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Developing a methodology for a species-based and spatially explicit indicator for biodiversity on agricultural land in the EU

Koen P. Overmars[a,*], Catharina J.E. Schulp[a,b], Rob Alkemade[a], Peter H. Verburg[b], Arnaud J.A.M. Temme[c], Nancy Omtzigt[b], Joop H.J. Schaminée[d,e]

[a] PBL Netherlands Environmental Assessment Agency, P.O. Box 30314, 2500 GH The Hague, The Netherlands
[b] Institute for Environmental Studies, Amsterdam Global Change Institute, VU University Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands
[c] Chair group of Land Dynamics, Environmental Sciences Group, Wageningen University, Droevendaalsesteeg 3, 6708 PB Wageningen, The Netherlands
[d] Environmental Sciences Group, Alterra - Wageningen University and Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands
[e] Institute for Water and Wetland Research, Radboud University Nijmegen, P.O. Box 9010, 6500 GL Nijmegen, The Netherlands

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ABSTRACT

In Europe agricultural areas are of great importance to biodiversity conservation. One of the aims of the Common Agricultural Policy (CAP) after 2013 is to avoid additional loss of agriculture-related biodiversity. Farmland biodiversity is a public good that provides ecosystem services necessary for the sustainability of agriculture itself as well as for a sustainable environment as a whole. To evaluate policies such as the CAP and to monitor the development of biodiversity in agricultural areas, specifically designed indicators are needed. Current EU-level indicators of agricultural biodiversity are often limited to a specific species group, for example the group of farmland birds, and are not designed for evaluation of future policies. This study presents a methodology for a new indicator that is targeted specifically at biodiversity in agricultural areas, considering a large variety of species and focussing on policy. The methodology combines maps of the potential occurrence of 132 relevant species (plants and vertebrates) on a 50 km grid, with detailed information (1 km grid) on the influence of environmental pressures on these species. A first indicator map on a 1 km grid for the EU is provided, based on available data. This map shows great variety in the state of the biodiversity of agricultural areas in the EU. Generally speaking, biodiversity in agricultural areas in the south and east of the EU is in a better state than in the west and north. However, spatial variability is high between and even within regions. The presented indicator may be used to explore the dynamics of biodiversity following policy interventions, using the biodiversity map or by modelling the effect of policies on the environmental pressures that form the basis of the indicator.

1. Introduction

Europe has an 8000-year agricultural history (Donald et al., 2002). Especially in medieval times large areas were deforested, after an earlier period of clearance in Roman times. Already three centuries ago the majority of current agricultural land was used for agriculture (Klein Goldewijk and Ramankutty, 2004). Because of the historical agricultural expansion a major part of biodiversity in Europe became dependent on agricultural land (Donald et al., 2002). Moreover, species from the Asian steppes and the Mediterranean semi-deserts benefited from the opening of the landscape for agriculture and spread over Europe (Donald et al., 2002). Traditional agricultural practises resulted in highly diverse farmland landscapes (Laiolo et al., 2004), consisting of open areas with extensive grazing or arable farming in combination with shrubs and woodlands. Nowadays a majority of Europe's biodiversity is associated with agricultural land (Reif et al., 2008; Pocock, 2010). Examples of agricultural landscapes with high levels of biodiversity are the large, extensively used grasslands in parts of northern Europe, silvo-pastoral systems in southern Europe (Paracchini et al., 2008) and extensive, often traditionally managed farming systems in mountainous areas (MacDonald et al., 2000). Generally, extensive agricultural systems are important to the biodiversity heritage of Europe. The area of extensive agricultural systems, such as semi-natural grassland, has decreased significantly during the last century, mainly due to conversion of semi-natural grassland into cropland, intensification, and, since the 1950s, abandonment of agricultural land, leading to encroachment by shrubs and trees (Laiolo et al., 2004; Sjödin et al., 2008). Simultaneously, the biodiversity associated with these semi-natural grasslands

* Corresponding author. Present address: Koen Overmars Consultancy, Jansveld 35A, 3512BE Utrecht, The Netherlands. Tel.: +31 06 48010758.
E-mail addresses: koen@koenovermars.nl, koenovermars@hotmail.com (K.P. Overmars).

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and extensive agricultural areas decreased dramatically, which is indicated, for example, by decreasing farmland bird populations (Donald et al., 2002) and plants species (Firbank et al., 2008).

The Common Agricultural Policy (CAP) of the European Union (EU) has long contributed to both intensification and abandonment of agricultural land (Donald et al., 2002), thereby contributing to the decrease in biodiversity in agricultural areas. Intensification results in large-scale agricultural production systems, with only a few species tolerant to high levels of inputs, monotonous landscape and other disturbances, whereas abandonment results in a decrease in species associated with farmland and an increase in those associated with forests and shrubland (Laiolo et al., 2004; Firbank et al., 2008). Understanding these processes is key to assessing the impacts of changes in the CAP on farmland biodiversity.

