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Measuring respiration profiles of soil microbial communities across Europe using MicroResp^{TM} method

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ABSTRACT

A European "transect" was established to assess soil microbial activity, using the MicroResp^{TM} method, as part of a larger project looking at soil biodiversity and function across Europe. 81 sites were sampled across five biogeographical zones described and mapped in the EEA report (EEA, 2012) and included the following classes; Boreal, Atlantic, Continental, Mediterranean and Alpine, three land-use types (Arable, Grass and Forest) incorporating a wide range of soil pH, soil organic carbon (org C) and texture. Seven carbon substrates were used to determine multiple substrate induced respiration (MSIR), incorporating; acids, bases, sugars and amino acids. Substrates included: D-(+)-galactose, L-malic acid, gamma amino butyric acid, *n*-acetyl glucosamine, D-(+)-glucose, alpha ketogluterate, citric acid and water. MicroResp^{TM} results showed discrimination of land-use type over a large spatial scale and response to soil pH and soil organic carbon. Substrates behaved differently depending upon combinations of land-use and soil properties specifically the greater utilisation of carboxylic acid based substrates in arable sites.

1. Introduction

As we move further into the 21st century, the assessment of soil quality has never been more critical. The recent withdrawal of the Soil Framework Directive (EU (European Union), 2006) has come at a time when there is increased concern about soil quality and food security, with proposed policy initiatives by the European Union to enhance sustainable use of soil in relation to the food production sector (COM(2011) 571). However, the assessment and monitoring requirements of soil quality have been debated for many years at both European and Global scales (Doran and Zeiss, 2000; Van Bruggen and Semenov, 2000; Schloter et al., 2003). Currently, monitoring frameworks exist across Europe and at national level within Member States, including the LUCAS-soil survey (Toth et al., 2013) and GEMAS (Reimann et al., 2014) at European scale, both of which assess physical/chemical aspects of soil quality monitoring, but as yet do not include a soil biological component. At Member State level there have been numerous surveys and monitoring frameworks in place in the last twenty years which in part include some biological measures of soil quality. Key examples of these include: the French National Soil Quality Monitoring Network "Reseau de Mesures de la Qualite des Sols" (Saby et al., 2009; Dequiedt et al., 2011), National Soil Inventory (NSI) of England and Wales (Bellamy et al., 2005) and a separate inventory for Scotland (Lilly et al., 2010; Yao et al., 2013), Countryside Survey UK (Black et al., 2003) and the Dutch Monitoring Network (Rutgers et al., 2009).

The Soil Framework Directive (SFD) (EU (European Union), 2006) however recognised that the loss of soil biodiversity is of critical importance, highlighting that soil biodiversity is essential for ecosystem functioning and contributes to soil functions. These functions include; support of primary productivity, cycling of nutrients through mineralisation, enhancing water infiltration, creation of soil aggregates contributing to the stability of soil structure and as a food source within a dynamic food web network of soil organisms. As well as emphasising the role of soil biodiversity for soil quality and associated ecosystem functions, Haygarth and Ritz (2009) also highlighted the need for further research and the imperative for the identification of robust biological indicators of soil quality. However, as the SFD highlighted in 2006, not enough information is available across Europe to quantitatively provide baseline information, from which changes in soil biodiversity could be measured (EU (European Union), 2006). This is due to a lack of data collection and consistency of methods applied to soil biological data across Europe. Thus, the major challenge set to soil biologists

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within Europe, was to provide baseline data for soil biodiversity across Europe and to demonstrate the feasibility of a European-wide biodiversity monitoring network. To meet this challenge, the EcoFINDERS project developed a unique sampling campaign named “the transect” to address this issue. It included the site selection of 81 sites across Europe based on five key variables; land-use, biogeographical zone (reflecting climate), soil pH, soil textural class and soil organic carbon content. Details of the site selection and sampling protocols can be found in Stone et al. (2016). The microbial community is considered the driver of many of the soil functions (Bååth and Anderson, 2003), playing key roles in aggregate formation, nutrient mineralisation (Schmidt and Waldron, 2015), plant health and is considered the basis of food webs in soils (de Ruiter et al., 1994). There are currently several microbial assays that can be applied to measure the activity of the microbial community including; the measurement of microbial community respiration, microbial biomass, enzyme activity, Biolog™ and MicroResp™ method for community level physiological profiling (CLPP). Microbial assays provide a rigorous means of comparing soil samples/sites under laboratory controlled conditions. Due to the manipulation of the soils during the procedure, they do not necessarily reflect real soil activity conditions, but rather allow the assessment of potential activity for a given site.

