



# Mapping ecosystem services' values: Current practice and future prospects



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## ABSTRACT

Mapping of ecosystem services' (ESS) values means valuing ESS in monetary terms across a relatively large geographical area and assessing how values vary across space. Thereby, mapping of ESS values reveals additional information as compared to traditional site-specific ESS valuation, which is beneficial for designing land use policies for maintaining ESS supply.

Since the well-known article by Costanza et al. (1997), who mapped global ESS values, the number of publications mapping ESS values has grown exponentially, with almost 60% being published after 2007. Within this paper, we analyse and review articles that map ESS values. Our findings show that methodologies, in particular how spatial variations of ESS values are estimated, their spatial scope, rational and ESS focus differ widely. Still, most case studies rely on relatively simplistic approaches using land use/cover data as a proxy for ESS supply and its values. However, a tendency exists towards more sophisticated methodologies using the ESS models and value functions, which integrate a variety of spatial variables and which are validated against primary data.

Based on our findings, we identify current practices and developments in the mapping of ESS values and provide guidelines and recommendations for future applications and research.

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## 1. Introduction

The framework of ecosystem services (ESS) is widely used for communicating links between ecosystems and human well-being (MA, 2005). Manifold studies aim to integrate ESS assessments into decision making processes (TEEB, 2010; UK NEA, 2011).

The economic value (i.e., contribution to human welfare) of an ESS is, as with any good or service, determined by its supply and demand. The supply side of an ESS is largely determined by ecological processes and characteristics (e.g., functioning, fragmentation, productivity, resilience or climate) that may be influenced by human activities, either deliberately or inadvertently. The understanding and modelling of the supply of ESS has largely been taken up by natural scientists (e.g., ecologists, geographers, hydrologists). The demand side is largely determined by the characteristics of human beneficiaries of the ESS (population, preferences, distance to

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resource etc.). The understanding and modelling of the demand side has largely been taken up by economists. It has been recognised that the determinants of both, the supply and demand of ESS, are spatially variable, which makes the assessment of ESS values inherently spatial. In recent years, a growing body of literature assesses ESS spatially by producing digital maps either of ESS supply or its value. In particular, the mapping of monetary values for ESS value has become an active research topic in recent years (Troy and Wilson, 2006; Maes et al., 2011a). In this paper we review studies that map monetary values of ESS. We define mapping of ESS values as the valuation of ESS in monetary terms across a relatively large geographical area that includes the examination of how values vary across space.<sup>1</sup> Thereby, mapping of ESS values reveals additional information as compared to traditional site-specific ESS valuation, which is beneficial for designing efficient policies and institutions for maintaining ESS supply.

To some extent spatial issues have been disregarded in environmental and resource economics, including ESS valuation, but have attracted increasing attention with the emergence of advanced GIS technology in the 90's (Bockstael, 1996). The first studies to map ESS values examine recreational values for Welsh forests (Bateman et al., 1995) and multiple ESS across a protected area in Belize (Eade and Moran, 1996). A milestone in this development is the well-known paper by Costanza et al. (1997), in which global ESS values are mapped. This paper raised a lot of attention and initiated a debate on value mapping in general and on the meaningfulness of aggregate global values. Since then, the number of publications mapping ESS values has grown exponentially, with almost 60% being published after 2007 (see Fig. 1). The methodologies applied in these studies differ widely, in particular with respect to how spatial variation in ESS values is estimated. The precision and accuracy of mapped ESS values has been questioned, and accordingly the utility for policy guidance. However, no consensus has been reached on which methods can and should be used to inform specific policy contexts (De Groot et al., 2010). Until now, no comprehensive review of the literature on mapping ESS values has been conducted.

Within this paper, we review all peer reviewed journal articles published before 2012 that map monetary ESS values. Articles were obtained by searching the SCOPUS, Science Direct and Google scholar databases with various key word combinations and by scanning the references of all relevant papers. In total, we obtained 384 articles of which 143 map ESS. We excluded all studies from the review that map only ESS supply (54) and that map non-monetary ESS values (20), because non-monetary valuation follows a different theoretical framework and applies a different set of valuation techniques. We analysed the remaining 69 articles and reviewed them according to the methodologies used for ESS quantification and valuation, the ESS assessed, study rationale and case study area characteristics. The purpose of this review is to identify current practices and developments in the mapping of monetary ESS values with a view to providing recommendations for future applications and research.

