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Supplementary Materials for

The fungal collaboration gradient dominates the root economics space in plants

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Supplementary Material

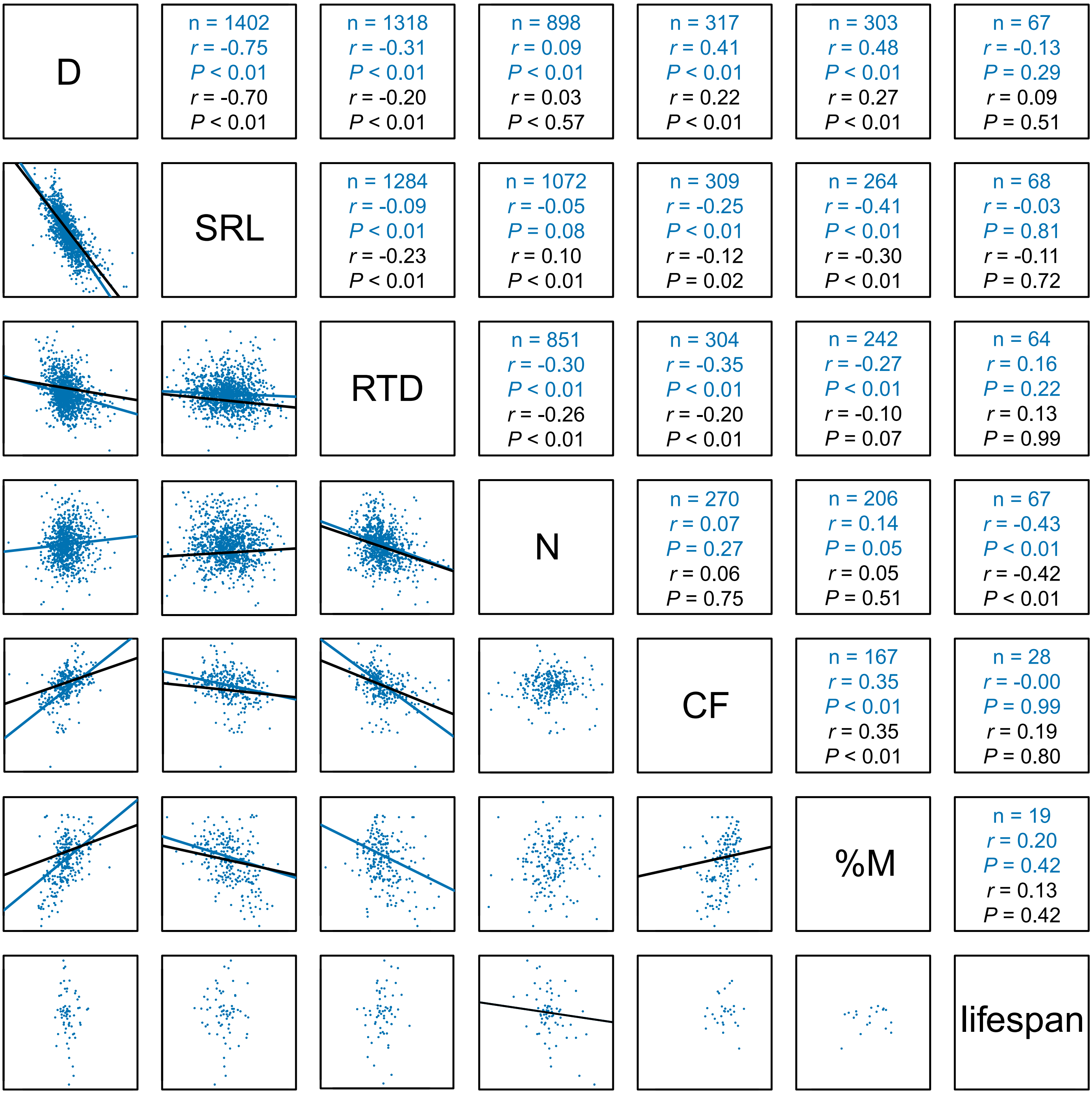

Fig. S1. Pairwise correlation of all traits used in the analysis. Scatterplots represent species mean trait correlations after correction for study design and publication. D – average root diameter, SRL – specific root length, RTD – root tissue density, N – root nitrogen content, CF – root cortex fraction, %M – arbuscular mycorrrhizal colonization intensity, lifespan – mean root lifespan. Regression lines represent significant correlations (blue) and significant phylogenetically corrected bivariate relationships calculated by fitting Phylogenetic Generalized Least Square models (black). Correlation coefficients are presented for the data without (blue) and with phylogenetic correction (black). Note that for the pairwise correlation of CF~%M as well as N~lifespan the two regression lines are too close to be distinguishable by eye.

