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A comparison of ecosystem services mapping tools for their potential to support planning and decision-making on a local scale

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ABSTRACT

The inclusion of an ecosystem services framework into planning and decision-making processes is increasingly being seen as a means to further a better implementation of the Ecosystem Approach and to achieve a more sustainable allocation of resources. Tools are slowly emerging to help scientists and practitioners with mapping ecosystem services. This study reviewed three tools with regard to their potential use as standard tools to be employed in local planning. To this end, an email survey was conducted first to identify the most important criteria practitioners require in an ecosystem services mapping tool. InVEST and EcoServ-GIS were then applied to produce several ecosystem services maps for a small catchment in the Scottish Borders. These maps were compared to already existing maps produced with another method, SENCE. We showed that there can be substantial variations in maps produced with different tools. These reflect the differences between the tools, especially in their requirements for data, their user friendliness and their accuracy. Our comparison highlights that tools so far have had to make a compromise between usability and scientific accuracy, which means that practitioners need to carefully weigh the requirements for a specific project before deciding on the appropriate tool.

1. Introduction

Recognition that human society is directly and indirectly dependent on ecosystem services derived from healthy, functioning ecosystems is not new (see for example: Westman, 1977; Costanza et al., 1998; Pearce, 1998; Potschin and Haines-Young, 2011). However, the acceptance of the potential use of the ecosystem services concept in policy-making and management only gained wider recognition with the articulation of the Ecosystem Approach in the Convention on Biological Diversity's Malawi Principles (CBD, 2000) and the production of the Millennium Ecosystem Assessment in 2005 (MEA, 2005) and, for the UK, the National Ecosystem Assessment in 2011 (UKNEA, 2011).

The potential inclusion of the ecosystem approach into management and policy provides many challenges, not least the need to focus on processes and functions of ecosystems and their interdependencies, in order to ensure long-term sustainability. In addition, as Everard (2012) notes, practical approaches are needed to bridge the gap between principles and policies and to ensure implementation through management and decision-making at regional, national and local scales. A key element of this is the requirement for mapping of ecosystem services as part of the process of sorting complex relationships and functions into manageable entities that can be recognized, described, communicated and, to a certain extent, valued, within a spatially defined context.

Policy makers are increasingly recognizing the potential that mapping ecosystem services might deliver for strategic resource planning, and potential means by which to embed ecosystem services into policies and laws have been proposed, such as for the EU Water Framework Directive (Vlachopoulou et al., 2014). Many projects which include identifying and mapping ecosystem services have now been initiated (see the Ecosystem Knowledge Network (http://ecosystemsknowledge.net/). The Scottish Government for example recently initiated two regional pilot projects as part of their national Land Use Strategy, which centres on very detailed ecosystem service mapping as part of an Ecosystem Approach (for details of the Scottish Borders pilot, see Spray, 2014).

These and other studies have shown the need for reliable maps to enable decision-makers to spatially identify areas that supply ecosystem services, to assess trade-offs and synergies between them, and to prioritize areas for specific and targeted management actions. Maps are also a powerful tool for communication (Fish and Saratsi, 2015; Pagella and Sinclair, no date).

To enable ecosystem services maps to be utilized on a routine basis in decision-making, it is necessary to have proven and

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practical approaches to their assessment and mapping. These also need to be transparent as to their scope and limitations. Preferably, this would include a standard approach, so that decision-makers can rely on the outcomes of their analyses, other stakeholders will feel confident in its outputs, and all will be able to share data as well as experiences.

To this end, tools with a variety of foci, application objectives and approaches are being developed. However, comparative studies to investigate strengths and weaknesses of different tools are still very limited, and almost non-existent on a local scale, so there are only limited resources and experience for practitioners to fall back on.

2. Aims

This study firstly reviews three available ecosystem service mapping tools and then compares them by applying them to the Eddleston Water, a small rural catchment within the Tweed UNESCO HELP Basin in the Scottish Borders, UK. A further element of the study was a survey of potential users of ecosystem service maps to elicit their requirements and desires of an acceptable ecosystem services mapping tool.

The aim of the research was to answer the following questions:

1. What are the requirements of practitioners for a commonly applicable ecosystem services mapping tool?
2. What are strengths and weaknesses of the currently available tools?
3. How can these tools be applied in practice?
4. How can we proceed to further a standard approach or tool for mapping ecosystem services in order to support practitioners?

