A Practice-Based Approach to Ecosystem Management

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Abstract: *Ecosystem management is a rapidly evolving philosophy or paradigm of natural resource management intended to sustain the integrity of ecosystems. The problem is that principles of ecosystem management are unsatisfactory for practical purposes. Three major approaches to the problem are evaluated: (1) clarification of the goals of ecosystem management, (2) construction of a better scientific foundation for management decisions, and (3) comparative appraisal of current practices. The evaluation concludes that neither of the first two approaches is necessary or sufficient for better management decisions because better decisions depend upon the complexities of particular contexts. The third, practice-based approach makes the most of the limited human capacity to cope with the complexities of ecosystem management in order to improve principles of ecosystem management, to inform particular management decisions through improved principles, and to incorporate clearer goals and a better scientific foundation as they become available. The evaluation draws on experience and disciplines beyond conservation biology and natural resource management, including policy sciences.*

Aproximación al Manejo de Ecosistemas Basada en la Práctica

Resumen: *El manejo de ecosistemas es una filosofía o paradigma de rápida evolución en el manejo de los recursos naturales enfocado al mantenimiento de la integridad de los ecosistemas. El problema es que los principios del manejo de ecosistemas no son satisfactorios para propósitos prácticos. Tres aproximaciones importantes son evaluadas: (1) Clarificación de las metas del manejo de ecosistemas, (2) construcción de una mejor fundamentación científica para decisiones de manejo y (3) aproximaciones comparativas de practicas actuales. La evaluación concluye que ninguna de las primeras dos aproximaciones son necesarias o suficientes para mejores decisiones de manejo, puesto que mejores decisiones dependen de las complejidades de un contexto en particular. El tercero, basado en la práctica aprovecha al máximo las limitadas capacidades humanas para abordar estas complejidades—con el fin de mejorar los principios del manejo de ecosistemas, para informar decisiones de manejo específicos a través de principios mejorados y para incorporar metas más claras, así como una mejor fundamentación científica tan pronto como se encuentren disponibles. La evaluación retoma experiencias y disciplinas más allá de la biología de la conservación y el manejo de los recursos naturales, incluyendo las ciencias políticas.*

Introduction

Conservation biologists and practitioners of natural resource management have accepted ecosystem management as an emerging philosophy (Jensen & Everett 19[illegible] or paradigm (Stanley 1995) in which the overriding [illegible] is to sustain the integrity of ecosystems. This reflects increased knowledge about the environment and re[illegible] changes in social aspirations (Golley 1993; Burrough[illegible] Clark 1995). The problem is that principles of eco[illegible]tem management are generally considered unsatis[illegible]tory for practical purposes (Alpert 1995). Satisfac[illegible]

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principles would be adaptable to ecosystems of different kinds on various scales; would provide practical guidance on what to do, and why, to sustain the integrity of particular ecosystems; and would represent a working consensus among managers, other practitioners, and researchers alike. However, as Keiter (1995:79) put it in a representative assessment of the current state of affairs, "confusion and uncertainty persist over how ecosystem management should be defined and what it means in practice." An avalanche of published material centers on eliminating the confusion and uncertainty (e.g., Constanza et al. 1992; Bormann et al. 1994; Interagency Ecosystem Management Task Force 1995).

Among many approaches to the problem, three are worth evaluating here because they are more influential or otherwise more significant for improving principles of ecosystem management. One approach relies on clarification of the goals of ecosystem management. For example, in an influential article, Grumbine (1994) identified five goals of ecosystem management (as well as 10 dominant themes) through a review of the academic literature. In general, the underlying rationale of this approach is that a clear goal is necessary to select the best action alternatives for achieving it. A second approach relies on constructing a solid scientific foundation for ecosystem management. For example, in December 1995 the U.S. Forest Service (USFS) conducted an extended workshop including world-class ecosystem scientists in an effort to shape ecosystem management for practical purposes. In general, the underlying rationale is that an objective scientific foundation is necessary for consensus and for effective decisions. A third approach relies primarily on practice and what can be learned from it. For example, a strategy of research, education, and action to protect old-growth timber in the Tongass National Forest in southeast Alaska has been considered successful enough to serve as a model for adaptation elsewhere (Kirchhoff et al. 1995). The assumption is that progress depends upon the evaluation, diffusion, and adaptation of innovative models of diverse kinds (e.g., Scaebler 1994).