Since the 1980s, intensification and abandonment have been recognised as threats to biodiversity on agricultural land in the context of CAP. Farmland biodiversity is recognised as a public good contributing to the ecosystem services that the agricultural system is providing. This includes the sustainability of the agricultural system itself as well as many other services including landscape, recreational services and clean water. Concrete examples are pollination of crops and contribution to pest control (Tscharntke and Brandl, 2004). High biodiversity is often related to higher carbon sequestration, lower erosion risk and higher production (Bullock et al., 2007). In the CAP reforms of the past two decades policies were adopted to counteract these processes. The most important policies are so-called agri-environment schemes (AES) and regulations to retain green structures within the agricultural landscapes. These measures and new, related measures, such as the 'greening' of the first pillar of the CAP (i.e. mandatory measures regarding ecological focus areas, crop diversification, and preservation of permanent grassland), are part of current discussions on a CAP reform for the 2014–2020 period (EC, 2010). However, the effectiveness of such measures within the context of continuing intensification of the surrounding agricultural areas is still under debate (Marshall and Moonen, 2002; Berendse et al., 2004; Grashof-Bokdam and Van Langevelde, 2005). Biodiversity indicators suitable to assess the impacts of policy measures on biodiversity in agricultural areas in a comprehensive manner are essential.

Biodiversity, generally defined as the variety of all forms of life, has many aspects. At the scale level of this study (Europe) biodiversity certainly includes both species richness and abundance. However, there is no overarching indicator for biodiversity (Gregory et al., 2005). The choice and design of an indicator depends on the purpose of a study. Choices should be made with respect to what the indicator is meant to reflect: the state of a specific species or biodiversity in general; whether the indicator is needed for monitoring purposes or for ex-ante policy evaluation; and whether or not the indicator should be responsive to environmental pressures. Furthermore, the spatial and temporal scale is important in designing an indicator (Gregory et al., 2005; EEA, 2007). Generally, indicators must have certain basic characteristics. They should be sensitive to the impacts addressed, representative, simplify information, be easily understood and policy relevant. Gregory et al. (2005) give a wider set of characteristics important to biodiversity indicators.

For this study, the objective was to develop an indicator to evaluate biodiversity effects of land use changes on agricultural land (e.g. more intensive use of inputs, or extensification in inputs or changes in number of cattle per ha), with a special focus on the CAP. Current indicators are not fully suited to this specific purpose, since their initial objectives were different. The focus of many indicators is on biodiversity in natural habitats, and they are unsuited to express the specific character of biodiversity in agricultural areas. Some indicators are primarily based on pressures on natural area and, therefore, lack a connection with species representative of agricultural areas (Alkemade et al., 2009). Many studies focus on one species group, for example, on birds (Donald et al., 2002; Scholefield et al., 2011). Many indicators (e.g. in Scholefield et al., 2011) do not have the spatial resolution necessary in policymaking around the CAP, where sub-national or regional information is needed. The EU uses the European Farm-land Bird Index (EFBI) as a Structural and Sustainable Development Indicator. In this approach identified farmland bird trends are used as a proxy for wider biodiversity trends on farmland (Butler et al., 2010). The spatial resolution of this indicator is the country level and one species group (birds) is included.

However, an indicator to evaluate effects of the CAP on biodiversity on agricultural land should be representative of all biodiversity in agricultural areas, not just of one species group. Furthermore, this indicator should be easily understood, in order for it to be useful to policymakers. The indicator has to be linked to the pressures that influence biodiversity, since potential policy measures are aimed to influence these pressures in order to support biodiversity; these policies are not aimed directly at biodiversity itself. Responsiveness to pressures also enables ex-ante evaluation by modelling those pressures. To be able to use the indicator for monitoring and assessment purposes of EU policies, it is important that the indicator consistently covers the entire territory of the EU and that the spatial resolution matches the effects of the policy measures under study.

This paper presents the methods for developing an indicator specifically aimed at biodiversity in agricultural areas. The indicator is targeted for ex-ante evaluations of the CAP, but may serve other policy evaluations, for example, of the EU biodiversity strategy (EC, 2011). The indicator is based on relations between species and the pressures of land cover, land-use intensity and fragmentation. The indicator covers the 27 countries of the EU (EU27) and has a resolution of 1 km. The indicator has been applied to the situation of the year 2000 by detailing species occurrence data with pressure data of the year 2000.

2. Data and methods

2.1. Overview

The indicator has been based on data from the BIOSCORE project (Delbaere et al., 2009; Louette et al., 2010) on species occurrence and their sensitivity to a variety of pressures. The main data used are species lists with sensitivity scores (not, low, medium, high) for 35 environmental variables (e.g. land use, patch size, soil acidity). Coarse spatial data on species occurrence was used (Section 2.2) and combined with detailed, spatially explicit data (1 km grid) on pressures (Section 2.3).

The most important determinant of biodiversity is habitat, which is here represented by land cover. Changing the land cover in a undesired direction for biodiversity is considered as a pressure. We used the CORINE Land Cover 2000 database (CORINE). Originally, CORINE has a resolution of 100 m. Here we use an adapted version (Verburg et al., 2006) with a resolution of 1 km. This data set represents the dominant land cover and does not distinguish between intensive and extensive management of agricultural areas. Therefore, the land-cover data were supplemented with a land-use intensity analysis for arable land and grassland. In this analysis we combined land use intensity data from FSS and point level data on crops from LUCAS to derive relations with spatially explicit data in order to construct an area-covering land use intensity map (more detail in Section 2.3.2). Intensity is pivotal to linking the indicator to a policy such as the CAP, since influencing the level of intensity is an important instrument in this policy. Permanent crops (e.g. fruit trees, olives and vineyards) are also included in the analysis,