

## Global Root Traits (GRoot) Database

### Supporting Information

**Table S1.** Definitions and units of root traits included in GRoot. Definitions based on the handbook of root traits (Freschet *et al.*, 2020), FRED guidelines (Iversen *et al.*, 2018) and CLO-PLA (Klimešová & Bello, 2009; Klimešová *et al.*, 2017, 2019). Traits categorization based on the handbook of root traits and McCormack *et al.* (2017).

Traits	Units	Definitions
<b>Anatomy</b>		
Root cortex thickness	μm	Thickness of the ring of cortical cells beginning outside the stele and extending to the root epidermis
Root stele diameter	μm	Diameter of root stele
Root stele fraction	%	Root cross-sectional area that is occupied by the stele
Root xylem vessel number	number mm <sup>-2</sup>	Root xylem vessel number per root stele area
Root vessel diameter	μm	Root vessel diameter
<b>Architecture</b>		
Root branching ratio	number number <sup>-1</sup>	Number of roots on a given order divided by the number of roots in the higher order
Root branching density	number cm <sup>-1</sup>	Number of laterals on a given length unit of total root length <sup>t</sup>
<b>Belowground allocation</b>		
Root mass fraction	g g <sup>-1</sup>	Ratio of root dry mass per total plant standing dry biomass
<b>Chemistry</b>		
Root structural carbohydrate concentration	mg g <sup>-1</sup>	Root cellulose and hemicellulose content per root mass
Root lignin concentration	mg g <sup>-1</sup>	Mass of lignin per root dry mass
Root carbon concentration	mg g <sup>-1</sup>	Mass of C per root dry mass
Root nitrogen concentration	mg g <sup>-1</sup>	Mass of N per root dry mass
Root phosphorus concentration	mg g <sup>-1</sup>	Mass of P per root dry mass
Root carbon to nitrogen ratio	g g <sup>-1</sup>	Ratio of carbon to nitrogen in root by mass
Root nitrogen to phosphorus ratio	g g <sup>-1</sup>	Ratio of nitrogen to phosphorus in root by mass
Root calcium concentration	mg g <sup>-1</sup>	Mass of Ca per root dry mass
Root potassium concentration	mg g <sup>-1</sup>	Mass of K per root dry mass
Root magnesium concentration	mg g <sup>-1</sup>	Mass of Mg per root dry mass

Root manganese concentration	mg g <sup>-1</sup>	Mass of Mn per root dry mass
<b><i>Dynamics &amp; decomposition</i></b>		
Root production	g m <sup>-2</sup> yr <sup>-1</sup>	Dry mass of root produced per soil volume and per year
Root lifespan	days	Time between birth and death of a root
Root turnover rate	year <sup>-1</sup>	Root dry mass production per dry mass of a given pool of roots over a period of time
Root litter mass loss rate	year <sup>-1</sup>	Dry mass lost by roots per initial dry mass of the roots per unit time
<b><i>Horizontal plant mobility</i></b>		
Lateral spread	cm yr <sup>-1</sup>	Distance a clonal plant grows laterally in one year
<b><i>Microbial associations</i></b>		
Root mycorrhizal colonization intensity	%	Percentage length of roots colonized by fungi
<b><i>Morphology</i></b>		
Mean root diameter	mm	Mean diameter of the root sample
Root dry matter content	g g <sup>-1</sup>	Dry mass of root per unit fresh root mass
Root tissue density	g cm <sup>-3</sup>	Dry mass of root per unit volume of fresh root
Specific root area	cm <sup>2</sup> g <sup>-1</sup>	Surface area of a root per unit dry mass
Specific root length	m g <sup>-1</sup>	Length of a root per unit dry mass
<b><i>Physiology &amp; respiration</i></b>		
Net uptake rate of nitrogen	μmol g <sup>-1</sup> d <sup>-1</sup>	Amount of labelled nitrogen accumulated within a plant individual per unit dry mass and time <sup>†</sup>
Specific root respiration	nmol g <sup>-1</sup> s <sup>-1</sup>	Amount of CO <sub>2</sub> released or O <sub>2</sub> absorbed by root per unit root dry mass per unit of time
<b><i>System &amp; distribution</i></b>		
Fine root mass to leaf mass ratio	g g <sup>-1</sup>	Ratio of fine-root mass to leaf mass
Coarse to fine root mass ratio	g g <sup>-1</sup>	Ratio of coarse root biomass to fine root biomass
Root mass density	g cm <sup>-3</sup>	Mass of roots per unit soil volume
Root length density	cm cm <sup>-3</sup>	Length of roots per unit soil volume
Maximum rooting depth	m	Maximum soil depth at which roots occur

<sup>†</sup> As the total root length in the category can vary across studies, this information needs to be interpreted with caution.

<sup>‡</sup> Combined uptake of <sup>15</sup>N as NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup> or glycine tracers in 24h per shoot dry mass, estimated as  $F = [T(AS-AB)]/AF$  with T is the plant N concentration, AS is the atom percent excess <sup>15</sup>N in the sample, AB is the atom percent excess <sup>15</sup>N in natural sample, AF is the atom percent excess <sup>15</sup>N in the tracer

**Table S2.** Relevant root traits not included in GRooT due to low coverage (data for <50 species available). Definitions based on the handbook of root traits (Freschet *et al.*, 2020) and FRED guidelines (Iversen *et al.* 2018). Traits categorization based on the handbook of root traits and McCormack *et al.* (2017).

Traits	Units	Definitions
<b><i>Architecture</i></b>		
Root branching intensity	number cm <sup>-1</sup>	number of laterals on a given length unit of parent root
<b><i>Chemistry</i></b>		
Root total non-structural carbohydrate concentration	mg g <sup>-1</sup>	the mass of carbohydrate molecules that do not participate in root structure per root dry mass
Root phenolic concentration	mg g <sup>-1</sup>	the mass of phenolic compounds per root dry mass
Root sulphur (S) concentration	mg g <sup>-1</sup>	the mass of S per root dry mass
Root aluminum concentration	mg g <sup>-1</sup>	the mass of Al per root dry mass
<b><i>Dynamics</i></b>		
Time root growth initiation	Date	the calendar date at which roots production stops or becomes minimal after a period of high growth
Time root growth cessation	Date	the calendar date at which root production starts increasing after a period of low or null growth
<b><i>Mechanical</i></b>		
Root tensile strength	Pascal	The force required to cause failure of the root per cross-sectional area
<b><i>Morphology</i></b>		
Root hair density	number mm <sup>-2</sup>	the number of root hairs per unit root length
Root hair length	µm	the length of fully-grown root hairs
<b><i>Physiology</i></b>		
Theoretical root specific hydraulic conductance	m <sup>3</sup> s <sup>-1</sup> MPa <sup>-1</sup> cm <sup>-2</sup>	the calculated amount of water that can move through tissue per the cross sectional area of the tissue
Maximum net ion uptake rate, I <sub>max</sub>	µmol g <sup>-1</sup> s <sup>-1</sup>	the amount of ion accumulated per unit root biomass and time under conditions of non-limiting nutrient concentration
Michaelis-Menten constant, km	mmol l <sup>-1</sup> or mM	the nutrient concentration where 50% of the maximum net ion uptake rate is observed
<b><i>Root system</i></b>		
Vertical root mass distribution index	Unitless	Extinction coefficient (β) of an asymptotic equation (Y = 1 - β <sup>d</sup> ) fitting the cumulative proportional root biomass over depth. Values of β approaching 1 imply a greater proportion of roots with depth
Lateral root mass distribution index	Unitless	Extinction coefficient (β) of an asymptotic equation (Y = 1 - β <sup>d</sup> ) fitting the cumulative proportional root biomass over depth. Values of β approaching 1 correspond to a greater proportion of roots away from the plant base
Lateral rooting extent	m	Maximum distance between superficial roots and the base of the plant

**Table S3.** Trait names across major trait databases with root traits. FRED is also included in the TRY Database. Aggregable trait variables into a single unique trait in GRooT are showed.

