Poster #1-67

Extrapolating Ecosystem Processes of Seasonally Dry Tropical Forests Across Geographic Scales and into Future Climates

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Seasonally dry tropical forests (SDTFs) experience a pronounced dry season lasting 3 to 7 months and were once abundant. Dry forests are understudied compared to tropical rain forests, and are poorly represented in earth system models. Important knowledge gaps include: i) whether STDF are vulnerable or resistant to changing rainfall regimes, ii) which nutrients, if any limit ecosystem processes, and iii) how nutrients and water interact to shape forest structure and function. We addressed these questions using multiple approaches including long-term observations, ecosystem-scale experiments, vegetation modeling, and surveys of plant hydraulic traits and allometry. Our results are transforming our understanding of this biome. First, the long-term records of forest mortality to show that a SDTF in Costa Rica is extremely sensitive to extreme drought, and that hydraulic safety margin explains interspecific variation in tree mortality. Second, the factorial nitrogen x phosphorus fertilization experiment showed that phosphorus addition increases fine root production, presumably because after phosphorus limitation is alleviated, trees become limited by water. Third, our large-scale throughfall exclusion x nutrient addition experiment confirms that nutrients and water interact to regulate productivity, but effects depend upon tree species. Last, our measurements of plant hydraulic traits in Colombia, Costa Rica, Mexico, and Puerto Rico underscore how rainfall regimes shape ecosystem function.

We have developed models to complement our empirical work. (i) Hydraulic traits have been implemented into ED2, and have been shown to be essential for simulating tropical dry forest phenology. Given our mortality observations, these hydraulic traits are also essential for the development of an improved mortality parameterization. (ii) In order to better understand the role of nutrients in this biome, we coupled for the first time a vegetation demographic model (ED2), a model microbial dynamics with carbon-nitrogen-phosphorus biogeochemistry (MEND), and a mechanistic model for nutrient competition (N-COM). This work illustrates how observed variation in soil properties can drive large variation in forest functioning and composition during secondary forest succession. (iii) We have also used this model to better understand the results from our nutrient fertilization experiment. As in the observations, the model simulates an increase in fine root production following phosphorus addition. The reason is that P addition makes the ecosystem more water limited, and the model responds by facultatively increasing the amount of fine roots per plant. Collectively, our results underscore how water and nutrients interact in fundamentally different ways in tropical dry compared to rain forests.