Plant nutrient acquisition strategies along an N:P gradient: implications for vegetation models

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Since modern days, anthropogenic activity significantly alters the nitrogen and phosphorus cycle, and these changes are substantially affecting terrestrial plant communities. Along with potassium (K), nitrogen (N) and phosphorus (P) are key nutrients limiting plant growth. Plants occupy distinct niches along N:P ratio gradients, and their physiological adaptation to these environments could potentially help us understand current and future species composition within N- and P-limited soils. Bergmann et al. (2020), provided an improved two-dimensional conceptual framework to understand resource acquisition through belowground rooting behaviour. They discerned two largely independent gradients: a conservation and a collaboration gradient. The conservation gradient differentiates between species with a slow strategy, which have a high root tissue density implying slow resource uptake and investment in long-living roots, and species with a fast strategy, that show high root N concentration implying high resource uptake but a short lifespan. The collaboration gradient goes from an outsourcing strategy with a high root diameter allowing carbon investment in fungal partners versus a do-it-yourself soil exploration strategy which requires a high specific root length. This framework, however, has not been assessed from a nutrient stoichiometric perspective. For this, we retrieved 12 belowground traits from trait databases and linked them to a European-wide field dataset of 990 vegetation recordings with species composition, site-productivity and nutrient contents of herbaceous ecosystems (extended dataset building on Wassen et al. (2021)). Using the framework of Bergmann et al. (2020), we show that plant communities in P-limited sites have adopted a slow and collaborative belowground strategy, whereas N-limited plant communities show a fast and do-it-yourself belowground strategy. Our result implies that, in addition to the benefit for fast-growing species in a nutrient-enriching world, anthropogenic alterations in the nutrient balance may also heavily affect species fitness and survival due to their nutrient-specific rooting strategies. The biggest remaining question is, however, if species will be able to adapt to changes in nutrient stoichiometry and if they can, how fast this adaptation process will be. Our results provide a new insight into belowground strategies under N or P limitation and may have consequences for the representation of plant traits in vegetation models. Finally, we strongly urge to analyse rooting traits of a larger number of species along a N:P gradient to increase the reliability of community trait estimates.
References:
