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Identifying effective approaches for monitoring national natural capital for policy use

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ABSTRACT

In order to effectively manage natural resources at national scales national decision makers require data on the natural capital which supports the delivery of Ecosystem Services (ES). Key data sources used for the provision of national natural capital metrics include Satellite Remote Sensing (SRS), which provides information on land cover at an increasing range of resolutions, and field survey, which can provide very high resolution data on ecosystem components, but is constrained in its potential coverage by resource requirements.

Here we combine spatially representative field data from a historic national survey of Great Britain (Countryside Survey (CS)) with concurrent low resolution SRS data land cover map within modelling frameworks to produce national natural capital metrics.

We present three examples of natural capital metrics; top soil carbon, headwater stream quality and nectar species plant richness which show how highly resolved, but spatially representative field data can be used to significantly enhance the potential of low resolution SRS land cover data for providing national spatial data on natural capital metrics which have been linked to Ecosystem Services (ES). We discuss the role of such metrics in evaluations of ecosystem service provision and areas of further development to improve their utility for stakeholders.

1. Introduction

Even those individuals who rarely step out of the city are entirely reliant on nature to supply their fundamental needs, i.e. breathable air, food, water, energy and shelter. Scientists have been highlighting the threat that globally degrading ecosystems pose for the environmental and economic sustainability of human systems (Daily and Ehrlich, 1992; Arrow et al., 1995). This has resulted in the emergence of the term 'natural capital' (NC) which casts natural resources such as those described above into an economic term 'capital' in order to ensure that nature is valued alongside other forms of capital which contribute to wellbeing. NC underpins the provision of services to humans (Ecosystem Services (ES)).

In the UK, the government set up an independent body, the Natural Capital Committee (NCC) in 2012, to advise the UK Government on how to value nature and to ensure England's 'natural wealth' is managed efficiently and sustainably. Global interest in valuing NC is reflected by the large numbers of businesses signing up to the natural capital coalition's natural capital protocol (Natural Capital Coalition, 2016).

Projects like TEEB (TEEB, 2010) have highlighted the importance of both measuring and monitoring Earth's natural resources over time, in order to enable their effective and sustainable management. The importance of biodiversity in supporting the functioning of ecosystems has led to it being both a key target for monitoring and a political focus for action (Cardinale et al., 2012). For example, EU legislation to protect the environment focuses on improving the status of ecosystems and their biodiversity. Monitoring biodiversity alone fails to capture the multitude of ways in which nature supports human wellbeing, there is therefore a need to provide NC metrics which help us to link NC assets (such as species, ecological communities and freshwater) to each other and to the natural processes which underpin ecosystem functions and service production (Natural Capital Committee, 2014; Maes et al., 2012). All EU countries have thus been tasked with mapping ES at a country level (European Commission, 2011) by 2014. Done well, this is a substantial and complex challenge for science and society, but will

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provide essential information for policy makers and actors seeking to manage resources effectively (Maes et al., 2012). A key part of the challenge is the collection and transformation of robust data on ecosystems into metrics at scales which can influence decision makers (Grêt-Regamey et al., 2014). There have been relatively few attempts to carry out ecosystem service mapping focused on national scales (TEEB, 2010; Hedden-Dunkhorst et al., 2015) including; England (Dales et al., 2014); Spain (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2014); Luxemburg (Liquete and Kleeschulte, 2014 and Becerra-Jurado et al., 2015); Germany (Rabe et al., 2016). The work by Dales et al. (2014) in the UK focused on the use of proxy measures of land cover linked to look up tables associated with land cover types (Burkhard et al., 2009, 2012) to provide measures for ES provision. Other methods used in Spain, Luxembourg and Germany (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2014; Liquete and Kleeschulte, 2014; Becerra-Jurado et al., 2015; Rabe et al., 2016) also used satellite based land cover information to provide information on the extent and locations of different habitat types. The use of habitat monitoring in this way has been identified as a potentially effective way of linking NC assets to service provision (Mace et al., 2015). However, work by Eigenbrod et al. (2010) has shown that attempts to provide measures/maps of NC relating to ES provision may suffer as a result of being based primarily on coarse proxy measures such as land cover. The difference between 'habitat' and 'land cover' may therefore be critical in the identification of methods and metrics which are appropriate for reporting on NC.

