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Evaluation and ecosystem management: new directions needed?

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Abstract

Increased attention to ecosystem management, and the need to evaluate policies expected to affect the structure and function of ecological systems, demands more holistic methods of environmental evaluation. Standard economic methodologies, which measure all values as units of human welfare, are too atomistic for this purpose, and current conceptualizations in ecology do not permit evaluative judgments. This paper relaxes the welfare assumption, which assumes all values will be measured as units of individual welfare, and proposes a multi-scalar system of analysis. For decisions with relatively short-term impacts, standard cost–benefit criteria are retained, but for decisions with predictably long-term impacts, a second criterion, an Opportunities/Constraints Index is suggested. This criterion, the values of which are not reduced to units of welfare, is applied in conjunction with cost benefit analyses to policies that may have multi-generational impacts, and measures the options and opportunities stored in ecophysical systems. Such a system must be based on a community-based effort to specify important values, and resource-use options associated with them, that are constitutive of the communities own sense of well-being. Two problems remain: the problem of operationalizing the criterion and the problem of reconciling conflicts between the two criteria. It is argued that, while the criteria must be formulated in local situations it is possible to identify measurable physical characteristics that can be associated with development paths that maintain ecophysically supported options and opportunities for the future. A two-tiered system of analysis, which classifies risks according to their temporal and physical scale, can be used to determine which criterion should be emphasized in various situations. © 1998 Elsevier Science B.V.

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1. Introduction

There is a pervasive trend toward ecosystem management today, a trend which is evident in federal, state, and regional agency actions as well as in publications such as this Special Issue. This is an important and laudable development; the purpose of this paper, however, will be to show how this pervasive trend creates an important gap in our ability to evaluate environmental policies, and to suggest a general direction that may prove useful in filling this gap.

Environmental management has traditionally been atomistic in the sense that it has addressed particular problems with particular legislation, and in the sense that it has usually addressed problems of wildlife management on a species-by-species basis (Norton, 1991). Accordingly, the methods of valuation that

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have been developed, and with which managers have most experience, are almost all scaled at the level of particular populations or species, and are designed to measure specific and identifiable changes in one aspect of the environment. There have been, for example, studies of the recreational use values of game species; there have been hypotheses about the genetic value of particular species for pharmaceuticals and as breeding stock for crop species; and attempts to determine by questionnaires how much consumers are willing to pay to retain this or that population or species for non-use, or 'existence' value (see Freeman (1993) for a survey of these methods). However imperfect these methods are, the really bad news is that even these limited methods are apparently unavailable to evaluate alternative ecosystem management plans because the features protected in ecosystem management are features exhibited in the processes and structures of ecological communities viewed, not atomically, but as holistic, functioning communities. In Section 2, I will provide as precise as possible a proof of this negative conclusion. Reacting to this result in the remainder of the paper, I then propose a new approach to environmental valuation, an approach that evaluates policies on multiple scales and emphasizes the importance of protecting options for future generations as an important goal of long-term environmental management.

2. A dilemma

I am forced to the conclusion that the need to evaluate ecosystem management plans and strategies will require a new approach to environmental valuation. My reasoning can be summarized in the following argument.

1. ASSUME: All social values are (in principle) measurable as units of individual welfare (The Welfare Assumption).
2. It apparently follows that we can evaluate changes in ecosystem states only if either A or B is fulfilled:

   A. There is a method by which it is possible to correlate, by using a physical, causal model that relates changes in the descriptive state of systems with changes in aggregated individual welfare, OR:

   B. There is a method by which it is possible to associate changes in welfare with changes in ecosystem states without employing a physical, causal model correlating changes in D with changes in V, directly. But
3. Ecologists doubt that a physical, causal model of this degree of resolution is possible, at least for the foreseeable future, making A an unlikely solution. And
4. Economists have not yet devised a method which fulfils condition B (Freeman, 1993) Therefore:
5. There currently exist no methods by which to quantify changes in V over time as a result of changes in states of ecological systems.

Possibility A is unlikely on its face. How could a physical model evaluate changes in ecosystem states? As Page (1992) (p. 111–112) has pointed out, ecologists, who are trained to approach science in a value-free manner, have not developed an evaluative vocabulary and to them, the problem of evaluation is seen as a task to be left to others. But this quick rejection of possibility A only pushes us over onto the other horn of the dilemma, where we must determine which economic or other evaluative methods might be appropriate in the ecosystem context.

