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Societal Dependence on Natural Ecosystems

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Chapter 4

Valuing Ecosystem Services with Efficiency, Fairness, and Sustainability as Goals

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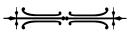

Valuation ultimately refers to the contribution of an item to meeting a specific goal. A baseball player is valuable to the extent he contributes to the goal of the team's winning. In ecology, a gene is valuable to the extent it contributes to the goal of survival of the individuals possessing it and their progeny. In conventional economics, a commodity is valuable to the extent it contributes to the goal of individual welfare as assessed by willingness to pay. The point is that one cannot state a value without stating the goal being served. Conventional economic value is based on the goal of individual utility maximization. But other goals, and thus other values, are possible. For example, if the goal is sustainability, one should assess value based on the contribution to achieving that goal—in addition to value based on the goals of individual utility maximization, social equity, or other goals that may be deemed important. This broadening is particularly important if the goals are potentially in conflict.

There are at least three broad goals that have been identified as important to managing economic systems within the context of the planet's ecological life support system (Daly 1992):

1. assessing and ensuring that the scale of human activities within the biosphere is *ecologically sustainable;*
2. *distributing* resources and property rights *fairly,* both within the current generation of humans and between this and future generations, and also between humans and other species; and

3. *efficiently* allocating resources as constrained and defined by 1 and 2 above, and including both marketed and nonmarketed resources, especially ecosystem services.

Several authors have discussed valuation of ecosystem services with respect to goal 3 above—allocative efficiency based on individual utility maximization (e.g., Mitchell and Carson 1989, Costanza et al. 1989, Dixon and Hufschmidt 1990, Barde and Pearce 1991, Aylward and Barbier 1992, Pearce 1993; see also chapter 3, this volume). In this chapter we explore the implications of extending these concepts to include valuation with respect to the other two goals: (1) ecological sustainability, and (2) distributional fairness. The "Kantian" or intrinsic rights approach discussed by Goulder and Kennedy (chapter 3) is one approach to goal 2, but it is important to recognize that the three goals are not "either-or" alternatives. While they are in some senses independent "multiple criteria" (Arrow and Raynaud 1986), they must all be satisfied in an integrated fashion to allow human life to continue in a desirable way. Similarly, the valuations that flow from these goals are not "either-or" alternatives. Rather than a "utilitarian or intrinsic rights" dichotomy, we must integrate the three goals listed above and their consequent valuations.

Valuations are also the relative weights we give to the various aspects of the individual and social decision problem, and the weights that we give are reflections of the goals and worldviews of the community, society, and culture of which individuals are a part (e.g., Costanza 1991, North 1994, Berkes and Folke 1994). We cannot avoid the valuation issue, because as long as we are forced to make choices we are doing valuation. But we need to be as comprehensive as possible in our valuations and choices about ecosystems and sustainability, recognizing the relationship between goals and values.

This paper is divided into three sections. The first addresses ecosystem valuation in a broader context, in which ecological sustainability and fair distribution are high-priority goals in addition to economic efficiency. The second discusses the assumption of fixed tastes and preferences (which underlies conventional valuation based on individual utility maximization) and looks at the implications of gradually relaxing this assumption for the concept of "consumer sovereignty" and other approaches to social choice. The third section raises the issue of the coevolutionary nature of preference formation, and puts individuals in their dynamic, social, environmental, institutional, and cultural context. As Sen (1995, p. 18) has noted: "Many of the more exacting problems of the contemporary world—ranging from famine prevention to environmental preservation—actually call for *value formation through public discussion*" (our emphasis).

Basing valuation on current individual preferences and utility maximiza-

tion alone, as in conventional analysis, does not necessarily lead to ecological sustainability or social fairness (Bishop 1993). We advocate a two-tiered approach for combining public discussion and consensus building on sustainability and equity goals with methods for modifying both prices and individual preferences to better reflect these community goals (Rawls 1971, Norton 1995, Costanza et al. 1995). Estimation of ecosystem values based on sustainability goals requires treating preferences as endogenous and coevolving with other ecological, economic, and social variables. Finally, we briefly discuss the possibilities for using integrated ecological economic modeling as a tool for valuation of ecosystem services in this broader context.

