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Nutrient cycling and plant trait variation - two crucial processes for simulating the community assembly and productivity of tropical forests

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Community assembly in highly diverse tropical rainforests is poorly understood and advancing our understanding is crucial for predicting ecosystem responses to future environmental change. Dynamic vegetation models which include plant trait variation are able to produce realistic plant communities by ecological filtering under climatic and edaphic drivers. Building upon more than a decade of field research in the biodiversity hotspot of the mountain rainforest in southern Ecuador, we implemented plant trait variability and improved soil organic matter dynamics in a widely used regional to global dynamic vegetation model (LPJ-GUESS) in order to explore how nutrients may influence community trait assembly and productivity along an altitudinal gradient.

In the new model version LPJ-GUESS-NTD (where NTD stands for nutrient-trait dynamics), each plant individual can possess different trait combinations which determine their demand for nutrients (N and P) and competiveness along conservative – acquisitive strategies. Nutrient availability is determined by the stoichiometry of the source organic matter and edaphic constraints to its decomposition, producing a feedback between vegetation traits and their drivers. Final community trait composition emerges via ecological sorting. Further model developments include mycorrhizal nutrient uptake.

The new model version reproduced the main observed community trait shift and related vegetation processes along the elevational gradient, but only if nutrient limitations to plant growth were activated. In turn, when traits were fixed, low productivity communities emerged due to reduced nutrient-use efficiency. The results strongly suggest that interactions between plant traits and nutrient limitations are crucial for community assembly and ecosystem functioning in our study area and probably in other systems where water is not limiting. Future studies based on the LPJ-GUESS-NTD model will include further traits based on the belowground carbon economy and

collaboration with mycorrhiza, and may provide important insights concerning the role of functional diversity for ecosystem resilience under climate change and increased anthropogenic nutrient deposition.