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A quantitative assessment of policy options for no net loss of biodiversity and ecosystem services in the European Union

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ABSTRACT

The Biodiversity Strategy of the European Union includes a target to "ensure no-net-loss of biodiversity and ecosystem services by 2020". Many policy options can be envisioned to achieve such a no-net-loss target, mainly acting on land use and land management. To assess the effectiveness of such policies at a European Union (EU) scale, we simulated land use changes and their impacts on biodiversity and ecosystem services indicators. We analysed a Business–as-Usual scenario, and three no-net-loss scenarios. The no-net-loss scenarios included measures that aim to reduce negative impacts of land use change on biodiversity and ecosystem services, by better implementation of existing biodiversity conservation measures (Scenario 1); and enhancement of existing measures (Scenario 2); and offsetting residual impacts on areas of high biodiversity and ecosystem service value (Scenario 3).

Results show that none of the scenarios achieved overall no-net-loss. Compared to a Business-as-Usual scenario, the no-net-loss scenarios reduced the overall degree of land cover change at EU level, hence reducing impacts on biodiversity and ecosystem services in large parts of the EU. The more comprehensive no-net-loss scenarios resulted in a gain of natural land cover. Moreover, natural areas became better connected, especially in peri-urban areas as a result of impact avoidance and offsetting. Richness of farmland bird species was projected to increase. Measures included in the no-net-loss scenarios had net positive effects on pollination and carbon sequestration, neutral effects on crop production, erosion prevention and flood regulation, and negative effects on nature-based recreation, compared to Business-as-Usual. In particular circumstances policy measures invoked displacement effects in land use allocation, reducing the effectiveness of the measures. This was primarily the case for flood regulation services throughout the EU.

This study differentiates the potential effectiveness of a no-net-loss policy framework in three manners: (i) considering biodiversity and ecosystem services simultaneously; (ii) in the light of existing policies and land use pressures; and (iii) in different land use contexts across the EU. Taken together, we conclude that achieving no-net-loss for biodiversity and ecosystem services throughout the EU remains challenging given high land use demands. Nevertheless, in large parts of Europe there appears room for improvement for certain kinds of biodiversity and ecosystem services compared to Business-as-Usual, while still meeting other land use demands.

1. Introduction

Policies to halt the loss of biodiversity and the degradation of ecosystem services are adopted worldwide (Balmford, 2005). As a contribution to this global effort, the European Union (EU) Biodiversity Strategy aims that "By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems" (Target 2) (European Commission, 2011), which is elaborated into, among others, Action 7 that aims to "ensure no net loss of biodiversity and ecosystem services". In support of this, the European Commission will propose an initiative to ensure there is no net loss of ecosystems and their services (e.g. through compensation or offsetting schemes). No net loss (NNL) can be defined in varying ways, but in the context of the EU's target it is where '*conservation/biodiversity losses in one geographically or otherwise defined area are balanced by a gain*

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elsewhere provided that this principle does not entail any impairment of existing biodiversity as protected by EU nature legislation'.[2]

A recommended framework for achieving NNL in the context of development (e.g. expansion of urban areas or infrastructure, extractive industry activities, forestry and agriculture) is the impact mitigation hierarchy (BBOP, 2009). Following this framework, first, negative impacts on the environment and on biodiversity following development should be *avoided* as much as possible. Second, impacts that cannot be completely avoided should be *reduced* or *minimized* in duration, intensity and/or extent where possible. Third, ecosystems subject to impacts that could not be completely avoided and/or minimized have to be subject to *restoration* measures that e.g. re-establish the ecosystem's structure, composition or function. Finally, residual impacts that cannot be avoided, reduced, or restored, should be addressed through *offsetting*. Offsets are defined as "measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken" (BBOP, 2009). To achieve NNL policy measures and related actions should acknowledge the mitigation hierarchy.

The concept of NNL, and associated instruments to achieve NNL, have received considerable attention in the literature (e.g., Bendor, 2009; Bull et al., 2014; Harper and Quigley, 2005). Although widely criticized (e.g. Maron et al., 2015), biodiversity offsets received more attention than avoidance, reduction, or restoration measures (e.g. Gibbons and Lindenmayer, 2007; Moilanen et al., 2009) as these are of most relevance for conservation objectives and are the focus of most current NNL policies. Moreover, while most studies on NNL focus on species and habitats of highest conservation concern, losses of biodiversity and ecosystem services are not limited to endangered species or protected habitats (Hoffmann et al., 2010), and common species contribute disproportionally to ecosystem biomass and functions (Gaston and Fuller, 2008). Therefore, NNL policies need to be assessed not just in the context of endangered species or habitats, but in the context of a wide spectrum of biodiversity and ecosystem services (e.g. Pilgrim et al., 2013b; Quétier et al., 2015; Van Teeffelen et al., 2014). This was underlined by the EU Environment Council of Ministers[3] who stressed "the importance of further work to operationalise the 'no net loss' objective of the (Biodiversity) Strategy for areas and species not covered by existing EU nature legislation".