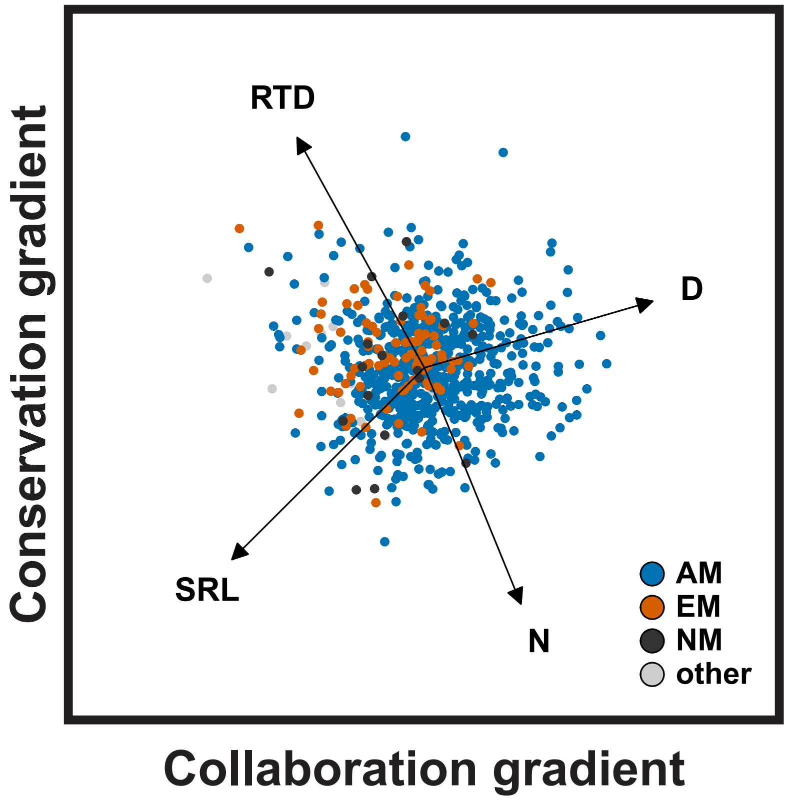

Fig. S2. The root economics space without phylogenetic correction. The general pattern of the root economics space showing the collaboration gradient and the conservation gradient can also be detected in a non-phylogenetically corrected principal component analysis. D – average root diameter, SRL – specific root length, RTD – root tissue density and N – root nitrogen content. Principal component analysis of the core species set (n=748). See Table S1 for the principal component analysis.

