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Relevance for decision making of spatially explicit, participatory scenarios for ecosystem services in an area of a high current demand

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ABSTRACT

Participatory ecosystem services scenarios can be used to inform decision making on the sustainable or wise use of biodiversity and ecosystem services (ES). To establish the plausibility and coherency of the recently constructed Biscay participatory scenarios, and to analyze policy options for improving sustainability of land use and the supply of ecosystem services, a spatially explicit analysis of land cover change was carried out. The modelling used an innovative methodology which included feedback from key stakeholders. Our study showed that scenario mapping can be a way of testing the credibility and internal consistency of scenarios, and a methodology for making them more coherent; it was also useful for highlighting land use trade-offs. The sustainability analysis for the ES supply side showed the benefits of promoting two land use/cover trends in the Biscay region: (i) an increase of sustainable arable land in the valley zones to reinforce biocapacity and self-provisioning while preserving agroecosystems' ES flow; and (ii) natural forest regeneration in mountainous and other zones to increase carbon storage and sequestration while enhancing biodiversity and other ES flows. We argue that even if already protected public agro-forest lands may be the best places to start promoting these changes, additional measures are needed to involve private landowners and guarantee changes at a landscape level. Finally, we reflect on the need to make complementary analyses of ES supply and demand as a way of contributing to a broad sustainability agenda.

1. Introduction

Scenarios are descriptions of how the future may plausibly unfold based on a coherent and internally consistent set of assumptions about key driving forces and relationships (MA, 2005a). They explore a range of future changes in ways that recognize and explore uncertainty from the decision-makers' perspective (Vervoort et al., 2014; Henrich et al., 2010). Currently, scenarios are a central component in assessment processes for a range of global issues, including climate change, biodiversity, agriculture and energy (O'Neill and Nakicenovic, 2008). Due to their capability to support the development of proactive management strategies (Wollenberg et al., 2000) and to improve adaptive capacity (Biggs et al., 2007; Vervoort et al., 2014) they have been used in global ecosystem assessments such as the Millennium Ecosystem Assessment (MA) (MA, 2005b), as well as in many Sub-Global Assessments such as the SAFMA assessment (Biggs et al., 2004), the Portugal Assessment (Pereira et al., 2009) or the UK National Ecosystem Assessment and its Follow-on (Haines-Young et al., 2011, 2014). The latter were innovative in terms of creating land use cover maps to illustrate the consequences of the different scenarios.

Scenarios should be plausible, internally consistent and relevant (Henrich et al., 2010; Haines-Young et al., 2014); that is they should be scientifically credible and coherent, and address the kinds of question that stakeholders want to explore. In fact, stakeholders' involvement is crucial to establish both the legitimacy of scenarios, i.e. the degree to which they are based upon our best understanding of what changes are likely and what their effects might be, and their impact, i.e. the degree to which they are found meaningful and are used as a basis for making proactive decisions. This is especially true when they are used to support public decision making (Henrich et al., 2010). In fact,

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the ecosystem approach specifically identifies participation as a means of ensuring the sustainable or wise use of biodiversity and ecosystem services (ES) (Haines-Young and Potschin, 2014). Participatory scenarios within place-based ecosystem approaches may enhance sustainable local or regional planning and facilitate public decision making. Such is the case in the Biscay region, where participatory scenario planning has been carried out as part of the MA in Biscay-Basque Country Sub-Global Assessment (Palacios-Agundez et al., 2013).

In the Biscay Assessment four scenarios were developed: (1) *Oppressed Biscay*, where decisions are made by an authoritarian local government that has a reactive approach to ecosystem management; (2) *Global Delicatessen*, where, although local institutions lose power to global institutions and decisions are made in a reactive way, the region specializes in high-end or 'elitist' agrotourism and local agroecological products; (3) *TechnoFaith*, a consumer society which relies heavily on imported goods and has put its faith in technological solutions, and where multinational corporations have a great deal of power and ecosystems are highly modified; (4) *Cultivating Social Values*, where education, knowledge sharing within society, participation and responsible social actions are key and there is a tendency towards self-provisioning and sustainable production and consumption. Our claim for their relevance is based on the fact that these scenarios were created through a participatory process that involved a representative set of stakeholders (Palacios-Agundez et al., 2013).

