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Evaluating the nature conservation value of field habitats: A model approach for targeting agri-environmental measures and projecting their effects

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ABSTRACT

Agricultural practice is one of the most important factors leading to biodiversity loss. EU policies addressing this problem involve the provision of incentives for agri-environmental measures (AEM) and setting of targets for AEM on the national scale (e.g. for the amount of organic farming according to the German sustainability strategy), as well as monitoring their success. For AEM to most efficiently target, implement and monitor, they require comparable evaluation of results, describing their quantitative effects on biodiversity and nature conservation. However, there is a dearth of regional data about species and habitats, parts of biodiversity that are relevant for nature conservation. Thus, quantitative analyses are not typically feasible. Furthermore, impacts of agricultural practices on biodiversity cannot be analysed and evaluated merely from individual cases. Comparisons with average or maximum achievements on different spatial scales (benchmarking) are needed. However, meaningful state and pressure indicators are lacking for modelling the nature conservation value of agricultural fields and the consequences of changing pressures from agricultural practice.

In this paper we present a model for evaluating the nature conservation value of field habitats based on projected field flora species richness. We propose a combination of an existing evaluation scale for habitat types, as the basis of the model setup, with field flora species richness. These are combined to obtain differentiated conservation values of field habitats as a measure of agricultural effects. We defined the field flora species richness as the total number of species on a homogenously managed field minus the cultivated crop. Indicators of the model are farming practices and site conditions. Based on an extensive literature review, these indicators were analysed regarding their influence on the flora species richness. Influences of the farming practices were reflected by the crop type, which was used as key indicator. As an outcome, the influence of conventional farming, organic farming and nature conservation oriented management on flora species richness was quantified. Additionally, we integrated the diversity of crop types and (semi-) natural habitats of the surrounding landscape into the model, in order to consider potential effects of landscape heterogeneity on field flora species richness.

The model was applied in a case study at the NUTS 3-regional level (Nomenclature of territorial units for statistics), using the example of the AEM organic farming. In a scenario, we evaluated the possible effects of a complete conversion to organic farming on the assumed flora species richness. The results reveal that the modelling approach can be used to test for the effects of (i) conversion between organic and conventional farming, (ii) changes in crop rotations, and (iii) targeted positioning of organic farming or botanical management agreements in comparison to the spatially untargeted offering of payments.

1. Introduction

Agricultural practice is an important driver for biodiversity loss (Henle et al., 2008) due to ecosystem transformation (e.g. from grassland to field) and degradation (e.g. from low input to high input farming) (Hole et al., 2005; MA, 2005). Currently, emphasis is

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on the restoration of agricultural landscapes and enhancing habitat and species richness (Kleijn et al., 2006) as parts of compositional biodiversity (Noss, 1990). Reflecting this, EU policy encompasses incentives for agri-environmental measures (AEM), target setting for selected AEM on a national scale (e.g. the amount of organic farming according to the German sustainability strategy) and monitoring their success. Concerning the latter, member states need to perform ex ante and ex post evaluations of AEM in order to demonstrate that funding is being efficiently spent. Two types of AEM have been developed: (i) nature conservation and area-related measures with concrete objectives (e.g. introducing semi-natural habitats and field margins into farmland) and (ii) production-related measures without a reference to specific areas and local protection objectives. The production-related measures have been implemented because it has been assumed that less intensive agricultural production processes generally have beneficial effects on the environment (Hartmann et al., 2006; Uthes and Matzdorf, 2013). A well-known example of this policy is the support of organic farming. However, methods to support target setting as well as ex ante projections of AEM effects or monitoring of their success is scarce. Projection is often hampered by a lack of knowledge about the quantitative impact of agricultural management practices on species and habitats.

In terms of qualitative impacts of agricultural management practices, converting conventional farming to organic farming is often aligned with public values and promotes biodiversity conservation (Haas et al., 2001). Comparative studies about the impacts of conventional and organic farming systems reveal positive effects of organic farming on habitat diversity and on the richness of flora and fauna species (Hole et al., 2005; Kleijn and Sutherland, 2003; Tuck et al., 2014). However, recent studies highlight that organic farming might not actually promote biodiversity. The effects of organic farming vary among taxa and several studies showed that some species even respond negatively (Dänhardt et al., 2010; Rundlöf and Smith, 2006). Furthermore, the positive effects of organic farming and other AEM, in comparison to conventional farming, are more pronounced in studies at a local or field-scale, which barely take the surrounding landscape into account (Bengtsson et al., 2005; Concepción et al., 2012). However, the effects of organic farming and other AEM not only depend on the changed management practices, but also on the biodiversity potential of the surrounding landscape, e.g. the species pool of the landscape, which is affected by local communities (Tscharntke et al., 2005).

