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European farm scale habitat descriptors for the evaluation of biodiversity

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ABSTRACT

Habitat descriptors are cost effective biodiversity indicators demanded by stakeholders and required for regional and global biodiversity monitoring. We mapped 195 farms of different types in twelve case study regions across Europe and tested 18 habitat descriptors for scientific validity, information content and ease of interpretation. We propose a core set consisting of (i) four descriptors to measure structural composition and configuration of farms (Habitat Richness, Habitat Diversity, Patch Size, and Linear Habitats), (ii) three descriptors addressing specific habitat types (Crop Richness, Shrub Habitats, and Tree Habitats) and (iii) one interpreted descriptor (Semi-Natural Habitats). As a set, the descriptors make it possible to evaluate the habitat status of a farm and to track changes occurring due to modified land use and/or management, including agri-environmental measures. The farm habitat maps can provide ground truth information for regional and global biodiversity monitoring.

1. Introduction

Biodiversity change is one of the biggest challenges of human society (Perrings, 2014). It is therefore important that the status and trends of biodiversity are known and monitored. Due to its complexity, biodiversity cannot easily be measured and appropriate descriptors or surrogates or indicators need to be selected. Selection often requires a trade-off between competing requirements, e.g. accuracy vs. generality, cost-effectiveness vs. certainty, etc. (Lindenmayer et al., 2015; Herzog and Franklin, 2016). Essential Biodiversity Variables (EBV) have recently been proposed (Pereira et al., 2013) and ecosystem structure is one of the six EBV classes. Whilst ecosystem diversity is one of the three components of biodiversity (genetic diversity, species diversity, ecosystem diversity; CBD, 1992), the occurrence, diversity and amount of habitat represent the component units of an ecosystem and are essential determinants of species diversity (Harrison and Bruna, 1999; Fahrig, 2001; Billeter et al., 2008; Liira et al., 2008; Fahrig, 2013).

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There is a plethora of possible habitat or landscape descriptors and indicators (McGarigal et al., 2002; Dramstad, 2009) and appropriate measures need to be selected to provide non-redundant information for a specific context, scale and environment (Bailey et al., 2007a, 2007b; Fahrig et al., 2011; Schindler et al., 2013). Here, we focus on agricultural landscapes, where agro-biodiversity conservation usually operates via habitat restoration and conservation. Through agri-environment schemes, farmers are compensated with payments to modify land use and farming practice to provide environmental benefits (Kleijn and Sutherland, 2003; Stoate et al., 2009). In the European Union, at least five per cent of each farm need to be managed as ecological focus areas under the cross-complicance regulation (EU, 2013). Not enough is known about the effectiveness of these schemes (e.g. Blomqvist et al., 2009; Gabriel et al., 2010; Concepción et al., 2012) as very few 'pockets of good monitoring practice' for agri-environment schemes exist (The European Court of Auditors: ECA, 2011).

In agricultural landscapes, the key stakeholders are actually the farmers. They decide on management practices that include the implementation of ecological focus areas and the adoption of agri-environment schemes. This makes the farmer the most important decision-maker on conservation issues for farmland biodiversity (Weibull et al., 2003; Öberg et al., 2007; Van Haaren et al., 2012). Habitat descriptors are therefore required at the farm scale to measure the status of farmland biodiversity in order to inform agri-environmental policy implementation and effectiveness. Ideally, farmland biodiversity monitoring would also provide a building block for large-scale biodiversity monitoring schemes such as those recommended under the EBV-framework (Pereira et al., 2013). Yet, monitoring habitat diversity at the farm scale is challenging. Farms are legal/economic units that are rented/owned by the farmer and consist of various land units either directly (e.g. arable fields) or indirectly managed (e.g. hedgerows) during the course of agricultural production. These may be intermingled with plots of land owned by other farmers or with land that has no agricultural function. The non-contiguous nature of many holdings means that the spatial arrangement of the habitats of an individual, non-consolidated farm has no ecological integrity.

