Soil Biogeochemistry and Nutrient Constraints on Productivity within the NGEE-Tropics Research Program

Richard J. Norby and the NGEE-Tropics Team

The U. S. Department of Energy is initiating a Next Generation Ecosystem Experiment (NGEE) in the tropics with the overarching goal of determining if tropical forests will act as net carbon sinks through the 21st Century. Throughout the expected 10-year research program, we will be developing through a close integration of modeling and measurement a representative, process-rich tropical forest ecosystem model in which the evolution and feedbacks of tropical ecosystems in a changing climate can be modeled at the scale and resolution of a next generation Earth System model grid cell. A critical component of this exercise will be to include model structures and processes that help to address the question: “How will the response of tropical forests to climate change be modulated by spatial and temporal heterogeneity in belowground processes?” Belowground processes that control nutrient availability provide a primary control on the tropical carbon sink. We know that tropical forest productivity varies across fertility gradients, but this is poorly represented in current models, which lack processes of nutrient availability, uptake, and physiological responses to nutrient limitation. Especially important for modeling tropical ecosystems will be including a phosphorus cycle and a physiologically-based representation of phosphorus limitation of productivity. To address this need, we will take an integrative approach, starting with insights from models and model uncertainty and guided by the need to inform and improve nutrient interactions in models. An initial focus will be on improving the phosphorus model through targeted measurements in a field campaign in Puerto Rico. The objective will be to make model-guided measurements to link soil chemistry, rhizosphere microbial activity, and root traits with P availability and uptake. Working across orthogonal transects of varying soil phosphorus availability and a range of forest development, we will employ a systems biology approach to microbial and plant function related to phosphorus availability, phosphorus acquisition, and nitrogen-phosphorus interactions. Belowground traits will be linked with more easily observable aboveground traits, including foliar nitrogen and phosphorus concentrations and spectral signatures that will inform spatial scaling. Disturbance patterns and secondary forest development have a large influence on the tropical carbon sink and alter the relationship between soil fertility and forest productivity, for example by shifting nutrient limitation from phosphorus to nitrogen. We will link the mechanistic studies of phosphorus availability to a broader scale quantification of forest biomass and leaf traits across a successional gradient using a multi-sensor, airborne, remote-sensing platform.