Valuing Ecosystem Services

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Hurricane Katrina emphasized the value of wetlands in limiting storm damage, and many have suggested that expanded wetlands should be part of any plan for rebuilding New Orleans. Expanded wetlands would affect everything from the value of Gulf-front properties, the recreational possibilities of residents, to the sites chosen for oil refineries, including port facilities and other infrastructure. In fact, wetlands are valuable for much more than storm protection, and how one values all the services they provide and the possible trade-offs among them should be an important factor in deciding to restore and expand wetland sites in the Gulf region.

How can we decide how to value coastal wetlands and whether such proposals have merit? An emerging field aims to deliver answers.

Natural Capital—the New Paradigm in Environmental Economics

A new paradigm is emerging in environmental economics. It views the natural environment as a form of capital asset, natural capital. This is fully in keeping with what is happening in other areas of economics, where alternative forms of capital are central to analyses that have become influential—human capital, intellectual capital, and social capital being notable examples.

Natural capital consists not only of specific natural resources, from energy and minerals to fish and trees, but also of interacting ecosystems. Ecosystems comprise the abiotic (nonliving) environment and the biotic (living) groupings of plant and animal species called communities. As with all forms of capital, when these two components of ecosystems interact, they provide a flow of services. Examples of such ecosystem services include water supply and its regulation, climate maintenance, nutrient cycling, and enhanced biological productivity.

This newly emerging area of environmental economics is concerned not only with the identification and analysis but also with the valuation of these ecosystem services. What are they? How do they affect human societies? How do the actions of human societies affect them? In

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short, what are the values arising from ecosystem services and why should humankind care about these values?

The NAS Committee on Valuing Ecosystems

In recognition of the importance of these issues and of the absence of widely accepted answers to most of these pertinent questions, the National Academy of Science (NAS) in 2002 established a Committee on the Valuation of Ecosystem Services. This committee was composed of economists, ecologists, and a philosopher: Its report was published earlier this year and is available online at http://www.nap.edu/books/030909318X/html/.

What Are Ecosystem Services?

Broadly defined, ecosystem services are the benefits people obtain from ecosystems, As described by the Millennium Ecosystem Assessment in 2003. Such benefits are typically described as follows:

Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.…In addition to the production of goods, ecosystem system services are the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well (Daily 1997, 3).

Thus, in the current literature the term “ecosystem services” lumps together a variety of “benefits.” In economics, these benefits would normally be classified under three different categories: (i) “goods” (e.g., products obtained from ecosystems, such as resource harvests, water, and genetic material); (ii) “services” (e.g., recreational and tourism benefits or certain ecological regulatory functions, such as water purification, climate regulation, erosion control, etc.); and (iii) cultural benefits (e.g., spiritual and religious, heritage, etc.).

Regardless of how one defines and categorizes ecosystem services, “the fundamental challenge … lies in providing an explicit description and adequate assessment of the links between the structure and functions of natural systems, the benefits (i.e., goods and services) derived by humanity, and their subsequent values.” (Heal et al. 2005, 2) Collaboration across disciplines is essential to this task.

Although the NAS report found that, to date, there has been good progress in establishing this “mapping” from ecological function to economic valuation for certain well-defined single ecosystem services of aquatic systems, valuing multiple ecosystem services typically greatly increases the difficulty of evaluation and, as a result, has yielded fewer successes.

Valuing a Single Ecosystem Service

One of the best-known examples of a policy decision that depended on the value of a single ecosystem service is the provision of clean drinking water by the Catskill Mountains for New York City.

Historically, the Catskills’ watersheds have supplied New York City “freely” with high quality water with little contamination as part of the “natural filtration” process of the rich and diverse ecosystems on the banks of streams, rivers, lakes, and reservoirs comprising these watersheds. However, increasing housing developments and pollution from vehicles and agriculture have threatened water quality in the region. By 1996, New York City faced a choice: either it could build water filtration systems to clean its water supply or the city could protect the Catskills' watersheds to ensure high-quality drinking water.

New York chose to protect the Catskills' watersheds.

In retrospect, the decision was an easy one. It was estimated that the total cost of building and operating the filtration system was in the range of $6 to $8 billion. In comparison, to protect the water provision service of the Catskills, New York is obligated to spend $250 million during a ten-year period to purchase and set aside over 140 thousand hectares in the watersheds. In addition, a series of land regulations were implemented controlling development and land use in other parts of the watersheds. Overall, New York City estimated that it would cost $1 to $1.5 billion to protect and restore the natural ecosystem processes in the watershed, thus preserving the clean drinking water service provided by the Catskills.

In the Catskills' case, it was not necessary to value all the services of the watershed ecosystems. It was sufficient simply to demonstrate that protecting and restoring the ecological integrity of the Catskills was less costly than replacing this ecosystem service with a human-constructed water filtration system. However, in other instances, it has proven necessary to go beyond comparing the cost effectiveness of an ecosystem service and to value explicitly a key service provided by a natural ecosystem.

