**Collaborative Adaptive Management Conference**
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Good afternoon! This conference is significant in its merger of three essential features of 21st century conservation and resource management—science, collaboration, and a focus on results. 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, non-linear interactions, and a hyper-volume of interacting axes; 3) interconnectedness—among issues, across landscapes, and between people and places; 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.

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. 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 across jurisdictions and among many participants, both public and private.

I remain a champion both of adaptive management and collaboration, but I want to push the intellectual envelope a bit. I'd like to explore what I perceive as several issues and challenges associated with adaptive management and the intersection of science and decision making. Is adaptive management falling short of our expectations? What are its limits?

I'd like to offer a few ideas today that draw from an article that I am writing with Steven Courtney of the Peer Review Group. Let me return to the four features of the resource management decision context and their implications.

First, let us look at the ubiquity of uncertainty. My colleague Steven Courtney, a biologist, likes to remind me that ecology isn't rocket science. It is much more difficult than that. On the one hand, this uncertainty justifies knowledge building, experimental project design, monitoring, and evaluation. On the other hand, 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* certainty? Scientists in the resource management arena often assume the long-standing convention (from statistics) that a 95 percent confidence level is appropriate for adopting a particular scientific interpretation. Policymakers use a different bar. For policymaker 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.

I suggest, thus, that the question of what level of certainty is sufficient to take management action is a policy decision. Within the context of adaptive management, it is *not* strictly a science decision. Yet I believe many assume, in experimental design and adaptive management evaluations, that action requires meeting the statistical bar of 95 percent confidence. This assumption causes delays or frustrations among both scientists and managers.

Let us turn to the feature of complexity. In a resource management framework, participants nearly always operate within a context of multiple, interacting variables, often compounded by cause-effect time lags, and by non-linearity. Faced with such complexities, scientists respond by asking: "how does the world work"? They set about dissecting and describing these rich complexities. That is how scientific reputations are built. Policy makers and managers, by contrast, have a different set of tasks. Policy makers ask: "what values do we care about"? Policy makers and managers ask: "what priorities should we set" and "what actions should we take to address those priorities?"

In some respects, managers need simplicity in how information is organized, portrayed, and interpreted. At an operational level, managers (and policy makers) need information that allows for nimble, 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.

Within the adaptive management context, this tension between the aims of the scientist and needs of the manager sometimes eludes resolution. The tension has implications for the selection of performance metrics and for experimental design in an adaptive management setting. It suggests that experimental design itself is *in part* a policy and management matter, not exclusively a science matter. How might scientists and managers find meaningfulness in a context of complexity and, at the same time, achieve simplicity in a context of management constraints of time and resources?

Let us set aside for a moment the feature of interconnectedness and turn to the feature of ever-present, perhaps sometimes dramatic, change. We are seeing dramatic changes in a context of new landscape uses and ever-broadening human hands on landscapes. And we see dramatic (often unanticipated) changes resulting from the effects of a changing climate.

Change can be so rapid that it affects relevant actions. Think about milestones and what happens when we get results to questions that are no longer relevant. How might we introduce suppleness into the application of adaptive management that enables a re-casting of experiments to new circumstances?

There is an even trickier question—one that touches on what is often considered a holy grail of good management. That is monitoring. I have assumed monitoring always is necessary and desirable. It has seemed to me to be the bedrock of good decision making and performance evaluation. How can we be confident in our success if we don't monitor along the way?

But sometimes there may not be enough time or resources for meaningful monitoring. In that circumstance, is it worth monitoring? Or could resources be better used elsewhere? Suppose, in the timeframe available, scientists can only deliver limited certainty of results with available time and resources. If so, should one monitor or can managers act anyway?

There are several dimensions to this question. 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 in response to proposed resource management. But we may already know that a primary constraint on butterfly prosperity is invasion of exotic plants—in this particular case, Scotch Broom. We may be better off applying our available dollars to remove invasive plants than spending them on monitoring, especially if that monitoring is not likely in a relevant management timeframe to yield meaningful information.

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, is monitoring the best use of dollars?

A third consideration is that of knowledge constraints linked to the nature of the problem set. Take species monitoring along the Rio Grande. Let us say we have three pairs of nesting birds. If we strive to enhance habitat, we might have 10 pairs after 10 years of effort. Over 10 years, we might see an increase from three to 10 pairs or we might see no change in numbers. But these sorts of numbers don't allow us to have any statistical confidence that change (or lack of change) reflects a response to management. It is not possible to achieve statistical significance, given the numbers and the timeframe. We can't draw management conclusions. We can't know whether our actions affected those outcomes or whether they were the result of random variations or other factors. Should we be monitoring in this case? Or should we be using ever-scarce dollars for restoration actions?

