Consequences of Plant Nutrient Uptake for Soil Carbon Stabilization

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Carbon storage in tropical forests is likely to respond to expected reductions in rainfall. Tropical forests are of particular importance in the global carbon cycle because they contain > 25% of carbon storage on land. However, this biome is poorly represented in large-scale models used to predict long-term changes in global carbon cycling. Belowground processes, in particular, present one of the largest sources of uncertainty inhibiting our ability to predict carbon cycle responses to climate change. This project examines how changes in rainfall in tropical forests alter the transfer of carbon from living plant roots into soil, where carbon can be stored for much longer time periods than in living plants. In addition to changes in rainfall, soil characteristics like nutrient availability can have a large effect on carbon transfer and storage. Root characteristics that can affect transfer of carbon into soils include root biomass, root death rates, exudates of carbon, tissue chemistry, and nutrient uptake rates, with each of these sensitive to changes in moisture and soil fertility. This project measures these root characteristics and soil carbon storage across a series of tropical forest sites in Panama. The sites include paired high- and low-fertility soils across a rainfall gradient, which allows the effects of rainfall to be distinguished from effects of soil fertility. The project also uses rainfall reduction structures to decrease rainfall by 50% at a subset of sites and a long-term nutrient addition experiment to assess the effects of drying and soil fertility on soil carbon storage in a controlled setting. Additionally, a greenhouse experiment uses isotopically labeled carbon dioxide to closely track how carbon moves into plant roots and the ways that this carbon then moves into soils or is lost back to the atmosphere. These cross-scale field and greenhouse measures are used in a plant-nutrient/soil-carbon model to scale up results and predict how tropical forest carbon storage will respond to reduced rainfall globally. This project undertakes fundamental research on tropical rainforest belowground dynamics and applies this research in modeling efforts to advance predictive understanding of complex environmental systems in the context of climate change. In particular, new information on drivers of long-term soil carbon storage in tropical forest soils may be used for more strategic atmospheric carbon dioxide mitigation efforts, which is necessary for a sustainable energy future and is central to the Department of Energy Office of Biological and Environmental Research mission.

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