Our purpose is to critique and integrate these three approaches, as part of the long-term effort of conservation biologists and practitioners to improve principles of ecosystem management for practical purposes. Our thesis is that ecosystem management must be an evolutionary process because ecosystem contexts are far too diverse, complex, and dynamic for anyone to understand completely, completely objectively, or once and for all. In this evolutionary process progress in sustaining the integrity of ecosystems can be delayed by taking clearer goals or a better scientific foundation as a priority or a prerequisite. Such improvements are neither necessary nor sufficient for management decisions; and, in any case, management decisions often cannot wait for them. Progress can be accelerated by relying on the third, practice-based approach, improving principles of ecosystem management through practical experience, informing particular management decisions through improved principles, and integrating clearer goals and better scientific knowledge as they become available.

To develop this thesis we evaluated the three approaches and reframed the problem and opportunity of ecosystem management in the broader perspective of other fields and disciplines that have addressed similar problems and opportunities and have learned from their experiences. Our intent was and is to open up corridors and interchanges between conservation biology and these other islands in the ecology of ideas.

Clearer Goals

Researchers and practitioners alike tend to assume that clearer goals are a priority for progress in ecosystem management. For example, from his review of the academic literature, Grumbine (1994:31) concluded that "[m]ost of the authors cited in this review agree that setting clear goals is crucial to the success of ecosystem management." From a review of ecosystem management in federal land management agencies (U.S. General Accounting Office 1994), Duffus (1994:1) concluded that "if [the Administration's] approach is to be effectively implemented, the policy goal for ecosystem management needs to be clarified and certain practical steps need to be taken...." At the field level several years earlier, USFS and National Park Service officials presumed the priority of "a 'vision' of ecosystem management as a desirable goal" after they established the Greater Yellowstone Coordinating Committee (GYCC) (Clark & Minta 1994:101). This priority proved to be misplaced when the committee's draft vision, released late in 1990, became a focal point for conflict in the area (Lichtman & Clark 1994).

A clear goal makes sense for technical problems, but not for all "problems of decision." A decision can be defined as a commitment to a course of action intended to realize goals in a context. For a technical problem of decision, one proceeds as if satisfactory alternative courses of action are available or within reach, the action alternatives can be evaluated according to a fixed or given goal, and the goal is clear enough to select the best alternative. Other considerations are effectively discounted or ignored as "externalities," and thus the context of decision is clearly bounded. Perhaps these conditions were approximated earlier in this century, when meeting timber production targets was the primary goal of the USFS throughout the national forest system, and the goal was backed by a political consensus (Shepard 1994; Kennedy & Quigley 1994). Given a clear goal and clear boundaries, a problem of decision largely reduces to improving the alternatives available through scientific and technical means.

A problem of decision becomes less technical when the context of decision opens up and the externalities can no longer be discounted or ignored. This happens when organized groups, competing in a pluralistic political arena, begin to advocate complementary opposite goals that may then together be prescribed into law. In particular, this occurred when consensus on the primacy of timber production broke down in the 1960s. According to Kennedy and Quigley (1994:17),

> The public shift toward valuing National Forests for recreation, wildlife, and landscape values was first indicated in the Wilderness Act of 1964. The legislative last hurrah for intensive timber management... came in that period as well, when Congress rejected a proposed National Timber Supply Act.... In 1969, the National Environmental Policy Action (NEPA) marked the beginning of the environmental era.

Under these circumstances the goal of a management decision becomes ambiguous because it must integrate multiple, often incompatible or incommensurable, goals. For example, prescribed "multiple uses" measured in board feet, recreation visitor days, and animal month units must be balanced with prescribed "sustained yields" that are difficult to measure especially if the moral and intergenerational dimensions are taken into account. The appropriate, or at least acceptable, balance in one forest or ecosystem is not necessarily appropriate in another. Moreover, as goals become ambiguous the evaluation of alternatives becomes uncertain. It is one thing to estimate the number of board feet using known techniques of production. It is quite another to estimate the indirect and cumulative effects of traditional commodity and amenity uses on sustainability and still another to estimate what will be acceptable within fuzzy political, legal, and moral constraints. Given these ambiguities, uncertainties, and questions of practical prudence, it may be unclear whether a satisfactory course of action exists in a particular ecosystem. This is typically the case in the practice of ecosystem management today.

