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Shifting spatial priorities for ecosystem services in Europe following land use change

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ABSTRACT

Policy objectives to maintain ecosystem services are increasingly set. Methods to identify priority areas for ecosystem services can assist in the implementation of such policy objectives. While land use change is an important driver of changes in ecosystem services over time, most prioritization studies do not account for land use change or only assess negative effects. We assessed the effect of land use change on ecosystem services in Europe for a 40-year period and the subsequent consequences for identifying priority areas.

We quantified five services under current and future land use. For both time frames all sites were ranked based on their service provision using Zonation. To assess the sensitivity of the prioritization to land use change we compared the location of priority areas and the level of ecosystem services within priority areas in the two time frames.

Land use change shifts the location of priority areas. Overlap in priority areas over time ranges from 34.8% overlap for the top 1% priority areas to 75.4% overlap for the top 25% priority areas. Moreover, land use change affects the availability of ecosystem services in top priority areas: Compared to current top priority areas, future top ranked priority areas have lower pollination and carbon sequestration capacity. Capacity of erosion control and flood control are stable over time and nature-based tourism increases.

Shifts in priority areas are driven not only by local land use change, but also by land use change in the wider landscape, through connectivity effects and shifts in the relative importance of sites. The real management challenge lies in maintaining ecosystem services within landscapes where production and conservation objectives need to be reconciled and priority areas are affected by both local and landscape wide changes in land use. Moreover, we show that land use change has both local positive and negative effects on ecosystem service priorities, indicating that prioritization studies should not solely incorporate negative effects of land use change.

1. Introduction

Multiple competing demands for land exist, ranging from the production of agricultural and forestry products to the need for recreational spaces and a healthy living environment. Ecosystem Services (ESs) are affected by different facets of land use change including land cover conversion, (de)intensification of land management and changing the spatial arrangement of land cover types (Seppelt et al., 2016). In order to maintain ESs, policies aim to protect land with high values for ESs alongside biodiversity (Convention on Biological Diversity, 2010). To assist implementation of these policies researchers have developed approaches to prioritize areas for services (Cimon-Morin et al., 2013; Remme and Schröter, 2016; Verhagen et al., 2017).

Prioritization analysis ranks landscape units with respect to the occurrence of multiple ESs and is often part of a wider approach for systematic conservation planning, aimed at identifying the most cost-effective protected area network (Moilanen et al., 2009). Priority areas are the highest ranked areas, often identified based on a predefined threshold, together providing the highest amount of ESs. Most prioritization analyses for ESs are based solely on the current state of land use and ESs (Luck et al., 2012). Such analyses, therefore, do not address the maintenance of ESs over time and do not support the development of management strategies to alleviate the impacts of land use change.

Within a conservation planning framework land use change is mostly considered as a threat to ESs (Cimon-Morin et al., 2016; Luck et al., 2012). Land use change can however have both positive and negative effects on ESs. Studies have indicated that for the European Union over time ES capacity increases for some services while decreasing for others, and is driven by changes in climate but especially by changes in land use (Polce et al., 2016; Schröter et al., 2005). At the local and regional level the effect of land use change varied from strongly positive to strongly negative, irrespective of the general trend

