Partitioning of plant functional trait variation into phenotypic plasticity and non-plastic components reveals functional differences among neotropical tree species

Florian Hofhansl[1], Eduardo Chacon-Madrigal[2], Ake Brännström[3], Ulf Dieckmann[1] and Oskar Franklin[1]

Background

Tropical plant communities exhibit extraordinary species richness and functional diversity in highly heterogeneous environments. Albeit the fact that such environmental filtering shapes local species composition and associated plant functional traits, it remains elusive to what extend tropical vegetation might be able to acclimate to environmental changes via phenotypic plasticity, which could be a critical determinant affecting the resistance and resilience of tropical vegetation to projected climate change.

Methodology

Based on a dataset compiled from 345 individuals and comprising 34 tropical tree species sampled in Costa Rica (**Fig. 1**) we here investigated the role of phenotypic plasticity versus non-plastic variation among key plant functional traits, i.e. wood density (**WSG**), maximum height (**Height**), leaf dry mass content (**LDMC**), leaf area (**LA**), specific leaf area (**SLA**), leaf thickness (**LT**), leaf nitrogen (**N**) and leaf phosphorus (**P**) content (**Fig. 2**). We hypothesized that trait variation due to plasticity is driven by environmental variability between forest stands, whereas non-plastic variation increases with geographic distance due to adaptation of the plant community to the environment.

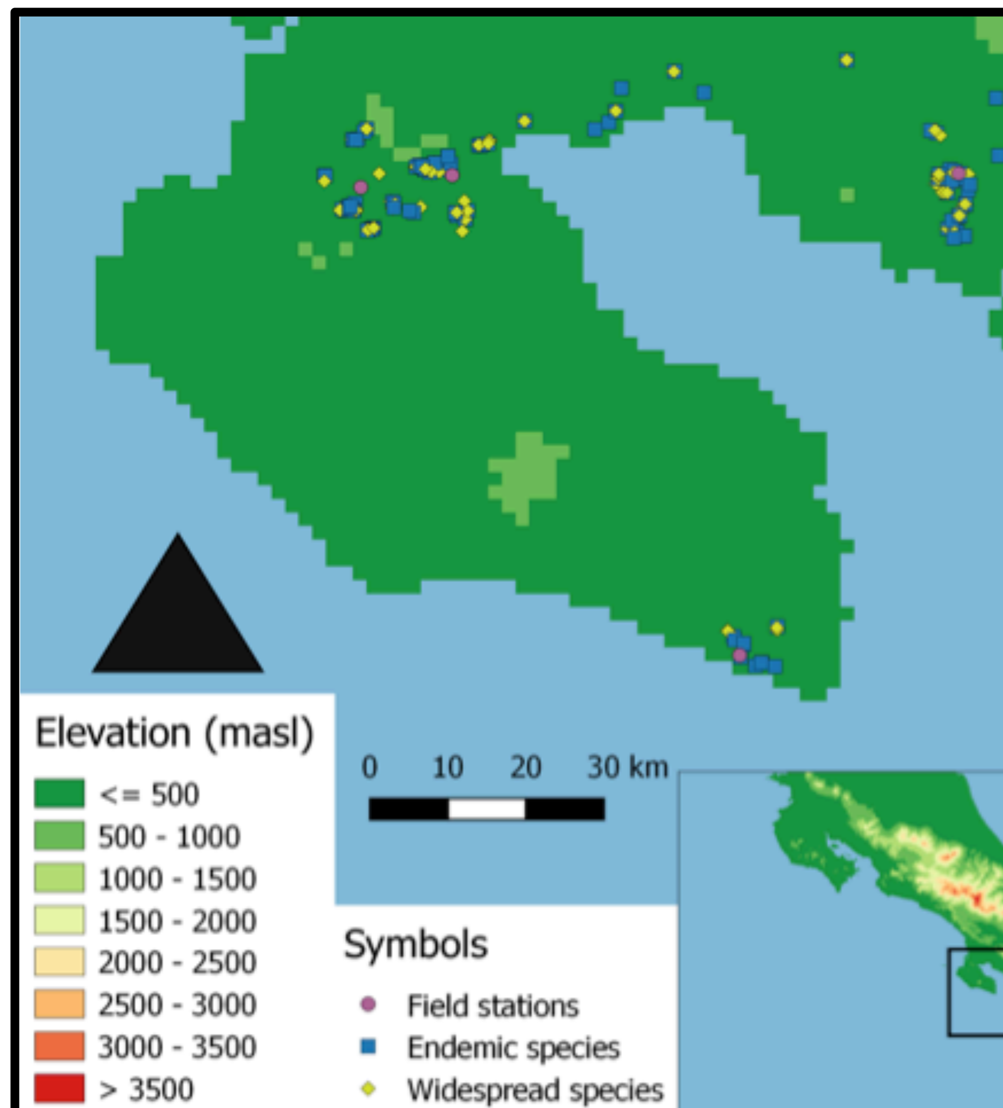

Figure 1. Geographic locations of plots sampled for plant functional traits. Points indicate locations of field stations and sampling sites of tree individuals selected for congeneric endemic and widespread tree species.

