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Soil Carbon Storage and Loss Across a Tropical Forest Rainfall and Nutrient Gradients with Drying

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Humid tropical forests contain some of the largest soil carbon (C) stocks on Earth, yet there is great uncertainty about how soil carbon dioxide (CO_2) fluxes will respond to projected changes in rainfall in this biome. Modeling experiments suggest that tropical forests will be more sensitive to changes in precipitation than to warming, opposite of trends in most other biomes. While shifts in soil moisture have been clearly linked to soil respiration, the magnitude of change in soil respiration may also be regulated by soil properties that influence root and/or microbial activity, like nutrient availability. To understand the potential effects of shifting rainfall on tropical forest soil CO_2 fluxes, we assessed seasonal patterns in soil respiration for 15 sites across rainfall and soil fertility gradients in Panama. We also established a 50% throughfall exclusion experiment at a subset of four sites. We predicted that changes in soil moisture would be the primary driver of soil respiration responses to seasonality, with a secondary role of nutrient availability in regulating the magnitude of the seasonal respiration response. We also predicted that the availability of organic C would be positively related to instantaneous soil CO_2 flux rates. We found that seasonal drying generally corresponded to declines in soil respiration, but there was great spatial variation, with a range of -19% to +360% in CO_2 fluxes during the wet versus dry season. The Wet:Dry season soil CO_2 flux ratio, used as an index of seasonal sensitivity, was best explained by a multiple regression including extractable resin P, base cations, and Wet:Dry season soil moisture ratios (positive relationships, $R^2 = 0.79$), with the strongest univariate relationship to resin-extractable P ($R^2 = 0.41$). Measures of dissolved organic matter were not related to soil CO_2 flux rates, but forest floor biomass accumulation during the dry season was positively related to soil respiration during the wet season ($R^2 = 0.26$), highlighting the contribution of litter decomposition to soil respiration. Preliminary results from the drying experiment indicate that instrumentation for soil temperature, moisture, CO_2 fluxes, and root productivity observation are all fully functional. Overall, our results from across the natural gradients indicate that scarce soil nutrients may be more important than shifts in soil moisture for driving seasonal soil respiration patterns across humid tropical forest landscapes. Thus, soil P and cation availability may determine tropical forest feedbacks to climatic change.