

Root traits as key proxies to unravel plant and ecosystem functioning - *entities, trait selection and outlook*

Boris Rewald*, Grégoire T. Freschet, Catherine Roumet, Alexia Stokes, Monique Weemstra, Richard D. Bardgett, A. Glyn Bengough, Louise H. Comas, Gerlinde B. De Deyn, David Johnson, Jitka Klimešová, Martin Lukac, M. Luke McCormack, Ina C. Meier, Loïc Pagès, Hendrik Poorter, Ivan Prieto, Nina Wurzburger & Marcin Zadworny

EGU2020: Sharing Geosciences Online

Session: Soil-Plant interactions, 05.05.2020, 14.00-15.45 o'clock, *online*

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The hidden half



Root systems play key roles in plant functioning and performance and affect many ecosystem processes and functions

The hidden half

Root systems play key roles in plant functioning and performance and affect many ecosystem processes and functions

→ **Nothing too new ...**

e.g. **Harry von Pistohlkors 1898.**

*Wurzelkenntnis und Pflanzenproduktion: Die Wurzelkenntnis - eine Bedingung des rationellen Anbaues unserer landwirtschaftlichen Kulturpflanzen („**Root knowledge and plant production: Root knowledge - a prerequisite for the rational cultivation of our agricultural crops**”).* O. Paul, Bonn



Böhm, W. 1979. Springer, Berlin

The hidden half



Root systems play key roles in plant functioning and performance and affect many ecosystem processes and functions

→ So why is the hidden half of plants still largely „uncharted territory“?

The hidden half



Root systems play key roles in plant functioning and performance and affect many ecosystem processes and functions

→ So why is the hidden half still largely „uncharted territory“?

→ **In this talk, we propose 3 major topics hampering root research**

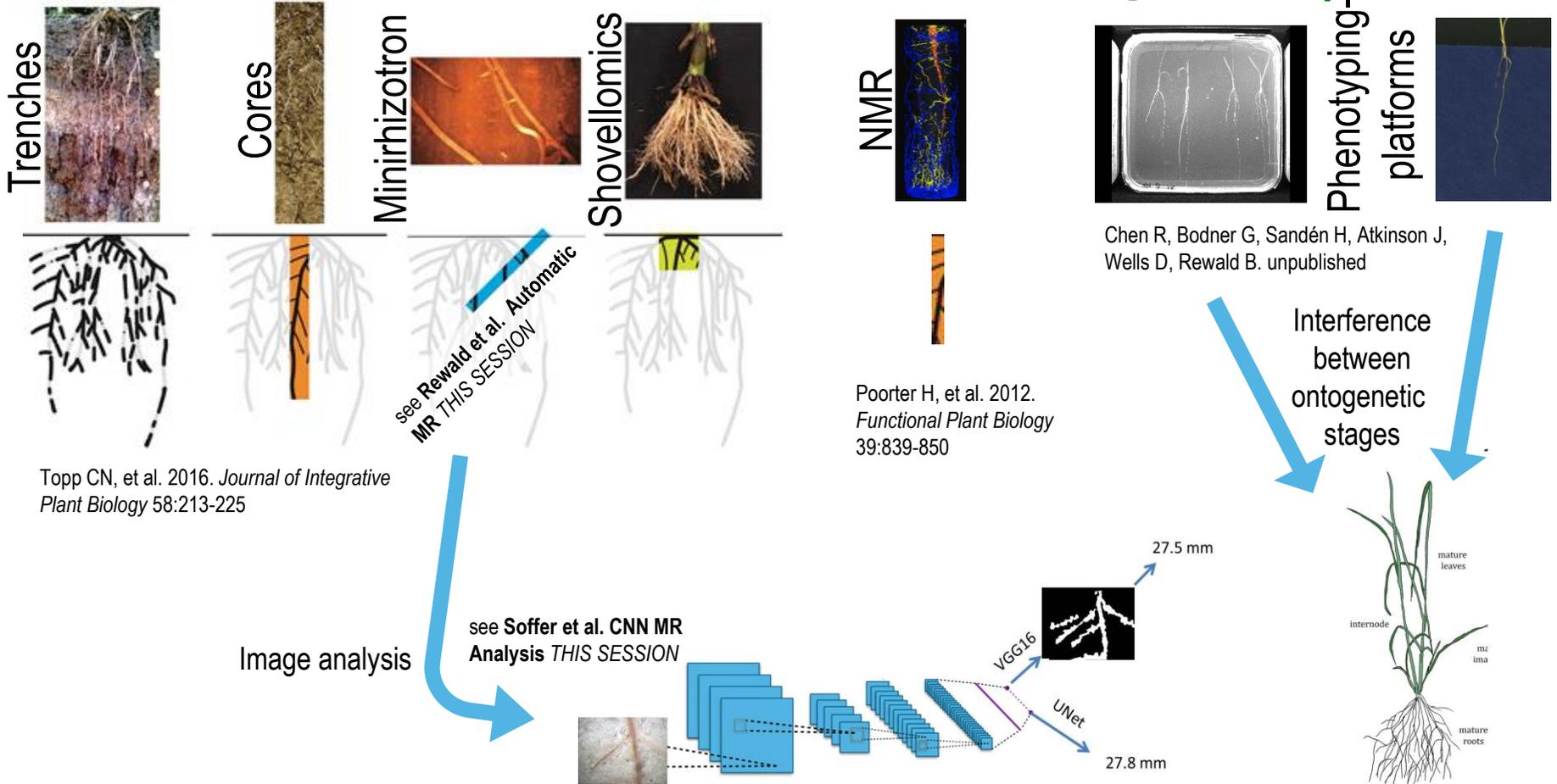
Hidden half

1) ... well, its hidden ...

Hidden half



1) ... and while there are many methods, it remains challenging (to get the whole picture)