Sustainability and Fairness as Goals

Ideally, a framework for economic analysis should contain information about the full implications (economic, social, and ecological) of various alternative policy options relative to existing policy. For every policy option, the various ecological-social-economic linkages should be traced to determine the various consequences for human welfare associated with that option, and where possible the various positive and negative impacts should be quantified and valued (Barbier et al. 1994). Economic analysis is about making choices among alternative uses of scarce resources, and it is in this context that valuation becomes relevant.

When a single goal or criterion is involved, the valuation problem is in principle fairly straightforward. But when multiple goals or criteria are involved, the problem can become much more complicated. A classic example of the multiple criterion problem can be found in the story about the drunkard, the miser, and the health freak (Farquharson 1969, Arrow and Raynaud 1986). All three sit on a committee that has to decide how to spend the money of a foundation earmarked for building a student residence. Three alternatives are determined:

1. no house now (leave the money in the bank to earn interest and build a better house later)
2. a house now without a bar
3. a house now with a bar

Suppose the rankings of the alternatives by the three committee members are:

miser—1, 2, 3

health freak—2, 3, 1

drunkard—3, 2, 1

The winning option depends on the order in which the voting is done and can be manipulated strategically. For example, if the miser were chairman of the committee, he could call a vote first on whether there should be a bar (option 3) or not (options 1 and 2). Since both the miser and the health freak prefer no bar (1 or 2), no bar would be chosen by a two-thirds majority. Then he could call a vote on the remaining two options (now or later), which would yield a two-thirds majority for later (option 1) and an overall ranking of 1, 2, 3. But if the health freak were chairman, he could suggest voting first on the question of whether to build the house now (options 2 or 3) or wait (option 1). The decision to build now would pass by a two-thirds majority. Then he could call a vote on the question of the bar, which would be rejected by another two-thirds majority, yielding an overall ranking of 2, 3, 1. Likewise, if the drunkard were chairman he could propose voting between the option 2 (now without a bar) and options 1 and 3 (either build now or wait). The second grouping would win by a two-thirds majority, since both the drunkard and the miser prefer either option 1 or 3 to option 2. Then a vote between options 1 and 3 would yield a two-thirds majority for option 3 (build now with a bar) and an overall ranking of 3, 1, 2. It can be shown that because of strategic manipulations and other "voting paradoxes" that multi-criteria problems do not have any clear-cut, unambiguous, systematic solutions (Arrow and Raynaud 1986) and it is only a dictatorship of one criterion over the others that could not be manipulated strategically (Satterthwaite 1975).

This result is obtained in an environment of fixed preference orderings and no discussion among committee members (criteria). Social choice theory in general has tended to avoid the issue of the connection between value formation and the decision-making process. As Arrow (1951, p. 7) put it: "we will also assume in the present study that individual values are taken as data and are not capable of being altered by the nature of the decision process itself." One way out of this dilemma is to relax the assumption of fixed preferences and allow the committee members to talk with each other, to convey information, to try to change each other's minds (preference orderings), and possibly to come to a consensus on the rankings, as they would do in a real committee. For example, the drunkard could argue that recent scientific evidence has shown that two glasses of red wine per day actually improves one's health, and this might convince the health freak to change his ordering to 2, 3, 1, or even to 3, 2, 1, especially if some restrictions were put in so that, for example, the bar could serve only beer and wine.

This *value formation through public discussion,* as Sen (1995) suggests, is essential to integrate the three goals of sustainability, fairness, and efficiency and can be seen, in fact, as the essence of democracy. As Buchanan (1954, p. 120) put it: "The definition of democracy as 'government by discussion'

implies that individual values can and do change in the process of decision-making." Limiting our valuations and social decision making to the goal of economic efficiency based on fixed preferences prevents the needed democratic discussion of values and options and leaves us with only the "illusion of choice" (Schmookler 1993). What are the implications of all this for the valuation of ecosystem services?

