Sustainability Indicators:
Integrating Evaluation Studies into Adaptive Management

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Part I. Measuring Sustainability and Evaluating Change

What would be the general shape and structure of an adequate and comprehensive accounting system that would measure the sustainability of a particular path into the future? This apparently simple question is fraught with difficulties and complexities. In this paper, I will take a broad-scoped look at this question, identifying two general strategies toward developing a comprehensive accounting of success and failure in managing for sustainability. It turns out—not too surprisingly—that these two strategies correspond to two different approaches to evaluating the impacts of anthropogenic change on the environment. To try to measure sustainability is to seek an indicator that reliably corresponds to a non-diminishing supply of the raw materials essential for the maintenance of social values. Needless to say, such vague generalities do not get us very far, except to show that there is a key connection between how we choose to evaluate human-caused ecological change, evaluating comparative impacts of different actions and policies on social values, and measuring progress toward sustainability.

Given this broad statement of the problem, I will examine two contrasting strategies for evaluating environmental change. One approach, which often finds its advocates among economists, is to use a single, monetary measure signifying wealth or economic prosperity. According to this approach, actions to achieve sustainability involve a trade-off between savings and current consumption (Solow, 1993). Even measuring savings and consumption, however, presupposes some method for deciding which actions preserve value—particular values—and which do not. By taking a very broad look at the problem of evaluating change, and doing so in a context of wondering about how to measure progress toward sustainability, I hope in this paper to broaden the dialogue about environmental values and valuation. The paper can be seen as an argument for two positions, one critical and the other positive:

1. Attempts to account for environmental values in a monolithic vocabulary that recognizes only one kind of value cannot be comprehensive. In particular, such accounts will miss certain values that can reasonably be called "ecological" values.

2. Achieving a comprehensive accounting of environmental values as affected by anthropogenic change will require a new direction in the analysis and measure of environmental goods. In particular, such a comprehensive accounting must be (a) pluralistic, (b) more holistic, and (c) multi-scalar.

I will begin by looking for progress in evaluating environmental change within the emerging discipline of "ecological economics," which at its inception was referred to by its founders as "the science of sustainability" (Costanza, 1991). Evaluating progress in this field will lead into a contrast between how welfare is measured by ecological economists and by more mainstream environmental economists.

If one judges the field of ecological economics on the basis of improved understanding of the interpenetration of ecological and economic forces, I believe great progress has been made. If, however, one were to ask whether the practitioners of ecological economics have evolved a new framework for evaluating ecological and economic impacts of anthropogenic change, I think the only honest answer is, "No; and progress, much less success, in developing that framework has been elusive." The shortcoming lies not in association with the old, conventional framework, but rather with inaction in developing a compelling alternative in the face of demonstrable weaknesses in current practice.

Ecologists still think like ecologists and economists still think like economists. The question is whether ecological economics will go forward with two sets of methodologies, applying descriptive and hypothesis-testing methods when uncertainty is faced, and applying economic value measurement methods using direct and indirect methods to estimate willingness to pay (WTP) for goods and services as methods for *evaluating* those changes? If the field does remain dualistic in this sense, it will be a result of confusion surrounding positivism's commitment to value neutrality in science. Ecologists, many of whom cling to value neutrality as if their science depends upon it, are anxious to shift responsibility regarding valuation to others; and once ecologists and economists began working closely together, the ecologists have simply ceded the ground to economic analysis, without challenging the mainstream economists' fiction that economics, itself, can be "positive" and value neutral (Arrow et al., 2004). One would look in vain among the writings of logical positivists of the Vienna Circle for a more impassioned commitment to positivism than is expressed by Milton Friedman and other advocates of free markets (Friedman, 1962). In the area of environmental valuation studies (the subfield that estimates values associated with anthropogenic environmental change), the myth of positivism appears as the fiction that economists' valuation studies merely measure human behavior in the search for human welfare.

While space does not permit a full-out refutation of this myth, here,[1] I simply note that positivism and its commitments to value neutrality have lost all plausibility given our developing understanding of the complex role played by assumptions and metaphors in the development of all "models," whether models of human behavior or models of galaxies. In the present case, it is simply not plausible for environmental economists, operating on the implicit metaphor of earth as a welfare-producing machine, to then use that hidden metaphor to narrow the ways one can legitimately value, or express one's values toward, nature. Or, at least, if they use such a value-laden metaphor, they should not claim that their measures are "value free." The metaphor of welfare machine illuminates one type of values drawn from nature while, for example, a metaphor of nature as "home" to ecological communities, or John Muir's insisting the forests are "man's cathedrals," highlight different values.