Trait name		
GRooT	FRED	TRY
<b>Anatomy</b>		
Root cortex thickness	Root cortex thickness	
Root stele diameter	Root stele diameter	
Root stele fraction	Root stele fraction and re-calculated Root stele diameter	
Root xylem vessel number	Root xylem vessel number	
Root vessel diameter	Root vessel diameter	
<b>Architecture</b>		
Root branching ratio	Root branching intensity (branching ratio)_Number of roots per higher order root	
Root branching density	Root branching intensity_root tips per total root length	
<b>Belowground allocation</b>		
Root mass fraction	Root mass fraction (RMF) and re- calculated shoot:root ratio	Root mass fraction (fraction of root dry mass per whole plant dry mass) and re-calculated shoot:root ratio
<b>Chemistry</b>		
Root structural carbohydrate concentration	Root cellulose and hemicellulose content per root mass or sum of Root cellulose content and Root hemicellulose content per root mass	Sum of root cellulose content per root dry mass and root hemicellulose content per root dry mass
Root lignin concentration	Root lignin content	Root lignin content per root dry mass
Root carbon concentration	Root C content	Coarse root carbon(C) content per coarse root mass; fine root carbon (C content per fine root dry mass; root carbon (C) content per root dry mass
Root nitrogen concentration	Root N content	Coarse root nitrogen (N) content per coarse root dry mass; Fine root nitrogen (N) content per fine root dry mass; root nitrogen content per root dry mass
Root phosphorus concentration	Root P content	Fine root phosphorus (P) content per fine root dry mass; root phosphorus (P) content per root dry mass
Root carbon to nitrogen ratio	Root C/N ratio	Fine root carbon/nitrogen (C/N) ratio; root carbon/nitrogen (C/N) ratio

Root nitrogen to phosphorus ratio		Fine root nitrogen/phosphorus (N/P) ratio; root nitrogen/phosphorus N/P ratio
Root calcium concentration	Root Ca content	Root calcium (Ca) content per root dry mass
Root potassium concentration	Root K content	Root potassium (K) content per root dry mass
Root magnesium concentration	Root Mg content	
Root manganese concentration	Root Mn content	
<b><i>Dynamics &amp; decomposition</i></b>		
Root production	Root growth_Annual mass production per ground area	
Root lifespan mean		
Root lifespan median	Root median lifespan_Main_d	
Root turnover rate	Root turnover_Annual root system replacement	
Root litter mass loss rate	Root decomposition_Annual k constant	Fine root litter decomposition rate constant
<b><i>Horizontal plant mobility</i></b>		
Lateral spread		Lateral spread
<b><i>Microbial associations</i></b>		
Root mycorrhizal colonization intensity		
<b><i>Morphology</i></b>		
Mean root diameter	Root diameter	Fine root diameter; root diameter
Root dry matter content	Root dry matter content (RDMC)	Fine root dry mass per fine root fresh mass (fine root dry matter content; RDMC); root dry mass per root fresh mass (root dry matter content; RDMC)
Root tissue density	Root tissue density (RTD)	Root dry mass per root volume (root density, root tissue density; root tissue density (root dry mass per root volume))
Specific root area	Specific root area (SRA)	
Specific root length	Specific root length (SRL)	Fine root length per fine root dry mass (specific fine root length, SRL); root length per root dry mass (specific root length, SRL)
<b><i>Physiology &amp; respiration</i></b>		
Net uptake rate of nitrogen	Plant N uptake_daily uptake of molar total 15N per shoot dry mass	
Specific root respiration	Root respiration rate per root dry mass CO2 release and Root respiration rate per root dry mass O2 uptake	Root respiration rate per root dry mass
<b><i>System &amp; distribution</i></b>		
Fine root mass to leaf mass ratio	Fine root mass to leaf mass ratio	
Coarse to fine root mass ratio	Coarse to fine root mass ratio	Coarse root to fine root ratio

Root mass density	Belowground biomass per soil volume
Root length density	Root length density (RLD) Root length per soil volume
Maximum rooting depth	Rooting depth and rooting depth max

---

**Table S4.** Available information on root entities available in GRootT. Definitions from the handbook of root traits (Freschet *et al.*, 2020) and FRED guidelines (Iversen *et al.*, 2018).

Column name	Definition	Categories and definitions
belowgroundEntities <sup>†</sup>	Selected main entities	<i>coarse roots (CR)</i> : root with large diameter, often roots > 2 mm in diameter; roots are generally lignified, with clear secondary development <i>fine roots (FR)</i> : root with small diameter, often roots ≤ 2 mm in diameter; roots are generally not lignified <i>total root system (TR)</i> : roots considered without specifying if coarse roots are included <i>total belowground (TB)</i> : belowground parts included but not specified <i>belowground steam (BS)<sup>‡</sup></i> : belowground steams <i>rhizomes (R)<sup>‡</sup></i> : usually shoot axis growing horizontally at or below the substrate and produces shoots above and adventitious roots below <i>unspecified</i> : information about entities not provided
belowgroundEntitiesOrderClassification	Root order-based classifications based on root branch hierarchy	<i>centrifugal</i> : also knows as developmental classification, it is a root- (i.e. growth axis-) based approach in which the lowest order root is the basal or shoot-borne root (i.e. order '0') and the highest order roots are the most distal (coarsest to finest) <i>centripetal</i> : also knows as morphometric or stream-order ('Strahler') classification, it is a segment order-based approach in which distal root segments are first-order and parent root segments are higher order (finest to coarsest)
belowgroundEntitiesOrder	Root branching order, either coarsest to finest (Centrifugal) or finest to coarsest (Centripetal).	numeric
belowgroundEntitiesOrderMin	Minimum root order included	numeric
belowgroundEntitiesOrderMax	Maximum root order included	numeric
belowgroundEntitiesFuctional	Root functional classification based on functionally similar categories of absorptive and transport roots. The absorptive/transport function is associated mostly with the presence/absence of phellem	<i>absorptive<sup>*</sup></i> : root with dominantly absorptive function <i>transport<sup>*</sup></i> : root with dominantly transport function

BelowgroundEntitiesDiameterMin**	Minimum root diameter included	numeric
BelowgroundEntitiesDiameterMax**	Maximum root diameter included	numeric

†Multiple categories together are also included

‡Belowground stem (BS) and rhizomes (R) were only included when measured together with roots.

\*Both categories together are also included

\*\*Information of root diameter in the traitName column can be used too for determining entities based on diameter cut-offs



**Table S5.** Selected information and meta-data provided in GRooT.

Column name	Description
<b>Source</b>	
GRooTID	Unique ID in GRooT by observation, it links root trait measurements performed on the same individual(s)
source	Main source of the data
versionSource	Version of the main source
originalID	Original ID in the main source
referencesAbbreviated	Abbreviation of the citation related to the data
references	Reference related to the data
referencesDataset	Reference dataset
referencesAdditional	Additional references associated to the dataset
<b>Plant taxonomical information</b>	
family	Family of the plant provided by data source
genus	Genus of the plant provided by data source
species	Species epithet of the plant provided by data source
infraspecific	Variety, cultivar, or subspecies of plant provided by data source
familyTNRS	Family of plant using the Taxonomic Name Resolution Service (TNRS)
genusTNRS	Genus of plant using TNRS
speciesTNRS	Species epithet using TNRS
infraspecificTNRS	Variety, cultivar, or subspecies of plant using TNRS
taxonomicStatus	If the species name is accepted, illegitimate, invalid, no opinion or synonym based on the name standardization
taxonomicInformation	Matching score and specifically database used to standardize the name (i.e., tpl, tropicos. usda, gcc, ildis)
group	Plant taxonomical groups (i.e., Angiosperm eudicotyl, magnoliid or monocotyl; Gymnosperm or Pteridophytes)
order	Plant taxonomical order
<b>Plant categorical information</b>	
growthForm	Plant growth form (i.e., fern, graminoid, herb, herb/shrub, shrub, shrub/tree, subshrub or tree)
photosyntheticPathway	Plant photosynthetic pathway (i.e., C3, C3/C4, C3/CAM, C4, C4/CAM, or CAM)
woodiness	Plant woodiness (i.e., non-woody, non-woody/woody, or woody)
mycorrhizalAssociationType	Mycorrhizal type from the original source (i.e., arbuscular (AM), ectomycorrhizal (EcM), ericoid (ErM), non-mycorrhizal (NM), orchid, EcM – AM, or NM – AM)
mycorrhizalAssociationTypeFungal Root	Standardized mycorrhizal types based on the FungalRoot Database (i.e., arbuscular (AM), ectomycorrhizal (EcM), ericoid (ErM), non-mycorrhizal (NM), orchid (OM), EcM – AM, NM – AM, NM – Am rarely EcM, species-specific: AM or rarely EcM-AM or AM, or uncertain.
nitrogenFixationNodDB	Nitrogen fixation capacity based on the NodDB (i.e., Rhizobia, Frankia, none, present, likely present, unlikely rhizobia, Nostocaceae, likely rhizobia)
abilityToGrownClonallyCloPla	The potential of a plant to produce physically independent rooting units from one genetic individual, i.e., present or absent
budBearingOrganCloPla	Belowground organ bearing reserve of dormant meristems (bud bank) that may be used for regeneration after seasonal

