

Digging deeper

Dr Philippe Lemanceau explains the reasons behind the launch of his latest project and indicates how it will provide greater understanding of soil biodiversity and its relationship with functions and ecosystem services

Could you begin by detailing the catalyst for the creation of the EcoFINDERS project?

Soils provide numerous essential ecosystem services, such as: primary production (including agricultural and forestry products); regulation of biogeochemical cycles (with consequences for the climate); water filtration; resistance to diseases and pests; and regulation of above ground biodiversity. However, soils are exposed to many threats, so there is an urgent need to preserve this resource. The European Commission wants to define a policy for the sustainable management of soils with a view to adopting a legally binding Soil Framework Directive, such as those that exist for air and water. Scientific and technological knowledge on soil biodiversity and functioning in relation to the aforementioned ecosystem services is required to reach this goal.

What are the greatest challenges in your plan to characterise the biodiversity of European soils and the normal operating range (NOR) according to soil types, climatic zones and land uses?

Soil biodiversity is now known to vary according to soil types and land uses, which makes comparison of soils from all over Europe very difficult. Identifying the NOR in European soils represents a major advance for soil management, as it will allow us to perform diagnostics of the soil quality across Europe according to the soil types and land uses. The greatest challenge for determining the NOR of soil biodiversity is to yield information on soils that are representative of the variety of the environmental situations in Europe. A high number of locations must be sampled and the locations sampled must be properly chosen. The databases that will be established within EcoFINDERS will enable the identification of NOR for major types of soils, climates and land uses. This tool will represent a first effort



that will have to be implemented by additional measures with time.

Can you detail how you will determine relationships between soil biodiversity, functioning and ecosystem services?

A better knowledge of the relationships between soil biodiversity, functioning and ecosystem services is a major goal of EcoFINDERS and, more generally, of soil biology research. Indeed, understanding soil biodiversity per se, although a very important task, is not informative enough, and must be further explored in terms of its relation to soil functioning and ecosystem services delivered. This information is essential for monitoring soil quality and for applying a policy of sustainable land use. The belief within EcoFINDERS is that the intensity of land use may impact not only on soil biodiversity, but also the relationships between soil biodiversity, its functions and ecosystem services and that, in terms of diversity, these relationships are impacted by environmental parameters. In the EcoFINDERS project, soil biodiversity/functioning/ecosystem

services relationships are being tested in core LTOs representing different land uses and climatic zones. This is made possible as the consortium brings joint expertise to assess biodiversity (microorganisms, fauna, plants) and ecosystem services on these LTOs.

Could you describe some of the tools that you have utilised to assist your evaluation of the impact of human activities on soil biodiversity, functioning and services? Moreover, what progress have you made on this front?

A large range of techniques and technologies are being used within EcoFINDERS to assess soil biodiversity and functioning. One of the major expected outputs of EcoFINDERS is to deliver Standard Operating Procedures for characterisation of microbial and faunal diversity. There is, a major need for standardisation to make data obtained in various sites and different locations comparable. This standardisation is also a prerequisite for the application of European soil policy. Among others, research efforts in SOP include soil sampling, DNA extraction, and bar coding for soil fauna.

You also seek to provide quantification of the economic values of soils. What advantages will this afford?

Quantification of the economic values that soils afford is a central goal of EcoFINDERS since it is expected to provide support to the European Commission for its Soil Thematic Strategy. This quantification is expected to deliver information on the cost of action, relying on sustainable land use, compared to the cost of non-action, and will therefore help the EC to convince European policy to promote a directive framework for soils. This economic assessment will also involve the evaluation of the cost-effectiveness of the bio-indicators delivered by EcoFINDERS.

Soil searching

The **EcoFINDERS** project seeks to address the existing gaps in knowledge about soil biodiversity and assist in unification of existing research in order to contribute to the basis for future European policy

AS DEFINED AT the Convention of Biological Diversity, biodiversity is the variation in life from genes to species, communities, ecosystems, and landscapes. Soils represent a vast reservoir of biodiversity, with several billion bacteria and fungi inhabiting 1 gram of soil, with more than 10 million different species, and several hundred species of fauna also living in a small volume of soil. The key functions supporting ecosystem services largely depend upon organisms that inhabit the soil. This diversity varies in terms of taxonomic richness, relative abundance and distribution according to soil types, climatic conditions, vegetation and land uses.

Against this background, soil biodiversity is subject to various threats, the most serious of which occur as the result of anthropogenic activities, which can impair soil biodiversity and functioning, with negative impacts on ecosystem service delivery and consequent effects on primary production and soil sustainability. However, in order to design and implement a sustainable soil management strategy, a deeper knowledge of the range of biodiversity and its connection to soil functioning and ecosystem services is required. At present, the range of biodiversity represented by soils remains superficially explored due to the small size of most relevant organisms, their immense abundance and diversity, their hidden location, as well as the heterogeneity of the soil matrix and the high variety of environmental situations. Until recently, researchers only had access to culturable microorganisms, which, it is now known, represent only a small fraction of the total microflora.

Significant improvements in soil DNA extraction, characterisation of DNA polymorphism, including sequencing techniques and the development of dedicated DNA databases have now opened the way to create a broader view of the microbial abundance, structure and diversity. In order to exploit these new technologies and respond to a European Union drive to define a policy for the sustainable management of soils, the Ecological Function and Biodiversity Indicators in European Soils (EcoFINDERS) project was launched to help unify existing research in soil biodiversity.