Fixed Tastes and Preferences and Consumer Sovereignty

As discussed above, conventional economic valuation is based on a social decision-making rule sometimes referred to as "consumer sovereignty." By consumer sovereignty is meant that consumer choices are paramount, and that individual consumer preferences, whatever they happen to be and however they are formed, should determine relative value. This rule embodies the assumption that tastes and preferences are fixed and that the economic problem consists of optimally satisfying those preferences. If tastes and preferences are fixed and given, then we do not have to know or care why consumers want what they want; we just have to satisfy their preferences as efficiently as possible. As long as economic efficiency is the only goal, this approach works reasonably well. But as soon as we introduce the goals of social fairness and ecological sustainability, we run into the multi-criterion decision problem (as discussed above), which has no systematic or "procedural" solution. One way out of this predicament is to relax the assumption of fixed tastes and preferences and allow some democratic discussion and modification of values. In addition, tastes and preferences do, in fact, change anyway, especially in the longer term (North 1994). They are shaped by the institutional framework under the influence of education, advertising, changing cultural assumptions, etc. (North 1990). For both of these reasons we need other criteria for what is "optimal" in addition to economic efficiency and more decision rules as well as consumer sovereignty.

Questioning consumer sovereignty raises legitimate concerns regarding the possible manipulation of preferences. If tastes and preferences can change, then who is going to decide how to change them? There is a real danger that a "totalitarian" government might be employed to manipulate preferences to conform to the desires of a select elite rather than the society as a whole. Two points need to be kept in mind, however: (1) preferences are already being manipulated every day; and (2) we can apply open democratic principles to the task of deciding how to manipulate preferences just as easily as we can apply hidden or totalitarian principles. So the question becomes: Do we want preferences to be manipulated outside of democratic

discussion and control, either by a dictatorial government or by big business acting through advertising? Or do we want to explore and shape them consciously, based on democratic social dialogue and consensus, with the additional goals of long-term sustainability and social fairness in mind? Either way, this is an issue that can no longer be avoided and one that we believe can best be handled using the principle of "democracy as discussion."

Four Degrees of Consumer Sovereignty

The "consumer sovereignty" principle of social choice is not quite as monolithic as we have portrayed it. There are actually quite a range of opinions and interpretations. Costanza et al. (1995) define four versions of the consumer sovereignty principle as positions on a continuum of degrees of preference endogeneity. These four degrees are labeled: (1) unchanging preferences, (2) preferences as given, (3) commitment to democracy, and (4) democratic preference change.

"Unchanging preferences" implies that preferences are both given and fixed. To say that preferences are given is to say that stated and revealed preferences of individuals will be accepted, at face value, as indicative of the individual's actual welfare. To say that preferences are fixed is to claim that preferences do not change through time. According to this view, preferences are locked in, at least in the sense that they are impossible to change through rational considerations (Stigler and Becker 1977).

A majority of economists adopt a somewhat weaker version of consumer sovereignty, according to which preferences are assumed to be given and fixed only in the methodological sense. Preferences are aggregated from "snapshots," not considered as dynamic processes. If preferences are given and fixed for the duration of the analysis, then they are not influenced by changes in other people's behavior and can be aggregated. But this represents a conscious tradeoff of reality for mathematical precision and explanatory power.

A third degree of consumer sovereignty takes given-ness as a purely methodological decision, admits that preferences change, but makes no attempt to change them in an explicit or systematic manner. This view argues that if we set out to change preferences, we have taken a giant step down the road toward paternalism, expertism, and perhaps even totalitarianism (Randall 1995). Preferences are highly individual, and nobody—not politicians, not philosophers, not social scientists, and certainly not environmental activists—is justified in telling individuals what their preferences should be, according to this view.