Certainly, there are interesting welfare approaches that could be explored if one chooses possibility B. For example, it might be posited that changes in large-scale ecological systems might be considered positive or negative 'externalities' of the market system of production and consumption and that impacts on ecological communities might impact future opportunities for consumption. At present, however, there exist no methods to measure ecosystem-level impacts as effects on economic well-being of individuals. Even if such methods were developed, they could be applied only if a rate of time preference applicable over long temporal durations could be agreed upon.

Worse, it seems likely that large-scale changes in ecological structure and functioning would also have impacts on non-use values and here the problems are even more daunting. For example, we heard one activist group, organizing to oppose chip mills in the Southern Appalachian Mountains, say: ''We like our hardwood forests; if the chip mills come in, they will strip the hardwoods and, at best, plant pines. We don't want to change the ecological character of our region.'' Assertions such as this would apparently involve significant commitments to non-use values. It is widely agreed that contingent valuation questionnaires, the only method available for measuring non-use values, must include a careful characterization of what the consumer will get as a purchased 'commodity' (Mitchell and Carson, 1989). Since the information does not exist to inform consumers of likely impacts on their welfare of any unit of ecosystem protection, the condition of economic modeling that assumes the consumer has full, or adequate, information cannot be fulfilled. To simply ask consumers what they are willing to pay to retain ecosystematic features without explanation of likely impacts is implicitly to expect consumers to do the very analysis of impacts of degradation and protection on their well-being that is impossible for experts.

We therefore must agree with the economist, Freeman (1993) (p. 485), that at least at present, no economic methodologies exist to measure welfare impacts of changes in ecological function and in ecosystem character. This conclusion forces us—assuming we believe it is necessary to evaluate ecosystem management activities in some manner—to call into question the welfare assumption itself, and consider evaluative measures that are defined independently of individual welfare measures. So the general approach outlined here ascribes social value to characteristics of ecosystems as complexes of processes directly, without claiming any ability to measure the impacts of these changes on individuals and their welfare. Note that this is a methodological decision and does not deny that there would be welfare impacts resulting from ecosystematic changes. Indeed, it may be assumed that welfare impacts are in many cases substantial—but it is decided for methodological reasons that these large-scale impacts will not be measured in terms of individual welfare. These social values will instead be expressed on a second level, or scale, and we will not attempt to aggregate across scales. This approach strives for quantification of values on all levels, but does not attempt aggregation of values across scales of time. In the remainder of this paper, I introduce a scale-sensitive approach to environmental values, by defining normative–descriptive terms such as 'ecosystem health', 'ecological resilience', or 'ecosystem integrity' as indicators of valued states of ecological systems.

3. Options versus constraints as a guide to long-term management

Theories of environmental value employing terms such as health, integrity, and resilience fall in the general category of 'strong sustainability' theories. Sustainability theories are usually advanced as accounts of what we owe the future, and why. Weak sustainability refers to the maintenance, into the future, of a non-declining stock of aggregated capital; according to this definition, a culture is acting sustainably if each generation passes on to the next as much capital in the form of natural resources, wealth, technological capabilities, laboring power, knowledge, etc., as they inherited from their predecessors (see, for example, Solow, 1993). Weak sustainability is built on the assumption of unlimited substitution among resources; it can accordingly be defined within the marginalist, single-equilibrium models of mainstream welfare economics. Weak sustainability is achieved provided each generation devotes an adequate proportion of income to capital investments, and thereby offers future generations economic opportunities equal to those encountered by individuals of earlier generations. Strong sustainability proposes a more stringent requirement—in addition to weak sustainability, strong sustainability requires that each generation protect certain specified processes and features of natural systems as essential elements of their bequest to future generations. Strong sustainability theorists believe that some processes and features of ecosystems—what might be called 'health', 'integrity', or 'resilience'—must be a part of any morally acceptable bequest package to future generations. Health and integrity are not simple descriptive terms in ecological science. They are rather, terms in public policy discourse, and their purpose is to articulate characteristics of systems that are associated with long-term social values and goals (Norton, 1998). Admitting that these terms are evaluative as well as descriptive, the task of developing an integrated approach to ecosystem evaluation requires that we can associate long term and widespread human values with specifiable and in principle measurable states of ecological systems.