The MicroResp™ method (Campbell et al., 2003) provides a way to measure microbial respiration rates induced by a range of carbon sources (Chapman et al., 2007), defined as Multiple Substrate Induced Respiration (MSIR). The amount of carbon utilised indicates the abundance of the microbial biomass able to utilise a specific carbon source. It is hypothesised that the greater the diversity of the microbial community the wider the range of carbon source utilisation (Creamer et al., 2009). Soil microbial biomass or diversity is often associated with available soil organic carbon content, with lowest biomass associated with dry conditions and low organic matter (desert) or wet conditions with extremely high organic matter (Boreal) (Fierer et al., 2009). It is therefore proposed that soils from Mediterranean and Boreal climates would be expected to have the lowest microbial biomass and therefore reduced carbon utilisation, compared to Atlantic, continental or alpine conditions.

In this study we employ the MicroResp™ method to assess the potential microbial activity of 81 sites of varying physiochemical parameters, located across a range of contrasting biogeographical (climatic) zones and land-uses across Europe. The objective of this study was twofold; firstly, to determine the range of microbial respiration activity for European soils, how this varies according to climate (biogeographical zone), land-use and is influenced by key

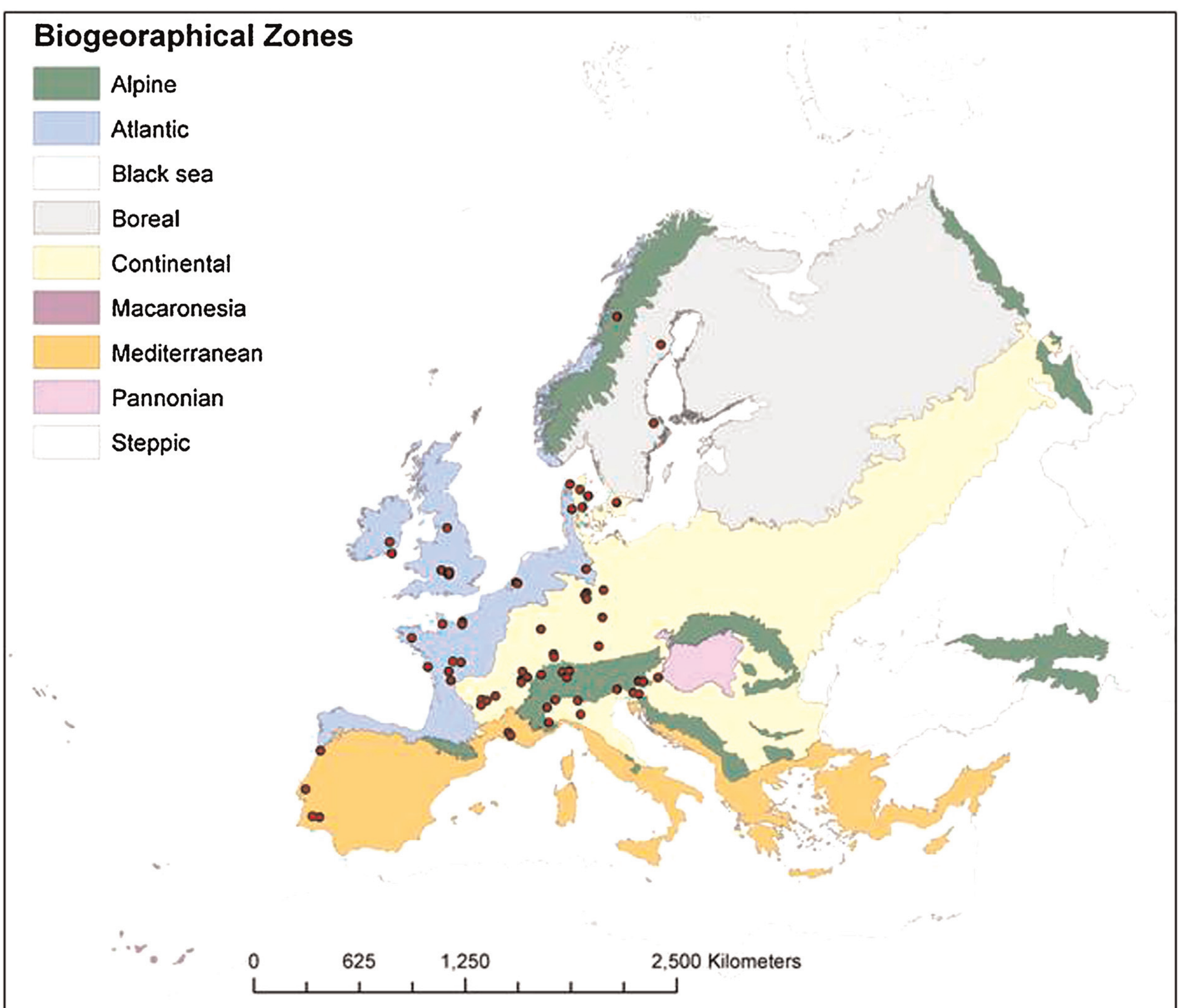

Fig. 1. Map of transect sites, based upon the Biogeographical zones of Europe (EEA, 2012).