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Sensitivity of tropical aboveground C stocks to climate anomalies in SW Costa Rica

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Albeit the fact that tropical forests store large amounts of carbon (C) in aboveground tree biomass, the sensitivity of forest C stocks to projected increases in climate fluctuations remains poorly resolved. Here, we aim at unraveling the mechanistic links between climatic drivers (i.e. temperature, precipitation), edaphic factors (i.e. geology, soil type, topographic position) and demographic parameters (species composition and vegetation structure) and how they determine the response of tropical aboveground C stocks to projected climate anomalies at the landscape-scale.

To account for spatial heterogeneity of structural and functional species composition in hyperdiverse tropical forests twenty 1ha permanent plots have been established in the Área de Conservación Osa (ACOSA), Costa Rica. The region harbors high biogeochemical and biological diversity due to topographic features, soil type and geologic history and constitutes the largest remaining tract of lowland forest on the American Pacific coastline. Based on remote sensing data the dominant ecosystem type is broad-leaved evergreen lowland forests with the following habitat types (1) hilltop (crest) positions, (2) slope positions, and (3) valley bottom positions, and (4) in secondary regrowth forests. These forest types are replicated in five regional clusters (i.e. La Gamba, Riyito, Rancho Quemado, Agua Buena and Piro). A total of 11.786 tree individuals have been located and identified to species level and are being monitored for measurements of tropical vegetation structure (i.e. tree diameter, total height, wood density) to estimate associated aboveground C stocks at the landscape-scale.

A previous study investigating aboveground productivity of these habitat types (ridge, slope, ravine forests) suggests that climate sensitivity differed in association to local site characteristics that affected the response of plant growth to a recent El Niño–Southern Oscillation (ENSO) anomaly. This result suggests that the climate sensitivity of crucial ecosystem processes (i.e. C sequestration) might be affected by local topography (via water availability) and disturbance history (via functional species composition) and will likely prevent uniform responses of tropical lowland forests to projected global changes. Whereas the proximate short-term tolerance to the strong El Niño drought period was predetermined by topoedaphic factors such as soil water availability, functional adaptation of the respective tree community could potentially compensate short-term disturbances via drought-induced shifts in tree species composition that further regulate the long-term sensitivity of tropical lowland rainforests to climate anomalies.

Here, we want to upscale these local findings to the regional level by extrapolating corresponding C stock estimates from these habitat types using the terrain position index (TPI) based on remote sensing products from SRTM digital elevation data to estimate potential landscape-scale C gain/loss under projected climate scenarios. Our results suggest that in response to projected increases of climate anomalies (i.e. prolonged drought periods and high-intensity precipitation events) different habitat types will not respond uniformly to the same climatic signal and therefore the spatial diversity of tropical lowland rainforests associated with differences in resource availability and functional tree species composition have to be considered in next generation approaches to reduce uncertainty of currently available projections of tropical ecosystem functioning under future scenarios.