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Mechanisms driving carbon allocation in tropical rainforests: allometric constraints and environmental responses

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Tropical forest ecosystems play a major role in global water and carbon cycles. However, mechanisms of C allocation in tropical forests and their response to environmental variation are largely unresolved as, due to the scarcity of data, they are underrepresented in global syntheses of forest C allocation. Allocation of gross primary production to wood production exerts a key control on forest C residence time and biomass C turnover, and therefore is of special interest for terrestrial ecosystem research and earth system science.

Here, we synthesize pantropical data from 105 old-growth rainforests to investigate relationships between climate (mean annual precipitation, mean annual temperature, dry season length and cloud cover), soil nutrient relations (soil N:P) and the partitioning of aboveground net primary production (ANPP) to wood production (WPart) using structural equation modelling.

Our results show a strong increase of WPart with ANPP, pointing towards allometric scaling controls on WPart, with increasing light competition in more productive forests triggering greater ANPP allocation to wood production. ANPP itself was positively affected by mean annual temperature and soil N:P. Beyond these allometric controls on WPart we found direct environmental controls. WPart increased with dry season length in tropical montane rainforests and with mean annual precipitation in lowland tropical rainforests. We discuss different trade-offs between plant traits, such as community-wide changes along the wood economics spectrum, the leaf economics spectrum and the plant resource economics spectrum, as underlying mechanisms for direct climatic controls on WPart.

We thereby provide new insights into mechanisms driving carbon allocation to WPart in tropical rainforests and show that low and high productive tropical rainforests may respond differently to projected global changes.