There is nothing unusual about such complex problems of decision. As Lasswell and McDougal (1992:26) observed, "in a pluralistic community . . . technical rules of law are commonly created in sets of complementary opposites, of highly ambiguous and incomplete reference, to express all pluralistic interests . . . ." Yet ecosystem mangers and other practitioners cannot avoid decisions indefinitely. At some point they must decide and act on their best interpretation of and judgment about the context. Even a nondecision may be construed as a decision to accept the status quo. To cope with such realities theory suggests that members of a community tend to disseminate symbols that refer parsimoniously to their basic aims or basic problems (Brunner 1987). In this case the symbols of "sustainability" and "ecosystem management" have become common currencies in the discourse of conservation biologists and practitioners over the last decade and a half (Simonov 1995). Like other key symbols, their function is not to evaluate action alternatives as if the decision problems were merely technical but to guide a collective and continuing evolutionary process that can reduce ambiguities and uncertainties and improve alternatives through the comparative evaluation of practical experiences. A corollary function is to avoid premature specifications and commitments that would foreclose potentially adaptive possibilities—a point that is often difficult to appreciate from a technical perspective.

These dynamics in ecology have been replicated on a larger scale in the U.S. constitutional process. The founding fathers did not attempt to define the goals of their republican ideology clearly and specifically. Rather, in the preamble to the Constitution, they crystallized an American consensus on basic aims "to establish justice, ensure domestic tranquillity, provide for the common defense, promote the general welfare, and to preserve the blessings of liberty to ourselves and our posterity...." In the body of the Constitution, on behalf of "[w]e, the people," they prescribed certain basic principles (e.g., separation of powers and procedures for elections and legislation) to guide progress with respect to the basic aims. Since then, countless Americans have found it expedient to invoke the enduring aims and principles of the constitution to justify and adjudicate conflicting claims on particular issues on all scales of decision (e.g., Short 1995). As these issues are decided, the meanings of the key symbols, including those in the preamble, are respecified at the margin; over time, the Constitution, statutes, regulations, and directives are adapted to diverse and changing circumstances, and social evolution is biased according to the consent of the governed (Brunner 1994). Any attempt to define "justice," "the general welfare," or "liberty" clearly and specifically would reduce the resilience of the constitutional process.

Processes like these arise in human communities because our capacity for reason is limited relative to the requirements of objectively rational behavior in the real world of decision (Simon 1981). There would be no conflicting claims to justify or adjudicate, and no need for politics, if everyone had a complete grasp of the same objective reality and aligned their identifications, demands, and expectations accordingly. As it is we must rely on basic aims and principles to resolve our differences through words and word equivalents and to serve as the shared premises that are necessary to exploit our limited capacity for reason in politics, science, religion, and other collective endeavors. Normally, the premises are accepted on faith, as self-evident truths, through socialization of the uninitiated, and they are far too abstract and open-ended for persuasive justification on rational grounds, even if the attempt were made (Lasswell & Kaplan 1950). Such process are self-sustaining as long as they generate enough progress to renew the community's faith in its basic aims and principles. But political ideologies, like scientific paradigms (Kuhn 1970), religious commitments, and management philosophies, are subjective human constructions vulnerable to revolution when faith collapses (Brunner 1993).

For practical purposes it is constructive to recognize that ecosystem management is not a technical problem (Gerlach & Bengston 1994). "Sustainability" is the basic aim in an emerging philosophy or paradigm of ecosystem management that is yet to be developed into satisfactory principles for practical purposes. Under these circumstances clear and specific but premature goal definitions would reduce the adaptability of ecosystem management as an evolutionary process. What are the practical implications of reframing the problem?

First, clearer goals are not necessary for the practical purposes of ecosystem management, as distinguished from the theoretical purposes. Conservation biologists and practitioners in the aggregate have long accepted the direction set by Leopold (1949) in his land ethic. Like the founding fathers, Leopold still serves as a figure to emulate and admire. More recently, the community has achieved enough consensus on the basic aim of sustainability to guide an evolutionary process of improvements, and the basic aim has been specified into goals that can be used to guide particular ecosystem management decisions. For example, Grumbine (1994:31) reports the following frequently endorsed goals:

(1) Maintain viable populations of all native species in situ.
(2) Represent, within protected areas, all native ecosystem types across their natural range of variation.
(3) Maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.)
(4) Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
(5) Accommodate human use and occupance within these constraints.

Similarly, Clark and Minta (1994:56) report that "there is remarkable consensus on the notion of what ecosystem management is" in 10 studies focused on the Greater Yellowstone Ecosystem. The priority is to use the working consensus that already exists to generate enough progress, beginning in the near term, to renew faith in ecosystem management. Otherwise, the attention and other resources now invested in ecosystem management may disperse.