The fourth degree is labeled "democratic preference change." If a demo-

cratic process, including safeguards for individual rights of present people, is in place, then it makes sense to inject into the debate moral concerns about the well-being of future generations, even if these arguments require questioning and criticizing individuals' sincerely felt current preferences. As in the miser/drunk/health freak example above, discussion and criticism of particular preference orderings may be in the form of rational suasion, of pointing out to people the consequences of their desires, of showing alternative paths to personal satisfaction that have less severe impacts on the future of society, and of modifying valuation procedures to reflect more closely the preference sets that are more likely to lead to ecologically sustainable and socially fair decisions. For short-run problems, it may seem reasonable to assume that preferences are given, but it is less reasonable for long-run problems, and in particular not for problems related to ecological sustainability and social fairness.

There is a huge literature on how preferences change, which we can only touch on here, with relevant research from psychology and economics, in particular recent research on preference reversals (Tversky and Kahneman 1986), revealed preferences, constructed preferences (Gregory et al. 1993), and decision making under uncertainty (Heiner 1983); social psychology and sociology, in particular research on social traps (Platt 1973, Cross and Guyer 1980); anthropology, especially research on coevolutionary adaptation of cultures and ecosystems, and ecological anthropology (Harris 1979); and animal ecology, especially research on animal feeding and foraging preferences.

Coevolving Preferences, Goals, and Values

There are certainly several historical examples of societies that managed to integrate the three goals of ecological sustainability, social fairness, and allocative efficiency. Some of their adaptations still survive (Gadgil et al. 1993, Norgaard 1994). In these societies a pattern of coevolutionary adaptation between social systems and natural systems must have been the norm, with the adaptations in many cases driven by crises, learning, and redesign (Holling et al. 1995a). Individual preferences acted in a cultural setting that promoted sustainability of the combined and coevolving social-ecological system, simply because behaving in a sustainable fashion was a necessity for survival and we only observe the societies that have survived.

Some of the most sophisticated coevolved institutions are common-property arrangements. Examples include Spanish *huertas* for irrigation, Swiss grazing commons (Ostrom 1990), and marine resource tenure systems in Oceania (Johannes 1978). In other areas, such institutions have evolved over

a short period of time (on the order of one decade) in response to a management crisis. An example is the Turkish Mediterranean coastal fishery in Alanya (Berkes 1992). There are social mechanisms in place that respond to ecological feedbacks and direct societies' adaptation toward sustainability. The coevolutionary character reflects the fact that ecological and social systems can change qualitatively to generate and implement innovations that are truly creative, in the sense of opportunities for novel cooperation and feedback management (Holling et al. 1995a).

Of course, such social mechanisms for adaptations cannot be captured in a conventional cost-benefit analysis, which only reflects what an aggregate of current individuals prefer, without discussion. The results of a benefit-cost study are not sufficient to address the question of which policy is best relative to all three goals mentioned above, since efficiency in a cost-benefit context does not guarantee sustainability or fairness (Bishop 1993, Perrings 1994).

Thus, we can distinguish at least three types of value that are relevant to the problem of valuing ecosystem services. These are laid out in table 4.1, according to their corresponding goal or value basis. Efficiency-based value (E-value) is described in detail in several recent publications (e.g., Mitchell and Carson 1989, Costanza et al. 1989, Dixon and Hufschmidt 1990, Barde and Pearce 1991, Aylward and Barbier 1992, Pearce 1993; chapter 3, this volume). It is based on a model of human behavior sometimes referred to as *Homo economius,* which suggests that humans act rationally and in their own self-interest. Value in this context (E-value) is based on current individual preferences that are fixed or given (level 1, 2, or 3 of consumer sovereignty, as described above). Little discussion or scientific input is required to form these preferences, and value is simply people's revealed willingness to pay for the good or service in question.

Fairness-based value (F-value) would require that individuals vote for their preferences as a member of the community, not as individuals. This species *(Homo communicus)* would engage in much discussion with other members of the community and come to consensus on the values that would be fair to all members of the current and future community (including non-human species), incorporating scientific information about possible future consequences as necessary. One method to implement this might be Rawls's (1971) "veil of ignorance," by which everyone votes as if they were operating with no knowledge of their own status in current or future society.