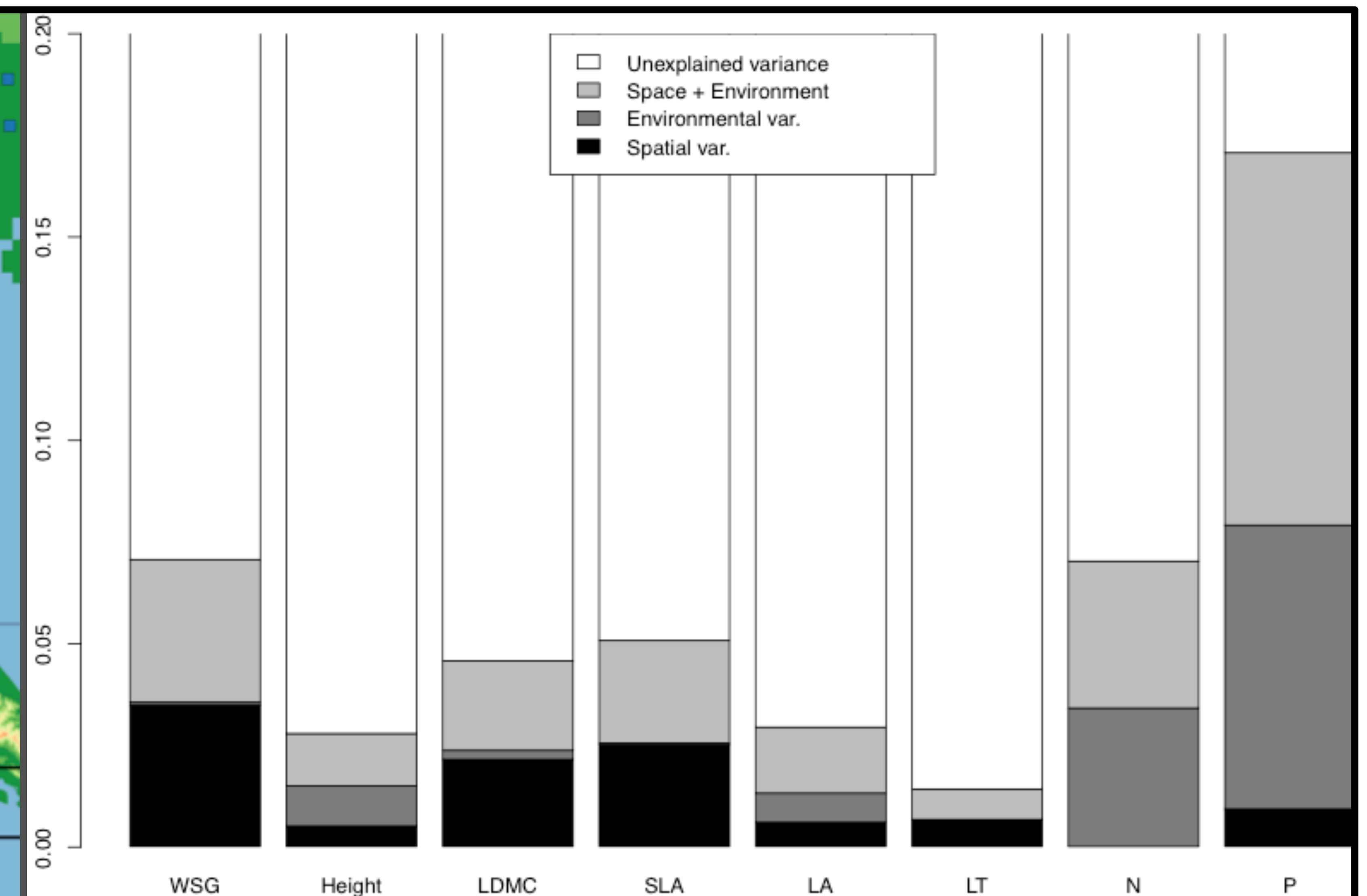

Figure 2. Variance partitioning showing respective amount of variance explained due to different controlling factors, such as geographic distance and environmental variation driving variability of plant functional traits (i.e. wood density, maximum height, leaf dry mass content, leaf area, specific leaf area, leaf thickness, leaf nitrogen and leaf phosphorus content) in the study region.

