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Perspective, part of Special Feature on Adaptive Management

Appraising Adaptive Management

Kai N. Lee

Williams College

ABSTRACT

Adaptive management is appraised as a policy implementation approach by examining its conceptual, technical, equity, and practical strengths and limitations. Three conclusions are drawn: (1) Adaptive management has been more influential, so far, as an idea than as a practical means of gaining insight into the behavior of ecosystems utilized and inhabited by humans. (2) Adaptive management should be used only after disputing parties have agreed to an agenda of questions to be answered using the adaptive approach; this is not how the approach has been used. (3) Efficient, effective social learning, of the kind facilitated by adaptive management, is likely to be of strategic importance in governing ecosystems as humanity searches for a sustainable economy.

KEY WORDS: adaptive management, conservation biology, ecosystem management, sustainability transition, sustainable development.

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INTRODUCTION

Adaptive management (Holling 1978, Walters 1986) -- implementing policies as experiments -- is a methodological innovation in resource management. Like any method, the adaptive approach implies revised ends as well as novel means: as its name implies, adaptive management promotes learning to high priority in stewardship. This essay considers the difficulties of realizing the promise of adaptive management in natural resource management and biodiversity conservation. I write as a social scientist and erstwhile decision-maker who sought to use adaptive management; I am an outsider to the technical practice, and my observations are meant to complement those of Walters and Holling (1990) by emphasizing the organizational and human dimensions of learning while doing. The questions proposed at the end of this essay invite critique from insiders as well as NGOs, managers, and others for whom the uncertainties of the natural world imply opportunity as well as concern.

The adaptive approach is an important component of a search for a new meaning for conservation -- a meaning that is *bioregional* in scope, and *collaborative* in governance, as well as adaptive in managerial perspective. Conservation of this kind is emerging from two forces: the realization that highly valued ecological processes and species can only be preserved in large ecosystems; and the recognition that many ecosystems high in biodiversity are and will continue to be inhabited by humans. These factors inform a redefinition of conservation in a way that points towards an ambitious goal: reconciling conservation biology with sustainable development -- that is, bringing together two of the principal themes of environmentalism. I return to that grand aspiration below.

APPRAISAL

Adaptive management, like other policy innovations, can be appraised using a framework devised by Garry Brewer (1973). Brewer proposed that appraisal be done by considering four dimensions of a policy design:

- Conceptual soundness: is the idea sensible?
- Technical: is the idea translated into practice well?
- Ethical: who loses and who wins?
- Pragmatic: does it work?

Appraisal examines questions that are obvious -- though not so obvious that they are considered automatically or even often.

Conceptual soundness: learning by experimenting

Adaptive management has been much more influential as an idea than as a way of doing conservation so far. Given that influence, consider theory first: why should one do adaptive management at all? (cf. Holling 1978)

Adaptive management is grounded in the admission that humans do not know enough to manage ecosystems. Managing is different from exploiting, which requires knowledge of how to capture or harvest. Harvest is a formidable task, but it is not management; managing is closer to cultivation or agriculture. Yet cultivating an ecosystem in order to foster its wild state is paradoxical. This paradox has been resolved by turning around the objective: to think of ecosystem management as managing the *people* who interact with the ecosystem. This focus for management raises questions to which there are few reliable answers, but they can be explored, among other ways, by experimentation.

Adaptive management, from this perspective, formulates management policies as experiments that probe the responses of ecosystems as people's behavior in them changes. (This experimental emphasis is called "active" adaptive management in Walters and Holling (1990).) In conducting these experiments we aim to learn something about the ecosystem's processes and structures, and we seek both to design better policies and to contrive better experiments. Note that the goal is to learn *something*: experiments can surprise the experimenter, and one mark of a good scientist is that she recognizes surprise and pursues its implications. This has not been considered the mark of a good manager, however, who is rewarded instead for steadfast pursuit of objectives.

Experimentation is not the only way to learn; indeed, an adaptive approach is often not the obvious way, as shown in Table 1 (also see Marcot 1998).

Table 1. Modes of learning.

each mode of learning	makes observations...	and combines them...	to inform activities...	...that accumulate into usable knowledge	***example***
LABORATORY EXPERIMENTATION	controlled observation to infer cause	replicated to assure reliable knowledge	enabling prediction, design, control	theory (it works, but range of applicability may be narrow)	*molecular biology & biotechnology*
ADAPTIVE MANAGEMENT (QUASI-EXPERIMENTS IN THE FIELD)	systematic monitoring to detect surprise	integrated assessment to build system knowledge	informing model-building to structure debate	strong inference (but learning may not produce timely prediction or control)	*Green Revolution agriculture*
TRIAL & ERROR	problem-oriented observation	extended to analogous instances	to solve or mitigate particular problems	empirical knowledge (it works but may be inconsistent & surprising)	*Learning by doing in mass production*
UNMONITORED EXPERIENCE	casual observation	applied anecdotally	to identify plausible solutions to intractable problems	models of reality (test is political, not practical, feasibility)	*most statutory policies*

Political conflict tends to weigh more heavily than scientific debate as one moves downward in the table. Cf. "Scientific uncertainty can be high so long as acceptability is high." (Walters and Holling 1990, 2067).

Environmental *policy* has been formulated in response to unmonitored experience (e.g., disappearance of valued species), but environmental *management* assumes one of the other modes of learning is possible (e.g., maximum sustainable yield).

Many public policies are grounded in anecdotal knowledge, especially those enacted by legislatures, referenda, and general-purpose governments. From this perspective trial and error is an unusually systematic way to learn.

In that light, one can reasonably ask how much of the scientific rigor of the laboratory is attainable in the field setting of adaptive management.

The adaptive approach rests on a judgment that a scientific way of asking questions produces reliable answers at lowest cost and most rapidly; this may not be the case very often. As Carl Walters has emphasized, adaptive management is likely to be costly and slow in many situations (e.g., Walters, Goruk, and Radford 1993), so those involved in stewardship need to think through whether the scientific approach is worthwhile in specific cases. In particular, it is important to spell out how much difference in management might result if adaptive learning proceeds as envisioned (Walters and Green 1997).