The Biscay Scenarios had different developmental paths with regard to indicators of the provision of ES, of human well-being and of biodiversity (Fig. 1). The most favourable scenario for ES and human well-being in Biscay appears to be *Cultivating Social Values*, which seems Pareto efficient with respect to the indicators. However, participants identified major constraints acting against this scenario, given the existing high consumption patterns in the region, as well as land use and population constraints. Moreover, as currently arable land covers less than 1% of the study area, grassland covers 20% and forest plantations cover 44%, self-provisioning alone does not seem wholly feasible and land use trade-offs are likely to occur. During the participatory scenario planning process described in Palacios-Agundez et al. (2013), participants proposed several measures for a more sustainable scenario, focused both on the ES demand side (where behavioural changes were expected to diminish consumption patterns) and on the ES supply side. For the supply side, local stakeholders identified the need for strategic landscape planning and management that would lead to a more sustainable and multifunctional landscape than presently exists (Palacios-Agundez et al., 2013, 2014). Local policy-makers also identified the need to conduct a detailed analysis of supply side ES for sustainable landscape planning. To do so, they asked for further analysis of the Biscay Scenarios' plausibility and coherency with regard to the landscape and to the possible land use trade-offs. The participatory process did not include the use of maps and references to landscape and land use change where therefore descriptive. However, in this paper we analyze the landscape implications of the Biscay Scenarios in a spatially explicit way.

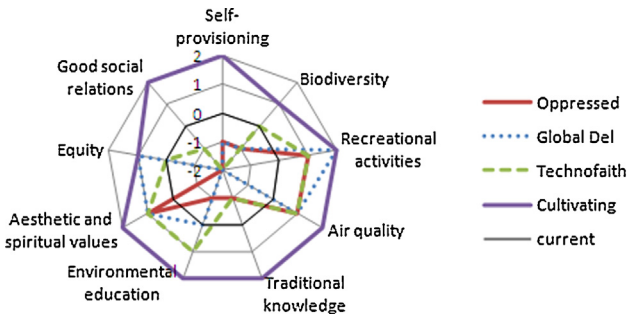

Fig. 1. Evolution of Biscay scenarios for biodiversity, self-provisioning, relevant ES and indicators of human well-being, compared to current conditions (substantial increase = 2; increase = 1; constant or increases in same aspects and decreases in other aspects = 0; decrease = 1; large decrease = 2) (based on Fig. 3 in Palacios-Agundez et al., 2013).

As in other studies (e.g. Thenkabail et al., 2005) we use 'land-use/land-cover' or LULC to refer to mapping of surface cover composed of different categories of land cover (i.e. observed biophysical attributes of the earth's land surface, Lambin et al., 2003) and land use (defined by the purposes for which humans exploit the land cover, Di Gregorio and Jansen, 2000). To enrich the qualitative projections that arose from participatory scenario work, and make them more plausible, coherent and useful for policy-making, we used quantitative projections to model how LULC would change under the different scenarios (cf. Henrich et al., 2010; Vervoort et al., 2014; Haines-Young et al., 2014). This spatial analysis was therefore used to visualize the existing trade-offs in land use while testing the coherency and plausibility of the scenario set.

This paper aims to show how qualitative participatory scenarios can be made relevant to sustainable land use planning, by analysing ES demand and supply and the trade-offs between services. To do this the work sought to: (1) verify the coherency and plausibility of LULC change for each scenario; (2) identify areas likely to experience LULC change; and; (3) analyze the sustainability of scenarios by reference to changes in biocapacity, carbon storage and sequestration. The latter were included because forest management has been identified as a key element for Biscay's future sustainable landscape (Palacios-Agundez et al., 2013, 2014), and because the ecological footprint accounts in Biscay have been shown to be influenced by the carbon footprint in the last eleven years (Palacios-Agundez et al., 2015). To achieve this we used a spatially explicit approach for mapping LULC change and for making the associated ES assessment.

2. Methodology

2.1. Study area

Biscay is located in the north of the Iberian Peninsula (43° 46′–42° 92′ N, 03° 45′-02° 40′ W), in the Basque Country (Fig. 3a). Its high population density (2213 km^2; 1.2 million inhabitants), especially along estuaries, is a consequence of industrialization during the nineteenth and early twentieth centuries. The region is mountainous (with altitudes up to 1500 m and around half the area having slopes exceeding 20°) and the climate is temperate and humid (average temperature 12.5 °C; average rainfall 1200 mm). More than half of the land surface (56%) is forest, mainly exotic plantations (*Pinus radiata* and *Eucalyptus* sp., 39% and 4% respectively), with arable land covering less than 1% and grassland 20% of the study area. The main natural forest types are mixed oak (*Quercus robur*), Cantabrian evergreen-oak (*Quercus ilex*) and beech (*Fagus sylvatica*). They represent the potential natural vegetation (Loidi and Fernández-González, 2012) of approximately 80% of the region, but currently they only cover 13% (Fig. 3; Table C.1 of Appendix A MC3).

2.2. Mapping land cover for 2050 in each scenario

Descriptions of likely changes under each of the scenarios were arrived at through stakeholder engagement, including the use of a questionnaire (answered by 35 participants) and two participatory workshops (39 participants in total) (described in Palacios-Agundez et al., 2013). These descriptions were used to derive