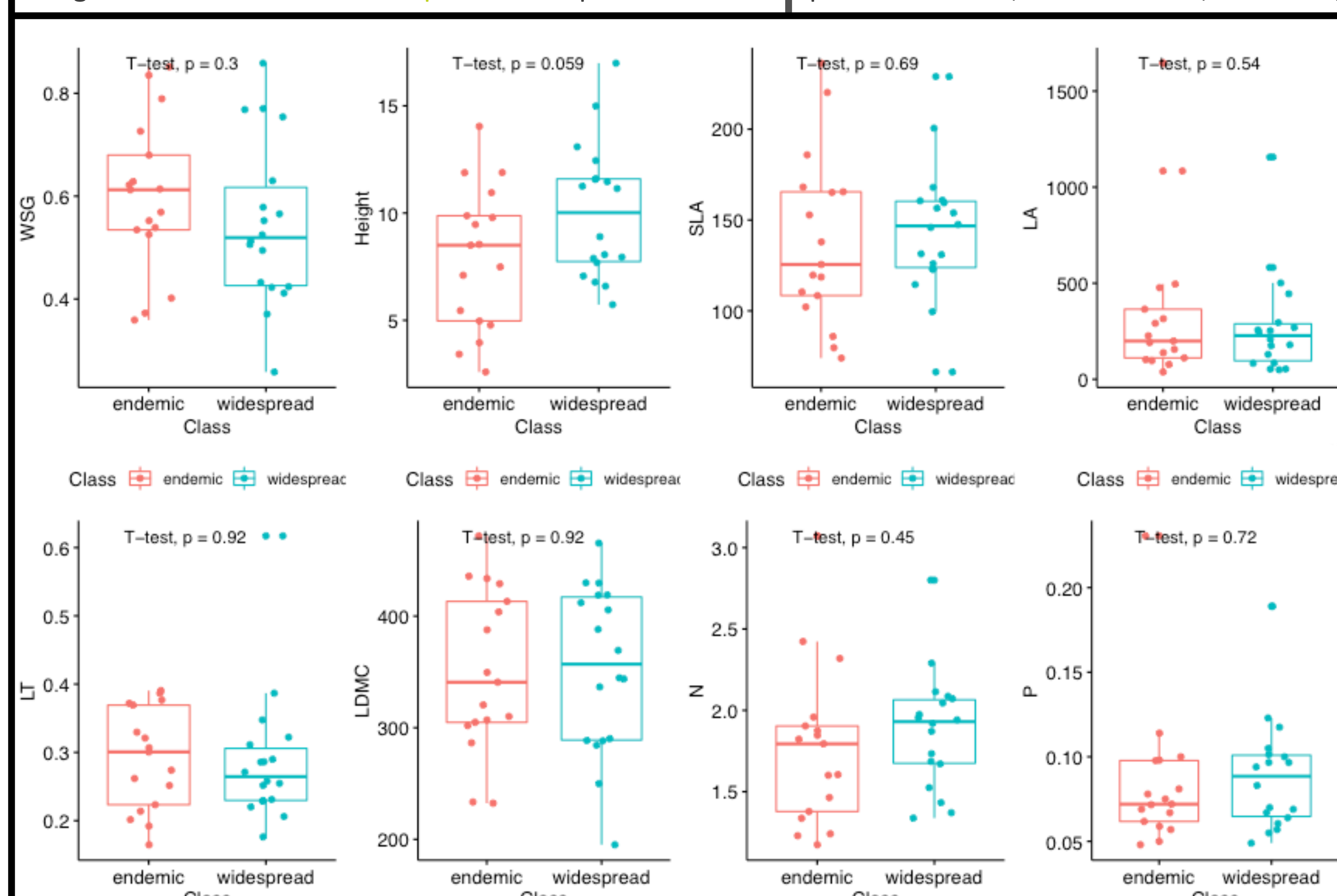

Figure 4. Boxplots showing mean and variance of plant functional traits, i.e. wood density, maximum height, specific leaf area, leaf area, leaf thickness, leaf dry mass content, leaf nitrogen content, leaf phosphorus content for congeneric endemic and widespread tree species.