In a Policy Forum article in Science, a prestigious, multi-disciplinary group of scholars urged that environmental policy set the protection of the resilience of ecological systems as an important social goal (Arrow et al., 1995). I would follow these authors in arguing that true sustainability requires resilient ecosystems, but I would go further and attempt to relate resilience more explicitly to important social values, especially to the value of maintaining options that depend upon ecological processes and features. Ecological systems will continue to respond and adapt to both natural and human-caused disturbances—some change is therefore inevitable. Humans cannot protect every process just as it is without freezing nature, which would be the ultimate, and self-defeating, outcome of over-doing ‘preservation’. But ecosystem management must not go to the other extreme either, it should not assume that ecosystems are unlimited in their plasticity and that they can really be ‘managed’, controlled, and manipulated at all levels for human ends. Ecosystem management is understanding human communities as ecological elements in larger, and longer-term, ecological communities and physical systems. Once we fully accept that humans are a part of natural systems, ecosystem ‘management’ loses its taint of hubris, more often than not, in ecosystem management; the unruly element in biotic communities—what requires ‘management’—is the human community and its impacts. What is needed, given these arguments, is a suite of characteristics—such as ‘resilience’ or ‘integrity’—which are sufficiently flexible to avoid ‘freezing’ ecosystems and stopping their natural development, but which are nevertheless essential to supporting future well-being and cultural development.

Members of every culture encounter their ‘environment’ as a mixture of opportunities and constraints. This mix is partly based on characteristics of the environment itself and partly based on what goals are being pursued. Explorers searching for gold encounter a paucity of gold ore as a constraint, whereas this lack is no constraint to the agriculturalist. Lack of gold ore is a state of reality; but the evaluation of that state is also a function of the goals and purposes of the explorers. The concepts of ‘opportunities’, ‘options for free choice’, and ‘constraints on free choice’, therefore represent an implicit ‘negotiation’ between the ‘hard’ facts of physical reality and the values and goals of individuals and cultures. This cluster of terms, then, represents an attractive approach to defining intergenerational obligations, because the terms options and opportunities imply both a physical state of the world and a positive judgment of its value. These words are ‘morally thick’ terms. Like ‘stalwart’ or ‘honorable’, in ordinary discourse, they embody both descriptive and prescriptive content (Williams, 1986; Nelson, 1995; Callicott, 1995).

I suggest that we attempt to operationalize, as the basis for a new approach to evaluation of ecosystem management plans, a physical, measurable index that tracks the degree to which ecological, as well as economic, options are protected for future generations. A process or feature of an ecological system will then be understood to have value to the extent that it is associated with economically or culturally important options that should be held open for future generations. The idea of options can play an important role because of its dual nature—the options available to members of a local culture in the future will be dependent on the land, on the physical and ecological characteristics of the landscape that is passed on to them by the present; and also by the goals, values, and aspirations of people in the future. The non-reductionistic approach suggested above now comes into play. Just as firms often keep separate accounts, with different time preference assumptions for operating and for capital budgets, the approach proposed here would keep separate accounts for economic well-being and for inter-generational values, understood as stored options.

Once we are resigned to keeping separate accounts for short- and long-term values, we can continue to use willingness to pay as a guide in the short term. Economic well-being—having economic resources to purchase needed and desired services—can be measured in dollars, which can be thought of as ‘options’ that can be exercised through exchange in ‘markets’. These markets model individual behavior against a backdrop of assumptions about market rules and trends, and also against a backdrop of assumptions about the constancy of the available resource base and the quality of the functioning of ecological systems and processes. Economic, cost–benefit models, therefore, continue to have an important role in policy analysis, especially regarding policies with short temporal horizons usually associated with economic planning and decision making.

