collaboration, and a focus on outcomes. These features are essential because conservation and resource management issues are characterized by: (1) a high degree of uncertainty; (2) complexity resulting from multiple variables, nonlinear interactions, and diverse human values; (3) interconnectedness—among issues, across landscapes, and between people and place; and 4) persistent, possibly dramatic, changes to ecosystems and land uses. In this context, many resource management decisions present information challenges, coordination challenges, action challenges, and challenges of understanding and measuring results. Collaboration and adaptive management, in part, are responses to these challenges.

While I served as Deputy Secretary and Chief Operating Officer at the U.S. Department of the Interior, I was often called on to articulate the case for adaptive management. In that role, I also set forth collaboration as a central operational principle for conservation—central to reducing conflict and central to integrating land, water, and wildlife management decisions across jurisdictions and among many participants, both public and private (McKinney 2010).

Both adaptive management and collaboration hold increasing relevance for natural resource management, but several issues and challenges persist for adaptive management, the intersection of science and decision making, and, more broadly, the implementation of collaborative adaptive management. Before turning to these challenges, it is useful to return briefly to three features of the resource management decision context—uncertainty, complexity, and change—regarding their implications in general and for collaborative adaptive management in particular.

THE UBIQUITY OF UNCERTAINTY

Consider challenges presented by the ubiquity of uncertainty. Biologist Steven Courtney has observed that ecology is not rocket science; it is much more difficult than that (Courtney 2011). Uncertainty justifies knowledge building, experimental project design, monitoring, and evaluation. Yet the very context of uncertainty invokes important questions about science and policy.

How much certainty about a particular cause and effect sequence or about projected futures is enough? Scientists typically use the long-standing protocol of a 95% confidence level as the bar necessary to affirm scientific results. Policy makers use a different bar. For policy makers or managers, how much uncertainty is acceptable invokes the reply: "It all depends." It depends on available resources, as well as the legal context that might dictate immediate action despite uncertainties. It depends on policy goals that might require action notwithstanding uncertain outcomes. It depends on policy interpretations of statutory requirements. For example, terms such as "foreseeable future" and "likely to occur," found in the United States' Endangered Species Act, regulations, and solicitor's opinions are not scientific terms and require policy judgments in their application to specific decision contexts (Williams et al. 2009).

Thus, the question of what level of certainty is sufficient for taking management action is often a policy decision. Because it is not strictly a science decision, the question introduces the potential relevance of collaborative adaptive management processes in which participants attempt to develop a shared understanding of issues, uncertainties, and decision making needs.

THE COMPLEXITIES OF COMPETING FRAMEWORKS

Consider now the feature of complexity. Within a resource management context, participants nearly always operate within a context of multiple variables, sometimes cause–effect time lags, and nonlinearity. In addition to these complexities of the natural world are complexities associated with competing purposes or frameworks. Scientists ask: how does the world work? Policy makers and managers, by contrast, ask: what values do we care about, what priorities should we set, and how do we allocate which resources to what priorities? (Scarlett 2010, p. 895).

"What is" questions are different from the normative matters involved in policy choices and have implications for the types of knowledge useful to scientists and managers. In some respects, managers need simplicity. At an operational level, managers (and policy makers) need information that allows for nimble, and sometimes quick action. They need a general sense of progress or signals about impending problems. They need easily accessible, readily comprehended information. These needs often mean policy makers and managers require general benchmarks, high-level clusters of proxy indicators that can provide a dashboard for action, and easy-to-use models or decision support tools. By contrast, scientists often deepen knowledge by exploring complex details. Science reputations are often built upon the dissection and discernment of complexities. Put another way, "management responds to problems and opportunities, and that is different from an experimental scientist's desire to explore a phenomenon systematically" (Lee 1999, p. 4).

Conservation biologist Charles Curtin illustrates the challenges presented by the differing contexts within which scientists and resource managers operate in describing his work with ranchers in the Arizona borderland region. He notes that there is a long history and accumulation of scientific work in the borderland region, but that:

> . . . it was insufficient to answer the questions ranchers and land managers wanted to answer. One reason was that the spatial and temporal scales of field research projects are typically much smaller than the scales on which ranchers and land managers operate. Scale matters; ecologists have increasingly recognized that one cannot extrapolate easily from experimental plots on the scale of meters to landscapes on the scale of kilometers, or from a year-long study to decades. (Curtin 2010, p. 259)

Within the adaptive management context, this tension between the aims of the scientist and needs of the manager sometimes eludes resolution. Yet this tension has implications for the design of performance metrics. It has implications for experimental design in an adaptive management setting. It suggests experimental design itself is in part a policy and management matter, not exclusively a science matter.

