Available online at www.sciencedirect.com
ScienceDirect
Resource and Energy Economics 30 (2008) 91–114
RESOURCE and ENERGY ECONOMICS
www.elsevier.com/locate/ree

Linking dynamic economic and ecological general equilibrium models

David Finnoff *, John Tschirhart

Department of Economics and Finance, Department 3985, 162 Ross Hall,
1000 East University Avenue, University of Wyoming, Laramie, WY 82071, United States

Received 4 January 2007; accepted 1 August 2007
Available online 14 September 2007

Abstract

Although ecosystems provide myriad services to economies, only one service is considered in most renewable-resource models. The general equilibrium bioeconomic model introduced here admits a second service, and more importantly it accounts for how the two services are impacted by interactions within an eight-species ecosystem and interactions within a regional economy. Endangered Steller sea lion recovery measures via alternative pollock quotas change all ecosystem populations and all economic variables. While non-use values associated with the ecosystem (e.g., existence values) are not considered, all species matter for the economy because they are all used indirectly as support for ecosystem services. Regional welfare changes from reduced quotas show the tradeoff between consumptive and non-consumptive uses of the ecosystem.

JEL classification: Q2; Q57; D58

Keywords: Ecosystems; Economics; Ecology

Ecosystems provide services that ‘‘sustain and fulfill human life’’ (Daily, 1997, p. 3). Economists have demonstrated a growing awareness that ecosystems services are important inputs into economic activity whose accurate valuations are necessary in accessing the tradeoffs inherent in natural resource development (Barbier and Heal, 2006). Towards these ends there are two themes that recur in the economics and ecology literatures: (1) ecosystems and economies are jointly determined, and (2) both systems are general equilibrium in nature. Regarding (1),

---

* Corresponding author.
E-mail addresses: finnoff@uwyo.edu (D. Finnoff), jtsch@uwyo.edu (J. Tschirhart).

doi:10.1016/j.reseneeco.2007.08.005

joint determination was emphasized early on by Daly (1968), and more recently Crocker and Tschirhart (1992), Perrings et al. (1995), Nordhaus and Kokkelenberg (1999) and Settle and Shogren (2002) among others have pointed to joint determination as a key ingredient in introducing biological issues into economics. Some authors have admitted considerably more ecological detail to capture the interplay between the systems (e.g., see Brown and Roughgarden, 1995; Carpenter et al., 1999; Brock and Xepapadeas, 2003; Tilman et al., in press).

Regarding (2), general equilibrium (GE) theory has been referred to as the most important development in economics in the twentieth century (Sandler, 2001). A quarter century ago Amir (1979) applied GE theory to ecology, and recently Eichner and Pethig (2005) integrated theoretical economic and ecological GE models. GE can be applied to ecology because ecosystems are subject to the same reality that economies are: ‘‘They are . . . highly non-linear complex adaptive systems with extensive interconnections among components’’ (Arrow et al., 2000).

In this paper we address both themes by linking a dynamic economic computable general equilibrium (CGE) model with a dynamic general equilibrium ecosystem model (GEEM). Variables as output from the CGE model serve as input parameters into GEEM, and vice versa. GEEM appeals to the oft-made analogies between economies and ecosystems by applying the concepts of rational behavior, efficiency and equilibrium to ecosystems (Tschirhart, 2000, 2002).[1] Like CGE that relies on individual consumer and firm behavior to drive macro outcomes, the individual organism behavior in GEEM drives the ecological macro outcomes (i.e., population changes). To our knowledge this represents the first time applied general equilibrium models of any kind have been linked.[2]

CGE/GEEM is applied to the Alaskan economy that is linked to an eight-species marine ecosystem. Generally, there are myriad linkages between economies and ecosystems, and probably many ways to model the linkages. Our approach is to make ecosystem services the linkages, and to show how the provision of the services is determined by both intra-ecosystem

---

[1] However, the similarities only go so far and there are features in GEEM that are not found in economic models (Tschirhart, 2003). For example, predators and prey do not engage in voluntary exchange, but in biomass transfers.

[2] A large literature introduces environmental issues into the CGE framework. Studies assessing the costs of environmental protection (Jorgenson and Wilcoxen, 1990, 1993) have been augmented by those that include contributions of environmental resources to consumer welfare in a separable (Perroni and Wigle, 1994) and non-separable (Espinosa and Smith, 1995, 2002) fashion. A body of literature has also investigated the consequences of optimal environmental taxation in the presence of preexisting distortions (Bovenberg and Goulder, 1996; Goulder et al., 1999; Fullerton and Metcalf, 2001). There have been many notable contributions concerning global warming and the expected impacts of climate change. Early literature focused on the costs of proposed CO_2 abatement strategies (including Manne and Richels, 1992; Nordhaus and Yang, 1996; Bohringer and Rutherford, 1997) while recent examples expanding this to look at the benefits and costs of mitigating climate change (Goulder and Schneider, 1999). In this work environmental quality is viewed as an aggregate stock degraded by economic pollution. The natural system underlying environmental quality is neglected, ignoring the mediating behavior of the economic and ecological systems. Amir (1979) and Crocker and Tschirhart (1992) present linked economic/ecological analytical models while Eichner and Pethig (2005) develop the integration further. Of the few analyses that attempt empirical economic/ecological linkages, Watts et al. (2001) use a CGE model to investigate the economic impacts of preserving several endangered fish species, and Seung et al. (2000) use a dynamic CGE model in conjunction with a recreation demand model to assess the impacts of water reallocation policies. Neither of these papers has a separate ecosystem model. Jin et al. (2003) merge a static economic input–output model of New England with a static ecological input–output model of a marine foodweb, but this approach omits dynamic and behavioral considerations. The work presented herein is differentiated from all of the above because the ecosystem is represented by a stand-alone, behaviorally based, dynamic, general equilibrium model. Just as the economic system consists of agents exhibiting behavior, the ecosystem also consists of agents exhibiting behavior, although the agents are plants and animals.