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Back to the roots - belowground plant functional traits as a proxy for tropical tree growth strategies

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EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-13211, https://doi.org/10.5194/egusphere-egu23-13211.

Belowground plant roots relate to form and function

'Traits are defined as any morphological, physiological or phenological feature measurable at the individual level'

OAK RIDGE National Laboratory

FRED
Fine-Root Ecology Database

https://roots.ornl.gov/

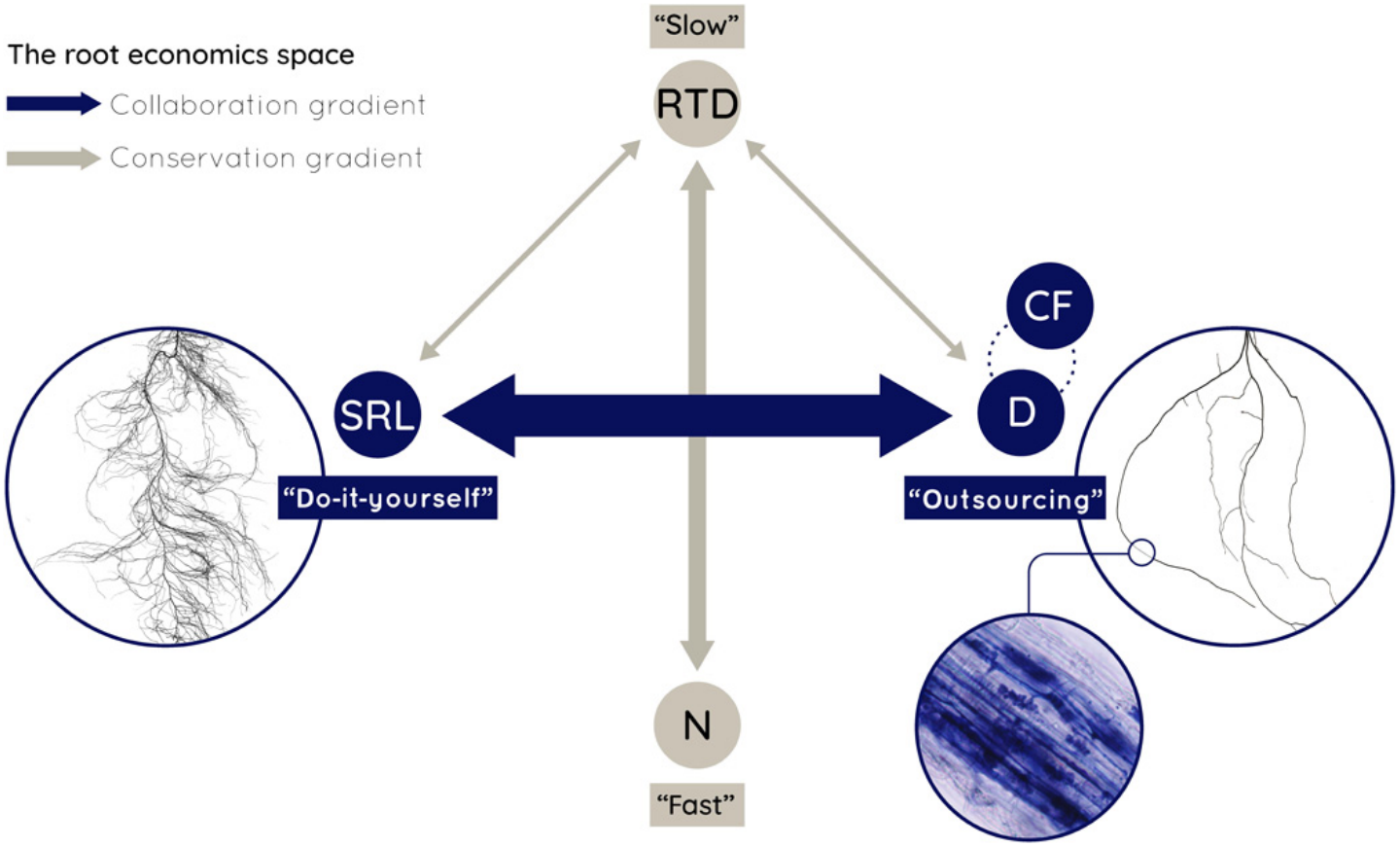
Tropical root trait initiative

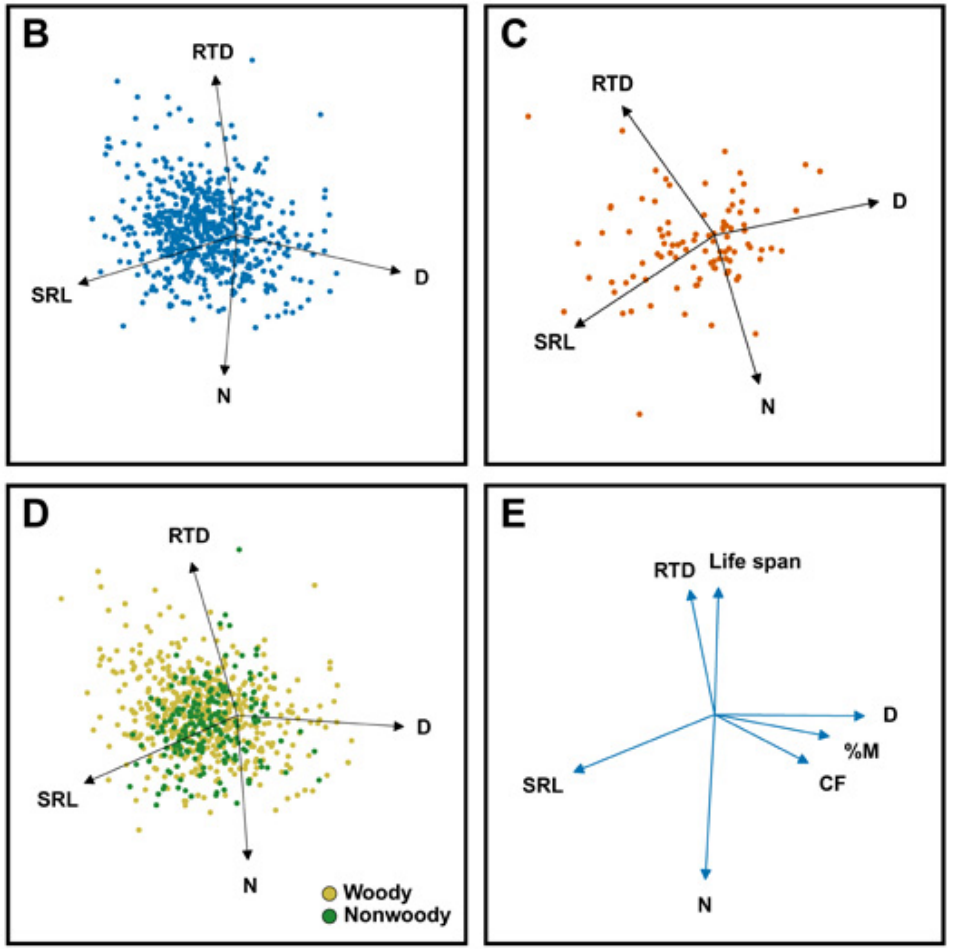
https://tropiroottrait.github.io/TropiRootTrait/#one

