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Potential contribution of soil diversity and abundance metrics to identifying high nature value farmland (HNV)

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ABSTRACT

Identifying and halting the decline of High Nature Value farmland (HNV) is seen as essential to the EU meeting its 2020 biodiversity targets. Data on HNV farmland is used to target policy instruments and monitor changes in HNV to assess policy impact and development. Initial estimates of HNV land were based on land cover data with limited spatial resolution. The EU has since taken a distributed approach, allowing countries to develop their own data and metrics to report on the presence of HNV land, and changes to it. Land cover type has been the main data used for reporting but no consistent set of data metrics have been agreed. Therefore, there is interest in both developing standardised reporting metrics and identifying land with high restoration potential to increase the area of HNV land. We explore the relationship between soil associations and broad habitats across a member state (Wales) to determine if any discernible patterns exist between soil and habitat diversity and if soils information might be useful for identifying areas with high restoration potential. We developed a set of criteria to identify soil abundance, combining soil diversity with ecological rare species approaches. The rare (< 1000 ha) and occasional (1000–10,000 ha) soils identified were associated with significantly higher levels of habitat diversity than the national average. We propose that soil diversity information could supplement habitat information in identifying areas of potential restoration interest. Two iconic areas of Wales, the Llŷn Peninsula and Conwy Valley, were compared for restoration potential. Soil diversity in both areas is higher than the national average; habitat diversity was average, or lower in the case of the Llŷn Peninsula. These areas with higher soil diversity offer greater potential for restoration to type-2 HNV. Soil diversity and habitat diversity were found to be positively correlated at a national level despite major management modification of habitats. Given this relationship it is proposed that soil diversity information offers useful metrics alongside land cover data for identifying or comparing areas with regard to potential restoration for HNV.

1. Introduction

The intensification of agriculture since the middle of the twentieth century has been recognised as a major driver of biodiversity decline (Kleijn et al., 2009). However, since the 1990's, it has been increasingly recognised that some types of farming are not only less damaging to the environment but are positively linked to both above- and below-ground biodiversity. What might be termed 'traditional', or 'low-intensity', farming systems have co-evolved with an inherent biodiversity and may play a crucial role in maintaining and restoring overall biodiversity (Baldock, 1990; Beaufoy et al., 1994; Bignal et al., 1994; Andersen et al., 2003, and references therein). These low intensity farming systems are of interest because they frequently enhance biodiversity, which is increasingly recognised as adding resilience to ecosystems and to ecosystem functions that are important for maintaining earth system life support (e.g., soil carbon storage, pollutant attenuation, pollination; Loreau et al., 2001). In Europe, these ideas are brought together under what is now termed High Nature Value (HNV) farmland (Andersen et al., 2003).

HNV farmland is increasingly seen by the EU as having an important contribution to meeting its 2020 biodiversity obligations, specifically to protect species and habitats, achieve more sustainable agriculture and forestry and maintain and restore ecosystems (Keenleyside et al., 2014). Recent CAP reforms also encourage more "greening" of agricultural areas by rewarding farmers who can demonstrate environmental benefits (such as farmland biodiversity) of their agriculture practices

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(European Commission, 2013; Bouma and Wösten, 2016). A definition of HNV farmland can be found in Andersen et al. (2003). It broadly recognizes three HNV types as defined in Paracchini et al. (2008):

- Type 1 – Farmland with a high proportion of semi-natural vegetation.
- Type 2 – Farmland with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers.
- Type 3 – Farmland supporting rare plant and animal species or a high proportion of European or World populations, e.g. corncrakes in the UK's Western Isles.
- Not HNV: Typically the major arable areas, intensively managed land (including livestock production).

Whilst both a noble concept and of practical value, creating a pan-European assessment of HNV is challenging. In a report for the EU, Andersen et al. (2003) tested three different approaches (land cover, farming system and species approaches) for assessing the total HNV land area. Each approach has strengths and weaknesses, but land cover, despite using the 25 km ∗ 25 km CORINE data set, gave the most precise and detailed picture of where the higher probabilities of finding HNV were. More recently, Paracchini et al. (2008) have presented a revised map on a 1 km basis using a combination of CORINE, EU and national scale biodiversity data. Assessing the extent, condition and dynamics of HNV farmlands is now mandatory under the Common Monitoring and Evaluation Framework (CMEF) and the reporting is left to each EU Member State. Whilst this bottom up approach allows those most familiar with the landscape to assess it, quantification remains challenging due to a lack of specific criteria and rules for the identification of HNV farmland. Recently, Lomba et al. (2014) have proposed a hierarchical, bottom-up approach to the collaborative monitoring of HNV which at least provides a coherent contextual framework which could help produce an 'accurate and realistic spatially-explicit' pan-European information set. Going forward this presents two major challenges:

- How do we best identify HNV land?
- If we want to reverse declines and restore land to HNV status, how do we identify land with the best potential for restoration?

