

Poster# 85

How Does Variation in Rainfall or a Drier Climate Affect Aboveground Biomass and Tree Mortality of a Seasonally Dry Tropical Forest in Panama?

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Tropical forests store more carbon in aboveground biomass (AGB) than any other terrestrial ecosystem on the planet. This carbon is largely stored in trees belonging to a range of plant functional types (PFTs) with different sensitivities to light and water resources. Climate models vary widely in their predictions of how precipitation patterns may change over tropical forests by the end of this century. The implications of how such changes may affect mortality rates and AGB of different PFTs is unclear. Land surface models that include demographic and plant hydrodynamic processes, such as the Ecosystem Demography model (ED2-hydro), are promising tools for resolving this uncertainty. In this study, ED2-hydro was driven with local meteorological drivers reconstructed to represent several of the predicted, yet contrasting, precipitation scenarios. These scenarios included less interannual variation, longer dry seasons, recurring El Niño related droughts, drier dry seasons, and drier wet seasons. ED2-hydro allows for dynamic competition between four PFTs—early- versus late-successional groups subdivided into drought-tolerant versus -intolerant groups—to occur along water and light resource gradients. ED2-hydro predicts that plant available soil water (PAW) will vary considerably between the different precipitation scenarios. In the simulations, PAW is regulated by both the mean and variation in precipitation, but can be buffered by increased rooting depth. Accordingly, ED2-hydro predicts that changes in the mean or variation of PAW will differentially alter the mortality rates of the four simulated PFTs, which in turn will lead to different AGB outcomes of each. Less variable precipitation tends to reduced AGB of drought tolerant PFTs, while a significant reduction in mean precipitation or greater variation caused by more extreme and frequent droughts tends to reduce AGB of drought intolerant PFTs. ED2-hydro predicts that total ecosystem AGB, however, will only be marginally altered by most of the precipitation scenarios. The only precipitation scenario that leads to a significant reduction in AGB by the end of this century is an intensification of the dry season. Model predictions are consistent with the intermediate disturbance hypothesis where some variation in precipitation, which includes El Niño related droughts and anomalously wet years, is important for promoting functional diversity; but, less variation, a significant reduction in the mean, or more frequent and intense droughts may be destabilizing to functional diversity.