Breaking new ground on soil biodiversity across Europe







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The EcoFINDERS project is opening the black box of soil processes and studying how below-ground organisms govern the functionality of soils across Europe. The increase in knowledge from this large-scale sampling campaign, co-led by Teagasc, is priceless for policy development in the area of soil health and productivity, explains Dr Dorothy Stone.

Soil provides a wide range of services, including primary productivity, water purification, carbon sequestration and nutrient cycling, all of which have been described in the preceding articles. The majority of these soil processes are mediated by soil biota, which are the driving forces behind most soil based ecosystem services. The European Commission acknowledges the importance of soil biodiversity in the role of ecosystem functioning and the Commission's soil strategy is to protect and enhance soil-based ecosystem services, with a view to promoting sustainable intensification of agriculture. However, while we have a good idea of the role of soil organisms in many of the processes that take place in soils, there is very little information on the geographical distribution and variation in soil biodiversity or the functional capacity of these below-ground communities.

In light of this, the EcoFINDERS (FP7) project was set up in 2011 to address this lack of spatial information on soils and to generate European datasets of soil biodiversity and ecosystem function. Teagasc is the lead partner in the work package dedicated to developing and evaluating indicators of ecosystem functioning, based on the combined knowledge of experts from across Europe. These indicators were measured at 81 sites across Europe: a sampling campaign of unprecedented scale for soil biodiversity. The sites cover a range of biogeographical zones, representing climatic regions that include: Atlantic, Continental, Boreal, Alpine and Mediterranean. Encompassed in these zones are a range of land uses: arable, grass and forestry and a large spectrum of soil properties (represented by pH, organic carbon, total nitrogen and texture).

Selecting indicators

We selected a range of biological methods that provide information on the abundance, diversity and functional capacity of organisms found in soils across Europe. There are many biological methods available and therefore, it was essential to select methods that: (1) provide good descriptive information; (2) are cost-efficient; and, (3) are not too laborious to carry out in the field (at time of sampling) or laboratory (during analysis). Table 1 describes the range of methods selected and how they relate to biodiversity or soil functioning. Here, we give three examples that describe the microbial, faunal and functional behaviour of organisms in soil across Europe. These include: (1) fungal diversity; (2) the diversity of Enchytraeid (potworms); and, (3) respiration.

Fungal diversity (an example of microbial diversity)

Soil fungal diversity across Europe varies in terms of number of species, their relative abundance and distribution according to land use (forest, grassland and arable), soil and climatic parameters. Fungal diversity (Shannon index) was lowest in forestry sites and greatest in arable soils. The highest abundances of DNA (measured by quantitative qPCR) were found in Boreal forestry sites and lowest in Mediterranean soils and in arable sites. Soil pH had a significant impact on the community structures of fungal diversity, showing a positive response to diversity and a negative response to the abundance of fungi.

Biodiversity	Function
Microbial diversity by TRFLP (eDNA)	
Microbial diversity by PLFA	
Functional Genes [nitrification] (eDNA)	
Functional Genes [denitrification] e(DNA)	
Enchytraeid species diversity	
Micro-arthropod species diversity	
Nematode species diversity	
	Bait Lamina
	Nitrification potential
	Microbial Respiration: MSIR (Micro-resp)
	Enzyme Activity

Table 1. Indicators selected

Photo 1. *Enchytraeus albidus.*

Enchytraeid diversity (an example of soil fauna diversity)

Enchytraeidae (Oligochaeta, Annelida), also known as potworms, were measured as a key faunal group. More than 30,000 specimens of enchytraeids were extracted from 518 soil cores. Specimens were identified to species in vivo and then fixed for morphological scrutiny or DNA barcoding. About 170 species were registered, 79 of which had not previously been described. Most of the new species were found in previously unstudied regions of France, Slovenia or Portugal. Diversity patterns showed a regional component at the species but not at the genus level. Changes in enchytraeid communities (such as species abundance patterns) correlate with changes of soil parameters such as pH and C:N ratios, and they are strikingly paralleled by changes in the microbial communities, which suggest that patterns of soil biodiversity across Europe can be predicted based on soil properties and land use.

Soil respiration (a measure of soil functioning)

Soil respiration was measured using the MicroResp method, which measures the respiratory response of the soil microbial community to a range of carbon sources. We applied seven different carbon sources, from readily available carbon such as glucose, to complex recalcitrant carbon sources such as alpha ketogluterate. The Microresp method measures the microbial response to the range of carbon sources; microbial communities that can respire a wider range of carbon sources are considered to have a better functional capacity in relation to C cycling. Respiration was greatest in the forest soils of the Boreal region. This was due to the high organic status of these soils. pH and soil texture also had a significant impact on the respiration potential of the soils.

Implications

The data collected as part of this project has significantly increased knowledge of soil biodiversity and functioning across Europe. This information is vital to inform policy decisions on the quality of biodiversity in soils across Europe. In addition, this extensive sampling and analyses of soil biodiversity and function, has provided a blueprint of possible indicators for soil quality monitoring at both national and European scale.

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Paper in *Nature*

EcoFINDERS recently hit a high note when it published in Nature Climate Change on a new guild of microbes that mediate against climate change. Nitrous oxide (N_2O) is a major greenhouse gas and at least 30% can be attributed to microbial cycling of nitrogen in agriculture. Although the reduction of N_2O to nitrogen gas (N_2) by microorganisms is critical for mitigation, it remains uncertain what determines a soil's capacity to act as a source or sink for N_2O. A key experiment in EcoFINDERS, using soil from Teagasc experimental farms, demonstrated that the soil N_2O sink capacity is mostly explained by the abundance and phylogenetic diversity of a newly described N_2O-reducing microbial group, which mediate the influence of edaphic factors. These microbes convert N_2O to N_2, which is the benign component of atmospheric nitrogen. Analyses of interactions and niche preference similarities suggest niche differentiation or even competitive interactions between organisms with different types of the enzyme that converts N_2O to N_2 The study was recently published in *Nature Climate Change*: Jones *et al.* (2014) recently identified microbial guild mediates soil N_2O sink capacity. DOI: 10.1038/NCLIMATE2301