Landscape and Urban Planning 132 (2014) 102–110

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Research Paper

Ecosystem service trade-offs from supply to social demand: A landscape-scale spatial analysis

Antonio J. Castro[a,b,*], Peter H. Verburg[c], Berta Martín-López[d], Marina Garcia-Llorente[d,e], Javier Cabello[a], Caryn C. Vaughn[b], Enrique López[a]

[a] Andalusian Center for the Assessment and Monitoring of Global Change (CAESCG), Universidad de Almería, , Ctra. Sacramento s/n, La Cañada de San Urbano, 04120 Almería, Spain
[b] Oklahoma Biological Survey, Department of Biology & Ecology and Evolutionary Biology Graduate Program, University of Oklahoma, Norman, OK, USA
[c] Institute for Environmental Studies, Amsterdam Global Change Institute, VU University Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands
[d] Social-Ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid, C. Darwin, 2, Edificio de Biología, 28049 Madrid, Spain
[e] Sociology of Climate Change and Sustainable Development Research Group, Department of Social Analysis, University Carlos III, 28903 Madrid, Spain

HIGHLIGHTS

- Supply and demand of ecosystem services are analyzed across different landscape units.
- Spatial mismatches between the biophysical, socio-cultural and economic value of ecosystem services are identified.
- High mountain and coastal platform units show the highest discrepancies.
- Different value-dimensions of ecosystem services give complementary information for landscape planning.

ARTICLE INFO

Article history:
Received 31 May 2014
Received in revised form 8 August 2014
Accepted 11 August 2014
Available online 7 September 2014

Keywords:
Stakeholder
Biophysical indicator
Contingent valuation
Landscape unit
Social preference
Spain
Drylands

ABSTRACT

Quantitative studies that assess and map the relationship between the supply and social demand of ecosystem services are scarce. Here we address both supply and social demand sides by spatially analyzing ecosystem service trade-offs from three value-dimensions – i.e., biophysical, socio-cultural and economic, and across different landscape units in southeast Spain. To accomplish this goal, within different landscape units, we quantify the supply side by mapping the biophysical values of five ecosystem services, and the social demand exploring their socio-cultural and economic values by analyzing social preferences and contingent valuation methods, respectively. Our results show that the assessments of ecosystem services using different value-dimensions are complementary and useful for (1) identifying ecosystem service trade-offs, both on the supply- and on the social demand-side, and (2) analyzing spatial mismatches among the three value-dimensions of ecosystem services. We also believe that our approach facilitates the exploration of ecosystem services trade-offs on a spatial landscape scale, and results can be used by managers to identify areas in which services are declining or priority areas for conservation based on maximizing ecosystem services, and will be useful in detecting potential conflicts associated with new management and planning practices.

1. Introduction

Over the past two decades, the ecosystem service concept, i.e., benefits that humans obtain from ecosystems (MA, 2005), has gained importance among scientists, managers and policy-makers worldwide as a way to communicate societal dependence on ecological life support systems that integrate perspectives from both the natural and social sciences. While researchers from different disciplines including ecology, geography and economics have begun to address ecosystem services (e.g., Turner, Morse-Jones, & Fisher, 2010; Verburg, Koomen, Hilferink, Pérez-Soba, & Lesschen, 2012; Willemen, Hein, & Verburg, 2010; Willemen, Veldkamp, Leemans, Hein, & Verburg, 2012), studies combining disciplines are uncommon (Müller, Burkhard, & Kroll, 2010). However,

* Corresponding author at: Oklahoma Biological Survey, Department of Biology & Ecology and Evolutionary Biology Graduate Program, University of Oklahoma, Norman, OK, USA. Tel.: +1 4054205115.
E-mail addresses: acastro@ual.es, acastro@ou.edu (A.J. Castro).

