Title: Extrapolating carbon dynamics of seasonally dry tropical forests across geographic scales and into future climates: improving simulation models with empirical observations

Program: TES

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BACKGROUND-- Seasonally dry tropical forests (SDTFs) experience a pronounced dry season lasting 3 to 7 months, and once accounted for approximately 40% of all tropical forest. Dry forests are understudied compared to tropical rainforests, and are poorly represented in earth system models. Thus, it is unknown whether SDTFs are uniquely vulnerable or resilient to global environmental changes including climate change and nitrogen deposition. We hypothesize that the responses of STDFs to global change depend critically on belowground processes, but we lack empirical data to verify this.

OBJECTIVES—The objectives of this project are to quantify how above- and belowground processes mediate the responses of SDTF carbon dynamics to environmental change, and incorporate that understanding into two state-of-the-art models, ED2 and ACME. To do so, we are using an interdisciplinary approach that integrates: 1) field observations of ecosystem processes and plant functional traits across a range of dry forest sites in Costa Rica, Mexico, Puerto Rico, and Colombia, 2) forest-scale experiments that manipulate water and nutrient availability in Costa Rica, and 3) model simulations that quantify sensitivity of ecosystem carbon cycling to external forcings. Ultimately, our combined measurement and modeling approach will elucidate controls on C cycling in SDTFs and yield improved models for the global change research community.

RESULTS AND PROGRESS-- Empirical results We established a large-scale factorial nitrogen (N) and phosphorus (P) fertilization experiment in Costa Rica. To date, we have found that belowground processes respond rapidly to fertilization. Soil respiration fluxes decreased in +N, +P and N+P relative to unfertilized plots, whereas root productivity increased in all fertilized plots. Mycorrhizal colonization decreased dramatically in the N+P treatment only, while nodulation more than tripled in the +P treatment. Ongoing work includes a large-scale throughfall exclusion experiment and observations of ecosystem processes across the network of sites. ED2 results The Ecosystem Demography model 2 (ED2) was updated with a trait-driven mechanistic plant hydraulic module and a new drought-phenology scheme. Four plant functional types were parameterized based on meta-analysis of plant hydraulic traits. Simulations from both the original and the updated ED2 were evaluated against 5 years of field data from a Costa Rican SDTF site and remote-sensing data over Central America. The updated model generated realistic simulations of tree diameter growth, litterfall, phenology and the variations of these quantities among functional groups. Overall, we find that mechanistic incorporation of plant hydraulic traits is necessary for simulating spatio-temporal patterns of vegetation dynamics in SDTFs in vegetation models. We have also developed a new, stoichiometrically-based formulation of plant nutrient limitation. This formulation includes symbiotic nitrogen fixation, plant-mycorrhizal interactions, and phosphatase exudation. Work is ongoing to parameterize both ED2 and ACME with data collected from the field sites.