Second, goals like those above would not be sufficient for particular ecosystem management decisions even if they were clarified. Such goals are properly used by practitioners as heuristics to guide attention to the more important values at stake in a particular context of decision. But in the particular context, should the practitioner act to "[a]ccommodate human use and occupancy within [ecological] constraints" as suggested above? Or should the practitioner put "human requirements and desires" first, at least as a procedural matter, as recommended by Jensen and Bourgeron (1994:3)? No clarification of general goals can solve this moral problem; it requires an interpretation of the particular context and a judgment about what is appropriate in that context. At this level of specificity a general consensus on goals tends to become debatable if not controversial within the community. Thus "[m]orality is rarely a matter simply of applying an unquestioned principle to a case that indubitably falls under its scope. The moral problem is to weigh conflicting principles and to act on a balance of probabilities on behalf of preponderant values" (Kaplan 1963:91). Moral principles and general goals can be refined and improved through reflection on a broad range of experience, but the specific goals that are appropriate in one context of decision may be inappropriate in another. Hence, there is a judgment to be made in every context.

Third, political differences in ecosystem management must be reconciled on a larger scale through the constitutional process. It would be self-defeating for conservation biologists and practitioners to assume that appeals to sustainability will justify proposed decisions among those Americans who take liberty or freedom, for example, as the overriding aim or to assume that references to ecosystem management will mobilize support among those who consider it a threat to private property and to the free market, which through the invisible hand is supposed to serve the general welfare in the philosophy of capitalism. The pragmatic alternative to preaching to the choir—to appealing only to those already committed to sustainability and ecosystem management—is to consider how to appeal more effectively to others on their own terms. For example, a particular decision might be justified in terms of "stewardship" rather than "ecosystem management" to minimize opposition if not broaden support; and a commitment to "ourselves and our posterity" might be exploited more effectively on behalf of sustainability. In such ways, conservation biologists and practitioners can contribute to the process of clarifying and securing the common interests that at least partially coincide with their own.

A Better Scientific Foundation

A better scientific foundation is often considered a priority if not a prerequisite for progress in ecosystem management. A study of ecosystem management activities in 18 federal agencies asserts that "[a]n enhanced scientific underpinning is fundamental to taking an ecosystem approach to managing our natural resources on a sustainable basis" (Morrissey et al. 1994:13). At the field level in the Greater Yellowstone Ecosystem, Goldstein (1992: 185) concluded that scientifically derived "baseline knowledge" and "the capacity to use this information" are prerequisite to improvements in the ability to manage for sustained ecological processes. And Boyce and Keiter (1991) identify several gaps in basic knowledge and research about the ecosystem that must be addressed, they believe, before progress can be made. These include research on plant and animal communities, fire ecology, riparian zones, and the impacts of various development and recreation activities on species and biotic communities. Such claims obscure important differences between the aims and methods of basic science and applied science. Because of these differences, basic science can provide a foundation for applied science but cannot be a substitute for applied science.

Basic science in the paradigm of the hard sciences aims to clarify functional relationships, if not scientific laws, that are supposed to predict the consequences of change with precision, scope, and accuracy (Friedman 1953). In addition, a scientific relationship should be universal, or independent of any particular context; any factor that affects the predictions in any context is supposed to be incorporated into the relationship. A scientific relationship should be objective, or independent of any particular viewpoint; on the presentation of appropriate evidence it is accepted by all scientists. The most persuasive evidence to justify a claim of progress with respect to the aims of basic science is replication of the results of controlled experiments. Such experiments compare the predicted consequences of change and no change in treatment and control contexts, respectively, that are otherwise equivalent and isolated from confounding effects. Basic science so conceived has served as a model for ecology (e.g., Peters 1991; Allen & Hoekstra 1992). According to one ecologist, as quoted by Roush (1995:314), "The push toward experimentation [in ecology] beginning in the 1960s was the result of 'physics' envy . . . . We wanted to be a hard science."

Applied science, in contrast, aims to clarify the feasibility and consequences of alternative courses of action in particular contexts. Each context is open to many factors that cannot be anticipated or controlled. Moreover, within each context, not all of the variables and relationships are known; many variables interact in unexpected ways to shape the consequences of alternatives even if the first-order relationships are known, and those relationships that are known are not necessarily stable if people or other living forms are involved. Responses to an environmental stimulus by living forms are differentiated to some extent by differences in their predispositions, genetic or acquired, which are subject to change in populations over time. How can managers and other practitioners respond? The pragmatic alternative to inaction or blind action is to confront these realities by integrating the general scientific knowledge and context-specific information available into an interpretation of the particular context, acting on one's best judgment about that context, and modifying prior expectations about alternatives, consequences, and goals in light of the experience that follows action. The aims and methods are pragmatic but not "scientific" as understood in the hard science paradigm.

Ecologists who confront the realities of practical decision are likely to move beyond experimental methods and disciplinary boundaries in order to understand more of the relevant variables and relationships. According the Meffe and Viederman (1995:327),

> Conservation biology began with a major emphasis on genetics, biogeography, and other ecological and evolutionary issues, but the field is now maturing to encompass other concerns beyond ecology, including economic, legal, and political issues. Because it is so young, the proper balance between basic and applied science...is still being sought.