A research-based approach can be reasonable when one takes into consideration the complexity and subtlety of natural systems, including those that have been driven far from their undisturbed state by human utilization. The complexity suggests that even simple steps may yield surprising outcomes -- and science is an efficient way of recognizing and diagnosing surprise. In principle, the scientific approach leads to reliable determination of causes; in practice, that means being able to learn over time how management does and does not affect outcomes. The complexity of the ecosystems and human behavior in the situations discussed here implies, however, that causal understanding is likely to emerge slowly, perhaps more slowly than the long struggle to understand the causal mechanisms of economic policy (Stein 1996, Hall 1989). The slow emergence of an economic policy paradigm reflects the fact that, to be effective, learning must become *social* -- knowledge that informs public policy and collective choice (Parson and Clark 1995, Heclo 1974).

Reliable knowledge of natural systems used by humans is essential if a sustainable economy is to be achieved. An experimental approach may be costly and onerous in the near term, but it is probably the only way to root out *superstitious* learning -- erroneous connections between cause and effect. As Walters has stressed, management of natural systems takes place against a dynamic background, and it is usually impossible to sort out the effects of management from those of concurrent changes in the natural environment (e.g., Walters and Holling 1990). The field is profoundly different from a laboratory in this respect. Yet the designs needed to distinguish treatment from background tend to be more costly and slower than non-experimental analyses of the past (what Walters called "passive" adaptive management).

So it is important to remember the value of explicit experimentation, which also addresses two other social misdirections of learning. The first is regression to the mean. Most environmental and resource problems come to notice in extreme situations, such as the decline of a commercial fishery. Yet in a dynamic, mutable world, extreme situations are usually followed by less-extreme ones: there is regression to the mean, not because something has been remedied but simply because the mix of fluctuating causal factors has changed. This is fertile ground for erroneous inferences. Second, as Levitt and March pointed out, superstitious learning is also enhanced when "evaluations of success are insensitive to the actions taken" (1988, 326); the mechanism is related to regression to the mean. In competitive situations, for instance, one contestant may be slightly ahead of the others for reasons that are not under the competitors' control. Yet as every athlete knows, contestants who are striving mightily are convinced of their own explanations for success or failure. Many of these do not stand up to scientific scrutiny. The more that resource managers are held to standards that have no grounding in ecological science, the more likely it is that accountability itself will induce superstitious learning. The rigors of experimentation provide a cure, but it is usually not an inexpensive one.

Experimentation has three components: a clear hypothesis, a way of controlling factors that are (thought to be) extraneous to the hypothesis, and opportunities to replicate the experiment to check its reliability. These guide the selection of treatments applied to test hypotheses, and the selection of techniques that define what is being controlled and which measurements are being replicated. Hypothesis, controls, and replicates are all important to reliable knowledge but none is easily achieved in conservation practice.

Adaptive management is learning while doing. Adaptive management does not postpone action until "enough" is known but acknowledges that time and resources are too short to defer *some* action, particularly actions to address urgent problems such as human poverty and declines in the abundance of valued biota. Adaptive management emphasizes, moreover, that our ignorance of ecosystems is uneven. Management policies should accordingly be chosen in light of the assumptions they test, so that the most important uncertainties are tested rigorously and early. This too is a criterion that managers have not valued. Management responds to problems and opportunities, and that is different from an experimental scientist's desire to explore a phenomenon systematically. Accordingly, there is no reason to think that adaptive management will work smoothly, that it will be easy to coordinate.

In theory, adaptive management recapitulates the promise that Francis Bacon articulated four centuries ago:

to control nature one must understand her. Only now, what we wish to control is not the natural world but a mixed system in which humans play a large, sometimes dominant role. Adaptive management is therefore experimentation that affects social arrangements and how people live their lives. The conflict encountered in doing that is discussed below; that conflict is a central reason that adaptive management has had more influence as an idea than as a way of doing conservation.

Technical: cost of information

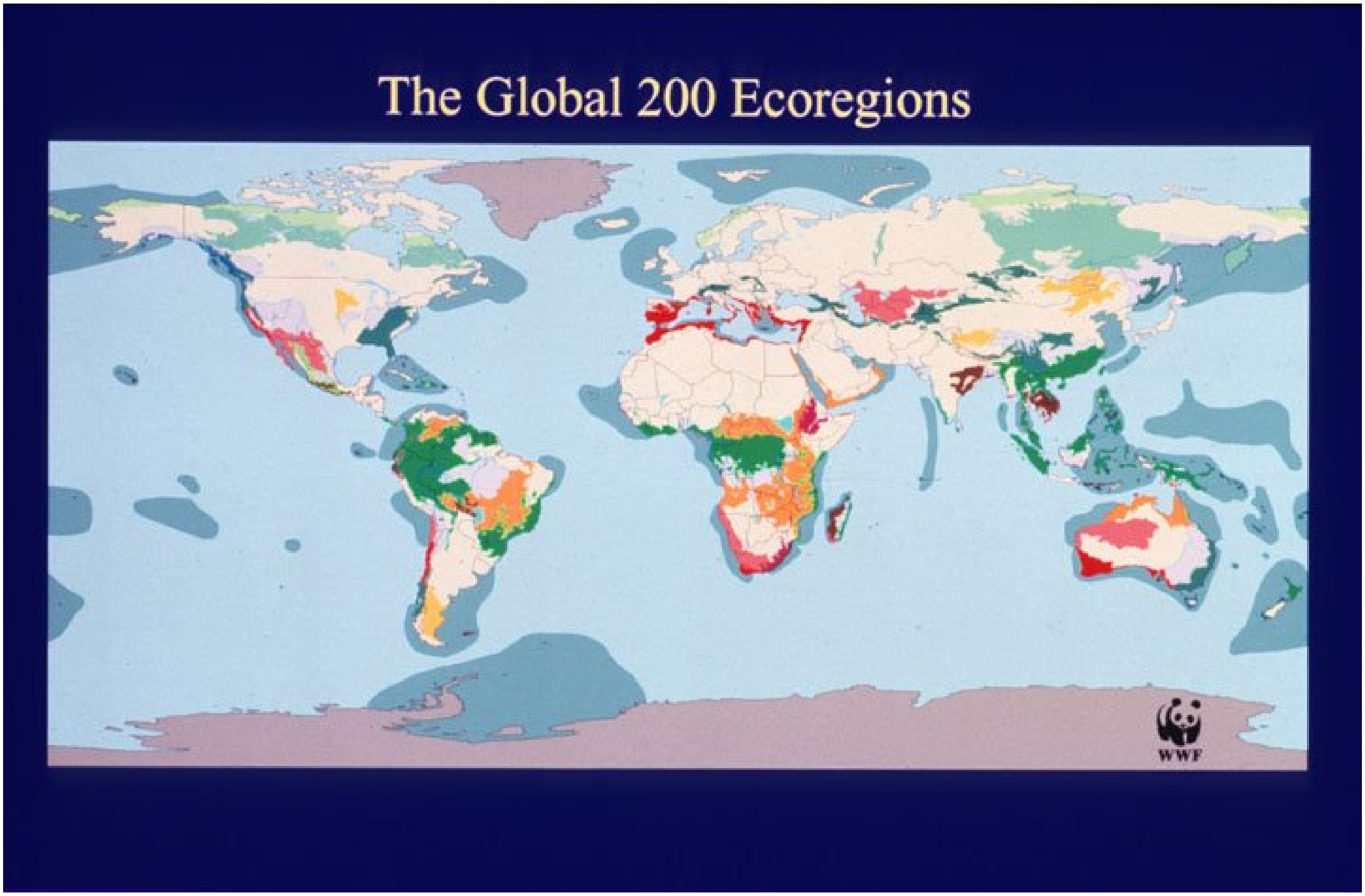
The essence of managing adaptively is having an explicit vision or model of the ecosystem one is trying to guide (Walters 1986). That explicit vision provides a baseline for defining surprise. Without surprise, learning does not expand the boundaries of understanding.

