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A method of establishing a transect for biodiversity and ecosystem function monitoring across Europe

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ABSTRACT

The establishment of the range of soil biodiversity found within European soils is needed to guide EU policy development regarding the protection of soil. Such a base-line should be collated from a wide-ranging sampling campaign to ensure that soil biodiversity from the majority of soil types, land-use or management systems, and European climatic (bio-geographical zones) were included. This paper reports the design and testing of a method to achieve the large scale sampling associated with the establishment of such a baseline, carried out within the remit of the EcoFINDERS project, and outlines points to consider when such a task is undertaken.

Applying a GIS spatial selection process, a sampling campaign was undertaken by 13 EcoFINDERS partners across 11 countries providing data on the range of indicators of biodiversity and ecosystem functions including; micro and meso fauna biodiversity, extracellular enzyme activity, PLFA and community level physiological profiling (MicroResp™ and Biolog™). Physical, chemical and bio-geographical parameters of the 81 sites sampled were used to determine whether the model predicted a wide enough range of sites to allow assessment of the biodiversity indicators tested.

Discrimination between the major bio-geographical zones of Atlantic and Continental was possible for all land-use types. Boreal and Alpine zones only allowed discrimination in the most common land-use type for that area e.g. forestry and grassland sites, respectively, while the Mediterranean zone did not have enough sites sampled to draw conclusions across all land-use types. The method used allowed the inclusion of a range of land-uses in both the model prediction stage and the final sites sampled. The

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establishment of the range of soil biodiversity across Europe is possible, though a larger targeted campaign is recommended. The techniques applied within the EcoFINDERS sampling would be applicable to a larger campaign.

1. Introduction

An essential requisite of food security is a healthy and fertile soil, yet soil itself is a non-renewable resource (EU, 2002; Wall and Six, 2015). The European Environment Agency's State of the Environment Report (EEA, 2012) stated that: soil resources in many parts of Europe are being over-exploited, degraded and irreversibly lost due to inappropriate land management practices, industrial activities and land-use changes that lead to soil sealing, loss of soil biodiversity, contamination, erosion and loss of organic carbon. Approximate estimates from the European Commission, indicate soils on nearly 105 million hectares (16% of total area) are subjected to water erosion and 45% of European soils have low organic matter contents (EEA, 2012). Europe's soil resource is predicted to continue to deteriorate, as a result of changes in climate, land-use and human activities in general (Gobin et al., 2004). This soil degradation will affect the entire society not just individual land-users (Semikolennykh, 2008).

The European Union (EU), presented with the issue of "*the importance of soil and the need to prevent further soil degradation*", proposed in the Sixth Environment Action Programme the development of a Thematic Strategy on Soil Protection ('the strategy')." (EU, 2002). Since 2002 there has been a steady increase in the awareness of the importance of soil protection. The European Commission set out a strategy developing a framework legislation with protection and sustainable use of soil as its principal aim. After 8 years of no effective action the proposal for a Soil Framework Directive has been withdrawn, but this raised the issues outlined in the Soil Thematic Strategy back into prominence.

Soil protection covers both soil health and/or quality (Pereira e Silva et al., 2012). For the purposes of this paper we will focus on soil quality, which can be defined as "the capacity of soil to function as a vital living system to sustain biological productivity, promote environmental quality and maintain plant and animal health" (Doran and Zeiss, 2000). The biodiversity of a soil is vital as it is the engine driving soil based ecosystem services such as food production, nutrient cycling, carbon sequestration and water purification (Turbé et al., 2010). The European Commission acknowledged the importance of soil biodiversity in the role of ecosystem functioning, stating that "these functions are worthy of protection because of their socio-economic as well as environmental importance". (EEA, 2012). However, it had already been recognised within the framework legislation for soil protection that there was not enough information currently known about the ranges of soil biodiversity per se in European soils and therefore the potential threat of loss, due to a lack of consistent soil biodiversity data across Europe (EU 2006).

While there are monitoring networks for soil properties, land cover, and various risks such as erosion, compaction, metal pollution and desertification, indicators related to the decline of soil biodiversity are measured very rarely (Morvan et al., 2008). A number of national surveys have been established in the last 20 years which include monitoring of soil biodiversity or ecosystem function, (examples include: The Netherlands (BISQ) (Rutgers et al., 2009), France (RMQS), (Cluzeau et al., 2009), UK (Countryside Survey) (Black et al., 2003) and Germany (BDF) (Römbke et al., 2013)). However, it was the EU's 7th Framework programme financed project ENVironmental ASsessment of Soil for monitoring (ENVASSO) (Kibblewhite et al., 2008), established in 2005, that was the first pan-European project to develop consistent indicators for the loss of soil biodiversity and recommend key indicators and methodologies to be applied (Bispo et al., 2009). Another outcome of the ENVASSO project was the demand for systematic sampling across the EU relating to land-use and soil-type categories to derive baseline and threshold values for soil biodiversity (Bispo et al., 2009). However, no monitoring system was instigated.

To address this lack of consistent data at a European scale, the EcoFINDERS project (EU Seventh Framework Programme funded), (estd. 2011) established a range of sites representing a varied set of soils ("transect") across Europe. This transect was established to harmonise and implement methods for measuring soil biodiversity across Europe and to generate operating range datasets for indicators of soil biodiversity and ecosystem function. This paper presents the development and implementation of a monitoring campaign to ascertain the range of soil biodiversity and associated ecosystem functions in 81 sites across Europe.

The main outcomes of this paper include:

1. The development of a soil biodiversity and ecological function transect. Utilising pan-European available databases of soil chemical and physical properties and a site selection approach to establish a transect of varying soil properties and land-uses across Europe.
2. Logistical requirements of a pan-European transect. Assessing the logistics of implementing such a sampling campaign, co-ordinating across 11 partner countries (Denmark, France, Germany, Ireland Italy, Portugal, The Netherlands, Slovenia, Sweden, Switzerland, UK).
3. Practicability of indicators used for monitoring. Evaluating sampling methodology (often highly time-dependent) used when assessing soil biodiversity and ecosystem function.

2. Methods

2.1. Development of a pan-European sampling campaign

The approach employed, was a systematic approach based on an initial map derived site selection using categories of land-use, soil pH (water), organic carbon and texture. Sites to be sampled for the transect were selected using EFSA spatial legacy data (Version 1.0) provided by the Joint Research Centre, of the European Commission (Gardi et al., 2011), which consists of 52 spatial layers. Four parameter maps were chosen: topsoil organic matter; topsoil pH (water); topsoil texture class; and EFSA Corine land cover data. Three land-uses were selected from the Corine Land cover data: grassland, forestry and arable. Indicative values for texture, pH and organic carbon were grouped into three categories for each parameter (Table 1).

Table 1
The grouping categories of soil properties used to select a range of soils within the transect.

Land-use	Texture	Organic carbon content (%)	pH
Arable	Coarse	<2% (mineral soils)	<pH 5
Grassland	Medium	2–15% (organo-mineral soils)	pH 5–7
Forestry	Medium fine/fine/ very fine	>15% (organic soils)	>pH 7