Let me offer a distinction and a caveat. Adaptive management often unfolds in a tiered context of ecological inquiry and management actions. In some instances, it may be difficult—or even impossible—to assess trends in, say, species numbers with any statistical significance. At the same time, it may be possible to assess the relative effectiveness of different management options in achieving some specific objective. For example, if managers are trying several different management tactics to assess their effectiveness in, say, weed removal, monitoring is essential to evaluating what works, what does not work, and which tactics are most cost-effective. The challenge, however, is to discern those instances in which monitoring can yield meaningful results—and those instances in which monitoring may yield data but not knowledge.

Thinking more broadly of adaptive management, we face the question of when and where it is most useful. Collaborative adaptive management can, perhaps, help us sort through these kinds of questions. A rich (and ongoing) dialogue among scientists and managers in an adaptive management context can provide a setting to explore questions about monitoring, its relevance, and its purpose.

In a review of adaptive management, the National Academy of Sciences reports that experience indicates limits to adaptive management.[1] The approach may be most feasible where four conditions are met. It may be most effective when:

- Temporal and spatial scales are relatively small;
- Dimensions of uncertainty are bounded so option experiments can yield clear results;
- Costs, benefits, and risks of experimentation are acceptable and course corrections are tolerated;
- Institutional support exists for flexibility and adjustments.

These features may not apply to some climate effects issues and contexts or some landscape-scale initiatives. Some analysts suggest a "deliberation with analysis" model may be more relevant.[2] This model refers to the iterative formulation of a problem, identification of interests and values relevant to addressing the problem, development of a shared understanding of risks, and crafting of responses using this shared knowledge.

With this backdrop, I want to explore a bigger question. I'd like to examine the relationship of science and decision making. The resource management setting is increasingly one of large landscapes, cross-jurisdictional challenges, and multiple, intersecting interests. The intersection of science and decision making presents both process questions and content questions.

Let us examine, first, the matter of process. Adaptive management, as practiced, is often undertaken mainly as a scientific endeavor with linkage to management falling short of its advertised potential. It is sometimes undertaken without a clear process to engage the decision making audience in iterative deliberations. These process questions are, fundamentally, governance and institutional design issues. Are our current institutions sufficient to generate a rich intersection of science and management and policy making?

This brings me to a content question about the intersection of science, policy and management. Let us use Everglades Restoration as an illustrative example. I want to tease out some observations on goals, governance, science, and adaptive management.

Consider goals. In practice, the goals for Everglades Restoration are articulated as the restoration of the "defining characteristics" of the Everglades.[3] But, increasingly, decision makers face questions about what, operationally, that means.[4] 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. We face rising sea levels and salt water intrusion not anticipated when the initial restoration vision was articulated.

As I worked with Interior Department 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" we are seeking. Is it a pre-drainage Everglades? The 1930s Everglades? Something else? Or something new?

It is not clear to me that those charged with implementing Everglades Restoration currently have answers to these questions. This perspective is echoed by my friend and long-time Everglades Restoration advocate John Ogden at Audubon of Florida. Yet answering these questions is important for project selection, priority-setting, and performance evaluation. Answering them is a prerequisite to using adaptive management, since judging the success of a field test requires agreement on goals. Answering these

questions becomes especially important as we go from programmatic and planning phases to project selection, design, and action.

This observation brings me to matters of governance, science, and metrics. Everglades Restoration is among the largest and most ambitious restoration endeavors in the Nation. It involves multiple federal agencies, Congress, State, 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. Do current decision structures facilitate what some have referred to as "network" or "shared" governance that engage all relevant participants? Do current structures reflect features of good governance that yield both effectiveness and efficiency?

Whether in the Everglades or elsewhere, we often lack governing mechanisms that include public/stakeholder participation. 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.[5]

Are there possible models to point to? Several, if imperfect, are suggestive. One is the Sonoita Valley Planning Partnership here at Las Cienegas outside Tucson. Another is the Northwest Marine Straits Initiative involving federal, state, local and other participants along the Puget Sound.

At the intersection of science and policy, I have talked about process and governance but what about content? What is the role of the scientist in decision making? I'd like to divide this discussion into two parts—one philosophical and one practical. Science is critical to understanding causes and effects, filling knowledge gaps, projecting future outcomes, modeling alternative options, and assessing restoration results. But what is the role of scientists in decision making? A corollary practical question is how to link science and decision making.

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.[6] 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 participatory democracy and collaboration and present a fundamental question: what are the respective roles of scientists, technical experts, and the public?

Thinking about this question, I borrow from the work of Denise Lach and her colleagues.[7] In their work, *Advocacy and Credibility of Ecological Scientists in Resource Decision-making,* they set forth along a continuum five roles for scientists. These roles range from:

- Reporting
- Reporting and interpreting
- Reporting, interpreting and integrating through articulation of action options
- Advocacy
- Decision making—helping select among options

Again consider Everglades Restoration and the intersection of science and decision making. There, the scientist's role is largely that of reporting and interpreting. Is that adequate? Should there be a mechanism for the voices of scientists to be at the decision table?