When concern shifts to multi-generational frames of time, we can retain the goal of measuring value in terms of options and free choices available, but we will not assume constancy of economic and background ecological conditions on this longer temporal scale. So we must replace dollars with another currency—a measure of ecologically sustained options maintained as a culture adapts to the opportunities and constraints embodied in the habitat of a human community over decades and generations. Whereas both operating and capital budgets are normally kept in monetary units, our system of evaluation for ecosystem management policies goes one further step—the longer-term analysis is expressed in different currency, and recognizes a different criterion for success. To keep matters simple, assume that short-term impacts of human choices can be measured in terms of dollars representing individual welfare, and that the decision criterion applicable to decisions with short-term impacts is the highest possible benefits-to-costs ratio (BCA criterion). Accounts constructed to calculate benefits of sustaining ecologically-based options, however, should be measured in terms of an Opportunities/Constraints Index (OCI). The OCI would be designed to track those particular physical characteristics of ecological and physical systems that would indicate the presence, in the physical environment of a culture, healthy ecological processes and structures that will maintain, into the indefinite future, culturally valued options and opportunities. Because this value is not assumed to be reducible to immediate and individual economic welfare, it can be interpreted as a more holistic, communitarian, and ecosystematic characteristic.

The evaluative system proposed is pluralistic in the sense that it keeps at least two sets of books and applies different criteria of acceptable action within distinct systems of analysis. Further, the metrics employed to measure success in the two sets of books refer to different units of value, one individualistic and one holistic. This dualistic system requires that we resolve two formidable conceptual problems. First, we must operationalize the OCI in such a way that it (a) designates physical states of ecological systems that are measurable, or at least operationalizable, and at the same time (b) represents a legitimate social value that could be supported democratically by concerned and informed citizens. Second, the employment of two decision criteria raises the problem of possible conflict: What happens if the two criteria point toward different policies. We can call the first problem that of operationalization and the second the problem of reconciliation. We will deal consecutively with these two problems in Sections 4 and 5.

4. Operationalizing the Opportunities / Constraints Index

Setting aside for the moment the problem that our criteria might point in different directions for policy and action, in this part we push the concept of an OCI as far as possible toward operationalization. It should be noted that, because of the high degree of local determinism regarding ecological conditions, opportunities, and constraints, it is questionable whether it is possible to define a single OCI as a general concept applicable everywhere. We may only be able to give general guidelines for developing many locally defined indices of the integrity of particular places. My goal here is to establish that it is in principle possible to define a measurable characteristic of human and natural systems that are likely to maintain their OCI, and to propose this index as an operationalizable measure of intergenerational equity. Again, we interpret our problem as that of defining a fair bequest package for future generations, and we assume our definition will express the idea of strong sustainability, that there are some structures and processes of nature—natural capital—that are essential elements in any fair bequest package to future generations. The next step is to show how certain interactions of economic and ecological forces can result in increased options, and how others can result in reduced options for a community as it develops over decades and generations.

As a first step in explaining the social value of maintaining options, consider an actual case, that of the rapid deforestation of the ancient temperate rainforests of the US Pacific Northwest over the last century. Can we—with hindsight, but from the perspective of 50 years ago—define an alternative development path for the Northwest that would have (a) used the magnificent resource of forests to build a strong regional economy and (b) resulted in a landscape that included a sustainable source of timber and sufficient old-growth to protect the biological diversity and key ecological processes in the region? In considering this example, it may be difficult to avoid well-publicized disagreements about what has happened, and is happening, in this area, but the example is a good one because the example is well known and it helps to be as concrete as possible. I will characterize the present outcome in the most sketchy terms, because it is my intention to avoid controversies about specific factual statements regarding the actual situation. The development of the Pacific Northwest since the 1800s has been characterized by (1) rapid development of resources such as old-growth forests, fisheries, and of water power resources, (2) relative independence of planning and development across sectors (for example, the power resource was developed without much thought regarding impact on the salmon fishery), (3) rapidly escalating exhaustion of resources, and conflicts among resource users across sectors and within sectors in the late twentieth century, resulting in serious political conflict, (4) overall acceptable rates of regional economic growth, as the economy makes up for losses in timber and fishery jobs with high-tech development in the larger cities, but localized pockets of extreme hardship emerge as resource-dependent industries shut down in areas where resources are exhausted.

There is no question that there are job losses and general decline in the importance of the resource-exploitation sector in the Pacific NW, but there are several important differences in the analyses offered of these changes. For example, one analysis says that there is a real shortage of timber, and that the timber industry is entering an inevitable decline, becoming a less productive sector in the economy. Many economists, however, deny that there is a real shortage of timber. There is plenty of harvestable new growth, this analysis argues, but it is not in the right place to provide jobs for existing timber-based communities, and because it is much smaller in stem size, it does not provide appropriate inputs for the technologies developed to exploit old growth.