2) Botanical root 'literacy' limited



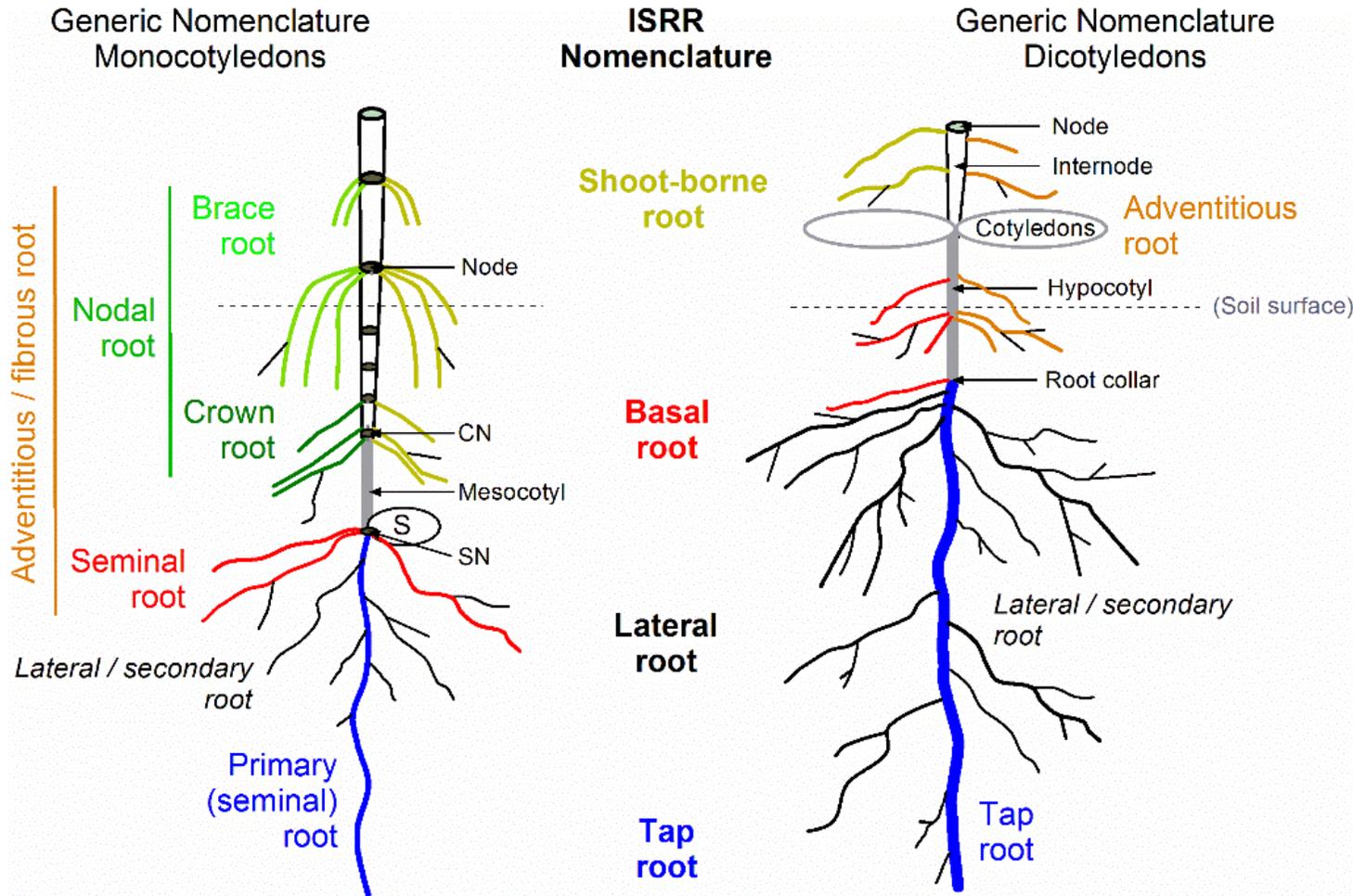
Turning
ROOT ZOMBIES
(AKA just '**Roots**')
into
TALKIN' ROOTS
(i.e. being able to name
Specific root entities)



Developmental classification

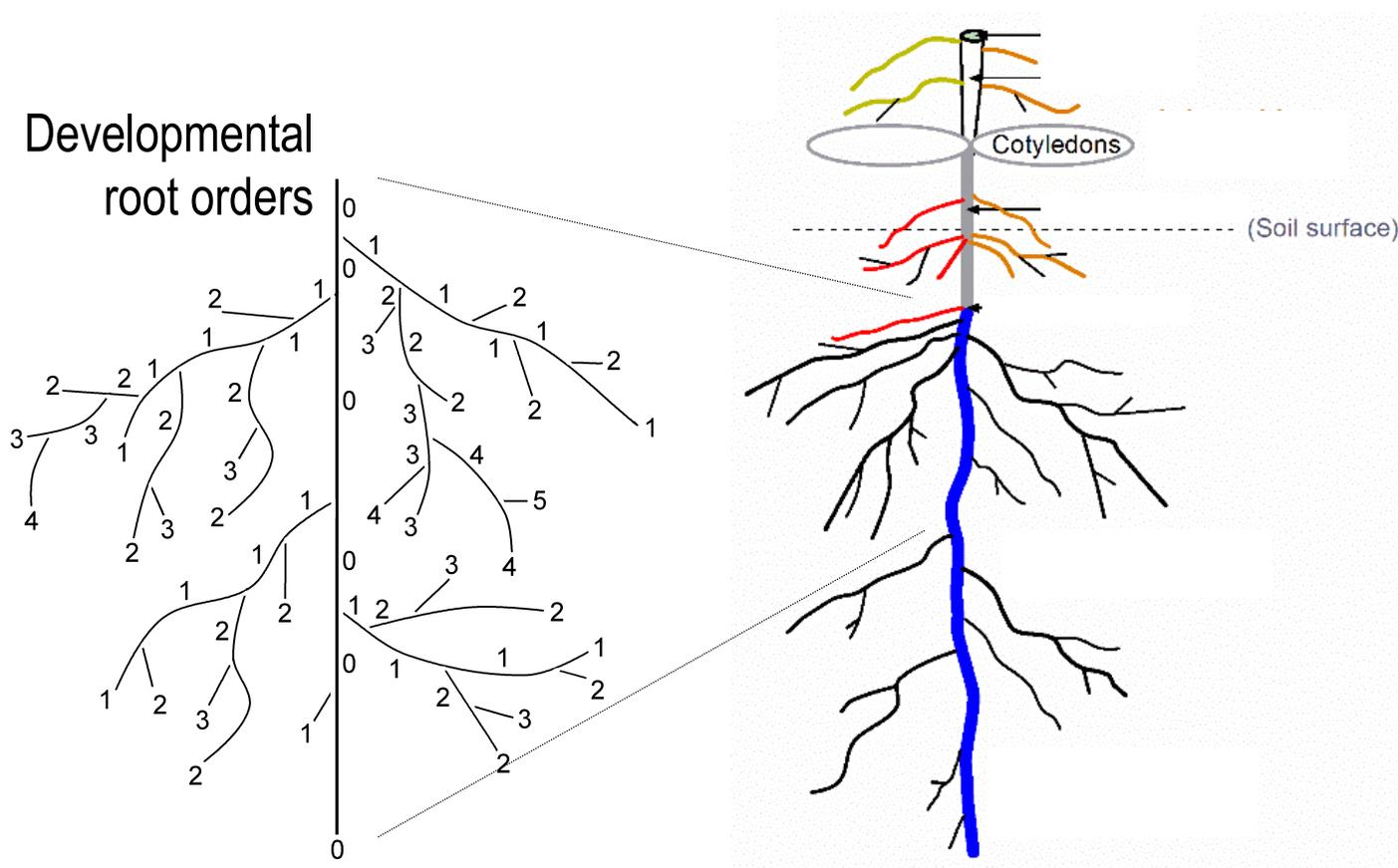


Nomenclature babel

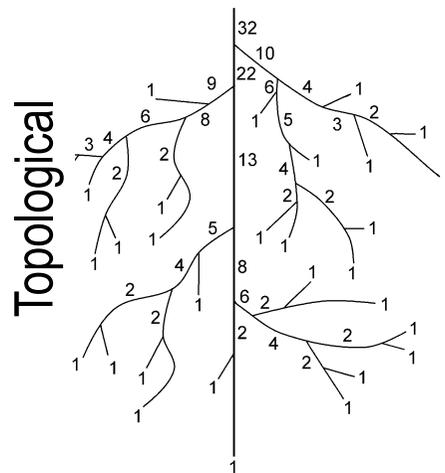
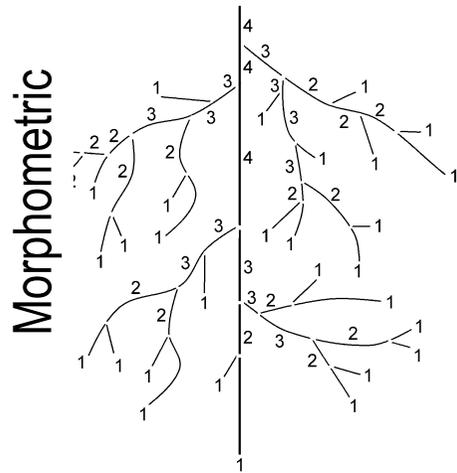


