Poster #9-9

Drought Impacts on Non-structural Carbohydrate Dynamics in Tropical Forests

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Non-structural carbohydrates (NSC) provide a measure of the carbon supply available to support tree respiration, growth, and defense. Support for a role of carbon starvation -- or depletion of NSC stores -- in drought induced tree mortality is varied without consensus for the tropics. The 2016 ENSO drought provided a unique opportunity to capture drought impacts on tropical forest carbohydrate dynamics. To quantify these impacts, we collected monthly NSC samples, in conjunction with diurnal leaf water potential, gas exchange, and leaf spectral measurements, across a rainfall gradient in Panama for the duration of the ENSO.

Foliar NSC depletion did not progress with drought duration as predicted, but showed little variation over course of the ENSO and across sites. We observed high variability in foliar NSC among species, however, with structural traits accounting for some of this variation. Leaf mass per area correlated positively with foliar NSC, consistent with the increase in leaf dry mass as sugars accumulate. Degree of isohydry was also predictive of NSC, with lower branch soluble sugars in relatively isohydric species (those that maintain constant leaf water potential as soil water potential declines) and higher branch soluble sugars in relatively anisohydric species (those that allow leaf water potential to decline progressively as soil water potential declines), possibly due to the need for osmoregulation to maintain water potentials under dry conditions. These results emphasize the importance of trait-based modeling to capture species variation in NSC. Significant, but weaker, relationships were also found between foliar NSC and photosynthesis, leaf water potential, and leaf temperature. These findings will be used to evaluate whether the current implementation of carbohydrate dynamics and carbon starvation in FATES is capturing observed trends in tropical forest carbon allocation and mortality, and to tune model parameters for improved predictive capability.

Given the logistical difficulty of accurately sampling and measuring NSC, particularly in the tropics where rapidly freezing samples to halt enzymatic activity is particularly challenging, we took advantage of our coincident NSC and leaf spectra measurements to explore the potential for remotely sensing foliar NSC. Our Partial Least Squares Regression (PLSR) approach yielded promising models for predicting foliar soluble sugars and starch with broadband spectral data. This study demonstrates the potential for rapid and accurate estimation of these difficult to measure foliar traits that are key for understanding and accurately representing canopy carbon dynamics in earth systems models (ESMs).