Carmona et al., (2021)

Violle et al., (2007)

Plant trait spectrum: above-ground vs. below-ground

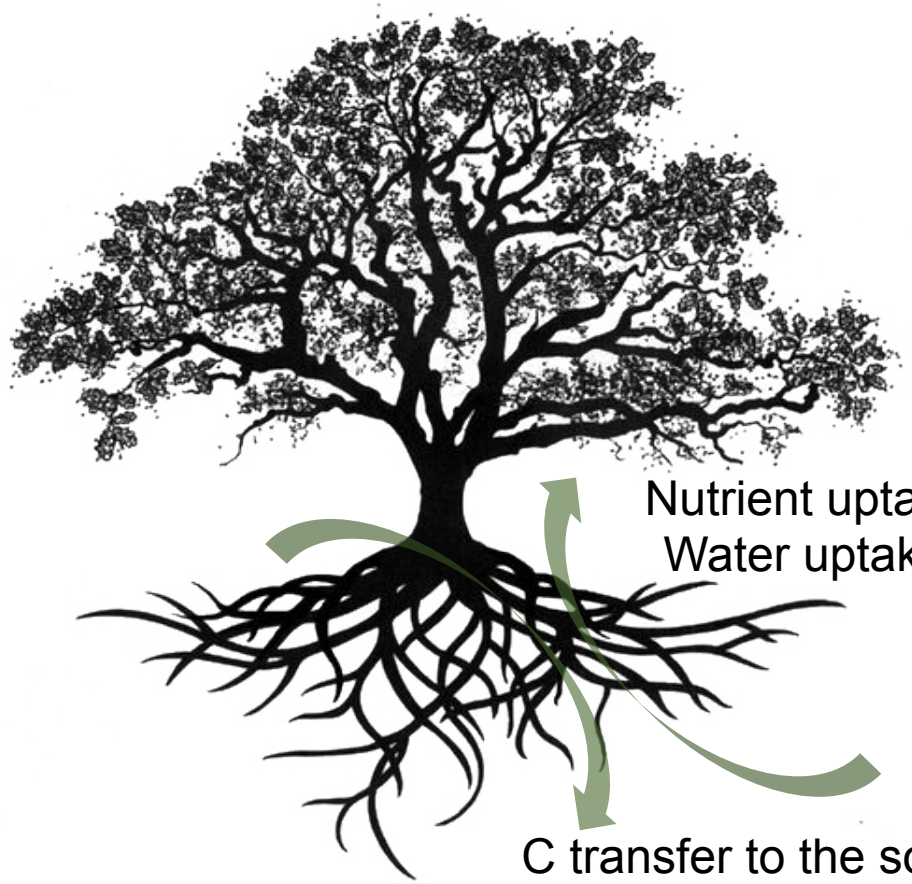


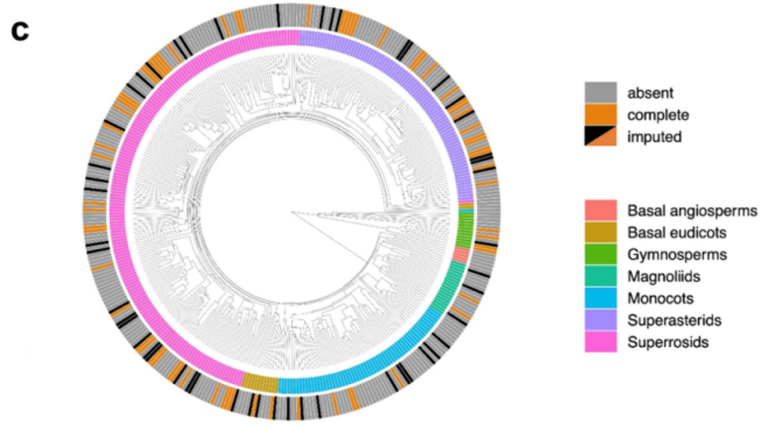


Root systems display tremendous diversity of growth forms in association with different functions (resource-use)

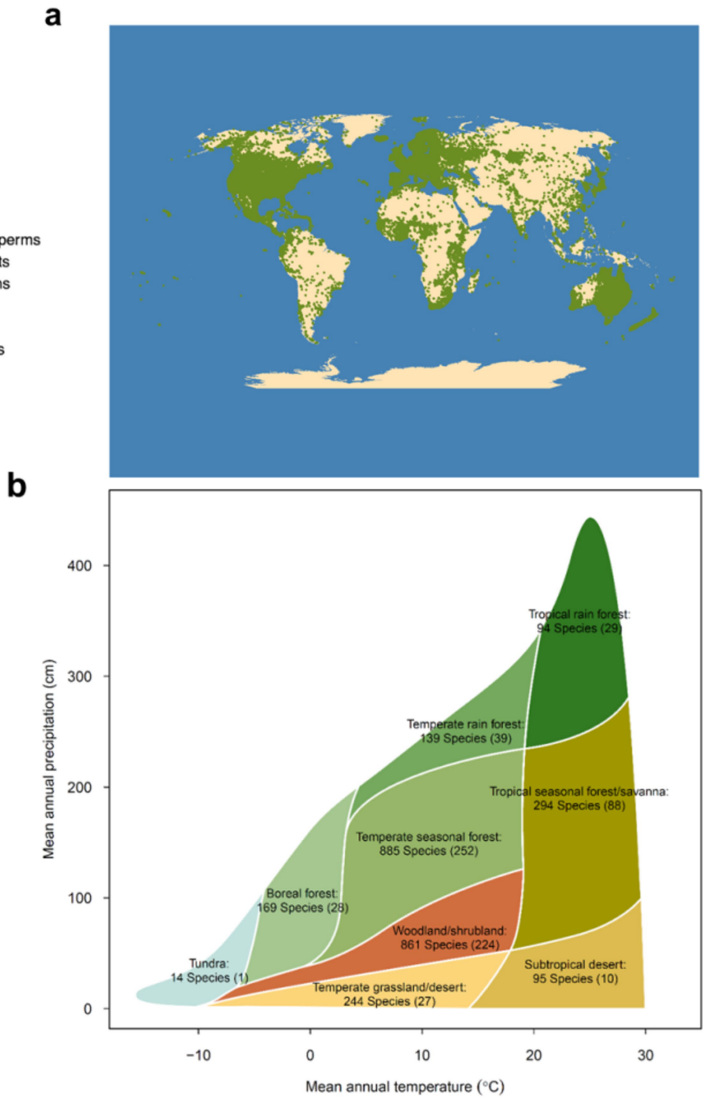
Bergmann et al., (2020), *Science Advances*, 6(27), 1–10. https://doi.org/10.1126/sciadv.aba3756

The hidden realm – half of the story is underground





Root properties remain notoriously understudied, and especially so for tropical ecosystems.



Carmona et al., Nature 597, 683–687 (2021). https://doi.org/10.1038/s41586-021-03871-y

Field survey: morphological and physiological root traits

1) Characterize root traits of tropical tree species
2) Do certain root traits sustain faster tree growth?

Between 2012 – 2013 more than 100 native tree species have been planted at a reforestation site ‘Finca Amable’.

In March 2018: collection of intact root systems from 19 planted species (12 families, 3 individuals per species).

Leaf: *Inga oerstediana*

Aboveground traits

- Stem diameter (DBH)
- Stem height
- Specific leaf area (SLA)
- Leaf N content (Nleaf)

Biologischer Korridor La Gamba
COBIGA

Root system: *Inga oerstediana*

Root morphological traits

- Specific root length (SRL),
- Specific root area (SRA)
- Root tissue density (RTD),
- Nodulation of N-fixing species

Root nutrient concentrations

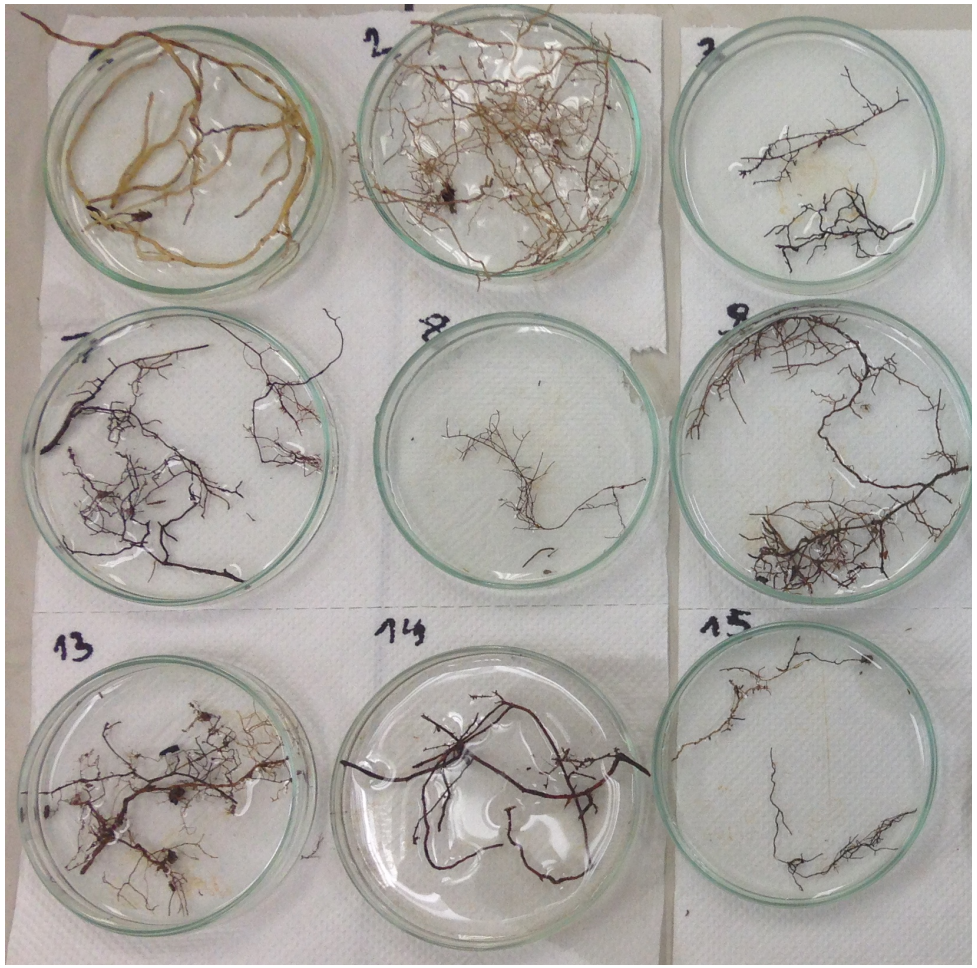
Physiological traits

