Microbial community proteogenomic analyses indicate extensive depth-dependent CO oxidation and C1 metabolism in soil and increased capacity for N_2O reduction with increased rainfall

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Global climate change will alter the patterns of distribution of rainfall over the continents, leading to shifts in the rates of production and consumption of greenhouse gases in soil. Microbial metabolism in soil plays a large role in these processes, yet some organisms, C and N currencies and transformation pathways are incompletely accounted for. Previous studies quantified species and/or functional gene abundances, but lack of information linking the organisms present to their metabolic capacities precluded comprehensive identification of biogeochemical processes ongoing in soil. Here, we quantified organism abundance, metabolic potential and in situ function in grassland soil at three depths using genomes reconstructed from 60 deeply sampled soil metagenomes, linked to proteomic analyses. Included in the study were samples from a rainfall manipulation experiment designed to simulate predicted climate change. We detect highly abundant organisms with genomically encoded capacities for C and N turnover whose abundances did not vary with depth and rainfall input. Among these is a novel Euryarchaeote that is inferred to play important roles in methane and/or ammonia oxidation. Many organisms have the capacity to oxidize CO, and the required proteins were highly represented in the proteome. CO is produced by plant roots, and generated through breakdown of heme and other porphyrins in plant and microbial biomass. The abundances of organisms predicted to produce greenhouse gases CO_2 from CO and N_2O from nitric oxide showed a statistically significant increase in abundance between 20 cm and 40 cm soil depths. Increased rainfall caused a statistically significant increase in the abundances of two Sphingobacteria capable of conversion of N_2O to N_2. One of these, represented by a near-complete genome, also has an extensive capacity for complex carbohydrate degradation. Overall, changed water inputs are predicted to affect the capacity for denitrification and N_2O production and the importance of C1 relative to complex carbon metabolism in soil.

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