Leaving aside these disputes, let us suppose that 50 years ago farsighted state governments in the Pacific Northwest had set up a revolving fund of low-interest loans to encourage local entrepreneurs to form milling and furniture-building cooperatives, diverting some investment from expansion of logging operations into the wood processing industry. Suppose also that the program was successful and the Pacific Northwest developed so that most cities or regions had a timber extraction industry, cooperatives to mill raw timber, and other businesses that produce wood products such as pre-fabricated elements of homes or outdoor furniture. The economy, rather than cutting and exporting whole logs, with these added incentives, might have organized to maximize value added near the site of timber extraction. It seems reasonable to believe that, since there would have been more value added per log, and more jobs generated per log cut, this alternative development path would have resulted in a more varied and diverse economy, with more options for careers and investments, and also with retention of more old-growth than in actuality has been retained. To define the difference between these two development paths in a general and operationalizable way—to distinguish economic policies that protect and expand opportunities from those that destroy and limit future options—would be to provide a more positive characterization of the values and goals embodied in the search for sustainable institutions and policies. This solution, that is, would provide a measure not of individual welfare, but of a set of characteristics observable at the community/ecosystem level; it would be to define strong sustainability as an intergenerationally measurable index of opportunities embodied in resilient ecological systems, as viewed from local perspectives.

It is now possible to understand how the current movement toward ecosystem planning and evaluation represents an important new direction in environmental management. Whereas traditional atomistic environmental management has focused mainly on commodity production and on the economic impacts of such production on individual consumers, ecosystem management layers a second scale of value on top of short-term economic measurement of social values. Economic valuation, based on supply and demand assumptions, models the relationships between the economic system of production and the freedom of consumers to choose affordable products generated by that system. Ecosystem valuation and management, by contrast, focuses on the larger- and longer-scaled relationships that develop between a human population and its habitat over generations. These levels of activities can be modeled independently, because many individual choices of producers and consumers will be cancelled out and have no significant impact on the larger system. For example, if one farmer chooses to cut down his woodlot and plant wheat, this may have no long-term impact on ecological features of the system if the farmer's neighbor simultaneously chooses to let his wheat field go fallow. Ecosystem management can build upon this independence between the short-term effects of individual decisions, and long-term impacts, and set out to model and evaluate these two relationships as distinct dynamic systems.

Traditional economic evaluation models attempt to represent future values as social values expressed in the present—as the willingness of present consumers to pay to protect future options. Valuation of ecosystem protection efforts, by contrast, can be envisaged as occurring on a larger scale—the multi-generational scale on which collective individual decisions (trends in an economy or a culture) impact the processes and structure of large scale ecological and physical systems on the landscape level. Imagine an ecosystem management project undertaken in the Pacific Northwest 50 years ago. Such a project might have involved a careful inventory of physical resources and productive processes. But such an inventory would only have meaning if it were accompanied by a social valuation process in which options and opportunities the community values are identified. For example, a social consensus that favored a wooded landscape with a mix of old growth and new growth forests, could be expressed as a commitment to hold open the option of remaining a culture that is based upon a timber production base. This recognition of a valued option might have led to a commitment to sustainable use of forests, and to the system of subsidies and incentives for investment in timber processing and building of components of houses, as mentioned above.