[1] For an all-out argument against the positivist myth of a fact-value dichotomy, see Norton (2005, especially Ch. 3 and Part 9.3).

Evaluative models built on the guiding—and value-laden metaphor—of nature as a welfare-producing machine embody normative assumptions; they are not "positive" as many economists would claim, and ecological economists will make a mistake if they evaluate ecological change only in economic terms. To buy into the economic model for "valuing change," is simply to embrace one of the many metaphors necessary to comprehend the complexities of environmental changes and their impacts on humans.

The alternative is to seek a new approach to evaluating change, an approach that takes into account insights from both economics *and ecology*. The successful integration of ecological and economic science into a "science of sustainability," depends upon whether the new field creates a new and more satisfactory approach to evaluating changes that occur as a result of human activities. I do not *oppose* making, publicizing, and discussing estimates of economic values; nor do I think this way of framing some research questions is incompatible with pluralism. What worries me is that the current enthusiasm for ecosystem service methods (used in tandem with contingent valuation methods) has locked the rhetoric of environmental evaluation into a single-valued, utilitarian, and economic vernacular that leaves little or no room for other social scientific methods, or for appeal to philosophical reasons or theological ideals. It also discourages a more profound re-examination of how one might create a rational process of policy evaluation that truly takes into account both economic *and ecological* impacts of human decisions. At the very least, enthusiastic pursuit of monistic analysis serves to distract the ecological economics from development.

While I do not think it is a conscious choice, I see ecological economists embracing quantitative analysis of non-market values and ecosystem services as the means to identify, monetize, and count environmental values in virtually every circumstance and context. Even if one grants—and I believe the jury is still out on this question—that placing dollar values on ecosystem services can be rhetorically effective, I still worry that the discipline of ecological economics is being swept by a tide of dollar-valuations toward a single methodology of estimating and aggregating benefits in dollar terms only. Especially, I worry that an exclusively monetary approach, which essentially takes a snapshot of aggregated human preferences at a moment in time, cannot provide an adequate framework for evaluating changes to ecosystems that unfold at a rate consonant with ecological time. I fear that, in the rush to quantify all value derived from nature in economic terms, the most promising alternative for developing an integrated approach to evaluation—pluralism—will never be given a chance.

Part II. The Choice: Monism or Pluralism

To explain the choice I think the field faces, I introduce a useful distinction— originally applied to ethical approaches to environmental policy analysis by the legal scholar, Christopher Stone—between "monistic" and "pluralistic" approaches to the evaluation of environmental outcomes (Stone, 1987). Monistic approaches to evaluation attempt to represent all environmental value in one framework of analysis—such as utilitarianism, cost-benefit analysis, or rights theory. Pluralistic theories, on the other hand, do not impose a universal vocabulary upon the discourse of environmental value. Monistic approaches are thought by many to have an advantage in that, given their requirement that all values must be expressed in one measure, they

can at least claim to be comparing comparables, and they can provide some hope of a definitive and decisive outcome in the form of a final accounting in a single system of analysis. Pluralistic theories, on the other hand, seem messy and confusing to interpret, leaving all kinds of open questions when our evaluative criteria point in different directions. I argue, however, that environmental problems *are* messy, often involving conflicts between competing goods, and that embracing—and somehow learning to manage—a pluralistic and diverse evaluation process seems more likely to be useful than seeking algorithmic predictions of costs and benefits or by assigning rights to more and more elements of nature. Messy environmental problems may best be addressed by pluralistic and diverse evaluation processes, not by a single, uniform evaluation method. Pluralists accept the fact that people express their values toward nature in many vernaculars, and then seek a methodology that will make sense of the cacophony (Minteer and Manning, 1999). Monism converts those expressions into a single vernacular, like a translator at the United Nations, while pluralism retains the original expressions and seeks appropriate frame for analysis.

Norton (2005, Part 4.1) argues in detail that most environmental problems have the classic characteristics of "Wicked Problems," as defined by Rittel and Webber (1973). Discussants, that is, cannot agree on problem formulation because their conflicting interests cause them to characterize the problem differently. Trying to force all values at issue into a single, monistic framework leads to a politics of ideology and exclusion, as interest groups that define the problem differently struggle to gain control of public discourse and enforce the methodology that yields "one right answer" to the problem as they characterize it. Issues of value formulation that should be discussed openly are hidden in bureaucratic decisions concerning "appropriate" discount rates, for example. Recognizing multiple values and multiple vernaculars, encouraging open discussion of values—pluralism—can lead to negotiation and reformulation of problems as people develop new, sometimes more similar, "mental models" of problem situations.