The technology of the geographic information system (GIS) now provides a ready template for assembling models. Into a GIS one can import physiographic and topographic databases, natural history observations, scientific measurements, and social and economic data.

Assembling information, attaching spatial coordinates and dates to the data, and preparing maps is a rapid, powerful way to create a shared view of the landscape. Figure 1 brings together a wide-ranging literature review by Eric Dinerstein and his colleagues at the World Wildlife Fund (Olson and Dinerstein 1998). Its identification of 200 regions of key importance to preserving representative species and ecosystem processes has catalyzed an international commitment to conservation at large spatial scales.

Maps provide a vivid portrayal of how geography matters to a threatened species or ecosystem function. Environmental concerns often have a crucial geographic dimension, and the power of maps to motivate non-biologists to act is a valuable tool in struggles that often seem abstract or remote from everyday life. Still, maps are only one element of the analytical toolkit needed for conservation or resource management.

Fig. 1. Global 200 Ecoregions, proposed by World Wildlife Fund.



Three cautions, at least, are important. First, any map emphasizes static structure rather than dynamic processes, although one may of course use a sequence of maps to show changes such as shrinking forest area. But a map is so engaging that one can easily forget that it is by itself static. Ecosystems are dynamic: what matters to learning is whether one can see policy-induced changes in the behavior of the ecosystem. For this, it is essential to ask whether the manager-experimenter *expects* to see a measurable difference due to manipulation of the experimental variables (Walters and Green 1997). This is a question for which a model is needed even to speculate sensibly; a map is not a model, in this important respect.

A second caution is that relatively little significant information is now available in geo-referenced form. As a result, measurements made at particular locations are often attributed to much wider areas. Maps, like statistics, can easily mislead -- indeed, any good map should make a clear point, which means that the map-maker is deliberately leaving out a lot.

Third and most important, having an explicit vision of an ecosystem does *not* mean having a complete or detailed or even correct baseline suite of data. Adaptive management is about urgency, acting without knowing enough, and learning. One can be surprised by one's own ignorance -- and one can learn from it. The focus should be on learning, not on getting ready to learn. A map is not an end in itself but a means.

(To be sure, a good baseline is desirable -- so much so, Walters (1997) suggests, that some resource managers are using models to *infer* parameters, as a substitute for actual measurements in the field. This is of course logically incorrect, compounding the errors in the information that went into the model in the first place.)

There is a broader theme here. Information is expensive. Scientists know this well, since they work hard for each data point. But scientifically trained professionals, who know something about statistical significance and error, have been slow to face a pressing problem in adaptive management: how to get information cheaply and with as few organizational and procedural hassles as possible. Unfortunately, would-be adaptive managers have often jumped too quickly to thinking of information gathering as monitoring. That *is* what an adaptive approach leads to, but it should emerge from a skeptical appraisal of what kinds of information one can afford to collect (Rogers 1998). The model of rapid assessment in conservation biology is worth remembering; the value of information needs to be balanced against the human and environmental values one is seeking to protect. Action guided by imperfect information is often -- though not invariably -- better than action guided by no information at all. (I do not, of course, suggest replacing monitoring with rapid assessment, a family of methods aimed taking an approximate inventoryof the biodiversity of a place.)

The issue is the cost-effective testing of hypotheses. Adaptive management is not laboratory science, where the burden of proof is tilted toward highly reliable findings by rules such as $p<0.05$, the notion that one's inferences should be reliable 95 percent of the time. In public policy and the world of action, the usual test is "more likely than not" -- that is, $p<0.5$. (There is also an important difference between methods that control for Type I errors, the kind discussed here, and the problem of Type II errors, which is often more germane to adaptive management of ecosystems (Anderson 1998).) The findings that emerge from such roughshod hypothesis testing will not be as reliable as academic science (see Walters and Green 1997). But that is the point: adaptive management is likely to be worthwhile when laboratory style precision seems infeasible but trial-and-error seems too risky. And that's much of the time in conservation.

Ethical: bear in mind ambiguity

Adaptive management is an unorthodox approach for people who think of management in terms of command. Learning is information-intensive and requires active participation from those most likely to be affected by the policies being implemented (see Margoluis and Salafsky 1998). Those who operate the human infrastructures of harvest -- farmers, ranchers, dam operators, loggers, fishers -- are usually those who know most, in a day to day sense, about the condition of the ecosystem. Their reports constitute much of the information that can be obtained at reasonable cost. Harvesters also see themselves as stewards of the resources upon which they rely, a claim that frequently turns out to be well-founded (McCay and Acheson 1987, Ostrom 1990, Getz *et al* 1999).

Those who would preserve species and ecosystems propose to alter the behavior of just these user-stewards. Change is normally resisted. Moreover, when conservation is the objective of management, environmental decline has become apparent, and those who have been users, owners, or governors of an ecosystem are already under fire from critics. Under these conditions, it makes sense to have low expectations. First, adaptive management will often be resisted or sabotaged. Second, when adaptive management works it will usually be the tool of those who want to affect how an ecosystem's human inhabitants earn their living; moreover, inhabitants of protected areas in the developing world are often vulnerable and poorly represented in official deliberations. Win or lose there is ethical ambiguity.