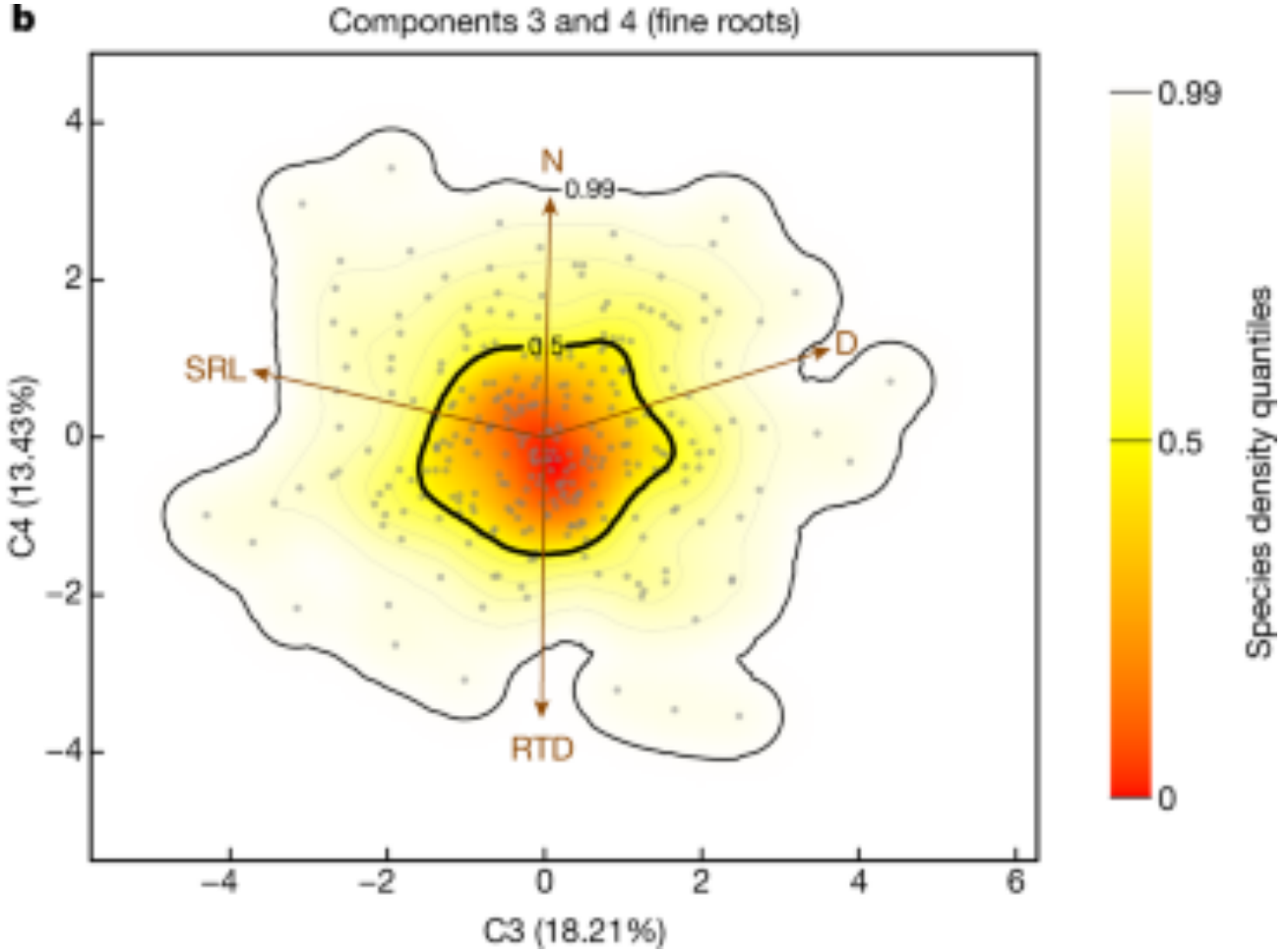
- Phosphatase enzyme rates

Interaction with soil microbes

Fig. 1.: Aerial photograph of the reforestated area (Anton Weissenhofer).

Belowground fine root trait characteristics





Probabilistic species distributions in the space defined by a PCA on fine-root traits of 301 species.

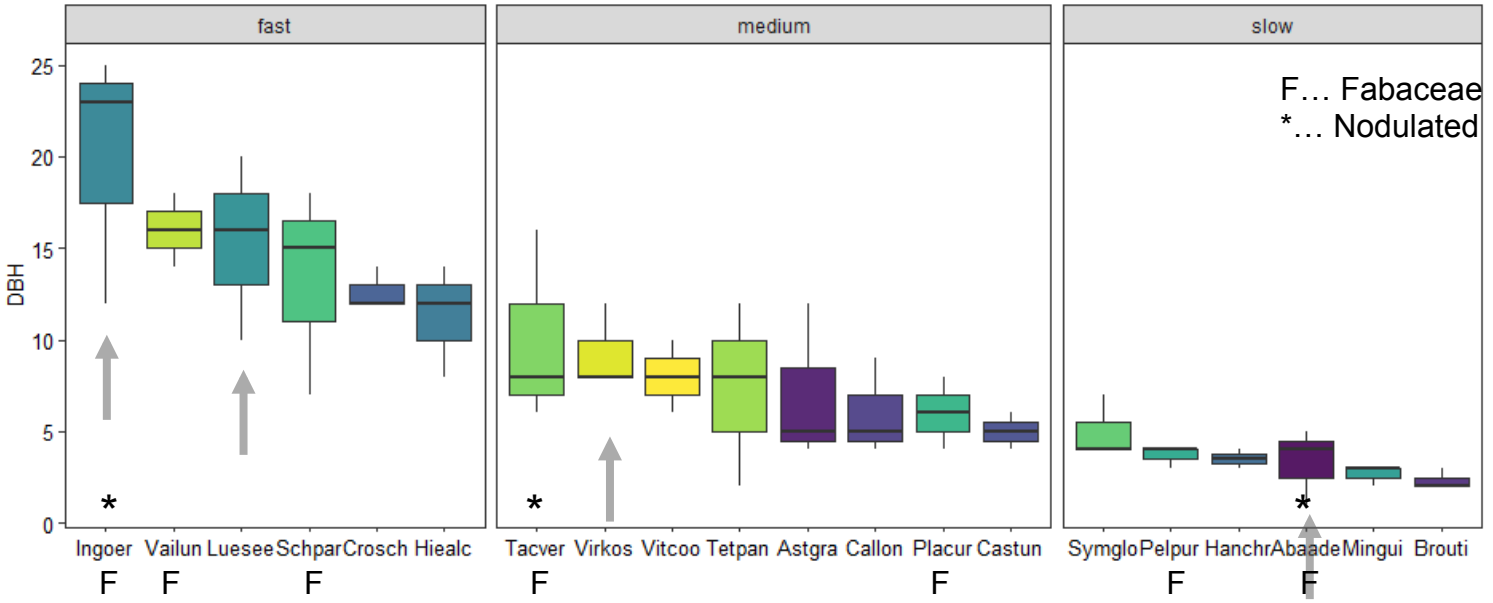
Carmona et al., Nature 597, 683–687 (2021). https://doi.org/10.1038/s41586-021-03871-y

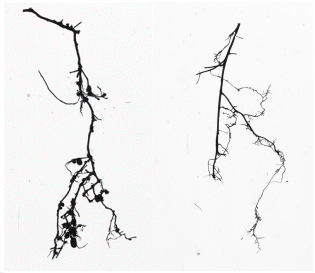
Do certain root traits allow trees to grow faster?

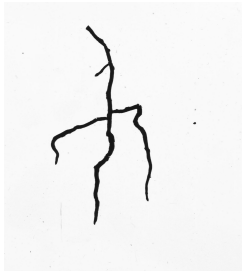
Which species had the largest stems:

Inga oerstediana

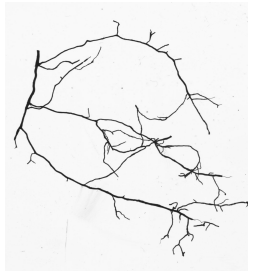
Brosimum utile







But how about roots:

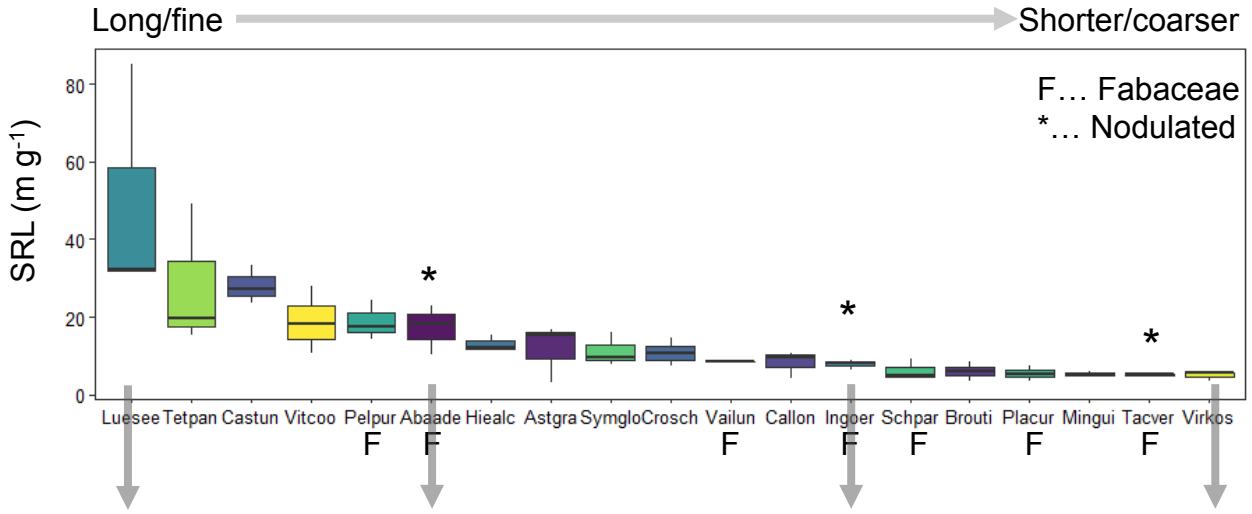


https://arboretum.ufm.edu/plantas/inga-oerstediana/2-inga_oerstediana/

Characteristics of tree roots – morphological traits

Specific root length

(Global average 88.7 m g^{-1})

