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Leaf economic traits in relation to soil nutrients, climate and water supply

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Leaf traits such as SLA (specific leaf area), LNCmass (leaf nitrogen concentration) and LPCmass (leaf phosphorus concentration) are strong indicators of the trade-off between how fast plants growth and leaf longevity. This trade-off has been extensively studied in plant ecology and is currently understood quite well, particularly in relation to nutrient and water stress in dry environments. The quantification of the continuous relationship of leaf traits to environmental factors can potentially be used to develop new modeling frameworks to study the effects of climate change. However, in studies involving regulation of leaf traits by environmental factors, there is a large residual variation in trait values which is not explained by a given factor. Here we present the results of research on the quantification of the relationship between nutrient supply and leaf traits, and the use of categorical classifications such as growth forms, woodiness and leaf habit to study the factors that contribute to variation in leaf economy. We quantified the relationship of leaf traits vs. nutrient supply in two separate data-sets: a global data set, obtained from published studies, consisting of 474 species distributed across 99 sites (809 records) and data-set of measured plant traits from 105 different species (254 observations) distributed across 50 sites in mesic to wet plant communities in The Netherlands. Abiotic information on soil total N, soil total P, water supply estimates and climate information was also collected. The additional, more detailed, study of factors contributing to trait variability was carried out with the data-set collected in the Netherlands only. For this study categorical classifications were used to better understand which other plant characteristics additionally contribute to variation in leaf economy traits and to understand the consistency of this contribution. Leaf trait vs. environmental factor relationships were quantified in each data-set using maximum likelihood methods. Differences among categorical classifications in the Netherlands data-set were tested with Bonferroni post-hoc tests.

In both data-sets, there was a consistent increase in SLA, LNC and LPC with increasing soil fertility. SLA was related to proxies of N supply and multivariate analysis showed that climate (in the global data-set) and water supply (in the Dutch data-set) interacted with indicators of N fertility. LNCmass and LPCmass in both data-sets were mostly determined by soil P alone. The analysis with the data-set from The Netherlands showed that variability within a given site was the largest source of unexplained variability, and that qualitative attributes could explain 8-23% of this variance in leaf traits vs. soil fertility relationships. From the variance among sites, environmental factors could explain between 30-50%. Altogether these results show that leaf traits can be used to characterize the continuous response of plants to resource supply (nutrients and water in this study). However, if these relationships are to be used for prediction purposes, we have to improve our understanding of the factors determining variability within and among sites. In these regard, categorical classifications can potentially be used to make better predictions of patterns of leaf traits in relation to nutrient supply. For improving predictions among sites, other factors such as disturbance and improved measures of nutrient supply need to be explored.