VALUING ECOSYSTEM SERVICES

TOWARD BETTER ENVIRONMENTAL DECISION-MAKING

Lake Mendota, Wisconsin. Photo courtesy Wisconsin Department of Natural Resources

Until the economic value of ecosystem goods and services is acknowledged in environmental decision-making, they will implicitly be assigned a value of zero in cost-benefit analyses, and policy choices will be biased against conservation. The National Research Council report, *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*, identifies methods for assigning economic value to ecosystem services—even intangible ones—and calls for greater collaboration between ecologists and economists in such efforts.

The millions of miles of rivers, streams, coastline, and acres of estuaries, wetlands, lakes, and reservoirs throughout the United States host a vast array of aquatic ecosystems that provide many benefits to humans. These ecosystems produce not only goods such as lumber and fish, but they also provide a number of important functions or services that play crucial roles in supporting human, animal, and plant populations. These services include nutrient recycling, habitat for plants and animals, flood control, and water supply (see Box 1).

Human activities often compete with ecosystem survival. For example, should a wetland be drained for suburban housing? Although the economic value of the new houses may be known, it is not as easy to quantify the value the lost ecosystem services of the wetland that would affect plant and animal life, alter storm runoff patterns, and interfere with water reclamation, among other impacts. Likewise, the decision to build a dam to meet drinking water and electricity needs could have dramatic consequences on downstream ecosystems.

In order to appropriately assess environmental policy alternatives and the decisions that follow, it is essential to consider not only the value of the human activity, but also to consider the value of the ecosystem service that could be compromised. Despite a growing recognition of the importance of ecosystem services, their value is often overlooked in decision-making, and, to date, that value has not been well quantified.

Valuation Should Measure Trade-Offs

The Catskills/Delaware watershed provides 90 percent of the drinking water for the New York City metropolitan area. Historically, the watershed has produced high quality water with little contamination, but increased housing developments, septic systems, and agriculture caused water quality to deteriorate. By 1996, New York City had two choices: build a water filtration system at an estimated cost of up to $6 billion or protect its major watershed.

When possible in environmental decision-making, policymakers should use economic valuation as a way

Box 1. Examples of Services from Various Aquatic Ecosystems

Wetlands transform inputs (nutrients, energy) into valuable outputs (fish, crustaceans, and mollusks).

Floodplains along rivers and coasts provide flood protection, water reclamation, pollution abatement, underground water recharge, and recreation.

Mountain watersheds provide water supply, recreation (e.g., hiking, camping, and fishing).

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to quantify the trade-offs in a policy choice. In order to protect the Catskills watershed, measures were taken to help limit further development, improve sewage systems, and reduce the impact of agriculture by using less fertilizers and building up riparian zones along river banks at a total projected investment of about $1 to $1.5 billion. New York City water managers chose to protect the watershed.

Link Economic and Ecological Models

In the Hadejia-Jama'are floodplain in Northern Nigeria, economists and hydrologists worked together to estimate both upstream benefits and downstream consequences of several proposed dam and water diversion projects. A 1998 study showed that the benefit of the project was $3 million in irrigation and potable water, but that downstream floodplain losses would result in about $23 million dollars in costs; an estimated net loss of $20 million. A study in 2001 found that a one meter drop in groundwater would result in an estimated $1.2 million loss in dry season agriculture and a $4.8 million loss in domestic water consumption for rural households.

Economists already produce estimates of value for environmental decision-making. However, the strength of their analysis depends in large part on how well the underlying ecology of an ecosystem is understood and measured. Ecologists are challenged because ecosystems are complex, dynamic, variable, interconnected, and nonlinear, and because our understanding of the services they provide and how they are affected by human actions are imperfect and difficult to quantify.

In an analysis, it is important to ensure that the ecosystem is well understood and also that the study is designed so that output from ecological models can be used as input to the economic models so that the two can be linked effectively. The example of the Nigerian floodplain also illustrates the importance of measuring expected *changes* in the ecosystem for a given ecological impact. Other changes that could be measured include stream flow, water temperature, and changes in the plant life and fish of the floodplain.