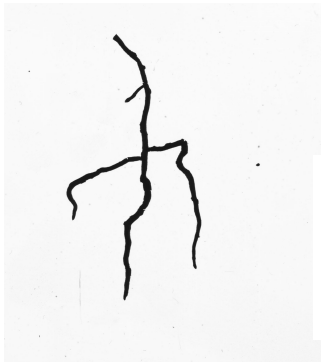


Luehea seemannii

Abarema adenophora

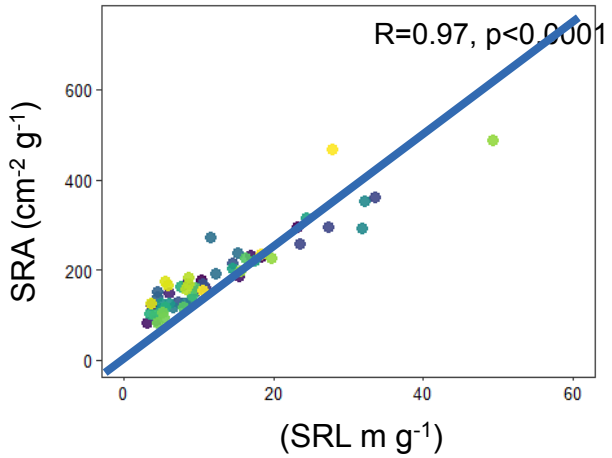
Inga oerstediana

Virola koschnyi



Specific root surface area

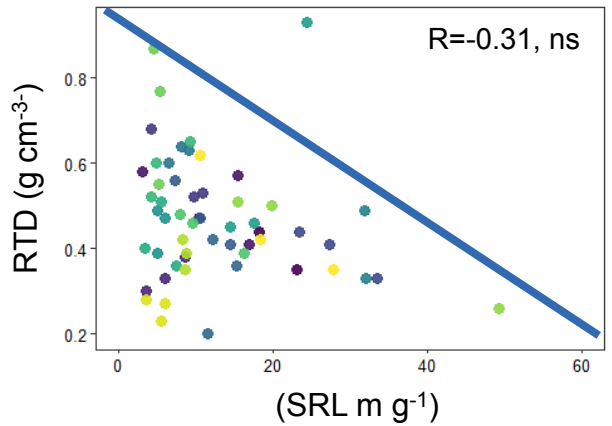
(Global average 617.7 cm^2 g^{-1})



High SRL == large root surface but low cost for plants, allows high resource uptake, (but only if root turnover is high)

Root tissue density

(Global average 0.25 g cm^{-3})

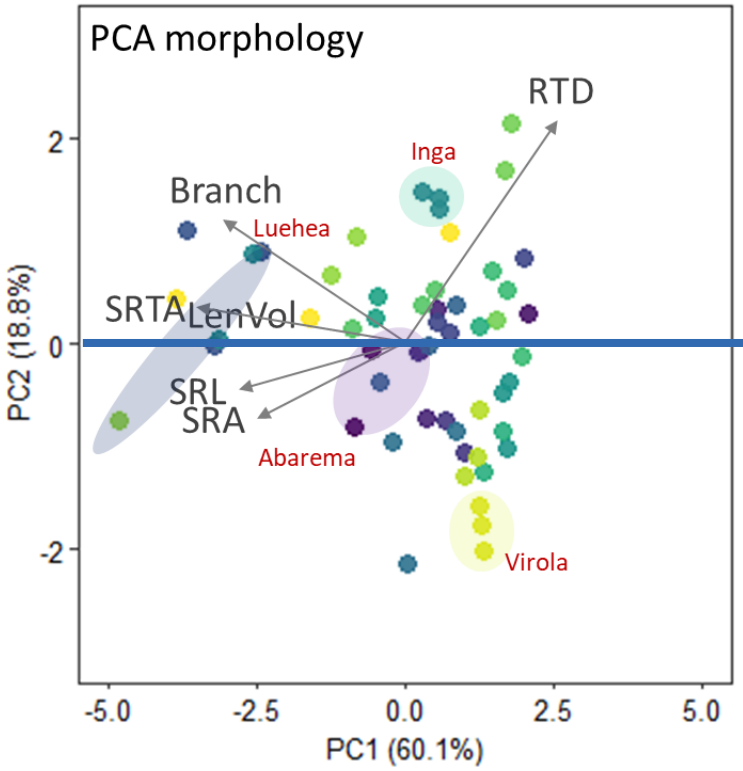


High RTD == increases roots lifespan and mechanical resistance
→ often decoupled.

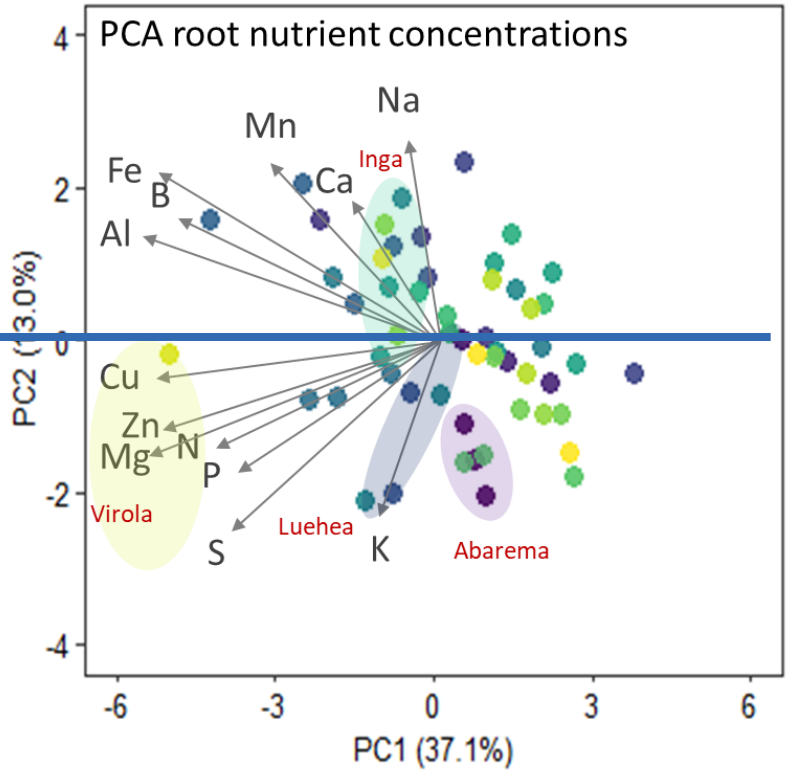
Global averages from Guerrero-Ramirez et al. (2020)