It is tempting to ignore this ambiguity but important not to do so because it usually emerges as conflict. Conflict is an essential element of governance. Differences are inevitable, and an orderly approach to resolving those differences is essential; over the time periods needed to establish conservation practices, conflict and turbulence must be expected and should be welcomed. But conflict needs to be bounded -- disputes should be conducted within the boundaries of a social process that the disputing parties perceive as legitimate. Unbounded conflict can tear apart the social fabric, thwarting learning. The difficulty is that conflict is a situation in which control of the rules of engagement are themselves contested. When the conflict is between sovereign powers like national governments, there is no superior authority able to impose a bounded process. In practice, even parties with little power can delay the resolution of conflicts enough to frustrate experimentation and learning.

A surprising aspect of the ethical ambiguity is that environmentalists have often been unwilling to confess the ignorance upon which adaptive management is founded. Armed with legal mandates such as the Endangered Species Act in the U.S., environmentalists often act to force reluctant authorities to obey their own laws. This is essential when environmental activists seek recognition as legitimate stakeholders: forcing action demonstrates power. Yet when environmentalists exercise power they often do so by denying that the natural world is uncertain. This forestalls the learning that will be needed if a sustainable policy is to be devised.

Another ethical challenge of adaptive management lies in the fact that knowledge is a public good: once discovered, knowledge can be transferred at much lower cost than was necessary to make the initial discovery. For this reason, an agency or property-owner carrying out adaptive management faces a situation of increasing but not well-controlled transparency. What is learned from the adaptive process reveals not only the way the ecosystem responds but also what the managers are doing, whether it works, and whose interests it serves. Because information needs to be gathered, usually from a variety of sources in the ecosystem, it is hard to keep what is being learned from diffusing outward via the communication channels through which data are collected.

Undertaking an experimental approach presents the manager with two faces of learning. There are benefits from increasing understanding of the social and natural interactions -- the usual justification for an adaptive approach. But there are costs, which Walters has pioneered in estimating (Walters and Green 1997). Perhaps more important than quantifiable costs, there are risks of disclosure of activities which look inappropriate in the eyes of one or more stakeholders. The balance between the uncertain future benefits of increased understanding and the risks of inconvenient disclosure, which may come soon or by surprise, is necessarily subjective. This means that the judgments applied in initiating and sustaining adaptive management are volatile. Moreover, the scope of the cooperation needed to gather information for adaptive management means that many besides the official manager or owner need to maintain a commitment to the learning process, each weighing anticipated benefits against costs and risks. It is likely in such a setting that some members of the coalition will waver or resist participating.

These frailties underscore the importance of leadership in making adaptive management work. The obvious leader is the manager herself, since the manager usually controls the flow of benefits of harvest from or protection of the ecosystem, a key role in motivating those whose cooperation is essential for information gathering, analysis, and diagnosis of surprises. When the manager is a public official, the balance between benefits and risks of learning is likely to be measured in political metrics. Thus, using the term "adaptive management" as a buzzword -- when what is happening is much less likely to lead to disruptive disclosures than truly active adaptive learning -- is a temptation hard to resist.

In Table 1 the Green Revolution is used as an example of successful learning by focused experimentation. It is useful to bear in mind that the benefits of increased rice, corn, and wheat harvest were visible in a short time, and that the sponsors of the learning initially were private donors who were removed from needing to please diverse stakeholders. Moreover, the controversies that came to beset the Green Revolution arose well after the process of breeding new varieties was well-established as an economic strategy. For all these reasons, the Green Revolution is both a clear model and a hard one to follow in the realm of natural resource management and conservation. (Bruton (1997, 142) stimulated the observations above with a remark that the Green Revolution is also an unusual example of direct transfer from science to agrarian practice. His comment is also a caution for adaptive management: the discoveries that result from learning may not be readily applied by all or even any of the stakeholders.)

Pragmatic: Making a difference

The pragmatic question is simple -- does adaptive management work? We do not know yet. We do not know for two reasons. First, the battle for control of ecosystems is not decided in a lot of places. So the learning process that adaptive management organizes is subverted or ignored if it is even attempted. Second, the time scales for ecosystem response are typically long, and it is too early to know how or even if changes in human management policies have made an unambiguous difference. Most natural indicators yield one data point a year; even a simple trend takes patience in a world with a 24-hour news cycle, quarterly profit reports, and congressional elections every other year.

The high-water mark, so far, in adaptive management practice appears to be a careful series of management experiments conducted in ground fisheries by Keith Sainsbury of the Australian CSIRO in Tasmania. Beginning in 1988 Sainsbury designed an adaptive management regime for a declining groundfish fishery off northwest Australia (Peterman and Peters 1998). Using a decision analysis framework to organize hypotheses and available information, Sainsbury analyzed the value of additional information to be gathered by an experimental program. He showed in that situation that the expected value of catch could be quadrupled by carrying out one set of management experiments. This was done, with results indicating that one of the four hypotheses had strong support. Fisheries regulation has now been altered in response to these findings. The adaptive learning program took about a decade to yield practical results in fisheries management.

In the U.S., adaptive management was initially adopted in 1984 by the Northwest Power Planning Council, as a way of organizing the council's activities to protect and enhance Pacific salmon in the Columbia River basin

(Lee 1993, chap. 2). Those efforts were diverted in 1990 by litigation under the Endangered Species Act, so that the experimental phase of the Columbia basin program did not get very far (Volkman & McConnaha 1993, National Research Council 1996).

Adaptive management has been implemented in several other settings (see Gunderson, Holling, and Light 1995, Walters and Green 1997). Three recent instances are noteworthy. First, the U.S. Forest Service has attempted to forge a consensus management plan for its Pacific coastal forests in California, Oregon, and Washington (FEMAT 1993). These have included the definition of Adaptive Management Areas "for land managers, researchers and communities [to] work together to explore new methods of doing business" (Olympic National Forest 1998). The Forest Service's definition of adaptive management does not emphasize experimentation but rather rational planning coupled with trial and error learning. Here "adaptive" management has become a buzzword, a fashionable label that means less than it seems to promise.