adversity or damage, i.e., horizontal stem, turions, stem fragments, budding, epigeogenous rhizome, hypogeogenous rhizome, stem tuber, bulb, root sprouting, or root tuber.

<b><i>Root information</i></b>	
vitality	Measured roots were living, dead, both or unspecified
<b><i>Experimental conditions</i></b>	
measurementProvenance	Data derived from experimental studies (either potted or hydroponic experiments) and field studies (i.e., natural conditions and plot and common garden experiments)
measurementTreatments	Treatments
measurementMethod	Method used for collecting the roots
year	Year in which roots were collected
yearBegin	Year in which the collection started
yearEnd	Year in which the collection finished
ageStand	Time since the established of the stand
agePlant	Age of the plant in years
<b><i>Geographic, climatic and biomes</i></b>	
locationID	Site ID provided by study
location	Location provided by the study
decimalLatitude	Latitude of the study
decimalLongitude	Longitude of the study
climaticInformation	Climate provided by the study
biomesKoeppen	Biomes classification based on the Koeppen Geiger classification
biomesKoeppenGroups	Biomes classification based on the Koeppen Geiger classification as main groups, i.e., arid, continental, polar, temperate or tropical.
temperatureColdestMonth	Temperature coldest month provided by the study
temperatureWarmestMonth	Temperature warmest month provided by the study
meanAnnualTemperature	Mean annual temperature provided by the study
meanAnnualPrecipitation	Mean annual precipitation provided by the study
elevation	Elevation provided by the study
slope	Slope provided by the study
<b><i>Soil conditions</i></b>	
soilpH	Soil pH measured in water provided by the study
soilTexture	Soil texture provided by the study
soilCarbon	Soil carbon concentration provided by the study
soilNitrogen	Soil nitrogen concentration provided by the study
soilPhosphorus	Soil phosphorus concentration provided by the study
soilCarbonToNitrogen	Soil carbon to nitrogen ration provided by the study
soilBaseCationSaturation	Soil base cation saturation provided by the study
soilCationExchangeCapacity	Soil cation exchange capacity provided by the study
soilOrganicMatter	Soil organic matter content provided by the study
soilWaterGravimetric	Soil water (gravimetric) provided by the study
soilWaterVolumetric	Soil water (volumetric) provided by the study

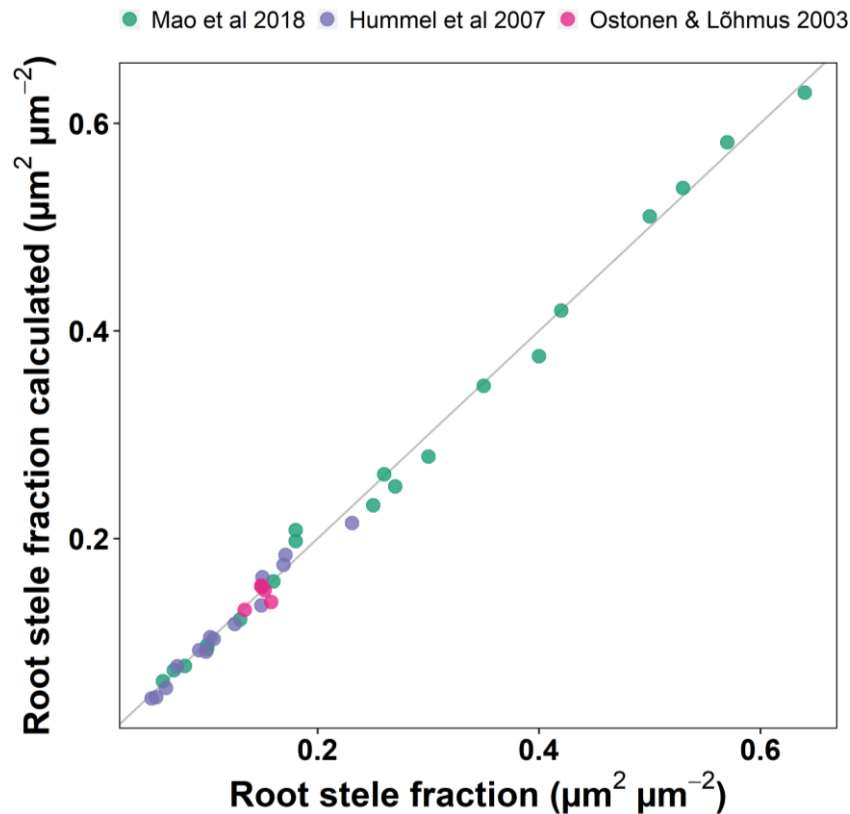
### Standardization across traits

Root mass fraction (RMF) was calculated from data of root-to-shoot biomass ratio (R:S) by:

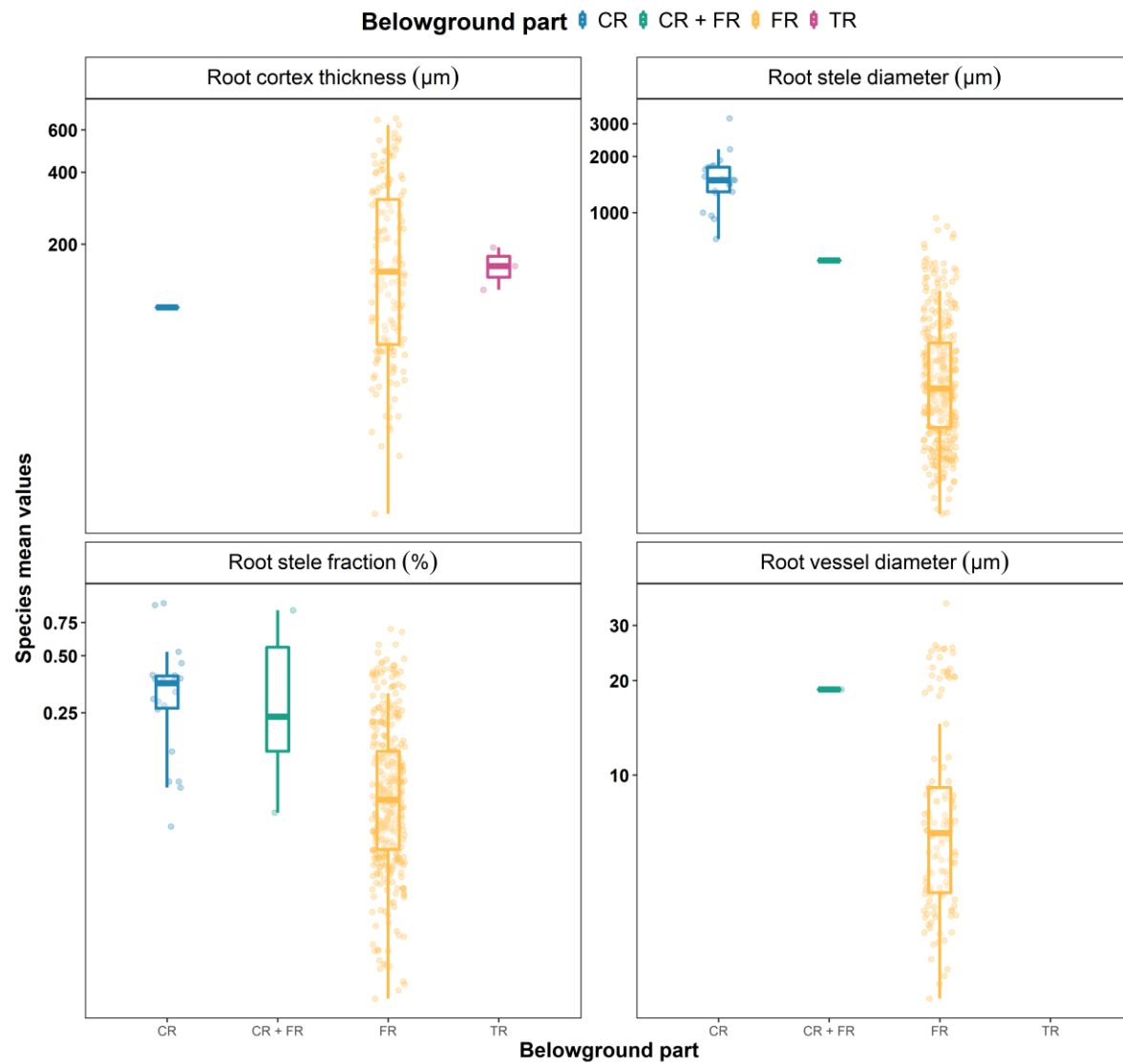
$$\text{RMF} = \text{R:S} / (1 + \text{R:S})$$