3. Study context

Although assessing and mapping of ecosystem services has grown in the wake of the Millennium Ecosystem Assessment, most studies develop their own tailor-made methodology, so comparability of results is limited. Eigenbrod et al. (2010) and Seppelt et al. (2011) found that most studies used proxy-based methods and that digital raster land cover maps were mainly used as they are widely available. Look-up tables were used to attribute ecosystem service indicators to particular land cover types. Alarmingly, Eigenbrod et al. (2010) go on to show that land cover proxy-based methods reflect actual distribution of ecosystem services very poorly.

Blackstock et al. (2015) further point out that maps of ecosystem services are only as good as the data available, and the choice of services to be included. In addition to often relying on proxies, they are dependent on the scale, scope and date of data, as well as the accuracy and relevance of the algorithms often used to convert data sets to service maps. Data is often missing and projects tend to map the most tractable services, not the full range (Raymond et al. 2009). In addition, criticisms of the GIS mapping approach and its use in catchment management planning note that it fails to deal with issues of uncertainty and with multiple (and possibly conflicting) perceptions when reduced to single maps (Smith et al., 2013).

Mapping of ecosystem services can go beyond biophysical maps to produce mapping of trade-offs, monetary values or services flows. It is important for decision-making to be able to show how ecosystems will react to change and to allow weighing improvement in one service against deterioration in another. Assigning a monetary value can support such cost–benefit comparisons, especially when applied to services that can be assigned a market value (Cowling et al., 2008). They can also support the design of payment for ecosystem services schemes (Schägner et al., 2013).

Approaches for mapping of ecosystem service flows as well as trade-offs are fairly limited so far (Burkhard et al., 2012, Bagstad et al., 2013a, Raudsepp-Hearne et al., 2010, Ruijs et al., 2013). There are more attempts at mapping monetary values, but most studies (78%) use the simplest approach of unit values, and combine this with land cover proxies to arrive at the ecosystem services' supply and unit values. The errors in this method are considered to be potentially very high (Schägner et al., 2013).

In terms of scale, ecosystem services are most frequently mapped at a regional scale (57%), followed by a national scale (Martínez-Harms and Balvanera, 2012). Fewer studies look at a global or local scale, although a more recent review indicates that there might be a shift towards a local or “municipality” scale (Malinga et al., 2015), meaning that experience is growing for mapping ecosystem services at the scale most important for local decision-making and planning. However, for a routine inclusion, standard tools are needed that local authorities can handle.

GIS-based tools are slowly emerging to help scientists and practitioners with mapping ecosystem services. These tools have mostly been applied to a limited number of case studies (Nelson et al., 2009, Kovacs et al., 2013, Villa et al., 2014, Vigerstol and Aukema, 2011, Bagstad et al., 2013b), but interest is growing to use them more widely and there are more examples of trials in a practical context, e.g. the Scottish Borders National Land Use Pilot Project (Spray, 2014) and the Carse of Stirling Ecosystems Approach Demonstration Project (LUC and STAR, 2014).

4. Methodology

4.1. Requirements for tools

Critical to an evaluation of the acceptability of the maps and tools for use in planning and management is an understanding of what success criteria potential users would chose. We therefore invited a range of practitioners, who between them represented the main users across Scotland, to state what they would be looking for in a tool. A total of 27 persons representing different sector perspectives were directly targeted by email and phone to answer a short questionnaire (for full list of institutions and questions please see Appendix I). From the answers received, key points were identified, classified into categories (accessibility and costs, data requirements, user friendliness, stakeholder engagement, outputs, range, scale, reliability, and others) and then the number of times each category occurred overall in the answers was counted.

4.2. Ecosystem services mapping tool selection

In the context of this study we excluded any tools that were not specifically designed for mapping ecosystem services, even if they might seem to have good potential to map individual services (compare for example Vigerstol and Aukema, 2011). It is assumed that only tools with the explicit aim and ability to map a number of different ecosystem services can in the end deliver a satisfactory common method. We further excluded any tools that are not spatially explicit, were still in the early stages of development, have only been tested very restrictively or have been developed outside the UK and are not free of access (see Bagstad et al. (2013b) for a comparative study of further tools).

After a careful review of a range of potential tools against these considerations, we explored two tools in detail, InVEST and ESS-GIS that were made available to us. A third tool (SENCE),