Second, the Plum Creek Timber Company (1998), a major landowner in Washington State, adopted a habitat conservation plan for its Cascade region lands in 1996, enabling harvest in a landscape where endangered species are found. Plum Creek has made specific commitments to experimental methods in the way it will carry out the conservation plan (see also Plum Creek 1999). Also in 1996 the U.S. Department of the Interior sought to rebuild riparian habitat in the Grand Canyon by deliberately releasing large quantities of water from Glen Canyon Dam (Glen Canyon Environmental Studies 1996, Grand Canyon Monitoring and Research Center 1998, see also Barinaga 1996). This spring flood was accompanied by a substantial monitoring effort, and it has been followed by research studies now being reviewed by a committee of the National Academy of Sciences.

None of these efforts has been as systematic as Sainsbury's decision analysis in Australia. That is probably appropriate to the state of the art: decision analysis assumes there is a single decision-maker, with a rationally structured set of preferences. In an economically significant fishery, it makes sense to measure preferences via the value of catch as Sainsbury did. But when conventionally measured economic value conflicts with environmental values, as in the U.S. cases, the fundamental premise that a non-controversial optimal decision can be identified is not plausible. (Walters and Green (1997) propose a way to estimate the economic value of non-market attributes. Although their method is less cumbersome than the elicitation methods developed for decision analysis, its practical utility remains to be shown.)

In sum (Table 2), adaptive management is an idea highly attractive to the scientifically sophisticated, who understand how little is really known about the behavior of modified ecosystems that continue to be used by humans. Its requirements for patient record-keeping and clear-headed assessment turn out to be hard to muster where there is conflict -- that is, in all the important cases. This practical reality has not seemed to dim the luster of the idea itself (e.g., National Research Council 1996). I am unsure whether to worry or to take comfort in that impression, but the uneven success of adaptive management is one indication of how far from realization is the "new social contract" (Lubchenco 1998) that thoughtful leaders have urged upon the scientific community and the society it serves.

Table 2. A schematic appraisal of adaptive management.

ADAPTIVE MANAGEMENT

treats management policies as experiments that probe the responses of ecosystems as human behavior changes.

Conceptual soundness
Hypotheses, controls, replication
Is the idea sensible? Learning is valuable, but learning is always a precarious value compared to action.

Technical
Models, cost-effective monitoring, value of learning in making decisions
Is the idea translated into practice well? Too little attention to the cost and delays of gathering information.

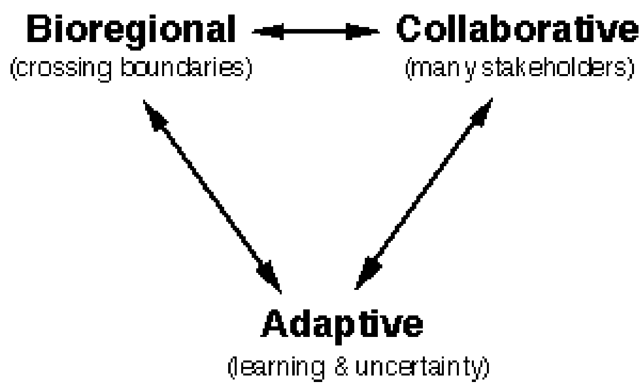
Equity
People live in and use ecosystems
Who loses? When conflict pushes aside learning, the ecosystem and resource-dependent communities decline while struggle continues.

Pragmatic
Does it work? We don't know (yet).

CONSERVATION IN A NEW KEY

Adaptive management and learning also play a strategic role in the emergent question of conservation at the ecosystem scale. There is growing agreement that biologically effective preservation of species, habitats, and ecological processes requires working on large spatial scales (Fig. 1; see Wilson 1993, chap. 11; Olson and Dinerstein 1998). Such ecoregions are so large that many of those landscapes will be inhabited or used by humans for the foreseeable future. Moreover, the lands and waters will not be under the control of a single owner or management agency, as is the case in existing nature preserves and parks. The formidable task of biodiversity conservation in such settings seems to require integrating at least the three themes in Fig. 2.

Fig. 2. Ecosystem-scale conservation.



First, working in the biological template of an ecosystem almost always requires acting across human boundaries.

Figure 3 shows a portion of the Global 200 map in Fig. 1. None of the ecoregional boundaries coincide with human jurisdictions; even the coastal zones are claimed under national sovereignty. When the jurisdictional boundaries mark off different human purposes, as does the line dividing forest from suburb, achieving coherent, coordinated action can be difficult.

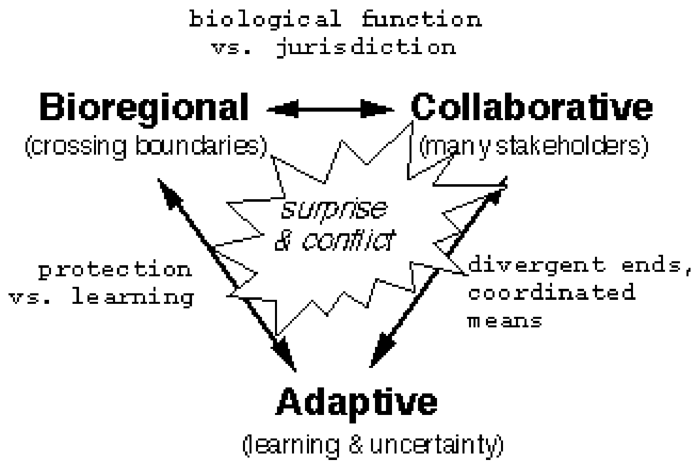
Fig. 3. South American ecoregions.

Second, in inhabited landscapes there are many stakeholders. Consider those who are *always* present: governments, owners, and consumptive users of the land and waters. In addition, there are environmental activists, political insurgents, and would-be investors from outside. These groups have conflicting goals. The art of the conservationist under these conditions is to reconcile conflicting objectives, at least temporarily, so as to make agreements on land use and other protective actions possible.

Third, there are the challenges of adaptive management discussed above.

Trying to act in this fashion, ecosystem conservationists encounter structural challenges (Fig. 4). I want to highlight the word "structural": trying to work at the ecosystem scale sets an agenda for collaboration, yet each of the elements of ecosystem conservation stirs up conflict. Cooperation is hard-won and difficult to sustain. A bioregional definition of the landscape crosses boundaries. A collaborative approach complicates experimentation, requiring stakeholders with divergent ends to work together if learning is to produce reliable knowledge. Experimentation often takes a long time to gather significant findings -- and may thus be hard to reconcile with urgent declines in highly valued species.