Root stele fraction was calculated using information on root stele diameter and root diameter.

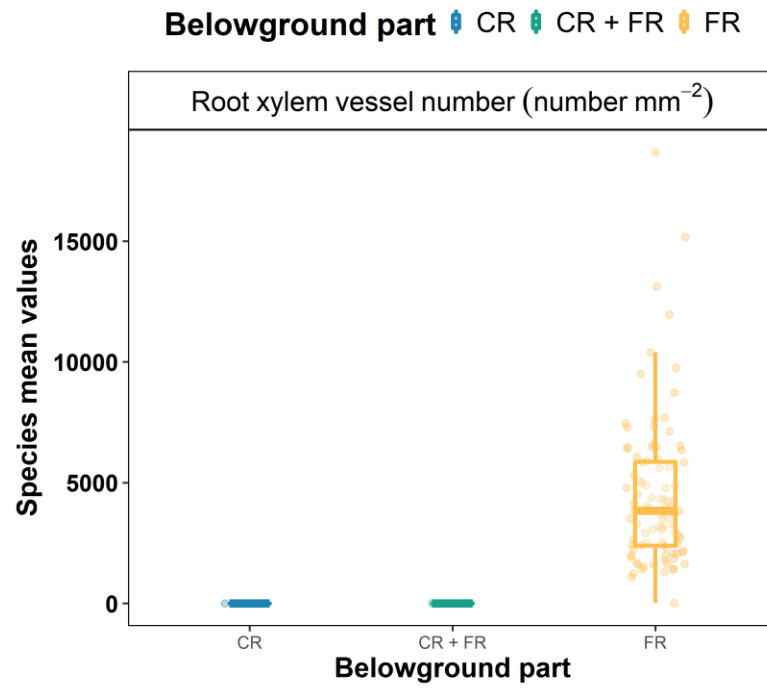
Data from papers reporting stele fraction, stele diameter and root diameter were used to compare between stele fraction measured directly and calculated values (Fig S1)



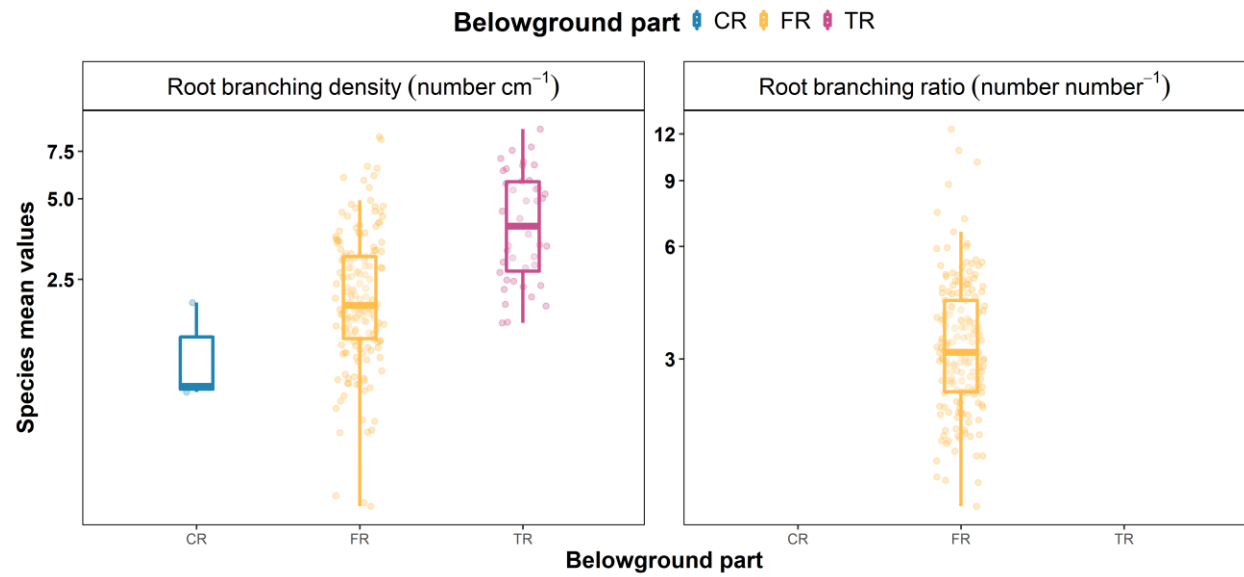
**Figure S1.** Comparison between root stele fraction reported (based on cross sectional area directly measured; x axis) and the calculated root stele fraction (y axis), determined by calculating cross sectional area of stele and root based on stele and root diameter, respectively. Points show studies in the database, that have data for both, area and diameter. The gray line has an intercept of 0 and a slope of 1. Results from a standardized major axis estimation show a positive relationship between the calculated and measured root stele fractions ( $R^2: 0.99$ ,  $p\text{-value } 2.22e^{-16}$ ).



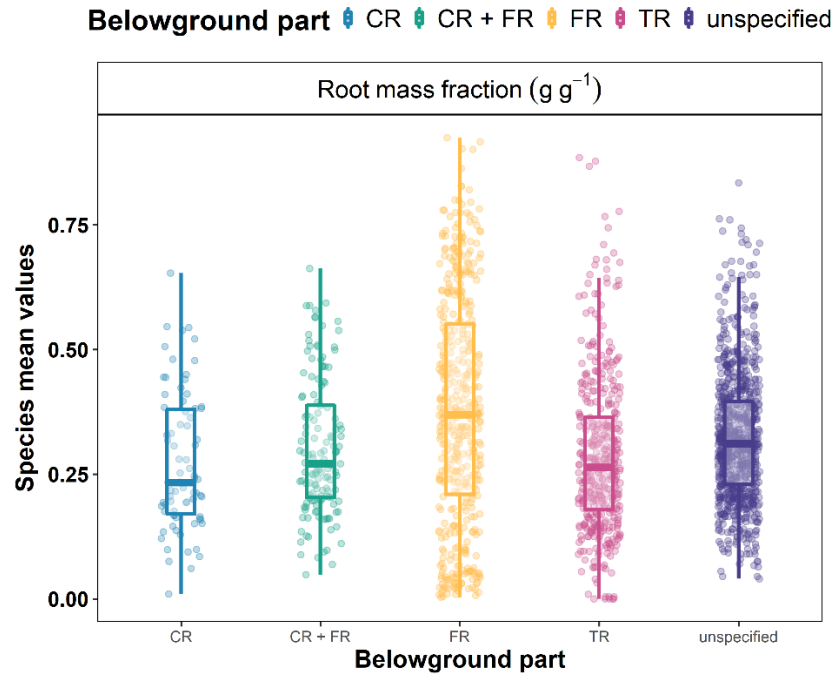
**Figure S2.** Density plots for anatomical traits. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR).