In the next Part, I explain the decision faced by ecological economists in more detail, referring to it as the "Ecologists' Dilemma," which arises if one assumes a monistically economic approach to environmental values. At the heart of this dilemma is the emergence and growing dominance of the ecosystem services methodology, which measures (in dollars) the economic contribution of certain aspects of nature (conceived as units of goods and services) to human welfare. The very success of this approach worries me because it is becoming so dominant in ecological economics that the field seems at this point to be adopting monism by default, without even canvassing for alternative approaches. In fact, there has been some questioning of the growing emphasis on ecosystem services, but I see little positive movement to develop more comprehensive valuational tools. If one seeks an integrated *and* comprehensive system for evaluating environmental and ecological change, one must embrace and develop a pluralistic, but integrated, system of evaluation and policy. Such an integrated system of evaluation would of course involve economic indicators and considerations—but it would be *pluralistic* in the sense that it counts values other than units of human welfare measured in terms of aggregated WTP. The pluralistic approach subsumes the monistic valuation exercise as an exploration of one (important) type of value, economic value.

Part III. Economic Monism and Ecology: A Problem of Units of Analysis

Can economic monism provide an adequate account of values gained and lost, such as the value of biodiversity and ecological complexity, as a result of anthropogenic change to ecological systems? The answer to this question hinges on whether the complex and long-term impacts recognized by ecological experts can be captured by an evaluation of the effects of ecological changes on human welfare measures understood as aggregations of individuals' WTP for the benefits. Can ecologists be confident that, if they pass the task of valuing ecological change to economists, or if they themselves engage in the economic valuation of ecosystem services, important "ecological values" will be adequately valued? By "ecological values," I mean the whole range of values that humans derive from ecological systems, including services, provision of material resources, aesthetic values attributed to pristine and/or healthy systems, recreation, spiritual, and bequest values (Mitchell and Carson, 61). For the sake of definiteness, I mention examples such as the values of biodiversity and ecological complexity because these are concepts that are widely used to describe "ecological goods." What is crucial here is to recognize how difficult it would be to construct a comprehensive accounting of these values within the disciplinary definition of value as understood in mainstream economics. It will be difficult precisely because of the mismatch between the production of those goods—which involves complex, interrelated ecological processes in which contributions of parts of the system are often impossible to separate into discrete units—and the methods of economists, which demand the identification of discrete units of good in order to associate dollar values with precisely specifiable changes in those units, so that consumers or respondents can choose their preferred trade-off. Specifying changes in units of goods does not map clearly or neatly onto changes in identifiable, discrete components of ecological processes.

The Ecologists' Dilemma, and it is a true, conceptual dilemma, turns on what methods are chosen to quantify welfare values. Will the monistic system of dollar-measured accounting be constructed according to the strict rules of economic analysis, as developed within the field of economics, or will there be some alternative to this dominant paradigm so that ecological values that have only tenuous and unquantifiable implications for measurable human welfare can be included in an "economic" analysis? The ambiguity, in this situation, of the term "economic" reflects the Ecologists' Dilemma. If "economic" benefits and costs are understood according to the *disciplinary definition* developed in mainstream environmental economics, then references to benefits and costs are to the effect of policy changes on the welfare of individuals, as marked by their own assessment of their well-being (Bockstael et al., 2000). I should note that these mainstream authors do not *assert* monism about environmental values; indeed, they mention both that there may be alternative *conceptions* of value and that, even within the economic conception, if only quantifiable measures of WTP are counted, there will no doubt be social values that will not be counted within that precise definition. Many mainstream economists accept that, in the political process, some value aspects of a situation will simply come down to judgments not based on economic data, and leading economists, such as Sen (2002), have explicitly rejected monism. I do not mean, then, to imply all economists are monists. My point, rather, is that the stampede of ecological economists toward monism in practice must ignore the very reasonable position of many mainstream economists that there are environmental and social values that will escape economists' measurement. The argument, then, comes down to which ecological services will be measured and how they will be measured in order to achieve—as

ecological economists seem to try to be doing—a monistic system of valuation on which all values are potentially expressed as WTP.

