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

Florian Hofhansl, Oscar Valverde Barrantes, Eduardo Chacón-Madrigal, Peter Hietz, Anton Weissenhofer, Judith Prommer, Wolfgang Wanek, and Lucia Fuchslueger
Belowground plant roots relate to form and function

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

https://roots.ornl.gov/

Tropical root trait initiative

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

**Field survey: morphological and physiological root traits**

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

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

**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 reforested 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.
Do certain root traits allow trees to grow faster?

Which species had the largest stems:

<table>
<thead>
<tr>
<th>Inga oerstediana</th>
<th>Brosimum utile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

But how about roots:
Characteristics of tree roots – morphological traits

**Specific root length**
(Global average 88.7 m g⁻¹)

- Long/fine
- Shorter/coarser

**Specific root surface area**
(Global average 617.7 cm² g⁻¹)

**Root tissue density**
(Global average 0.25 g cm⁻³)

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

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 appear at least two groups – N/P related and Mn/Ca related

Inga oerstediana
Average 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

Watt et al. (2005)

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 $\rightarrow$ plant strategy

`Fast` growers have a narrower SRL spectrum

`Slow` growers have a narrower RTD spectrum
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?
Thank you for listening!

Happy to take your questions...

Florian HOFHANSL
Biodiversity, Ecology, and Conservation Research
Group Biodiversity and Natural Resources
hofhansl@iiasa.ac.at