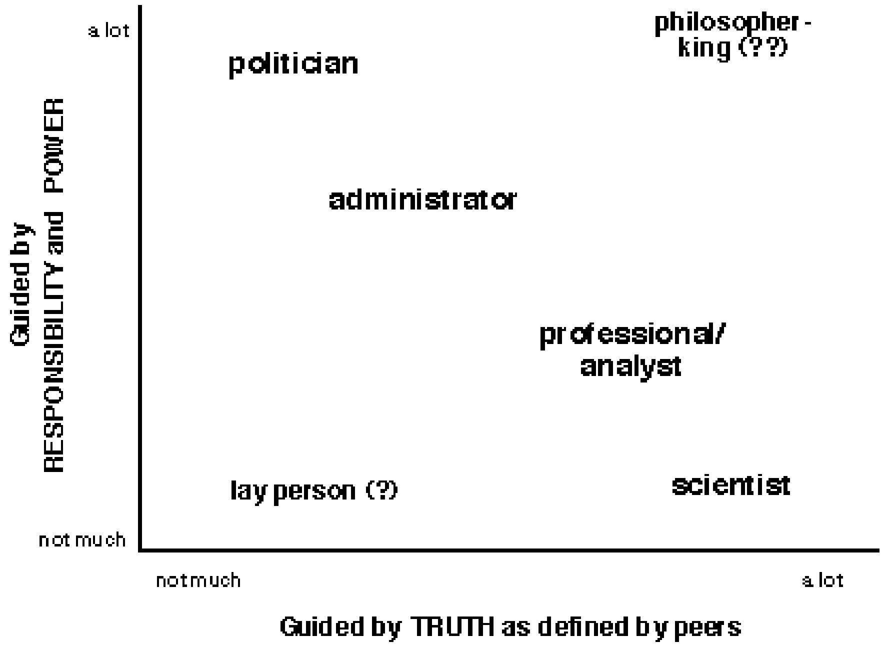
Fig. 4. Ecosystem scale conservation -- structural challenges.



The persistent theme is conflict. Stakeholders usually cannot be bypassed if they are not cooperative. So the alternative is to find ways to overcome or avoid their opposition. This is easy to say but hard to do. The scientist's predisposition, faced with these social complications, is to find somewhere else to carry out the experiment. Why look for hassle when there is all that uncertainty to probe? This is correct from a scientific perspective. But if a landscape is of high biological value, the social complications may be unavoidable. In this important respect a conservationist is not just a scientist.

Consider Fig. 5, modified from an analysis advanced a generation ago by Don Price (Lee 1993, chap. 7). Price's point is often forgotten today, but it remains valid. Scientific investigation is fundamentally different from the exercise of power. Power is about responsibility for the welfare of others; science is about determining truth or, more modestly, finding reliable knowledge. Price concluded that the goals of Truth and Power are not incompatible, exactly, but that there are usually tradeoffs: a real human being cannot be for long a philosopher-king of the kind Plato described. More sadly, in a complex, technological society most of us are lay persons most of the time, unable on our own to exercise much power or to determine truth without a lot of assistance. In our work lives, Price argued, truth and power *do* work together, but in roles that constrain as well as enable knowledge and responsibility to be combined.

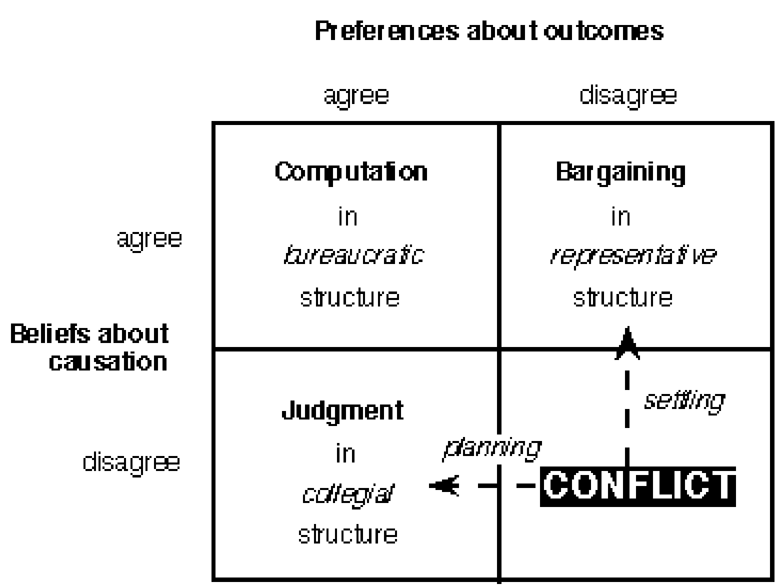
Fig. 5. The spectrum from truth to power. Adapted from Price, (1965); see Lee (1993, chap. 7).



A question still being answered is where ecosystem conservation might fit in this chart, not only on an individual level but as an organized endeavor. After all, international corporations have shown considerable capacity for climbing toward the upper right corner, marshalling both knowledge and power for their own ends. So it seems possible that a collaborative, bioregional, adaptive conservation strategy might be able to do things that environmentalists or government officials cannot do by themselves, while opening opportunities for economic actors that developers in the traditional mold might not think to explore.

How might that happen? I do not have a recipe, but I do have a suggestion, spelled out via another diagram, shown in Fig. 6 (Lee 1993, chap. 4).

Fig. 6. Deciding and intervening -- some organizational alternatives. Source: Lee (1993, chap. 4, modifying Thompson and Tuden, 1959).



Here, two sociologists looked at how decisions were made in different social settings. They observed that institutions and groups organized themselves differently to address different kinds of decision-making problems. Let me describe four circumstances, in search of answers to the question, What kinds of decision-making situations are central to ecosystem conservation?

The distinction drawn in this matrix is between outcomes and causality. That is similar to ends and means. In the upper-right box, people face the need to harmonize divergent ends (preferences about outcomes). This is what happens, for example, in assembling a budget: apples and oranges must be combined under a single spending ceiling. The way that is normally done is by bargaining -- trading votes for what is often disdainfully referred to as "pork." However it is characterized, reconciling dissimilar objectives is something that all organizations do routinely.