Meanwhile, there have been numerous calls for interdisciplinary problem solving (e.g., Kiefer et al. 1991; Brewer 1995). Ecologists have also moved beyond controlled experiments to other methods of observation and analysis and as a result opened themselves to criticism by those who invoke the basic aims and methods of the hard science paradigm (Roush 1995). Nevertheless, opening up disciplinary and methodological boundaries is justified from a pragmatic standpoint: These adaptations can reduce (but not eliminate) uncertainties about the consequences of action alternatives.

These dynamics in ecology have been replicated on a broader scale in the policy sciences, which evolved from the philosophy of John Dewey and other pragmatists (Lasswell 1971) more than a half century ago and remain the oldest distinctive part of the policy analytic movement (Brunner 1991). The basic aim of the policy sciences is not prediction but freedom through insight (Lasswell 1951,1966). Uncertainty is an indication that the future is not entirely determined by universal or immutable laws of humans or nature. Scientific insight brings unperceived factors in the self and in the environment into conscious awareness so that people are free to take them into account in making choices and decisions. Although freedom through insight helps people make more of their limited capacity for rational decisions, it also exacerbates uncertainty and undermines the accuracy of scientific predictions. Because no problem of policy decision, including ecosystem management and sustainability, falls entirely within the scope of any discipline, relevant knowledge and information from many sources are interpreted in the context and integrated according to the problem at hand. The basic methods are "scientific" in a pragmatic sense, as well as contextual, integrative, and interpretive.

As one pragmatist put it,

> Policy must be scientific to be effective.... But to say scientific is not to speak [only] of the paraphernalia and techniques of the laboratory; it is to say realistic and rational—empirically grounded and self-corrective in application. Policy is scientific when it is formed by the free use of intelligence on the materials of experience (Kaplan 1963:92).

Attempts to restrict "science" to the hard science paradigm alone would inhibit our ability to learn from experience beyond the closed context of the laboratory.

The policy sciences are an adaptation to cognitive constraints (Simon 1981) and the complex realities of open contexts. Those realities can be brought into focus through a simple thought experiment. If only 100 dichotomous variables were required to describe the context of any ecosystem management decision, there would be 2^{100} possible decision contexts. This is a number well in excess of the number of actual decision contexts or cases of decision. Hence, there would likely be no actual instance of most of the possibilities and only one instance of the remaining possibilities. In short, every context is unique under a comprehensive description. To cope with the uniqueness, diversity, and openness of decision contexts, we must distill general concepts, theories, and procedures from proximal similarities and differences among particular cases. These generalizations would be unnecessary if there were no constraints on human cognitive capacity. However, these generalizations are necessary to bring a broader base of experience to bear on interpretation and judgment in the particular context. According to the strict standards of the hard sciences paradigm, a model of an open context cannot be verified or validated even in principle (Oreskes et al. 1994). Consequently, claims of progress in a pragmatic approach to ecosystem management are better justified and adjudicated by the standards of good practice—what works in the field.

For practical purposes it is constructive to recognize that ecosystem management is not a problem that can be solved through basic science as understood in the hard science paradigm. Applied science, the "free use of intelligence on the materials of experience," broadens the base of relevant experience beyond the laboratory to the field. What are the practical implications of reframing the problem?

First, a better scientific foundation of functional relationships is not necessary for the practical purposes of ecosystem management, as distinguished from the theoretical. The priority is to evolve improvements in principles of ecosystem management through reflection on the experience that follows decision and action. The decisions should, of course, integrate the best available scientific relationships on a continuing basis. This priority affirms the judgment of Jensen and Bourgeron (1994:1), who "do not believe that the development of new science theory is a prerequisite to ecosystem management. Instead, [they] emphasize the importance of using existing science principles (in more creative ways) to meet our evolving land management needs." It also affirms Clark and Minta (1994:75), who contend that for practical purposes "[t]here is little possibility of a unified theory for ecological systems. Although we have principles and generalizations to guide us, ecosystem analysis must be approached case-by-case." The lack of scientific laws did not deter James Watt from practical improvements in steam engines to lift water from mines in 18th century England. And it should not be overlooked that trial-and-error tinkering with heat engines, by Watt and others, led to crystallization of the laws of thermodynamics a century later.