Soil science may have an important contribution to make towards answering these questions through the increasingly developing field of soil-, or pedo-diversity (Ibañez et al., 1995, 1998; Amundson et al., 2003). We argue that in many landscapes, soils and above-ground habitats have co-evolved and that above-below ground biodiversity and below-ground soil properties (i.e. physical, chemical and biological) are often linked in native systems from species to habitat levels (John et al., 2010). Whilst modern agricultural intensification may drastically reduce above-ground biodiversity, we suggest that in many cases the soil can maintain a long-term record (ca. 10–1000 years) of the landscape's potential habitat diversity that can be exploited in restoration. Recent work has demonstrated that strong relationships exist between species distributions and pedodiversity or soil resource diversity in some ecosystems (John et al., 2010; Petersen et al., 2010). Ibáñez et al. (2005a, 2005b) have gone as far as to argue that soils and pedodiversity indices are the single best predictor of habitat heterogeneity as they reflect the synthesis of many environmental factors. Petersen et al. (2010) argue that given the importance of soils as an indicator, and because soils are a more stable landscape property than above-ground biodiversity, they can be used to detect local to regional impacts on biodiversity. Conversely, pedodiversity measures may serve as an indirect estimator of biodiversity when species data is limited or unavailable.

Given the potential importance and usefulness of soils information to identifying HNV, and potential HNV, farmland our aim for this research was to determine if soils information is useful in the context of assessing areas of high nature value, which has not been done before. We focus particularly on HNV type-2 farmland because it is concerned with mosaics, which pedodiversity may directly contribute to. Our objectives are:

- To develop criteria for assessing soil abundance and rarity.
- Determine if rare soil types are associated with more diverse habitats, than soil types that are more common.
- To establish if there is any relationship between pedodiversity and habitat diversity across a highly modified landscape like Wales, given more diverse habitats are associated with HNV.
- To use the above information to determine if soil information could be used as an indicator of HNV restoration potential for highly modified farmland areas.

This research is intended to act as an initial assessment of pedodiversity in the context of HNV and determine its potential usefulness and identify challenges, knowledge and data gaps.

2. Materials and methods

2.1. Data

2.1.1. Soils — NATMAP

The soils of Wales are mapped as part of the soil survey of England and Wales (Avery, 1980; Rudeforth et al., 1984). The National Soil Map (NATMAP) for Wales is available at reconnaissance scale (soil associations), 1:250,000 for all of Wales (NSRI, 2001). The soil survey of England and Wales uses a hierarchical classification scheme that identifies four hierarchical levels; 11 Major Groups, 44 Groups, 125 Sub Groups and 747 Series (e.g. 5.00, Brown soils; 5.1, Brown calcareous earths; 5.11, Typical brown calcareous earths; Coombe series). There is no discrete coverage of Wales at the series level of classification, so the 1:250,000 scale map groups series into soil associations, for which 298 are recognised in England and Wales (Cranfield University, 2015), with 94 being mapped in Wales (excluding uncategorised soils). The soil subgroups are used in the following analysis to identify rare soils and to assess spatial patterns across Wales.

2.1.2. Land cover — LCM2007

Land Cover Map 2007 (LCM2007) (Morton et al., 2011) is a vector-based land cover map for the UK containing around 10 million objects. The LCM2007 spatial framework is based on the generalisation of national cartography products (OS MasterMap for Great Britain and Ordnance Survey Northern Ireland for NI). LCM2007 was derived by classifying 30 m-pixel size satellite data, with classes based on the UK Biodiversity Action Plan Broad Habitats. It was validated against 9127 ground reference polygons distributed across the UK and representative of all the LCM2007 classes. The validation gave an overall accuracy for LCM2007 of 83%, although accuracy varied widely between classes and between countries, highlighting the thematic and spatial variability of the classification accuracy (Morton et al., 2011). There are additional knowledge-based enhancements (KBEs) which resolve spectral confusion and/or increase the thematic resolution of land cover using contextual and ancillary information. These are regionally adaptive rules that reassign land parcels to a more appropriate land cover class and therefore enhance the accuracy of LCM2007. They may be based on additional data such as soils, and are particularly relevant to habitats that are difficult to classify remotely such as grasslands. This study uses the Broad Habitat Sub-Class information to assess landscape pattern and diversity and compare these to pedo-diversity metrics. Since we are most interested in type-2 HNV land (farmland with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers), habitat diversity based on spatial patterns of land cover should provide enough information to allow comparison of above and below