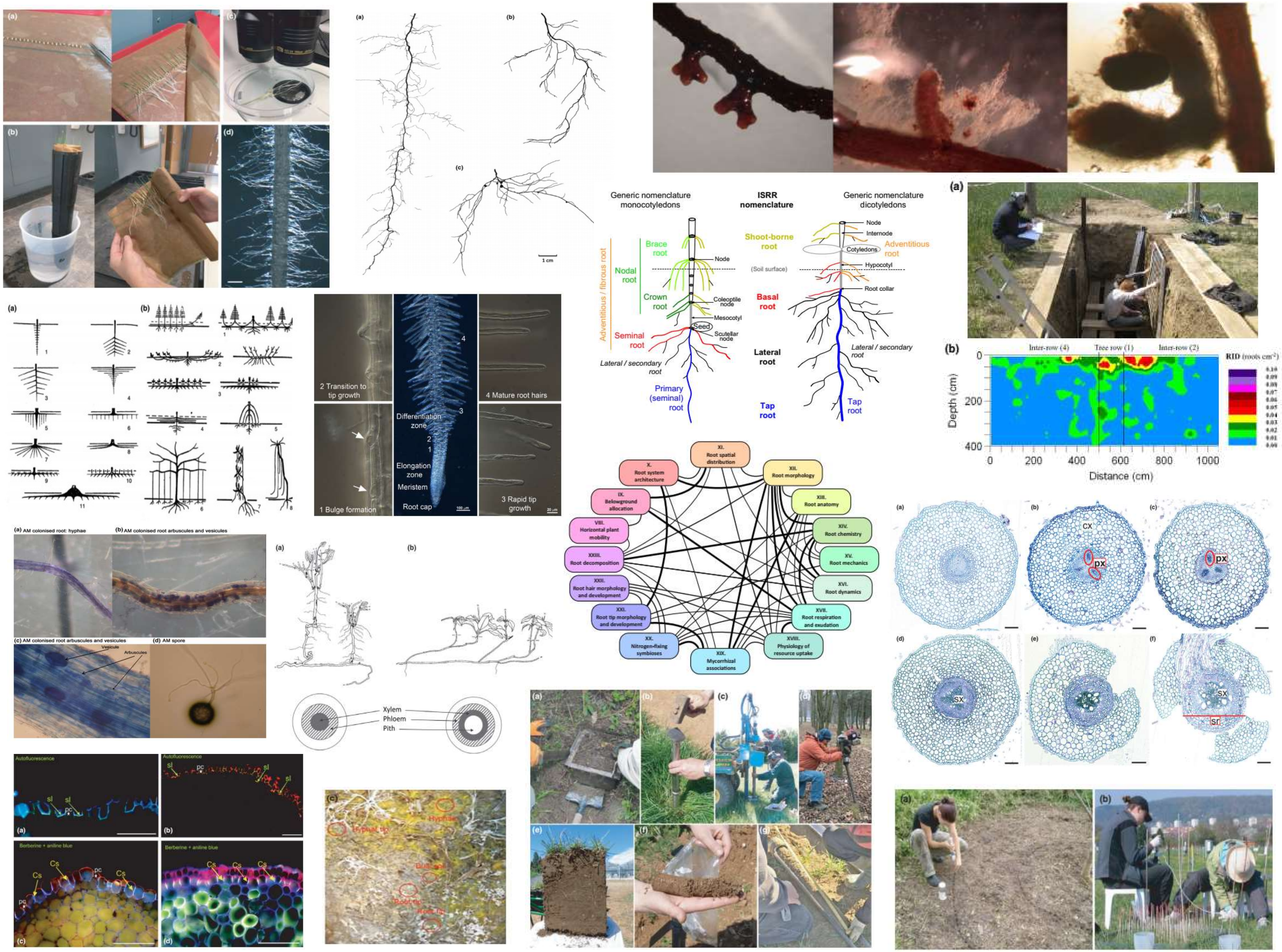

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ISRR nomenclature
Generic nomenclature dicotyledons
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Brace root
Nodal root
Crown root
Seminal root
Lateral / secondary root
Primary (seminal) root
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Coleoptile node
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Seed
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Shoot-borne root
(Soil surface)
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Distance (cm)
Inter-row (4)
Tree row (1)
Inter-row (2)
RID (roots cm⁻²)
cx
px
sx
sr

Vue sur la valée du Lez - La Croix du Char (720m) Couserans Février 2018

Root traits as drivers of plant and ecosystem functioning

Grégoire T. Freschet

CForBio presentation

2022-04-28

Insights from a large collaborative project

New Phytologist

Forum

Community resources

A starting guide to root ecology: strengthening ecological concepts and standardising root classification, sampling, processing and trait measurements

Grégoire T. Freschet[1,2], Loïc Pagès[3], Colleen M. Iversen[4], Louise H. Comas[5], Boris Rewald[6], Catherine Roumet[1], Jitka Klimešová[7], Marcin Zadworny[8], Hendrik Poorter[9,10], Johannes A. Postma[9], Thomas S. Adams[11], Agnieszka Bagniewska-Zadworna[12], A. Glyn Bengough[13,14], Elison B. Blancaflor[15], Ivano Brunner[16], Johannes H. C. Cornelissen[17], Eric Garnier[1], Arthur Gessler[18,19], Sarah E. Hobbie[20], Ina C. Meier[21], Liesje Mommer[22], Catherine Picon-Cochard[23], Laura Rose[2,24], Peter Ryser[25], Michael Scherer-Lorenzen[26], Nadejda A. Soudzilovskaia[27], Alexia Stokes[28], Tao Sun[29], Oscar J. Valverde-Barrantes[30], Monique Weemstra[1], Alexandra Weigelt[31], Nina Wurzburger[32], Larry M. York[33], Sarah A. Batterman[34,35], Moemy Gomes de Moraes[36], Štěpán Janeček[37], Hans Lambers[38], Verity Salmon[39], Nishanth Tharayil[40] and M. Luke McCormack[41]

Freschet *et al.* (2021)
New Phytologist 232: 973–1122

New Phytologist

New Phytologist

Viewpoints

Viewpoints

Root traits as drivers of plant and ecosystem functioning: current understanding, pitfalls and future research needs

Root traits as driver ecosystem function understanding, pitf research needs

Grégoire T. Freschet[1,2*], Catherine Roumet[2], Louise H. Comas[3], Monique Weemstra[2], A. Glyn Bengough[4,5], Boris Rewald[6], Richard D. Bardgett[7], Gerlinde B. De Deyn[8], David Johnson[7], Jitka Klimešová[9], Martin Lukac[10,11], M. Luke McCormack[12], Ina C. Meier[13,14], Loïc Pagès[15], Hendrik Poorter[16,17], Iván Prieto[18], Nina Wurzburger[19], Marcin Zadworny[20], Agnieszka Bagniewska-Zadworna[21], Elison B. Blancaflor[22], Ivano Brunner[23], Arthur Gessler[24,25], Sarah E. Hobbie[26], Colleen M. Iversen[27], Liesje Mommer[28], Catherine Picon-Cochard[29], Johannes A. Postma[16], Laura Rose[1], Peter Ryser[30], Michael Scherer-Lorenzen[31], Nadejda A. Soudzilovskaia[32], Tao Sun[33], Oscar J. Valverde-Barrantes[34], Alexandra Weigelt[35], Larry M. York[22] and Alexia Stokes[36]

Freschet *et al.* (2021)
New Phytologist 232: 1123–1158

Key challenges in root ecology

1. Difficulty to define a common, unambiguous language to accurately communicate among disciplines of root science

2. Uneven quality and reproducibility of trait measurement methods

3. Relatively superficial understanding of root trait ecological meaning

4. Difficulty to navigate the high number of technical and practical choices associated with both lab and field studies

Key challenges in root ecology

5. Current focus on few easily measured root traits, to the detriment of a wider range of traits

6. Isolation of the many different disciplines of root ecology

7. Poor accounting of spatial and temporal variability of root traits

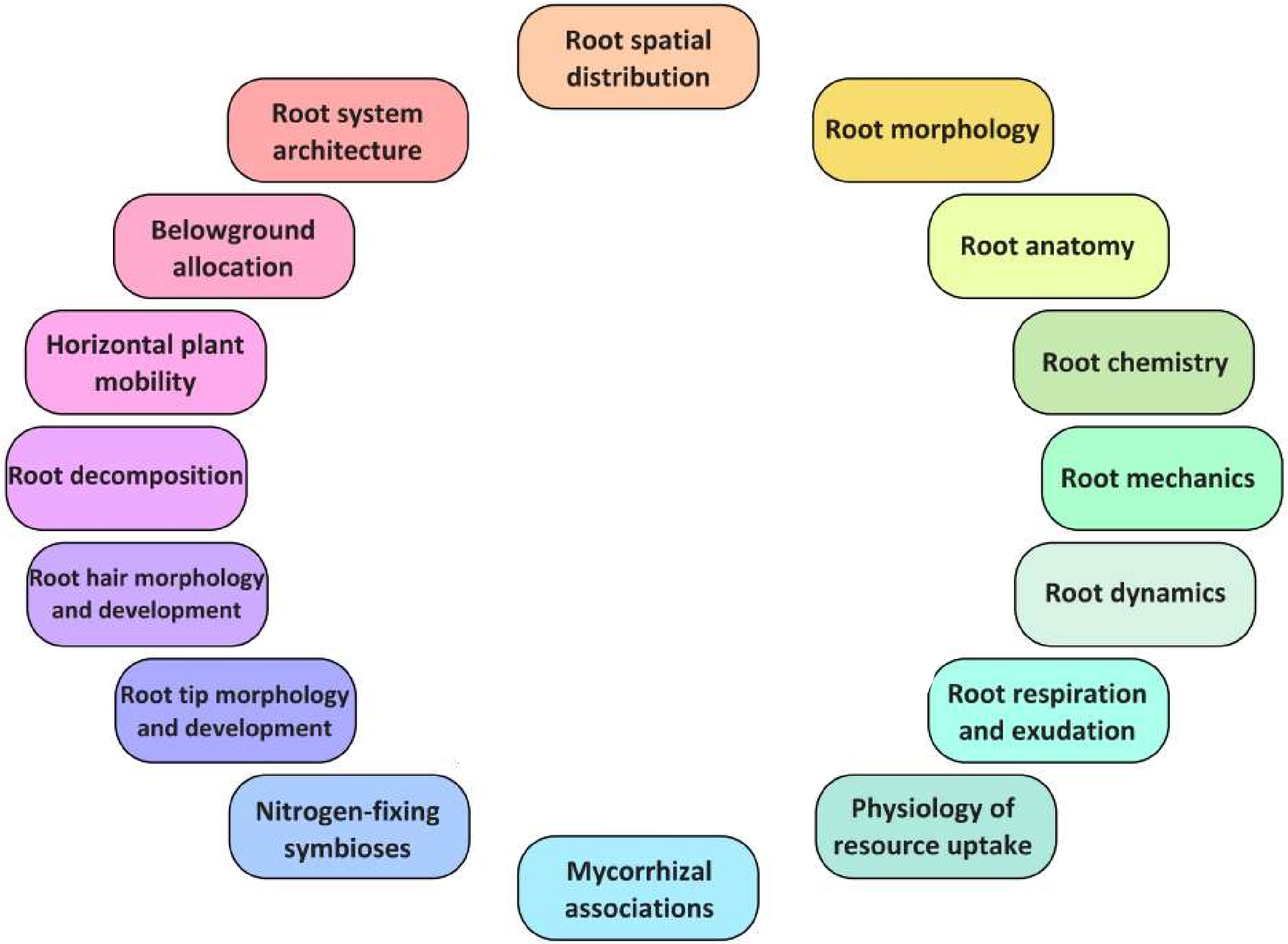
8. Lack of explicit approach to scale-up root traits to ecosystem functioning

Main objectives

1. A guide of root ecology

2. A synthesis of root traits – ecosystem functioning relationships

Key Challenge: Advertise the diversity of traits – Identify the big players



Key Challenge: Advertise the diversity of traits – Identify the big players

Resource acquisition

Plant N acquisition

Plant P acquisition

Plant water acquisition

Resource protection and re-use

Plant nutrient and C conservation

Plant protection against pathogens and herbivory

Plant resistance to uprooting

Plant resistance to and avoidance of drought

Plant regeneration

Plant storage

Plant tolerance to waterlogging

Cycling of elements

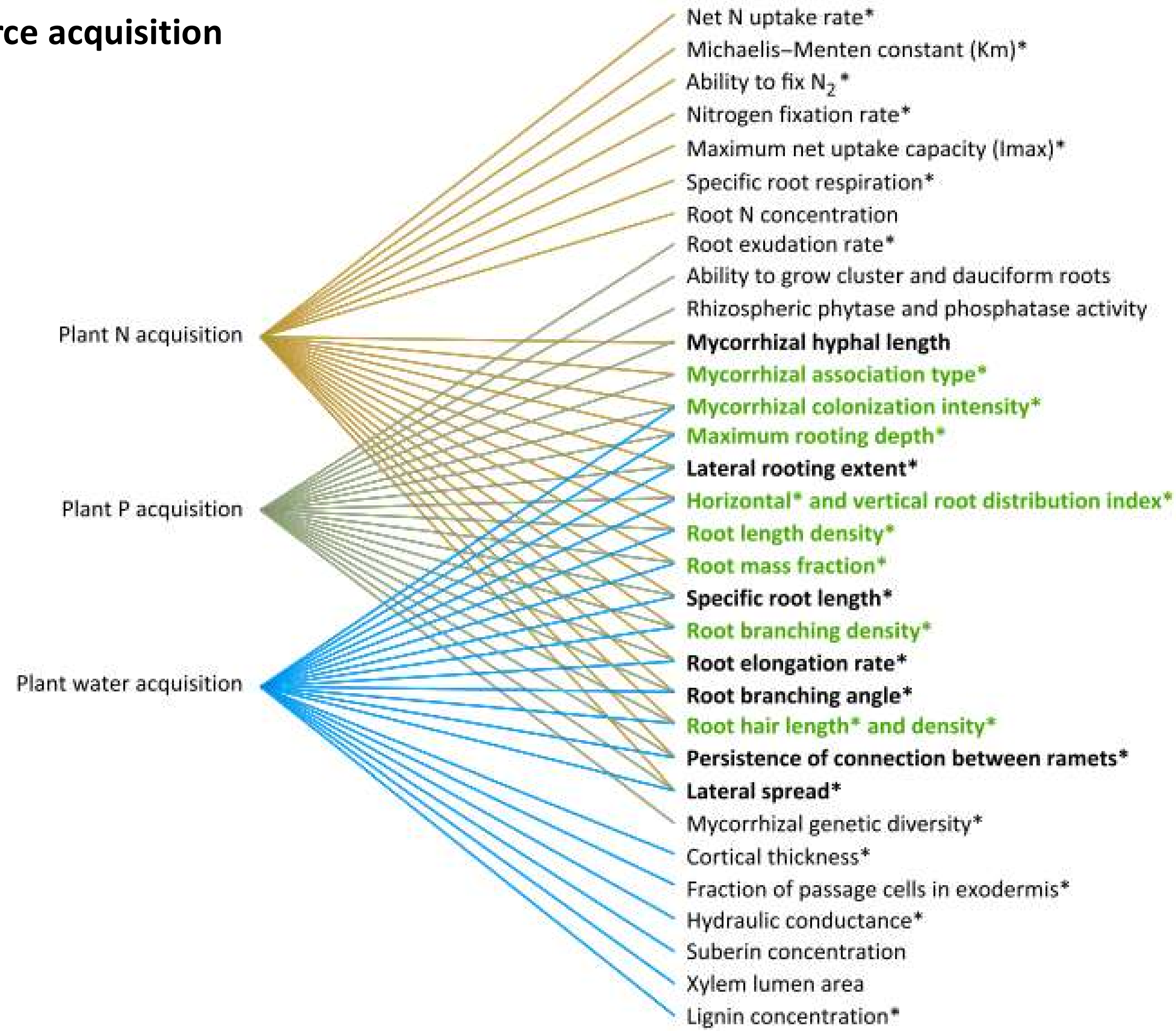
Ecosystem C cycling

Ecosystem N cycling

Ecosystem P cycling

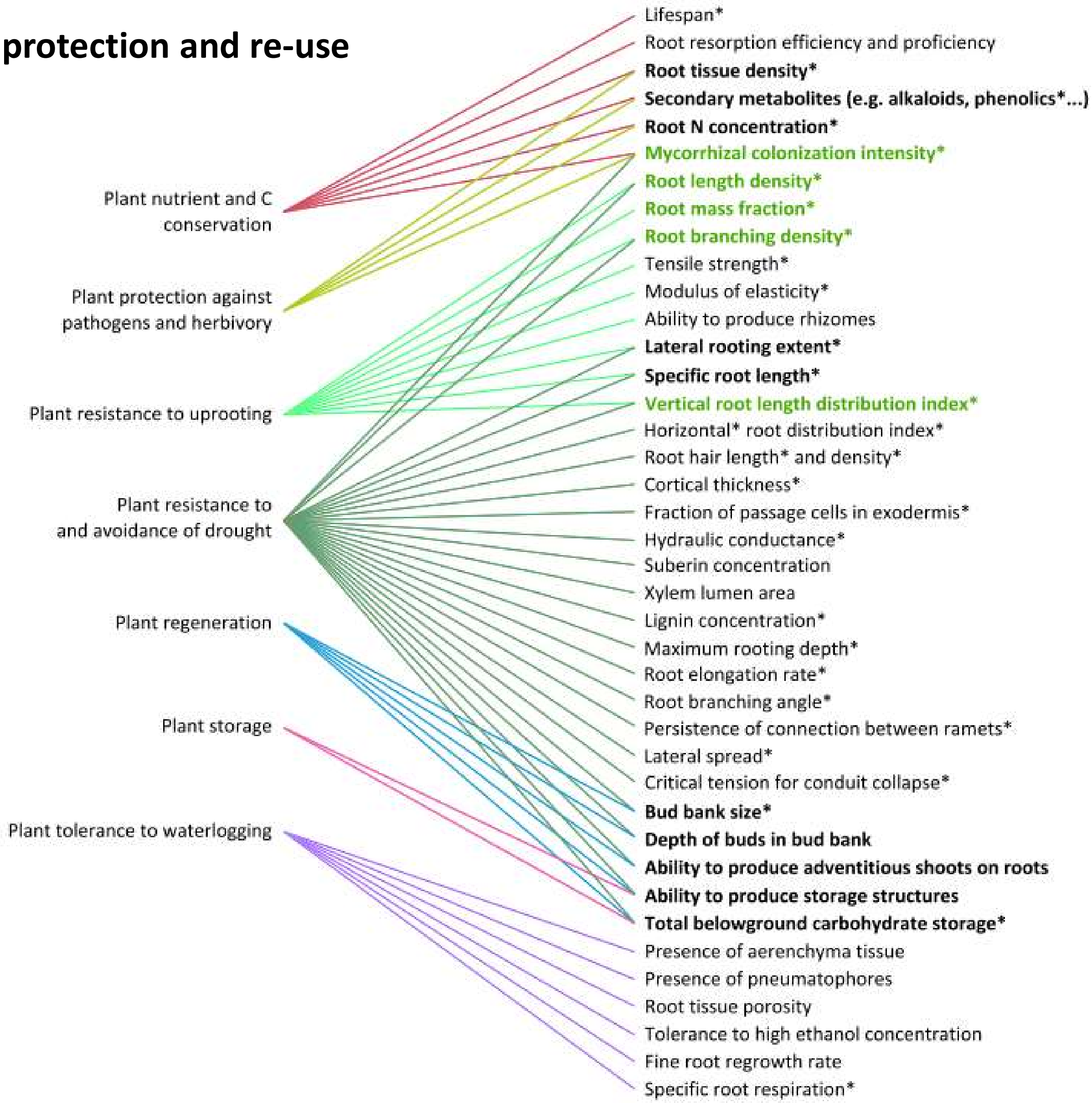
Bedrock weathering

Resource acquisition

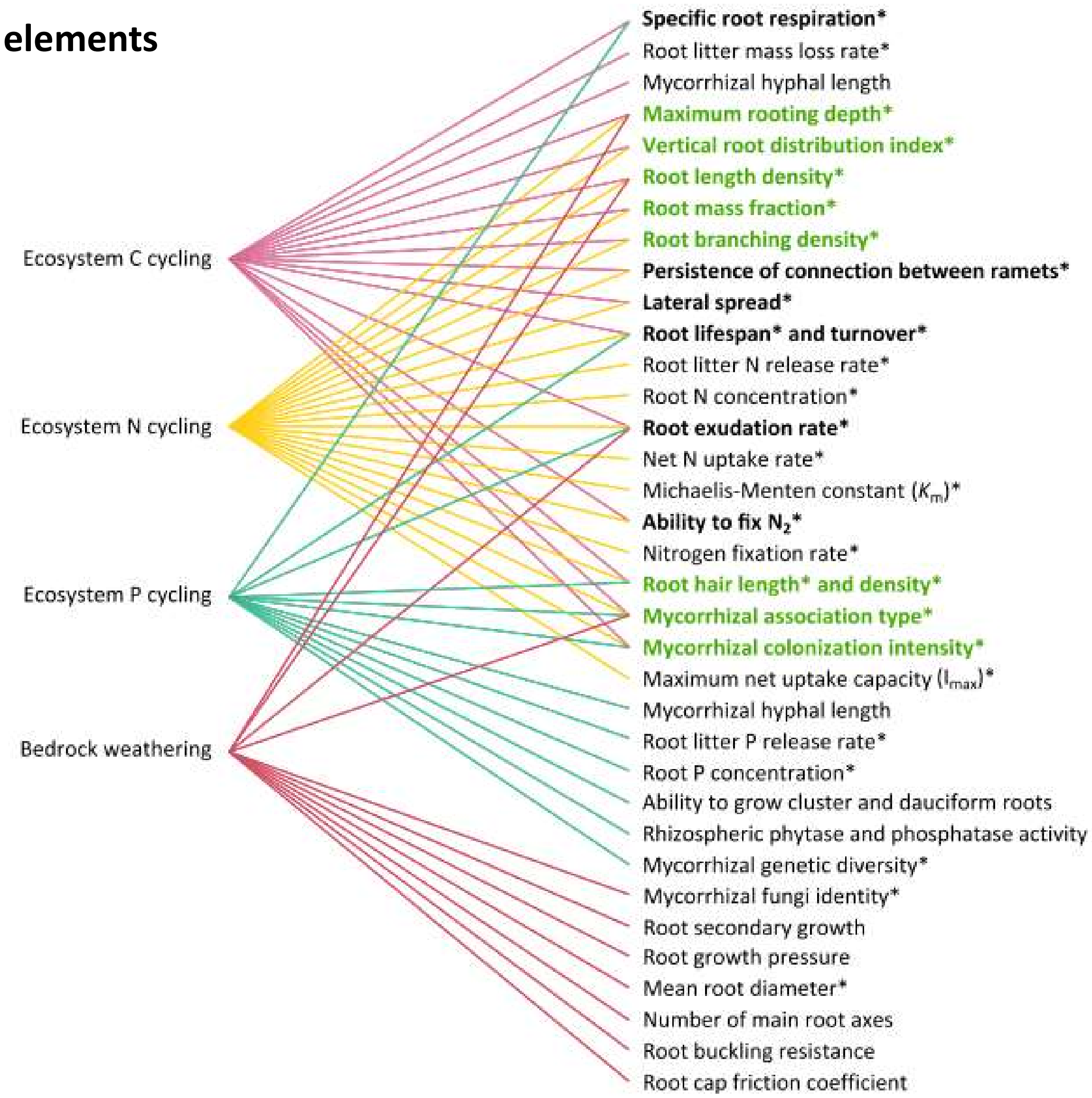


Key Challenge: Advertise the diversity of traits – Identify the big players

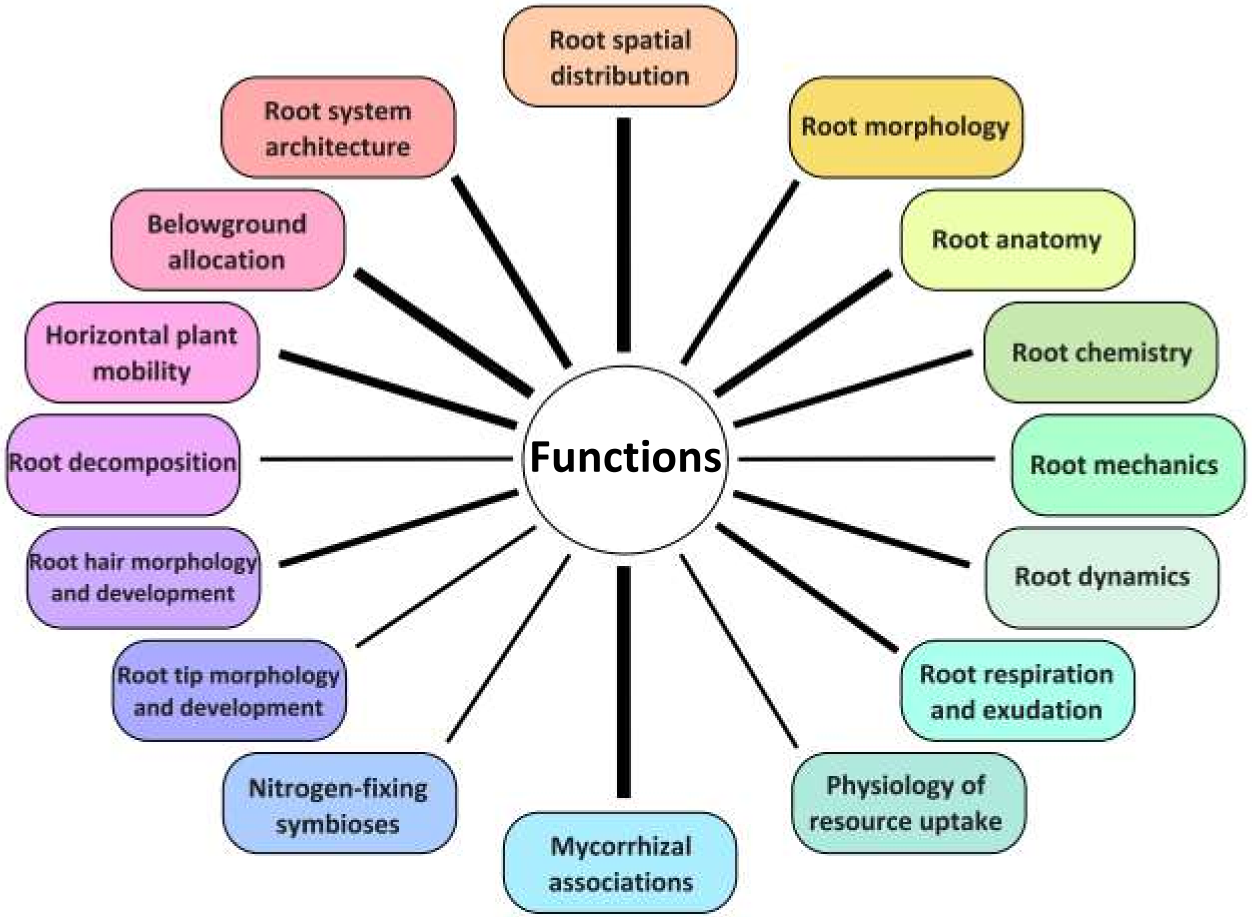
Resource protection and re-use



Cycling of elements



What is the relative ‘representation’ of the trait categories?



What are the traits most often connected to functioning?

SRL?

RNC?

Root diameter?

RTD?

What are the traits most often connected to functioning?

Category	Traits
Belowground allocation	Root mass fraction Root length density
Root spatial distribution	Vertical root distribution index Maximum rooting depth
Root system architecture	Root branching density
Mycorrhizal associations	Mycorrhizal association type Mycorrhizal colonization intensity
Root hair morphology and development	Root hair length and density

