Ecological Economics 136 (2017) 136–147

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Impact Fees Coupled With Conservation Payments to Sustain Ecosystem Structure: A Conceptual and Numerical Application at the Urban-Rural Fringe

Yong Jiang [a,b,*], Stephen K. Swallow [c]

[a] UNESCO-IHE Institute for Water Education, Westvest 7, 2611AX Delft, The Netherlands
[b] Department of Public Management, Faculty of Humanities and Social Sciences, Dalian University of Technology, Dalian 116024, China
[c] Department of Agricultural and Resource Economics and Center for Environmental Sciences and Engineering, University of Connecticut, Storrs, CT 06269, USA

ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form 4 February 2017
Accepted 6 February 2017
Available online xxxx

Keywords:
Land use regulation
Land preservation
Impact fees
Ecosystems
Public finance
Urban sprawl
Wetlands
Development rights
Spatial
Metapopulation

ABSTRACT

Communities in exurban areas increasingly rely on land preservation as a strategy to balance sprawling land development with maintaining environmental amenities. Based on a review of existing approaches for preserving land, we consider a conceptual model of environmental impact fees (EIFs) coupled with conservation payments for managing private land of ecosystem value. In this framework, conservation payments are intended to cost-effectively target fair market value compensation for heterogeneous land for preservation that sustains ecosystem health. EIFs serve as a financial instrument to augment conservation payments and to allow flexibility for landowners with private information to pursue development opportunities while accounting for environmental impacts. Using a bioeconomic model of nature-reserve design, we develop an empirical illustration of how to estimate the EIF of development damage to critical habitat in southern Rhode Island in an effort to preserve land as an environmental infrastructure that maintains ecosystem health.

1. Introduction

Maintaining the quality of public services, particularly environmental amenities, is of policy interest to communities at the urban-rural fringe. Over recent decades, amenity-driven migration has strongly influenced the evolution of American life, characterized by pursuit of low density residential development in exurban and rural areas (see Marcouiller et al., 2002; Irwin et al., 2009). Sprawling land development, while imposing pressure on provision of public services, threatens local ecosystems and environmental amenities, as well as agricultural and rural landscapes (Johnson, 2001; Daniels and Daniels, 2003; Odell et al., 2003; Mcdonald et al., 2009). Concern over environmental degradation motivates local policy initiatives to regulate growth and to protect the environment (Myers and Puentes, 2001; Marcouiller et al., 2002; Bengston et al., 2004).

Recognizing the potential impact of urban sprawl, communities increasingly rely on land preservation as a strategy to balance residential development and maintain environmental amenities (Daniels and Lapping, 2005; Jiang and Swallow, 2015). The rationale is that environmental amenities can be sustained by protecting from development certain private undeveloped land that is environmentally valuable. The efficiency, effectiveness and political feasibility of land preservation in pursuit of intended goals, however, depends upon the extent to which land acquisition takes into account the economic cost of land (Ando et al., 1998; Polasky et al., 2001), the development rights of owners (Innes, 1995, 1997), incentives for different land uses including conservation (Innes and Frisvold, 2009), as well as the role of land and its use in the remaining ecosystem (Swallow, 1996a, 1996b).

In this study, we propose an impact fee framework coupled with conservation payments to manage private land of environmental value in an incentive-based system. This approach is motivated by a review of existing land acquisition approaches such as planning and incentive-based programs, which are found insufficient to achieve land development while sustaining valued environmental resources at the urban-rural fringe, particularly in a heterogeneous landscape with ecologically interdependent land parcels, constitutional protection of property rights, and local conservation financing challenges (see section 2 for further detail). Our intent is to provide an intuitive framework to motivate and implement impact fees as a tool to mitigate environmental impacts of land development while being ecologically effective and financially self-sufficient. This intent follows from the recommendations of Portney (2004)

* Corresponding author.
E-mail addresses: y.jiang@unesco-ihe.org (Y. Jiang), stephen.swallow@uconn.edu (S.K. Swallow).

http://dx.doi.org/10.1016/j.ecolecon.2017.02.007

who calls economists to offer environmental policy alternatives of potential practical value for improving social welfare, even when complete benefit-cost analysis may be impossible.

We consider a novel policy, environment impact fees (EIFs), which are inspired by the practice of development impact fees in the public sector. Development impact fees are used to finance local infrastructure, such as schools and sewage systems, and to control overdevelopment and urban sprawl (Brueckner, 1997; Burge et al., 2007). Similarly, EIFs can serve as a tool to finance conservation, to create "green infrastructure" providing ecosystem services such as pollution purification, flood mitigation, and a green space or wildlife habitat network. For this paper, such a network is analogous to the infrastructure supporting conventional community services such as schools or public safety services, and the EIF approach strives to reduce the cost for a community to achieve a conservation network designed to sustain a targeted level of ecological health. Simultaneously, EIFs can serve as a Pigovian instrument to internalize any negative impact of land development on the local environment (Clinch and O'Neill, 2010a, 2010b). Indeed, previous studies have suggested using impact fees for environmental purposes such as protecting open space (Nicholas and Juergensmeyer, 2003) and encouraging "green" buildings (Kingsley, 2008).

