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Hydrogen stable isotope probing of lipids demonstrates slow rates of microbial growth in soil

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The rate at which microorganisms grow and reproduce is fundamental to our understanding of microbial physiology and ecology. While soil microbiologists routinely quantify soil microbial biomass levels and the growth rates of individual taxa in culture, there is a limited understanding of how quickly microbes actually grow in soil. For this work, we posed the simple question: what are the growth rates of soil microorganisms? In this study, we measure these rates in three distinct soil environments using hydrogen stable isotope probing of lipids with ^{2}H-enriched water. This technique provides a taxa-agnostic quantification of *in situ* microbial growth from the degree of ^{2}H enrichment of intact polar lipid compounds ascribed to bacteria and fungi. We find that growth rates in soil are quite slow and correspond to average generation times of 14 to 45 days but are also highly variable at the compound-specific level (4 – 402 days), suggesting differential growth rates among community subsets. We observe that low-biomass microbial communities exhibit more rapid growth rates than high-biomass communities, highlighting that biomass quantity alone does not predict microbial productivity in soil. Furthermore, within a given soil, the rates at which specific lipids are being synthesized do not relate to their quantity, suggesting a general decoupling of microbial abundance and growth in soil microbiomes. More generally, we demonstrate the utility of lipid stable isotope probing for measuring microbial growth rates in soil, permafrost, and rock-hosted systems, highlighting the importance of measuring growth rates to complement more standard analyses of microbial communities.