Second, the functional relationships of basic science would not be sufficient for ecosystem management decisions, even if they were improved. No scientific generalization can be considered universal from a practical standpoint, regardless of the number of successful predictions and replications in the laboratory. Its relevance and reliability are contingent upon the context of decision. As Simon (1985:301) put it, even physicists "get only a little mileage out of their general laws. Those laws have to be fleshed out by a myriad of facts, all of which must be harvested by laborious empirical research" into the particular context. Because context matters, ecosystem managers and other practitioners cannot avoid interpretations and judgments, regardless of the objectivity of basic science. Consequently, a consensus on general scientific relationships, like a consensus on general goals, tends to become debatable if not controversial at the operational level because interpretations and judgments can differ. In addition, science is not the only consideration in a decision. Ehrenfeld observed that "science alone does not have and never will have solutions to the fundamental environmental problems of our time, which are religious in the largest sense of the word, dealing as they do with values and the human spirit" (quoted in Meffe & Viederman 1995:330).

Third, applied science as "the free use of intelligence on the material of experience" can help the community of conservation biologists and practitioners evaluate the belief that ecosystem management is doomed to fail. In one statement of this belief, hope in the short-run is an illusion: Various practical "approaches offer some hope of ecological integrity while still permitting human use. Unfortunately, as has been recognized by others, such approaches are only temporary measures that in the long run must fail" (Stanley 1995:261) because of human population growth and resource consumption, the key factors in ecological degradation and destruction. The underlying problem is a doctrine of final causes that "fosters the [arrogant] humanist belief that nature is ours to control" (p. 257) through science-based technologies. "Success in the long run will require that we address the problem rather than its symptoms, beginning with a rejection of the doctrine of final causes" (p. 262).

From a pragmatic standpoint, it is difficult to understand how anyone can know the outcome in the long run, even if the doctrine of final causes is the primary factor underlying ecological degradation. It is also difficult to understand how the doctrine of final causes can be rejected, short of dictatorship, without temporary measures that are successful enough to sustain an evolutionary process of improvements and to propagate the values of ecological integrity more broadly through society. However, it is easy to understand how ecosystem management will fail if enough key people, in the absence of a doctrinal revolution, believe at the outset that it is doomed to fail (Salwasser 1994). Any collective and continuing human endeavor depends upon the faith that it can succeed and on renewal of that faith through progress in the short run. This includes, by the way, the U.S. constitutional process. Americans accept the folk wisdom that nothing is certain but death and taxes. But "[w]e do not always remember that [Benjamin] Franklin wrote these words in a passage appraising the prospects of survival of the newly adopted Constitution" (Kaplan 1963:96-97).

A Practice-based Approach

A third approach to ecosystem management tends to surface in conversations with some conservation biologists and practitioners, and occasionally in print. For example, the USFS has circulated project bulletins on innovative approaches and results in a series titled "Ecosystem Management: New Perspectives for National Forests and Grasslands." The standard format includes comments on stewardship and flexibility in each project and gives a contact for further information. Similarly, but in more detail, Kirchhoff et al. (1995) describe how some stands of relatively rare, high-volume, old-growth timber in the Tongass National Forest have been protected through research and education and through action in administrative, legislative, and judicial processes. "These efforts...have met with modest success. We offer them as an example of how similar strategies might be applied to advance science-based conservation policies elsewhere" (p. 360). Culotta (1995:1688) reports an effort to restore the kinks in the Kissimmee River in the Everglades "to bring back the invertebrates, fish, and, eventually, the wading birds that once nested" there.

Because they are not omniscient, these and other practitioners must make interpretations and judgments that function as maps for self-orientation in the decision context. However well informed—by general goals, scientific relationships, and practical prudence, as well as by context-specific information—each map is necessarily a simplified and subjective representation of the context. When practitioners act on such maps, the consequences of their actions unfold in a much more complex world that provides a reality check. They may discover that important considerations were overlooked or misconstrued when action was taken. Practitioners in the adaptive management of ecosystems exploit such opportunities to learn from field experience (Holling 1978; Walters 1986; Clark 1993, 1995; Gunderson et al. 1995). For this purpose they follow certain guidelines:

> First, they are explicit about what they expect, so that they can design methods and apparatus to make measurements. Second, they collect and analyze information so that expectations can be compared with actuality. Finally, they transform comparison into learning—they correct errors, improve their imperfect understanding, and change action and plans (Lee 1993:9).

Adaptive management, in this version at least, is itself a recent adaptation of basic science to practical realities. In principle it accepts the experimental ideals of basic science and rejects trial and error. But in practice it incorporates fundamental insights long ago appreciated in applied science. The maps on which we act can be improved by methods short of the controlled experiment, even though the maps cannot be perfected. These insights are more readily appreciated by practitioners than by researchers working within the hard sciences paradigm.