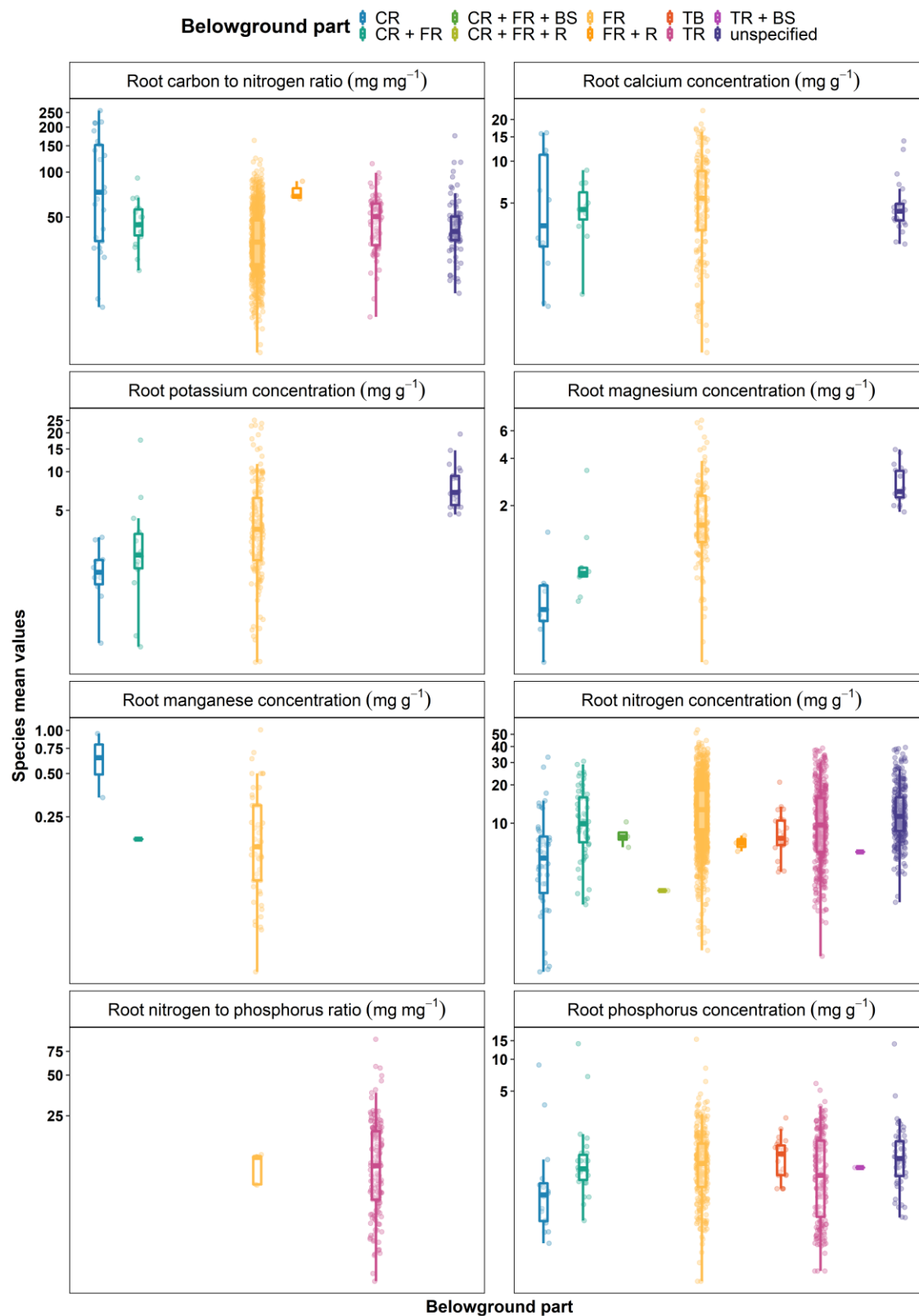
**Figure S3.** Density plots for root xylem vessel number. Points represent species mean values. Data from coarse (CR) and fine roots (FR).



**Figure S4.** Density plots for architectural traits. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR).

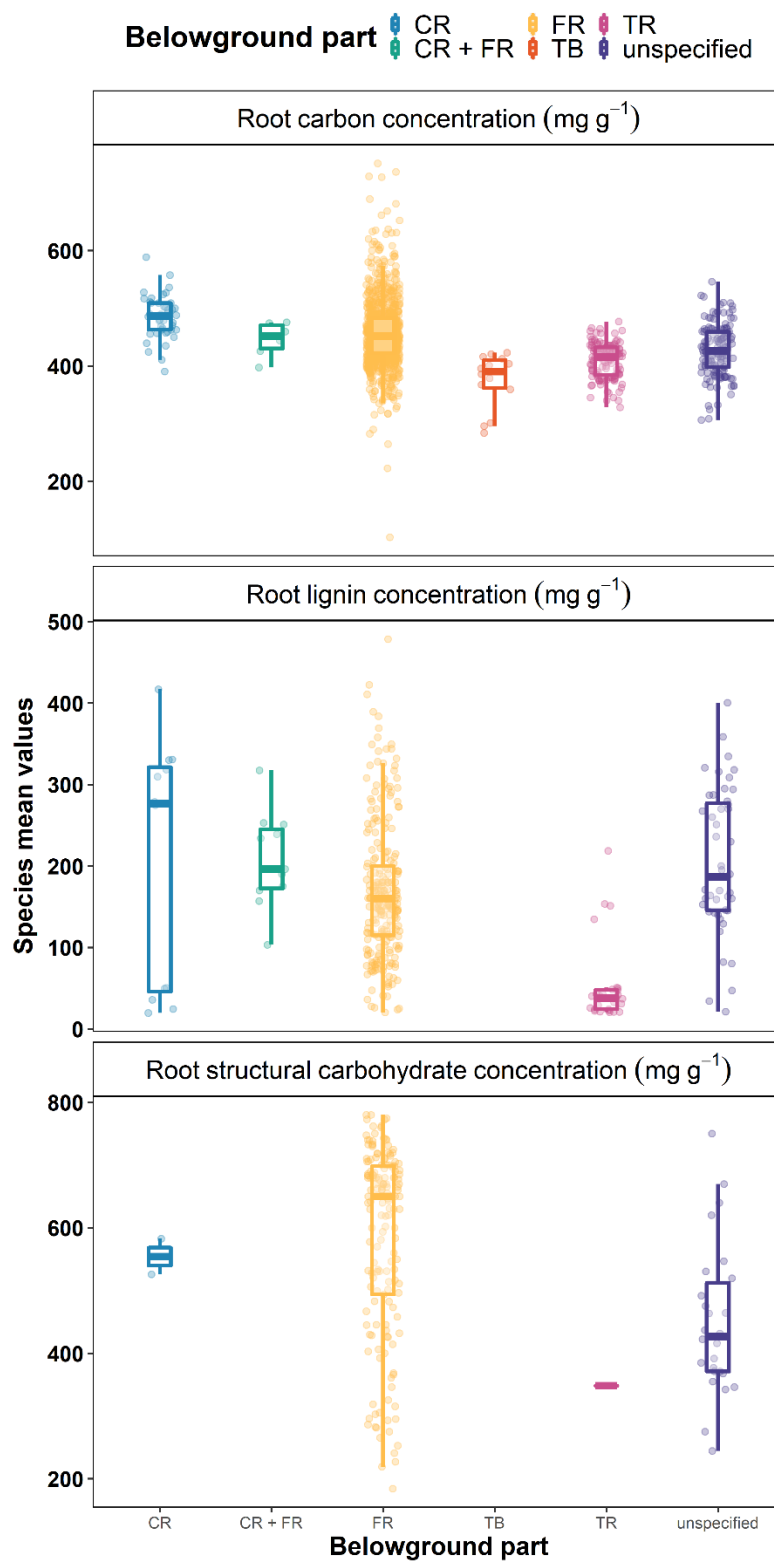


**Figure S5.** Density plots for root mass fraction. Points represent species mean values. Data from coarse (CR), fine (FR) and total roots (TR) or unspecified.

