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Coupling stakeholder assessments of ecosystem services with biophysical ecosystem properties reveals importance of social contexts

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ABSTRACT

We asked whether different stakeholders perceive ecosystem services in similar ways and how these perceptions relate to measured ecosystem properties. Farmers and conservationists were asked to state (1) their preference for ecosystem services and (2) their perception about the value of several grassland vegetation units in providing these services. Additionally, biophysical parameters were collected on 46 plots. Structural equation models were applied to test which stakeholder perceptions corresponded to the data.

For conservationists, the services regional belonging and soil fertility were related to conservation value, whereas farmers associated them with forage production. Conservationists' perception of forage production was related to biomass removal, groundwater level and income from forage production, whereas farmers focused on the potential of ecosystems to produce forage, rather than the actual land use. The conservation perception of farmers was related to low land use intensity, whereas the conservationists associated it with endangered meadow birds. Conservationists associated carbon sequestration with below-ground peat formation, but farmers with above-ground plant productivity.

We conclude that perceptions of ecosystem services are strongly influenced by social contexts, involving livelihoods, interests and traditions. Use of stakeholder assessments to establish sustainable land management should consider the fact that stakeholders interpret ecosystem services with different meanings.

1. Introduction

Ecosystem services have recently emerged as a powerful inter- and trans-disciplinary approach to assess the benefits people obtain from ecosystems (MEA, 2005; Fisher et al., 2009; Hutchison et al., 2013). A participatory approach involving stakeholders is seen as crucial to evaluate the services from the point of view of their beneficiaries, and so to include local knowledge and societal demands in service assessments and land management decision making (Cowling et al., 2008; Koschke et al., 2012). Common perceptions of ecosystem services of stakeholders from different societal sectors may increase landscape level partnership and identity (Fürst et al., 2014). Therefore, an increasing number of assessments are based on stakeholder perceptions, either for the identification of relevant ecosystem services or the evaluation of suitable management options (Seppelt et al., 2011). However, ecosystem services may have different meanings for different stakeholder groups, depending on their knowledge, professional experience, and socio-economic situations (Lamarque et al., 2011; Martín-López et al., 2012; Orenstein and Groner, 2014). Often, a given ecosystem service represents different ecosystem properties (Buijs et al., 2008; Quétier et al., 2010; Lamarque et al., 2011), which points towards multidimensional cognitive constructs (Law and Wong, 1999; Edwards, 2001; Fischer and Young, 2007).

Stakeholders may be very familiar with services closely linked to their profession. For instance, farmers successfully produce agricultural goods if they are capable of evaluating the ecosystem properties and processes determining agricultural yield. Likewise, conservationists usually have good knowledge of the value of habitats for species protection (Barrera-Bassols and Zinck, 2003; Desbiez et al., 2004; Anadón et al., 2009). On the other hand, regulating services such as water retention or carbon sequestration are hard to assess even by experts (Fang et al., 2007; Eigenbrod et al., 2010). Here we aim at answering the following questions: How are provisioning, regulating and cultural services assessed by local stakeholders? To what extent is there a mutual understanding of services between stakeholders of different societal sectors (Herzon and Mikk, 2007; Lamarque et al., 2011)? How do stakeholder assessments relate to measured ecosystem properties?

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Although most studies address ecosystem assessments either from the biophysical or from the social aspect, some studies have shown how stakeholder perceptions of individual ecosystem functions conform to data measured in the field. For instance, Anadón et al. (2009) showed that shepherds in southeastern Spain could well assess the abundance of terrestrial tortoises. Desbiez et al. (2004) compared soil fertility assessments by Nepalese farmers with measured indicators of soil fertility. There is also a growing number of assessments involving biophysical measurements and questionnaire surveys, each for different services (Andersson et al., 2015; García-Llorente et al., 2015). It has, however, rarely been studied how stakeholder perceptions of services link to the biophysical properties and functions of ecosystems on which service outputs are based (Martín-López et al., 2012; Quétier et al., 2010). In this study, we address this question using a participatory approach, involving local farmers and conservationists (see also Karrasch et al. (2014)) by assessing conservation values (cultural and supporting services), forage production (provisioning service), soil fertility (supporting service), carbon sequestration (regulating service) and regional belonging (cultural service). The assessments were made in the coastal agricultural landscape of northwest Germany.

In agricultural landscapes, farmers and conservationists often hold opposing views on the value of vegetation units for the provision of ecosystem services, particularly agricultural values and species conservation on grasslands and wetlands (Bignal and McCracken, 1996; Kremen and Miles, 2012). This is due to a trade-off between highly productive meadows and pastures, where a few common species are favoured, and semi-natural grasslands, which are less productive and rich in endangered species (Vitousek et al., 1997; Chapin et al., 2000). Farmers have been regarded as a key stakeholder group for the local implementation of conservation management schemes in agricultural landscapes (Siebert et al., 2006; Bugalho et al., 2011). A successful adoption of such schemes depends to a great extent on their knowledge, perception and attitudes about biodiversity and nature conservation (Morris and Potter, 1995; Herzon and Mikk, 2007; Burton et al., 2008).

