Resource and Energy Economics 31 (2009) 75–88

Contents lists available at ScienceDirect

Resource and Energy Economics

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

Spatial patterns of biodiversity conservation in a multiregional general equilibrium model

Florian V. Eppink [a,b,*], Cees A. Withagen [c,d]

[a] UFZ - Helmholtz Centre for Environmental Research, Department of Economics, Permoserstraße 15, 04318 Leipzig, Germany
[b] Institute for Environmental Studies, VU University Amsterdam, Amsterdam, The Netherlands
[c] Department of Spatial Economics, VU University Amsterdam, Amsterdam, The Netherlands
[d] Department of Economics, Tilburg University, Tilburg, The Netherlands

ARTICLE INFO

Article history:
Received 1 December 2005
Accepted 1 September 2008
Available online 25 December 2008

JEL classification:
Q39
Q57
R38
R52

Keywords:
Biodiversity conservation
Extinction risk
Monopolistic competition
Population dynamics
Regional specialisation
Reserve sites
Spatial economics

ABSTRACT

Migration dynamics and local biodiversity are interrelated in a way that is likely to affect patterns of regional specialisation. We assess this relationship with a New Economic Geography model that has been extended with biodiversity. Biodiversity is heterogeneous, and responds to habitat availability. The results indicate that a symmetric pattern of regional specialisation is more likely, and that additional equilibria may emerge as the marginal utility of biodiversity increases. In the policy analysis we focus on the case where the overall social optimum is symmetric and show that it can be supported as a non-cooperative Nash equilibrium. However, multiple Nash equilibria may exist.

1. Introduction

In this paper we propose and analyse a formal model to study the interaction between human population dynamics and biodiversity. The model integrates a number of feedbacks between the two phenomena. In this introduction we sketch the theoretical framework within which we wish to address this issue.

* Corresponding author at: UFZ - Helmholtz Centre for Environmental Research, Department of Economics, Permoserstraße 15, 04318 Leipzig, Germany.
E-mail address: florian.eppink@ufz.de (F.V. Eppink).

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doi:10.1016/j.reseneeco.2008.09.007

The interactions between population and the environment are numerous and complex. In a special issue of the Population and Development Review, Lutz et al. (2002) advocate that population–environment (P–E) analysis is treated as a specific field of research. It has become increasingly clear that populations have impacts on the environment, e.g., air, water, climate, and biodiversity through the extraction and consumption of natural resources. Conversely, the environment may influence size, composition, location, etc. of human populations through pollution or by affecting fertility. Environmental disasters furthermore may lead people to move to safer places. The present paper tries to capture both sides of the P–E interaction. The emphasis will be on the dynamics of the population, in particular from the spatial perspective of location choice.

It is a well-documented issue that individuals may migrate for environmental reasons. In their study on migration within the US, Mueser and Graves (1995) include weather variables as well as an indicator of recreational amenities of lakes. Hunter (2005) surveys the theoretical and empirical literature on migration caused by natural environmental hazards, such as earthquakes and hurricanes, as well as technological hazards, such as nuclear waste and chemical spills. Inspired by the issue of climate change, Reuveny (2005) investigates the relationship between environmental degradation and migration, and the possible conflicts arising from this migration. The relationship between population growth, migration and local air pollution is addressed by Cramer (2002). Marquette and Bilsborrow (1999) list numerous studies concerning the interaction between land use, natural resources and migration. A contribution by Hunter (2000) goes into the effect of population size and distribution on e.g. climate change, deforestation, and land use. Particularly interesting for our purposes is the work by Chu and Yu (2002), who deal with migration and biodiversity. They focus, however, on the impact of human populations on biodiversity, and not so much on the reciprocity that exists between the two.

One of the aims of the present paper is to take into account the reciprocal relationship between local biodiversity, and particularly its amenity value, and human migration. An important issue in biodiversity conservation is the fragmentation of habitat reserve sites, which is generally perceived as a threat to long-term persistence of biodiversity (Barbier et al., 1995; Armsworth et al., 2004). It prevents individuals of species' populations to (re)colonise habitat areas, thus increasing the extinction risk of the overall population (Hanski and Gilpin, 1991). On the other hand, fragmentation may also have a positive effect on populations by spatially restricting the impact of stochastic disturbances, such as fire or disease (e.g., Fahrig, 2003). Fragmentation of habitat reserve sites, however, has largely been studied in isolation from spatial-economic considerations. Production and consumption levels, for instance, are dependent on the spatial distribution of economic activity as shown by the New Economic Geography model (Fujita et al., 2001; henceforth FKV). In this paper, we consider the problems of habitat fragmentation and biodiversity loss in connection to such a complete economic system.

We first briefly survey the economic literature on the design of reserve sites, making a distinction between optimal design and the spatial structure as a result of decentralised economic behaviour.

The optimality of the spatial design of reserves sites has traditionally been analysed by economists using one of two modelling approaches (see Eppink and van den Bergh, 2007). The first approach has been to include the use of land in models of renewable resource management. Sanchirio and Wilen (1999) present one of the first of such models that includes patchy habitats and analyse the optimal spatial distribution of harvesting effort (biodiversity is measured only in terms of biomass). Similar, more recent models focus on the impact of reserve sites on harvesting in catch-areas (e.g., Sanchirico and Wilen, 2001; Armstrong and Skonhoft, 2006). The second approach poses the design of habitat reserve sites as a 'maximum coverage problem' (MCP). It finds the spatial pattern of reserve sites that maximises the number of species preserved given budget constraints. This type of modelling is starting to include economic costs in models for the planning of biodiversity reserve sites, as in, e.g., Ando et al. (1998), Polasky et al. (2005) and Naidoo and Adamowicz (2006). Both approaches to optimal spatial allocation of reserve sites remain characterised by an absence of feedback effects between production, consumption and levels of biodiversity that may arise at the macro level from the behaviour of individual economic agents.

The economic literature has recently started to give attention to the use of space in conjunction with biodiversity conservation as an outcome of decentralised decision-making. Armsworth et al.