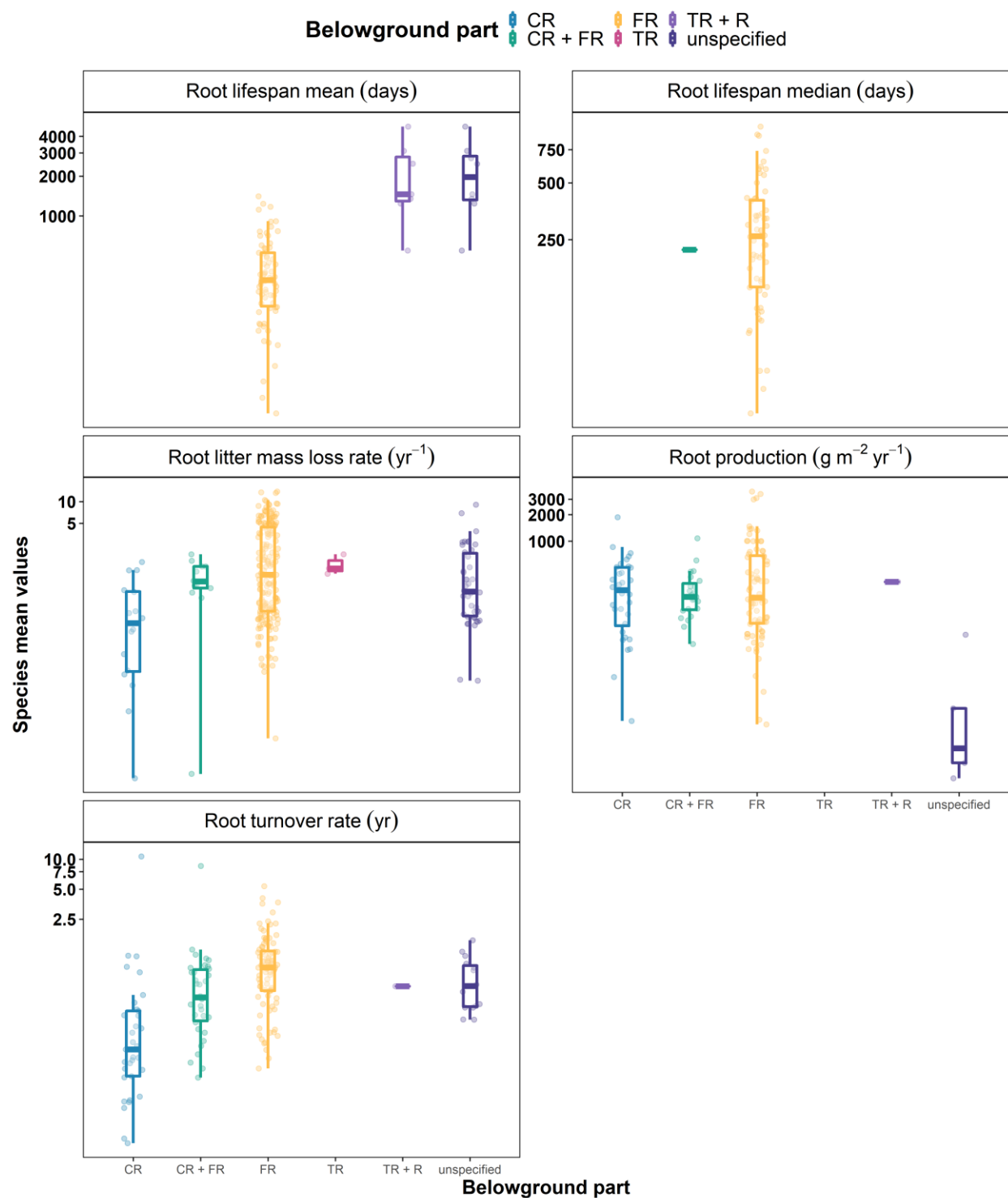


**Figure S6.** Density plots for chemical traits. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR), belowground stem (BS), rhizomes (R), total belowground (TB) or unspecified.

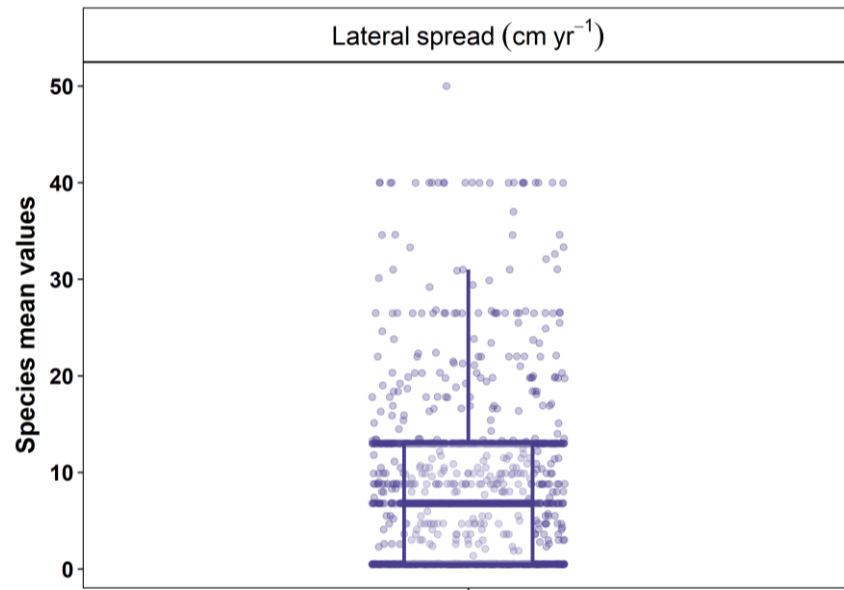




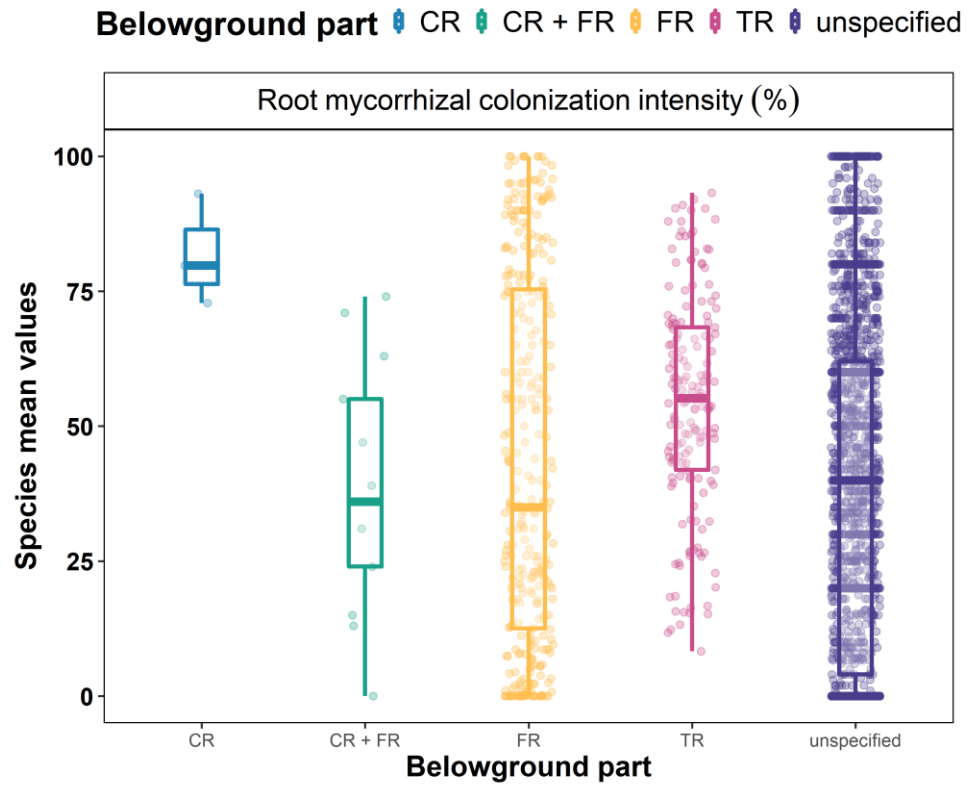
**Figure S7.** Density plots for chemical traits. Points represent species mean values. Data from coarse (CR), fine (FR) and total roots (TR), total belowground (TB) or unspecified.



