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Pricing the ecosystem and taxing ecosystem services: A general equilibrium approach

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Abstract

In an integrated dynamic general equilibrium model of the economy and the ecosystem humans and other species compete for land and prey biomass. Each submodel exhibits a price-driven competitive allocation mechanism, and the endogenously determined habitat is either openly accessible or privately owned. In both scenarios specific corrective taxes or subsidies are needed to internalize ecosystem externalities. An open access habitat causes additional inefficiencies through diverging prices for biomass and land in both subsystems. Values of all ecosystem components are determined in an efficient steady state clarifying the role and the interplay of ecosystem prices and economic prices.

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1. The problem

Despite our rich knowledge of significant and large-scale interdependencies between the ecosystem and the economy (Alcamo and Bennett [2]), many pertaining environmental-economic studies tend to be somewhat unbalanced by offering an elaborate analysis of economic activities and far less elaborate modeling of the ecosystem and ecological feedback effects. To the extent that such studies “... do merge economic and ecosystem concepts [they] tend to ad-

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dress isolated markets and a very few species” (Tscherhart [33, p. 13]). Such approaches offer limited insights only in the complex impacts on the ecosystem of human activities such as land conversion for economic use or biomass harvesting. These economic activities have ramifications and trigger adaptations in the ecosystem and eventually adversely affect ecosystem services that support human lives.

In his state-of-the-art survey Brown [9] emphasizes that renewable natural resources are embedded in complex technological interdependencies of ecosystems and that their allocation is characterized by an “... interplay of poorly defined property rights, externalities and market failure” [9, p. 875]. He also observes that economic models rarely extend resource interdependence beyond one or two natural resources (similar: Deacon et al. [15]) and he criticizes the propensity of economists to treat their oversimplified resource models as more than a metaphor when they offer policy advice, e.g. based on an optimal single species solution that ignores predator-prey interactions and other ecosystem interdependencies. Among Brown’s [9] prime research desiderata are increased efforts to better understand the role and function of ecosystems as well as the need to better integrate economics and ecology. Similar programmatic statements have been made by Amir [3], Crocker and Tscherhart [12], Tscherhart [33] and Finnoff and Tscherhart [19,20].

While economists have a good understanding of the resource allocation mechanism in market economies by applying the *economic* concept of general competitive equilibrium analysis¹ we are not aware of a comparable approach to the ecosystem that would be, at the same time, a suitable microfounded building block for a truly general dynamic equilibrium analysis encompassing the economy and the ecosystem as its interdependent subsystems.² To cope with major interdependencies and feedback effects within and between the ecosystem and the economy, we aim at developing such an integrated general equilibrium analysis that encompasses both subsystems, the ecosystem and the economy, and treats both at the same level of analytical complexity. We address the dynamic allocation of land and non-human biomass with a major emphasis on the ecosystem model and its links to the economic submodel. In the joint system to be constructed human activities of harvesting biomass and converting land for economic use³ trigger in the ecosystem pervasive (intertemporal) repercussions which, in turn, impact on the quality and quantity of ecosystem services. Our attention is ultimately focused on the regulation through taxes and subsidies needed to attain allocative efficiency in the joint system under two different property-rights regimes for the ecosystem. We show that full property rights for land (comprising land for habitat as well as land for human use) are not enough to secure efficiency in the no-policy case and that each property-rights scenario calls for a specific corrective policy. Our model is based on the belief shared with many authors (e.g. Boulding [5], Amir [3], Crocker and Tscherhart [12]) that common principles operate in economic and ecological systems. We therefore use economic methodology to explain the interaction of species building on a small but growing literature.

Since the 1970s one can observe an intensified effort towards using economic models in ecology and vice versa. Optimality considerations have emerged in ecology both independently of

¹ For general equilibrium analyses applied in environmental economics see e.g. Mäler [26], Bovenberg and de Mooij [6], Bovenberg and Goulder [7] or Fullerton and Wolverton [21]. All these studies consider the environment or ecosystem only in a rudimentary way through a more or less elaborated so-called damage function.

² For dynamic ecological economic analyses along other lines see e.g. van den Bergh and Nijkamp [35].

³ To sharpen our focus on land and biomass we exclude from our model the pervasive pollution externality link between the ecosystem and the economy that is an important topic in environmental economics since the seminal paper of Ayres and Kneese [4].

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