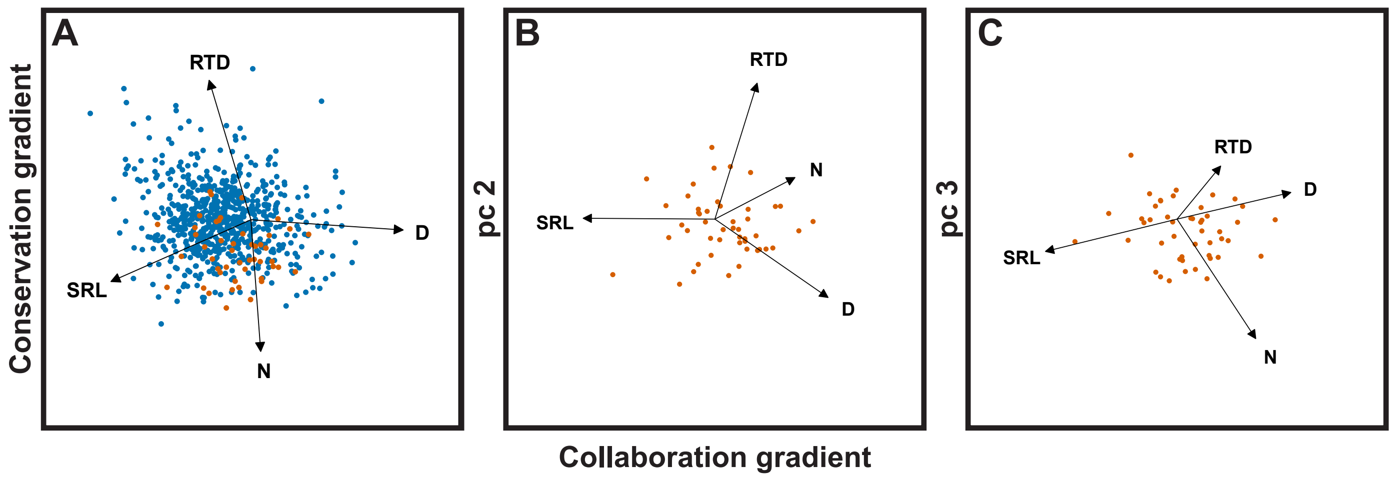

Fig. S3. The collaboration gradient represents the main axis in the root economics space of plants associated with nitrogen fixing bacteria. D – average root diameter, SRL – specific root length, RTD – root tissue density and N – root nitrogen content. Phylogenetically informed principal component analysis of the core species set (n=748) with plants associated with N-fixing bacteria highlighted in red (**A**). N-fixers differed from the rest by being located on the "fast" side of the conservation gradient associated with high root nitrogen content (table S4). Within the N-fixing subset the collaboration gradient appeared to be the first axis while the conservation gradient loaded on principal component 2 and 3 (**B, C**). See Table S1 for the principal component analysis.

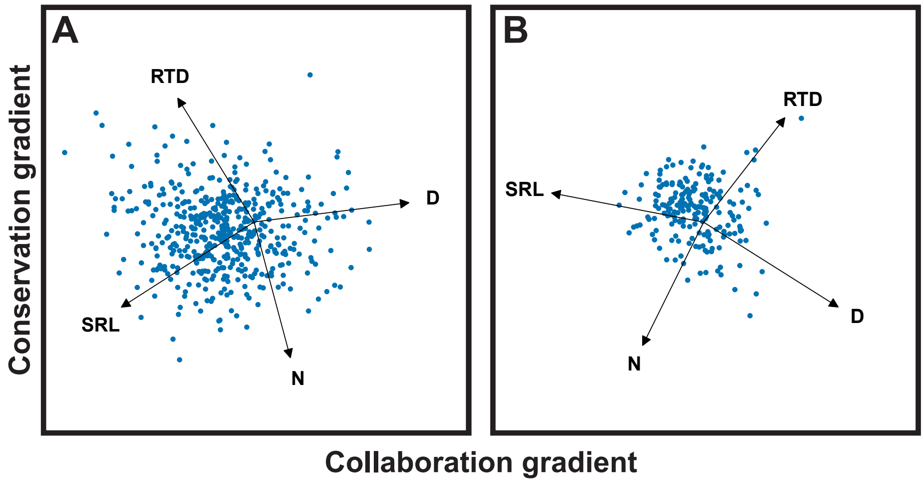

Fig. S4. The root economics space is present in different growth forms. D – average root diameter, SRL – specific root length, RTD – root tissue density and N – root nitrogen content. Root traits and trait relations are known to vary among plant growth forms (*11*, *28*, *62*). We found no respective between group variation within the root economics space (table S4). Still, to test whether the concept is broadly generalizable, we present separate PCAs for woody (**A**) and non-woody (**B**) species. We found that the root economics space was apparent within both plant growth forms. See table S1 for principal component analysis.

Table S1. The root economics space can be detected irrespective of mycorrhizal association, N-fixing ability, biome or growth form. Analysis of the core species set with full information for the four core traits. Presented here is a principal component analyses of the global species set based on raw data as shown in fig S2 and phylogenetically informed principal component analyses of the global species set as well as different species subsets as shown in Fig. 2A, B and C, fig S2, 3 and 4. Displayed is the Eigenvalue as well as the proportion of variance explained by each principal component (PC) and the loadings of the root traits. D – average root diameter, SRL – specific root length, RTD – root tissue density and N – root nitrogen content.