DYNAMISM AND THE IMPLICATIONS OF RAPID CHANGE

Let us turn to the third contextual feature—ever-present and sometimes dramatic change. Dramatic changes are evident as a result of land transformations from increased urbanization, rapidly expanding energy development, and other land-use changes. In addition, dramatic changes are transpiring from the effects of a changing climate (National Climate Assessment and Development Advisory Committee 2013).

Change can be so rapid that it affects relevant actions. But the matter of change also introduces the relevance of ongoing collaborative processes in which goals can be re-examined and information needs and actions can be adjusted (Nichols et al. 2011).

IN SEARCH OF EFFECTIVENESS—REVISITING COLLABORATIVE ADAPTIVE MANAGEMENT

Collaborative adaptive management, at least conceptually, provides a context for ongoing dialogue among scientists, stakeholders, and managers to develop a shared understanding of decision contexts and needs, including, for example, an understanding of relevant information, decision timelines, and tolerable levels of uncertainty for decision makers. Many critiques of adaptive management have focused on what might be described as its technical elements (Walters 1997, Johnson and Williams 1999). The increasing emphasis on collaborative adaptive management has turned some attention to negotiation processes and social dynamics (Pinkerton 1999, Susskind et al. 2012). Less attention has been paid to institutional design, decision rules, and governance issues, including the broader legal setting within which collaborative adaptive management unfolds (Curtin 2010, Susskind 2011, Matso 2012, Craig and Ruhl 2013).

In considering collaborative adaptive management as a tool for integrating science and policy making, I will first return to the broad issue of science and decision making and the role of scientists. I will then briefly examine several technical issues, which are relevant both to adaptive management and collaborative adaptive management. I will then turn to governance and decision processes, which are particularly relevant to collaborative adaptive management.

RE-EXAMINING THE ROLE OF SCIENTISTS

Structuring collaborative adaptive management processes invites questions about the science–decision maker interface and roles. The centrality of science and technical expertise in a resource management context involves a conundrum—what some refer to as the "technocracy versus democracy" quandary (Lach et al. 2003). Many resource management questions are technical and complex. But policies and project decisions affect people and places. They often involve trade-offs. These effects heighten the relevance of stakeholder collaboration and present a fundamental question: what are the respective roles of scientists, technical experts, and the public?

Denise Lach and her colleagues (Lach et al. 2003) address this question in *Advocacy and Credibility of Ecological Scientists in Resource Decision-making.* They set forth, along a continuum, five roles for scientists. These roles include reporting; reporting and interpreting; reporting, interpreting, and integrating through articulation of action options; advocacy; and decision making.

Consider this continuum in the context of the Everglades Restoration in Florida and the intersection of science and decision making. There, the scientist's role is largely that of reporting and interpreting. Yet a reporting role may be insufficient to explore, in a dynamic context, the different possible effects of various policy and management options on a real-time basis. Resource management issues are often sufficiently scientifically complex that having scientists at the decision table can help pinpoint the possible, define the do-able, and shape and evaluate options through iterative conversation among decision makers. Such discussions do not transform scientists into decision makers, but they do engage them at the midpoint of the continuum set out by Lach and her colleagues. Likely there is no one, single resolution to questions regarding the interface of science and decision making, but architects of collaborative adaptive management processes need to consider and address them.

TECHNICAL ISSUES

Monitoring and adaptive management

Beyond broad general questions about the role of scientists in decision-making processes, including collaborative adaptive management, several technical issues raise questions about the interface of science and decision making. For example, many resource managers assume monitoring is both necessary and desirable; it is perceived as a holy grail of good management. While many managers understand the benefits of monitoring, they also face constraints. Sometimes the decision time frame may not be sufficient for meaningful monitoring. In that circumstance, resources may be better deployed elsewhere.

