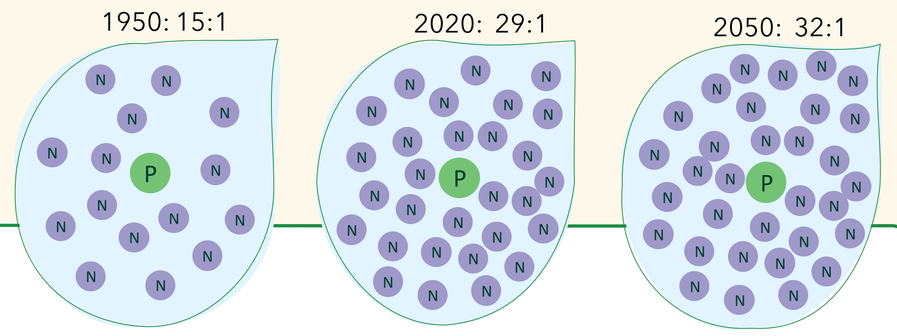
Nutrient imbalances shift plant trait distributions across fertility gradients

Annegreet Veeken[1], Jerry van Dijk[1], Benjamin Delory[1]

1. Copernicus Institute of Sustainable Development, Utrecht University

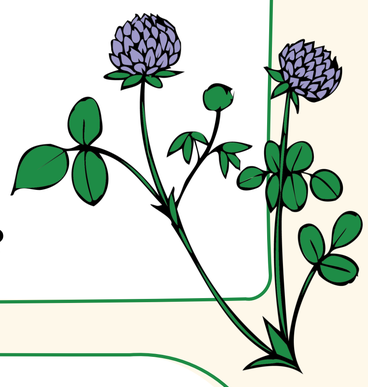
✉ *veeken.g.a@gmail.com*

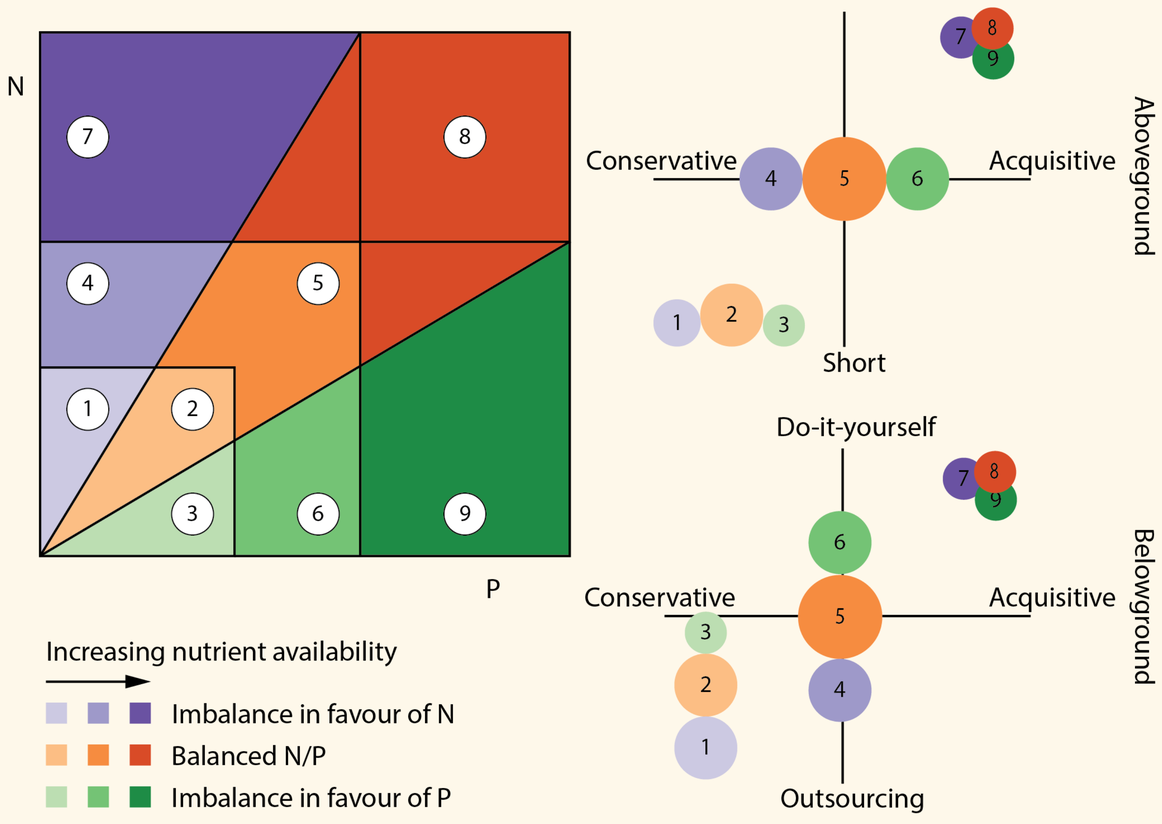


Introduction

- Next to changing nutrient availability in general, human activities have disrupted the biogeochemical cycles