The most important step in such a process would have been the explicit self-definition of the community as having a particular cultural identity, and that step can be understood as a choice of a set of 'core values' that provide, in general outlines, the goals and direction of future development. We can think of these values as defining the boundaries between culture and nature—as defining the shape of relationships that guide the intertwining of local cultures/communities with the specific, particular habitat that forms the context of their future adaptation. The imaginary example is the more poignant because it presses upon us the irreversibility of bad decisions in contexts such as these. Failure, 50 yr ago, to address issues of the impacts of unrestrained forest extraction as the dominant development path in the Pacific Northwest has led to the current, sad outcome. The extraction industry, having stripped the countryside of its options and opportunities (stored as centuries-old trees in ancient forests), has now noted the comparative lack of sunshine to accelerate tree growth as a constraint on second-growth profitability, and is divesting itself of holdings in the Pacific Northwest and moving to the Southeast. Since the forest landscape has been pushed to its limit, any pattern of cutting the remaining scraps of old-growth forest entails the virtual end of the forest-based economy, and also the culture of the region. Having turned the ancient forests into economic profits, the timber industry can move its investments (the fruits of exploiting the Northwest's resources elsewhere), leaving residents mainly with the constraints of local ecophysical limitations. Nor can timber culture be made whole again by replacing the option of being a lumberjack with an equivalent number of jobs in high-tech industry. The loss of a timber industry in the Pacific Northwest expresses itself in countless experiences, losses of meaning and value as the children of timber workers are denied the option of following in their parents' footsteps. Ecosystem management projects, at their best, can avert tragedies such as this if they help communities and regions to articulate not just their economic goals, but also their multi-generational aspirations—the values that give meaning and distinctiveness to their culture. Once these values are articulated, ecologists, ecosystem managers, and the concerned public must undertake many experiments by which one hopes to discover development opportunities that build upon, and protect, core values as a guide to decisions that shape the landscape of the future.

But a democratic process such as an ecosystem management project, involving communication of scientist and the public, could only be undertaken rationally if there were some means to (a) determine which culture and economic options are of lasting social value and (b) to relate those socially valued options to measurable characteristics of ecological systems. These steps in the ecosystem management process, I am suggesting, would best be undertaken with a system of analytic concepts that are scaled, embodying descriptive and evaluative concepts that would apply at different physical scales.

Consider, by analogy, the way a citizen who is asked to serve as a delegate to a constitutional convention will be expected to evaluate proposals on a scale of multiple generations, whereas most consumer decisions are evaluated according to a relatively shorter scale of time (Page, 1997). We can think of these different evaluation processes as taking place within more than one distinct temporal horizon—our citizen is understood as evaluating changes as part of more than just one dynamic (Norton and Ulanowicz, 1992). Consumer choices are understood and modeled in short temporal frames —from zero to three-to-five years. On this scale, it makes sense to use willingness-to-pay as a reasonable measure of value. But most individuals think of themselves also as members of an ongoing and developing community. On this level, citizens share a love of culture and natural heritage, and they share hopes and aspiration to see future cultural adaptations—institutions and practices—as having continuity with the present and the past. Continuity of a culture as it unfolds within a place, what might be thought of as the ‘natural history’ of the evolution of a culture, is in this sense an expression of a hard-won cultural self-identity.

I am proposing that we undertake the evaluation of ecosystem management plans by, first, opening the possibility that important decisions made by a community should be evaluated on at least two scales, which embody two separate accounting systems and two different approaches to time preference. The short-term accounting system, which should be dominant in decisions with impacts up to 5 year or so, can be very similar to current cost–benefit methods. For decisions with a longer frame of time, the consequences of which might last decades, will also be evaluated according to an evaluation system with a horizon of many generations.

5. The reconciliation problem

But what of the reconciliation problem? The system proposed here is pluralistic both in the sense of employing multiple action criteria and by invoking different sources for, and interpretations of, the values that motivate those criteria. Indeed, as just noted, the evaluation system proposed here implies that some decisions, at least those that have long-term impacts as well as shorter term, economic impacts, will be evaluated according to two separate criteria. It is possible that, given two accounting systems, we will get conflicting evaluations from our two criteria, which may lead to arbitrary choice of one action rather than another (Callicott, 1990). But a pluralistic system need not justify arbitrarily different actions in the same situation. Our approach is, rather, to seek an ‘integrated pluralism’, an approach that recognizes multiple values, and multiple action criteria, and then to show how these multiple criteria interact to yield a single policy direction in each particular situation (Norton, 1991).

Our approach to integration is to assume our system of policy analysis is ‘two-tiered’ (Norton, 1995; Page, 1997). A two-tiered system includes, in addition to the tier on which we apply a given action criterion to a particular problem in search of a policy decision, a prior decision tier in which there is a procedure by which one classifies and categorizes a problem. Once a given problem is analyzed and categorized, it is then possible to choose, non-arbitrarily, and for good reason, an action rule that is appropriate to the type of risk entailed in the decision (Norton, 1995; see Fig. 1).