		PC1	PC2	PC3	PC4
Global species (raw) n=748 fig. S2	Eigenvalue	1.408	1.078	0.863	0.335
	Variance	0.496	0.291	0.186	0.028
	D	0.673	-0.171	0.125	0.709
	SRL	-0.569	0.496	0.194	0.626
	RTD	-0.376	-0.594	-0.632	0.325
	N	0.285	0.610	-0.740	0.006
Global species n=748 Fig. 2A	Eigenvalue	1.332	1.143	0.878	0.387
	Variance	0.443	0.327	0.193	0.037
	D	0.960	0.058	0.067	0.266
	SRL	-0.882	0.351	0.187	0.251
	RTD	-0.263	-0.791	-0.538	0.127
	N	0.062	0.744	-0.665	-0.005
AM n=621 Fig. 2B	Eigenvalue	1.324	1.144	0.890	0.384
	Variance	0.438	0.327	0.198	0.037
	D	0.945	0.191	-0.055	-0.260
	SRL	-0.916	0.254	-0.184	-0.252
	RTD	-0.126	-0.829	0.530	-0.128
	N	-0.073	0.722	0.688	0.011
EM n=94 Fig. 2C	Eigenvalue	1.376	1.105	0.869	0.360
	Variance	0.474	0.305	0.189	0.033
	D	0.946	0.169	-0.117	0.251
	SRL	-0.807	-0.465	-0.291	0.218
	RTD	-0.532	0.648	0.529	0.133
	N	0.255	-0.746	0.614	0.037
N-fixers n=47 fig. S2	Eigenvalue	1.409	1.055	0.889	0.333
	Variance	0.496	0.278	0.198	0.028
	D	0.817	0.510	-0.172	-0.209
	SRL	-0.949	-0.006	0.210	-0.233
	RTD	0.305	-0.885	-0.334	-0.110
	N	0.569	-0.266	0.779	-0.031
Temperate n=329 Fig. 3A	Eigenvalue	1.409	1.082	0.831	0.382
	Variance	0.497	0.293	0.173	0.038
	D	0.943	-0.175	0.003	-0.282
	SRL	-0.802	0.503	-0.210	-0.245
	RTD	-0.592	-0.543	0.586	-0.106
	N	0.320	0.771	0.551	0.021
Tropical n=81 Fig. 3B	Eigenvalue	1.342	1.189	0.830	0.211
	Variance	0.450	0.353	0.172	0.024
	D	0.970	-0.077	0.092	0.211
	SRL	-0.765	0.575	0.223	0.189
	RTD	-0.437	-0.730	-0.477	0.128
	N	0.228	0.738	-0.635	0.001

Arid n=10 Fig. 3C	Eigenvalue	1.431	1.120	0.752	0.365
	Variance	0.512	0.314	0.141	0.033
	D	0.932	0.109	0.241	0.248
	SRL	-0.946	0.115	-0.154	0.261
	RTD	0.366	-0.796	-0.478	0.057
	N	0.387	0.772	-0.505	-0.015
Continental n=91 Fig. 3D/E	Eigenvalue	1.317	1.056	0.973	0.450
	Variance	0.434	0.279	0.237	0.051
	D	0.923	-0.170	0.164	-0.303
	SRL	-0.915	-0.263	-0.043	-0.303
	RTD	0.022	0.887	-0.442	-0.134
	N	-0.214	0.481	0.850	-0.026
Woody n=498 fig. S3A	Eigenvalue	1.365	1.127	0.854	0.370
	Variance	0.466	0.318	0.182	0.034
	D	0.958	-0.107	-0.064	-0.260
	SRL	-0.822	0.473	-0.216	-0.233
	RTD	-0.471	-0.686	0.541	-0.122
	N	0.224	0.751	0.621	-0.002
Non-woody n=207 fig. S3B	Eigenvalue	1.390	1.009	0.922	0.448
	Variance	0.483	0.254	0.213	0.050
	D	0.825	0.464	-0.148	0.287
	SRL	-0.931	-0.160	-0.043	0.324
	RTD	0.495	-0.569	0.646	0.113
	N	-0.372	0.672	0.640	-0.026

Table S2. Principal component analysis based on phylogenetically corrected bivariate relationships of all trait pairs. Displayed are the standard deviation (SD) and the loadings of the root traits for each principal component (PC) which were used to create Fig 2E. D – average root diameter, SRL – specific root length, RTD – root tissue density, N – root nitrogen content, CF – root cortex fraction, %M – arbuscular mycorrhizal colonization intensity, lifespan – mean root lifespan.

	PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
SD	1.423	1.244	1.097	0.946	0.799	0.710	0.433
D	0.590	0.006	0.152	0.446	0.112	0.088	0.640
SRL	-0.556	0.226	-0.397	-0.113	-0.034	0.134	0.671
RTD	-0.097	-0.487	0.498	-0.510	0.076	-0.329	0.363
N	-0.037	0.650	0.257	0.077	-0.194	-0.682	0.042
CF	0.364	0.188	-0.432	-0.434	0.635	-0.243	-0.012
%M	0.447	0.085	-0.196	-0.491	-0.700	0.132	0.080
lifespan	0.015	-0.496	-0.529	0.306	-0.224	-0.574	0.021

Table S3. All traits show strong phylogenetic signal. Displayed is Pagel´s lambda of all traits within the entire dataset as well as of the two proposed root economics gradients within the core 748 species. D – average root diameter, SRL – specific root length, RTD – root tissue density, N – root nitrogen content, CF – root cortex fraction, %M – arbuscular mycorrhizal colonization intensity, lifespan – mean root lifespan.

