Modeling Leaf Investment with Optimization Theory

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1. Objectives

Leaf area per basal area (LA:BA) and photosynthetic capacity (measured by V_{cmax}) are very plastic traits and significantly impact global carbon and water cycles. Predicting how LA:BA and V_{cmax} vary spatially and temporally is key to estimate the magnitude and impacts of future climate change.

Yet, how plants optimize LA:BA and V_{cmax} is poorly understood. We propose a model that optimize LA:BA and V_{cmax} simultaneously by maximizing GCP:

$$\mathrm{GCP} = \mathrm{CNPP} - \mathrm{LCC} \quad (1)$$

$$\mathrm{CNPP} = \int (A(t) - R(t)) \cdot \mathrm{d}t \quad (2)$$

$$\mathrm{LCC} = \mathrm{LCBM} + \mathrm{NS} \quad (3)$$

GCP Growing season canopy profit
CNPP Canopy net primary productivity
LCC Leaf construction costs
LCBM Leaf carbon biomass costs
NS Nutrient supply costs

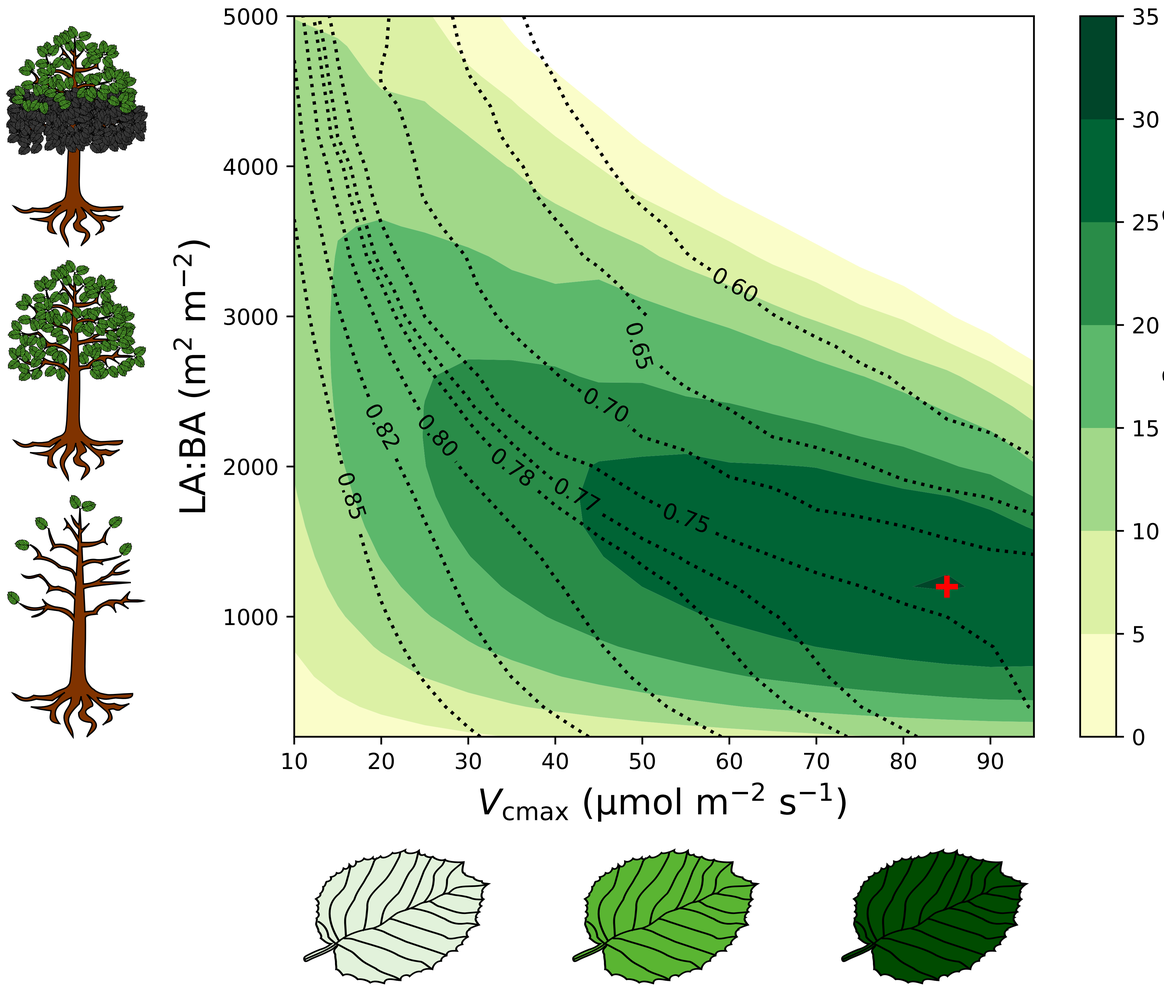
We further evaluate the sensitivity of optimal LA:BA and V_{cmax} to

