Title: Benchmarking and Parameter Sensitivity of Physiological and Vegetation Dynamics using the Functionally Assembled Terrestrial Ecosystem Simulator (FATES) at Barro Colorado Island, Panama

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Project Abstract: Plant functional traits determine vegetation responses to environmental variation, but variation in trait values is large, even within a single site. Likewise, uncertainty in how these traits map to Earth system feedbacks is large. We use a vegetation demographic model (VDM), the Functionally Assembled Terrestrial Ecosystem Simulator (FATES), to explore parameter sensitivity of model predictions, and comparison to observations, at a tropical forest site: Barro Colorado Island in Panama. We define a single 12-dimensional distribution of plant trait variation, derived primarily from observations in Panama, and define plant functional types (PFTs) as random draws from this distribution. We compare several model ensembles, where individual ensemble members vary only in the plant traits that define PFTs, and separate ensembles differ from each other based on either model structural assumptions or non-trait, ecosystem-level parameters, which include: (a) the number of competing PFTs present in any simulation, and (b) parameters that govern disturbance and height-based light competition. While single-PFT simulations are roughy consistent with observations of productivity at BCI, increasing the number of competing PFTs strongly shifts model predictions towards higher productivity and biomass forests. Different ecosystem variables show greater sensitivity than others to the number of competing PFTs, with the predictions that are most dominated by large trees, such as biomass, being the most sensitive. Changing disturbance and height-sorting parameters, i.e. the rules of competitive trait filtering, shifts regimes of dominance or coexistence between early and late successional PFTs in the model. Increases to the extent or severity of disturbance, or to the degree of determinism in height-based light competition, all act to shift the community towards early-successional PFTs. In turn, these shifts in competitive outcomes alter predictions of ecosystem states and fluxes, with more early-successional dominated forests having lower biomass. It is thus crucial to differentiate between plant traits, which are under competitive pressure in VDMs, from those model parameters that are not, and to better understand the relationships between these two types of model parameters, to quantify sources of uncertainty in VDMs.