There are several dimensions to these questions. One pertains to the ecosystem context. Consider one case of a Habitat Conservation Plan for butterflies in California. Scientists could monitor, at a cost of millions of dollars, to try to track butterfly trends. But managers already know that a key constraint on butterfly prosperity is invasion of exotic plants —in this particular case, Scottish broom (Steven Courtney, RESOLVE, *personal communication* 2011). In such a case, managers may be better off applying dollars to the removal of invasive plants than on monitoring.

A second consideration is that of the decision context. Monitoring is relevant and useful *if* managers have the capacity to change their actions in response to new information. If the legal or political context is one that will not countenance change, monitoring may not be the best use of available (and constrained) funds. These are fundamental considerations for managers and policy makers who operate with limited budgets and multiple competing uses for human and financial resources.

A third consideration is that of knowledge constraints linked to the nature of the problem set. Take species monitoring along the Rio Grande (in Colorado and New Mexico). Let us say there are three pairs of nesting birds. As resource managers strive to enhance habitat, they might see an increase from three to ten pairs or no change in numbers. But the math is not workable. It is not possible to provide statistical significance, given the numbers and the time frame. Scientists and managers cannot draw management conclusions from these data. They cannot know whether their actions affected those outcomes or whether they were the result of random variations or other factors. The challenge for managers is to discern those instances in which monitoring can yield meaningful and actionable results.

Performance measures

Adaptive management pertains, in part, to the generation of information through experimentation and monitoring. But it also involves information flows and deliberative processes. Managers need to have ownership of adaptive management plans, and they need indicators to assess performance. Development of performance indicators raises challenges at the intersection of scientists and decision makers. Many scientists and others have developed “dashboard” indicators to assist resource managers in understanding the trends and status of lands, waters, and wildlife. Many useful efforts to winnow down the welter of possible indicators into an accessible, smaller subset have emerged at the Everglades and elsewhere.

But two issues often complicate development and use of these indicators. First, the metrics of success for adaptive management initiatives often are calculated in terms of location-specific targets such as those for avian populations in the Everglades or along the Rio Grande. Yet location-specific population targets may cause managers to lose sight of the forest for the trees. For example, a few years ago in south Florida a review of the snail kite and other avian species requested by U.S. Fish and Wildlife Service managers concluded that a mosaic of conditions is more important than particular population numbers in specific locations (Sustainable Ecosystems Institute 2007). Current metrics are more focused on particulars rather than on an integrated whole. Yet managers would benefit from a combination of ecosystem process indicators and population metrics.

A second point about metrics relates to communication. While at the Interior Department, I received various indicator reports. Yet I faced a challenge of interpretation. I could see trends expressed—for example, whether spoonbill populations were rising or falling. Yet it was not possible, from the information presented, to link to actual decision options faced by the policy makers and land managers. These interpretations and the intersection of metrics and management are essential. Yet resource managers and scientists often segregate the enterprise of metrics development and reporting from the enterprise of management and policy making.

An indicator issue of particular relevance to collaborative adaptive management pertains to its social–behavioral dimensions. Incorporating collaboration into adaptive management processes is, in part, motivated by attempts to enhance the credibility, relevance, and legitimacy of information used to inform decisions. One needs social sciences metrics to assess whether collaboration is enhancing trust and resulting in the generation of information that is perceived as credible, useful, and legitimate.

THE BIGGER PICTURE—GOALS AND GOVERNANCE

While scientists and resource managers have paid considerable attention to the technical dimensions of adaptive management, its limitations in practice often reside in broader policy and governance challenges. There is often an absence of decision-making mechanisms through which policy makers can consider the scientific information as it is generated within an adaptive management context, even where scientists and managers have coordinated to shape the adaptive management plan. There is often no "ongoing place" for scientists to deliver and discuss scientific revelations with decision makers (John Ogden, formerly of the South Florida Water Management District, *personal communication* 2010). There is no clearly accessible decision-maker audience, conversational context, or, even, legal procedures for nimble adjustments in actions based on new knowledge.