Developmental classification

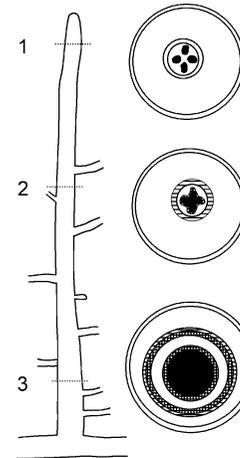
Ordering schemes dependent on aim \neq universal



Morphometric, Topological, Functional classification

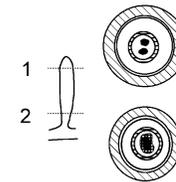


Long FR

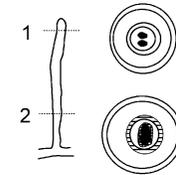


Short FR

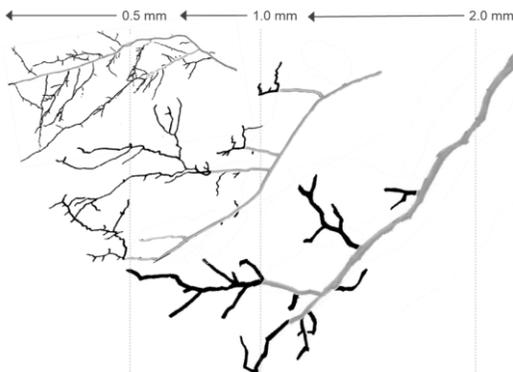
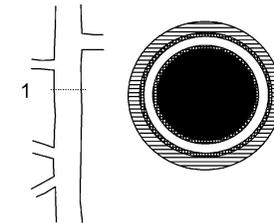
Ectomycorrhized



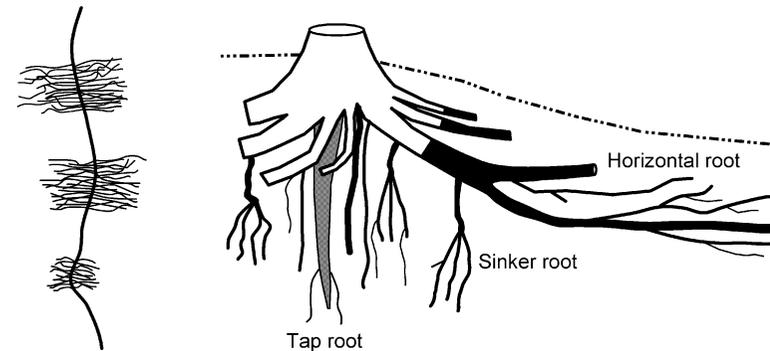
Non-mycorrhized



Coarse roots



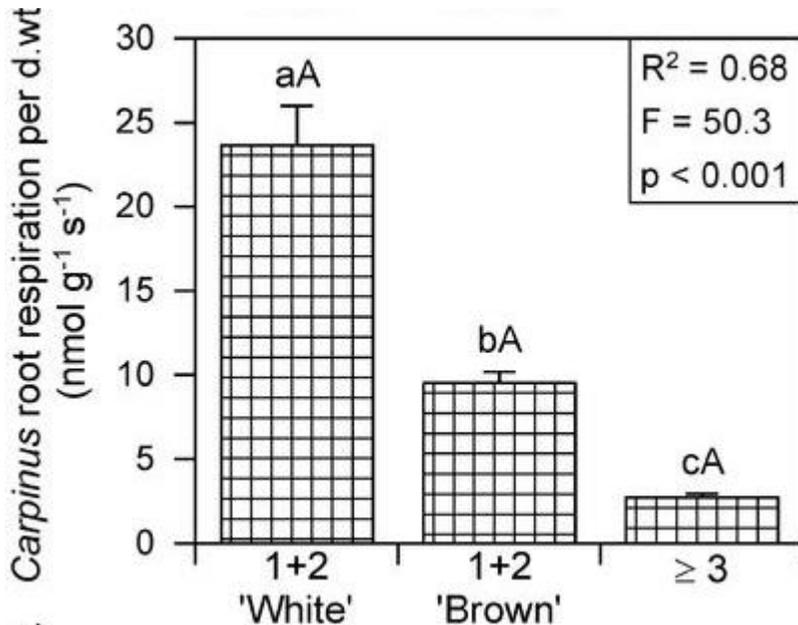
Functional classes



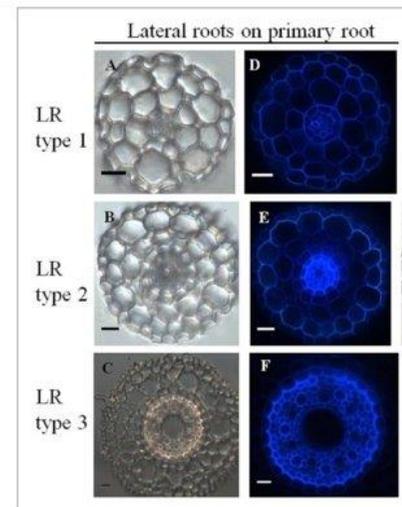
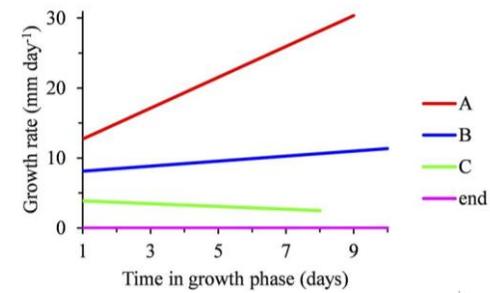
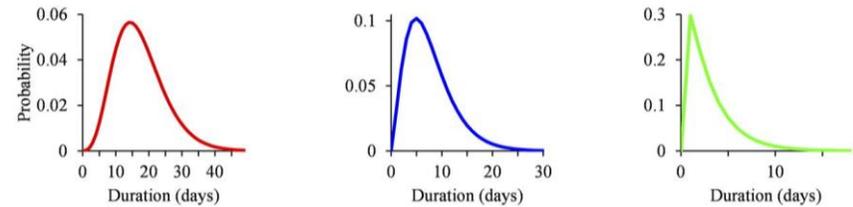
McCormack ML, et al. 2015. *New Phytologist* 207:505-518

Root classification ... to be continued!

