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Analysis of temporal change in delivery of ecosystem services over 20 years at long term monitoring sites of the UK Environmental Change Network

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ABSTRACT

The drivers and pressures experienced by farmland, forestry and upland sites in the UK Environmental Change Network (ECN) over the last 20 years are reported through the lens of recognised approaches to the assessment of ecosystem service delivery. Temporal trends in ecosystem service delivery were examined using two methods: qualitative narratives and quantitative scoring of ecosystem service delivery according to land cover. While all sites included in this study are within the same national governance unit (i.e. UK), individual local management decisions were the main agents driving change, influenced by EU and national policies. Gradual change in focus from provisioning to cultural ecosystem services was a persistent trend across most sites, and apparent in both methods. There was generally no net loss in regulating services at the sites. The two methods were subjective but as data were not available for the breadth of ecosystem services present at the sites between 1993 and 2012, it was concluded that it is more informative for holistic assessments to draw on qualitative expert opinion than to ignore less quantifiable services such as many of the cultural services.

1. Introduction

The concept of ecosystem services (ES) is increasingly being used to analyse coupled social-ecological systems in order to enhance ecological sustainability and human well-being. The results of such analyses can inform land-use managers, planners and policy makers by providing integrated social, ecological and economic knowledge (Millennium Ecosystem Assessment (MA), 2005; The Economics of Ecosystems and Biodiversity (TEEB), 2010; Sukhdev et al., 2014). The global importance of this concept is evidenced by the creation of the Intergovernmental Panel on Biodiversity and Ecosystem Services – IPBES (Díaz et al., 2015).

Specifically in the UK, the government, in its 2011 White Paper, "The Natural Choice" (Anon, 2011), set the objective: "*to be the first generation to leave the natural environment in a better state than it inherited*". The development of robust indicators and processes for quantifying and mapping natural capital and the ecosystem services which flow from the natural assets is recognised as fundamental in order to achieve this objective.

Development of a consistent framework for measuring and monitoring changes in natural capital and ecosystem services is also an important step towards meeting the EU Biodiversity Targets for 2020. For example, Target 2 (Action 5) states that ecosystems and their services must be maintained and enhanced and requires EU Member States to map and value ES within their national territories. This explicit inclusion of ES in EU conservation legislation imposes a responsibility on member states to consider a wide array of ecosystem services (Maes et al., 2013).

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There is consequentially a high demand for appropriate quantification and spatially explicit methods to conduct practical assessments of ecosystem services and natural capital (Crossman et al., 2013; Burkhard et al., 2013; Alkemade et al., 2014). Several lists of recommended ES indicators have appeared in the literature, e.g. de Groot et al. (2010), Kandziora et al. (2013) and the Common International Classification of Ecosystem Services (CICES 4.3; Haines-Young and Potschin, 2010). The long-term ecosystem research network of Europe (LTER Europe) has also created and tested lists of ES indicators at the local scale (Dick et al., 2011a,b, 2014a). The Environmental Change Network (ECN) in the UK has compared the local assessment with pan-European methodologies (Dick et al., 2014b) and also compared local knowledge with publicly available data (Dick et al., 2013). One focus of the ECN in recent years has been to understand the benefits ecosystem services provide to society and how they have changed over time in order to aid our understanding of human reliance on the natural world and the actions required to ensure we can continue to benefit from these services in the future.

Understanding the effects of management choices, which can change the type, magnitude, and relative mix of services provided by ecosystems – i.e. trade-offs – is a core function of ecosystem assessments (Carpenter et al., 2009). Trade-offs occur when the provision of one ES is reduced as a consequence of increased use of another ES. In some cases, a trade-off may be an explicit choice; but in others, trade-offs arise without premeditation or even awareness that they are taking place. Trade-offs in ES have been classified along three axes: spatial scale, temporal scale, and reversibility (Rodriguez et al., 2006). In this paper we focus on the temporal scale spanning 1993–2012.