Valverde-Barrantes et al. (2017)

Morphological traits and nutrient composition



Some **species** clearly **cluster**,
Others more distributed

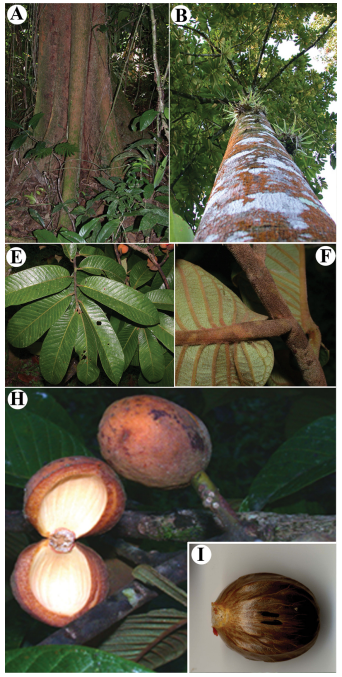


There apear at least two groups –
N/P related and **Mn/Ca** related

Inga oerstediana

Averge SRL, but very **dense roots**, with a lot of Ca and Mn

Nodulation - expensive
Low fine root turnover!

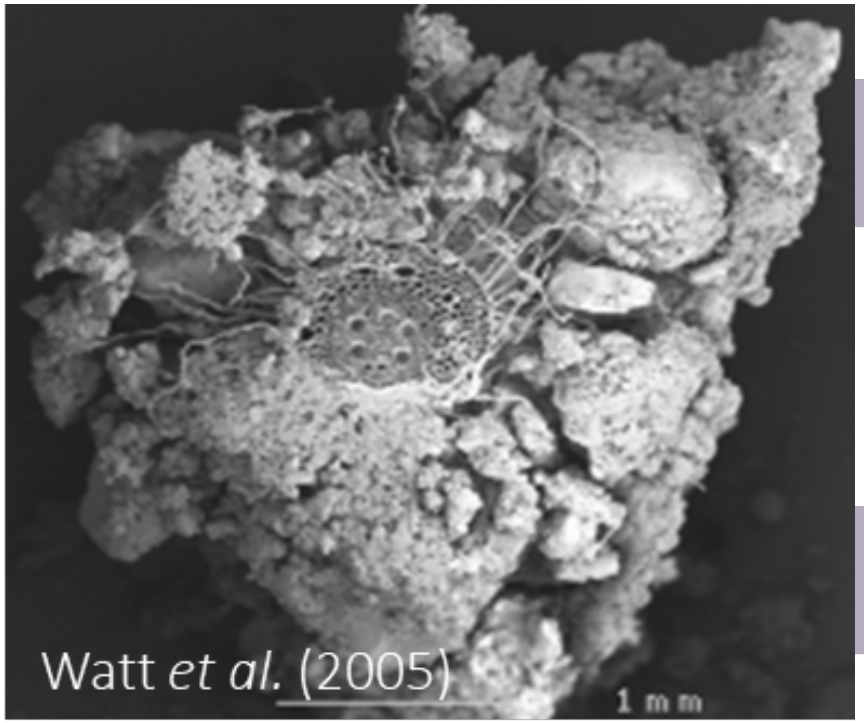


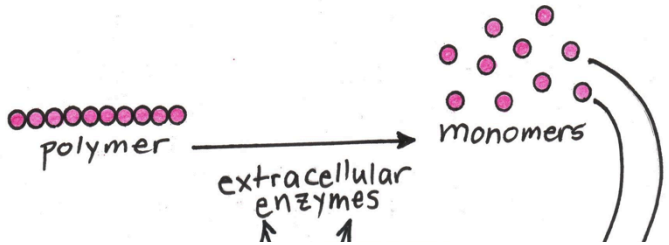
Virola koschnyi

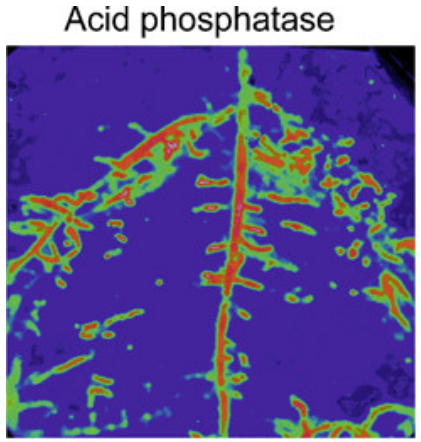
Low SRL, low RTD but **rich in N and P**

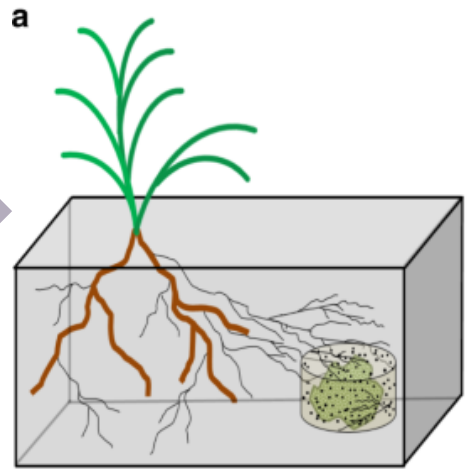
Higher turnover/
decomposition rate?
Hosting mycorrhiza?

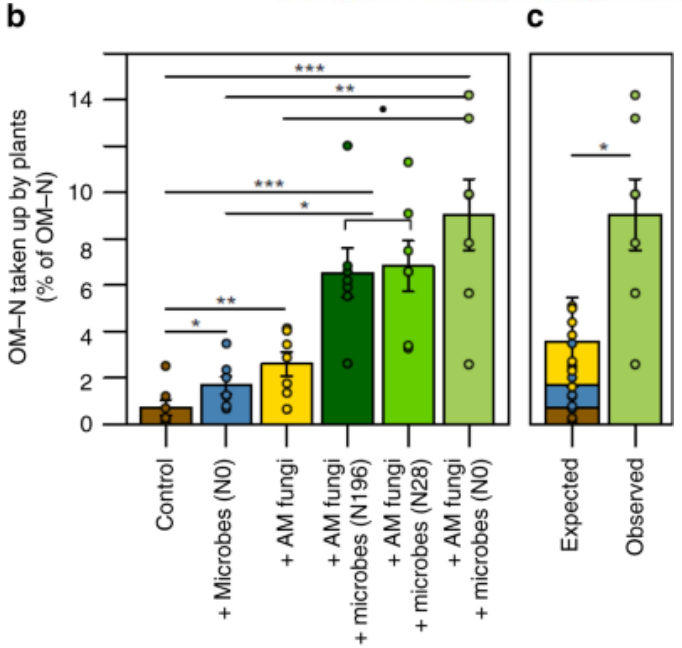
Nutrient acquisition traits – interaction with soil microbes





