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Mapping cultural ecosystem services: Connecting visual landscape quality to cost estimations for enhanced services provision

F. Ungaro[a,b,*], K. Häfner[b], I. Zasada[b], A. Piorr[b]

[a] National Research Council, Institute for Biometeorology (CNR Ibimet) Via Madonna del Piano 10, 50019 Sesto F. no, Italy
[b] Leibniz Centre for Agricultural Landscape Research (ZALF), Institute of Socio-Economics, Eberswalder Str. 84, 15374 Müncheberg, Germany

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ABSTRACT

This paper presents a methodology to map demand for cultural ecosystem services assessed via a visual choice experiment approach aimed to estimate the contributions of different landscape elements to the overall landscape preference in a case study region in North-East Germany. The levels of four landscape attributes, i.e. green linear elements, green point elements, livestock and crop diversity are mapped over 100 m regular square grid, which allows identifying priority areas for local landscape management from an aesthetic perspective. Taking into account local conditions, target thresholds were set in terms of optimal probability of occurrence for linear and point elements in order to enhance cultural services supply. For the whole area an average potential increase in attractiveness of nearly 24% was estimated, resulting from the increase of both point and linear elements. Likewise, an average potential loss of 23% in attractiveness results from the removal of landscape elements down to the reference median thresholds. As the increment in linear element probability was mapped, the associated density increase and preference score were calculated. The related costs were estimated and mapped as well. Setting local reference thresholds equal to the observed median frequencies results in an estimated increase in linear elements of ca. 43 km. Depending on the element types, total costs are estimated between 389 and 842 k€, respectively 15–30 € ha^{-1}. Costs in terms of increased landscape attractiveness, expressed in utility class score, are estimated as well. The findings are discussed in a planning and policy intervention context.

1. Introduction

Cultural ecosystem services refer to "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (Millennium Ecosystem Assessment, 2005). Despite their importance, given their intangibility these benefits have often been overlooked in many assessments because of the many difficulties associated with assessing and mapping them (Feld et al., 2009), and only a few studies addressed explicitly the spatial variations of the provision and demand of cultural services (Hernández-Morcillo et al., 2013). Furthermore, different stakeholders value cultural services in extremely different and often controversial ways, affecting decision making processes, landscape planning and policy formulation even at local level (Grammatikopoulou et al., 2012). Spatial mapping can effectively support such processes as it represents a powerful tool for understanding the socio-cultural realities of landscapes and ecosystems as it enables the localization of potential conflict areas, i.e. cultural services "hotspots" and "coldspots" (Bryan et al., 2010; Plieninger et al., 2013; Ungaro et al., 2014), the comparisons about spatial distribution in different case studies (van Zanten et al., 2016) and improves transparency about trade-offs and costs (Raudsepp-Hearne et al., 2009). It further allows reflection with other services provision (e.g. provisioning and regulating services) and integration of local ecological knowledge. Nevertheless, despite the importance of cultural landscapes (Meeus et al., 1990; European Landscape Convention, 2000; TEEB, 2010) only few available studies presented maps of cultural services of European rural landscapes.

van Berkel and Verburg (2013) for instance linked respondents' appreciation for landscape aesthetic beauty to individual landscape features and to the structure and composition of the whole landscape in western Netherlands. In doing so, they integrated both a spatial quantification and an economic valuation of cultural services for a rural landscape. Plieninger et al. (2013) mapped and quantified cultural ecosystem services at community level in Eastern Saxony (Germany) through a combination of mapping and

* Corresponding author at: National Research Council, Institute for Biometeorology (CNR Ibimet) Via Madonna del Piano 10, 50019 Sesto F. no, Italy. Fax: +49 33432 82 308.
E-mail address: f.ungaro@ibimet.cnr.it (F. Ungaro).

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structured interviews. Their approach combined the participatory mapping of Fagerholm and Käyhkö (2009) with the technique of representation of landscape values and special places proposed by Tyrväinen et al. (2007), i.e. pre-identification and numbering of special sites on the map and their annotation in the questionnaire. Carvalho Ribeiroa et al., (2013) presented a comprehensive spatial framework to translate local scale preferences into regional scale planning settings, developed particularly for the fuzzy landscape settings of the Mediterranean areas. The framework, tested in the Portuguese region of Alentejo, was based on responses from different stakeholder groups in ten municipalities to a photo-based questionnaire aiming at identifying preferences for land cover pattern (based on Corine Land Cover classes). Another common approach to cultural services mapping is to resort to proxies (Egoh et al., 2012), using condition indicators such as the density of tourist attraction per unit area (Raudsepp-Hearne et al., 2009), the presence of facilities for recreation (van Berkel and Verburg 2013; Lovell et al., 2010) or the quantity of public green areas (Barthel et al., 2005), or benefit indicators such as travel costs (Martín-Lopez et al., 2009). Different approaches can be used to represent the spatial distribution of cultural services across a target area and their efficiency is related to a number of factors such as: (i) criteria for delineation, (ii) choice of boundaries, (iii) internal homogeneity of target areas, (iv) spatial heterogeneity of costs and benefits, (v) spatial context(s) addressed. In terms of scale, available studies vary from local to national or even global scale. A recent example at national scale is given by Turner et al. (2014) who made a spatial analysis of 11 ecosystem services at a 10 km × 10 km grid scale covering most of Denmark. The proxies considered to assess the spatial distribution of cultural services were recreation and ecotourism, nature appreciation, sense of place, summer cottages, and hunting. The study highlighted a strong tendency for cultural services to be potentially vulnerable to trade-offs with agricultural provisioning services and regulating and cultural services to be able to form synergies. At the opposite end of the spatial scale, Bieling and Plieninger (2013) explored the potential for tracing visible manifestations of cultural ecosystem services in a field walk-based landscape analysis. Their results provided information on the character, significance, and spatial distribution of cultural services and allowed analysing the correlations among landscape features and ecosystem services bundles.