A two-tier system is especially helpful when it is elaborated so that the second tier, on which it is decided which action criterion to apply, embodies a system of categories based on the scale of potential problems resulting from a proposed action or policy. If an action or policy entails risk of irreversible harm over a very large area, an appropriate decision rule

Tier II: The Meta-Criterion: (A Categorization of Problems according to Spatial-temporal Scale of Impacts and the Social Values Threatened)		
A. Classification of scale of potential impacts of a practice/policy B. Judge likelihood of impacts at levels that affect social values C. Choose appropriate criterion from Tier I.		
Tier I: Action Criteria: (Several Criteria are Offered to Guide Practice/policy in Situations as Determined in Tier II)		
A. Benefit/Cost (BCA)	**B. Safe Minimum Standard (SMS)**	**C. Precautionary Principle (PP)**
A good policy is one that maximizes the ration of B/C	Save the resource, provided the social costs are bearable	Take affordable steps today to avoid catastrophe tomorrow
Applies to decisions with small scale impacts and short time horizons	Applies to decisions with ecosystems/landscape-level with more than one lifetime reversal time	Applies to Possibly catastrophic outcomes in the distant future
ECONOMIC SUSTAINABILITY	**ECOLOGICAL SUSTAINABILITY**	**GLOBAL SUSTAINABILITY**

Fig. 1. A two-tier decision process.

would be the precautionary principle—better safe than sorry. If, on the other hand, there is risk of impacts that are local and reversible, it makes sense to apply the benefit–cost test. The two-tier approach builds scale into the system for analysis of impacts: as a part of the formulation of the problem and the choice of indices to monitor, an environmental problem is assigned a scale that is appropriate given the social value that is to be protected (Norton, 1995). On an economic scale, policies should encourage individual opportunity. On the scale of multiple generations and large landscapes, our management criteria, and the scientific testing that is done, however, relate to a broader, longer-term goal—that of protecting the integrity of a place. This management goal can be thought of as protecting socially important options, options that give continuity and meaning to social life, and which establish our connection as individuals with the larger ecological system on which we directly and indirectly depend. The bequest from one generation to the next, according to the strong sustainability approach outlined here, requires not just equality of economic opportunity across generations, but also equality of ecological and cultural opportunity—the opportunity to build upon past natural and cultural history, and to contribute to an ongoing culture with economic, institutional, and ecological integrity expressed in personal and cultural ties to a particular place.

We finally have all of the elements necessary to define the ecological integrity of a place—which can be defined as a state of multi-generational harmony between the economic/cultural activities of a human community—and its eco-physical context, such that each generation achieves economic well-being through activities and policies that do not cause a cross-generational decline in the OCI. Or, to use our multi-scaled analysis more explicitly, maintaining the integrity of a place is to (a) maintain an expanding set of economic options within each generation while (b) ensuring that future generations will encounter a constant or expanding OCI, which measures the mix of opportunities and constraints that determine the range of ecophysically supported options available to each generation. The term, integrity of place, therefore acts as a dual filter, selecting policies that protect both economic and ecological opportunities, and is therefore a useful term to serve as a guide in defining, at many and diverse local places, the proper goal of an integrated ecosystem management plan.

6. Conclusion

Ecosystem management is a social process, a process that is cognizant of, and interested in, good ecological science, but which is driven by a search for deeply held, culturally rich, connections between local communities and their place. One of the most important steps in any ecosystem management plan is early public involvement, involvement in a process of value articulation and in the development of a shared sense of community identity. Scientists must participate in this process, because the public needs to know its natural history and to understand the ecological scenarios that may unfold under various management plans and policies. But scientists can also learn which ecological features are important to the identity of a culture, and in this way receive guidance about what local cultures value in their interactions with the natural communities they inhabit.

Terms such as integrity and resilience—once they are defined as associated with maintaining human options, embody sufficient semantic richness to connect discourse about values, especially the value of future freedom of choice, with physical discourse about ecological systems experienced as a mixture of opportunities and constraints. These terms therefore provide a new alternative for evaluation methodologies. Admitting that we still have much to learn about how to value options that will be faced in the future, and admitting that we need a lot more work to operationalize physical features that can be expected to be associated with important human option values, we at least have a bridge for connecting these two bodies of information, a bridge that will allow communication back and forth between the social and natural sciences, and new opportunities to correct our beliefs and our valuations.

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