Experience with adaptive management at the Glen Canyon Dam (on the Colorado River in Arizona) offers an illustration. Susskind and his colleagues note that “three highly publicized and much celebrated ‘high-flow experiments’ yielded important scientific data about the River’s downstream hydrology and ecosystems, but 15 years on these data have not led to adjustments in the management or operation of the dam, despite the persistence of problems” (Susskind et al. 2012, pp. 48-49). The authors note that “this is because the [adaptive management plan] has no procedure requiring that information gleaned over time be used to adjust its management protocols” (Susskind et al. 2012, p. 49). My experience validates this observation. On the one hand, such challenges result from some statutory constraints that appear to require decision certainty. On the other hand, the Department of the Interior's National Environmental Policy Act regulations and other policies provide ways to incorporate, in effect, flexibility into resource management operational decisions (Office of Environmental Policy and Compliance 2008). However, in some cases the challenges are more fundamental. The limits on the capacity to adjust actions as a consequence of new knowledge link to ongoing fundamental political conflicts and values disagreements.

Susskind et al. (2012) suggest that effective collaborative adaptive management is tied to four process-related (governance and management) requirements. These include establishment of clear goals and objectives; mechanisms for promoting participation; clear roles and processes for shared learning; and the dynamic management of the adaptive management programs themselves. More recently, legal scholars Robin Craig and J. B. Ruhl (2013) have identified “handcuffs” that administrative and other laws put on adaptive management that limit decision makers’ capacity nimbly to adjust actions. These and other observations about collaborative adaptive management processes and governance help point in the direction of enhancing their effective utilization. But the potential effectiveness of collaborative adaptive management situates within the broader scales at which conservation and resource management decisions are occurring, which is discussed briefly in the following section.

CHALLENGES OF FRAGMENTED DECISION STRUCTURES

Many landscape-scale initiatives across the United States are tangled in procedures designed for piecemeal, one-project-at-a-time implementation. Current procedural tools seldom allow for holistic decision making about intersecting, integrated collections of actions that comprise the restoration whole. Budgets are fragmented and usually annually determined. Often National Environmental Policy Act processes, Endangered Species Act deliberations, and other procedures are undertaken one project at a time and one species at a time. Under these circumstances, some natural resource conservation progress is occurring. But processes are cumbersome—and perhaps too fragmented and slow to shift the tides of ecosystem degradation.

These issues are neither new nor unique. With all the progress made on conservation and restoration, challenges remain significant and future successes will depend on governance and collaboration, including use of decision frameworks such as collaborative adaptive management. But collaborative adaptive management, as well as many resource management initiatives, situate within larger landscapes with interconnected issues. How can existing institutions evolve to facilitate conservation at ecosystem scales and across interconnected lands and waters?

Kirk Emerson describes “collaborative federalism,” in which joint decision making occurs among multiple governing units (Emerson 2010). The model she describes is one of “shared governance”, not divided and distributed decision-making. The concept of shared or collaborative governance may be applicable at a regional scale among local, interacting jurisdictions striving to coordinate policy and action. But collaborative federalism presents challenges regarding, for example, how decision makers can convene and motivate a cross-jurisdictional polity (Foster 2001). Fundamentally, policy makers face the challenge of how to achieve a decision scale “big enough to surround the problem, but small enough to tailor the solution” (Foster 2001). They also face a challenge of how to set goals among multiple participants and across governing units. There are at least two sets of challenges relating to goals: who sets goals, and how?

GOAL SETTING

Consider the issues of goal selection. In practice, the goals for Everglades Restoration are articulated as the restoration of the defining characteristics of the Everglades (Water Resources Development Act of 2000). But, increasingly, decision makers face questions about what, operationally, that means (John Ogden, formerly of the South Florida Water Management District, *personal communication* 2010). Only a portion of the traditional River of Grass landscape is available for restoration. Some areas have been dramatically transformed with invasive species, altered water and soil chemistry, and peat subsidence (Committee on Independent Scientific Review of Everglades Restoration Progress 2012). We face rising sea levels and salt water intrusion not anticipated when the initial restoration vision was articulated.

As I worked with Department of the Interior managers on an updated Everglades vision document, we faced questions about how much water should flow, when, where, and with what distribution. Everglades Restoration decision makers cannot answer those questions without some sense of the restoration “picture” the nation is seeking. It is not clear that those charged with implementing Everglades Restoration have defined the restoration endpoint. Yet such clarity is a prerequisite to using adaptive management, because judging the success of a field test requires agreement on goals. Clarity regarding end outcomes is especially important as managers move from programmatic and planning phases to project selection, design, and action.