E.g. differences in root tips' specific respiration rates



E.g. differences in laterals' phenology, anatomy and growth rates

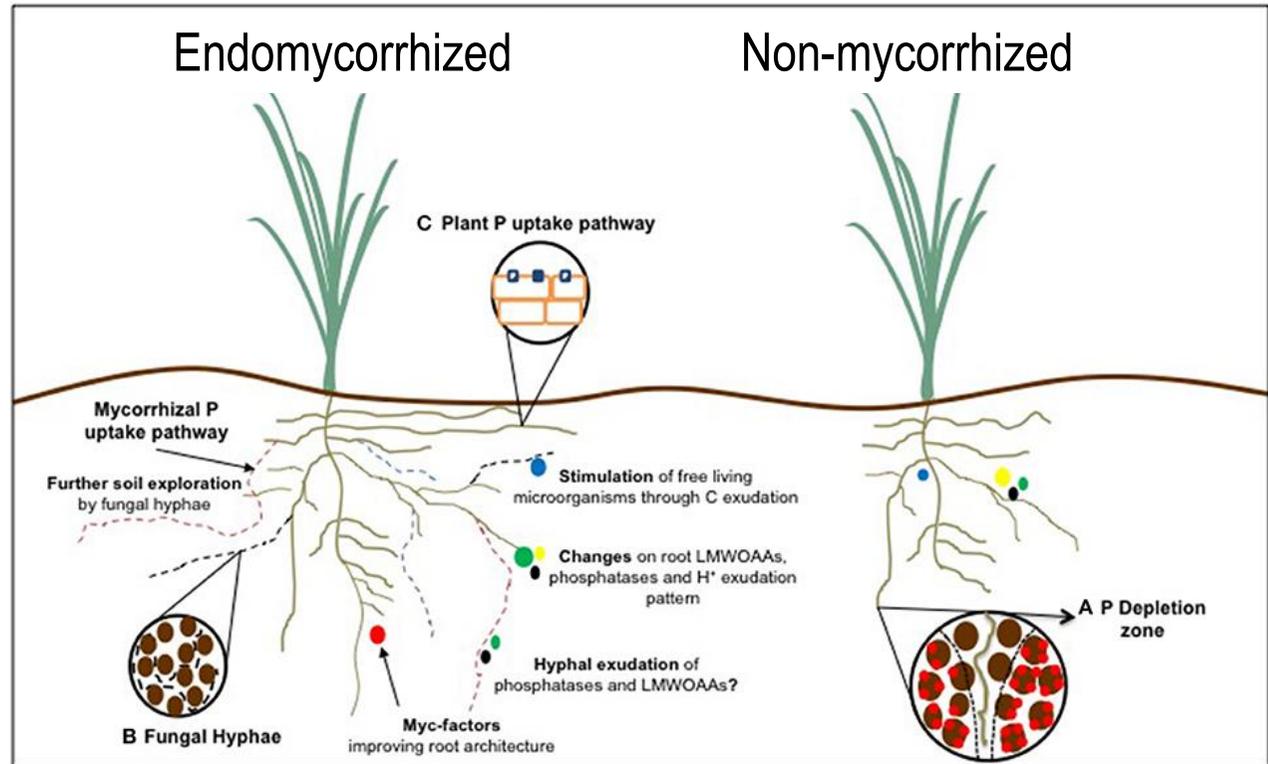
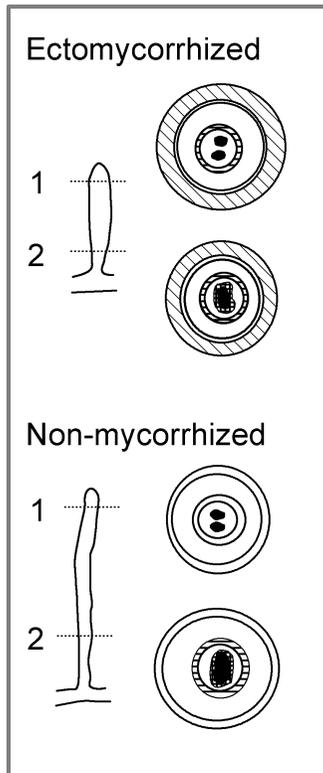


Rewald B, et al. 2014. *Plant Physiology* 166:736-745

Passot S, et al. 2018 *Plant Physiology*: 177:896-910
 Passot S, et al. 2016. *Frontiers in Plant Science* 7:829

Root classification ... to be continued!

E.g. With / without or different types of Endosymbionts (EM, AM,...)



Campos P, et al. 2018. *Frontiers in Plant Science* 9:752

3) Root ecological science still

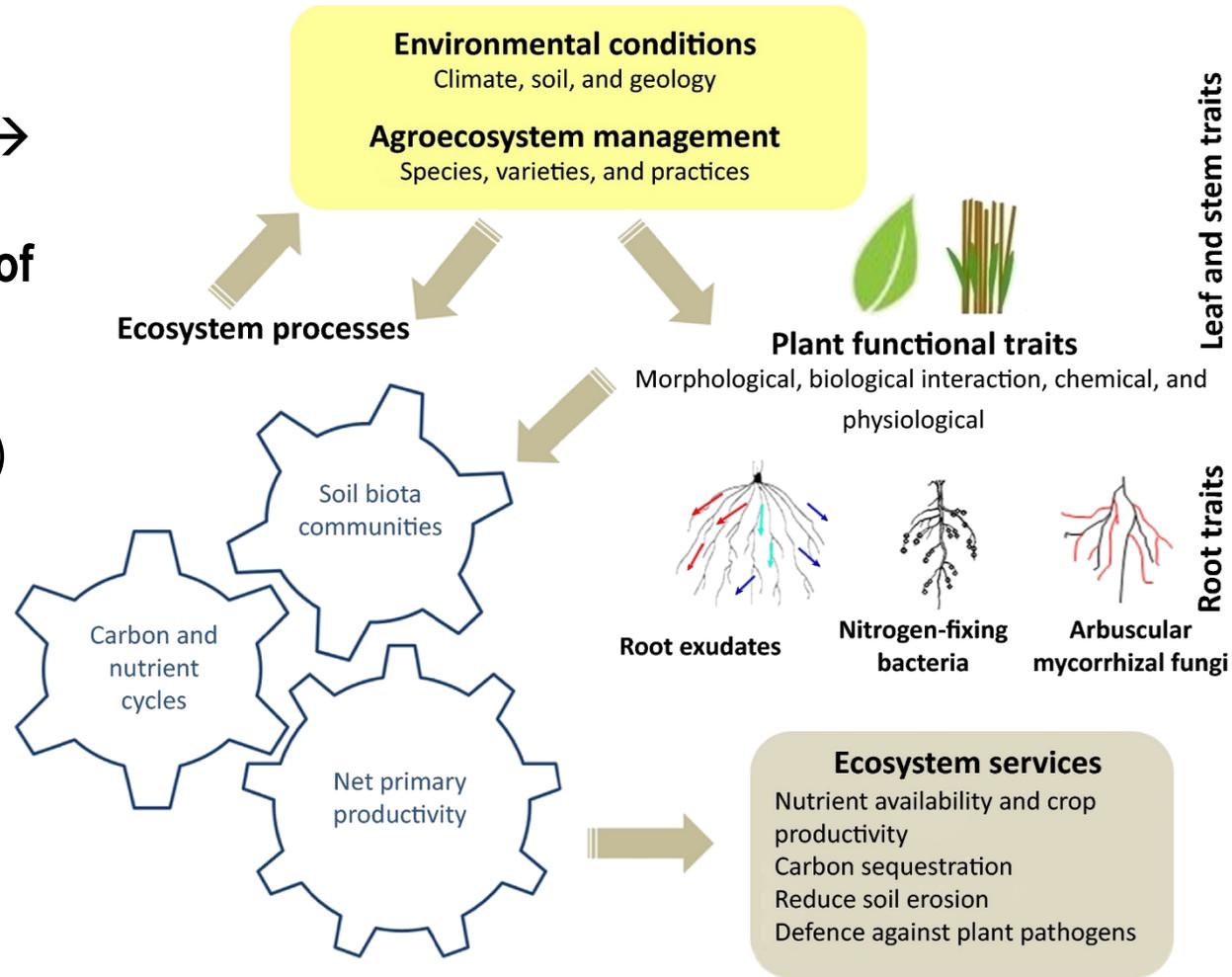


- **Interference from aboveground traits to root traits limited**
- Too many simple traits used
- Methodologies not standardized
- Trait interrelations unclear

