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Unraveling the mechanisms of below- and aboveground liana-tree competition in tropical forests

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Lianas, or woody vines, are abundant throughout forests worldwide, but are especially common in the tropics. Their presence can strongly suppress tree wood production, and presumably also reduce the strength of the tropical forest carbon sink. In intact neotropical forests, liana presence has been increasing over the past few decades, though the mechanisms remain under debate. Vexingly, lianas are not represented at all in current-day climate models. Better knowledge of liana morphology and allocation is required to unravel the mechanisms of below- and aboveground liana-tree competition in tropical forests. Such knowledge is also an essential step toward incorporating lianas into mechanistic forest dynamics models. To address these liana knowledge gaps, we have initiated a new project that integrates empirical and modeling work. Our objectives in this presentation are to compare observed liana allocation patterns to allocation patterns predicted by theory, and then to demonstrate how these results can be integrated into a numerical model.

Empirical measurements are being carried out in tropical dry forests in Guanacaste, Costa Rica. These measurements will eventually include excavations of ~80 entire trees and lianas, which will enable measurements of belowground and aboveground biomass of co-occurring trees and lianas, coarse and fine root vertical distribution, and lateral root spread. Also being measured are liana traits (including several critical hydraulic traits), above- and belowground productivity, and species-level fine root productivity. The modeling work includes the incorporation of lianas into the TROLL model, which is a mechanistic, individual-based forest dynamics model. The model will simulate the unique features of lianas, accounting for their structural parasitism and their different allocation strategies and morphology compared to trees. The simulated trees and lianas will compete aboveground for light and belowground for water. Thus, the model will integrate above- and belowground processes and couple the carbon and water cycles. Traits measured as part of this project are being used to parameterize the model.

Thus far, 33 mature, canopy-exposed individuals (18 trees and 15 lianas) have been harvested and

analyzed. For both trees and lianas, biomass partitioning to roots, stems, and leaves were consistent with the predictions of allometric biomass partitioning theory. This result thwarted our initial expectation that lianas, with their narrow-diameter stems, would allocate proportionally less to stems than trees. We also found that vertical root profiles varied across life forms: lianas had the shallowest roots, evergreen trees had the deepest roots, and deciduous trees had intermediate rooting depths. The liana root systems also had notably broader lateral extents than the tree root systems. These results run contrary to previous work that reported that lianas were relatively deeply-rooted.

Our empirical results have helped to motivate model development. Each of our modeled liana individuals is assigned a laterally-widespread root system that can potentially extend beneath many trees. The liana root system is then permitted to put up aboveground shoots that associate with trees within the footprint of the root system. Comparisons of simulated and observed above- and belowground productivity are currently being conducted to help evaluate model assumptions.