Take home message

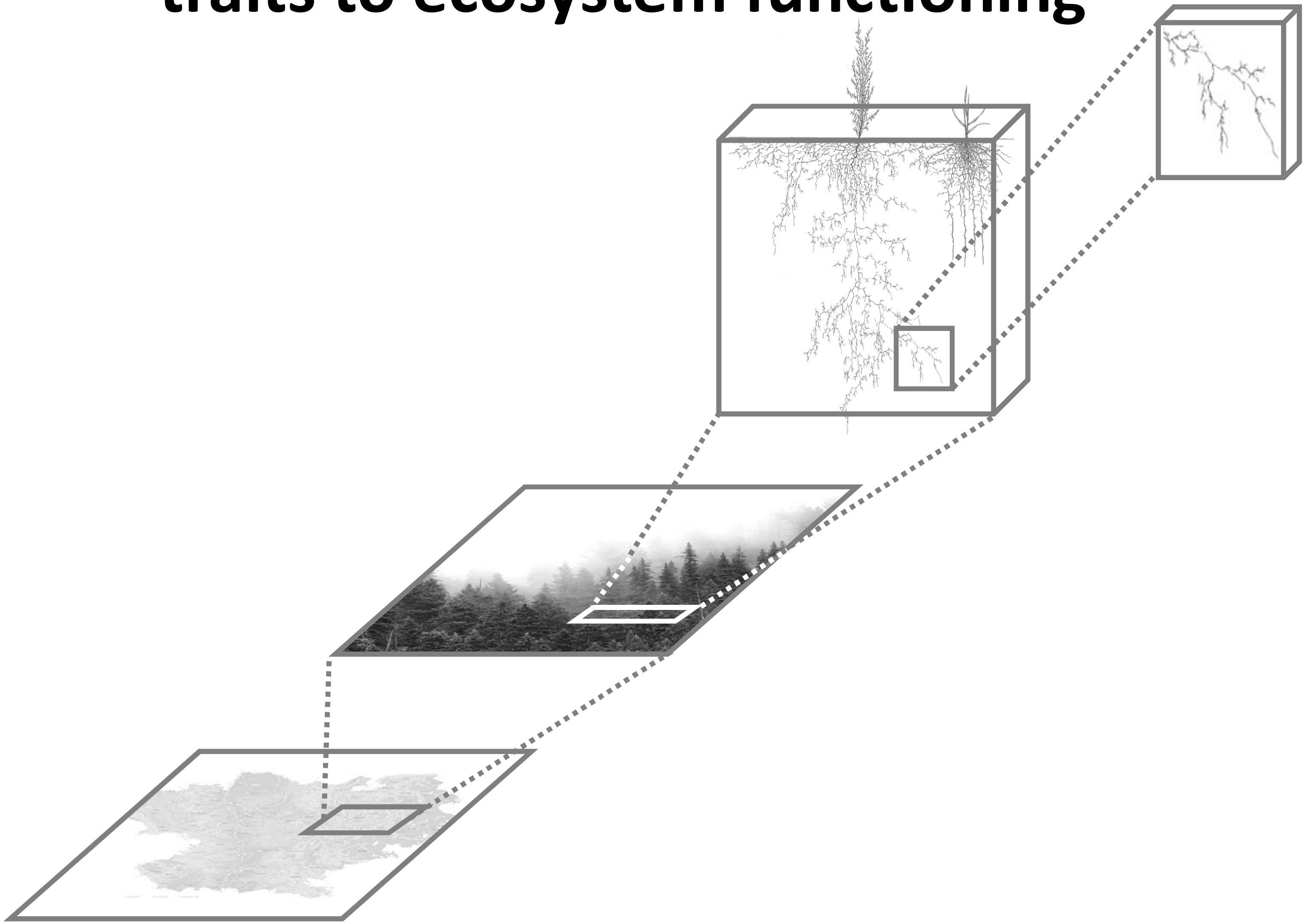
Below-ground traits with the widest importance in plant and ecosystem functioning are not necessarily those that are the most commonly measured.

The relevance of commonly measured (soft) traits to plant and ecosystem functioning is often indirect and insubstantial, or requiring further testing.

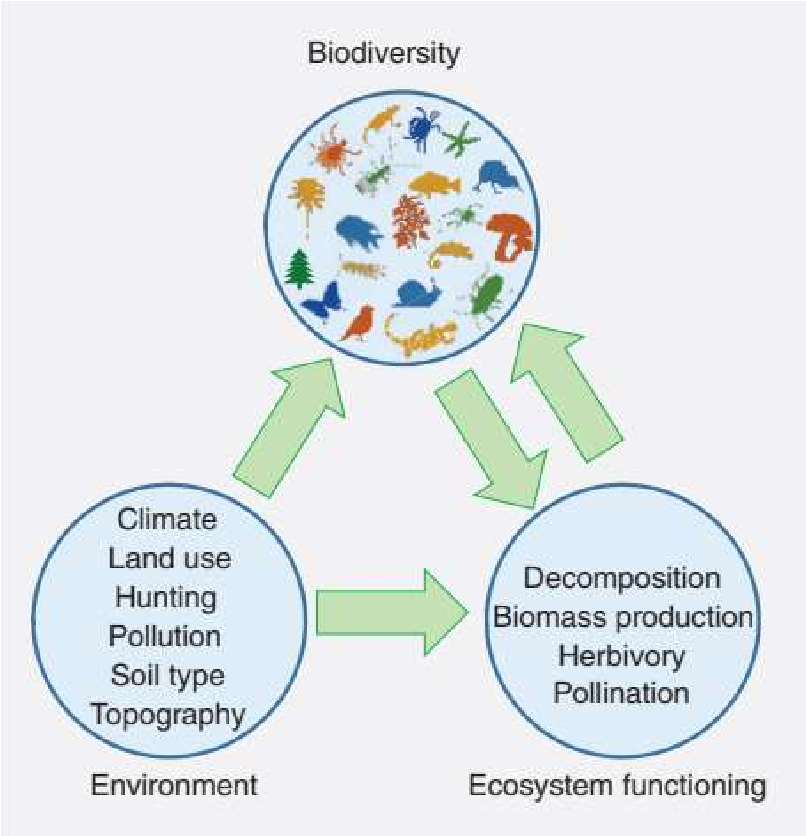
Important traits belong to a range of categories representing a diversity of research fields

Interdisciplinary approaches are needed to adequately capture the plant effects on ecosystem functioning