Plant functional traits

Functional traits of organisms → **morpho-physio-phenological traits that impact the fitness of individual species** via their effects on growth, reproduction and survival (Violle et al., 2007)

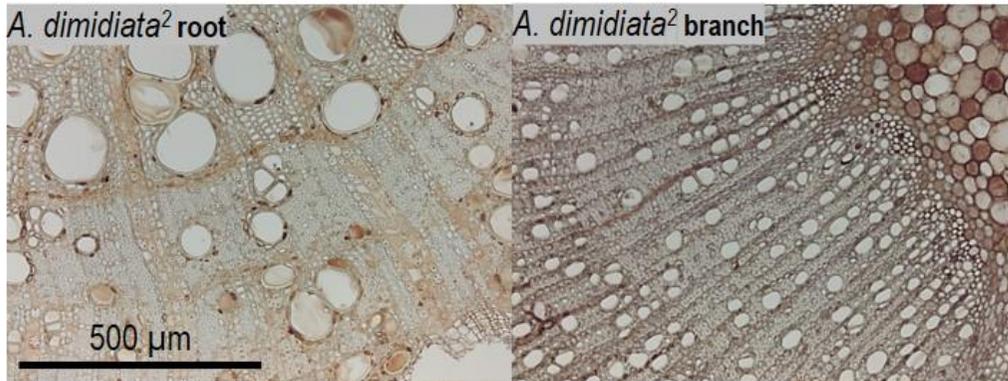
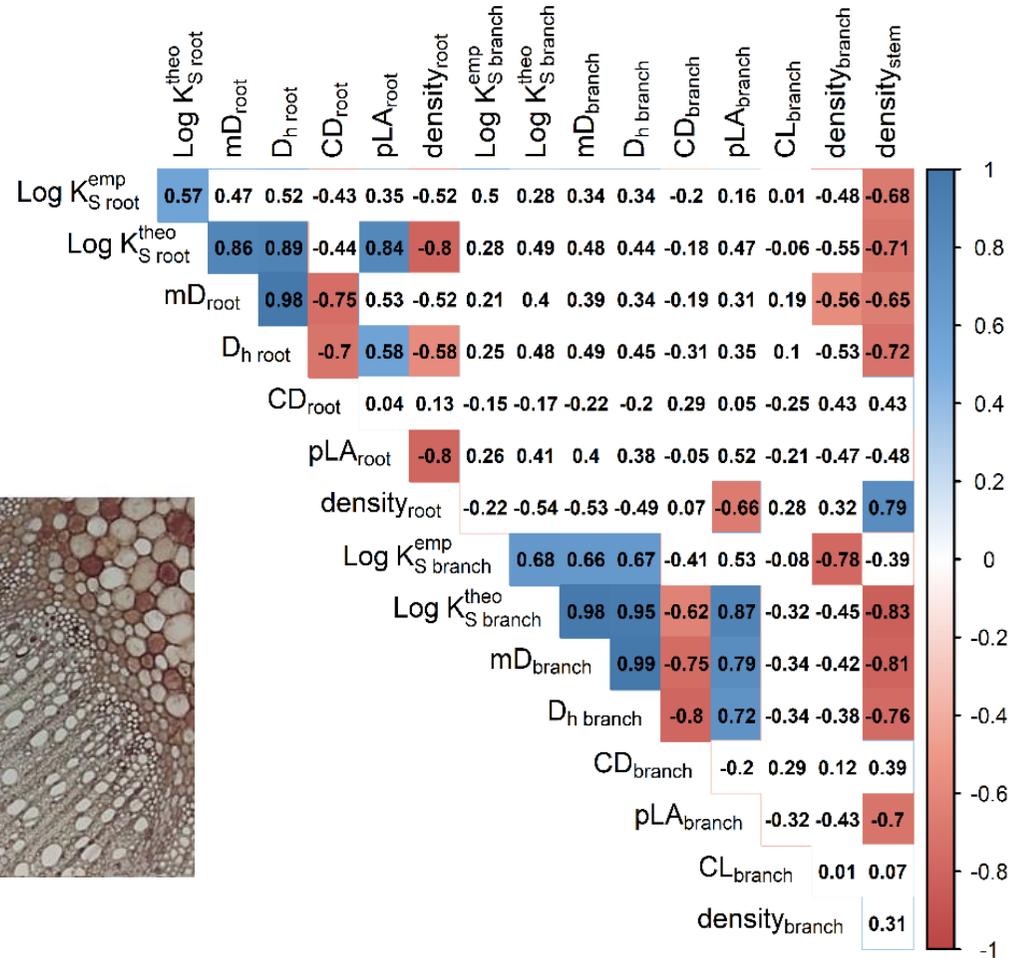
Functional traits as community averages → **effects on ecosystem services**



Faucon MP, et al. 2017. Trends in Plant Science 22:385-394

Trait convergence across organs

Large divergence of hydraulic trait values coarse roots vs. 2nd year branches



Schönauer M, Hietz P, Rewald B. In preparation.

