

Poster #9-16

Using a Process-Based Model to Disentangle Hydraulic Trait Relationships in Observations of Tropical Trees

Thomas Powell^{1*}, Brett Wolfe², Charles Koven¹, Boris Faybishenko¹, and Lara Kueppers¹

¹Lawrence Berkeley National Laboratory, Berkeley, CA

²Smithsonian Tropical Research Institute, Smithsonian Institution, Panama City, Panama

Contact: tpowell@lbl.gov

BER Program: TES

Project: Ngee-Tropics

Project Website: <https://ngee-tropics.lbl.gov/>

In recent decades a considerable amount of data on the hydraulic traits of tropical forest tree species have been accumulated. These data are used to understand the physiology of water transport and its variation across species, ecosystems and precipitation gradients. It has been postulated that in areas with variable precipitation, fundamental trade-offs among hydraulic traits must exist in order for coexistence of a diversity of plant functional types (PFTs) to occur. However, strong evidence from direct observations for such a trade-offs has been elusive. Therefore, we use a process-based terrestrial ecosystem model with mechanistic representation of water transport, the Ecosystem Demography model (ED2-hydro), to perform a controlled set of simulations that explore how trade-offs emerge among xylem hydraulic conductivity (Kx), xylem vulnerability (xylem-P50), stem capacitance (Cs), stomatal control (stomatal-P50) and rooting depth, enabling coexistence of multiple PFTs. ED2-hydro was forced with local meteorological drivers and soil conditions from Barro Colorado Island, Panama. ED2-hydro was parameterized with various combinations of Kx, xylem-P50, Cs, and stomatal-P50 in a large ensemble of simulations to identify robust trade-off relationships.

When all trait combinations that resulted in coexistence across all simulated PFTs are considered, none of the ED2-hydro hydraulic traits appear to be strongly correlated, which is similar to observations of species-averaged traits compared within and across tropical ecosystems. However, ED2-hydro predicts that strong trade-offs between hydraulic traits do exist, but they only emerge when the traits of individuals that are in direct competition with each other are compared. For example, in ecosystems with seasonally and inter-annually variable precipitation, an axis of coexistence between hydraulically-safe and hydraulically-efficient PFTs occurs where the difference in xylem-P50 is inversely proportional the ratio of Kx for safe versus efficient PFTs. The model also predicts that coexistence occurs under variable precipitation when only the rooting depth differs, while holding the other hydraulic traits equivalent across PFTs. Based on our results from ED2-hydro, we hypothesize that hydraulic traits are strongly coordinated among individuals growing in direct competition at the forest-gap scale. We also recommend a series of field measurements to test if the relationships predicted by this modeling framework promote coexistence between PFTs with alternative hydraulic strategies.