In our conceptual model, the EIFs are intended to augment conservation payments or other incentive-based conservation programs of a community, and to address the potential conflict between landowner discretion and public interest in environmental amenities. In a heterogeneous landscape, conservation programs cost-effectively target private land of critical environmental value by offering payments for enrollment in conservation. Such payments comprise just compensation for taking private development rights for the public purpose of establishing a conservation reserve network (or green infrastructure). EIFs explicitly account for the possible external impact of an individual development decision involving private land that has been identified and targeted for a conservation network. That is, EIFs directly link the assessment of development damage imposed on a planned conservation network to the additional financial expenditures a community would face to compensate for such damage and allow the community to achieve level of environmental amenities expected from the original plan.

To empirically demonstrate the EIFs, we apply a spatially explicit bioeconomic model of a nature reserve design to guide the conservation program in cost-effectively targeting land for preservation, thereby establishing green infrastructure – e.g., a wildlife habitat network - that sustains a healthy ecosystem. We estimate EIFs for each undeveloped land parcel that has been incorporated within a community's plan to create, cost effectively, a conservation network that will sustain the local ecosystem. The EIFs are derived from minimization of the cost of conservation payments needed to acquire land that is essential to sustaining a socially (municipally) chosen ecosystem health or environmental quality index. Our case study illustrates empirical estimation of spatially-sensitive EIFs for different levels of development damage to the community's plan to establish a conservation reserve network.

This study is relevant to land use policy and public decision-making. There is an increasing literature that reveals the linkage between landscape elements and ecosystem structure and process (e.g., Araujo et al., 2002; Bauer et al., 2010; Bennett et al., 2006; Ernoult et al., 2006; Pearson and Dawson, 2005; Polasky et al., 2001; Polasky et al., 2005; Swallow et al., 1997). The present study attempts to develop and illustrate a conceptual, integrated framework that links the conservation literature to community land use management in a socio-bioeconomic framework. It addresses an important land use issue, characteristic of communities at the urban-rural fringe. Our case study demonstrates the potential and importance of research integration for a more comprehensive analysis of land use management aimed to improve economic efficiency, environmental quality, and political acceptance (Plantinga, 2015).

In the next section, we review existing approaches. Section 3 describes the conceptual model of EIFs coupled with conservation payments designed to protect the local landscape's capacity to sustain a minimal level of ecosystem health while accommodating land development. Section 4 presents an example, estimating EIFs for different levels of development damage to a network of land that, if preserved at an optimal level, could cost-effectively sustain a target level of ecosystem health. Section 5 draws conclusions.

2. Literature Review

A traditional approach to protecting land relies on zoning and land use planning, such as low density zoning (Fischel, 2000) and conservation subdivision (Arendt, 1999). The planning-based approaches can increase the amount of undeveloped land by regulating development density or intensity, but may not effectively address the conservation needs of local ecosystems (Kretser et al., 2008; Carter, 2009). Moreover, the welfare consequences in terms of efficiency and equity of those planning approaches are often of concern as those instruments may be rigid and may create land rent and windfall gains differentially affecting landowners while producing significant transaction costs reducing the efficiency of land use management (Thorson, 1996, Heikkila, 2000, cf. Lewis et al., 2009).

The pitfalls of the planning-based approach may partially explain the increasing popularity of market-based instruments to promote desirable land use, such as fee-simple purchases of land, conservation easements, or transferable development rights (e.g., Rushman, 2000; Bengston et al., 2004; Watzold and Drechsler, 2005; McConnell et al., 2006; Carter, 2009). Market-based instruments typically acknowledge landowners' development rights and create a market setting enabling retirement of landowners' development rights and, thus, land preservation through the more flexible market mechanism. Their major advantage over the traditional planning-based approaches lies in the potential to improve equity and efficiency moderated through the market mechanism.

To improve land use patterns, particularly in the context of protecting biodiversity and ecosystem function, economists have also examined incentive-based mechanisms in designing payments or programs to acquire land (Parkhurst and Shogren, 2003; Lewis et al., 2011). Examples include contracts with landowners who protect endangered species (Smith and Shogren, 2002), "agglomeration bonus" to encourage preservation of large tracts of land (Parkhurst et al., 2002; Drechsler et al., 2010), spatially uniform versus heterogeneous compensation payments (Watzold and Drechsler, 2005; Lewis and Plantinga, 2007), direct land acquisition for preservation versus indirect approaches to affect relative returns to various land uses (Langpap and Wu, 2008), and incentives for reducing habitat fragmentation (Lewis et al., 2009). Exhibiting varying advantages with desirable welfare implications, these programs all can reduce the negative impact of land use on local ecosystems.

In a heterogeneous landscape with ecologically interdependent land parcels, pure incentive-based programs or market-based instruments alone may still be insufficient to address local ecosystem needs (e.g., Anderson and King, 2004). Ecosystem health relies on spatially heterogeneous land uses and attributes which establish a structure through which parcels may contribute an unequal share to ecosystem process and function (Swallow, 1996b; Swallow et al., 1997; Wiens et al., 2006). This reality implies that the spatial configuration of preserved land is an important element in addition to the total acreage that may be preserved. Yet, incentive or market-based conservation programs often do not explicitly link land preservation to ecosystem process and function (Jiang et al., 2007; Lewis et al., 2011), and by relying on voluntary participation and landowners' discretion, decentralized land use decisions can leave uncertain the resulting pattern of land use and outcomes for ecosystem function (Lewis et al., 2011). From the ecological and political perspective, a more effective mechanism is needed to protect landscape elements and the structure consistent with ecosystem