Sustainability-based value (S-value) would require an assessment of the contribution to ecological sustainability of the item in question. The S-value of ecosystem services is connected to their physical, chemical, and biological role in the long-term functioning of the global system. Scientific information about the functioning of the global system is thus critical in assessing S-value, and some discussion and consensus building is also necessary.

Table 4.1. Valuation of ecosystem services based on the three primary goals of efficiency, fairness, and sustainability

Goal or Value Basis	Who Votes	Preference Basis	Level of Discussion Required	Level of Scientific Input Required	Specific Methods
Efficiency	*Homo economius*	Current individual preferences	low	low	willingness to pay
Fairness	*Homo communicus*	Community preferences	high	medium	veil of ignorance
Sustainability	*Homo naturalis*	Whole system preferences	medium	high	modeling with precaution

If it is accepted that all species, no matter how seemingly uninteresting or lacking in immediate utility, have a role to play in natural ecosystems (Naeem et al. 1994, Tilman and Downing 1994, Holling et al. 1995b), estimates of ecosystem services may be derived from scientific studies of the role of ecosystems and their biota in the overall system, without direct reference to current human preferences. Humans operate as *Homo naturalis* in this context, expressing preferences as if they were representatives of the whole system. Instead of being merely an expression of current individual preferences, S-value becomes a system characteristic related to the item's evolutionary contribution to the survival of the linked ecological economic system. Using this perspective we may be able to better estimate the values contributed by, say, maintenance of water and atmospheric quality to long-term human well-being, including protecting the opportunities of choice for future generations (Golley 1994, Perrings 1994). One way to get at these values would be to employ systems-simulation models that incorporate the major linkages in the system at the appropriate time and space scales (Bockstael et al. 1995). To account for the large uncertainties involved, these models would have to be used in a precautionary way, looking for the range of possible values and erring on the side of caution.

A Two-Tiered Decision Structure

How does one integrate these three goals and their related forms of value in a social-choice structure that preserves democracy? We advocate a two-

tiered conceptual model (Page 1991, Norton 1994, Costanza et al. 1995) that makes value formation and reformation an endogenous element in the search for a rational policy for managing human economic activities. More like the decision-making process going on in the real world and less like most models for evaluating environmental policies, this conceptual model embeds both economic models and ecological models in a larger social process. The first step in that process, however, is political, not scientific. It is necessary for the various elements of a community or society, perhaps through representatives of the stakeholder groups, to propose and discuss various visions that they would set as positive outcomes of a process of economic development over generations. An important part of this will be the ranking of risks and attempts to set some kind of priorities in addressing risk problems. But comparative risk processes are not as important as public discussions of the positive, long-term aspirations of the stakeholders for their region. It may be possible to begin by attempting to agree on some possible management goals and some projects (to be undertaken in willing local communities), to experiment with pilot projects and to evaluate them scientifically in pursuit of shared, if tentative, goals. The implementation of Agenda 21 of the U.N. Conference on Environment and Development in 1992 is one example of such a process, based on a shared vision of a sustainable society formulated by the global community.

The model is hierarchical in the sense that economic models represent large subsystems that are embedded in larger-scale ecological, biogeochemical, and hydrological systems (figure 4.1). We model economic behaviors and activity on a shorter frame of time (several years), while modeling the relationship of the economy to the larger physical systems that form its management context on longer scales of time (decades to centuries). A two-tier system of analysis sorts possible environmental problems and risks according to the likely temporal and spatial scale of their impacts, and applies an appropriate action criterion—such as a cost-benefit criterion or a Safe Minimum Standard criterion—given the scope and scale of possible risks of a policy. The model is an action-based model that includes economic models and ecological models in a larger system that sets goals, engages in experiments and pilot projects in search of those goals, monitors progress toward those goals scientifically, and then factors scientific results into an ongoing public process of revising goals and the policies designed to achieve them (Costanza et al. 1995). It is this learning or "adaptive management" (Walters 1986) that submits policies to rigorous re-examination both with regard to progress toward the stated goals, and also with regard to the "appropriateness" of current individual preferences under various models.

