

Soil and land use change

Assessing soil microbial diversity across Europe

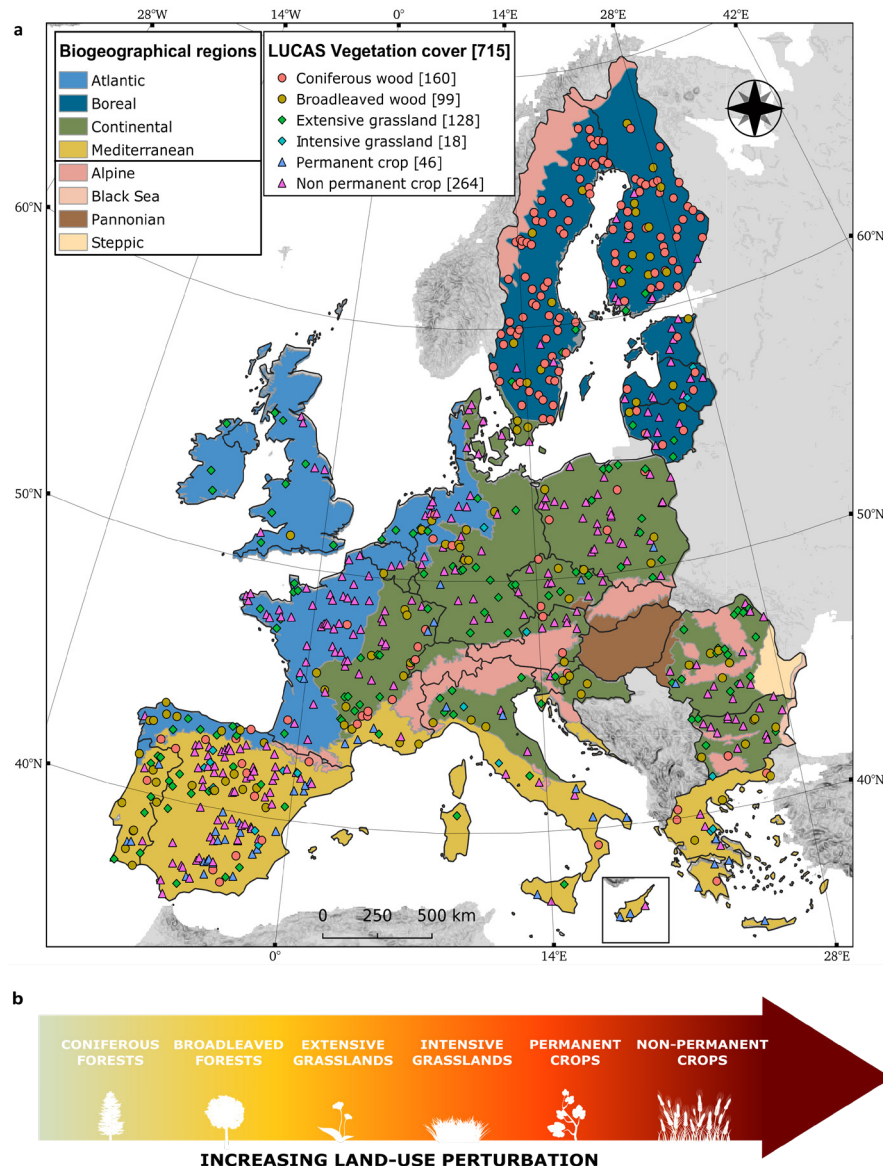
Soil is a crucial resource involved in the provision of many ecosystem services including food production, climate regulation and cultural and educational services. Consequently, soil ecosystems deserve the same level of protection as water, air and the marine environment. The EU Soil Strategy for 2030 aims to ensure healthy soil conditions by monitoring soil quality and promoting sustainable soil use and restoration. To achieve this, monitoring and protection plans for soil organisms need to be enforced, as they also play a vital role in ecosystem services like food production and climate regulation.

While the drivers of above-ground biodiversity have been extensively studied over the past decades, our understanding of belowground diversity (e.g., microbial diversity) is still limited, especially at large scales like continents. Conducting comprehensive surveys and collecting standardized datasets are necessary actions to assess the factors influencing soil community diversity. Currently, only a few surveys have been conducted at the continental scale, hindering our understanding of how belowground communities assemble and respond to perturbation. To address this, the European Commission introduced a soil biodiversity module to the Land Use/Cover Area frame Survey (LUCAS) in 2018. <https://esdac.jrc.ec.europa.eu/projects/lucas>

LUCAS is the largest European soil survey for biodiversity; it gathers soil biological data from over 700 sites across different vegetation cover types ordered along an increasing gradient of land-use perturbation, from woodlands to croplands (see Figure 2). The samples were analyzed using DNA metabarcoding methods, and soil properties were measured according to ISO standards. In order to promote research and exchange with researchers at the European Union, a collaborative doctoral partnership was established between the European Commission's Joint Research Centre in Ispra and the University of Zurich to investigate patterns of soil bacteria and fungi for the first time at the European scale under a wide range of soil and climatic conditions. This partnership and the application procedure have been coordinated by the PSC, and a joint PhD was established.

The first results of this project have been recently published in *Nature Communications* (Labouyrie et al. 2023). It demonstrated the effects of land use and patterns in soil microbial diversity across Europe. The work further emphasized the significance of both taxonomic and functional annotations in understanding soil microbial diversity. It showed that more disturbed areas like croplands and grasslands exhibit higher richness and diversity but may also harbor a higher number of undesirable taxa, like potential plant pathogens. Relying solely on taxonomic diversity may thus lead to the misleading assumption that higher microbial biodiversity translates to enhanced ecosystem functioning.

The study also highlighted the diverse responses of soil communities to contrasting environmental conditions. Bacterial diversity was primarily influenced by soil conditions, while fungal diversity was shaped by vegetation cover. We argue that managing vegetation cover alongside other management practices focused on soil can enhance the conservation of soil microbial diversity.



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Maëva Labouyrie, Cristiano Ballabio, Ferran Romero, Panos Panagos, Arwyn Jones, Marc W. Schmid, Vladimir Mikryukov, Olesya Dulya, Leho Tedersoo, Mohammad Bahram, Emanuele Lugato, Marcel G. A. van der Heijden & Alberto Orgiazzi (2023). Patterns in soil microbial diversity across Europe. *Nat Commun* 14, 3311. <https://doi.org/10.1038/s41467-023-37937-4>

Figure 2: Sampling design. (a) Sampling points distribution coloured by vegetation cover type. The number of sites is indicated between brackets. (b) Vegetation cover types ordered along a gradient of increasing land-use perturbation (Labouyrie et al. 2023). © European Union, 2023.

It is crucial to consider different drivers and their impacts on specific functional groups when implementing conservation measures.

Studying the impact of individual factors is valuable, but learning more about their combined effects can help us monitor and preserve soil variety. Identifying clusters of action for implementing suitable monitoring and preservation actions in specific areas could indeed be done by segmenting huge areas into patches depending on environmental characteristics that affect targeted microorganisms. In our next set of activities, we will investigate three-way interactions between pH and land cover as drivers of microbial diversity, produce maps of microbial diversity across Europe and investigate the role of pesticides as drivers of microbial communities across Europe.



This project receives funding from the European Union under the Collaborative Doctoral Partnership Agreement No. 35594 with the European Commission Joint Research Centre and University of Zurich.