Most mainstream environmental economists have no problem, in principle, with attributing WTP value to ecosystems, including both "use" values, such as tertiary treatment of sewage, and "existence" values—the value placed on the very existence of a pristine ecosystem, for example. The problem, rather, is whether there exist today, or could exist in the foreseeable future, methods that can provide, not only "in-principle-possible," but also "in-reality-available" estimates of the full value of ecosystems. Can estimates of individuals' WTP, measured by an acceptable method of estimating economic choice behavior—as measured in either actual or hypothetical markets—be expected to capture all or most of the values that ecologists associate with ecological functioning, processes, and complexities?

With this context set, I can state the Ecologists' Dilemma concisely and rigorously: Should ecologists, who wish to assert that natural systems and their features have value, accept the economists' "disciplinary definition" of value and the methodological strictures that come with it? Or should they relax that definition, allowing the more liberal counting of values of "ecosystem services"? I proceed by examining, in turn, the prospects for capturing ecological values in a useful economic analysis if ecologists give an affirmative or a negative answer to this dilemmatic question.

The disciplinary definition has been elaborated with a variety of taxonomies of environmental values, taxonomies that usually include both "market" and "non-market" goods (Freeman, 2003; Mitchell and Carson, 1989). Economists have offered a variety of classifications of benefits (goods) and damages (bads) derived from natural systems (Freeman, 1993, 12-13), as well as more general ecological values. In order to explore whether important ecological goods such as maintaining biological diversity and ecosystem functions are likely to be included in an exclusively economic accounting, I follow loosely the taxonomy offered by Mitchell and Carson in their respected book on the contingent valuation method (1989, 61). Mitchell and Carson have two large categories, "use" and "existence" benefits that can be measured, and illustrate these categories with the example of improvement of freshwater quality. Under "use" values, they include, for example, "enhanced general ecosystem support, (food chain)," as one category of value. Can economists provide reasonable estimates of people's WTP for goods such as this?

Economists differ in their degrees of optimism on this question. Until recently, indeed, most economists who considered this question argued that, unless an ecological change can be associated with a measurable change in a good or service, it could not be registered as either a benefit or a cost in economic terms (Baxter, 1974; Freeman, 1993; Freeman, 1995). Samuelson’s (1954) reservations about the practical limits of our ability to measure values related to pure public goods hold sway in many quarters. For example, Freeman, in a "qualification" in the conclusion of his comprehensive account of the measurement of environmental values in 1993, referred to such values as "biodiversity, the reduction of ecological risks, and the protection of basic ecosystem functions," and stated: "When policies to protect biodiversity or ecosystems are proposed, economists may be able to say something sensible about the costs of the policies; but except where nonuse values are involved and where people use ecosystems (for example, for

commercial harvesting of fish or for recreation), economists will not be able to contribute comparable welfare measures on the benefit side of the equation" (Freeman, 1993, 485).

Today, there seems to be more interest and confidence, in placing dollar values on ecological benefits such as "enhanced general ecosystem support" by devising ingenious ways to estimate welfare measures for such goods. In the second edition of the 1993 book cited above, Freeman (2003, 458-459) weakens his qualification, arguing that—at least in principle—it is possible to estimate values of "ecological services," within an accounting of individual's willingness-to-pay; but, as will be noted below, he sets what would appear to be impossibly high requirements for actually measuring such values.

This is where the distinction, mentioned above, between "in-principle" and "in-reality" methods that can actually measure ecological goods comes to bear. While some economists may expect a breakthrough, a new method to measure the currently unmeasurable aspects of dynamic changes affecting "ecological values" seems unlikely. In practice, many crucial economic values associated with ecological change may never be measurable. Economists, as noted above, list both market and non-market benefits and costs of ecological change. The value of market goods can be determined by examining actual transactions. In some cases, non-market goods can be measured as indirectly "revealed preferences," as in the hedonic method of calculating travel cost (where values for a good can be inferred from costs incurred to access the good, or estimates of values can be inferred from differentials in home sale prices, for example), where associated market transactions allow the imputation of willingness to pay for the good. In other cases, especially where no "use" is associated with the valuing of a good, no market behavior can guide estimates, so economists have developed the "contingent valuation" method and associated methods that construct situations in which respondents "state" their preference in a hypothetical market, a questionnaire, or a bidding game. Values such as "existence" values—the value derived from just knowing that something exists or that an aspect of the natural world is protected—can only be estimated using stated preference methods. Despite some concern about the comparability of revealed and stated preference estimations, most economists can see ways to aggregate the values attributed by these methods, and hence they treat these approaches as complementary, allowing their aggregation in a cost-benefit analysis that can, in principle, accommodate both market and non-market goods (Freeman, 2003, 456-457).

