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Theory and Methodology

On the optimal management of a class of aquatic ecological–economic systems ☆

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Abstract

This paper studies aquatic ecological–economic systems such as the Chesapeake Bay. The stability of such ecological–economic systems depends on the successful functioning of a small number of generalist species in a wide range of ecological and economic conditions. We first characterize the persistence of such systems. We then analyze the dynamic and the stochastic aspects of the resource allocation problem faced by the manager of an aquatic ecological–economic system. This manager wishes to allocate his scarce financial resources optimally among economic activities and the maintenance of the generalists species of the aquatic ecological–economic system. © 2001 Published by Elsevier Science B.V.

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1. Introduction

Economists and ecologists now agree that the problems associated with desertification, habitat loss, and species extinction, are global in scope. As well, researchers also concur that the solutions to these problems that have been proposed by scholars working within the confines of economics and ecology are not working because these solutions are, *inter alia*, narrow in scope. This recognition has led to a considerable amount of interdisciplinary research between economists and ecologists. [1] This body of research has emphasized the fact that ecological and economic systems are

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[1] For more on this research, see Perrings et al. (1995a); Swanson (1995); Dasgupta and Maler (1997); Batabyal (1998a,b,c); Levin et al. (1998).

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jointly determined. The clear implication of this is that if we are to truly comprehend the many *interdependencies* between such systems, then we must study these systems jointly.

Despite the significance of this implication, a number of issues relating to the functioning of jointly determined ecological–economic systems remain poorly understood. Consequently, the objective of this paper is to study aspects of the stability and the optimal management of a class of aquatic ecological–economic systems; examples include coastal and estuarine ecological–economic systems such as the Chesapeake Bay in USA. As Costanza et al. (1995) have noted, the distinguishing feature of these ecological–economic systems is that their stability depends on the successful functioning of a *small* number of generalist species in a wide range of ecological and economic conditions. In the Chesapeake Bay, for instance, the various species of submerged aquatic vegetation [2] make up an important part of this set of generalist species.

There are many ways in which one can think of the stability of an ecological–economic system. Indeed, as Stuart Pimm (1991, pp. 13–14) has noted, ecologists have used the word stability to refer to a number of different concepts. These concepts include the notions of persistence, resistance, and variability. Because of the many meanings of stability, the question as to which specific meaning one should use in a given situation depends greatly on the context that the researcher is interested in studying. In this paper, we are interested in studying the optimal management of aquatic, i.e., coastal and estuarine ecological–economic systems like the Chesapeake Bay. For these ecological–economic systems, it is essential that management focus on how long the composition of the small number of generalist species (in the Chesapeake Bay the various species of submerged aquatic vegetation), that collectively determine the stability of the ecological–economic system, lasts. Now, persistence refers to "how long a variable lasts before it is changed to another value" (Pimm, 1991, p. 21). [3] This tells us that the stability concept that we should be concentrating on is persistence. This is the reason for focusing on persistence in this paper.

Although, ecologists and economists have been interested in the management of ecological–economic systems, they have gone about the task of managing such systems in their separate ways, each behaving as if the other did not exist. For instance, O'Neill and Kahn (2000) point out that the current paradigm in ecology views humans as an external disturbance on the natural ecosystem and that the current paradigm in economics sees ecosystems as external to human societies. This way of viewing the world has led economists to think of "the environmental resource-base as an indefinitely large and adaptable capital stock" (Dasgupta, 1996, p. 390, emphasis in original). Similarly, this isolationist attitude to the management of ecological–economic systems has led ecologists to view "the human presence as an inessential component of the ecological landscape. This has enabled them to ignore the character of human decisions and, so, of economics" (Dasgupta, 1996, p. 390). [4]

Fortunately, this unhappy state of affairs has begun to change. In particular, recent research in ecological economics has led to a number of new insights into the management of ecological–economic systems. [5] However, this research and the attendant insights into management that this research has yielded, have both been very recent. Consequently, there are a number of outstanding research questions about the optimal management of jointly determined ecological–economic systems. In this paper, we shall study the following hitherto unanswered question: How should the manager of an ecological–economic system allocate his scarce financial resources so as to optimally manage coastal and estuarine ecological–

[2] An example of such a species is epiphytic algae. See Costanza et al. (1995, p. 101) for additional details.

[3] An implication of this definition is that persistence is measured in time units.

[4] For more on these issues, see the April 2000 issue of *BioScience*.

[5] For more on this research, see Perrings et al. (1995b); Perrings (1998); Batabyal (1999a,b, 2000); Dasgupta et al. (2000).