This question raises philosophical issues. Specifically, scientists seek objectivity in their inquiries about how the world works. Nonetheless, the question merits transparent consideration. Why? Complexities and uncertainties place Everglades Restoration into a context of adaptive management. Restoration issues are not purely scientific and technical: they involve trade offs and value choices. But the restoration issues are sufficiently scientifically complex that science at the decision table can help pinpoint the possible, define the doable, and shape and evaluate options through iterative conversation among decision makers.

The current governance structure in the Everglades places scientists largely in a reporting role. Is that sufficient? Does that reporting role permit the sort of collaborative interaction regarding the implications of setting particular restoration goals on the ecosystem, various species, water quality, and land uses? Is a reporting role sufficient to explore in a dynamic context the different possible effects of various policy and management options on a real-time basis?

But let me turn from the philosophical to the practical. I want to focus on two items: adaptive management and performance indicators. Adaptive management is partly about the generation of information. But it also involves information flows and deliberative processes. Adaptive management is *not* simply about scientific experiments. It is fundamentally about shaping the questions and generating knowledge that address key management needs. Adaptive management plans need to be an enterprise of scientists and managers. Managers need to have ownership of adaptive management plans.

As I look at adaptive management endeavors, I see two primary shortcomings. First is a tendency for scientists within adaptive management framework to address interesting and pioneering science questions. But these questions are not always the questions for which decision makers most acutely need scientific input. Second is the absence of good decision making mechanisms through which policymakers can consider scientific information and analysis. Often, as noted earlier, there is no ongoing place for scientists to "deliver" and "discuss" scientific revelations with decision makers. There is no clearly accessible decision maker audience and conversational context.

Much more can be said about adaptive management, but I want to discuss, briefly, the matter of performance indicators. I greatly appreciate the outstanding work of scientists and others to develop the "dashboard" indicators. I appreciate efforts to winnow down the welter of indicators into an accessible, smaller subset. But I want to mention two issues. 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. Are these the right metrics? Do location-specific population targets cause us to lose sight of the forest for the trees?

Think of the snail kite and the multi-species avian ecology review of a few years ago in South Florida.[8] That review concludes that a mosaic of conditions is more important than particular population numbers in specific locations. Yet current metrics are more focused on particulars rather than on an integrated whole.[9] Perhaps managers need a combination of ecosystem process indicators and population metrics.

A second point about metrics relates to communication. As a policy maker, I received various indicators reports. Yet I faced a challenge of interpretation. I could see trends expressed—for example, whether spoonbill populations were rising or falling. But what do such trends mean? How do they 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 we tend to segregate the enterprise of metrics development and reporting from the enterprise of management and policy making.

Let me step back and offer one final, big-picture comment. Many landscape-scale initiatives across the Nation are tangled in procedures designed for piecemeal, one-project-at-a-time implementation. We have no good procedural tools to 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, the Nation will make some restoration progress. But it will be cumbersome—and maybe too slow to shift the tides of ecosystem degradation.

All these issues that I raise are neither new nor unique. They are fundamental to the restoration challenges we face across the Nation. We have an opportunity, with all the progress made on conservation and restoration, to do still better. But much of that success will depend on better integration of science and decision making. Much of it will depend on clearer articulation of goals. Much will depend on the availability of more resources. Much will depend on governance and collaboration. Can we evolve governing institutions to facilitate large, landscape scale conservation?

I think our institutions need to nurture collaboration among many participants. They need to enhance coordination among many agencies and the laws and regulations under which they operate. They need to strengthen the iterative processes by which information needs are articulated and information is generated, communicated, and used. Kirk Emerson describes "collaborative federalism," with joint decision making among multiple governing units.[10] 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. How do we convene and motivate a cross-jurisdictional polity? [11] And policy makers face practical challenges associated with limits on their authorities to expend funds outside jurisdictional boundaries. Yet such expenditures may be important. Consider source water protection in which relevant lands may lie outside a city's boundaries. Or consider the need to sustain cool instream water temperatures along an entire watershed.

Fundamentally, as the Lincoln Institute has noted, 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."[12] Policy makers also face a challenge of how to share both goal-setting and financing across governing units.

In considering all these issues, I close with the words of Bertrand Russell: "In all affairs it's a healthy thing now and then to hang a question mark on the things you have long taken for granted."[13]

[1] National Academy of Sciences
[2] Ibid.
[3] Yellow Book
[4] John Ogden
[5] F. A. Hayek, "The Uses of Knowledge in Society,"
[6]
[7] Denise Lach, et al.
[8]
[9] Some biologists suggest that population targets by location are critical to ensure that proper protections remain in place for specific populations of species and express concern that a focus on the ecosystem "whole" could tempt decision makers to abandon protections of the species in certain areas. I believe this is a policy and management question that can be raised and addressed in a collaborative context that includes scientists and policy makers. It is not an issue that intrinsically invalidates the perspective that ecosystem process measures are important, yet often not developed.
[10] Kirk Emerson,
[11]
[12]
[13] Bertrand Russell,