ELSEVIER

Ecological Economics 42 (2002) 301–311

ECOLOGICAL ECONOMICS

This article is also available online at:
www.elsevier.com/locate/ecolecon

ANALYSIS

On the joint determination of biological and economic systems

Chad Settle [a,*], Thomas D. Crocker [b], Jason F. Shogren [b]

[a] *Department of Economics, University of Tulsa, Tulsa, OK 74104-3189, USA*
[b] *Department of Economics and Finance, University of Wyoming, Laramie, WY 82071-3985, USA*

Received 2 November 2001; received in revised form 12 April 2002; accepted 12 April 2002

Abstract

Scarce natural resources and our choices to protect or develop them make ecological and economic systems jointly determined—human choices affect nature; nature affects human choices. This essay considers whether a dynamic model that integrates details of an economic system and an ecosystem with explicit feedback links between them yields significantly different results than does ignoring these links. We focus on the case of exotic invaders that put native species at risk in Yellowstone National Park. The results suggest that integration does matter—in each scenario, cutthroat trout populations differ in both magnitude and survival rates, depending on whether feedback is allowed between the two systems. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Economics; Ecology; Integration; Trout; Yellowstone; Exotic species

1. Introduction

Despite the common rifts between the two disciplines, economics and the biological sciences are rife with similarities. Both are disciplines of limits—how to deal with scarcity. Whether it is a human reaction to a limited budget and unlimited wants or a fish's response to limited food and unlimited appetite for reproduction, species must deal with their limits. The limiting factors in both disciplines drive their research efforts. Yet failure to account for joint influences upon these limits in economic and biological systems can cause inaccurate perceptions of how each system works and provide misleading policy recommendations (Dasgupta et al., 2000).

Joint determination creates a sequence of natural and human actions and reactions, and a feedback loop is born. The disturbances in one system set off repercussions in the other system, and these repercussions feedback into the system where the disturbances originated. The issue of risks to threatened and endangered species provides a vivid example. Conservation biologists often maintain that thresholds of species endangerments are functions of the present signs, trends and distributions of species' populations and their likely interactions with habitats—strictly a bio-

* Corresponding author. Tel.: +1-918-631-3157; fax: +1-918-631-3546

E-mail address: chad-settle@utulsa.edu (C. Settle).

PII: S0921-8009(02)00105-2

logical question. We hold that this perspective is too narrow. Economic circumstances affect the quality of habitat. The circumstances that matter include the relative returns to human users from alternative sites, the relative returns from alternative uses on a particular site, and human welfare. Sites with low relative returns in their 'highest and best' use are more likely to be left undisturbed. Moreover, the rich can better afford to set aside quality habitat. Species survival is determined by economic as well as by biological parameters. Lacking unequivocal evidence to the contrary, the validity of separate treatments of the two parameter sets ought to be systematically demonstrated rather than routinely invoked.

Models in which economic systems affect ecosystem outcomes are abundant in the economic literature. Fishery and forestry management models incorporate economic function into ecosystem representations (Clark, 1976). In the fishery context, these models often include predator–prey relations, selective harvesting or multiple species and may even introduce a spatial component which humans can influence. But these models are missing an important point of integration—feedbacks. Allowing for fishing pressure or harvest effort in a model accounts for how economic agents can alter the ecosystem. Having fishing pressure or harvesting effort as a constant, however, does not account for how humans adapt to a change in the fishery. With constant fishing effort, as fish populations fall due to an array of biological considerations, the harvest of fish also falls. Integrating economic systems and ecosystems via fishing effort captures this initial change. What it does not capture is how a change in one system can lead to a change in behavior in the other. When the fish species declines, will fishing effort actually be constant? When the fish population declines, an array of economic factors can cause humans to shift their efforts from one fish species to another or from fishing to other activities. This shift in behavior could lead to a different ecosystem steady state than if no account were taken of these feedbacks.

This essay evaluates what taking account of the evolution of the details of jointly determined natural and human systems implies for a key, but heretofore empirically untreated, question in the management of environmental and natural resources. Can a dynamic model that integrates an economic system and an ecosystem by formulating the details of feedback links between the two systems yield significantly different results than does the standard practice of giving short shrift to these links? We show how accounting for feedback between humans and nature affects the predicted ecological impacts—the population of a native prey species—caused by an exotic invader in Yellowstone Lake in Yellowstone National Park, Wyoming. The results show how acknowledgement of feedbacks might alter the core propositions, procedures, and public policy implications of both ecology and economics.

2. An application: exotic invaders in Yellowstone Lake

Organisms that move beyond their traditional natural range can have undesirable ecological and economic consequences. Science has documented numerous examples of exotic plants and animals causing monetary and non-monetary damages (see Williamson, 1996). Consider a few classic examples. Field bindweed (*Convolvulus arvensis*) is estimated to cause over $40 million in crop damages in Kansas every year (FICMNEW, 1998). The zebra mussel (*Dreissena polymorpha*) in the Great Lakes has significantly diminished phytoplankton biomass and harmed man-made structures (MacIsaac, 1996). The Nile perch (*Lakes niloticus*) has caused extinction of native fish and water quality problems in Lake Victoria.

We now confront a similar problem in Yellowstone Lake, Wyoming, with the invasion of exotic lake trout (*Salvelinus namaycush*). Yellowstone Lake is one of the last great inland fisheries in the United States for the native Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*). Cutthroat trout are popular with fishermen and many predators such as ospreys (*Pandion halieatus*), white pelicans (*Pelecanus erythrorhynchus*), river otter (*Lutra canadensis*), and grizzly bears (*Ursus arctos*). In 1994, however, an angler caught a lake trout in Yellowstone Lake. Lake trout are an