Freeman, while apparently more optimistic about the development of rigorous methods to measure ecological benefits in 2003 than he was in 1993, sets out a frightful challenge if one were to attempt to use standard tools for measuring stated value, the "good" for which respondents must express a WTP. "To estimate the economic value of a basic ecosystem function, I need to know the link between that function and the ecosystem service flows that it supports. This will not always be easy to uncover," he says. This understatement is followed shortly with an acknowledgment that "[i]n fact some aspects of ecosystem behavior might be fundamentally unpredictable." Freeman also notes that this link might be made by conceiving the ecosystem as a "production process," but then one faces the complication that "in terms of production theory, ecosystems are multiproduct production systems in which jointness in production is likely to be a dominant feature" (Freeman, 2003, 459; Norton, 1988).

The difficulties involved notwithstanding, economic analysis requires that, if ecological values are to be included within the disciplinary definition of value accepted in economics, there is a well-defined change that a consumer or respondent can react to, whether the behavior is registered in real or hypothetical markets. The marginal approach of economic value involves not absolute, but comparative, trade-off value and this requires a precise characterization of the "good" involved, which may in the case of ecological changes prove impossible in practice. To illustrate this point, consider the "good," listed by Mitchell and Carson (1989), of "enhanced general ecosystem support (food chain)." Could the value for this good be inferred from actual behavior, either directly or indirectly? Apparently not directly, since enhancements of food chains are not traded in markets. Could the value of this good be attributed to consumers indirectly, for example, if an enhanced food chain would perhaps lower seafood prices, resulting in welfare gains? In order to estimate the decrease in seafood price, one would have to know how, and to what degree, the food chain improvement, over what period of time, affected future prices. In order to fulfill Freeman's requirements, one would have to be able to specify the "production process" if one were to assess the indirect effect of food chain enhancement on seafood prices. Further, if the food chain is considered as a contribution to a production process, it clearly involves jointness in production, requiring even more detailed information of causal nexuses in complex ecological system. Information necessary to accomplish a precise characterization of such a good is unknown, and much of it is virtually unknowable.

So, if ecologists in the ecological economics field choose the first horn of the dilemma, they should not expect those methods to provide anything like comprehensive estimates of ecological values for the foreseeable future, because even if one accepts the in-principle possibility of developing such methods, economists are very far from the methodological breakthroughs that would be necessary to *actually* estimate those values (not to mention the costliness of available practices!). Even if the validity of positive economics and monism were uncontested, the practical limits of economic valuation in a cost-benefit framework are substantial. These practical limits may seriously constrain the usefulness of conventional economic valuation as a means to measure sustainability of goods associated with ecological processes.

Some ecologists, becoming impatient with these disciplinary strictures, and the intransigent methodological problems they pose, have expressed frustration that strict adherence to the disciplinary definition of economic value makes it difficult to measure and assign dollar values to highly valued aspects of ecosystems, and have recommended the relaxation of the strict rules of economic valuation. Ecologists and others, grasping the second horn of the Ecologists' Dilemma, have thus proposed calculating the total contribution of natural systems to economic well-being through the delivery of "ecosystem services" (Costanza et al., 1997; Dailey, 1997). Advocates of this approach measure, by whatever means available, the economic impacts of various ecological processes and outcomes on human well-being. They have thus relaxed the disciplinary definitions and rules that allow careful comparison of resource elements on a *marginal* basis. The value of a resource element, within the disciplinary system, is the difference in value between that element and the value of the next best substitute. Advocates of ecosystem service accounting, on the other hand, often offer either "absolute" values—the value that would be lost if the service in question were to be completely lost—or they estimate the value of an

element as what it would cost to provide the service, once performed by natural systems for free, through technological fixes.

Mainstream environmental economists have reacted strongly to this proposed alteration of disciplinary definitions and rules. Bockstael et al. (2000, 2) have referred to the large numbers estimated by advocates of the relaxed definition as the aggregated contribution of natural systems to human well-being as "absurd," because the total value of these services exceeds the aggregated annual total of global Gross National Product, implying people are willing to pay more than they make to protect ecosystem services. Mainstream economists argue that the advocates of the relaxed definition have rejected the "current concepts of *economic* value," and they are asking questions that are not relevant to the concept of economic value as it is used disciplinarily and in the development of cost-benefit analyses (Bockstael et al., 2000, 2). This disagreement, then, is at the heart of the Ecologists' Dilemma.