The upper left box is the realm of bureaucracy. When we agree on both preferred outcomes and causation, an organization can be set up around rules that can be applied mechanically. We reduce the judgment of whether someone can drive safely to a licensing exam -- clear-cut rules that usually frighten only a 16-year old. Bureaucracies like the Environmental Protection Agency are designed *as if* there were no arguments about the preferred outcomes they should pursue -- that is, their missions. That is false, of course, which is one reason that life is often frustrating for people who work in those settings: the organization's structure and function are ill-suited to the social environment in which it must work.

In the lower left is the realm of science, the arena in which causation is poorly understood. Peer review is one of the collegial devices familiar to academic folk: an anonymous colleague is asked to judge whether a paper is worth counting as a significant contribution to knowledge.

The lower right box is where the hard stuff happens, including ecosystem conservation. When there is disagreement over both means and ends, over causation and desirable outcomes, there is no structural solution. Thompson and Tuden put in this box originally, "Intuitive decisions made by charismatic authority."

My suggestion, building on the considerable success of informal dispute resolution over the past 20 years, is to think of dispute resolution as strategies designed to move conflicts from the unresolvable to one of the cases we do know how to handle structurally. This is what one might try to do with ecosystem conservation.

It matters a lot which path one pursues. The most common cure for environmental problems is to recommend planning. Indeed, the modes of learning while doing listed in Table 1 all require planning as an initial step. The point stressed now is that interventions in established patterns of human-nature interactions typically engenders dispute. Planning is often thought to be an adequate response to those tensions; even though it can do that sometimes, science is put at risk, usually inadvertently.

Planning is the arrow pointing to the left. Planning attempts to defer conflict. The planner says, We are all in this complicated situation together -- at an abstract level, our preferences about outcomes are not really different. Let a group of experts figure out some ways to get to that consensus future. Their plan will show us how to work together. While sorting out a complex situation usually opens up opportunities for collaboration that were obscured by conflict, planning illuminates irreconcilable differences too. This typically leaves the experts -- including scientists -- vulnerable to the remaining disagreements.

In ecosystem conservation, furthermore, it is normally the scientists who are the trouble-makers to begin with: they are among the advocates who want to divert the path of economic development. So, when the process for resolving conflict is planning, it is highly likely that scientific ideas like adaptive management or a bioregional template will be perceived to be the instruments of an invading power. This stiffens resistance. The questions that adaptive management seeks to answer will be seen in terms of whether they spell further trouble for ecosystem inhabitants. People who worry about getting the "wrong" answer can usually interfere with experiments enough that the experimenters cannot obtain a reliable answer. They are likely in any case to seek to shape the perception of what is found. While these tensions cannot be avoided entirely, their potential to disrupt adaptive management should inform one's judgment of the worth of learning in a conflict-laden situation.

What about the other approach, which I have labeled "settling"? Now, the strategy is to focus first on the fact that preferences about outcomes diverge. The bargaining searches for objectives that disputants want to pursue even though they do not agree on long-term goals. In an environmental settlement negotiation, one of the bargainers' tasks is to hammer out agreements on the questions about causality that all parties want answered. From that agreement an adaptive approach to conservation can emerge.

A danger of the settling strategy is that there may be no common ground: in order for conservation to be accepted at all, it needs to be legitimate -- something that must be done at some level, though there may be room to bargain over how much to do at a given time. In many places the human representatives of biodiversity have yet to be given a place at the table. The rapid proliferation of protected areas may mean that there are now getting to be enough places where settling can create a viable structure for ecosystem conservation.

If conservation is legitimate, then science can play quite a different role than it does in planning. Now, the scientific questions can be answered with a shared sense of their importance. Science is not the servant of one set of interests but a tool to pursue a common agenda. And its answers, which may still be unwelcome, will have the considerable protection of a shared interest in asking the questions in the first place.

What this means, bluntly, is that a collaborative structure should be in place *before* an adaptive exploration of the landscape gets underway. This is not how adaptive management has been used. Instead, experimentation has been adopted in a planning context. This may be a reason why there have been few successes.

There is another frailty in the settling strategy. It lies in the word "representative." In a jumble of jurisdictions of the kind one finds in bioregional conservation it is not clear what counts as proper representation. What has happened in North America is that general-purpose governments like states, Native American tribes, and national governments all weigh in. This complicates the bargaining because there are lots of parties and lots of arenas in which to bargain. Moreover, the institutional independence of the judiciary in parliamentary democracies means that litigation is often a parallel disputing process, available to the disgruntled. This is a consequential problem because it enlarges the social resources needed before biologically significant actions can be taken. Yet it is not easy to suggest workable alternatives. Sir Winston Churchill remarked once that democracy is the worst form of government save for all others; an ecosystem conservationist often ponders that observation.

SEARCHING FOR TRANSITIONS

Adaptive management is difficult to initiate and to sustain. However valuable the surprises it produces may turn out to be, adaptive management is unlikely to be considered affordable in many instances. But there is reason to think that this mode of learning is important, possibly essential, in the search for a durable and sustainable relationship between humans and the natural world. It is useful to recall that ours is not the first generation to face the tension between human power and natural wealth.

Over the past two centuries, human population growth, technological change, and economic development have transformed the conditions of human life and altered the planet we inhabit. In the coming century, there is reason to be hopeful (National Research Council, forthcoming). The long-term demographic transition, signaled by the absolute peaking of the population growth rate in the late 1960s, continues, with human numbers growing but at steadily slowing rates; a stable population size is plausible in the twenty-first century. It also appears that technological improvements can moderate the waste of energy and materials the pollute local and regional environments and alter the atmosphere and climate (see Ausubel 1996). More and more places have been declared protected areas (see World Conservation Monitoring Centre 1999), demonstrating the will to conserve biodiversity, even as we continue with the sixth great mass extinction in the history of life (Wilson 1993, chap. 12).

If humanity is to achieve a transition toward a sustainable economy from the recent patterns of development, however, learning is of central importance. None of the elements of the transition sketched here, even population stabilization, is likely to be completed without the support and encouragement of societies and their leaders. Moreover, all aspects of preserving the life-support systems of Earth, particularly the protection of biological diversity and ecological processes, lie at or beyond the frontier of established practice or reliable knowledge. The history of "sustainable" exploitation of natural resources is a discouraging one (Ludwig, Hilborn, and Walters 1993; cf. Levin 1993). Analyses of sustainable yield have been used not only to guide action but also to rationalize heedlessness. This is not a reason to dismiss analysis but rather to see that analysis is one stage of a historical process of adaptation. Analysis and learning can be influential, even when the policies they inform do not completely succeed. The U.S. Endangered Species Act, beleaguered throughout its quarter century as a legislative mandate, does seem to be bringing ecological science to bear in a small but significant set of decisions about land use (Kareiva *et al* 1999).