	Lambda	P
SRL	0.620	< 0.0001
D	0.752	< 0.0001
N	0.558	< 0.0001
RTD	0.490	< 0.0001
CF	0.432	< 0.0001
%M	0.614	< 0.0001
lifespan	0.391	0.0005
Collaboration gradient	0.799	< 0.0001
Conservation gradient	0.491	< 0.0001

Table S4. Permutational multivariate analysis on 748 species displaying variation between mycorrhizal types, biomes, plant growth form and nitrogen (N) fixing capacity. AM - arbuscular mycorrhizal (n=621), EM – ectomycorrhizal (n=94), NM – non mycorrhizal (n=17), ErM – ericoid mycorrhizal (n=13), AM+EM (n=3).

Pairs	Sums of squares	*F*	R^2	*P*
AM vs EM	17873.91	25.94	0.035	**0.003**
AM vs NM	4247.95	5.86	0.009	**0.025**
EM vs AM+EM	112677	2.37	0.024	0.153
NM vs AM+EM	483.82	0.59	0.032	0.556
AM vs AM+EM	1494.89	2.08	0.003	0.171
EM vs NM	529.81	0.99	0.009	0.448
AM vs ErM	15943.58	22.07	0.034	**0.003**
EM vs ErM	5096.54	9.90	0.086	**0.003**
NM vs ErM	2892.91	3.45	0.110	0.096
AM+EM vs ErM	1658.14	2.32	0.142	0.171
Temperate vs tropical	1470.99	1.73	0.004	0.351
Temperate vs arid	344.433	0.43	0.001	0.697
Tropical vs continental	2015.41	2.89	0.017	0.351
Tropical vs arid	102.73	0.11	0.001	0.907
Temperate vs continental	963.34	1.33	0.003	0.351
Arid vs continental	756.13	1.76	0.018	0.351
Woody vs non-woody	3431.28	4.73	0.007	**0.011**
N-fixing vs non-fixing	12843.62	17.77	0.023	**0.001**

Table S5. Mean and kurtosis values of four fine root functional traits for multiple clades in the Spermatophytes. Values are standardized to represent deviation from the mean of each trait, so negative and positive values indicate clade relative mean deviation from the mean value for the entire phylogeny (1,810 species). Bold values represent clades that had mean or kurtosis values different (95% confidence interval) from the overall values for the entire phylogeny. Positive kurtosis values indicate underdispersion of values in the clade, whereas negative values represent overdispersion. 'n' indicates the number of species per clade and 'se' the standard error of the mean. Phylogenetic patterns in root trait distribution confirm the previous observations that ancestry explains a remarkable amount of variation in seed plants and contrasting trait patterns among numerous clades. For instance, our study confirms the relative large root diameter (D) prevalent in the Magnoliids and Gymnosperms compared to other seed plant groups (*62*). Magnoliids also showed lower root tissue density (RTD) and Magnoliales higher root nitrogen content (N) than other seed plants, highlighting the particular set of traits in this group. On the other hand, Caryophyllales and Myrtales showed smaller D, higher specific root length (SRL) and RTD than other clades. Monocots and Poales showed high SRL and low N compared to other plants. The clade of Fagales and Fabales also showed higher RTD and N than most clades, possibly showing the ubiquitous association of these species with N-fixing bacteria and the dominance of woody species (*29*, *63*). Most of the Lamiidae clades showed low RTD values indicating the dominance of non-woody plants in these clades. Patterns in the evenness of the distribution among clades were also interesting. Campanuliids showed a remarkable conservatism in D, whereas Fabales and Fagales showed tight variation in N content. RTD was particularly low in Magnoliid and Lamiales, contrasting with the high values registered among Myrtales, Fagales and Rosales (*28*).