The paper is organised as follows: in Section 2 we give an overview of the rationale and contribution of ESS value mapping to ESS research and policy making. Section 3 gives a quantitative review of general study characteristics, such as location, scale of analysis, and ecosystems and ESS addressed. In Section 4, different methodologies used for mapping ESS values are analysed and studies are classified within a methodology matrix. We discuss evidence on the accuracy of current value mapping exercises and

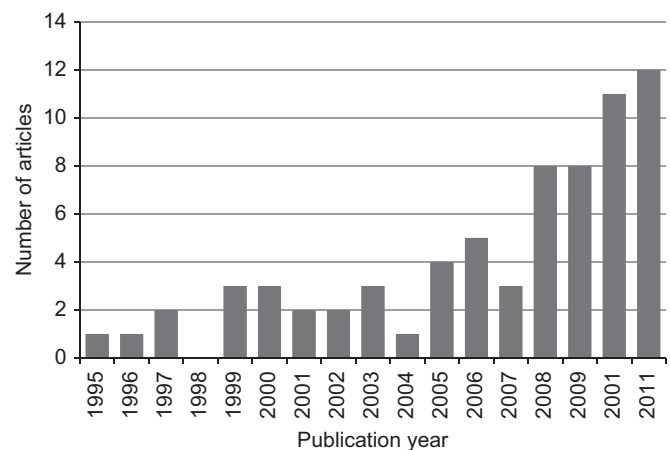


Fig. 1. Published articles per year.

evaluate the different methodologies. In Section 5, we give an outlook on future prospects and avenues for development. Finally, Section 6 provides some conclusions.

## 2. Why map values?

Natural ecosystems produce various ESS, which strongly contribute to human well-being (TEEB, 2010; MA, 2005). Nevertheless, due to the public good characteristics of many ecosystems and their vulnerability to externalities, such as air, soil and water contamination, the costs of ecosystem degradation are not sufficiently incorporated into individual or public decision-making. As a result, ecosystems in all parts of the world are being degraded to a suboptimal extent, causing loss of ESS supply. Various national and supranational policies have been introduced to protect natural ecosystems, which have only been partially effective (e.g. Ramsar Convention on wetlands of international importance; Convention on Biological Diversity 2010 target). Reversing the degradation of ecosystems requires “significant changes in policies, institutions, and practices that are not currently under way” (MA, 2005).

One of the main challenges in designing effective policies derives from the complexity of integrating multidimensional environmental impacts into decision making processes. Typically, decisions are based mainly on information that is well understood and known with high certainty, for example information on readily observable financial or market transactions. Ecological externalities are typically insufficiently considered because of uncertain estimates regarding expected impacts, difficulties in interpreting results from various disciplines and difficulties in translating impacts into changes in social welfare. Monetary valuation of ESS is a method to overcome such difficulties. It enables the aggregation of multidimensional costs and benefits of alternative measures within a one-dimensional welfare measure (Pearce et al., 2006). Although the practice of monetary valuation and its underlying framework are subject to debate and criticism (Spash and Carter, 2001; Sagoff, 2004), the concept of monetary valuation and cost-benefit analysis is widely accepted and subject to intensive research activity.

The estimation of accurate ESS values, however, is not straightforward, in part due to spatial heterogeneity in biophysical and socioeconomic conditions. The spatial perspective of variation in ESS values is relatively new and has not been extensively researched. Insufficient knowledge exists about how ESS values differ across space and what their spatial determinants are (Bockstael, 1996; Bateman et al., 2002; Plummer, 2009; De

<sup>1</sup> The literature that we examine does therefore not only include studies that produce graphical value maps but also includes analyses that explicitly address spatial variability in values.

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