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Lipidomic and genomic based indicators of soil health in agricultural pastures

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Soils play a crucial role in biogeochemical cycles and sustaining societal wellbeing. However, essential soil ecosystem services such as producing plant biomass, purifying water, sequestering carbon, cycling of nutrients and supporting biodiversity are threatened by unsustainable human practices. While threats such as organic matter loss, nutrient imbalance and contamination have garnered attention, movement beyond the status quo has been limited. The plight of soil is partly due to our inability to effectively measure and track soil functions for the myriad land use and soil types. In recent years, the concept of soil health - the degree to which a soil can perform its functions - and soil health assessment frameworks have been established to address these limitations. However, the success of soil health assessments are ultimately reliant on the development of robust methods for testing physical, chemical and biological parameters that are important for key soil functions. The aim of this project is to 1) use lipidomic and genomic tools to establish baseline omics-based data for different land use and soil type combinations and 2) combine omics data with established parameters to develop robust sets of indicators for use in soil health monitoring programmes. Soils (n=219) were sampled across Ireland between Sep 2023 and April 2024. Based on the CORINE Land Cover thematic classes and the Irish Soil Information System database, 51% of samples corresponded to pastures, 13% to agricultural with natural vegetation, and 12% to peat bogs while the main soil types were luvisols, brown earths, peat soils and surface-water gleys. Extraction and mass spectrometric analysis of ester-linked fatty acids, phospholipid fatty acids and intact esterified polar lipids highlights gross variation in microbial biomass abundance in different soil and land use types. The distribution of lipids containing methyl-branched fatty acids, 18:2ω6,9 and polyunsaturated fatty acids are effective bacterial, fungal and protist markers and reveal variation at broad taxonomic levels. Ongoing analysis of these data with microbial and faunal community composition, pH and protein concentrations will help highlight potential lipid fingerprints of soil status and/or validate the use of other parameters as effective soil health indicators.