In order to support agri-environmental policy making, greater scientific knowledge is needed concerning nature conservation values of field habitats (arable land), which cover approximately 40% of the EU's land surface area (Eurostat, 2013). In order to determine the nature conservation value of field habitats and, thus, to efficiently allocate AEM, the present site-specific value of species and habitats, the pressures from land use and also the development potential of specific sites should be known. It will only be possible to support strategic policy decisions, for example at the NUTS 3-regional level (Nomenclature of territorial units for statistics, EP/CE, 2003), through site specific knowledge of the combination and interaction of indicators (e.g. spatially explicit information on soil characteristics or crop types) (Fürst et al., 2013; Lütz and Felici, 2009). This administrative level is crucial for implementation of policy decisions as it represents the suitable monitoring scale for downscaling global targets, spatially unspecific funding of farming systems, and for the regional and area specific allocation of AEM or restrictions.

Decision-making and policy formulation are in need of spatially explicit and quantified information on changes of ecosystem functions (Schulp et al., 2012). This applies accordingly to efficient targeting, implementation and monitoring of AEM at the NUTS 3-regional level. They are most effectively supported by quantitatively comparable and standardised evaluation data. The evaluation of state and changes within and between NUTS 3-regions may follow either ordinal or cardinal value-scale rankings. While an ordinal scale of measurement implies relatively weak comparability (irreducible values), a comparative evaluation based on cardinally scaled values (ratio scales) implies strong comparability because different values can be ranked by a single comparative measuring unit (Martinez-Alier et al., 1998).

However, differentiated data on habitats and quantitative data on species are scarce and not available for all NUTS 3 regions. In particular, data is lacking for field habitats and their fauna and flora and, to a lesser extent, for grassland habitats. Field habitats are not sufficiently classified and mapped in existing data sets on biodiversity and land cover (e.g. EU Habitats Directive Annex 1, European Nature Information System, CORINE land cover) to represent the impacts of farming practices or the habitat value of a specific arable field. Recent studies estimate the distribution patterns of high nature value (HNV) farmland by combining biodiversity data and land cover, at the national and European level (Paracchini et al., 2008), but do not consider specific agricultural practices. Data about species usually only comprise of grid data about European or national target species. The lack of local data, as well as the need for standardised assessment concepts, highlights the need for modelling biodiversity at NUTS 3-regional level.

Recent biodiversity models focus on pressure indicators and their effects on biodiversity (e.g. REPRO (Küstermann et al., 2010), ROTOR (Bachinger and Zander, 2007), MODAM (Sattler et al., 2010) or the current approach of Schader et al. (2014)). These models allow for comparisons between farming systems or management practices. However, a characterisation of the state of species and habitats, as well as the differentiated impact of measures under different site and landscape conditions, has to be considered in order to address and to evaluate site-specific measures. Regions where the impact of farming severely affects biodiversity should be identified so that funding can generate optimal results. Additionally, the success of AEM in promoting species richness or habitat quality cannot rely on pressure-related models. Site conditions, such as soil type, or the duration of a certain management and the state of the seedbank at a particular site, are important factors that are not included in pressure-related models (José-María and Sans, 2011; Marshall et al., 2003). In addition, species richness is dependent not only on the existence and quality of specific habitats, but also on their spatial context and connectivity (Nagendra et al., 2013). However, knowledge on interactions between species, habitats, farming practice and landscape heterogeneity is required but has not been included in existing models. As a measure of such interactions, we considered the habitat value to be appropriate as it addresses the aforementioned factors. Specifically, the field flora species richness and its underlying seedbank has been used as an effective indicator of biodiversity on the field scale (Fuller et al., 2005; Storkey et al., 2012; Tuck et al., 2014) because it is an important livelihood for various groups of species, e.g. associated herbivores and their predators and parasitoids (Hawes et al., 2010).

Consequently, our research objective is to develop a model for cardinally evaluating the nature conservation value of field habitats at NUTS 3-regional level, taking into consideration the influence of farming practice, site conditions and landscape heterogeneity on field flora species richness. The model should be appropriate for the projection of effects of the general (non-targeted) versus area specific introduction of organic farming or of other AEM. Both are expected to foster diverse and endangered flora on arable fields. We present a system of indicators and characteristic values by which species richness of field flora and related habitat values can be modelled. The model was applied in a case study located in the region of Hannover, Germany. We describe the results with regard to data availability and the applicability of the method by