Several of the papers within this special issue are concerned primarily with the quantification of change in specific physical, chemical and biological trends at ECN sites over the past two decades, how these interact and what wider conclusions can be drawn regarding the causes and ecological consequences of long-term change (e.g. Monteith et al., this volume; Rose et al., this volume; Sawicka et al., this volume). Particular attention is given to potential regional-scale effects from changes in climate and air pollution identified by recognising common temporal signals across sites. However, while land management at each ECN monitoring site's Targeted Sampling Site (TSS – a 1 ha area used for less destructive sampling) has been held as constant as possible since ECN monitoring began, changes across the wider areas surrounding the TSSs are inevitable over a full 20 years of operation. It is important that such factors are taken into account when attempting to attribute environmental change effects and, in particular, changes in the delivery of ecosystem services, many of which are linked to landscape scale management. With both ES evaluation and land management changes in mind, therefore, ECN site managers met at a workshop to discuss possible approaches to quantifying and categorising changes in the ecosystem services delivered at their sites. It was agreed to adopt both qualitative and quantitative analysis to assess ecosystem services over the years 1993–2012.

The quantitative analysis followed the method proposed by Burkhard et al. (2014) who collected data from different case study applications, international workshops and conferences, the work in the International Association for Landscape Ecology German Region (IALE-D) working group on Ecosystem Services and from the three Ecosystem Services Partnership (ESP) thematic working groups on Indicators, Mapping and Modelling Ecosystem Services. They proposed a method, based on the collated information, while also concluding that a single method would not satisfy all ecosystem service assessments. However, there is a clear need to independently test available and widely acknowledged ES assessment tools and methodologies in order to determine their efficacy.

In this paper we apply the quantitative approach reported in Burkhard et al. (2014), hereafter referred to as the "matrix method", and compare the results with a qualitative analysis across diverse terrestrial sites in the UK. The methods were used at nine ECN sites that have been managed for different purposes: (i) two sites with significant woodland (Alice Holt and Wytham; the latter also encompasses an organic farm), (ii) four farm sites (North Wyke, Rothamsted, Sourhope and Glensaugh) and (iii) three upland sites subject only to light grazing, in addition to tourism pressures (Snowdon, Moor House and Cairngorms).

2. Methods

2.1. Qualitative approach

Following the ECN workshop to discuss the change over 20 years in the delivery of ecosystem services and the possible drivers of change, site managers collated information and described the change in the ecosystem service delivery at their sites in the form of an unstructured written report.

The site managers were well acquainted with the ecosystem service concept and ecosystem service indicators as they were all authors in previous publications identifying indicators (Dick et al., 2011a,b). The majority have been involved in the routine monitoring of their site for between 5 and 10 years and a few since 1993. The nine sites participating in this exercise all had a scientific research purpose to some degree and ranged from the lower altitude grasslands and arable areas of southern England to the uplands of Wales, northern England and the highlands of Scotland (Table 1).

Site managers described important changes in the supply of ecosystem services at their site between 1993 and 2012 and, where appropriate data were available, quantified the magnitude of these changes. They were guided by the ecosystem service assessment conducted in 2009 (Dick et al., 2011a). In that study, indicators for supporting ecosystem services were omitted to avoid double accounting (Dick et al., 2011a). Where necessary, site managers referred to site diaries and research documents, or interviewed people who had been associated with the site in 1993.

ECN site managers also reported the most likely drivers of the changes, as perceived by them. Summary data for each site were tabulated following deductive content analysis (Elo and Kyngäs, 2008). In effect, when change in the structure of the ecosystem was reported this was assigned, where possible, to either a regulating, provisioning or cultural ecosystem service, following the MA typology (MA, 2005) in line with previous analysis of these sites (Dick et al., 2011a). The presentation and associated interpretation of the narrative information for each site was checked at a face-to-face meeting in order to ensure accuracy.

2.2. Semi-quantitative approach

The matrix method reported in Burkhard et al. (2014) was conducted by site managers following the ECN workshop where the method was explained. Essentially, it involved completing a matrix of CORINE land cover class (columns) versus ecosystem service (rows). Each intersection was populated with a value on a 0–5 scale, indicating the degree to which the ecosystem service was provided by the land cover present on the site. Site managers were provided with a spreadsheet containing the CORINE land covers (Bossard et al., 2000; 25 m × 25 m resolution) for their site in the year 2000, and the suggested ecosystem service scores of Burkhard et al. (2014) linked to these assigned land cover categories. They assessed the ecosystem services supplied by their site at two points in time: 1993 and 2012. Site managers again used site diaries and research documents, or conducted interviews with people who had