

Functional traits associated with multiple abiotic stress tolerance strategies in woody plants of the Northern Hemisphere

NICOLA PAVANETTO^{1*}, CARLOS P. CARMONA², ÜLO NIINEMETS¹, LAURI LAANISTO¹, GIACOMO PUGLIELLI³

¹Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu 51006, Estonia

²Institute of Ecology and Earth Sciences, University of Tartu, Lai 40, 51005 Tartu, Estonia

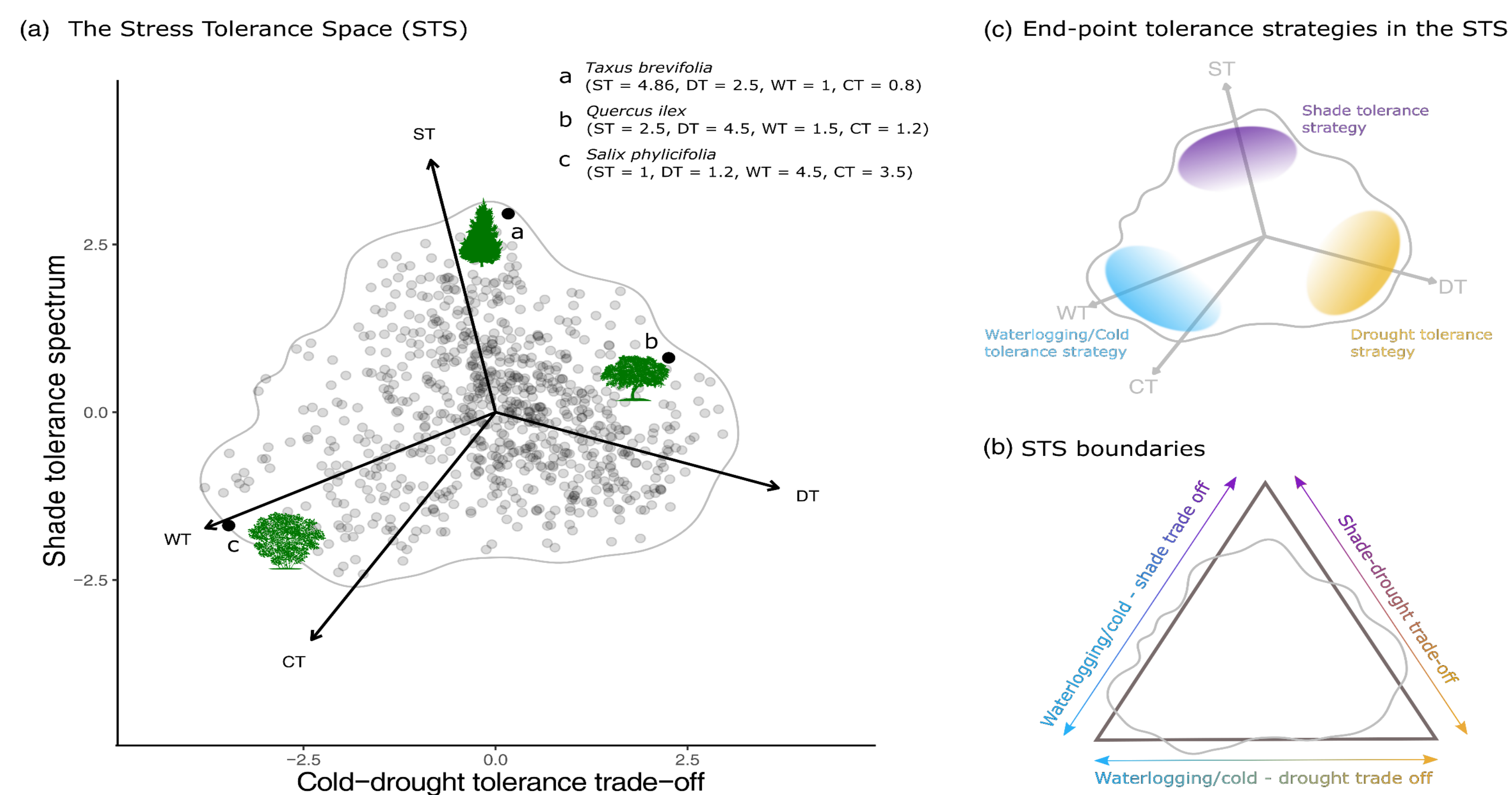
³Departamento de Biología Vegetal y Ecología, Universidad de Sevilla, 41080 Sevilla, Spain

* nicola.pavanetto@emu.ee

(A) Background

- Trade-offs among tolerances to different abiotic stressors limit polytolerance in woody plants
- However, the general trait syndromes that underlie large-scale tolerance patterns of woody plants remain controversial¹.
- Recently, a **stress tolerance trade-off space**² (STS) was formalized, defining the major axes of differentiation of woody plants' tolerance strategies towards **drought, shade, waterlogging, and cold** for 799 species of the Northern Hemisphere.
- Using the STS framework we tested if the leading trait dimensions that define the **global spectrum of plant form and function**³ capture the underlying trait trade-offs limiting woody plant polytolerance.

(B) The Stress Tolerance Space (STS) framework



(a) STS is defined by combinations of tolerance to **drought (DT)**, **shade (ST)**, **waterlogging (WT)** and **cold (CT)** for 799 species in the Northern Hemisphere. The first axis reflects a trade-off between drought and cold/waterlogging tolerance, while the second axis is a shade tolerance spectrum.