The objective of this study is to propose a core set habitat diversity descriptors at farm scale, which are:

(i) Scientifically sound and ecologically meaningful, i.e. methods are standardized, clearly described and can be reproduced, and results can be interpreted;
(ii) Attractive and useful for stakeholders, i.e. they differentiate between farms and yield information that is useful for farmers, administrators, policy makers, representatives of NGOs, etc.;
(iii) Applicable across Europe, i.e. the methods and the resulting descriptors can be applied to major farm types (arable, grassland, etc.) and across major bio-geographical regions.

To this end, we mapped the habitats of 195 farms across 12 European case study regions and a variety of farm types. The next section describes the approach to farm habitat mapping, and the selection and calculation of descriptors. By detailing the decisions that had to be made to allow for a standardized mapping process, this goes beyond the usual Methods section of a scientific article. In the following section, results for different categories of habitat descriptors are presented. This involves direct descriptors, which are needed to describe the composition of a farm, including selected habitat types. We also tested various interpreted descriptors that involve some degree of expert judgment because stakeholders express interest in descriptors that attempt to capture the ecological value of farm habitats from the perspective of biodiversity conservation.

The results presented here are part of the findings of a European research project on farmland biodiversity indicators ranging from genetic diversity of crops and husbandry animals, species diversity (vascular plants, earthworms, wild bees, spiders) and habitat diversity and also involving farm management descriptors. The focus here is specifically on descriptors of habitat status, whilst a comprehensive overview of the results is available from Herzog et al. (2012) and more specific findings from e.g. Kovács-Hostyánszki et al. (2011), Last et al. (2014) and Lüscher et al. (2014a, 2014b, 2015). The original data have been published by Lüscher et al. (2016).

2. Methods and principles for measuring habitat diversity at the farm scale

Prior to the definition of habitat recording methods, an exhaustive literature review of potential farm-scale habitat descriptors was conducted. Fifty-eight habitat descriptors were listed that were sensitive to change, reproducible, comparable across different farm types, applicable at the plot- and farm-scale and possibly related to ecological function and quality (Dennis et al., 2009). Many more habitat descriptors exist (see e.g. McGarigal et al., 2002) but were not appropriate for the farm scale, e.g. fragmentation or connectivity measures due to the non-contiguous characteristic of farms. The list was then submitted to a stakeholder advisory board, consisting of 20 professionals of national and European administrations and of non-governmental organisations (farmers associations, nature protection organisations, consumer and marketing organisations). The stakeholders assessed the descriptors according to pre-defined selection criteria (Pointereau and Langevin, 2012). For example, it was essential that the descriptors were easy to develop, to record, were comprehensive, flexible, low cost and appropriate for use by farmers, consumers and administration. They should also enable the assessment of the farmer's progress, management plans and agricultural policies, and be applicable to all farm types across Europe. The interaction with stakeholders worked through a series of workshops, starting with the kick-off meeting of the project. Scientists synthesized information on potential descriptors on fact sheets, which were then evaluated in a structured process by the stakeholders. Where there were disagreements between the evaluations of scientists and stakeholders, the issues were discussed in workshops and consensus was sought. This process yielded 18 descriptors for testing, most of them with several sub-descriptors. Mapping rules were then devised to enable the consistent mapping of farm habitats across the case study regions.

2.1. Case study regions and definition of farms as units of investigation

In order to identify habitat descriptors suitable for a broad range of farming situations, farm habitat status was investigated in 12 regions occurring in 11 European countries. Four major farm types were represented: Field crops and horticulture, specialist livestock grazing, mixed crop and livestock, and permanent crops. The individual case study regions were homogenous in terms of biogeography and farm production type. In each region 10–20 farms were randomly sampled (Table 1) and where both organic and non-organic holdings existed, both were selected. See Herzog et al. (2012) for a detailed description of the case studies.

The focus at farm scale contrasts with most landscape ecology studies in that it has no pre-defined spatial cohesion. Individual fields can be far apart and intertwined with other farms. Farm habitat included the Utilized Agricultural Area (UAA; e.g. crop fields, sown and permanent grassland, intensively managed orchards and vineyards) and the less intensively managed parts of the farm associated with ecological structure (e.g. hedgerows, extensively managed orchards, wildflower strips and grazed forest). As the