Habitats provide a pragmatic link between efforts to conserve populations of individual species and more integrated approaches to landscape-level management (Bunce et al., 2013). As well as including species and ecological communities, habitats reflect interactions between these and their relationships with natural processes. In contrast, land cover is typically information derived from interpretation of spectral imagery from SRS for large areas, including national extents (Morton et al., 2011). The recent launch of the Sentinel satellites and huge steps in data capacity and processing are likely to increase the potential for SRS data to go beyond land cover to more detailed interpretation of habitats and improved NC monitoring (particularly at local to regional scales) in the future. However, given the difficulties encountered in defining habitats consistently (even in the field) (Bunce et al., 2013), there will always be a role for field survey both for detailed monitoring of habitats, as well as for monitoring (the majority of) species and sub-surface soil and water. 'Habitat monitoring' as put forward by Mace et al. (2015), therefore implies the need to go further than merely providing information on land cover.

The challenges of identifying possible methods for producing NC metrics (and other closely related variables) and the associated monitoring which would be required has been the focus of a number of publications, many of which are summarised in Pettorelli et al. (2016). Skidmore et al. (2015) advocate the benefits of using SRS, particularly for global scale, cross-border monitoring of vegetation, but stress the importance of close working between ecologists and users of remote sensing in optimising the potential of such data. Tallis et al. (2012) and the GEO BON Ecosystem Service Working Group (Tallis et al., 2012) have produced a conceptual framework for monitoring trends in ES globally, which is based on numerical modelling combining SRS and field-based monitoring with national statistics data. Many of the concerns about the appropriateness of SRS metrics for ecosystem service (ES) supply or NC monitoring outlined in Pettorelli et al. (2016), relate to interpreting the complexity of relationships between potential measures and ES supply. This relates to a range of SRS metrics which go beyond land cover; including measures such as Net Primary Productivity (from NDVI data) and Land Surface Temperature and Equivalent Water Thickness (Pettorelli et al., 2016). Key concerns surround how SRS metrics can be linked to ES supply at appropriate scales. The challenge is to produce metrics at national scales which relate to SRS metrics but provide us with more useful information about the factors influencing those metrics and hence subsequent ES supply.

The recognised need for robust NC metrics which can provide information on the factors influencing NC at national scales points to the need for aligned nationally representative field and SRS survey. Here we combine spatially representative field data from a historic national survey of Great Britain (Countryside Survey (CS)) with concurrent high resolution SRS land cover map data within modelling frameworks to produce national NC metrics which provide a 'measure' of nature at a national scale. We describe below the field survey design and aligned SRS product which enable this approach together with examples of modelling approaches which have been used for the production of metrics. The metrics demonstrate the potential breadth of metrics which a combined field/SRS approach can enable, and include metrics describing; water quality, bee nectar plant richness and soil carbon. Water quality in headwater streams is an important indicator of the provision of clean water for drinking, household use and recreation. Bee nectar plant richness (here) indicates the resource available in the most extensive habitats across GB for wild bee populations which (aside from managed honeybee colonies), are the most important pollinators of crop monocultures (Klein et al., 2007). Soil C/organic matter storage is important for a wide range of regulating services including mitigation of flooding and climate change. We discuss the constraints and opportunities for the use and evolution of these methodologies and how they fit with policy requirements for information to assist with the effective management of NC for ecosystem service provision.

2. Materials and methods

The dataset which we used to generate NC metrics was the GB Countryside Survey (CS). The survey structure (described below) is integral to its use for the provision of national NC metrics.

2.1. Countryside Survey

CS is a country-scale, long term national monitoring project which has taken place five times: in 1978, 1984, 1990, 2000 and 2007. The relevance of the survey to policy as a means of 'Accounting for Nature' (Haines-Young et al., 2000) was recognised soon after the initial survey resulting in government support for all of the following surveys. The last three surveys incorporated both SRS and field survey data and in 2007 habitats in both parts of the survey were described according to UK Broad Habitat definitions (Jackson, 2000). Both the field and SRS surveys map habitats on a common Ordnance Survey Mastermap framework.

2.1.1. Field survey

The field survey was designed to provide national estimates of metrics relevant to natural resources (Norton et al., 2012), based on a randomly stratified sample of 1 km squares (591 in 2007). The stratification of GB into Institute of Terrestrial Ecology (ITE) land classes which underlie CS, was based on soil, geology and climate variables (Fig. 1) (Bunce et al., 1996); each land class was sampled in relation to its extent. Within each of the sample squares complete habitat and landscape feature mapping and a set of integrated sampling protocols results in the collection of data representative of each of the ITE land classes for the extent and condition of habitats, landscape features, vegetation, soils and freshwater. Sampling protocols, detailed on countrysidesurvey.