Valuing Ecosystem Services

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Summary

Economists have extended the concept of "natural capital" to include ecosystems and their services. Two fundamental questions have emerged: what are the values arising from ecosystem services and why should humankind care about these values? An interdisciplinary National Academies of Science committee attempted recently to address these questions. This article discusses the committee's main findings, and describes examples where valuation of ecosystem services has influenced environmental decision-making: the provision of clean drinking water by the Catskills Mountains for New York City, coastal habitat-fishery linkages in Mexico and North Carolina, and multiple services of Lake Mendota, Wisconsin.

KEYWORDS: Ecological Economics, Ecosystem Services, Natural Capital, Valuation

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Introduction

There is a new paradigm emerging in environmental economics.

For many years the mainstream has had as its intellectual base a combination of cost-benefit analysis and regulatory economics, and a typical issue has been how best to regulate the emissions of a pollutant, and how to value the gains resulting.

The emerging paradigm has at its center a clear link to environmental sciences, and rests on the idea of 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 emerged and 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 (non-living) 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.

The newly emerging area of environmental economics is concerned with the identification and analysis and valuation of these ecosystem services. What are they? How do they affect human societies? How do the actions of human societies affect them? In short, what are the *values* arising from ecosystem services and why should humankind care about these values?

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 set up a Committee on the Valuation of Ecosystem Services, 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" (Millennium Ecosystem Assessment 2003, p. 53). Such benefits are typically described as follows (Daily 1997, p. 3):

> *"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."*

Thus in the current literature the term "ecosystem services" lumps together a variety of "benefits", which in economics 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 how one defines and categorizes "ecosystem services", as the recent NAS report has emphasized, "the fundamental challenge of valuing ecosystem services 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, p. 2). Collaboration across disciplines is essential to this task.

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

Valuing a Single Ecosystem Service

One of the best known examples of a policy decision depending on the value of a single ecosystem service is the provision of clean drinking water by the Catskills 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 Catskill watersheds to ensure high-quality drinking water.

New York chose to protect the Catskills.

In retrospect, the decision was an easy one. It was estimated that the total costs of building and operating the filtration system were in the range of $6 billion 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 watershed. In addition, a series of land regulations were implement controlling development and land use in other parts of the watershed. Overall, New York City estimated that it would cost $1 billion 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 of part of 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 value explicitly a key service provided by a natural ecosystem.

For example, 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; i.e., it supports and enhances the productivity of fisheries, which are in turn valued for their commercial or recreational catch.

It is nevertheless possible 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 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 impacts, whereas the reality may be quite different.

For example, in Campeche, Mexico it was estimated that conversion of one square kilometer of mangrove 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 mangroves in Campeche, especially in the vital Termino de Lagunas Bay region.

However, some times even an important ecosystem service, such as the habitat function performed by a coastal wetland, may not prove to be sufficiently valuable to consider 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 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.

But this conclusion could clearly 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 protection of coastlines from erosion and storm events to controlling flooding and water quality and 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 policy makers 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 and recreational fishing, and concerns over unpredictable blue-green algae outbreaks, prompted inter-disciplinary 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 ecosystem 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 provision of drinking water. Such integrated modeling also facilitated the testing of alternative strategies for managing the entire ecosystem to examine tradeoffs between water pollution control and fisheries management.

As a result of the modeling efforts and field experiments, a novel approach to lake management was adopted. The key to the approach was to use the complex food web of the lake to improve both the fisheries and water quality. It was found that recreational fishing could remove unwanted nutrients, especially phosphorous, and alter pathways of food webs in the entire lake ecosystem so that algal blooms are minimized. 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

Valuing ecosystem services poses two challenges to economists who might be more comfortable with the "mainstream" approach of our discipline.

First, we cannot begin to understand the complex functioning of ecosystems, let alone how these ecosystem functions lead to the key services that benefit humans, without working with and learning from ecologists and other natural scientists.

Second, such inter-disciplinary collaboration requires economists to "think outside the box". In this case, we have to step outside our normal concept of our "box" being an economic system in total isolation 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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