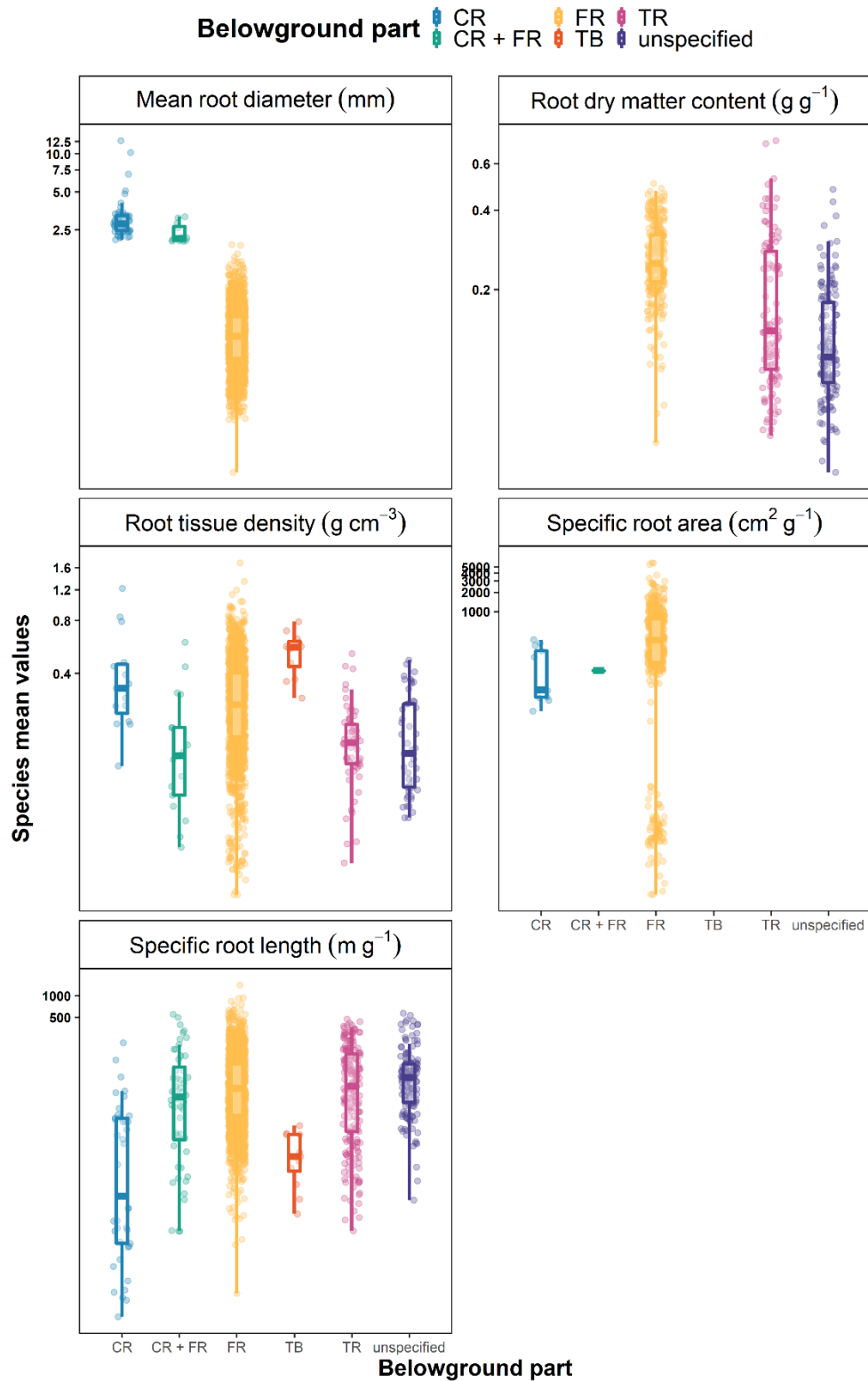
**Figure S8.** Density plots for dynamics and decomposition. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR), rhizomes (R), or unspecified.



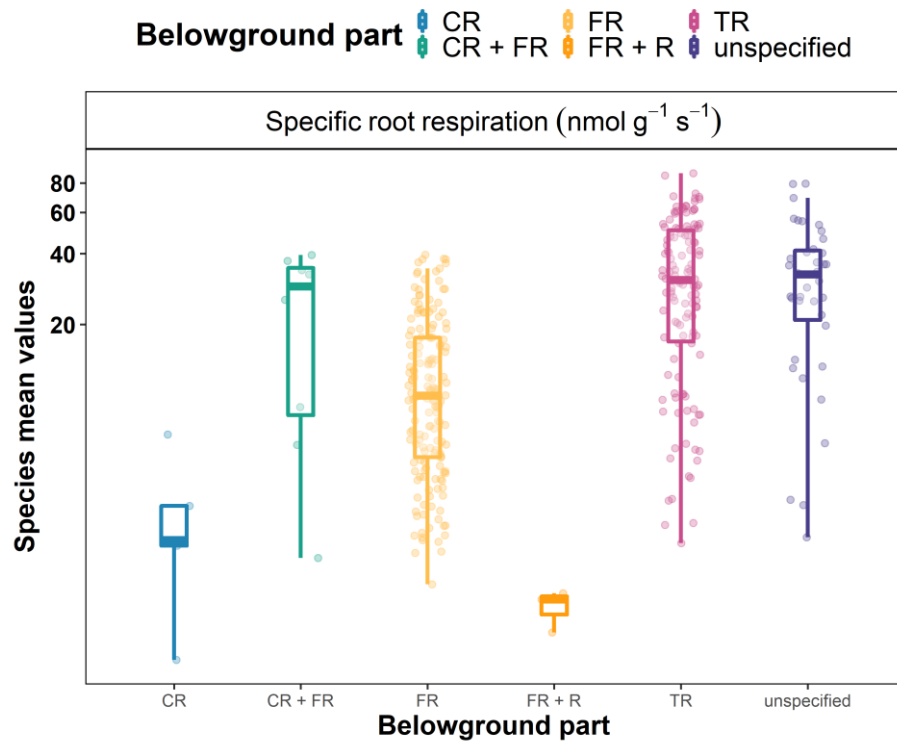
**Figure S9.** Density plots for lateral spread. Points represent species mean values. Distances are estimated within categories, with mean values of their ranges.



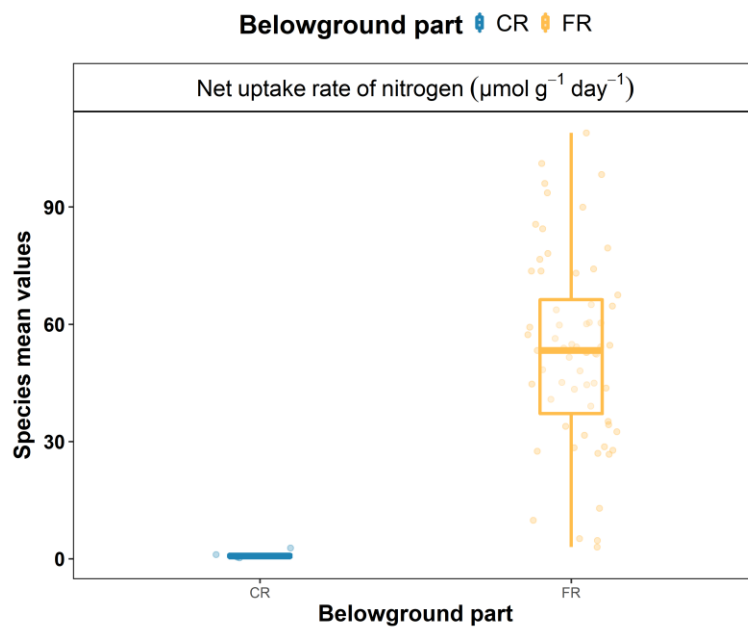
**Figure S10.** Density plots for root mycorrhizal colonization intensity. Points represent species mean values. Data from coarse (CR), fine (FR) and total roots (TR), or unspecified.