				Diameter				
Clade	n	mean	se	05% CI	95% CI	kurtosis	05% CI	95% CI
Spermatophyta	1524	-0.008	0.013	3.307	-0.030	0.020	-1.270	1.320
Gymnosperms	65	**0.150**	**0.052**	**3.790**	**0.030**	0.280	-4.191	4.110
Pinales	31	0.051	0.044	0.130	-0.130	0.240	-6.570	1.020
Cupressales	31	**0.267**	**0.074**	**1.415**	**0.090**	**0.450**	-5.190	2.290
Angiosperms	1459	-0.022	0.016	3.108	-0.040	0.020	-1.620	1.300
Magnoliids	88	**0.649**	**0.049**	**-0.333**	**0.550**	**0.760**	**8.210**	**0.240**
Laurales	46	0.606	0.080	-0.605	0.460	0.760	8.061	0.000
Lauraceae	45	0.600	0.082	-0.615	0.450	0.750	8.311	-0.020
Magnoliales	41	0.690	0.055	-0.534	0.530	**0.850**	**7.980**	**0.160**
Magnoliaceae	34	0.691	0.052	-0.580	0.520	**0.870**	**7.500**	**0.240**
Monocots	285	0.005	0.028	4.548	-0.050	0.070	-1.570	3.740
Poales	129	-0.078	0.040	6.116	-0.160	0.020	-1.270	5.910
Poaceae	78	**-0.207**	**0.028**	**1.126**	**-0.320**	**-0.090**	-6.850	1.280
Basal Eudicots	31	0.046	0.065	0.640	-0.140	0.230	-6.040	1.520
Eudicots	1083	-0.076	0.015	4.435	-0.100	0.040	-0.360	2.680
Rosids + Saxifragales	568	**-0.152**	**0.022**	**4.312**	**-0.190**	**-0.100**	-1.000	3.020
Rosids	553	**-0.153**	**0.022**	**4.354**	**-0.190**	**-0.100**	-0.980	3.070
Fabids	372	**-0.142**	**0.024**	**2.401**	**-0.190**	**-0.080**	-3.371	1.380
Fagales + Fabales	296	**-0.100**	**0.028**	**2.997**	**-0.150**	**-0.030**	-3.021	2.140
Fagales	177	**-0.252**	**0.034**	**4.335**	**-0.320**	**-0.170**	-2.460	3.910
Rosales	94	**-0.204**	**0.051**	**5.594**	**-0.310**	**-0.100**	-2.311	5.650
Rosaceae	62	**-0.203**	**0.061**	**9.087**	**-0.330**	**-0.070**	1.220	9.450
Fagales	83	**-0.306**	**0.043**	**0.570**	**-0.410**	**-0.190**	-7.321	0.680
Fagaceae	78	**-0.327**	**0.043**	**0.625**	**-0.440**	**-0.210**	-7.250	0.790
Fabaceae	119	**0.126**	**0.038**	**1.255**	**0.040**	0.230	-6.281	1.090
Malpighiales	74	-0.305	0.049	-0.018	-0.420	-0.180	-7.840	0.200
Malvids	177	-0.182	0.046	5.132	-0.250	-0.100	-1.630	4.660
Sapindales	68	-0.124	0.081	4.062	-0.240	0.000	-3.950	4.340
Malvales	41	0.034	0.106	4.231	-0.120	0.200	-3.511	4.900
Myrtales	42	-0.467	0.065	-0.884	-0.620	-0.310	-8.161	-0.240

Myrtaceae	31	-0.550	0.076	-0.874	-0.730	-0.370	-7.651	0.020
Caryophyllales + Asterids	484	0.005	0.021	5.207	-0.030	0.060	-0.300	4.030
Caryophyllales	34	**-0.208**	**0.050**	**-0.885**	**-0.380**	-0.030	-8.102	-0.050
Asterids	447	0.020	0.023	5.176	-0.020	0.070	-0.461	4.040
Campanuliids	**225**	**0.101**	**0.031**	**9.133**	**0.040**	**0.170**	**2.720**	**8.520**
Asterales	**176**	**0.086**	**0.033**	**12.915**	**0.010**	**0.170**	**6.060**	**12.460**
Asteraceae	**172**	**0.098**	**0.033**	**13.292**	**0.020**	**0.180**	**6.260**	**12.860**
Apiales	31	0.120	0.104	1.459	-0.060	0.300	-5.200	2.350
Lamiids	143	-0.025	0.034	1.118	-0.110	0.070	-6.030	0.860
Lamiales	66	**-0.006**	**0.036**	**-0.352**	**-0.130**	**0.120**	**-8.250**	**-0.050**
Gentianales	44	-0.096	0.085	0.005	-0.250	0.060	-7.570	0.620
Ericales	67	-0.189	0.065	0.361	-0.310	-0.060	-7.731	0.671

