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Connecting forest canopy structure with size distributions and tree demography in the Amazon

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A primary feature of forests is how individuals are distributed over the tree diameter size-range. An important question is wether demographic transitions that underlie this forest size distribution are critically influenced by a pattern of increasing light availability with tree size that emerges from the gross properties of forest canopy structure. To test this hypotheses it is necessary to first understand how the leaf area of trees of different sizes is arrayed over strata and light environments in the canopy. Based on theories of canopy architecture, we developed a detailed quantitative model to link vertical patterns of leaf area and light penetration with size distributions in tropical forest. Applying this model to a data set from one-hectare plots (N=36) in two sites with contrasting forest structure 500km apart in the central Amazon, we showed that above-ground canopy structure and size distributions can be rapidly remotely detected with Light Detection and Ranging (LiDAR) technology. The model provided strong support for the plasticity of tree crown architecture in different light environments---only by incorporating plasticity was a single model parameterization able to predict site differences. We next used the model to estimate the light absorbed by leaves in trees of different sizes (a previously unavailable quantity) and found that absorption predicted site differences in demographic transitions over tree size and, thus, size distributions. In contrast to the prediction of a light limitation of growth hypothesis, higher light absorption was associated with greater mortality relative to growth over most of the size range. Thus, understanding the link between light absorption and size distributions requires an enhanced understanding of tree mortality. The quantitative links between canopy structure, size distributions, and demography developed in this investigation may critically improve understanding and prediction of biosphere-atmosphere interactions in the Amazon.

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