Adaptive management is a mode of learning. It is one attractive to natural scientists, drawn to the trustworthiness of experimentation as a way to establish reliable knowledge. Practitioners of adaptive management are moving the method toward the pragmatics of trial and error learning, while seeking to preserve the rigor of scientific logic (Walters and Green 1997). In doing so, the adaptive approach becomes entangled with the sociological difficulties of the Spectrum from Truth to Power (Fig. 5). Adaptive management has been framed so as to win favor with those who are nominally in charge of stewardship -- typically government managers or harvest regulators and private landowners. When these stewards' legitimacy is under attack, adaptive management has at times appeared to be a way to deflect criticism by opening the way to trying novel ideas. But unless those novel ideas turn out to command a consensus within a short time of adoption, adaptive management is no more than a way to justify trial and error in the midst of a political free-for-all. Logically, one does not need the armature of scientific methods for that purpose. If there is a lurking consensus, however, the careful thought demanded by adaptive management may be a way to elicit agreement (Walters and Green 1997).

An alternative is proposed above, to hammer out a provisional agreement before turning to experimental methods to sort out uncertainties that are agreed to be significant by all stakeholders. Using this strategy does not assure that the initial consensus about questions to answer will hold. Indeed, since surprise is endemic to experimental learning, emergent Truth will inevitably challenge Power. That is, of course, a reflection of the necessity for conflict and debate in the process of finding a way to live in durable prosperity. Sadly, humans have difficulty distinguishing between message (conflict is healthy) and messenger (adaptive management reveals conflict rather than causing it). In an approach to learning that requires large organizations' support, this confusion may be the limiting factor in our ability to find a sustainable future.

Conservation now requires harmonizing the insistent demands of poverty and capitalism with the quiet obligations of the biotic community. Heeding those obligations requires an uncommonly broad perspective, one that takes seriously social institutions, human needs, and biogeography. It is also a perspective that recognizes the productivity of conflict, while sustaining a patience consonant with the rhythms of the biosphere.

As in the spectrum from Truth to Power, I do not propose that single individuals embrace all these qualities. But how to organize the skills and commitments of a diverse human community to strive for these uncommon aims is a challenge we are only beginning to address. The unifying idea is the dream of humans living in harmony with nature. For the first time, humans are seeking to govern themselves so as to preserve something they cannot see -- the web of life upon which all depend. But it is far from the only time that humans have tried to govern themselves according to invisible ideals; indeed, the influence of ideas and ideals is usually thought to be a distinctive and (sometimes!) admirable trait of our species.

To paraphrase Walters (1997), the need now is not so much better ammunition for rational debate but creative thinking about how to make adaptive management and social learning an irresistible opportunity, rather than a threat to various established interests. That is, we need to show that adaptive management can create feasible accommodations for those who gain their livelihood from the land and waters, property owners, public officials, and environmental activists -- as well as scientists.

Where we cannot, we should concede that science cannot displace power often enough to be a basis for policy. Science is at most the servant of those who act; the question is, whom should scientists seek to serve. Those who can agree, despite conflict, to search for answers bring a degree of social stability that seems little enough for the practical realities of adaptive management. Those who cannot agree furnish reason for citizens, including scientists, to act politically; that is not adaptive management but a different, sometimes higher calling.

Questions inviting comment

Seeking to stimulate the creative thinking called for above, I advance some troublesome questions to which I do not have answers, with an invitation to comment:

1. Are there clear-cut successes in adaptive management, other than Sainsbury's work?

2. When an adaptive management design is *not* feasible, is there experience to guide trial and error learning?

3. Adaptive management appears to be unsuitable *unless* there is a governmental authority that monopolizes physical access to the resources being managed. This raises the question of what can be learned under conditions of partially open access or limited enforcement of regulations. Relevant experience is invited.

4. Put another way, adaptive management appears to be a "top down" tool, useful primarily when there is a unitary ruling interest able to choose hypotheses and test them. Markets are inherently bottom-up learning mechanisms, with messages transmitted by prices and availability of goods and services. Collaborative management works by sharing understanding of the behavior of an exploited natural system within a community of harvesters (Ostrom 1990). Is there a broader analytical perspective on how action improves understanding that would be useful to add to this set?

5. Are there clearly articulated scientific criteria for putting short-term conservation ahead of learning? (That is, are there conservation situations where we know enough not to need to worry about surprises?)

6. When should near-term conservation objectives (notably species preservation) take precedence over an ecosystem approach? When is a conservationist justified in short-circuiting participation by inhabitants and other stakeholders in decision making? (Much action in behalf of endangered species implicitly answers these questions in the affirmative.)

7. Efforts to design sustainable-use regimes in collaboration with established or traditional user communities have had difficulty integrating scientific perspectives, and adaptive methods have not been used to my knowledge. What lessons are emerging from co-management concerning the usability of ecosystem models and explicitly adaptive processes?

8. Any learning process seems to require enough stability for the learning to take place, but environmental problems are characteristically accompanied by social change. Are there ways to record observations and assumptions so that one enhances the probability of learning by those who follow, even if they are not the same persons and may be motivated to learn for different reasons?

9. The emphasis on a transition to a sustainable material economy in the last section does not equate growth with greed (cf. Ludwig, Hilborn, and Walters 1993). Is this a mistake?

10. Is it possible to achieve biodiversity conservation without sustainable development ...or *vice versa*? (The development of national parks in the U.S. and other OECD countries implicitly assumed the possibility of conservation -- though not of biodiversity as we now understand it -- without sustainable development.)

RESPONSES TO THIS ARTICLE

Responses to this article are invited. If accepted for publication, your response will be hyperlinked to the article. To submit a comment, follow this link. To read comments already accepted, follow this link.

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Address of Correspondent:
Kai N. Lee
Center for Environmental Studies, Williams College, P.O. Box 632,Williamstown MA 01267 USA
Phone: (413)597-2358
Fax: (413)597-3489
Kai.N.Lee@williams.edu