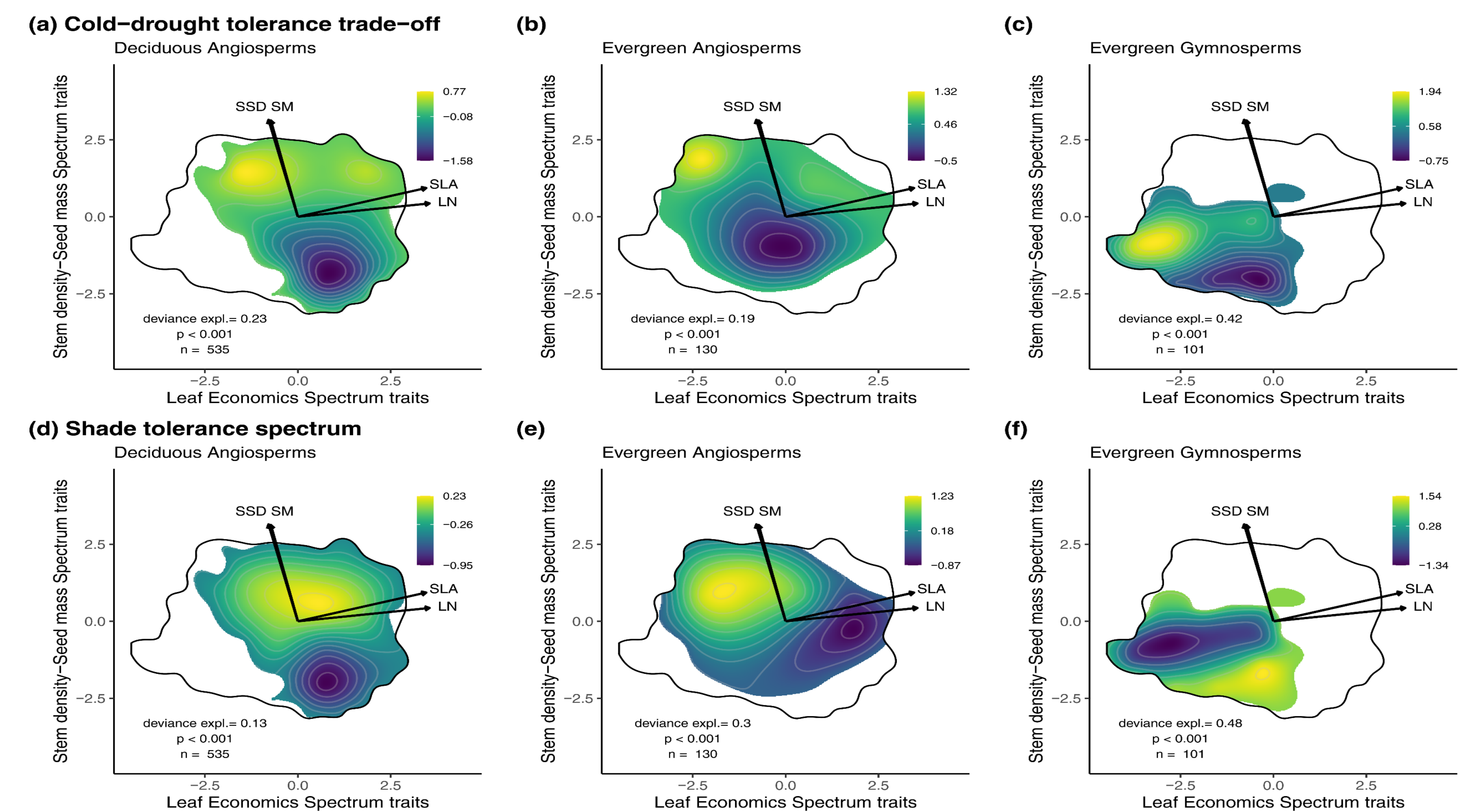
(b) Three end-point tolerance strategies can be identified, which should correspond to contrasting trait syndromes underlying drought, shade, and cold/waterlogging tolerance.

(c) The STS boundary sets the limits on the abiotic stress tolerance strategies of woody plants from the northern hemisphere, and it is defined by three trade-off axes that culminate in either one of the three end-point tolerance strategies.

(C) Methods

- We used a dataset of 779 species to link the trait dimensions defining the **global spectrum of plant form and function (GSPFF)** with two dimensions summarizing tolerance syndromes to drought, shade, cold and waterlogging
- We used Generalized Additive Models (GAMs) to map the two dimensions defining the STS within the GSPFF.
- Patterns were analyzed at the plant functional type-level (PFT, deciduous/evergreen angiosperms, evergreen gymnosperms) since PFTs occupy different GSPFF regions.

(D) Stress tolerance strategies in the GSPFF



- Drought-tolerant angiosperms showed greater specific stem density (SSD) and seed mass (SM), and lower specific leaf area (SLA) and leaf nitrogen content (LN), compared to the cold/waterlogging tolerant species.
- Shade tolerant angiosperms displayed greater SSD-SM and lower SLA-LN compared to intolerant angiosperms.
- For evergreen gymnosperms, the shade-drought trade-off was the key tolerance strategic axis of differentiation in trait adaptations.

Conclusions

- The two trait dimensions of the GSPFF well summarise the functional constraints on polytolerance in woody plants at a large-scale.
- The 'SSD-SM' and the 'SLA-LN' dimensions distinguish cold or drought-tolerant woody angiosperms and shade- or drought-tolerant gymnosperms.
- Our results also support a stress tolerance strategy for shade-tolerant compared to intolerant species, with some differences between plant functional types due to contrasting leaf lifespans.

References

- ¹ Puglielli et al. 2023, Flora, 229
² Puglielli et al. 2021, New Phyt, 229: 1354-1362
³ Diaz et al. 2015, Nature, 529: 167-171

Acknowledgments

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