As Doremus and others note, effective collaborative adaptive management requires participants to be empowered to develop and implement management actions (Doremus et al. 2011), “but these must be linked to an overarching set of goals” (Susskind 2012, p. 48; Doremus et al. 2011). Both Everglades Restoration and the Glen Canyon Dam adaptive management efforts result from legislation that sets forth missions for the two endeavors and broad goals. However, in neither case are those goals fully operationalized within the legislation in ways that clarify priorities and criteria for assessing trade-offs. Susskind notes, for example, that the adaptive management plan for the Glen Canyon Dam provides a strategic plan and a range of goals, but the plan “simply rehashes the conflict” among various users of the river and its water flows (Susskind et al. 2012, p. 49).

GOVERNANCE

The Everglades Restoration initiative is among the largest and most ambitious restoration endeavors in the United States (Committee on Restoration of the Greater Everglades System 2003). It involves multiple federal agencies, the U.S. Congress, states, tribes, and multiple stakeholders. It involves the South Florida Water Management District and local governments. As with many endeavors in landscape-scale conservation, decision making requires integrated, cross-jurisdictional, multi-agency, public–private deliberations and decisions. Whether in the Everglades or elsewhere, resource managers often lack governing mechanisms that include dynamic public/stakeholder participation in a deliberative setting. This participant gap limits the legitimacy of decisions. It limits relevant flows of experiential knowledge—the knowledge of time, place, and situation—and the articulation of multiple values (Hayek 1945). Collaborative adaptive management is one cog in this larger governance wheel.

THE BOTTOM LINE—A DECISION MAKER’S PERSPECTIVE

The nature of conservation and resource management challenges—i.e., uncertainty, complexity, and change—point toward collaborative adaptive management as a potentially useful decision framework. The emphasis on collaboration embodies a recognition that these three characteristics pertain not only to physical systems but, also, to human communities. Collaborative adaptive management presents prospects of enhancing mutual learning among scientists, stakeholders, and decision makers, which thereby would also enhance the perceived credibility, relevance, and legitimacy of the science deployed to inform decisions. These qualities can provide the foundations for action and measurable, meaningful outcomes. But collaborative adaptive management does not transcend the realities of social complexity, diversity, and conflict. Kai Lee notes that “adaptive management . . . affects social arrangements and how people live their lives . . . . conflict is a central reason that adaptive management has had more influence as an idea than as a way of doing conservation” (Lee 1999, p. 4). Linking collaboration with adaptive management processes strengthens the capacity to understand conflicts and, sometimes, as in the case of the Platte River Recovery Implementation Plan, achieve pathways to action. It does not, of course, eliminate either conflict or politics.

Lynn Scarlett, former Deputy Secretary of the U.S. Department of the Interior, is a Visiting Scholar and Co-Director of the Center for Management of Ecological Wealth at Resources for the Future in Washington, D.C.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/5762

Acknowledgments:

I am indebted to Steven Courtney, Senior Scientist, RESOLVE (Washington, D.C.) for his insights as a scientist on the challenges of implementing adaptive management. I am also indebted to John Ogden, who worked for 40 years in various capacities on Everglades Restoration, including working with the National Park Service, the South Florida Water Management District, and Audubon of Florida, and as a consultant for the Army Corps of Engineers.

LITERATURE CITED

Allen, G. M. and E. M. Gould. 1986. Complexity, wickedness, and public forests. *Journal of Forestry:*20-23.

Brown, C. 1993. *Handling confrontation: negotiated adaptive managemen*t. Working Paper 93-13, October 14, 1993(1). Conflict Resolution Consortium, Boulder, Colorado, USA.

Canter, L. W., and S. F. Atkinson. 2010. Adaptive management with integrated decision making: an emerging tool for cumulative effects management. *Impact Assessment and Project Appraisal* 28(4):287-297. http://dx.doi.org/10.3152/146155110X12838715793002

Cash, D. W., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jager, and R. B. Mitchell. 2003. Knowledge systems for sustainable development. *Publications of the National Academies of Science* (100)14:8080-8091. http://dx.doi.org/10.1073/pnas.1231332100

Code of Federal Regulations. Title 43: Public Lands: Interior. Part 46—Implementation of the National Environmental Policy Act of 1969. October 15, 2008.

