Seasonal and El Niño changes in LiDAR-derived LAI and leaf area profiles in an Amazonian forest

Marielle Smith[1*], Scott Stark[1], Tara Woodcock[2], Mauricio Ferreira[1], Eronaldo De Oliveira[3], Luciana Alves[4], Natalia Restrepo-Coupe[2], Tyeen Taylor[2], Michela Figueira[3], Luiz Aragao[4]

[1]Department of Forestry, Michigan State University; [2]Department of Ecology & Evolutionary Biology, University of Arizona; [3] Universidade Federal do Oeste do Pará; [4]Center for Tropical Research, Institute of the Environment and Sustainability, University of California, Los Angeles; [4]Instituto Nacional de Pesquisas Espaciais

*Correspondence Author. E-mail: mariellenatashasmith@gmail.com

Background: The ecophysiological dynamics of Amazon forests influence climate through carbon and energy cycling. With drought frequency projected to increase, improving simulations of forest drought responses in Earth System Models (ESMs) is a current priority. Insights may be gained from observations of seasonal dry periods. Previous studies have characterised the seasonality of total leaf area index (LAI) in evergreen tropical forests but few have investigated whether seasonal patterns of LAI differ between canopy strata. We hypothesize that the variability of plant traits with height and microenvironment gives rise to vertically structured LAI seasonality and drought responses. **Methods:** We assessed seasonal patterns of LAI and vertical canopy structure across three years, including the 2015-2016 El Niño-induced drought, in the Tapajós National Forest, Brazil using monthly ground-based LiDAR measurements. **Results:** Large and opposing seasonal swings in LAI at different canopy levels aggregated to small variations in total LAI. In all years, leaf area increased in the upper canopy during the dry season, and decreased in the lower canopy. The trends reversed at the onset of the wet season. Seasonal changes in satellite-derived enhanced vegetation index (EVI) agreed best with LIDAR-derived upper canopy LAI, not total LAI or the lower canopy. During the El Niño year, the seasonality of LAI and vertical canopy structure were similar to other years, but amplified. Total LAI declined dramatically at the height of the El Niño. Initially, the lower canopy was most strongly affected, but towards the end of the drought, the upper canopy lost considerable leaf area. **Conclusion:** Our results show that small seasonal changes in total LAI can mask more dynamic phenologies at different levels in the canopy. Satellite-derived EVI appears to primarily capture seasonality of the canopy surface. Seasonal structural responses are indicative of stronger drought effects. Lower canopy responses are consistent with water limitation of small trees, and the upper canopy with changes in light availability. Significant deep soil water depletion may explain the delayed negative response of the upper canopy to drought. The dynamic nature of within-canopy structural changes implies differences in the carbon balance of canopy strata, as aspect which could help to improve ESM predictions of seasonal patterns of productivity and drought responses at evergreen tropical forest sites.

Keywords: tropical forests, drought, forest structure

ID:1134
Wednesday Celestún
Symposium: Exploring the fate of tropical forests under drier climates: linking mechanisms to models

---

Mortality of tropical dry forest tree species following an extreme drought

German Vargas G.[1*], Xiangtao Xu[2], Christina Smith[1], David Medvigy[1], Leland Werden[1], Justin Becknell[3], Tim Brodribb[4], Daniel Peréz-Aviles[6], Jennifer Powers[5]

[1]Department of Plant and Microbial Biology, University of Minnesota; [2]Department of Geosciences, Princeton University; [3]Institute For Environment, Brown University; [4]Plant Sciences, University of Tasmania; [5]Department of Ecology, Evolution & Behaviour, University of Minnesota

*Correspondence Author. E-mail: varga111@umn.edu

Background: During the past El Niño Southern Oscillation event, Central American region experienced the most severe drought on record. Precipitation deficits varied regionally, but the most severe decline occurred in areas with tropical dry forests (TDF). As TDF trees species cope with recurrent seasonal drought, it is possible that they are resistant to unusual drought. By contrast, it is possible that dry forest trees are vulnerable to drought, as their dynamics are closely linked to rainfall. Thus, our goal was to understand the effects of an abnormal drought event on TDF tree communities, linking species responses to drought with their physiological traits. **Methods:** We conducted our study in the tropical dry forest of the northwestern region of Costa Rica. We recorded tree growth, mortality and recruitment along a period of eight years in 18 plots that span edaphic and successional gradients. Additionally, during 2015 we surveyed eight 200 m transects in order to incorporate landscape patterns of tree mortality. Furthermore, in order to provide insight into the underpinning mechanisms determining tree mortality patterns we collected functional traits data on the most common species (27) in our surveys. **Results:** We found an overall increase of mortality during the drought from a yearly average of 3.1 to 6.2% yr^{-1}, which correlated with the decrease in precipitation. Interestingly, 2015 mortality rates varied from 60 to 0 %yr-1 depending upon species. Some species showed a decrease in growth rates prior to mortality, consistent with the hypothesis of carbon starvation. While there was no preferential mortality by size class, older forests were more affected than early successional stages. Surprisingly, plant functional traits were not strong predictors of interspecific variation in mortality rates. **Discussion:** A significant reduction in precipitation for two years led to a large increase in mortality, suggesting that tropical dry forest tree species are sensitive to drought. At the same time, we found that responses are highly variable among species and possibly depend on several physiological mechanisms working together. From our data, we propose that both mechanisms, hydraulic failure and carbon starvation, take place when species undergo severe drought stress for long periods.

Keywords: Ecophysiology, growth rates, rainfall deficit.

ID:1133
Wednesday Celestún
Symposium: Exploring the fate of tropical forests under drier climates: linking mechanisms to models

---