One of the most important services provided by marshes, mangroves, and other coastal wetlands is the provision of important breeding and nursery habitat for many fisheries in near-shore and marine waters. The value of this wetland habitat function arises only indirectly; that is, it supports and enhances the productivity of fisheries, which are in turn valued for their commercial or recreational catch.

It is possible nevertheless to estimate the indirect value of this habitat-fishery linkage. For instance, an increase in wetland area increases the abundance of fish and lowers the cost of finding and catching fish. The value of the wetland habitat support for the fishery can then be imputed from the resulting change in consumer and producer value for the marketed catch.

Valuing the habitat-fishery linkage has proved important in cases where rapid coastal development and population growth has led to the widespread loss of mangroves, marshlands, and other coastal wetlands. Without considering the value of the habitat function of these wetlands, it is often assumed that coastal developments have little or no environmental impact. The reality may be quite different.

For example, in Campeche, Mexico, it was estimated that the conversion of one square kilometer of mangroves to industrial, urban, and agriculture development reduced the annual shrimp harvest in the Gulf of Mexico by more than $150,000. Such a large value implied that, based on the habitat-fishery linkage alone, it should be worth protecting more of the mangroves in Campeche, especially in the vital Termino de Lagunas Bay region.

However, sometimes even an important ecosystem service, such as the habitat function performed by a coastal wetland, may not prove to be sufficiently valuable to justify reversing development decisions that could eliminate that service. This was the case for estuarine peat bog wetlands on the Pamlico Sound, North Carolina. The habitat support of these wetlands for the shrimp fishery in the Sound was estimated, indicating that the loss of normal quality wetlands reduced fishery values by $277 per square kilometer. The study concluded that protecting these wetlands is not justified because the economic value of increased shrimp production would be less than that of coastal agriculture development.

However, this conclusion clearly could be incorrect, as it compares the economic value of only a single ecosystem service of coastal wetlands with the value of a commercial development alternative. In reality, coastal wetlands could provide a wide variety of ecosystem services, from habitat-fishery linkages to the protection of coastlines from erosion and storms to controlling flooding, water quality, and the provision of habitat for water birds.

As a consequence, recent advances in modeling and estimating ecosystem services recognize the importance in some policy contexts of assessing multiple services and benefits.

Valuing Multiple Ecosystem Services

Ecosystems provide a wide range of services. Because of the complex ecological processes that interact to produce these services, it is often difficult—and possibly misleading—to isolate and value just one ecosystem service without simultaneously considering other services.

There may also be situations where focusing on a single ecosystem service provides the wrong guidance for policy. For instance, as we have just seen, we cannot be sure that irreversible agricultural development of coastal wetlands will be the best policy decision when only one service provided by the wetlands is valued and others are ignored.

Even when the preferred option is to maintain or restore a healthy ecosystem, we may need to consider how best to manage the ecosystem to yield multiple services with a variety of benefits. For example, clean drinking water, food production, and recreation are all benefits arising from a well-maintained lake ecosystem, but is it correct to measure and value each of these benefits separately when policymakers need to resolve conflicts and tradeoffs over management options to provide different combinations of these benefits?

This was exactly the problem that arose at Lake Mendota, near Madison, Wisconsin, in the late 1980s. Declining walleye populations, recreational fishing, and concerns over unpredictable blue-green algae outbreaks prompted interdisciplinary research to determine whether water quality, “food web” management, and recreation can be reconciled and successfully integrated.

To address this management problem, researchers developed integrated ecological-economic models of the lake system and surrounding land uses. This approach has the advantage of capturing more fully the functioning and dynamics of the entire lake ecosystem, focusing in particular on the complex relationships between nutrient cycling, hydrological flows, and land-use change that underlie the key ecosystem services of recreational fishing and the provision of drinking water. Such integrated modeling also facilitated the testing of alternative management strategies to examine tradeoffs between water pollution and fisheries management.

Integrated ecological-economic modeling and some field experiments led to a novel approach to lake management. The key to the approach was to compare different management strategies that use the complex food web of the lake to improve both the fisheries and water quality. Policies that improved recreational fishing opportunities could remove unwanted nutrients, especially phosphorous, and alter pathways of food webs in the entire lake ecosystem to minimize algal blooms. This food web approach was supplemented by diverting some tributaries that were overloaded with nutrients into Lake Mendota and controlling nutrient pollution by key sources around the lake. The resulting management strategy ensures not only that the enhanced lake ecosystem can provide more recreational fishing and improved drinking water but also that fisheries management becomes part of the solution to enhancing the water quality of the lake.

Final Remarks

In order to properly value ecosystems, economists must work with and learn from ecologists and other natural scientists. Such interdisciplinary collaboration requires economists to "think outside the box." In this case, we have to step outside our normal concept of an economic system in total isolation being the "box" and to think more in terms of an "integrated" ecological-economic system.

Such challenges may not appeal to all economists. But, to those that are attracted, the intellectual rewards are often as exciting as the opportunities to influence new approaches to environmental decision making and management.

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