Specific Root Length

Clade	n	mean	se	05% CI	95% CI	kurtosis	05% CI	95% CI
Spermatophyta	1636	0.013	0.012	0.173	-0.020	0.020	-0.210	0.210
Gymnosperms	68	-0.229	0.043	5.326	-0.360	-0.130	4.170	6.130
Pinales	34	-0.192	0.046	1.050	-0.360	-0.050	-0.370	2.150
Cupressales	31	**-0.300**	**0.056**	**-0.532**	**-0.480**	-0.140	-1.990	0.640
Angiosperms	1568	0.024	0.012	0.152	-0.010	0.040	-0.230	0.200
Magnoliids	88	**-0.424**	**0.031**	**-0.151**	**-0.540**	-0.340	-1.201	0.550
Laurales	46	**-0.434**	**0.045**	**-0.455**	**-0.580**	-0.310	-1.771	0.510
Lauraceae	43	**-0.424**	**0.048**	**-0.523**	**-0.580**	-0.300	-1.860	0.480
Magnoliales	41	-0.410	0.045	0.121	-0.570	-0.280	-1.260	1.150
Magnoliaceae	34	-0.415	0.043	0.107	-0.590	-0.260	-1.330	1.210
Monocots	215	**0.162**	**0.031**	**0.256**	**0.090**	0.210	-0.470	0.660
Poales	182	**0.209**	**0.032**	**0.425**	**0.130**	0.270	-0.350	0.880
Poaceae	152	**0.215**	**0.036**	**0.556**	**0.130**	0.280	-0.290	1.060
Basal Eudicots	34	**0.042**	**0.066**	**-0.462**	**-0.130**	0.190	-1.871	0.641
Rosids + Saxifragales	625	0.041	0.019	0.281	-0.010	0.070	-0.230	0.450
Rosids	416	0.008	0.023	0.107	-0.050	0.040	-0.460	0.350
Fabids	413	0.008	0.023	0.091	-0.050	0.040	-0.490	0.330
Rosales	103	0.106	0.046	-0.038	0.000	0.190	-1.010	0.600
Rosaceae	64	0.081	0.060	-0.450	-0.050	0.190	-1.640	0.390
Fagales	79	**0.128**	**0.040**	**1.638**	**0.010**	**0.220**	**0.550**	**2.380**
Fagaceae	51	0.080	0.045	3.147	-0.060	**0.200**	**0.178**	**4.070**
Fabales	143	**-0.242**	**0.036**	**-0.239**	**-0.330**	-0.180	-1.090	0.290
Fabaceae	142	**-0.246**	**0.036**	**-0.231**	**-0.340**	-0.180	-1.110	0.300
Malpighiales	60	0.205	0.054	-0.810	0.070	0.310	-2.070	0.050
Saxifragales + Rosids	194	**0.118**	**0.038**	**0.509**	**0.040**	0.170	-0.250	0.940
Malvids	179	**0.132**	**0.039**	**0.492**	**0.050**	0.190	-0.280	0.960
Sapindales	71	0.054	0.061	0.688	-0.070	0.150	-0.440	1.470
Sapindaceae	30	0.183	0.049	-0.597	0.010	0.340	-2.080	0.560
Malvales	42	**-0.078**	**0.080**	**-0.429**	**-0.230**	0.050	-1.801	0.580
Myrtales	46	0.279	0.057	1.086	0.130	0.410	-0.190	2.060
Myrtaceae	38	0.283	0.065	1.072	0.120	0.420	-0.370	2.120
Caryophyllales + Asterids	603	0.024	0.019	0.285	-0.030	0.050	-0.230	0.460
Asterids	533	0.017	0.020	0.325	-0.030	0.040	-0.210	0.530
Campanuliids	452	-0.002	0.021	0.251	-0.060	0.030	-0.300	0.490
Caryophyllales	70	**0.079**	**0.053**	**-0.051**	**-0.040**	0.180	-1.210	0.731
Asterales	293	-0.022	0.025	0.187	-0.090	0.020	-0.481	0.510
Asteraceae	217	-0.025	0.028	0.143	-0.100	0.030	-0.591	0.540
Apiales	35	**-0.093**	**0.075**	**-1.085**	**-0.260**	0.050	-2.490	0.010

Lamiids	159	0.034	0.040	0.124	-0.050	0.100	-0.720	0.620
Lamiales	106	-0.029	0.046	0.295	-0.130	0.050	-0.690	0.930
Lamiaceae	30	**0.023**	**0.074**	**-0.573**	**-0.160**	0.180	-2.060	0.600
Gentianales	46	0.176	0.075	-0.466	0.030	0.300	-1.790	0.510
Ericales + Cornales	81	**0.126**	**0.060**	**0.387**	**0.010**	0.210	-0.700	1.110
Ericales	68	0.194	0.057	-0.434	0.070	0.290	-1.560	0.361