3) Root ecological science still

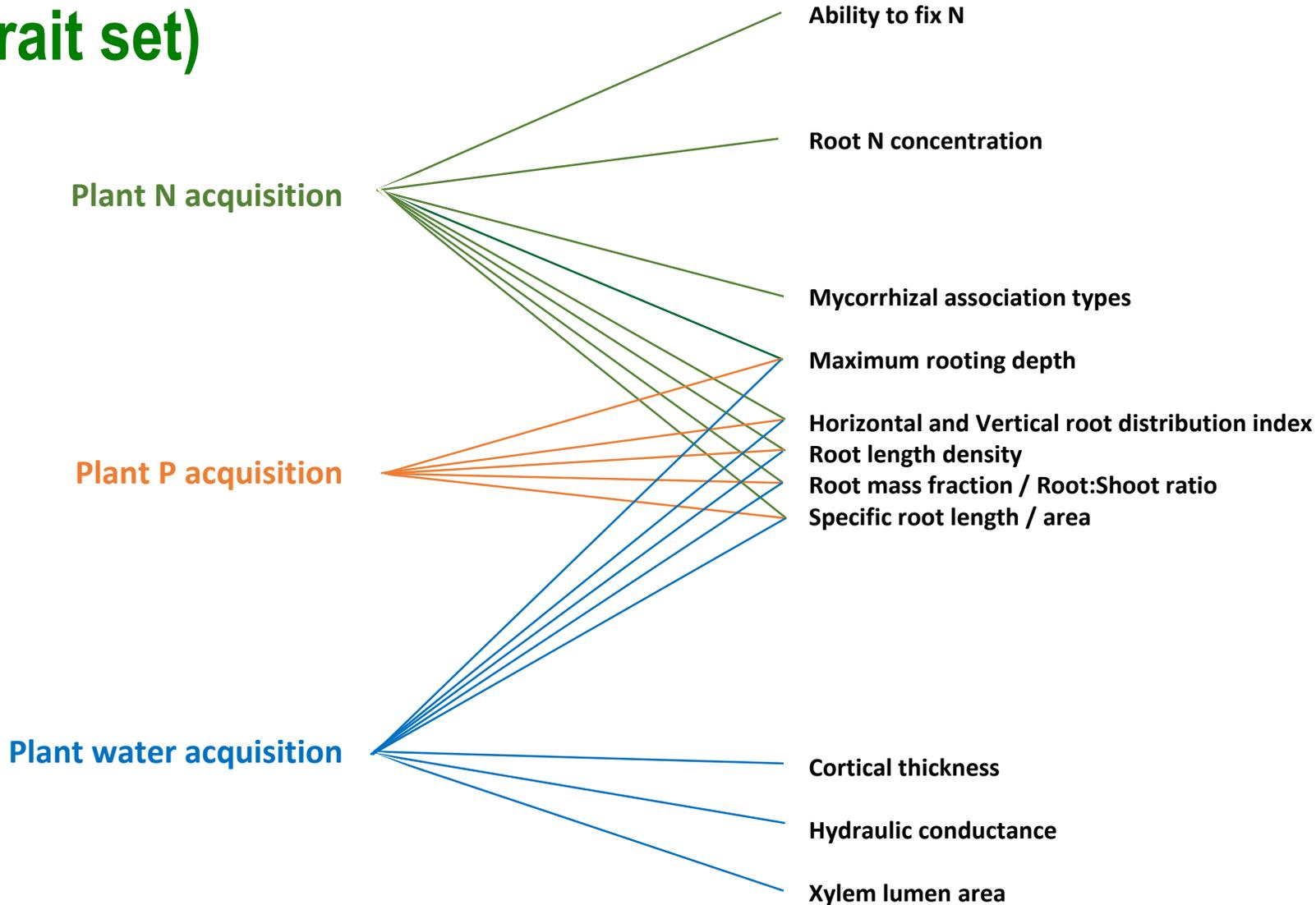


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Root traits & Plant functioning

Resource Acquisition

(Basic trait set)



Root traits & Plant functioning

Resource Acquisition

(Basic trait set)

Plant N acquisition

Do we consider too many 'easy' traits?