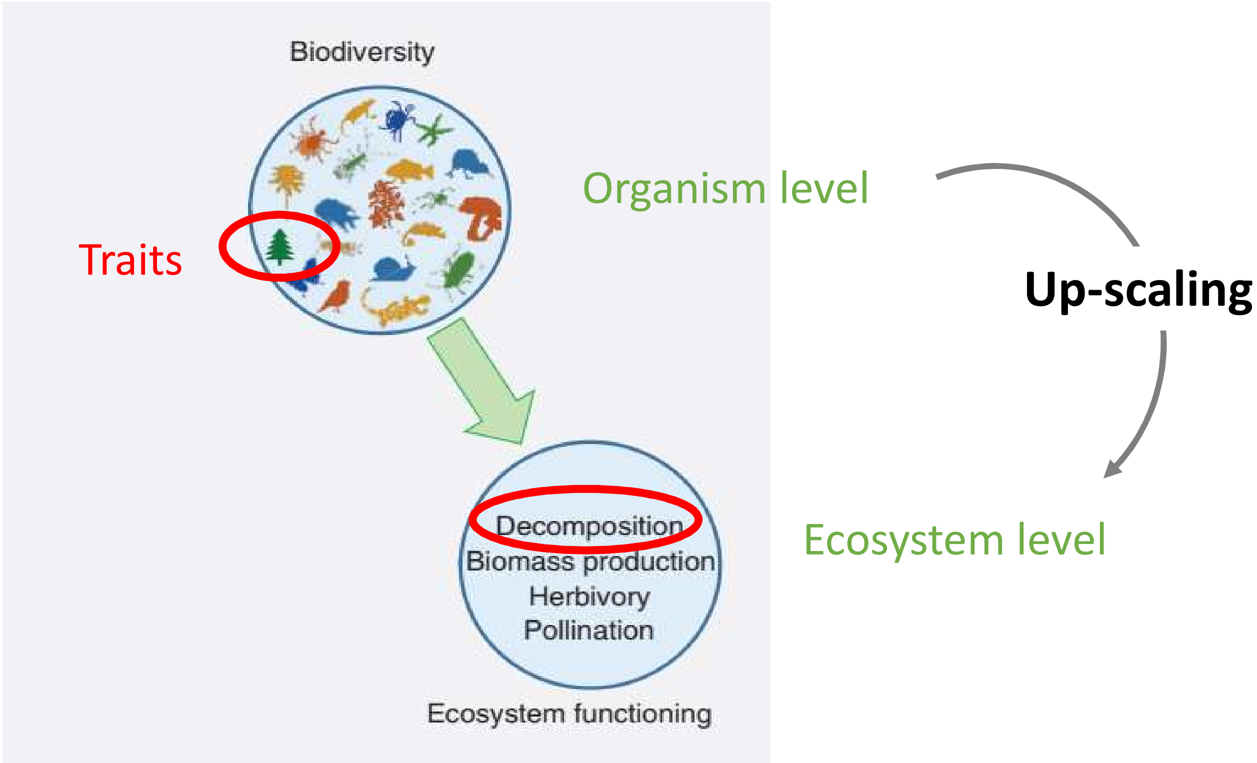
Key Challenge: Meaningfully scaling-up root traits to ecosystem functioning



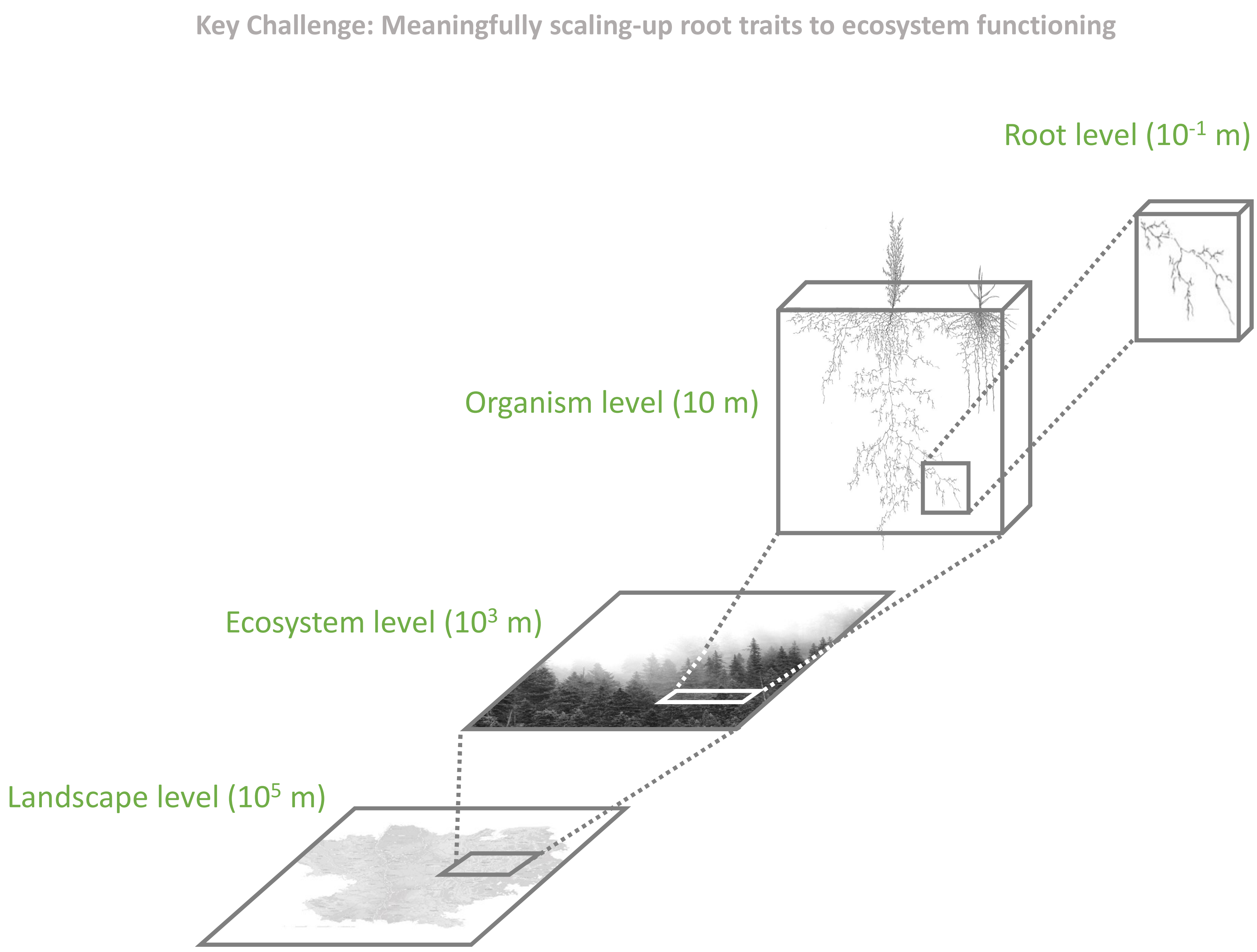
Organism diversity – ecosystem functioning



Van der Plas et al. 2019 *Biol. Rev.*



How small parts of a system do affect the system as a whole


Key Challenge: Meaningfully scaling-up root traits to ecosystem functioning
Root level (10^{-1} m)
Organism level (10 m)
Ecosystem level (10^{3} m)
Landscape level (10^{5} m)

