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FTICR-Based Metabolomics Reveals the Dynamics of Soil Metabolic Complexity of Primary Succession at the Landscape Evolutionary Observatory at Biosphere 2, Az, USA

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Soil microbial communities play a crucial role in landscape evolution and ecosystem development by driving biogeochemical cycling of nutrients, carbon, and water in terrestrial ecosystems. Primary succession, the process of ecosystem development from bare soil, is an

important driver of soil microbial community dynamics in newly formed ecosystems. However, the mechanisms underlying the changes in soil metabolic complexity during primary succession are not well understood.

In this study, we used Fourier Transform Mass Spectrometry (FTICR-MS) to analyze the metabolic or organic matter profiles of soil samples collected from three different stages of primary succession at The Landscape Evolutionary Observatory (LEO) at Biosphere 2, Az, USA: bare soil, early microbial colonization (biocrust), and early vegetation (moss). We applied MetaboDirect, a bioinformatics tool that enables the analysis of complex environmental metabolomes, to analyze the metabolic profiles of the soil samples. Our analysis revealed significant differences in organic matter composition in soils from different stages, indicating that plant succession and other environmental factors play a key role in shaping soil metabolic and organic matter complexity. Metacommunity ecology was also employed to elucidate the ecological interactions driving these changes in soil metabolic and organic matter complexity.

Our study contributes to the understanding of the mechanisms driving landscape evolution and primary succession. Our data processing pipeline and analytical approach can be applied to other environmental metabolomics studies, facilitating the integration and comparison of data across different ecosystems and enabling the development of best practices for analyzing complex environmental metabolomes. Overall, our study demonstrates the power of FTICR coupled with MetaboDirect and metacommunity ecology for understanding soil metabolic complexity during landscape evolution and primary succession.