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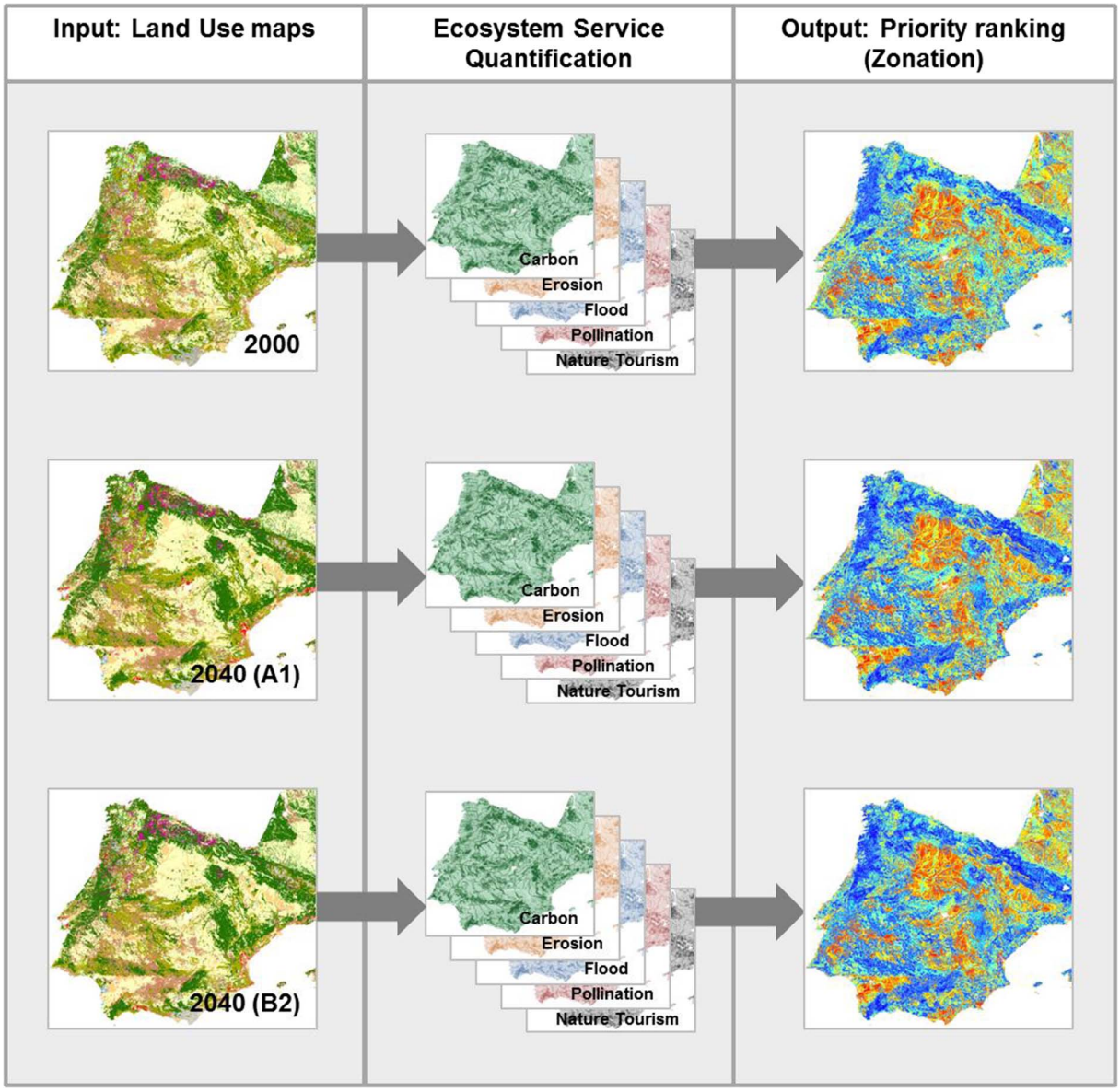

Fig. 1. Schematic overview of the analysis. We have a total of three land use maps which are used as an input to calculate the capacity of five ecosystem services. These ecosystem service maps are the input for the prioritization analysis which results in a full priority ranking of the landscape per experiment. For the prioritization analysis in Zonation the ecosystem service input maps are split by flow zone, meaning that erosion, flood control and pollination each have multiple input maps. The maps presented here are only used for display purposes and do not represent the input or output maps of the analysis.

in ES capacity at the EU level (Metzger et al., 2006; Polce et al., 2016; Schröter et al., 2005; Stürck et al., 2015b). The local effects of land use change on ES capacity depend on the type of land use change, the service considered and the local biophysical context. Prioritization studies should thus account for both positive and negative effects of land use change on ESs.

A number of previous studies have linked land use change to ES models and prioritization techniques. Some studies directly link land use change to the prioritization analysis, without quantifying ESs under future conditions. One example of this are studies that exclude areas from the prioritization network based on projected land use change or development (Cimon-Morin et al., 2016; Troy and Wilson, 2006). Another example thereof are studies that assign positive and negative weights in the prioritization analysis to areas with projected land use change (Luck et al., 2009; Nagendra et al., 2013; Phua and Minowa, 2005; Pouzols et al., 2014; Wendland et al., 2010). The main limitation of these approaches is that the effect of land use change on ESs is often assumed uniform irrespective of the local context. Other studies use the assessment of ESs as an intermediate step in the prioritization analysis. Quantifying ESs under both current and future land use simulations can account for non-uniform responses of ESs to land use change based on local conditions. This type of approach has been mostly used to study the effect of a single land use change process, such as deforestation and urbanization, on future ESs and prioritization (Reyers et al., 2009; Venter et al., 2009). Recently, Fan et al., (2016) prioritized areas in a watershed in Japan for multiple ESs and multiple land use change processes using this approach.

The provision of ESs can depend on local close by or global far-off ecosystems depending on the characteristics of ES flow (Fisher et al., 2009). ES flows are the connections between areas with ES capacity and those with ES demand. Not accounting for ES demand results in the identification of priority areas with high ES capacity but possibly low