Convergent patterns of $\alpha$- and $\beta$-functional diversity across tropical and temperate mountain forests.

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Summary:
Large-scale global biodiversity gradients are one of ecology’s most fundamental unresolved patterns. Diversity arises as lineages undergo physiological shifts—thus, functional aspects of biodiversity are vital to furthering our understanding of biodiversity as an ecological phenomena.

We characterize multi-trait functional $\alpha$- and $\beta$-diversities for 6 New World mountain forest gradients across a 100° latitudinal span. Surprisingly, despite the large shifts in climate associated with increasing latitude, consistent patterns of functional diversity and change hold true across all 6 gradients. We find that 1) species rich sites are highly functionally diversified, even when accounting for the obvious sampling effects; and 2) functional turnover between sites increases with elevational separation more quickly than random turnover of species can explain.

Methods
1) Data assembly
4 primary traits: SLA, height, seed mass, wood density. Additional leaf traits for secondary analysis. Species mean trait values obtained on-site or from TRY database. Data gap-filled using 1) congenerics and 2) mice imputation.

2) Diversity analysis
Hypervolumes represent each species as a point in a shared multidimensional trait space. $\alpha$-diversity: trait ‘volume’ occupied by all the species at a site. $\beta$-diversity: proportion of overlap between two sites’ hypervolumes.

Data gathering. Undisturbed forest communi-ties were sampled using a uniform Gentrasos protocol along an elevational gradient in each locale. Bottom right: species richness declines with elevation and latitude.

Locale Latitude Sites m.a.s.l.
RMBL 38° 4 2506 – 3261
Sequoya 36° 8 686 – 3187
Santa 32° 4 1862 – 2542
El Cielo 23° 7 835 – 3200
Guanacaste 11° 5 3 – 1500
Rio Savgre 9° 6 75 – 3250

Hypotheses:

Environmental filtering:
FD gradients reflect changes in abiotic constraints on plant traits. Thus, alpha diversity will be reduced into areas of best fitness, and beta diversity will increase with geographic shift. Both effects will be strongest in temperate areas, where abiotic factors are most extreme.

Biotic interactions:
FD gradients reflect interspecies interactions such as competition, which favor diversification into novel niches. Thus, alpha diversity will be increased in species rich, competitive sites (tropics, low elevations).

Neutral effects:
Diversity gradients reflect functionally neutral, non-ecological phenomena (historical, spatial, etc.) Thus, both alpha and beta FD will be equivalent to null modeling scenarios, affected only by the size of local and regional species pools.

Results:

A. Calculated alpha diversities (dots, representing pooled values from multiple imputation outcomes) compared to 95% CI’s for null models (bands). Null models were functionally randomized and iterated 999 times. Primary analysis results are shown in brown, secondary leaf-trait only analyses in green.

B. Alpha diversities standardized to reflect their deviation scores from null expectations. Scores with an absolute value >2 (solid lines) represent significant deviations from a functionally neutral scenario. All gradients diverged from null expectations, but no differences between gradients were detectable. Inset: results from leaf-trait only analyses were less pronounced, but qualitatively identical.

Above: Beta functional overlap decreases with elevational shift.
C. Actual beta functional overlap (in % shared functional space) compared to 95% CI’s for null models. Colors, etc., as in panel A.
D. Standardized beta overlap scores show a strong trend for decreasing functional similarity with elevational separation, although the span of our data was not quite sufficient to show true, systematic deviation from null expectations, either in standard scores or multiple linear model coefficients. Inset: as in B.

Conclusions and future work:
The patterns of functional diversity seen in our results do not align with any one hypothesis for the origin of biodiversity. The increased alpha diversity in species rich communities may reflect competition and niche differentiation; the apparent correlation between functional and environmental similarity seen in beta analyses is more in line with environmental filtering dynamics. Both hypotheses, however, predict climate differences, which were absent in our study.

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Key references:
Blonder, B., Peet, R., McGilva, K., Lamanna, C., Violle, C., Kraft, N., Marcuse-Sandel, J., Spencer, N., Thiers, B., Wiser, S., and Jorgensen, P. (2013), Filling the gap between gradients were detectable. Inset: results from leaf-trait only analyses were less pronounced, but qualitatively identical.?