We used partial least squares structural equation modelling (PLS-SEM) to explore the relationships between the stakeholders' perceptions and ecosystem properties measured in the field. PLS-SEM has been recently introduced into ecological studies (Peppler-Lisbach et al., 2015), though it has been extensively used in social sciences (Serrano-Cinca et al., 2009; Hair et al., 2011; Henseler et al., 2012; Ayeh et al., 2013). It allowed us to use both ordinal assessment data and continuous ecological data without the need of normalizing the variables (Hair et al., 2013).

We expect that conservationists and farmers have different preferences for the ecosystem services, reflecting their professional and social interests. We assume that they have a common understanding of the services, as they have been living and working in the same landscape for a long time. As an alternative, farmers´ and conservationists´ perceptions of certain services may be significantly different, indicated by diverging correlations with measured ecosystem properties. This would point to diverse social contexts strongly affecting stakeholder-based service assessments (Quétier et al., 2010).

2. Methods

2.1. Study site

The study area is located in the municipality of Krummhörn (E 07°02', N 53°27', NW-Germany). It has a mean annual temperature of about 9.4 °C, an elevation ranging from −2.5 to 1.5 m above sea level, and a mean of 823 mm annual rainfall (Wetterdienst, 2012). Most of the landscape is covered by different types of grassland vegetation ranging from salt marshes and reed vegetation to managed grasslands such as wet and fertilized mesic grasslands. Sea walls, so-called dikes, protect the land against storm surges. The salt marshes in front of the dike are exposed to regular inundations with sea water, whereas the land use in the low-lying hinterland is secured by extensive drainage systems (Wolff et al., 2010).

The earlier natural landscape has been intensively modified and drained by human beings for centuries, resulting in today´s coastal cultural landscape (Knottnerus, 2005). For centuries, or even millennia, large areas of the landscape were used rather extensively by farmers as wet grasslands, both, seaward and landward of the dike (Lotze et al., 2005). Although recent land use intensification has eliminated many habitats during the last few decades (Schrautzer et al., 1996), the remaining wetlands have maintained habitat conditions for rare plant and bird species (Plieninger et al., 2006). Use of most salt marshes was abandoned as a consequence of the establishment of the Wadden Sea National Park of Lower Saxony in 1986.

2.2. Stakeholder survey

Stakeholders belonging to the agricultural sector (n=4, Table A1) and to the nature conservation sector (n=7, see Table A1 for affiliations) were invited to contribute to the study in a participatory process, requiring repeated meetings over several years. The stakeholders, termed farmers and conservationists in the following, were introduced to the concepts of both ecosystem services and vegetation units and had the opportunity to extensively discuss these concepts. Subsequently, they were asked to develop own, locally adapted classifications of ecosystem services and landscape units (Table A2). The meetings were accompanied by a scientist (LK), who served as knowledge broker to communicate scientific issues in a comprehensible manner (Reed et al., 2014). The participatory approach ensured that all stakeholders had a common understanding of the landscape units and ecosystem services, so that preferences and rankings were not biased by different understandings of the underlying concepts (see Karrasch and Klenke, (2016); Karrasch et al. (2014) for a more detailed description of the process). Subsequently, farmers and conservationists were asked to state their preferences for four vegetation units and their ecosystem services (scale 0–100). The units were (i) extensively-used wet grasslands, (ii) fertilized and frequently grazed or mown mesic grasslands, (iii) reed vegetation, and (iv) saltmarshes. The services were: forage production, soil fertility, carbon sequestration, conservation value and regional belonging (Milcu et al., 2013). This ranking showed which landscape unit and which ecosystem service were most relevant to the stakeholders. Finally, stakeholders were asked to rank each of the units in terms of their provision or support of the ecosystem services (scale 0–5).

2.3. Biophysical indicators of ecosystem services

Independent of the stakeholder survey, during 2011–2013 we collected biophysical indicators of ecosystem services on plots in the study regions (Table 1). These plots (4 m^2, n=46) were randomly placed in the same vegetation units as assessed by the stakeholders: fertilized intensive grasslands (n: 7), wet extensive grasslands (n: 10), salt marshes (n: 16) and reeds (reed and sedges vegetation; n: 13) (Table A2). Assignment of plots to vegetation units was verified based on interviews with the owners of the site and on vegetation classification.

At each plot, soil samples from each soil horizon down to a depth of 80 cm were collected in March 2012, air dried and sieved. Plant-available potassium (K) and phosphorus (P) were determined by extraction with ammonium lactate-acetic acid at pH 3 (Egnér et al., 1960), atomic absorption spectroscopy and continuous flow analysis (Murphy and Riley, 1962), respectively. Available nitrogen was calculated from the combined nitrate and ammonium values (CFA analysis) for the uppermost soil layer.

In each plot, we recorded groundwater levels fortnightly between March and October of 2012, using a drainage pipe installed vertically in