Land Use Policy 47 (2015) 145–155

Contents lists available at ScienceDirect

Land Use Policy

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

Provisioning ecosystem services supply and demand: The role of landscape management to reinforce supply and promote synergies with other ecosystem services

Igone Palacios-Agundez[a,*], Miren Onaindia[a], Pilar Barraqueta[b], Iosu Madariaga[a,c]

[a] Plant Biology and Ecology Department—University of the Basque Country, Campus de Leioa, Barrio Sarriena s/n, 48940 Leioa, Biscay, Spain
[b] Ekos, Environmental Research and Consultancy, C/Convenio 11-trasera, 48340 Amorebieta-Etxano, Biscay, Spain
[c] Environment Department of the Regional Government of Biscay, Alameda Rekalde, 30, 4, Planta, 48009 Bilbao, Bizkaia, Spain

ARTICLE INFO

Article history:
Received 28 September 2014
Received in revised form 22 February 2015
Accepted 14 March 2015

Keywords:
Ecosystem services
Scale mismatch
Ecological footprint
Land use policy
Basque Country

ABSTRACT

Currently, trade enables regions to have a higher provisioning ecosystem services (ES) demand than that provided by ecosystems in the same region. This practice leads to a supply and demand provisioning ES scale mismatch, which may affect the provision of other ES. To address such an issue from the sub-national scale, an ES approach implementation step to provide realistic, context-specific pathways toward sustainability is necessary. This paper provides a detailed quantitative assessment of ecosystem services over time in Biscay, Basque Country, Spain. The aim is to identify ways of balancing the local provisioning ecosystem service supply and demand and to enhance sustainable land use. We studied the ecological footprint evolution of the province for 11 years and its relation to ecosystem services. We determined that the replacement of the current forest plantations' monocultures to a multifunctional landscape reinforces food security and enhances biodiversity and essential ES. This place-based ecosystem services assessment, which integrates ecological footprint calculations into an ecosystem service framework, demonstrated that provisioning ES-scale mismatches may be confronted locally by implementing sustainable landscape management strategies, including actions focusing on the supply and demand of ES. The current globalised economy promotes a global reduction in ecosystem integrity and ecosystem services. Reducing the ecological footprint at the local scale would contribute to the reduction of provisioning ecosystem services' demand at the global scale. Thus, maximising a mosaic approach to land use locally would help improve the provision of ecosystem services and therefore also contribute to the global footprint reduction.

Introduction

Ecosystem services (ES) are the conditions and processes by which natural ecosystems and the species that they comprise, sustain and fulfil human life (Daily, 1997). The Millennium Ecosystem Assessment (MA) (2005) explored the link between human well-being and the status of ecosystems and their sustainable use. This assessment focused on how ecosystem changes have affected, are affecting and will affect human well-being. It demonstrated that although the use of ecosystems has led to an increase in human well-being, some advances have been made at the cost of other services that are essential for human well-being (Millennium Ecosystem Assessment (MA), 2005).

The MA preceded many scientific, social and political concern on ES and the relevance of their sustainable use at different scales (e.g., Fisher et al., 2009; Perrings et al., 2011). Despite academic progress, many important issues regarding sustainability need to be further developed for the implementation of ecosystem services assessments, such as the current ES demand and supply scale mismatch (Burkhard et al., 2012) (We use the term mismatch here to explain the imbalance between the supply of resources and the societal demand in industrialised societies). Trade, through imports, enables regions to increase consumption levels without increasing pressure on domestic ecosystem services, but results in impacts elsewhere (Kastner et al., 2014). The scale mismatch occurring in many industrialised regions between the supply and demand of ES is especially important for provisioning ecosystem services (e.g., food, fibre, energy, raw materials), which have been

* Corresponding author. Tel.: +34 946018382.
E-mail addresses: igone.palacios@ehu.es (I. Palacios-Agundez), miren.onaindia@ehu.es (M. Onaindia), ekos@ekos-eeco.com (P. Barraqueta), iosu.madariaga@bizkaia.net (I. Madariaga).

http://dx.doi.org/10.1016/j.landusepol.2015.03.012
0264-8377/

historically managed as commodities traded in markets (Viglizzo et al., 2012). In the current globalised economy, trade allows some regions to have a higher provisioning ecosystem services demand than that provided by ecosystems in the same region, promoting a global reduction in ecosystem integrity and ecosystem services. Regulating ecosystem services, on the contrary, with some notable exceptions, such as global climate regulation, are often characterised by physically connected areas of supply and demand (Burkhard et al., 2012). Similarly, cultural ecosystem services are mostly site specific (e.g., Otero-Rozas et al., 2013), even if the interpretation of the cultural ES demand side is more complex because of human perceptions (Kumar and Kumar, 2008) and, for example, the scale mismatch related to the satisfaction obtained from the existing value of cultural ES is not easy to track.

Despite the agreement about the importance of including ecosystem service demand-side issues in ES assessments (McDonald, 2009; Anton et al., 2010), there are few ES assessments (the UK-NEA are exceptions, Weighell, 2011) that incorporate provisioning ecosystem service supply and demand scale mismatches. Additionally, there is a lack of place-based assessments that analyse how confronting the provisioning ES demand locally may influence other local ecosystem services. A place-based approach can help us understand issues regarding natural capital, multi-functionality, and the role of landscape in framing debates concerning ecosystem services and sustainability (Potschin and Haines-Young, 2013). For the recently established Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), studies on synergies and trade-offs between ES at the local scale are required. The research community needs to move toward solution-oriented research to provide realistic, context-specific sustainability pathways (DeFries et al., 2012).