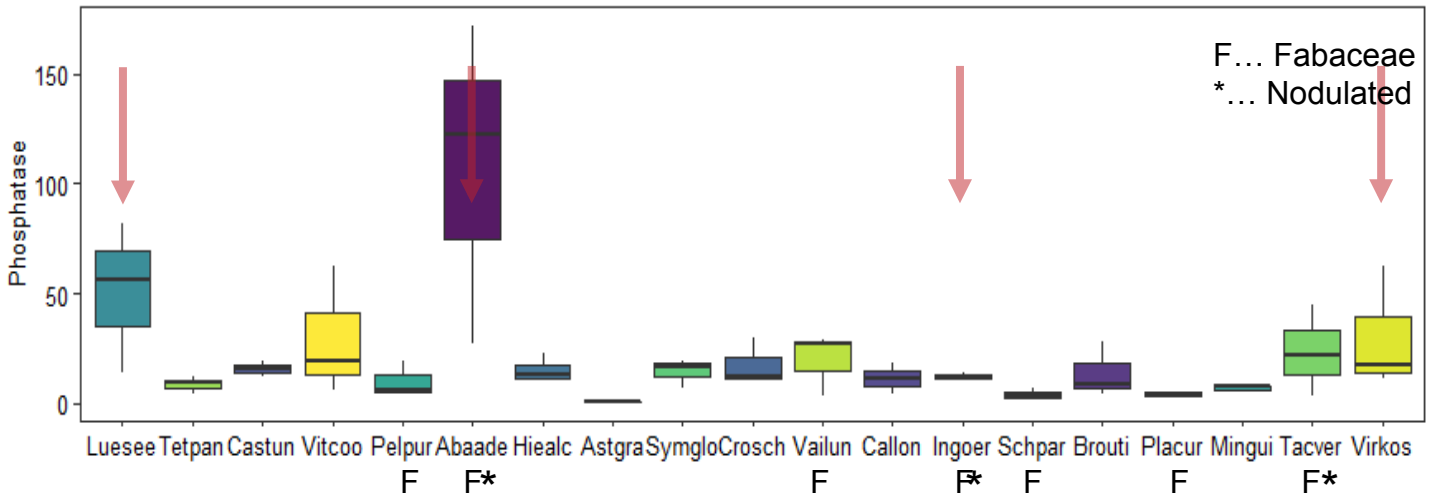


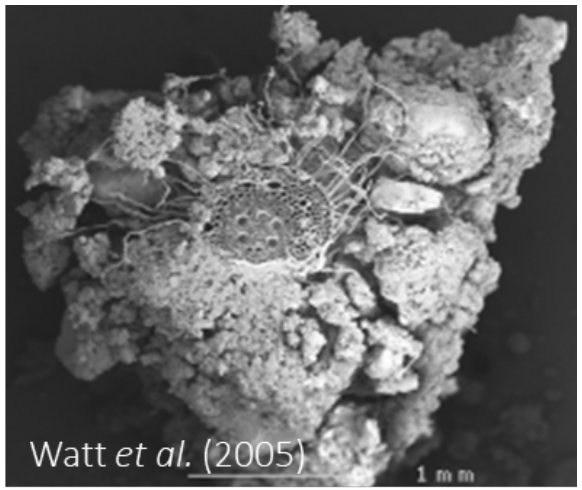




Hestrin, et. al., 2019 *Commun Biol* 2, 233. https://doi.org/10.1038/s42003-019-0481-8

