Using trait and phylogenetic diversity to evaluate the generality of the stress dominance hypothesis in eastern North American tree communities

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BACKGROUND

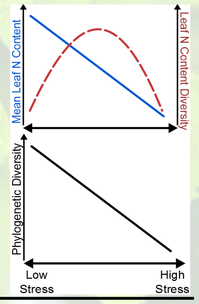
Are there general rules for which processes structure ecological communities? One framework, the **Stress Dominance Hypothesis (SDH),** predicts that environmental filtering will be more important in stressful environments, while competition will be more important in benign environments. Trait diversity (TD) & phylogenetic diversity (PD) are community-level properties that can be used to detect the importance of different processes.

RESEARCH QUESTION

Is the SDH generally true across eastern North American tree communities?

HYPOTHESES

	Low Stress (strong competition)	High Stress (strong environmental filtering)
Leaf Nitrogen Content	Convergence on high nitrogen content. Low resource-use efficiency enables faster growth.	Convergence on low nitrogen content. High resource-use efficiency enables stress tolerance.
Phylogenetic Diversity	Competition limits functional similarity of co-exising species, resulting in high phylogenetic diversity.	Strong environmental filtering excludes species without physiological tolerance, resulting in low phylogenetic diversity.



* We also examined Seed Mass and Wood Density.

METHODS

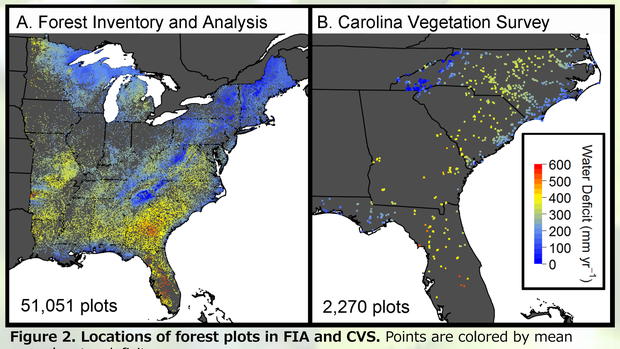


Figure 2. Locations of forest plots in FIA and CVS. Points are colored by mean annual water deficit.

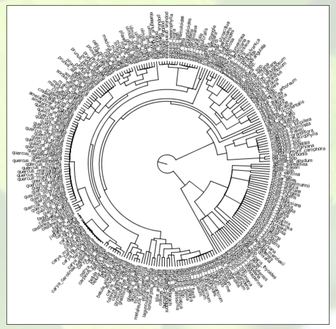


Figure 3. Phylogeny of tree species. This genus-level phylogeny was generated using Phylocom and is based on APG III.

- Two complementary tree community datasets: FIA (Forest Inventory & Analysis) and CVS (Carolina Vegetation Survey)
- Examined changes in community-weighted mean leaf N, leaf N TD[1], and PD[2] across two environmental stress gradients in eastern United States:
  - **Climatic water deficit** = PET – AET
  - **Soil fertility**

[1]*TD: Rao's Q*

[2]*PD: MPD = Mean pair-wise phylogenetic distance between taxa*

RESULTS

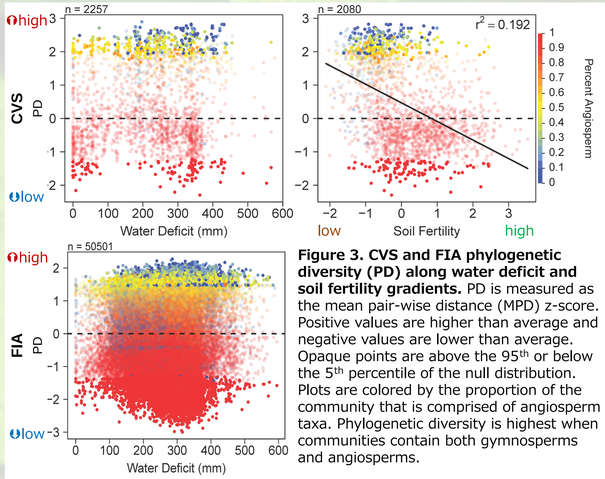


Figure 3. CVS and FIA phylogenetic diversity (PD) along water deficit and soil fertility gradients. PD is measured as the mean pair-wise distance (MPD) z-score. Positive values are higher than average and negative values are lower than average. Opaque points are above the 95th or below the 5th percentile of the null distribution. Plots are colored by the proportion of the community that is comprised of angiosperm taxa. Phylogenetic diversity is highest when communities contain both gymnosperms and angiosperms.

Leaf N

- Filtering for low N in high water deficit & low soil fertility.
- No change in diversity, consistently underdispersed.

PD

- Decreased with increasing soil fertility (contrary to hypothesis).
- Driven by angiosperm-gymnosperm split.

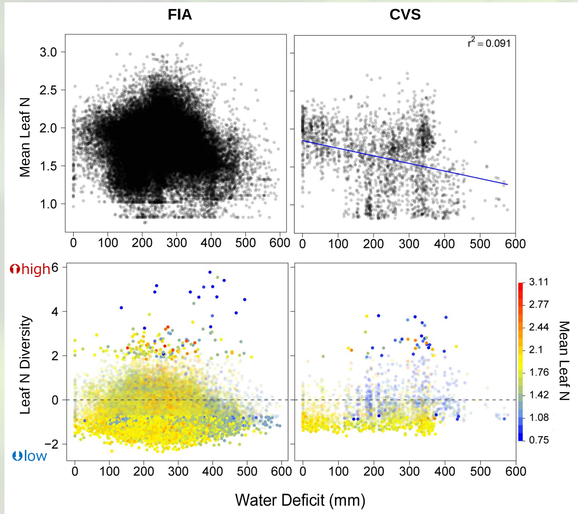


Figure 4. Effect of water stress on mean leaf N and leaf N diversity in FIA and CVS plots. Higher values of water deficit correspond to higher water stress. Points are colored by the mean trait value in the plot. Blue lines show the best fit models and only models for which the coefficient of determination is greater than 0.05 are shown.

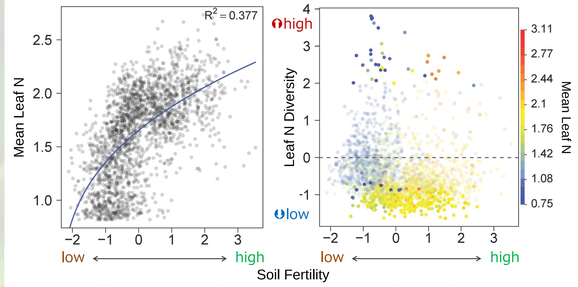


Figure 5. Effect of soil fertility on mean leaf N and leaf N diversity in CVS plots. (See Figure 4 for explanation of symbology)

CONCLUSIONS

1) There is little support for the SDH across eastern North American tree communities.
2) There are many limitations to using large-scale data to assess this hypothesis.

Why does trait diversity not respond to stress gradients?

- ✗ 1) Data set did not encompass a wide enough environmental range to capture both stressful and benign conditions.
- ✗ 2) Traits examined are not subject to the environmental gradients measured.
- ✗ 3) Species-level mean trait values masked local trait-environment relationships.
- ✗ 4) Diversity metric did not accurately capture existing trait convergence or divergence.
- ☺ 5) Hypotheses about processes structuring tree communities along stress gradients are not generally true across eastern North America.

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