Note that the Ecologists' Dilemma arises once a commitment is made to monism. One can avoid the dilemma simply by embracing an explicitly pluralistic conception of environmental values, as suggested by Bockstael et al. (2000). I have made much of the difference between the two approaches (of mainstream economists' and of ecologists' like Costanza) to measuring ecological services, but my central point is that, regardless of their differences regarding how to define and measure impacts of ecological processes on human welfare, these approaches are equally committed to expressing environmental values as increments in individual welfare.

To see, on a deeper level why monism in valuation is unlikely to provide a useful measure of the value of sustaining ecological goods, one must recognize the model-dependent and metaphor-guided aspect of models, including models of preference and choice. Return briefly to Freeman's discussion of the possibility of articulating the value of ecological goods jointly produced by ecosystems. Freeman (2003, 459), attributing the solution to Barbier, suggests that one can "think of the relevant components of the ecosystem as being involved in a production process," and then try to identify "changes in service flows in response to changes in ecosystem conditions." This is a telling point. Freeman recognizes that, in order to measure an ecological service produced by an ecosystem, one can "think of the ecosystem as" a production system, which is only one of many alternative ways one can "think of an ecosystem." Freeman refers to this decision as a question of "model uncertainty," but this is a misnomer: it is a *choice* of a model considered appropriate for a given task. There is no underlying "true" model of an ecosystem. The choice of an appropriate metaphor is not a matter of uncertainty that may be remedied by more data—it is instead a choice of a guiding metaphor which, in turn, highlights some values and hides others. Barbier's approach generates dollar values *on the assumption that ecosystems are production processes for human goods.* This assumption, itself, is not based on empirical data, but rather on what Barbier thinks is important, what he wants to know about the system, and on what he values.

The point here is that, if I recognize that the decision to model ecological values in the economic framework is a *choice* among multiple possible metaphors and models, then the decision as to what is important to measure rests on a value judgment. The decision to treat nature as a production system for the purpose of measuring economic values was a decision *not to employ alternative metaphors that would highlight alternative pathways and alternative*

values. This choice exercises an underlying *value* which in turn determines how the model will be constructed. Ecologists' contribution to the valuation of ecological goods, will probably not be, at least not solely, one of identifying causal pathways once an economist has already chosen an economics-based, production-related model for characterizing value. The ecologists' contribution will be, rather, to illuminate the multiplicity of ways one can understand ecosystems, and in relating multiple values and kinds of values to ecological change by identifying and helping communities to choose alternative guiding metaphors for ecological processes. In Part III, I further explore the crucial role of metaphors in understanding and evaluating ecological change.

Part IV. Post-Positivist Ecology

In a series of papers with several co-authors, Steward Pickett has explored the possibilities of using lessons of ecology to better understand the lived environment, and how to sustain it, by applying lessons they have drawn from their study of the Baltimore Long-Term Ecological Research site (LTER) (Pickett and Cadenasso, 2006; Pickett et al., 2004). Advocating the use of the ecosystem concept as a useful tool for communication among scientists and among scientists and the interested public, including stakeholders and government agencies (Pickett and Cadenasso, 2002, 5; Pickett et al., 2004), these authors identify several "frameworks" that have been useful in Baltimore, and they think these may be useful in other contexts as well. These are: (i) "spatial patch dynamics …," (ii) the watershed as an integrative tool," and (iii) "the human ecosystem framework" (Pickett and Cadenasso, 2006, 114). These authors frame the question as one of choosing a model appropriate to one's purpose, arguing that "The richness of topics, complexity of model domains, and range of behaviors that models can exhibit suggest that ecosystem models can be used for diverse purposes" (Pickett and Cadenasso, 2002, 5; Pickett and Cadenasso, 2006; Kolasa and Pickett, 2005) This pragmatic, constructivist, and instrumentalist approach to models is linked by Pickett and co-authors with an explicit endorsement of the importance of metaphors associated with ecosystems, seeing them as having a creative and generative role in science; and as valuable in communicating ecological ideas to the public and policy makers in public discourse.