In this context, actively seeking to influence preferences is consistent with a democratic society. In order to operationalize real democracy at least a

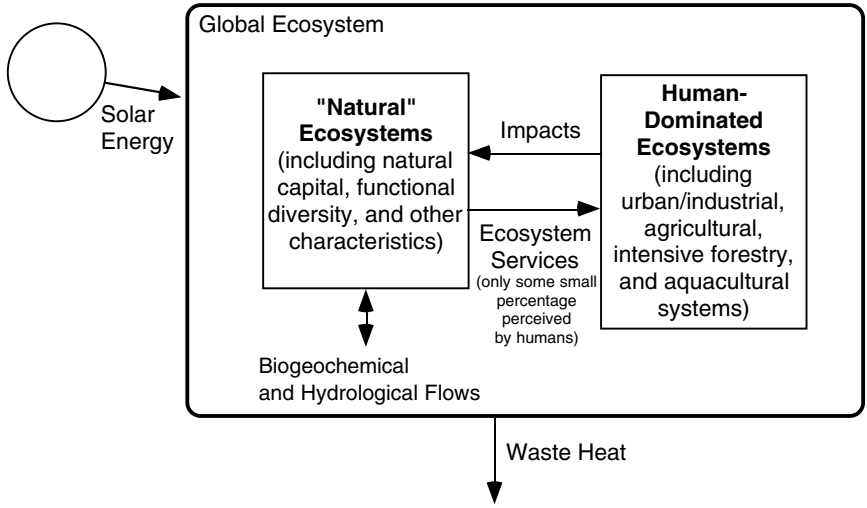

Figure 4.1. Human-dominated ecosystems are parts of the overall global system. Ecosystem services are essential for the development and well-being of human society, but only a fraction of this work is covered by market prices or perceived by humans.

two-tiered decision structure, or, better, a multilayered set of institutions (Ostrom 1990, Hanna 1997), ought to be used. This is necessary in order to eliminate "preference inconsistencies" between the short term and the long term and between local and global goals, a phenomenon described in the social psychology literature as a "social trap" (Platt 1973, Cross and Guyer 1980). There must first be general, democratic consensus on the broad, long-term goals of society. At this level "individual sovereignty" holds in the sense that the rights and goals of all individuals in society must be taken into account, but in the context of a shared dialogue and discussion aimed at achieving the broadest consensus possible. Once the broad goals are democratically arrived at, they can be used to limit and direct preferences at lower levels. For example, once there is general consensus on the goal of sustainability, then society is justified in taking action to change local behaviors that are inconsistent with this goal. It may be justified, for example, to attempt to change either people's preferences for driving automobiles or the price of doing so (or both) in order to change behavior to be more consistent with longer-term sustainability goals. In this way we are utilizing the foresight that we do possess in order to modify short-term cultural evolutionary forces toward achieving our shared long-term goals.

Such a process is going on continuously at various levels in society. From the level of the household to international agreements, the institutional framework (formal and informal norms and rules) constrain and shape the preferences of individuals. Institutions are defined as the humanly devised constraints that structure incentives in human exchange, whether political, social, or economic, and that shape human interactions and the way societies evolve through time (North 1990).

Integrated Ecological-Economic Modeling and Assessment

Addressing the goal of ecological sustainability requires a large measure of scientific assessment and modeling (Faucheux et al. 1996). The process of integrated ecological-economic modeling can help to build mutual understanding, solicit input from a broad range of stakeholder groups, and maintain a substantive dialogue between members of these groups. In the process of adaptive management, integrated modeling and consensus building are essential components (Gunderson et al. 1995). A recent Scientific Committee on Problems of the Environment (SCOPE) project on Integrated Ecological Economic Assessment (IA for short) developed the following basic framework (Costanza and Tognetti 1996). The framework is seen as a creative and learning process rather than a purely technical tool—within which a well-rounded decision can be achieved through the consensus of stakeholders. The process consists of twelve steps and assumes feedback loops from later steps to earlier steps:

1. *Define the focus of attention.* This would likely result from a proposed development opportunity and/or an ecological concern.
2. *Identify stakeholders.* These typically would include the government, business, landowners, nongovernmental organizations, funding agencies, community-based organizations, researchers, etc.
3. *Establish techniques to bring stakeholders together (e.g., roundtable).* This step presupposes that one or more of the stakeholders has sufficient interest to draw the remaining stakeholders to a meeting. It may be that specific stakeholders need to be persuaded that it is in their best interest to convene in such a roundtable. Other stakeholders may need to convince them of the value of developing a participatory approach.
4. *Seek agreement on an acceptable facilitator.* Ideally such a person should be as neutral and unbiased as possible and without a stake in the outcome of the process. The facilitator should nevertheless be

committed to the process and be able to balance the differing powers of the stakeholders.

5. *Define stakeholder interests.* Before the roundtable meeting, stakeholder groupings should be encouraged to meet and discuss their own interests.
6. *Hold roundtable.* The roundtable should ideally be convened jointly by several stakeholders. The agenda should include opportunities for:
   - sharing individual visions
   - identifying complementarity and conflicts
   - agreeing that a process is necessary to address conflicts
   - seeing that integrated assessment is a way forward with the potential to develop consensus and arrive at a "win-win" situation
   - establishing a structure for ongoing dialogue including a stakeholder committee to oversee the process and feedback opportunities to the stakeholder groups and to all stakeholders collectively.
7. *Undertake a scoping exercise.* This process is necessary to identify the key issues, questions, data/information availability, land-use patterns, proposed developments, existing institutional frameworks, timing and spatial consideration, etc. It provides a means to determine whether a specific action will have significant effects on expressed values and to link the model with those values. This scoping exercise is also seen as building trust among the stakeholders, as well as an acceptance of the process. The stakeholders build upon knowledge and capacity.
8. *Build and run a scoping model.* A scoping model provides a relatively quick process of identifying and building in the key components in order to:
   - generate alternative scenarios
   - identify critical information gaps
   - understand the sensitivity of the scenarios to uncertainty
   - identify and agree on additional work to be undertaken by one or more methods of detailed modeling.

Stakeholders participate in the development of the scoping model.

9. *Commission detailed modeling.* Additional information is gathered and the chosen model(s) are modified, extended, and run.
10. *Present models.* Also present results of model scenarios and discuss findings among stakeholders.
11. *Build consensus recommendations.*

12. *Proceed with, and monitor the development of, the preferred scenario.* Learn from the results and iterate the IA process as necessary. Perceptions change as things actually happen, thus the process must permit changing values to influence decisions at each stage. As iterations occur, the scenario conception changes, leading to new issues for resolution among groups.

Several examples of applying this process are discussed in Costanza and Ruth (1996). One example worth noting is in the Patuxent River drainage basin in Maryland, where integrated ecological-economic modeling and analysis are being applied in order to improve understanding of regional systems, assess potential future impacts of various land-use, development, and agricultural policy options, and better assess the value of ecological systems (Bockstael et al. 1995, Reyes et al. 1996). The integrated model will allow stakeholders to evaluate the indirect effects over long-time horizons of current policy options. These effects are almost always ignored in partial analyses, although they may be very significant and may reverse many long-held assumptions and policy predictions. It will also allow us to directly address the functional value of ecosystem services by looking at the long-term, spatial, and dynamic linkages between ecosystems and economic systems (figure 4.2).

While integrated models aimed at realism and precision are large, complex, and loaded with uncertainties of various kinds (Costanza et al. 1990, Bockstael et al. 1995), our abilities to understand, communicate, and deal with these uncertainties are rapidly improving. It is also important to remember that while increasing the resolution and complexity of models increases the amount we can say about a system, it also limits how accurately we can say it. Model predictability tends to fall with increasing resolution due to compounding uncertainties as described above (Costanza and Maxwell 1994). What we are after are models that optimize their "effectiveness" (Costanza and Sklar 1985) by choosing an intermediate resolution where the product of predictability and resolution (effectiveness) is maximized