of Nitrogen (N) and Phosphorus (P) **disproportionately**, increasing the availability of N more strongly than P[1]
- The resulting **changes in N/P stoichiometry** can have important implications for biodiversity
- To understand community assembly when nutrient availability and N/P balance shift, we study **trait distributions**

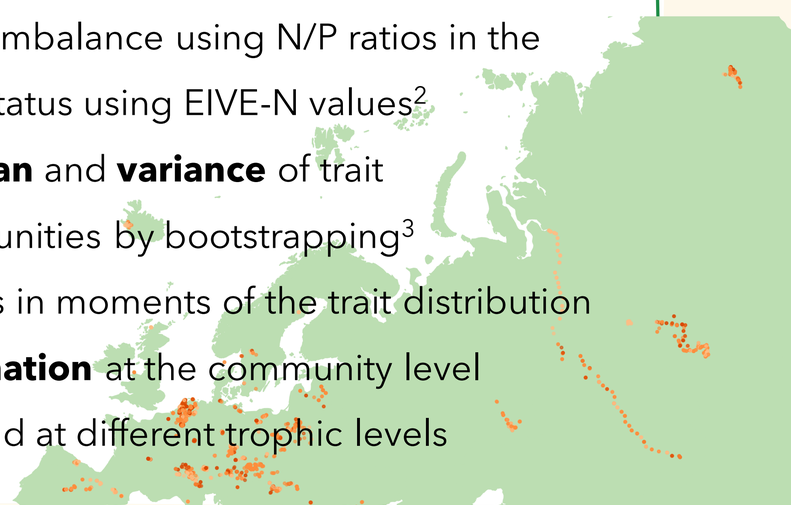
How does nutrient availability and N/P balance jointly influence trait distributions in herbaceous communities?