Plant P acquisition

Plant water acquisition

Ability to fix N

Root N concentration

Mycorrhizal association types

Maximum rooting depth

Horizontal and Vertical root distribution index

Root length density

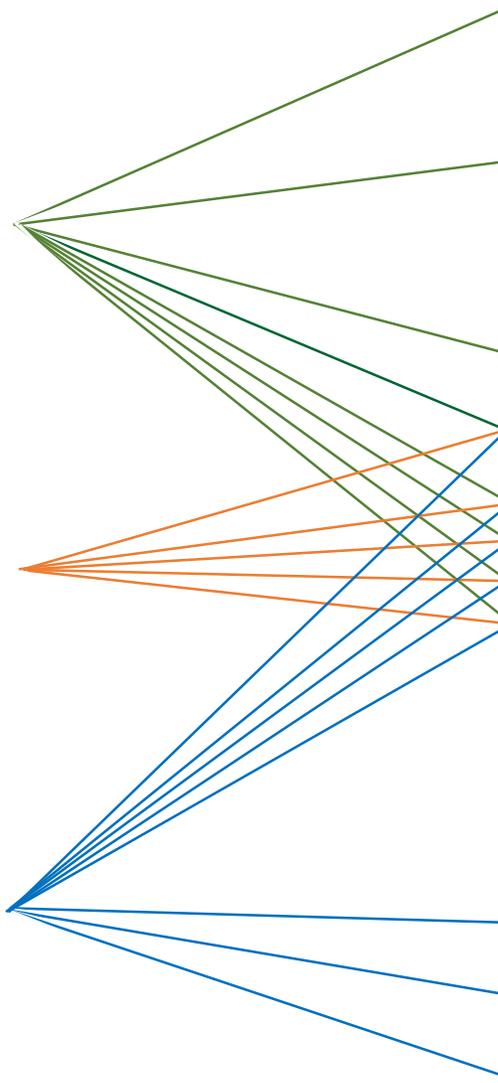
Root mass fraction / Root:Shoot ratio

Specific root length / area

Cortical thickness

Hydraulic conductance

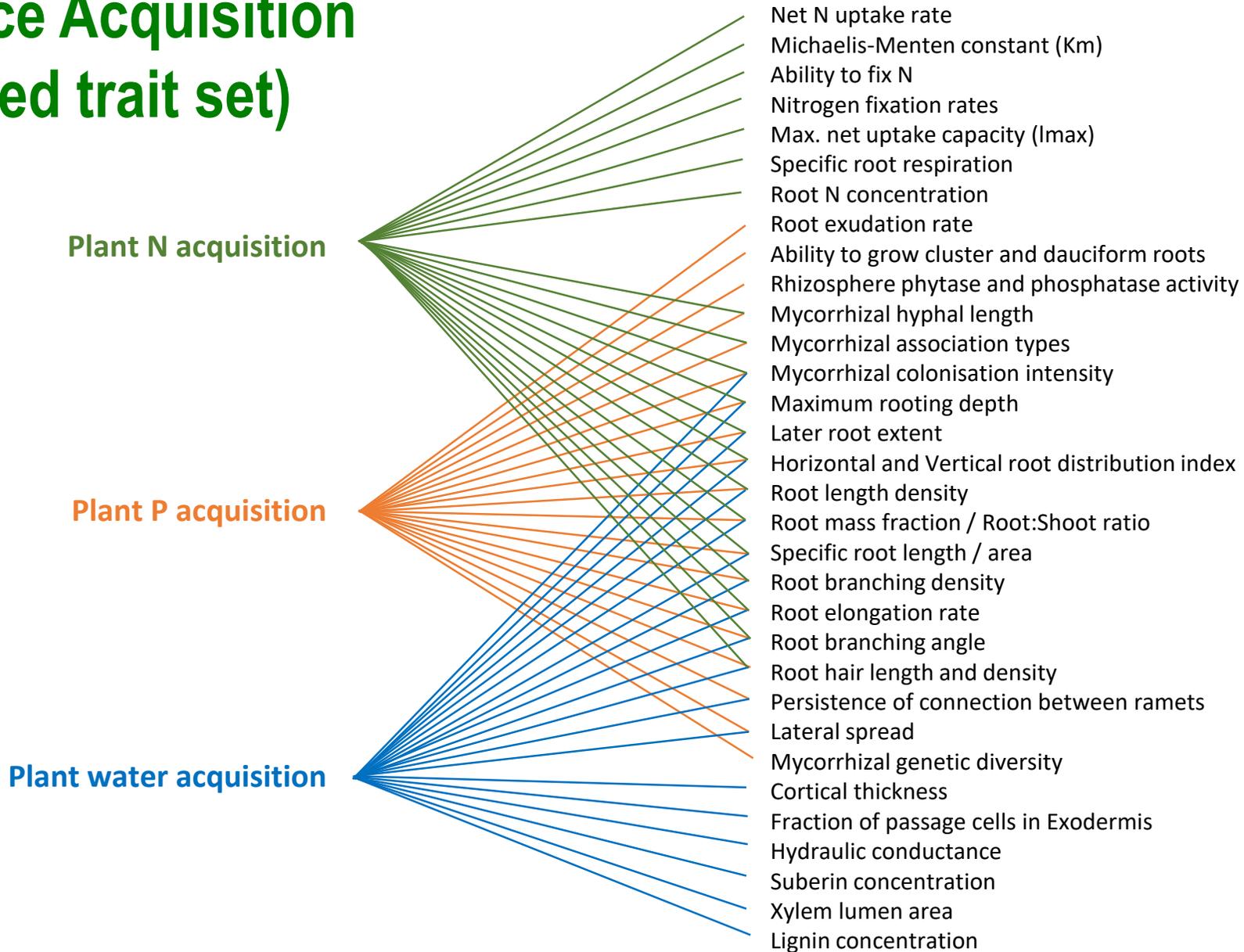
Xylem lumen area



Root traits & Plant functioning

Resource Acquisition

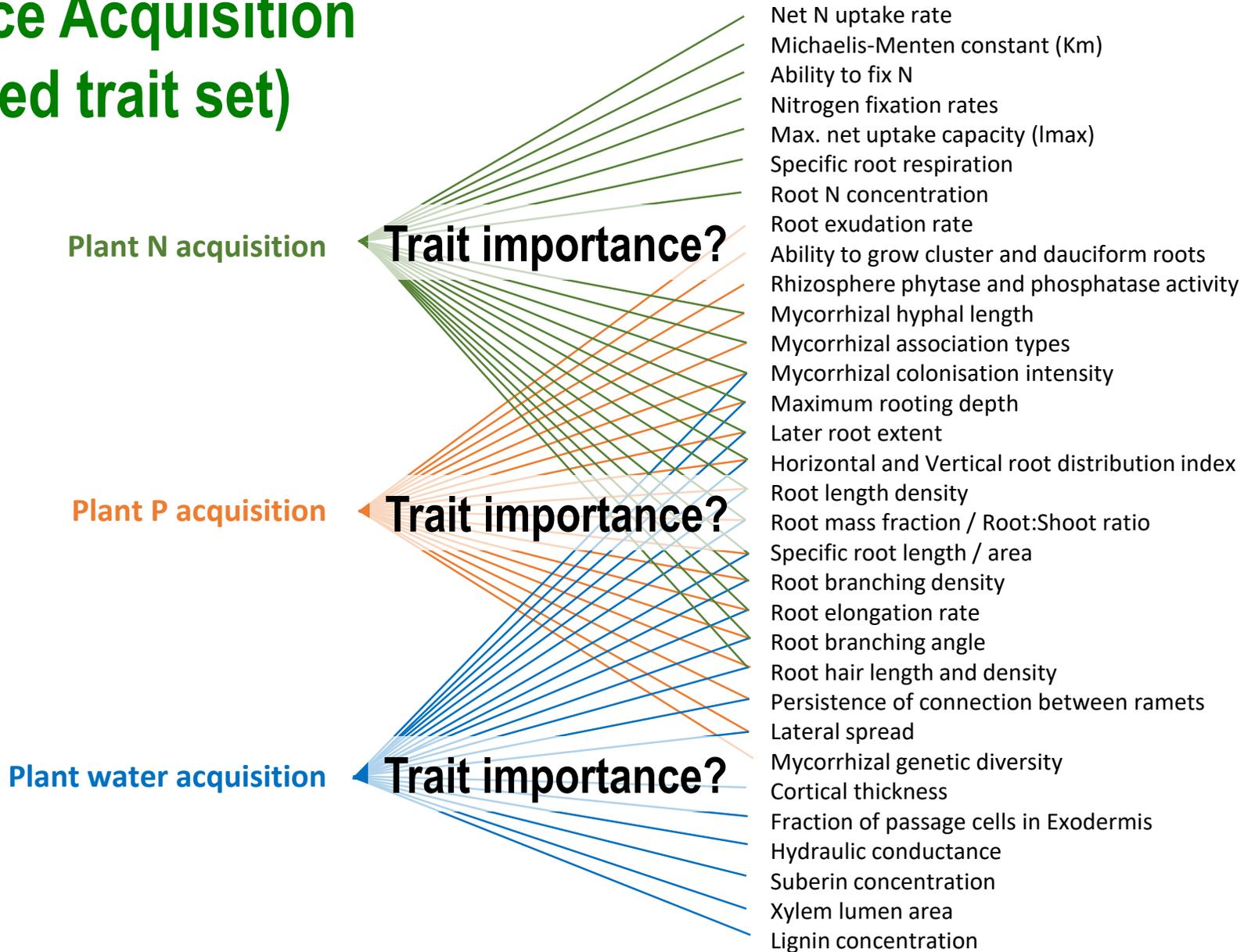
(Extended trait set)



Root traits & Plant functioning

Resource Acquisition

(Extended trait set)



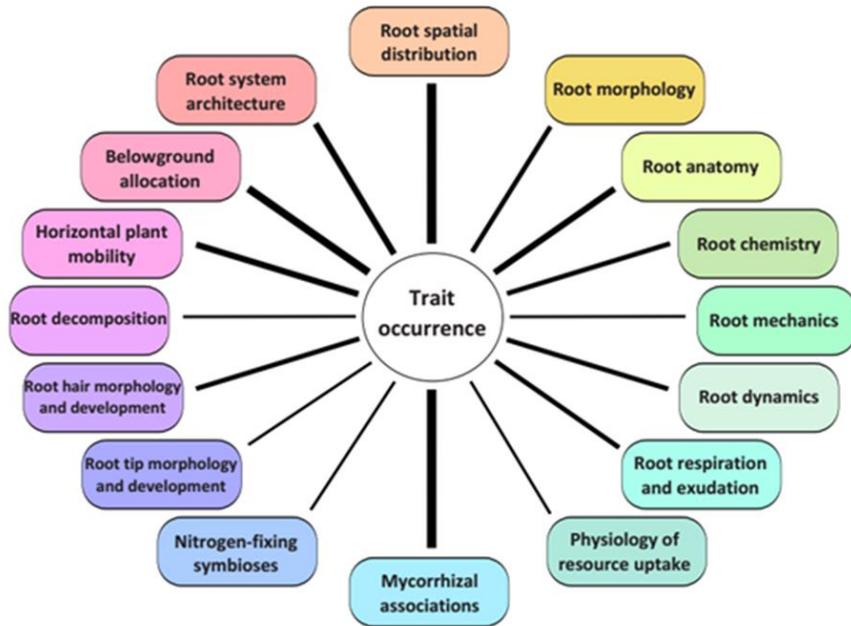
3) Root ecological science still



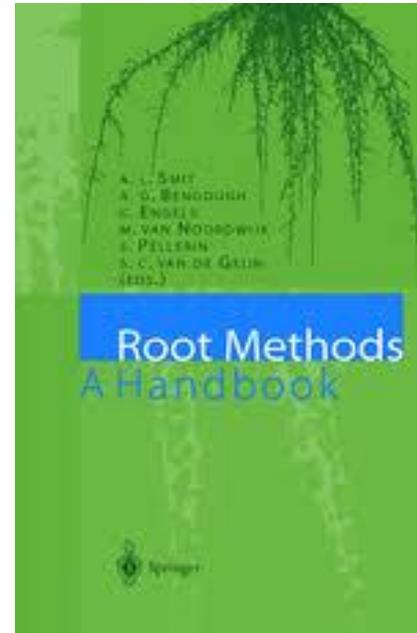
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Standardizing trait measurements