Committee on Analysis of Global Change Assessments, National Research Council of the National Academies. 2007. *Analysis of global change assessments lessons learned*. National Academies Press, Washington, D.C., USA.

Committee on Independent Scientific Review of Everglades Restoration Progress, National Research Council of the National Academies. 2006. *Progress toward restoring the Everglades: the first biennial review—2006*. National Academies Press, Washington, D.C., USA.

Committee on Independent Scientific Review of Everglades Restoration Progress, National Research Council of the National Academies. 2012. *Progress toward restoring the Everglades: the fourth biennial review—2012*. National Academies Press, Washington, D.C., USA.

Committee on Restoration of the Greater Everglades System, National Research Council of the National Academies. 2003. *Adaptive monitoring and assessment for the comprehensive everglades restoration plan.* National Academies Press, Washington, D.C., USA.

Courtney, Steven. 2011. Science and decision making. Keynote presentation, Fifth Annual CAMnet Rendezvous, April 16–17, 2011, Keene, New Hampshire. Collaborative Adaptive Management Network, Meridian Institute, Dillon, Colorado, USA.

Craig, R. K., and J. B. Ruhl. 2013. *Designing administrative law for adaptive management*. Public Law & Legal Theory Working Paper Number 13-6. Vanderbilt University Law School, Nashville, Tennessee, USA. http://dx.doi.org/10.2139/ssrn.2222009

Crona, B., and J. Parker. 2011. Network determinants of knowledge utilization: preliminary lessons from boundary organizations. *Science Communication* 33(4):448-471. http://dx.doi.org/10.1177/1075547011408116

Curtin, C. 2010. The ecology of place and natural resource management: lessons from marine and terrestrial ecosystems. *In* I. Billick and M. Price, editors. *The ecology of place: contributions of place-based research to ecological understanding*. Columbia University Press, New York, New York, USA.

Doremus, H., W. L. Andreen, A. Camacho, D. A. Farber, R. L. Glicksman, D. Goble, B. C. Karkkainen, D. Rohlf, A. D. Tarlock, S. B. Zellmer, S. Jones, and Y. Huang 2011. *Making good use of adaptive management*. Center for Progressive Reform White Paper #1104, and UC Irvine School of Law Research Paper No. 2011-24. http://dx.doi.org/10.2139/ssrn.1808106

Emerson, K., and P. Murchie. 2010. Collaborative governance and climate change: opportunities for public administration. *In* R. O'Leary, D. M. Van Slyke, and S. Kim, editors. *The future of public administration, public management, and public service around the world: the Minnowbrook perspective.* Georgetown University Press, Washington, D.C., USA.

Foster, K. A. 2001. *Regionalism on purpose*. Lincoln Institute of Land Policy, Cambridge, Massachusetts, USA.

Hayek, F. A. 1945. The use of knowledge in society. *American Economic Review* 35(4):519-30.

Holling, C. S. editor. 1978. *Adaptive environmental assessment and management*. John Wiley & Sons, London, UK.

Iverson, D. 1999. The forest service as a "learning challenged" organization. *Eco-Watch Dialogues* 2/5/1999.

Johnson, F., and K. Williams. 1999. Protocol and practice the adaptive management of waterfowl harvests. *Conservation Ecology* 3(1):8.

Lach, D., P. List, B. Steel, and B. Shindler. 2003. Advocacy and credibility of ecological scientists in resource decisionmaking: a regional study. *BioScience* 53(2):170-178. http://dx.doi.org/10.1641/0006-3568(2003)053[0170:AACOES]2.0.CO;2

Lee, K. N. 1999. Appraising adaptive management. *Conservation Ecology* 3(2):3. http://dx.doi.org/10.1201/978-1420042597.sec1

Leong, K., D. J. Decker, T. B. Lauber, D. B. Raik, and W. F. Siemer. 2009. Overcoming jurisdictional boundaries through stakeholder engagement and collaborative governance: lessons learned from white-tailed deer management in the U. S. *In* K. Anderson, et al., editors. *Beyond the rural urban divide: cross-continental perspectives on the differentiated countryside and its regulation*. Emerald Group Publishing, Bingley, West Yorkshire, UK.