- Plant hydraulic traits
- Leaf traits
- Water supply
- Environmental conditions

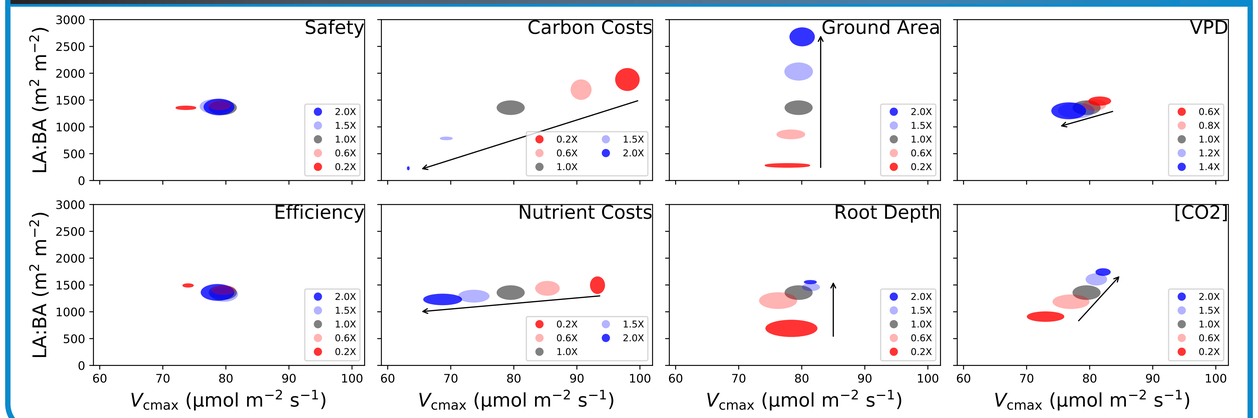
5. Conclusions

- Leaf construction costs (LCBM and NS) and root depth (H_{root}) are the key traits
- Environmental conditions have great impact on leaf investment
- Leaf investment is insensitive to hydraulic traits, but these traits are required for predicting tree health status
- Elevated CO_2 results in higher LA:BA and V_{cmax}, suggesting the reported lower V_{cmax} in FACE experiments is due to other factors, e.g., higher LCBM or NS
- Quantifying key plant traits and their coordination and acclimation is essential for mechanistically modeling leaf investment

2. Optimization Theory

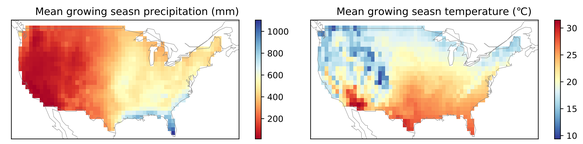


3. Sensitivity to Physiological and Environmental Traits



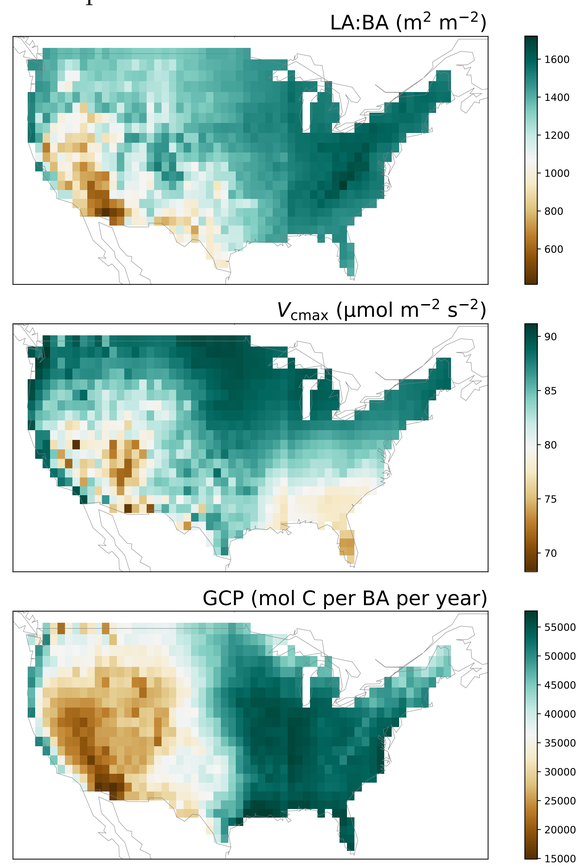
4. Potential

Precipitation and temperature



EVI:

Model prediction:



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