Consider All Ways Ecosystems are Valued

Clean drinking water, food production, and recreation are all services of a lake ecosystem, but it is not easy to measure each one separately or to resolve conflicting views on which is more or less important to a management decision. Many economists use the **Total Economic Valuation (TEV) Framework** to incorporate the multiple ways that individuals or groups could value an ecosystem—most of which have no market or commercial basis (see Figure 1). Elements of the framework include:

- **Use and Nonuse Values:** Although different TEV frameworks are used to assess value, most

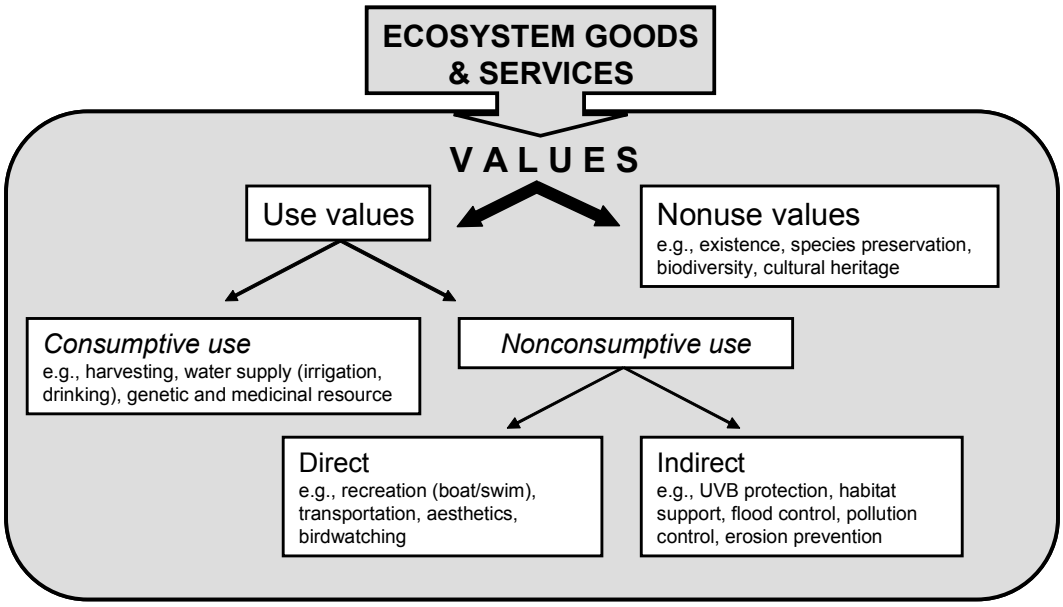

Figure 1. The figure shows the multiple types of values from ecosystem goods and services that are considered within a total economic valuation (TEV) framework.

of them include both "use" and "nonuse" values. For example, an oil spill on a popular beach that prevents people from using it represents lost use value. Alternatively, if the oil spill did not disrupt beach use, but damaged plant and animal life offshore, this would represent a lost nonuse value. Use values can be further divided into consumptive uses (goods, water supply) and nonconsumptive uses (recreation, habitat support, flood control).

- **Willingness to Pay and Willingness to Accept:** If the quality of a freshwater lake were improved to enhance sportfishing, the economic measure of the value of such an improvement to a recreational angler would be measured by his *willingness to pay* for such a change. If however the quality of a lake was worsened from its current level, then the economic measure to a recreational angler would be his *willingness to accept* compensation for the damage, or the minimum amount of money the angler would accept as compensation.

Quantify Ecological Impacts

How can a dollar amount be applied to ecosystem changes? There are several economic methods that can be used to place a value on ecosystem services (see Box 2). These methods base values on various aspects of consumer and producer behaviors, and draw on stated or revealed individual preferences.

In the Great Lakes, policymakers conducted a complex analysis to decide whether and how to control the sea lamprey, an invasive species that preys on the native lake trout, sturgeon, salmon, and other large fish. One study polled 2,000 Michigan anglers to estimate the value to them of a higher catch rate at various fishing sites, taking into consideration distance and travel costs to those sites. The study showed that even a 10% increased catch rate would have a value of about $3.3 million to fisherman. This value was compared against the cost of various methods to control the sea lampreys, for example using a lampricide treatment, so that an appropriate decision could be made.