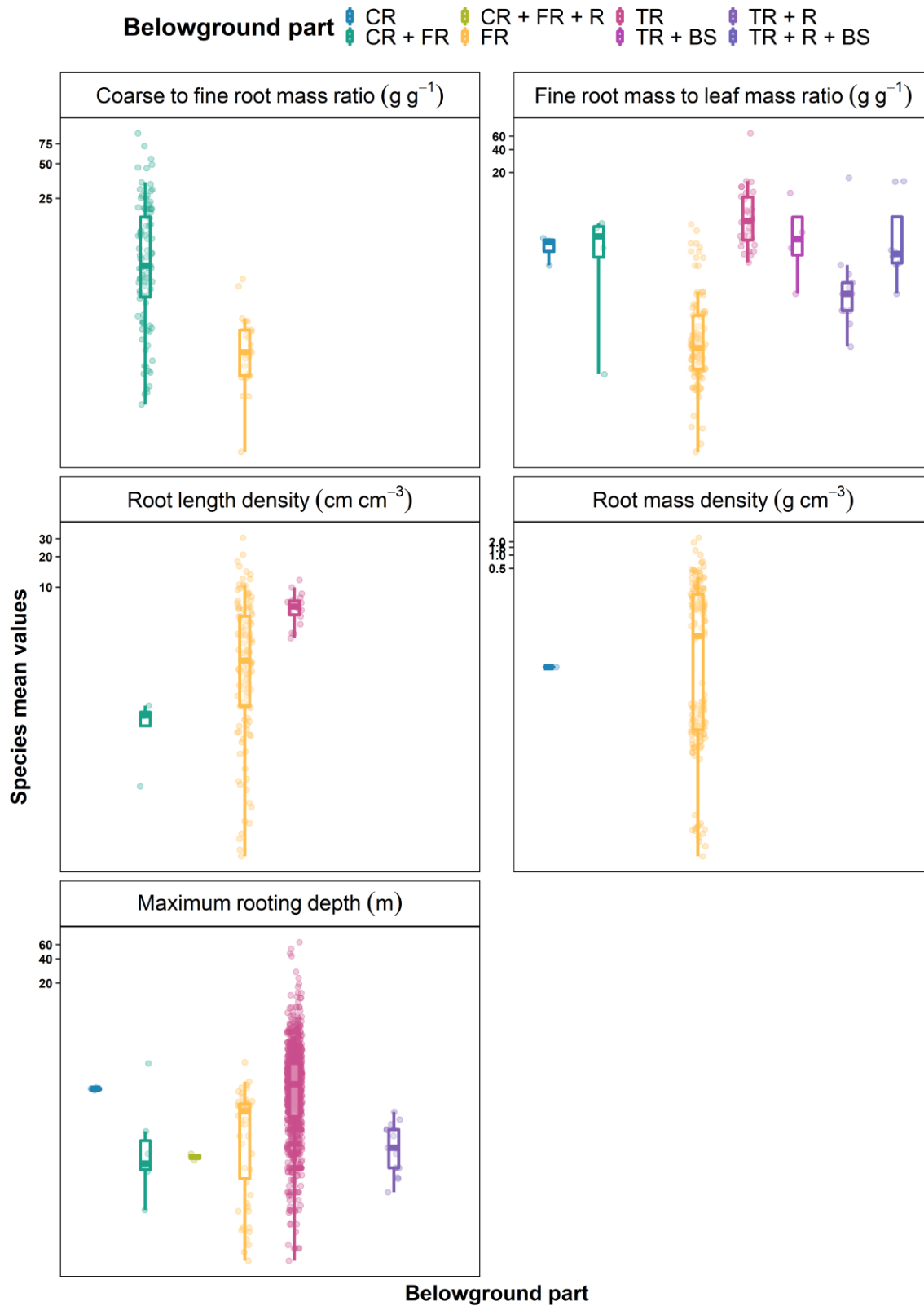
**Figure S11.** Density plots for morphological traits. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR), total belowground (TB) or unspecified.



**Figure S12.** Density plots for specific root respiration. Points represent species mean values. Data from coarse (CR), fine (FR) and total roots (TR), rhizomes (R) or unspecified.



**Figure S13.** Density plots for net uptake rate of nitrogen. Points represent species mean values. Data from coarse (CR) or fine roots (FR).



**Figure S14.** Density plots for system and distribution traits. Points represent species mean values. Axis “y” is logarithmic base 2. Data from coarse (CR), fine (FR) and total roots (TR), belowground steam (BS), and rhizomes (R).



## References

- Freschet, G.T., Pagès, L., Iversen, C.M., Comas, L.H., Rewald, B., Roumet, C., Klimešová, J., Zadworny, M., Poorter, H., Postma, J.A., Adams, T.S., Bagniewska-Zadworna, A., Blancaflor, E.B., Brunner, I., Cornelissen, J.H.C., Garnier, E., Gessler, A., Hobbie, S.E., Lambers, H., Meier, I.C., Mommer, L., Picon-Cochard, C., Rose, L., Ryser, P., Scherer-Lorenzen, M., Soudzilovskaia, N.A., Stokes, A., Sun, T., Valverde-Barrantes, O.J., Weemstra, M., Weigelt, A., Wurzbürger, N., York, L.M., Batterman, S.A., Bengough, A.G., Gomes de Moraes, M., Janeček, Š., Salmon, V., Tharayil, N. & McCormack, M.L. (2020) A starting guide to root ecology: strengthening ecological concepts and standardizing root classification, sampling, processing and trait measurements. *HAL hal-02918834*.
- Iversen, C., Powell, A., McCormack, M., Blackwood, C., Freschet, G., Kattge, J., Roumet, C., Stover, D., Soudzilovskaia, N., Valverde-Barrantes, O., Van Bodegom, P. & Violle, C. (2018) *Fine-Root Ecology Database (FRED): A global collection of root trait data with coincident site, vegetation, edaphic, and climatic data, Version 2*, Oak Ridge National Laboratory, TES SFA, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A.
- Klimešová, J. & Bello, F.D. (2009) CLO-PLA: the database of clonal and bud bank traits of Central European flora. *Journal of Vegetation Science*, **20**, 511–516.
- Klimešová, J., Danihelka, J., Chrtěk, J., Bello, F. de & Herben, T. (2017) CLO-PLA: a database of clonal and bud-bank traits of the Central European flora. *Ecology*, **98**, 1179–1179.
- Klimešová, J., Martínková, J., Pausas, J.G., de Moraes, M.G., Herben, T., Yu, F.-H., Puntieri, J., Vesk, P.A., de Bello, F., Janeček, Š., Altman, J., Appezzato-da-Glória, B., Bartušková, A., Crivellaro, A., Doležal, J., Ott, J.P., Paula, S., Schnablová, R., Schweingruber, F.H. & Ottaviani, G. (2019) Handbook of standardized protocols for collecting plant modularity traits. *Perspectives in Plant Ecology, Evolution and Systematics*, **40**, 125485.
- McCormack, M.L., Guo, D., Iversen, C.M., Chen, W., Eissenstat, D.M., Fernandez, C.W., Li, L., Ma, C., Ma, Z., Poorter, H., Reich, P.B., Zadworny, M. & Zanne, A. (2017) Building a better foundation: improving root-trait measurements to understand and model plant and ecosystem processes. *New Phytologist*, **215**, 27–37.