http://dx.doi.org/10.1016/j.landurbplan.2014.08.009
0169-2046/

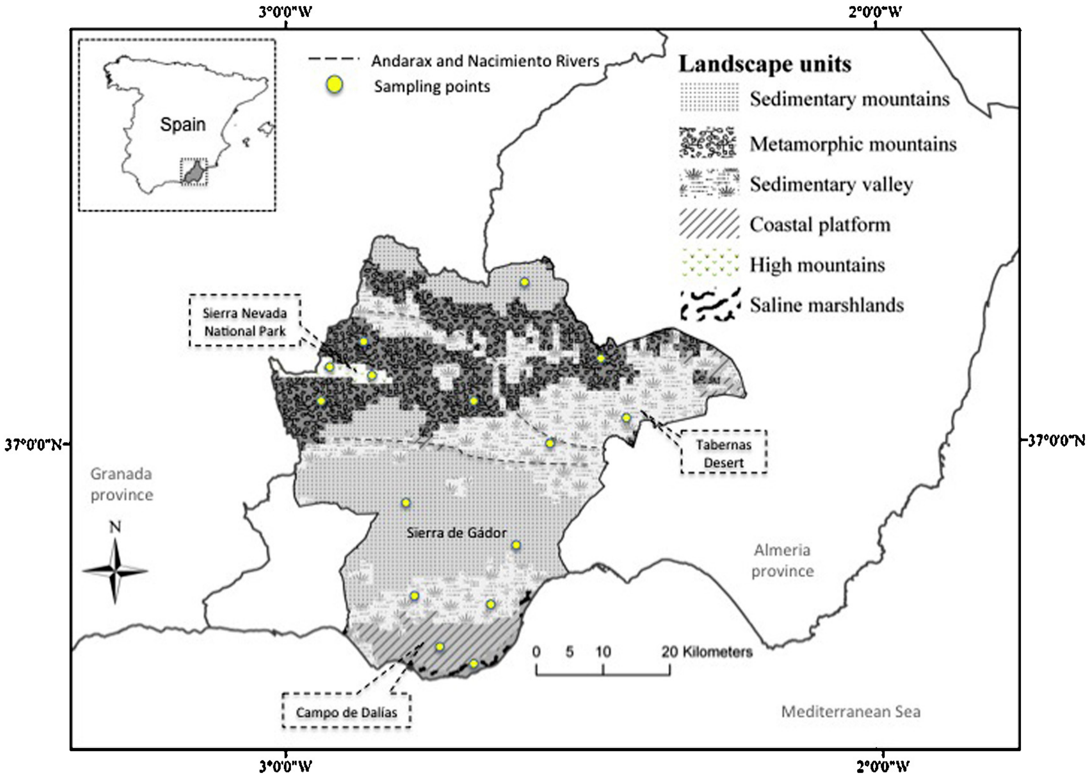

Fig. 1. (a) Map of the area and landscape units. Sample points of the socio-cultural and economic valuation surveys are shown.

interdisciplinary approaches examining ecosystem services are greatly needed because accurate quantification of these services requires spatially mapping the biophysical, socio-cultural and economic values of services (Chan, Satterfield, & Goldstein, 2012; de Groot, Wilson, & Boumans, 2002).

A challenge in ecosystem services research is to identify an ecosystem's capacity to provide services (supply side) and the social demand for those services (demand side) (Martín-López, Gómez-Baggethun, García-Llorente, & Montes, 2014). Addressing both of these sides demonstrates that the status of an ecosystem service is influenced not only by an ecosystem's properties but also by societal needs (Castro, García-Llorente, Martín-López, Palomo, & Iniesta-Arandía, 2013). Burkhard, Kroll, Nedkov, and Müller (2012) defined supply side as the capacity of a particular area to provide ecosystem services, and demand side as the sum of ecosystem services currently consumed, used, or valued in a particular area over a given time period. Martín-López et al. (2014) recently developed an approach for quantifying ecosystem services that spans both supply and demand-side services. Using this approach, the supply-side can be measured as biophysical indicators, such as hectolitres of water supplied or tons of carbon sequestered by ecosystems. Social demand can be valued using non-monetary indicators including assessment of people's perceptions of the importance of different services (Martín-López et al., 2012) or using economic valuation techniques in real or hypothetical markets (Turner et al., 2010). The combination of these different approaches can provide an integrative methodological framework for assessing ecosystem services (Tallis & Polasky, 2009).

Ecosystem services that are provided, and thus trade-offs among those services, will vary with different landscapes. Thus, it is important to examine the role of landscape in identifying trade-offs. Our goal was to identify ecosystem service trade-offs across landscapes by estimating their biophysical, socio-cultural, and economic values. For six different landscape units in southern Spain, we mapped the spatial variation of the biophysical values of five ecosystem services (supply side). Then, based on a previous study by Castro et al. (2011), we explored their socio-cultural and economic values through social preferences analysis and contingent valuation methods respectively (social demand side). Following the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2013), we examined one provisioning (cultivated crops through agricultural production) and four regulating (climate regulation through carbon stocks, water flow maintenance through groundwater recharge, control of erosion through soil loss, and maintaining habitats based on potential habitat area for threatened species) services. We did not include cultural services due to the difficulty in accurately quantifying their biophysical and economic values (Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013).

2. Study area

Our study was conducted in eastern Andalusia in the southeastern Iberian Peninsula and covers approximately 28% (2459 km^2) of Almeria province (8774 km^2, 700.000 inhabitants, 79.7 inhab/km^2) (Fig. 1). Approximately a third of the province is protected, including mountains, coastal regions and agricultural lands. Almeria is semiarid and considered one of the driest regions in Europe (Armas, Miranda, Padilla, & Pugnaire, 2011), with average rainfall of 250 mm per year (Castro et al., 2011). Winter temperatures vary between 12 and 15 °C, and average summer temperatures are as high as 40 °C (Lázaro, Rodrigo, Gutierrez Carretero, Domingo, & Puigdefábregas, 2001).

We used Metzger, Bunce, Jongman, Mücher, and Watkins' (2005) approach to map six ecologically homogeneous landscape units in the study area that differed from their surroundings based on a previous landscape stratification of Andalusia (Montes, Borja, Bravo, & Moreira, 1998; Fig. 1). Landscape units were: (1) sedimentary mountains (average altitude 1210 meters above sea level (masl), annual mean rainfall of 331 mm, and an annual mean temperature of 13.5 °C), (2) metamorphic mountains (average altitude