Mapping, Understanding and Predicting Soil Microbial Diversity Across France

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Microorganisms are extremely abundant and diverse in soils. Their huge diversity is central in soil functioning regarding the diversity of functions it supports (mineralization, detoxification, stability of soil…) and is more and more studied, especially in a context of increasing pressure on soil resources. Conversely to macroorganisms whose distribution on a wide scale has been studied for over a century, spatial scaling and determinism distribution of soil microorganisms on nationwide scale still needs to be documented, notably to decipher the environmental filters shaping these communities. Over ten years, the soil microbial communities were investigated at the scale of France to characterize their distribution, understand the ecological processes and the underlying environmental filters shaping their distribution, and predict their abundance and their biodiversity. This long-term study was based on the French Soil Quality Monitoring Network (2200 sites, RMQS), which is representative of soil and land-use diversity in France. On each RMQS site, soil microbial communities were investigated for their biomass, richness (bacteria and fungi), community composition and relative abundance of each taxa, notably by means of high-throughput sequencing techniques. Mapping these characteristics provided the first extensive referentials on soil microbial communities, demonstrating their heterogeneous and non-random distribution at the scale of France into biogeographical patterns (radius from 40 to 260 km). Examining the turnover of soil microbial community composition demonstrated it was similar for micro- and macroorganisms, conversely to standard postulates. This turnover was supported by two non-exclusive environmental selection and limited

dispersal. Whatever the soil microbial characteristic (biomass, richness, community composition, taxa relative abundance), it was mainly determined by soil characteristics and land-use but the filters and their hierarchy changed with the characteristic considered. Based on these referentials; models were developed to predict soil microbial diversity over the whole France; and, for the first time, 16 microbial habitats were delineated according to their specific bacterial community and environmental context (soil parameters, land use, climate), and characterized for their bacterial interaction network. Gathered into the French Atlas of Soil bacteria, these findings support innovative tools to diagnose soil microbial quality.

Keywords: Wide-scale; soil; microbial community; biomass; diversity; structure; referential; habitats; interaction network.