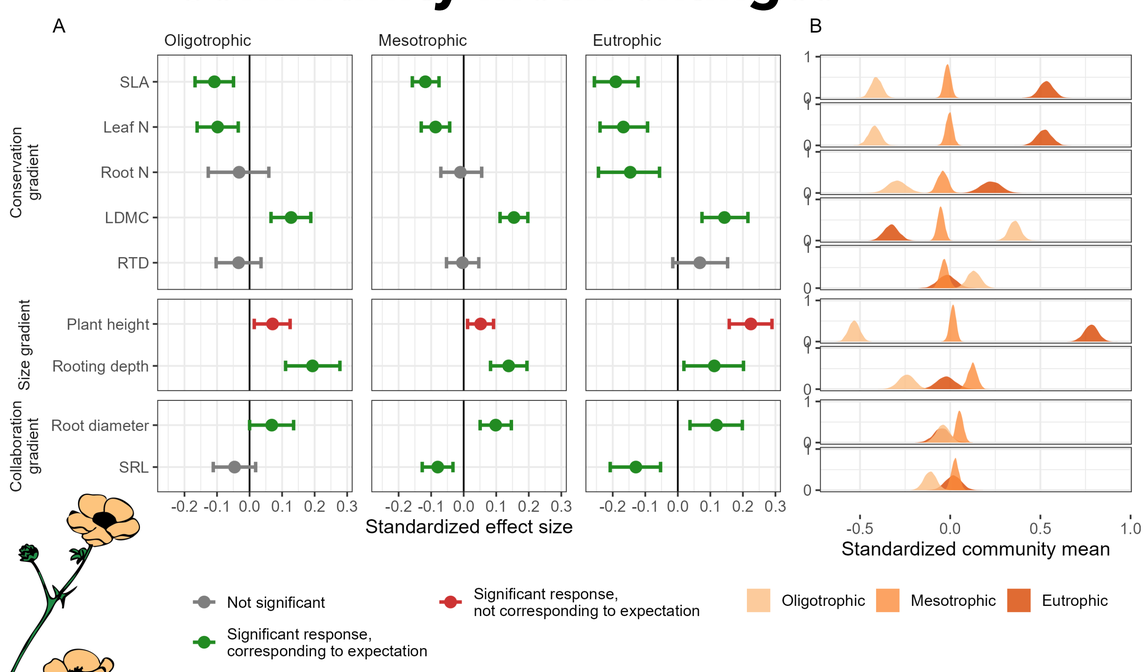


Methods

- We analysed a dataset of **3,689 observations** of species composition and nutrient concentration in aboveground living biomass
- We assessed nutrient imbalance using N/P ratios in the biomass and trophic status using EIVE-N values[2]
- We quantified the **mean** and **variance** of trait distributions of communities by bootstrapping[3]
- We evaluated changes in moments of the trait distribution and **trait-trait coordination** at the community level along N/P gradients and at different trophic levels

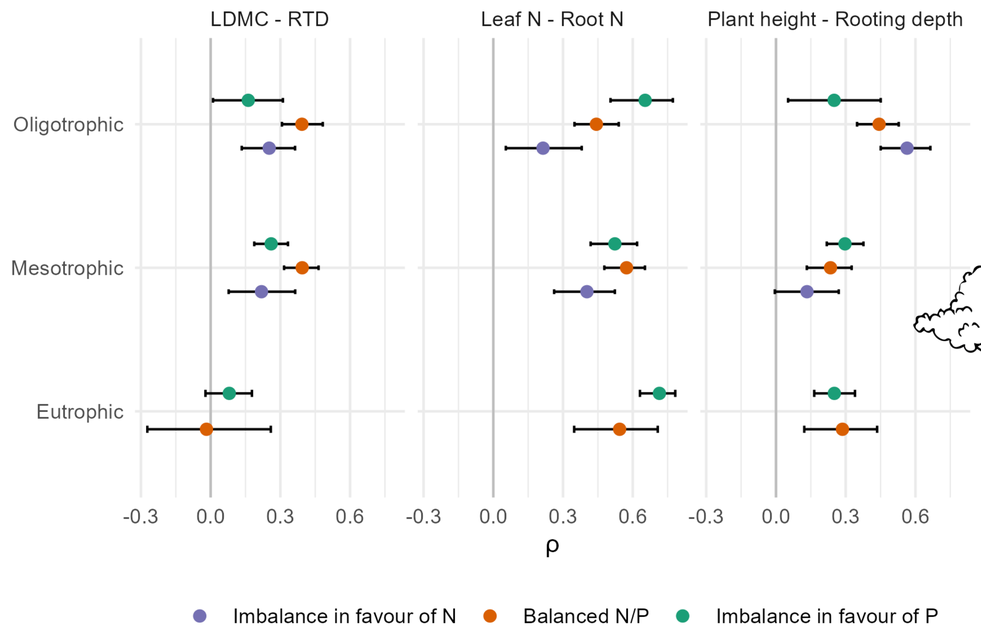


Community mean changes



A) Responses of community trait mean to nutrient imbalance in the different trophic levels, shown as the standardised effect size +/− 95% credibility intervals **B)** Distribution of community trait means in the different trophic levels.

Trait-trait coordination



Correlation between functional analogous traits above- and belowground in the three trophic levels and nutrient imbalances. CI's estimated by bootstrapping.

Key findings

- **Conservation:** Increasing N/P ratios shift aboveground traits toward conservative strategies across all trophic levels. In oligotrophic communities, above- and belowground conservation response is decoupled with changing N/P
- **Size:** Plant height (unexpectedly) and root depth both increase with N/P ratio, but the strength of the response is trophic-level dependent
- **Collaboration:** Root traits indicate increased outsourcing strategies under P limitation in meso- and eutrophic communities. High variance at opposite ends of the N/P spectrum mesotrophic sites (not shown) indicate high variation in uptake strategies at N/P imbalance

Utrecht University

1. Penuelas, J., Janssens, I. A., Ciais, P., Obersteiner, M. & Sardans, J. Anthropogenic global shifts in biospheric N and P concentrations and ratios and their impacts on biodiversity, ecosystem productivity, food security, and human health. *Global Change Biology* 26, 1962–1985 (2020).

2. Dengler, J., et al. (2023). Ecological Indicator Values for Europe (EIVE) 1.0. Vegetation Classification and Survey, 4, 7-29.

3. Maitner, B. S., et al. Bootstrapping outperforms community-weighted approaches for estimating the shapes of phenotypic distributions. Methods in Ecology and Evolution, 14, 2592–2610.