Hence there is a need for a better understanding of (i) the effectiveness of a coherent suite of NNL policy options in a particular study area, and (ii) the effectiveness of NNL policy on ecosystem services as well as on biodiversity. Even so, only very few studies assess either of these two aspects, let alone both. Kiesecker et al. (2010) did consider multiple NNL policy options besides offsetting, such as avoidance and minimization, in landscape-level planning. In terms of ecosystem services and NNL, Levrel et al. (2012) assessed the extent to which ecosystem services were considered in current US legislation for marine ecosystems, and concluded that criteria were weakly defined. Vaissière et al. (2013) detected differences in the maintenance costs associated to the compensation of damaged ecosystems, depending on whether regulating, cultural or provisioning ecosystem services were the focus of compensation. Jessop et al. (2015) have empirically assessed ecosystem service supply in 30 mitigation wetlands, identifying trade-offs among services, including biodiversity.

With NNL objectives increasingly being set, including in the EU, it is important to understand how policy measures that follow the mitigation hierarchy are expected to contribute to reaching NNL objectives, and what trade-offs occur among ecosystem services and biodiversity. In this paper, we assess potential changes in biodiversity and ecosystem services in the EU as a result of land use change for a 20-year period, under a set of hierarchical policy scenarios which reflect the mitigation hierarchy. Given that loss of biodiversity and ecosystem services is to a large extent driven by land use changes, we apply an approach based on modelling future land use changes at the European scale, and a subsequent analysis of the impacts of these land use changes. As such, the insights of this study are important because they: 1) show the potential effectiveness of a coherent set of policy options, in a realistic policy and development context; 2) measure effectiveness for a comprehensive set of biodiversity and ecosystem services indicators, beyond threatened species or ecosystems; 3) show how EU policy may play out across the entire EU. This allows insight into spatial trade-offs and displacement effects of policy measures and provides a broad insight into how a generic policy works out in different contexts, such as (peri) urban zones, agricultural landscapes, or high nature value farmland.

2. Methods

2.1. Overview

The analysis presented here comprised four steps. First, four scenarios were developed (Section 2.2). Second, land use changes were simulated with the Dyna-CLUE modelling framework, a high-resolution dynamic land use change allocation model that is widely used to assess potential future land use change trajectories (Verburg et al., 2010). We included 27 European countries (i.e. all Member States of the EU in the period 2007–2013, henceforth referred to as "EU-27") to provide insights on the impact of the scenarios on land use change (Section 2.3). Third, based on these land use change simulations, three biodiversity indicators and six ecosystem service indicators were calculated (Section 2.4). Fourth, the indicators were used to quantify the impact of land use changes on biodiversity and ecosystem services following the analyses described in Section 2.5.

2.2. Policy scenarios

Four policy scenarios were considered, a Business as Usual scenario (BaU) and three no-net-loss scenarios (NNL1, NNL2, NNL3). The no-net-loss scenarios take increasing steps towards the no-net-loss goal in accordance with the mitigation hierarchy (Table 1). Preliminary no-net-loss policy options and scenarios were presented in a workshop in July 2013 where expert views were collected, which were used to further develop the scenarios. Workshop participants comprised 57 experts from ten EU countries representing business interest groups, non-governmental organizations on biodiversity conservation at European and national level, EU and national governments, research institutes, as well as experts on NNL (details are provided by Tucker et al., 2013; Annex 11).

The *Business as Usual (BaU)* scenario assumed a continuation of current trends on demography, resource use, and spatial policies. It assumed an annual population growth of 1.8%, an annual growth of the Gross Domestic Product by 1.5%, no further enlargement of the EU or changes in trade patterns (Lotze-Campen et al., 2013). Product quota and farm payments were set according to the June 2013 proposals for the 2014–2020 Common Agricultural Policy. A 5% share of biofuel in transport fuel was assumed, in line with the proposition for the EU at the time (i.e. 2013). Some spatial restrictions were assumed, including disincentives for the expansion of

[2] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/envir/122950.pdf.

[3] http://data.consilium.europa.eu/doc/document/ST-11249-2011-INIT/en/pdf.