2020

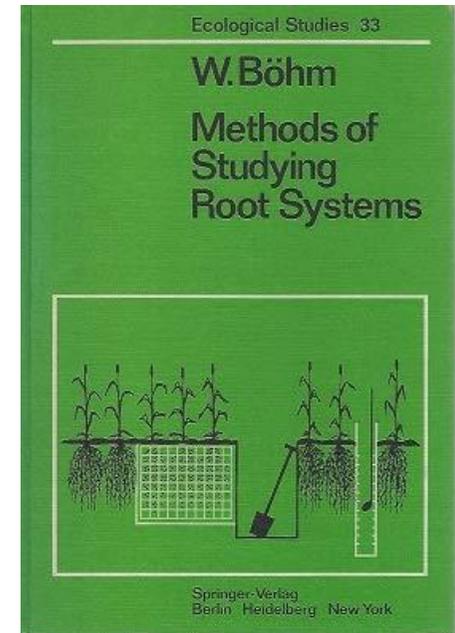


2000



Smit, A.L. et al. (eds.) 2000. Springer, Berlin

1979



Böhm, W. 1979. Springer, Berlin

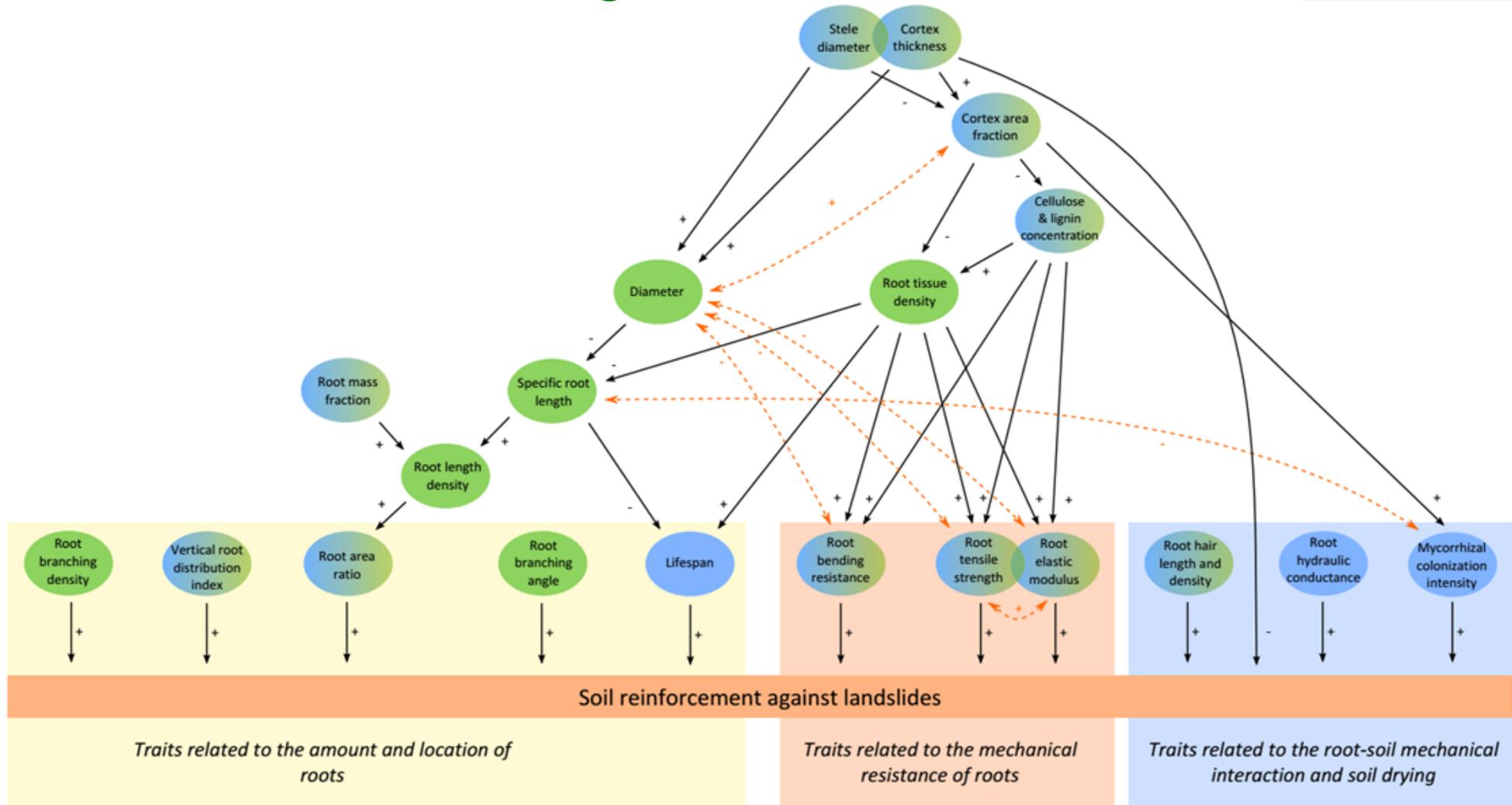
Freschet et al. **A starting guide to root ecology:** strengthening ecological concepts and standardizing root classification, sampling, processing and trait measurements. *New Phytologist*, under review.

3) Root ecological science still



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Soil reinforcement against landslides



Outlook & Steps forward



- 1) Know your root entity and report it
- 2) Identify (demonstrated) functional traits and not 'just the simple ones'
- 3) Use standardized methodology whenever possible, report deviations
- 4) Consider trait interrelations and hierarchies

→ Start analysing roots & deposit data (e.g. FRED, <https://roots.ornl.gov/>)

Upcoming Publications



Images not referenced otherwise originate from the following manuscripts:

- Freschet GT*, Pagès L, Iversen CM, Comas LH, Rewald B, Roumet C, Klimešová J, Zadworny M, Poorter H, Postma JA, et al. **A starting guide to root ecology: strengthening ecological concepts and standardizing root classification, sampling, processing and trait measurements.** *New Phytologist*, under review
- Freschet GT*, Roumet C, Comas LH, Weemstra M, Bengough AG, Rewald B, Bardgett RD, Deyn GBD, Johnson D, Klimešová J, et al. **Root traits as drivers of plant and ecosystem functioning: current understanding, pitfalls and future research needs.** *New Phytologist*, under review

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Thank you for your attention!

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