What is really fresh in this work is that it is based on a recognition that human purposes—goals, values, priorities—are integral to ecological model-building.[2] Pickett and Cadenasso (2002, 6) say, "This area of communication includes education, the media, policy making, and management. In such public uses, the precision and narrow focus of technical terms is eschewed in favor of richness of connotation and in support of socially important, if sometimes controversial, values. " Substantively, Pickett and Cadenasso also advocate the identification of ecological systems with spatially defined areas, and also advocate encouragement of recognition of systems as "places" with social meaning and endowed with "responsibility and empowerment" (Pickett and Cadenasso, 2002, 6). This work is so important because, drawing heavily on recent thought in the philosophy of science, Pickett and colleagues are creating an integrated dialogue about environmental policy and scientific research that is

[2] I do not mean to suggest this group of authors is alone in making this dramatic move, nor in their application of ecological insights to policy discussions. See, especially, Clark (2002) and Taylor (2005).

post-positivist and self-reflexive about the choices that are made in building models and framing environmental problems.

I believe ecological economists should respond to this opportunity to rethink the relationship between the models used to describe natural processes and the models used to evaluate changes in their processes. Pickett and the others just cited in the last footnote are advocating no less than an inversion of our usual thinking about science, values, and policy. The old positivist model advocated first gathering descriptive information and data, and then predicting impacts of actions, followed by a microeconomic estimate of the dollars-worth of impacts on the welfare of consumers. Norton (2005) calls this "the Serial View of Science and Policy" and criticizes it in more detail.

Pickett and colleagues argue that, at its deepest level, the ecosystem concept rests on metaphors, and these metaphors connect our values and emotions with our choices of models. In order to be applied to real-world situations, the ecosystem concept demands experimentation with new analogies and interpretations, and this level of "experiment is deep enough to connect to our values, fears, and aspirations. They do not propose that one first describe changing systems and then evaluate the changes according to a single computation of the effects on human welfare. Instead, they embrace an open-ended search for many partial, but complementary, models that tell stories from multiple points of view, recognizing that this search will be guided by our diverse values and purposes. Taylor (2005, 226-227) refers to such an approach to research as "reflexive" ("applying one's method to one's own work") and as involving "practical reflexivity" … "that takes into account the range of practical conditions that enable researchers to build and gain support for their *representations.*"[3]

Part V. Ecologically Sensitive Evaluation: A Sketch

As was noted above, most environmental/ecological "problems" emerge as "messes," as what Rittel and Webber (1973) called "wicked problems": they do not emerge as well-defined problems that are formulated similarly by different participants in the discussion. There will, on the contrary, be varied complaints and varied explanations of what the problem is, often associated with varied value positions and perspectives of the participants. Positivist science, in these early stages of problem formulation, is irrelevant. One cannot test hypotheses—indeed one cannot even know what hypotheses to test—if participants in the discourse differ radically about the nature of the problem at hand. The positivists' analyses of policy bypass the "messes" that are key to beginning an ongoing, iterative, public dialogue. It is in this messy dialogue about goals and aspirations, however, that metaphors and similes allow the reconstruction of a problem by virtue of reconstructing the models used to characterize that problem. What is useful at this stage is a discussion of values, goals, and aspirations, interspersed with attempts to achieve short-term and intermediate goals that can be agreed upon.

[3] My colleagues and I have developed what we call a "two-phased process" of policy formation and evaluation, which incorporates reflexive thinking into adaptive management (Norton et al., 1998; Norton and Steinemann, 2001; Norton, 2005).

I suggest a shift in the unit of analysis to *development paths* (Vatn and Bromley, 1994; Norton, 2005). Development paths are ways a community/place can develop over time and into the future. Development paths can be thought of, alternatively, as *scenarios.* Proposed policies can be understood as interventions to modify or stabilize systemic effects on community or place, and simulations can be used to explore how policy options might lead to varied scenarios. Goals can be set, not as abstract principles that demand maximization of a single index value (e.g., economic welfare) but as descriptions of favored development paths. Proposed policies, and the development paths they are modeled to shape and encourage, can then be evaluated on multiple criteria, including economic criteria (such as job creation and comparative efficiency of different institutional means to achieve improvements on key criteria), but also including longer-term impacts on ecological systems. So, I am proposing an alternative approach to evaluation of environmental change which shifts the unit of evaluative analysis from WTP for atomized, discrete commodities to development paths that can be evaluated according to impacts on multiple scales of time and space. In this way it is possible to choose development paths to protect a range of human values, recognizing the multiple ways humans value nature.

Where do these criteria come from? They should be worked out in the process of building models that are responsive to social problems, within the broader process of adaptive management. This process—what I call "adaptive management"—ideally includes public involvement as well as agency and managerial participation in an ongoing process that attempts to learn by doing. Individuals and groups will argue that certain features and processes are of value; further discussion will explore whether these features and processes can be associated with a measurable indicator. Discussion of environmental policy will be reformed as debate turns from how values will be expressed as measurable dollar quantities to proposals of varied economic and ecological indicators, proposals of management goals with respect to those indicators, and discussion of priorities among goals and indicators.

