Photosynthetic acclimation under CO2 fertilization: new perspectives from current experiments

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Abstract

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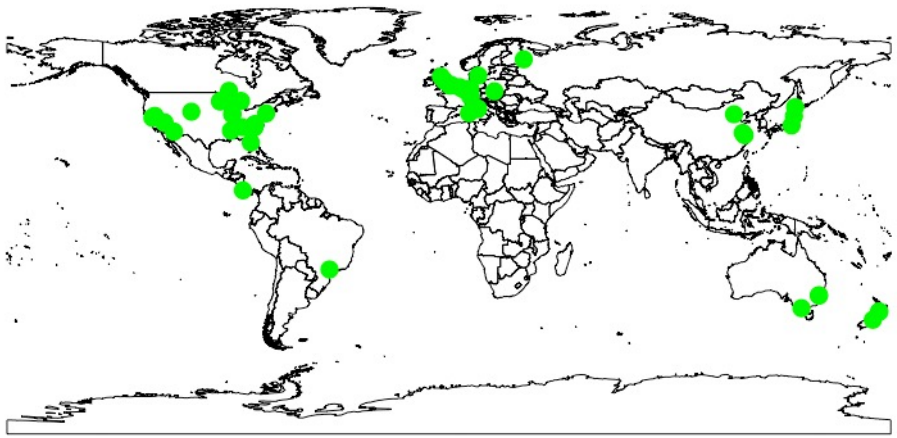
Background

Reductions in the maximum rate of carboxylation (V_{cmax}) and electron transport (J_{max}) under elevated CO_2 were explained by constraints of:

- **N demand** (Terrer et al. 2018; Smith & Keenan 2020; Dong et al. 2022)
  - Rubisco investment in leaf
  - N acquisition from belowground
- **N supply** (Luo et al. 2004)



51 CO_2 fertilisation sites for measuring V_{cmax} and J_{cmax}

Objectives

To better understand V_{cmax} acclimation to elevated CO_2 and balance the evidence for contrasting model formulations.

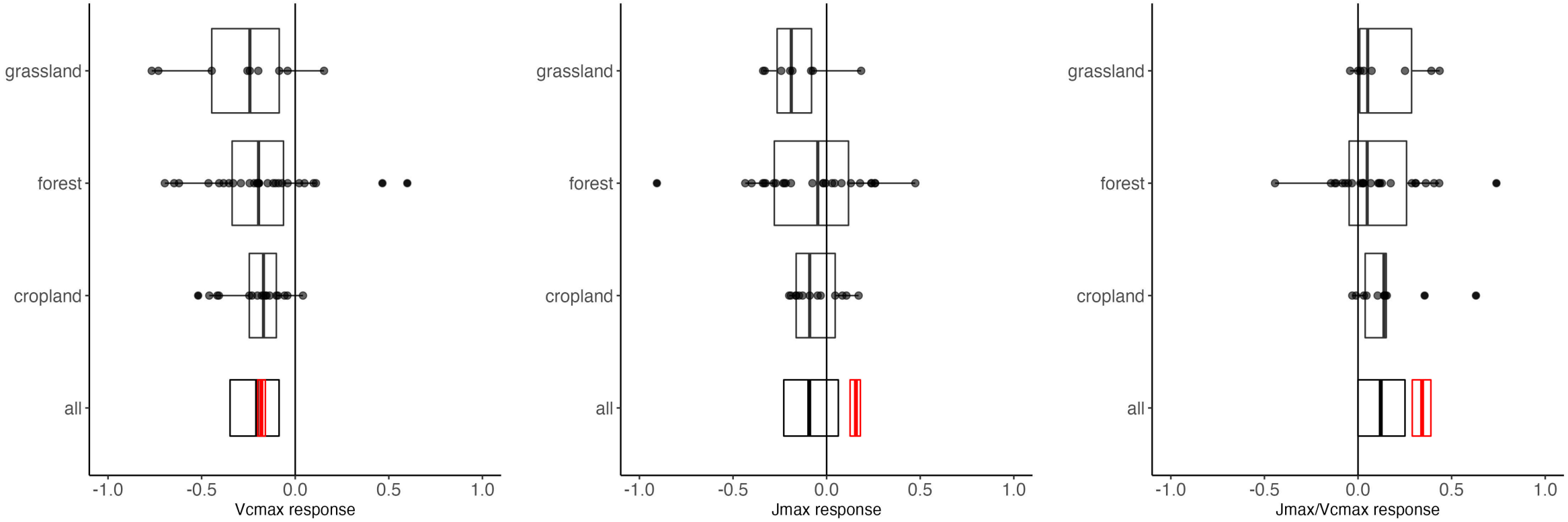
- Contrasting measurement vs. **optimality-based model** (Prentice et al. 2014; Wang et al. 2017).
- With collections of biomass, allocation, leaf and soil traits, to test all possible hypothesis in **meta-analysis.**

Swiss FACE experiment (Grassland Group, ETH)

V_{cmax} and J_{max}/V_{cmax} responses captured by optimality model

- **V_{cmax} reduction:** Increasing CO_2 reduces cost of carboxylation, requiring less investment of Rubisco (an important photosynthetic enzyme for carboxylation) to support a given rate of photosynthesis.
- **J_{max} / V_{cmax} increase:** plants underinvesting J_{max} than V_{cmax}, limiting potential leaf photosynthesis at eCO_2.

$$\textbf{Sensitivity coefficient} = \frac{\ln (V_{cmax}\,[ele.] \,/\, Vcmax\,[amb.])}{\ln (CO_2\,[ele.] \,/\, CO_2\,[amb.])}$$



Photosynthetic acclimation to eCO_2 explained by optimality principles

- **V_{cmax}, J_{max} and N_{mass} decrease consistently**
- **LMA increases with CO_2**
- **The more V_{cmax} decreases, the more NPP and root allocation increases:**
  - Additional photosynthate is produced, with higher root allocation shown to transport more N required for higher NPP.
- **V_{cmax} response was irrelevant to N supply**