It is also necessary to place the modeling process within the larger framework of adaptive management (Holling 1978) if it is to be effective. We need to view the implementation of policy prescriptions in a different, more adaptive way, which acknowledges the uncertainty embedded in our models and allows participation by all the various stakeholder groups. "Adaptive management" views regional development policy and management as "experiments," where interventions at several levels are made to achieve understanding and to identify and test policy options (Holling 1978, Walters 1986, Lee 1993, Gunderson et al. 1995). This means that models, and policies

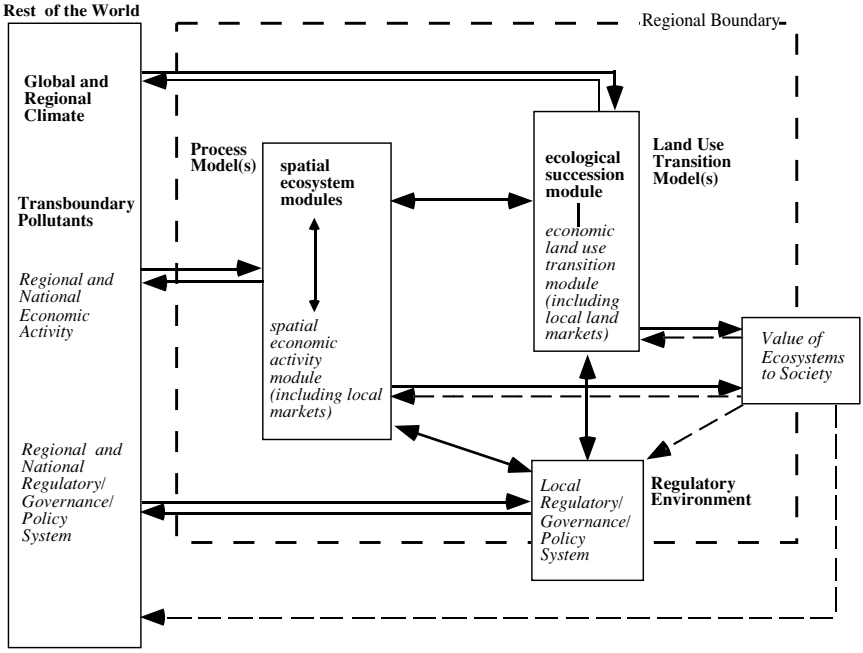

Figure 4.2. Integrated ecological economic modeling and valuation framework.

based on them, are not taken as the ultimate answers, but rather as guiding an adaptive experimentation process with the regional system. More emphasis is placed on monitoring and feedback to check and improve the model, rather than using the model to obfuscate and defend a policy that is not corresponding to reality. Continuing stakeholder involvement is essential in adaptive management.

Conclusions

If economics and other social sciences are to adequately address problems of sustainability, it will be necessary to develop evolutionary models that make preference formation and reformation an endogenous part of the analysis, and to develop mechanisms to modify short-term cultural evolutionary forces in the direction of long-term sustainability and social fairness goals. Society has begun to do this with the recent growing consensus that sustainability is an appropriate long-run, global goal (WCED 1987), but

there is still a long way to go in developing explicit, shared visions of a sustainable and desirable society (Meadows 1996).

We believe that society can make better choices about ecosystems if the valuation issue is made as explicit as possible. This means taking advantage of the best information we can muster about ecosystem services and being aware of the different goals of society and their attendant values. In this paper we have discussed the goals of ecological sustainability, social fairness, and economic efficiency as a basis for valuation in an integrated way. Methods for valuation relative to the efficiency goal are well developed. Methods relative to the other two goals need much further development. For valuation relative to fairness we may need to operate behind a "veil of ignorance" as to our status and position in current and future society (Rawls 1971). For valuation relative to sustainability we need to develop truly integrated assessments and models of the quality, quantity, and spatial and temporal dynamics of ecosystem services and the various aspects of their connection to human well-being in the long run. In all cases it also means acknowledging and communicating the huge uncertainties associated with this endeavor, and developing new and better ways to make decisions that achieve our goals in the face of these uncertainties.

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