Up-scaling

Organism selection

Trait selection

Data acquisition

Data synthesis

Temporal and spatial scale of sampling

Modelling approach

…

Organism selection

1) Focusing on one type of organism only (if possible, the most important one for functioning)

2) Using multitrophic frameworks

______

1) Focusing on a priori important species

2) Focusing on dominant species

Trait selection

1) Focusing on a range of easily measurable traits (potentially with low connection to the function)

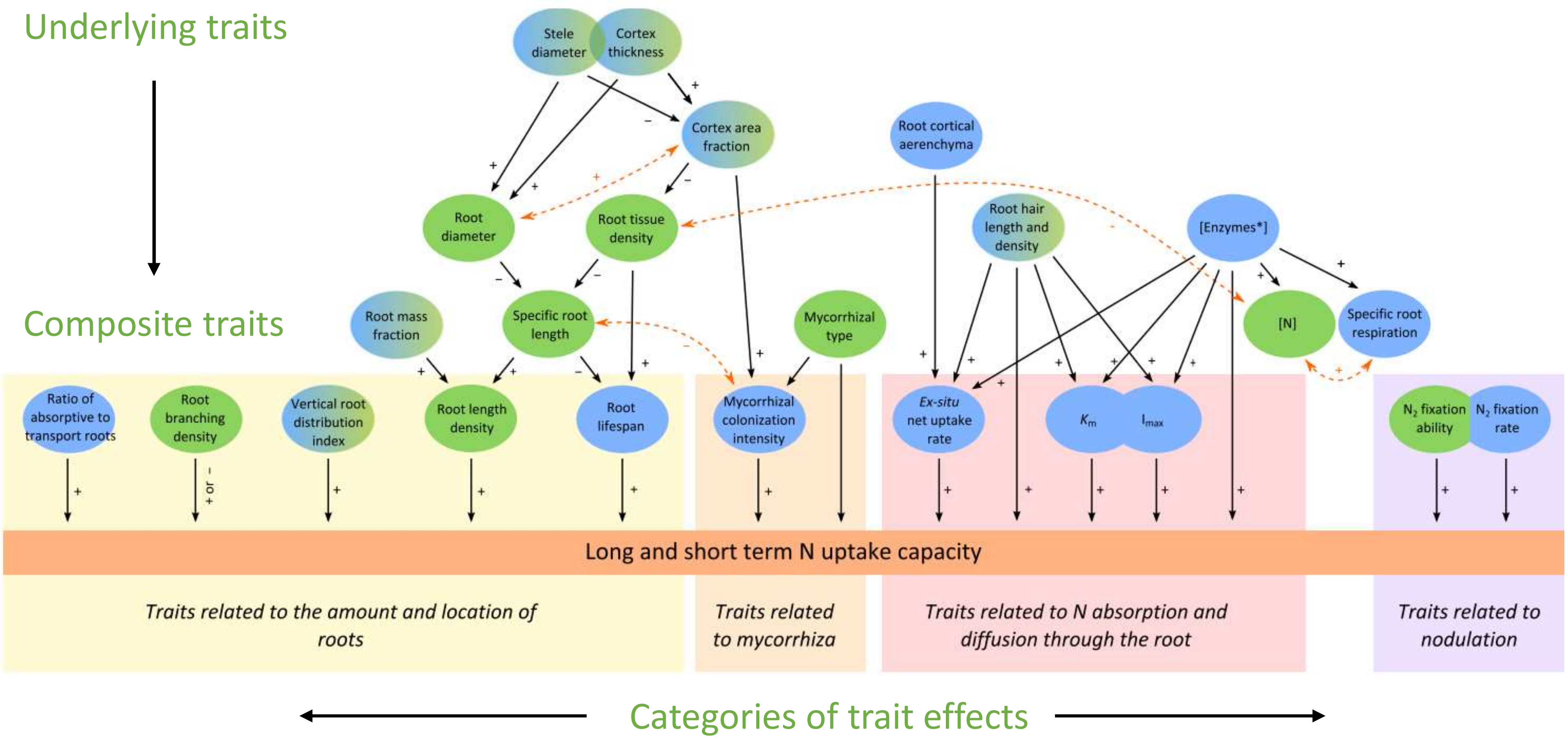
2) Targeting a smaller range of 'hard' traits (with more direct connection to the function)

______

1) Targeting traits based on univariate explanatory power

2) Targeting traits on a priori knowledge of trait inter-relationships and non-overlapping predictive power

Example of trait inter-relationships



Freschet et al. 2021 *New Phyt.*

Trait acquisition

1) Use of databases (local, regional, global: uneven data and meta-data coverage)

2) On-site measurements (include to some extent intraspecific trait variation)

Approaches to synthetize trait data
(across multiple coexisting organisms)

1) Mean field approaches (assume that organisms contribute proportionally to their own weight in the community)

2) Diversity-explicit approaches (includes metrics of the shape of trait distribution: e.g. mean, variance, skewness, kurtosis)

Temporal scale of sampling

1) One measurement in time (e.g. peak of productivity in summer for plants)

2) Several measurements (e.g. across seasons, measurements of interannual differences, …)

Spatial scale of sampling

1) Include one well-identified spatial scale

2) Include several spatial scales

_____

1) Spatial averaging (ecosystem functioning is the average of all small-scale functioning)

2) Spatially-explicit sampling of ecosystem sub-units (ecosystem functioning can be provided by few sub-units)

Statistical/modelling approach

1) Using statistical models (univariate, multivariate, structural equation modelling…)

2) Construct more complex models (such as process-based models)

Take home message

Up-scaling is a critical approach to fill in the gap between the small-scale mechanistic understanding of reduced systems and large-scale integrative, but mostly descriptive assessments.

Complex models are built up from simple models. There are many complementary approaches where less labour intensive choices on the one hand is needed to explore more complexity in another aspect.

'Model-experiment' integration (or Mod-Ex) as a way forward:
combines current empirical understanding with model conceptualization, parameterization, and validation in an iterative process to improve model representation of the natural world.

The reverse approach of down-scaling has sometimes been used successfully, starting from the observation of major differences in functioning between systems, and tracking back the causes to individual organisms and traits.

Thank you!

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