Nutrient acquisition traits – interaction with soil nutrients

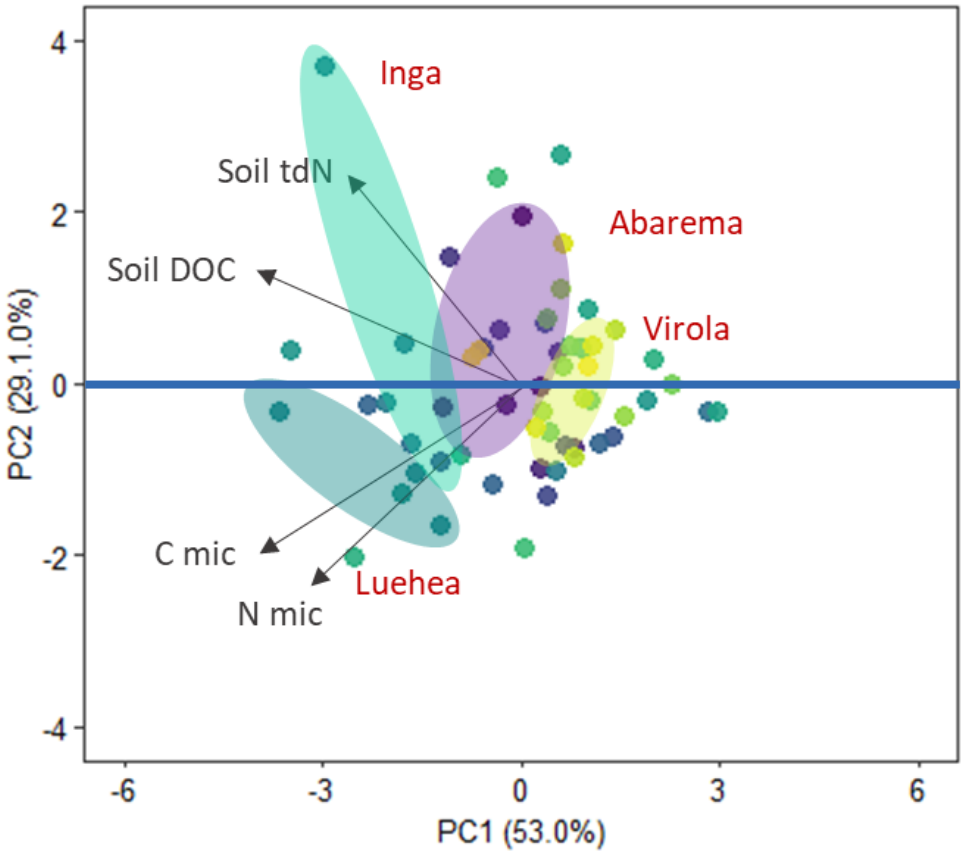




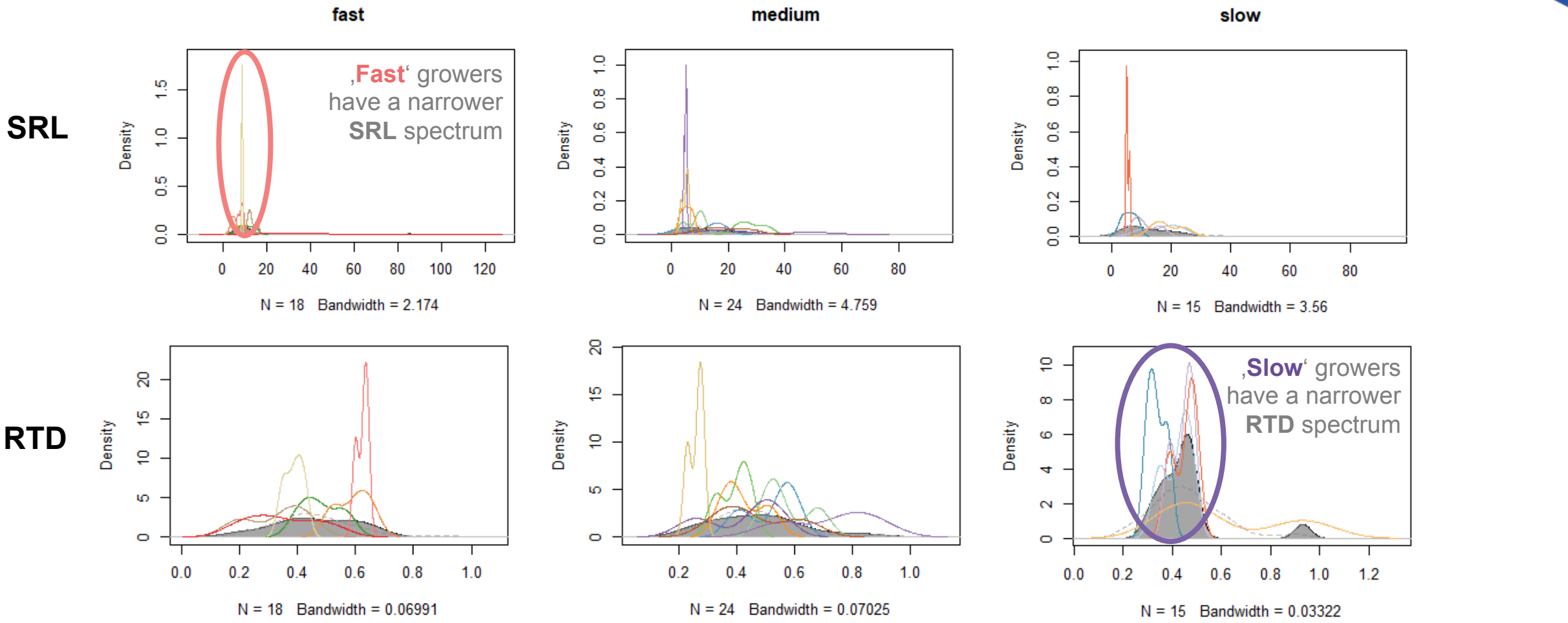
Some **N fixers** with root nodules **increase tdN**

Others have high **microbial biomass** in the rhizosphere

Clear differences between species



Root trait distribution by growth type → plant strategy



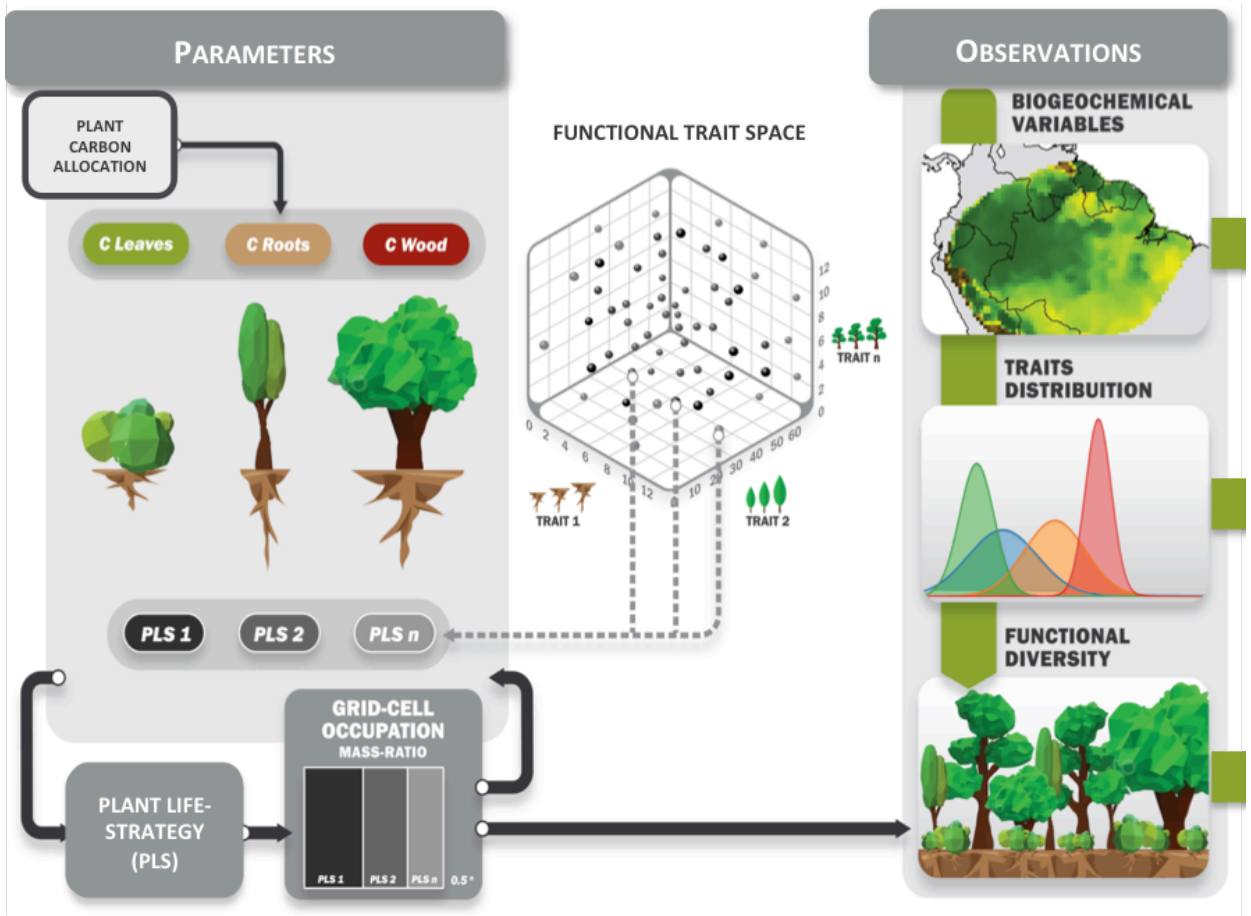
Simulating vegetation response to the environment

By representing plant functional traits in vegetation models we can assess the following questions:

R1: What is the relationship between diversity and ecosystem productivity?

R2: What is the relationship between diversity and ecosystem functioning?

R3: What is the relationship between functional diversity and ecosystem resilience to climatic extreme events?



Rius, B.F., …, Hofhansl, F., et al., (2023). Higher functional diversity improves modeling of Amazon forest carbon storage. *Ecological Modelling*. 481, e110323.

Acknowledgements & Partners

Thank you for listening!

Happy to take your questions…

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