Table of Contents

Comment on "Ecological and Social Dynamics in Simple Models of Ecosystem Management" by S. R. Carpenter, W

RESPONSES TO THIS ARTICLE....2

LITERATURE CITED....2

Comment on "Ecological and Social Dynamics in Simple Models of Ecosystem Management" by S. R. Carpenter, W. A. Brock, and P. Hanson

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- [Responses to this Article](#)
- [Literature Cited](#)

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A charge frequently brought against ecological economics is that it has failed to turn the insights yielded by an interdisciplinary approach into models that are distinct from those already used by economists and ecologists. There are three main insights of the approach. The first is that the economy and its environment are jointly determined systems, and that the scale of economic activity is such that this matters. The second is that the dynamics of the jointly determined system are characterised by discontinuous change around critical threshold values, both for biotic and abiotic resources and for ecosystem functions. The third is that the stability of the jointly determined system depends less on the stability of individual resources than on the resilience of the system, or the ability of the system to sustain its self−organization in the face of stress and shock. It has been argued that an understanding of these properties of the system affects environmental management and policy. More particularly, it affects both the targets of management and policy and the instruments required to hit those targets. The paper by Carpenter, Brock, and Hanson provides convincing evidence that, although the construction of decision models that reflect these insights may be hard, it is feasible, and that the benefits of doing so are considerable.

The set of models described in the paper are all based on the best experimental science of the behavior of shallow lakes subject to pollution by phosphates. The equations of motion in each case reflect the characteristics of many ecological systems: they are nonlinear and marked by multiple equilibria, path dependence, discontinuities, threshold effects, and hysteresis. They differ in their treatment of the decision process and the objectives that decision makers are assumed to have. The three main variants all assume a different political or property rights structure. What is novel about the models is the integration of the two components: the decision problem and its socioeconomic context, and the underlying dynamics of the natural system. The models make the ecological effects of distinct decision processes quite transparent. In particular, they show how the decision makers' understanding of the system (the way they form expectations about its future state, their beliefs about its structure, and so on) affects its evolution. It turns out that the way decision makers learn about the behavior of the ecosystem turns out to influence that behavior.

Economists have long been interested in the problem of sustainability. Most contributions explicitly or implicitly adopt one of two main approaches. The first is associated with the welfarist tradition in philosophy. It assumes that the appropriate way to represent human preferences for future consumption is via an intertemporal welfare function, and the appropriate way to discuss sustainability is via the optimal consumption path for a given intertemporal welfare function (Dasgupta 1995, Dasgupta and Mäler 1995, Chichilnisky 1996, Heal 1998). The second is associated with the "resourcist" tradition in philosophy. It identifies rights and obligations that support the sustainable use of resources. That is, it identifies "sustainability constraints" or rules of the game. The most widely explored sustainability constraints are those associated with the investment rule identified by Hartwick

(1977, 1978) to satisfy the Rawlsian rule proposed by Solow (1974). In both cases, however, sustainability implies either intertemporal preferences or rules of the game that are consistent with the dynamics of the natural system. However, the paper shows that the dynamics of the natural system themselves depend on both intertemporal preferences and the rules of the game.

Economists (including Brock) have also been interested in the dynamics of complex, nonlinear systems for some time (see, for example, Anderson et al. 1988, Brock and Malliaris 1989, Puu 1989, Goodwin 1990, Arthur 1992). However, they have not addressed the connections between decision processes informed by short−term signals and the long−run behavior of the natural system. Natural systems tend to be hierarchical, with smaller, quicker processes embedded in and constrained by larger, slower processes. Management strategies and policies that focus on the small, fast−moving components can have significant consequences for the slower processes and, thus, for the long−run evolution of the whole system. The Carpenter et al. paper shows that management strategies and policies that do not allow for fast−enough learning about uncertain long−run dynamics of the system can have the same effect. This is rather fundamental.

If the ecological−economic system being modeled were globally stable, uncertainty about its long−run evolution would be unimportant. It is because the system is capable of flipping between locally stable states that it is important. In the shallow lakes example, there are significant costs to being trapped in a locally stable eutrophic state, and also costs to behavior that risks flipping the lake into such a state. This suggests that an aim of decision makers should be to maintain the system in a desirable state, i.e., to ensure that the state is sustainable. Although "stabilization" of the system is a legitimate policy goal, this does not mean freezing the system at some point. As Carpenter et al. remark, "frozen policy is a route to disaster." Not only is it inconsistent with the dynamical behavior of cyclic systems, but also it reduces the manager's capacity to learn about the system. The aim of policy should rather be to assure the sustainability of desirable states by assuring the resilience of the system in those states.

Resilience is taken to be a measure of the size of the stability domain corresponding to some attractor. This is what determines the capacity of the system to absorb stresses and shocks without leaving the orbit of the attractor. Although ecological economics has recognized the link between sustainability and resilience (Arrow et al. 1995, Perrings 1998), there are few models that capture the linkages between allocation decisions and resilience as well as these. There are fewer still that demonstrate such an understanding of the linkages among sustainability, resilience, and learning.

Carpenter, Brock, and Hanson draw two main conclusions from their work. The first is that sustainability requires that the decision maker understand the stability of desirable states. This implies experimentation, learning, and adaptation to uncover the properties of the stability domain and its sensitivity to management. The second is that resilience depends on both fast and slow processes. The authors argue that "slow variables and their interaction with fast variables are the most important scientific information for sustainable management." It is hard to overemphasize the importance of these conclusions. Although they diverge quite sharply from existing work, at least in environmental economics, there are certainly echoes of them in at least some of the finance literature. Understanding the linkages between fast and slow processes is critical to understanding any complex dynamical system.

The authors of this paper do not claim to be writing in any particular field, but the development of an interdisciplinary (sometimes referred to as transdisciplinary) perspective on the dynamics of managed ecosystems is the hallmark of ecological economics. This paper offers a nice example of what the field has to contribute to both economic and ecological theory. It is also a nice demonstration of the emergent properties of collaborative work of this kind. Although the authors are individually rooted in limnology, ecology, and economics, the joint product transcends the limitations of each discipline.

RESPONSES TO THIS ARTICLE

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Return to Table of Contents for Volume 3, Issue 2