The first objective of the present study is to analyse in spatially explicit terms the contribution of different landscape attributes to the overall landscape preference from a visual quality of view in a rural area in Eastern Germany, translating preferences for landscape elements into a 2D spatial model. In doing so we considered the distinctive features of the cultural landscapes such as the presence of linear and point elements, the crop mosaic, and the presence of livestock. As a result, the paper presents a map of potential landscape aesthetic attractiveness and a spatially explicit assessment of the contribution of different landscape elements to the potential provision of cultural services in the different spatial contexts of the study area. Secondarily, the spatial mapping results are applied to (i) assess to which extent the removal or the addition of specific landscape elements affect the appreciation of landscape aesthetics, and (ii) to estimate costs of increased landscape attractiveness, as expressed in utility class score for the levels of the considered elements.

2. Material and methods

2.1. Study area

The case study area (576.4 km^2) is located in the Federal State of Brandenburg (North-East Germany), and extends from the eastern fringe of Berlin towards the Oder valley at the German-Polish border, encompassing ten municipalities (Fig. 1). Relief and morphology (elevation ranges between 5.8 m and 144 m a.m.s.l.) are shaped by glacial and peri-glacial geomorphologic processes. As a results the area can be subdivided into six major landscape units (Meynen and Schmithüsen, 1962; Fig. 1), including glacial valleys: (1) Rotes Luch (45.0 km^2, 7.8%) and (2) Buckow Valley (92.0 km^2, 15.6%), ground- and end-moraines plateaus: (3) Lebus Plateau (88.1 km^2, 15.3%), (4) Barnim Plateau (206.6 km^2, 37.8%) and (5) Oberbarnim (88.0 km^2, 15.3%) as well as slope sides: (6) River Oder Valley (45.0 km^2, 7.8%). Forests occupy 39.9% of the total area, agricultural land represents 45.8% of the total area (of which 8.8% is represented by grasslands), artificial surfaces cover 6.5%, and water bodies 2%. 43% of the case study's territory (245 km^2) is subject to a form of nature protection and management, with the Naturpark Märkische Schweiz (205 km^2) as major protection area. Nevertheless, particularly its agricultural areas face various conflicting land use interest, mostly due to intensification of farming practices and field enlargements, with consequent removal of landscape elements and reduction of habitats for biodiversity. Field size ranges between 0.01 and 353 ha (average field size is about 22 ha, N = 1,202), but 50% of the fields is slightly above 5 ha (MIL, 2012). In the paper at hand, we used the subdivisions in municipalities, landscape units and protected vs. non-protected areas to analyse the actual and potential provision of cultural landscape services as related to the visual appreciation of specific landscape elements. This multilevel approach is functional to identify priority areas for local landscape management from an aesthetic perspective, e.g. at municipality level taking into account local condition, i.e. sub-landscape units and environmental protection.

The area is characterised by a remarkable presence of landscape elements, such as linear (hedgerows, tree rows, tree alleys and windbreaks) and point elements (kettle holes, isolated trees, tree groups, riparian woodlands). Currently the total length of the linear elements in the agricultural areas sums up to ca. 275 km, including tree rows (72.7 km), hedgerows and windbreaks (136.2 km) and tree alleys (66.1 km). In addition, there are 604 woodlots, 59 single trees and 474 kettle holes with an area of less than 1 ha (MIL, 2012). More recently, new institutional actors and large land investment companies became more active in the region (Tietz et al., 2013). As a result farming activities are increasingly carried out in larger scale, resulting in field enlargement and intensification of agricultural practices and affecting at the same time landscape structures and elements with significant effects on ecosystem services provision due to removal of landscape elements (Fig. 2). Among the landscape elements of great ecological and aesthetic value, various types of trees still characterise the cultural landscape as linear or point elements. These have been profoundly affected by the agricultural structure changes which challenged their role as ecosystem service supply hotspots in the agricultural landscape, as fields' enlargement and agricultural intensification are often, if not always, coupled with the removal of these elements (Plieninger, 2012).

Along with the nature conservation legislation which are mainly addressing the non-agricultural part of the landscape, there are several landscape management schemes in place to support the protection and development of the cultural landscape, encompassing its structures and element, including agri-environmental measures of the Rural Development framework of the European Common Agricultural Policy (CAP) as well as a regional program for voluntary contractual nature protection (*Vertragsnaturschutz*; MUGV, 2014). These measures cover organic farming (high crop diversity), extensive grassland management with traditional livestock and the maintenance of hedges, fruit tree alleys and orchards in the agricultural landscape (linear and point elements) as well as the protection of kettle holes and surrounding natural vegetation buffers and field margins. The different measures are