Specific attention should be paid to pursuing research at the "cutting edge" of the valuation field to support this type of analysis. Because they are time consuming, project-specific valuations have sometimes been replaced by the benefits transfer method, which assesses value based on an existing study of a similar ecosystem. However, benefit transfer methods should be considered second best to careful analysis of the specific ecosystem in question.

Incorporating Judgment and Uncertainty

Perhaps the most important choice in any ecosystem valuation study is how the initial question is framed. In the Catskills/Delaware watershed, policymakers made the critical decision early on that it was not necessary to value all the services of the watershed, but instead to focus only on water quality. Other judgments may be necessary in framing an issue, for example the choice between using the

Box 2. Assigning a Dollar Value: Nonmarket Valuation Methods

Following are some of the most common methods that are used to measure the economic value of ecosystems services.

Household Production Function Methods model consumer behavior based on the assumption that ecosystem services can be substitutes for or complementary to a marketed commodity. Travel-cost models infer the value of an ecosystem according to the travel time and costs needed to visit it. Averting behavior models quantify what people would spend to avoid a negative impact on health, for example installing a filter if water quality is poor. Hedonic methods analyze how characteristics, including environmental quality, alter how much people would pay for something.

Production Function Methods model the behavior of producers and their response to changes in environmental quality that influence production. These methods have been applied to explore the habitat-fishery, water quality-fishery linkages, and erosion control and storm protection.

Stated-Preference Methods are commonly used to measure the value people place on a particular environmental item. Examples include how much people would pay annually to obtain swimmable, fishable, and drinkable freshwater, or to protect

Pooling Revealed- and Stated-Preference Methods uses combined data from different valuation methods to estimate a single model of preferences.

Benefit Transfer Methods estimate the value an ecosystem based on existing studies of a roughly similar ecosystem.

concept of willingness to pay or willingness to accept in an analysis.

Uncertainty can arise at many steps in an analysis. For ecosystem valuation, one of the biggest sources of uncertainty is the lack of probabilistic information about the likely magnitudes of some variables. Other sources of uncertainty arise from models or parameters used. Economic factors can introduce uncertainty as well. For example, how does the degree of visible cleanliness or the degree of development and crowding affect the value of a popular recreational watersite?

Although uncertainty and judgment are inevitable, they are not debilitating to ecosystem valuation and do not undermine the validity of the analysis. It is only necessary to provide a clear explanation of how judgments were made and how uncertainties were accounted for.

Overarching Recommendations

When faced with environmental policy decisions that seek to balance human activity and conservation, the process of valuing ecosystem services can inform the policy debate and lead to better decision-making. The report makes the following recommendations for how policymakers should conduct ecosystem valuations:

- Seek to evaluate trade-offs: where possible, value should be measured in a way that makes analysis of trade-offs possible. If the benefits and costs of an environmental policy are evaluated, then the benefits and costs associated with the changes in an ecosystem service must be evaluated as well.
- Frame the valuation appropriately: Measure changes in ecosystem services, rather than the value of an entire ecosystem.
- Delineate all sources of value from the ecosystem and determine whether they are captured in the valuation.
- Quantify ecological impacts where possible beyond a simple listing and qualitative description of affected ecosystem services.
- Make sure that economic and ecological models are appropriately linked. The output from ecological modeling must be in a form that can be used as an input to economic analysis.
- Seek to value the goods and services most important to a particular policy decision.
- Base economic valuation of ecosystem changes on the total economic value framework. Include both use and nonuse values.
- Consider all relevant impacts and stakeholders in the scope of the valuation.
- Scrutinize any extrapolations made across space (from one ecosystem to another), time (from present to future impacts), and scale (from small to large changes) to avoid extrapolation errors.

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This brief was prepared by the National Research Council based on the committee's report. For more information, contact the Water Sciences and Technology Board at 202-334-3422. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making* is available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242 or 202-334-3313 (in the Washington area); www.nap.edu.

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