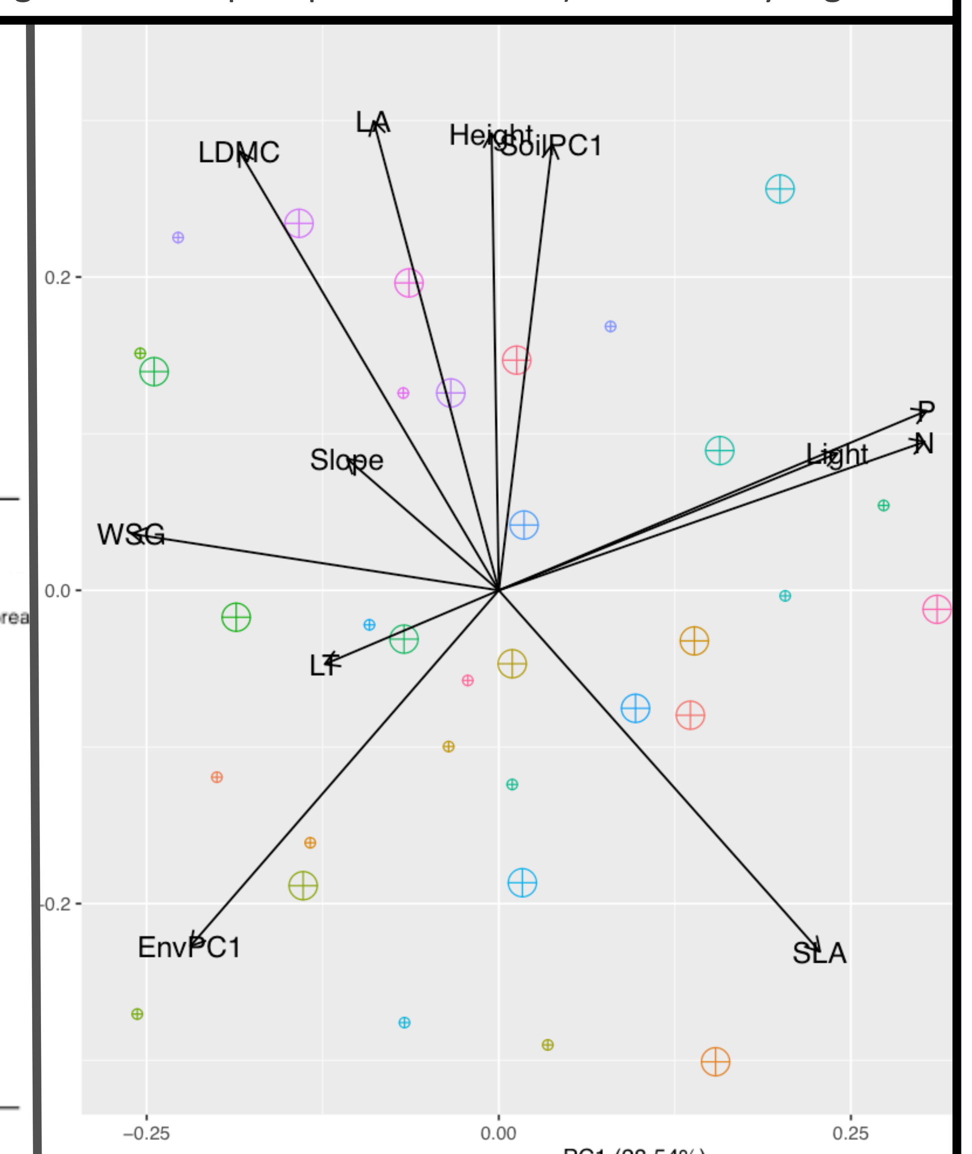

Figure 3. Principal component analysis showing relation between environmental controls, plant traits, tree species (point colour) and range size (point size).

Results

We partitioned total trait variation into phenotypic plasticity and non-plastic components and quantified respective amount of variation related to environmental acclimation and spatial distance. We found that trait variation was strongly related to spatial factors, thus often masking phenotypic plasticity in response to environmental factors (**Fig. 2**). However, environmental controls differed among plant tissues, such that leaf traits varied in association with light regime and soil nutrient content, whereas wood traits were related to topography and soil water content (**Fig. 3**).

Conclusions

Our results suggest that plant functional trait variation differed among congeneric neotropical tree species, indicating differences in life-history strategy between congeneric range restricted endemics and widespread tree species. While, wood density was on average higher, maximum tree height was on average lower for endemic than for widespread species (**Fig. 4**). We therefore conclude that plant functional response spectra might differ among coexisting neotropical tree species, such that species with more conservative ecological strategies could be especially prone to projected climate change.

Affiliations:
[1]International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria
[2]Escuela de Biología, Universidad de Costa Rica, San José, Costa Rica
[3]Department of Mathematics and Mathematical Statistics, Umeå University, Umeå, Sweden

Contact:
Dr. Florian Hofhansl
Mail: hofhansl@iiasa.ac.at
Web: http://www.tropicalbio.me

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at