A similar adaptation in various fields and disciplines is prototyping, a strategy of inquiry that falls between controlled experiments and full-scale interventions in a more comprehensive strategy (Lasswell 1963). A prototype is an innovation in practice, typically small in scale, intended to discover how to solve a problem. Unlike a controlled experiment, prototyping begins with a guiding goal but leaves some flexibility in programmatic details in anticipation of the unexpected problems and opportunities that normally arise. (Hence, one aim of any prototype is to devise a better program as experience unfolds). Unlike a full-scale intervention, the small scale of a prototype helps keep it out of sight to minimize political visibility and therefore vulnerability until the results have been evaluated. If unsuccessful, a prototype can be terminated more easily than a full-scale intervention because it is less likely to have acquired a large constituency willing and able to defend it. If successful, it can be diffused laterally and adapted elsewhere to solve similar problems. In the U.S.F.S. the Tongass National Forest and Everglades practitioners had something like a prototyping strategy in mind when they swapped bulletins or proposed "models" for others to adapt. This is a partial demonstration of the feasibility of a prototyping strategy.

A prototyping strategy in effect factors a widespread problem into more tractable parts and relies on decentralized decisions by groups that face variations on a common problem. For example, the common problem may be protecting old-growth timber, restoring wetlands, or recovering endangered species and the groups may be field offices of the USFS, wetlands communities, or recovery teams for various species. Such groups tend to organize themselves into open networks and to engage in processes of innovation, diffusion, and adaptation.

Innovation: As the common problem becomes too pressing to ignore, some groups are likely to abandon conventional practices in favor of innovations designed to ameliorate or resolve their own problem. Some are more successful in practice than others.

Diffusion: The innovations come to the attention of others facing a similar problem and do so with sufficient frequency and vividness to clarify de facto (in lieu of de jure) standards of good practice and to provide field-tested models for meeting those standards.

Adaptation: Under pressure from leaders or followers to meet those standards, other groups tend to select from the more successful models—and to delete and modify selected elements—according to their own unique circumstances.

The prototypes adapted to new circumstances may stimulate additional waves of innovation as long as the common problem remains a priority within the open network, higher standards and better models are demonstrated and diffused, and resources for adaptation are available. But these processes can malfunction if, for example, claims of successful innovation are hyped or otherwise unfounded, the diffusion of higher standards and better models is unorganized or otherwise restricted, or leadership and other resources for adaptation are unavailable.

People tend to engage in processes of innovation, diffusion, and adaptation more or less spontaneously at all scales of organization, including world politics (Lasswell et al. 1952) because these processes are generally economical in the use of the limited time and attention available for purposes of decision. De facto standards are normally crystallized whenever people compare their experiences over time through any means, including such mundane means as swapping stories on what works (or does not work) over the phone. Once crystallized, de facto standards guide attention to what has been achieved by leaders—and what perhaps can and should be achieved by followers—in the network. Models for meeting those standards integrate many relevant considerations into context-sensitive narratives that are relatively interesting, easy to understand, and interpretable in similar contexts (Brunner et al. 1987). In contrast, it is rather difficult to start from scratch with a "tool kit" that compiles various general goals, scientific relationships, and practical maxims that are presumed to be relevant everywhere. General awareness of higher standards and better models tends to motivate people to take action—or to explain why not—in order to avoid the reputation of a laggard, if nothing else. Moreover, models successfully field-tested in one context tend to reduce political opposition to action in other contexts. Tangible results are among the factors that can change opinion; propaganda alone tends merely to reinforce predispositions or to have no effect (Lasswell & Kaplan 1950:113).

For practical purposes it is constructive to recognize that everyone will remain less than omniscient, regardless of clearer goals or a better scientific foundation. However, we can use processes of innovation, diffusion, and adaptation to accelerate improvements in principles of ecosystem management for practical purposes, especially if we understand how the processes work and attend to potential malfunctions. What are the implications of reframing the opportunity?

First, it is crucial to organize a process for appraisal of innovative ecosystem management decisions that have been made across at least the United States, in order to clarify de facto standards of good practice and to provide models for practitioners motivated to meet those standards. In particular, researchers could begin by reviewing the literature and contacting ecosystem managers and other practitioners to identify important cases, and by selecting for more intensive study the most relevant and promising cases. Researchers could then work with the practitioners involved to document each selected case according to a checklist of important considerations, including the actions taken, the significant intended and unintended consequences to date, and explanations and assessments of those consequences. Concurrently, researchers and practitioners could distill general principles or de facto standards of good practice from the comparative evaluation of the cases. Finally, researchers could disseminate working standards and the documented cases as models to other practitioners, who would then have access to a broader range of experience in accessible forms and a choice to adapt whatever models they consider relevant, in whole or in part. Such standards have begun to emerge from explicit prototyping strategies (e.g., Clark et al. 1995) and from published comparisons of experiences (e.g., Barth et al. 1994; Gunderson et al. 1995; Frentz et al. 1995).

Second, within the national appraisal process it is important to design and field-test innovative models (or prototypes) that address critical problems within particular ecosystems. For example, four of the five major barriers to ecosystem management in Greater Yellowstone Ecosystem (Clark & Minta 1994) are "disagreement[s] among the major actors" over (1) "the size and boundaries of the ecosystem" (p. 39); (2) the "timetables for management and policy" (p. 44); (3) "current management and policy problems and the importance of these problems" (p. 47); and (4) "...what ecosystem management is specifically and whether or not it can solve the problems" (p. 56). This pattern of disagreements suggests that the larger problem is a primitive power-balancing process among organized interests that interact in fragmented and overlapping jurisdictions. In this pattern each interest tends to commit resources to control the current issue, to be blocked by competing interests, and to wind up with little or nothing to show for the effort. Typically, the effect is a cumulative increase in frustration. If this definition of the problem is correct, the task is to design an innovative strategy that capitalizes on the frustrations to transform the power-balancing process into one that helps participants clarify and secure their common interests. There is a body of theory and practice that might be mobilized for the task. Beyond that, cases documented in a national appraisal process might provide insights into the design of the strategy; and what would be learned from an innovation could be diffused through the national appraisal process. Note that even an innovation that failed to transform the power-balancing process would at least clarify what to do differently, and perhaps better, on future occasions.

Third, it is important to use the national appraisal process to identify and address constraints on good practice that recur across cases in ecosystem management. A common constraint might be a moral dilemma that many practitioners face in various forms with little guidance on possible trade-offs if necessary or integrative solutions if possible. Another common constraint might be scientific uncertainty about the indirect and cumulative effects of a particular human use of ecosystems. Still another common constraint might be an administrative, legal, or political barrier at any level, especially the national level. Keiter (1995) argues correctly that management decisions in particular ecosystems must take the larger national context into account. The question is where to target limited resources to maximum effect. The suggestion here is to target the most common constraints that have frustrated otherwise sensible strategies around the country. Once identified through a national appraisal process, the most common constraints can be addressed through research and action intended to free practitioners who are already motivated to meet standards of good practice, already understand a particular decision context, and have some insight into how to proceed.

In general, appraisal processes work best when they are independent and continuous (Lasswell 1971). Independence minimizes the possibility that appraisal becomes an opportunity for promotion on behalf of special interests in the public or private sector. Independence can be enhanced by organizing multiple and separate teams of researchers in the appraisal process, by locating some teams beyond the control of any one organization with a direct stake in the results, and by including competing interests in the documentation of each selected case. Continuity helps diffuse and establish the expectation that de facto standards of good practice and field-tested models for meeting them do exist; this motivates practitioners to meet the standards through existing or innovative models or to explain why they have not. Annual or other periodic appraisals and publications can enhance continuity.

Conclusion

The practice-based approach recognizes that moral, scientific, and practical considerations are integrated implicitly or explicitly into ecosystem management decisions. It recognizes that such decisions, in the end, are the human factors that most directly affect the integrity of ecosystems, either sustaining or degrading them. And it recognizes that such decisions cannot be postponed indefinitely, pending further research on goals and scientific relationships. Clearer general goals and a better scientific foundation are means for improving decisions on behalf of ecosystem integrity, but they are not ends in themselves or substitutes for practice-based improvements. Practice provides a reality check on the considerations integrated into decisions, the best opportunity for learning from experience, and the only reliable gauge of progress in ecosystem management.

Progress in sustaining the integrity of ecosystems can be accelerated through the systematic appraisal of decisions nationwide in order to improve the basic principles of ecosystem management, to apply them as guidelines for subsequent decisions, and to integrate clearer goals and better scientific knowledge and information as they become available. Initially, accelerated progress depends on recognition by conservation biologists and practitioners of natural resource management that ecosystem management is an evolutionary process. It is not a technical problem that can be solved by clearer goals alone, by basic science alone, or by some combination of the two. This reframing of the problem opens up practical insights into how to proceed—insights from such diverse sources as biology, constitutional politics, pragmatism, adaptive management, and prototyping. Beyond that initial step accelerated progress in ecosystem management, as in any other collective and continuing human endeavor, depends upon the good effort, good judgment, and good faith of those involved.

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