IMPETUS

The main hypothesis of the EcoFINDERS project is that changes in soil biodiversity efficiently and effectively indicate the direction and rate of changes in soil functioning and associated ecosystem services; identification of the corresponding bio-indicators allows economic valuation of the observed soil functioning and resulting ecosystem services, leading to

appropriate soil management. The project, therefore, has three main objectives: to increase knowledge of soil biodiversity and its role in ecosystem services across different soils, climate types and land uses; to develop standardisation of methods and operating procedures for characterising soil biodiversity and functioning, and the development of bio-indicators; and to assess the added value produced through cost-effective bio-indicators, and the cost effectiveness of alternative ecosystem service maintenance policies.

In the initial stages of the project, case studies will be presented to illustrate the connection between soil biodiversity and functions. Data demonstrating the contribution of environmental filters as drivers of microbial communities will then be developed and finally, a brief overview of the EcoFINDERS will show how it can provide the EC with scientific, operational and economic information on biodiversity to design and implement strategies for ensuring sustainable use of soils.

INITIAL OBSERVATION

The project will characterise the biodiversity of European soils by following two major strategies. The first, employs Long Term Observatories (LTO), which have been specifically chosen as representative of both the major types of land use as well as the variety of climates: Atlantic, boreal, continental Mediterranean, Pannonia. Additionally, they allow the assessment of ecosystem services addressed in EcoFINDERS, such as nutrient cycling, carbon storage, water regulation, soil structure regulation, resistance to diseases and above ground diversity regulation.

In each of these LTOs, three levels of agriculture intensification are being considered. The reason for this approach is neatly outlined by the coordinator of the project, Dr Philippe Lemanceau: "The major aim of this first strategy is to relate soil biodiversity to soil functioning and ecosystem services, and see how the agricultural intensification may impact this according to the type of land use and climate".

WIDER SCOPE

The second strategy relies on the characterisation of the soil biodiversity across a European transect and will include a larger number of locations, allowing for a better representation of the variety of environmental situations at the European scale. Data yielded will be applied to establish a database of soil biodiversity across Europe, which in turn will allow the researchers to identify the Normal





Operating Range (NOR) of soil biodiversity for different types of soils, climates and land uses.

This European transect will also be applied to test the range of variations of the bio-indicators that will be delivered by EcoFINDERS. Alongside the observations, researchers will adopt an experimental approach in mesocosms and soil monoliths, including the soils from LTOs. This approach consists of testing hypotheses related to the minimal diversity required for soil functioning, and are also related to the impact of biotic and abiotic parameters on soil biodiversity and relations between soil biodiversity and functioning. The corresponding relations will be modelled. The final databases resulting from the research will represent a unique tool in the field of soil diagnostics for end users and policy makers.

CAREFUL SELECTION

The high potential for success from the project is directly related to the particular selection of partners within the consortium. Expertise from partners within EcoFINDERS includes biodiversity on a wide range of soil organisms and plants, ecology, modelling, agronomy, bio-indicators, data management and processing, modelling and environmental economics. More generally, EcoFINDERS will interact with all projects dealing with soils, in the hope that such interactions will be beneficial for both sides allowing implementation of databases and referential testing of bio-indicators in a wider range of situations. In turn, it is hoped

this will achieve an overall standardisation of operating procedures. The end-users targeted by EcoFINDERS will not only be the soil policy makers, the farmer advisers and farmers, but also the companies working in bioremediation and soil quality. A stakeholder forum has been established to maintain close relations with end users and take into account their expectations and suggestions.

SUCCESS STORY

The most significant accomplishments of the first year of the EcoFINDERS project relate to the sampling of the five core LTOs in spring and autumn for biodiversity assessment. All DNA samples have been extracted from the corresponding soil samples and their diversity analysed.

The project is moving into the next phase, utilising a questionnaire and dedicated workshop to identify relevant bio-indicators. These will be further tested for their relevance. A website has been constructed and the first dissemination events have taken place to promote soil biology to the general public, alongside presentations at international conferences.

Overall, the project is moving quickly, and as Lemanceau suggests, it is working well towards assisting the EU to "promote its Thematic Soil Strategy, convince the European parliament to adopt a Soil Thematic Strategy," and instigate major advances in scientific soil research.

INTELLIGENCE EcoFINDERS

ECOLOGICAL FUNCTION AND BIODIVERSITY INDICATORS IN EUROPEAN SOILS

OBJECTIVES

To provide the EC with tools to design and implement soil strategies aimed at ensuring sustainable use of soils, including:
i) Characterisation of European soil biodiversity; ii) Determination of relations between soil biodiversity, soil functions and ecosystem services; iii) Design of policy-relevant and cost-effective indicators for monitoring soil biodiversity.

PARTNERS

For a complete list of partners, please see the project website, listed below.

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DR PHILIPPE LEMANCEAU is a senior soil microbiologist at INRA with a widely recognised expertise in plant-microbe interactions. He has edited several books, and published more than 80 papers and 30 book chapters. He belongs to the editorial board of the *ISME Journal* and has been editor for *FEMS Microbiology and Ecology* for several years. He currently heads a large research Unit on Agroecology in Dijon. Besides EcoFINDERS, he has coordinated several programmes including a European project within the Fourth Framework-Programme (FP4).



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