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ECOSYSTEMS

COMMENTARIES

Opening the Black Boxes: Ecosystem Science and Economic Valuation

Stephen R. Carpenter* and Monica Turner[1]

Center for Limnology and [1]Department of Zoology, University of Wisconsin, Madison, Wisconsin 53706 USA

Ecologists increasingly are enlisted to participate in economic valuations of ecosystem services, proposed restoration activities, or conservation projects. Economic assessments are required by some environmental statutes and policies, such as the US Clean Water Act. Valuation appeals to diverse constituencies, ranging from free-market advocates who believe it will improve economic efficiency, to managers in search of integrative metrics to guide decision making, to environmentalists who believe that the standing of neglected natural services will be enhanced by recognition of their economic value. Nevertheless, valuation has proven to be controversial in practice.

Aldo Leopold, a pioneering conservationist, raised some of the central questions about valuation nearly 70 years ago in a famous pair of essays entitled “Conservation Economics” (Leopold 1934) and “The Conservation Ethic” (Leopold 1933). Leopold saw serious limitations in government-sponsored conservation programs and doubted that top-down regulation would solve environmental problems. He called for institutional incentives to induce private landowners to manage their land in forward-looking ways that served the public interest and future generations. Leopold further argued that sustainable management of land required ethical principles beyond the pale of economics. He suggested that conservation ethics were evolving and ultimately adaptive for humanity. Social and natural systems were viewed as integrated, rather than separate. The following essays demonstrate significant progress in understanding the connections between social and natural systems, yet much work remains to be done.

If we are to understand the linkages of people and nature, then diverse disciplines must learn to view each other as more than just another black box. “The economy” must become more than just a node in the ecosystem scientist’s flowchart, and “the ecosystem” must become more than just another state variable to the economist. As the black boxes have opened up, several poorly understood connections between the economy and the ecosystem have come to light. These become the focus of questions, controversy, and research. Some examples include nonlinearities and irreversibilities in ecological systems (Holling and Sanderson 1996) and problems of discounting over the long time horizons relevant to ecosystem processes (Heal 1997; Heal and others 1998).

Ecological valuation studies generally attempt to measure the marginal value of a proposed or hypothetical ecosystem manipulation (Freeman 1993). The marginal value is the change in economic flows caused by a given change in the ecosystem. For example, to measure the marginal value of wetland area in the Mississippi River drainage, one would estimate the change in economic flows resulting from a given incremental change in wetland area. A specified increase in wetland area would yield measurable benefits by removing nitrate and sediments from the water, enhancing populations of wildlife, waterfowl, and fishes and so forth. Such ecosystem services are converted to flows of money (Goulder and Kennedy 1997). Measurable costs would accrue in the form of foregone opportunities for agriculture or development, which also are monetized. The

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**Corresponding author; e-mail:* srcarpan@facstaff.wisc.edu

valuation scientist attempts to estimate the net difference in these flows of benefits and costs, discounted over an infinite time horizon. Such research is impossible without both ecological and economic information. More importantly, it requires genuine communication and understanding across the disciplines.

Any calculation of ecological values also requires careful synthesis of a great deal of information, much of which involves significant measurement errors and other sources of variability. Ecologists routinely calculate synthetic quantities (for example, net primary production) from complex information (for instance, spatial patterns of net carbon fixation by all primary producers). Such calculations have considerable uncertainty and frequently are debated in the literature. Similar uncertainties and debates will surround the results of ecological valuation studies. For example, the value of water quality in a lake depends on ecological forecasts of the lake's response to policy actions (such as incentives and regulations to manage nonpoint pollution) and economic estimates of the flows of benefits from polluting activity and water quality (Carpenter and others 1999). A complex calculation combines these uncertain quantities into an estimated value for a given policy choice, and the policy choice that maximizes the estimated value is selected as "optimal." The economic optimization procedure has powerful implications for the state of the ecosystem (Figure 1). Ecologists participating in valuation studies can expect the results to be scrutinized closely by other scientists and challenged by various stakeholders.

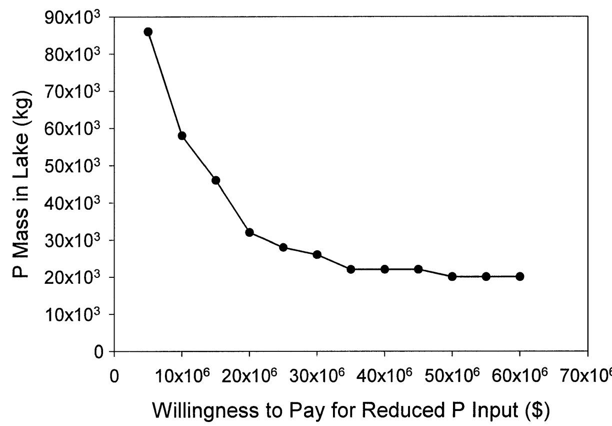

Figure 1. Economically optimal mass of phosphorus (P) in Lake Mendota, Wisconsin, (kg) as a function of the public's willingness to pay (WTP) for reductions in nonpoint inputs of P (dollars), calculated according to Carpenter and others (1999). Each P mass maximizes the net discounted economic value of activities that generate pollution and ecosystem services for a given WTP. P is the cause of eutrophication in the lake. If WTP is low, water quality will be poor; if willingness to pay is high, water quality is greatly improved. Policy choice is highly sensitive to WTP, which can be estimated by various valuation methods (Freeman 1993; Goulder and Kennedy 1997). Like any estimated quantity, WTP is subject to variability. WTP is also dynamic, so the "optimal" policy is a moving target.

Thus valuation is a nexus of both opportunity and controversy for ecosystem scientists. We increasingly are asked to participate in economic studies, yet methods are debated, uncertainties are high, and the results will be challenged by those most impacted by them. Because of the emerging importance of valuation to ecologists, we invited a diverse group of leading natural and social scientists to write commentaries for *Ecosystems*. In particular, we asked each author to discuss an aspect of valuation that seemed especially important for ecologists to understand. Costanza summarizes the motivations for valuation studies and distinguishes three goals (efficiency, fairness, and sustainability) that lead to differences in approach and method. Chavas summarizes economists' approaches to valuation problems. Starrett explains the economic concept of shadow pricing in relation to ecological valuation. H.T. and E.P. Odum, who were among the first ecologists to consider economic valuation of ecosystems, explain how ecologically based units (energy) may be a useful alternative to traditional economic units (money). Heal considers valuation from an economist's perspective and suggests that ecologists might focus more productively on incentives. Ludwig critiques valuation from a natural scientist's perspective and suggests important questions that an ecologist should ask before undertaking a valuation study. Pritchard and others point out that ecological values are a dynamic consequence of interactions of nature and society and argue that adaptive deliberation among clearly defined alternatives is better able to cope with ecological, social, and political uncertainties.

We offer this set of commentaries to ecologists as a diverse, readable introduction to some of the major current and emerging issues in ecological valuation. Readers who seek a more comprehensive and thorough treatment of the subject will find many entry points to the current literature in this set of commentaries.

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