Matso, K. 2012. *Producing science that gets used by coastal communities: what funders should do to link more science with decisions*. Dissertation. University of New Hampshire, Durham, New Hampshire, USA.

McKinney, M., L. Scarlett, and D. Kemmis. 2010. *Large landscape conservation: a strategic framework for policy and action*. Lincoln Institute for Land Policy, Cambridge, Massachusetts, USA.

National Climate Assessment and Development Advisory Committee. 2013. *Draft Third National Climate Assessment Report*. U.S. Global Change Research Program, Washington, D.C., USA.

Nichols, J. D. et al. 2011. Climate change, uncertainty, and natural resource management. *The Journal of Wildlife Management* (75):6-8. http://dx.doi.org/10.1002/jwmg.33

Office of Environmental Policy and Compliance. 2008. *Department of the Interior Departmental Manual. Series: Environmental Quality Programs. Part 522: Adaptive Management*. *Effective Date: 2/1/08*. U.S. Department of the Interior, Washington, D.C., USA.

Panel on Strategies and Methods for Climate-Related Decision Support, National Research Council of the National Academies. 2009. *Informing decisions in a changing climate*. National Academies Press, Washington, D.C., USA.

Pinkerton. E. 1999. Factors in overcoming barriers to implementing co-management in British Columbia salmon fisheries. *Conservation Ecology* 3(2):2.

Platte River Recovery Implementation Program. 2012. *Adaptive management on the Platte River*: *2012 state of the Platte report.* Kearney, Nebraska, USA.

Scarlett, L. 2010. Climate change effects: the intersection of science, policy, and resource management in the USA. *Journal of the North American Benthological Society* 29(3):892-903. http://dx.doi.org/10.1899/09-135.1

Selin, S., and D. Chavez. 1995. Developing a collaborative model for environmental planning and management. *Environmental Management* 19(2): 189-195. http://dx.doi.org/10.1007/BF02471990

Sims, S. A., and J. Pratt Miles, editors. *CAMNet fifth annual rendezvous, adaptive governance in the face of environmental and social change, April 16-17, 2011, Antioch University, Keene, NH*. Summary. Collaborative Adaptive Management Network (CAM*Net*), Dillon, Ohio, USA.

Stern, P., and G. D. Brewer, editors. 2006. *Decision making for the environment: social and behavioral science research priorities*. Panel on Social and Behavioral Science Research Priorities for Environmental Decision Making. National Research Council. National Academies Press, Washington, D. C., USA.

Stern, P., and H. Fineberg, editors. 1996. *Understanding risk: informing decisions in a democratic society.* Committee on Risk Characterization, and Committee on Behavioral and Social Sciences and Education, National Research Council. National Academies Press, Washington, D.C., USA.

Susskind, L. 2010. Complexity science and collaborative decision making. *Negotiation Journal* 26:367-376. http://dx.doi.org/10.1111/j.1571-9979.2010.00278.x

Susskind, L., A. E. Camacho, and T. Schenk. 2012. A critical assessment of collaborative adaptive management in practice. *Journal of Applied Ecology* 49:47-51. http://dx.doi.org/10.1111/j.1365-2664.2011.02070.x

Susskind, L., and J. L. Cruickshank. 1987. *Beyond impasse: consensual approaches to resolving public disput*es. Basic Books, New York, New York, USA.

Sustainable Ecosystems Institute. 2007. *Everglades multi-species avian ecology and restoration review, final report*. Portland, Oregon, USA.

Thomas, J. C. 2012. *Citizen, customer, partner: engaging the public in public management*. M.E. Sharpe, Armonk, New York, New York, USA.

Thomson, A. M., J. L. Perry, and T. K. Miller. 2007. Conceptualizing and measuring collaboration. *Journal of Public Administration Research and Theory* 19(1):23-56. http://dx.doi.org/10.1093/jopart/mum036

van Maasskers, T. 2009. *How can practitioners analyze and engage in science-intensive public disputes*? Thesis. Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. *Conservation Ecology* 1(2):1.

Water Resources Development Act of 2000, 114 Statute 2572, Public Law 106–541—December 11, 2000.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. *Adaptive management: the U.S. Department of the Interior technical guide*. Adaptive Management Working Group, U. S. Department of the Interior, Washington, D.C., USA.