I am suggesting that *ecological economics* abandon the artificial mindscape of positivism. That mindscape encouraged the serial treatment of science, the completion of an account of the key variables constituting a problem before values and human purposes can be consulted and brought to bear upon problem formulation. It has also imposed upon us, relying on the unrealistic and artificial distinction between descriptive and prescriptive discourse, the divide that still separates ecologists and economists. The dualistic, serial view of science and policy is a hopeless model because one cannot know what science is relevant, or what data to collect, until one knows what is important. As long as problem formulation remains unresolved—as it typically does in unproductive management processes—it is impossible to know what data is relevant. Discussion deteriorates into turf wars among disciplines, all urging their particular data and analysis as definitive. In place of the serial view, I suggest making the process of evaluation—and the process of problem re-formulation— endogenous to adaptive management, and that we adopt an experimental approach to understanding and evaluating changes in social values entailed by human impacts on natural systems. This experimental approach—experimenting with different metaphors and "models" to characterize a problem—exemplifies Pickett's third aspect of model-building, which embodies a reflexive, critical process of choosing appropriate models for communicating about, and working to solve, environmental problems.

Making evaluation a sub-process of ongoing adaptive management processes should make us—philosophers, economists, and ecologists alike—aware of the choices we make when we "model" deterioration or recovery of ecological systems. The choices we make in scaling models, in locating boundaries—both spatio-temporal and conceptual, and in describing the mechanisms and processes driving a problem—occur at the metaphorical level as described by Pickett and colleagues. At this deep level, the metaphors participants choose and the "models" they build re-conceptualize "messes" as emergent problems capable of encouraging learning through doing. This learning can only take place, however, if goals and values are open for public debate in an ongoing discourse that encourages rich metaphors and diverse values.

In place of the methodological debates about how to force all values into a single measure, this approach offers a public discourse focused on choosing appropriate "indicators" of sustainability. Choices of indicators reflect the choosers' values in the indirect sense that choosing to monitor some ecological process is evidence that that process is of interest to the choosers, or at least that it is associated with some other factor of interest to them. So, discussion of environmental values can be absorbed into a community-level process of choosing some small set of indicators which, if followed and stabilized, would protect most of the community's values. Given shared and varied values drawn from nature, the community decides what indicators to monitor. Values people have remain important in the process, but these values feed into an ongoing process of discussion, debate, and management experiments. Crucial to these experiments is reflexive model-building directed at characterizing and communicating the nature of perceived threats to social values. Embedding the search for models and guiding metaphors in public discourse encourages problem-based model-building—a process that in turn encourages "social learning" at the deepest, metaphorical, level.

This new approach does not decide, before doing research, what kind of values will be found. Rather, my colleagues and I suggest elicitations following the important methodological breakthroughs of Kempton et al. (1995), whose researchers begin the characterization of people's environmental values with open-ended interviews. In this way they can maintain the richness and diversity—and look for the similarities—among varied respondents' answers.

Also, the context of evaluation is shifted. Evaluation will no longer be monistic: proposed policies will be evaluated according to multiple criteria applicable at multiple spatial scales—impacts on a list of indicators that is currently hypothesized to reflect, at least roughly, the values of participants who helped to choose them. As various problem models are introduced into the public discourse, as various metaphors are tried out and scenarios are developed, there is the possibility of reconciling problem formulation through the adoption of common models characterizing the problem. In successful cases, these exercises in community model-building can lead to the kind of social learning that can "re-model" complex and wicked problems and improve communication by disentangling messes into manageable problems that can be addressed by setting agreed-upon goals. In this process, public policies and actions will be hypothesized to affect various valued and monitored processes. Proposed actions can then be compared according to their likely effects on the list of monitored processes. And these comparisons, if taken together, can function as a multi-criteria evaluation of possible actions in the service of sustainability.

Key to all these connections and learning about them is the creative choice of appropriate metaphors, and the development of effective and transparent models for seeing the likely effects of possible choices that will determine development paths—and what gets protected—as we move into the future. As these models operationalize chosen metaphorical representations, attention then shifts back to evaluating the effects of proposed actions and policies on those monitored processes (indicators). Adaptive management and social learning, on this approach, are given the chance to address problems iteratively, embodying plural values in multiple criteria, and by focusing attention on important choices that will constitute the future.

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