An indicator that analyses the interaction between goods production and consumption and shows the intensity of human impact on them is the ecological footprint. The ecological footprint indicator is an estimation of resource consumption and waste assimilation requirements of a defined human population in terms of corresponding productive land area (Wackernagel and Rees, 1996). Ecological footprint calculations can be directly related to human consumption patterns and, therefore, identify benchmarks of sustainable activities (Jenerettea et al., 2006). In fact, they quantify human–ecosystem relationships by estimating the land area required to sustainably supply the ecosystem services consumed (Wackernagel and Rees, 1996). In other words, the ecological footprint represents the demand for ecosystem products and services in terms of the appropriation of various land use types (Borucke et al., 2013).

These two prominent approaches, the ecosystem services approach and ecological footprint calculations or accounts (which relate the ecological footprint to the bio-capacity), link the production of ecosystem services with their consumption by societies (Jenerettea et al., 2006). The aim shared by these approaches is to promote the sustainable use of goods and products provided by nature or, in other words, ecosystem services. However, the integration of these perspectives rarely has been applied, perhaps because of the different conceptual framework and the distinct units used in the two approaches. The integration of the ecosystem services approach and an ecological footprint analysis into a coherent analysis could help inform sustainable guidelines for a more sustainable management of goods' supply and demand. We combined these two approaches to better understand the variation on demand and supply of ecosystem products or services in relation to land management.

Local policy makers involved in the Millennium Ecosystem Assessment in the Biscay-Basque Country Sub-National Ecosystem Services Assessment, considering local stakeholders' perceptions and in agreement with the Local Agenda 21 action plan, demanded more information on Biscay's recent provisioning ecosystem service supply and demand evolution (Onaindia et al., 2015). The current demand for provisioning ES in the province is high, but arable land covers less than 1% of Biscay and grassland covers 20% (Fig. 1). Accounting for the data requirements of local policy makers, we performed a detailed quantitative assessment of provisioning ecosystem service supply and demand of Biscay for eleven years. Time trends are valuable to document the human use of natural capital, providing effective support in assisting decision makers (Wackernagel et al., 2004a). The aim of this study is threefold: first, to track the interactions of different provisioning ecosystem service supply and demand over time; second, to analyse how actions towards an appropriate balance of the local provisioning ecosystem service supply and demand may influence biodiversity and other ES; and finally, to help sub-national policy makers identify suitable landscape management strategies that favour such a balance and to enhance synergies with biodiversity and other ES. To accomplish these objectives, we studied the ecological footprint evolution of Biscay from 2000 to 2010. This accounting tool enables the analyses of the provisioning ecosystem services consumed by a given population during a concrete period with regards to the productivity available in the same area and period (Borucke et al., 2013). This approach visualises the possible provisioning ecosystem service supply and demand scale mismatches and links local actions to global socio-ecological and sustainability issues (Aall and Norland, 2005; Collins et al., 2006).

Methods

Study area

This study was performed in Biscay (2213 km^2; 1.2 million inhabitants), northern Spain (43°46′–42°92′N, 03°45′–02°40′W), in the Basque Country (Fig. 1). Its high population density, focused in the river estuaries, is a consequence of the heavy industrialisation that Biscay underwent during the nineteenth and early twentieth centuries. Iron-based economic development characterised the social and economic development of the region until the beginning of the 1990s. Biscay then underwent a profound transformation. The industry sector evolved toward a new type of industry in which the service sector was clearly strengthened (e.g., currently covers 72% of the total Gross Domestic Product-GDP, Eustat: Basque Statistics Office, 2013).

The industrialisation period entailed high rural land abandonment after which an important transformation process occurred in the rural sector. To confront the rural crisis, reforestation with exotic tree species was promoted (Groome, 1990, Madariaga et al., 2011). Currently, more than half of the land surface in Biscay (59%) is dominated by forest, predominantly exotic plantations (*Pinus radiata* and *Eucalyptus* sp., 39 and 5% of the area, respectively), but arable land covers less than 1% and grassland covers 20% of the study area (Fig. 1). Typically, logging occurs every 30–35 years for coniferous plantations and every 15 years for *Eucalyptus* sp. The primary natural forest types in Biscay are Cantabrian evergreen-oak forests (*Quercus ilex*), mixed oak forests (*Quercus robur*) and beech forests (*Fagus sylvatica*). These forests represent the potential vegetation of approximately 80% of the region, but they currently only cover 13% of the area (Fig. 1). The current Biscay landscape is dominated by monoculture forest plantations, and the traditional Basque multifunctional countryside mosaic landscape has been severely reduced. These monoculture plantations, with fast-growing exotic tree species and aggressive forms of management, are associated with a series of environmental problems, such as soil erosion, soil compaction, nutrient loss, turbidity and supply of surface water, and biodiversity loss (Amezaga and Onaindia, 1997; Merino et al., 2004; Santos et al., 2006; Leslie et al., 2012).