Root Tissue Density

Clade	n	mean	se	05% CI	95% CI	kurtosis	05% CI	95% CI
Spermatophyta	1343	0.025	0.016	1.256	-0.030	0.030	-0.640	0.570
Gymnosperms	47	**0.148**	**0.095**	**-0.455**	**-0.050**	0.291	-4.380	0.310
Pinales	52	0.043	0.050	0.706	-0.150	0.180	-3.051	1.390
Cupressales	50	0.077	0.045	0.395	-0.120	0.220	-3.350	1.101
Angiosperms	1291	0.024	0.017	1.189	-0.030	0.030	-0.700	0.530
Magnoliids	88	**-0.357**	**0.048**	**-0.092**	**-0.510**	-0.260	-3.621	0.320
Laurales	46	**-0.287**	**0.074**	**-0.722**	**-0.490**	-0.140	-4.570	0.021
Lauraceae	43	**-0.267**	**0.079**	**-0.782**	**-0.480**	-0.120	-4.751	0.020
Magnoliales	41	-0.437	0.057	1.428	-0.650	-0.270	-2.461	2.240
Magnoliaceae	34	-0.465	0.055	1.890	-0.700	-0.290	-1.800	2.830
Monocots	210	0.072	0.043	0.703	-0.040	0.130	-2.060	0.710
Poales	186	**0.143**	**0.042**	**0.009**	**0.030**	0.200	-2.850	0.061
Poaceae	166	**0.142**	**0.044**	**0.020**	**0.030**	0.210	-2.970	0.121
Eudicots	1078	0.016	0.019	1.322	-0.040	0.030	-0.620	0.700
Core Eudicots	990	0.049	0.019	1.328	-0.010	0.060	-0.650	0.740
Pentapetalae	961	0.055	0.020	1.191	-0.010	0.070	-0.790	0.600
Rosids + Saxifragales	513	**0.174**	**0.028**	**1.088**	**0.100**	0.200	-1.140	0.730
Rosids	498	**0.175**	**0.029**	**1.076**	**0.100**	0.200	-1.160	0.730
Fabids	331	**0.163**	**0.033**	**1.029**	**0.070**	0.200	-1.420	0.830
Fagales + Fabales	158	**0.291**	**0.050**	**0.908**	**0.170**	0.360	-2.110	1.040
Rosales	82	**0.190**	**0.067**	**0.205**	**0.040**	0.290	-3.410	0.641
Rosaceae	49	**0.238**	**0.077**	**0.277**	**0.040**	0.380	-3.500	1.020
Fagales	71	**0.408**	**0.077**	**1.584**	**0.240**	0.520	-2.120	2.090
Fagaceae	67	**0.391**	**0.080**	**1.491**	**0.220**	0.510	-2.150	2.040
Fabales	102	0.026	0.052	1.365	-0.120	0.110	-2.040	1.681
Fabaceae	101	0.026	0.053	1.323	-0.120	0.120	-2.020	1.670
Malpighiales	69	0.054	0.075	1.240	-0.110	0.170	-2.421	1.770
Saxifragales + Rosids	167	**0.198**	**0.054**	**0.890**	**0.080**	0.260	-2.060	1.010
Malvids	163	**0.209**	**0.055**	**0.861**	**0.090**	0.280	-2.141	0.980
Malvales	114	0.132	0.064	0.134	-0.010	0.220	-3.120	0.411
Sapindales	61	0.068	0.088	1.026	-0.110	0.200	-2.691	1.620
Sapindaceae	44	0.048	0.101	1.366	-0.160	0.200	-2.480	2.150
Myrtales	40	**0.374**	**0.101**	**0.197**	**0.160**	0.530	-3.590	1.030
Myrtaceae	32	**0.467**	**0.117**	**0.688**	0.230	0.650	-3.980	0.690
Caryophyllales + Asterids	448	-0.083	0.026	0.865	-0.160	-0.050	-1.420	0.560
Asterids	420	-0.106	0.026	1.251	-0.190	-0.070	-1.081	0.970
Campanuliids	209	-0.159	0.033	1.160	-0.270	-0.100	-1.660	1.170
Asterales	151	-0.218	0.035	0.900	-0.340	-0.150	-2.190	1.060
Asteraceae	147	-0.213	0.035	1.051	-0.330	-0.140	-1.980	1.201
Dipsacales	30	0.070	0.079	0.544	-0.180	0.260	-3.011	1.560
Lamiids	134	-0.142	0.048	0.608	-0.270	-0.060	-2.570	0.821
Lamiales	80	**-0.181**	**0.062**	**-0.210**	**-0.340**	-0.070	-3.701	0.250
Gentianales	42	-0.090	0.091	1.389	-0.300	0.060	-2.421	2.210
Ericales	59	0.164	0.079	0.853	-0.020	0.290	-2.891	1.480

Root Nitrogen Content

Clade	n	mean	se	05% CI	95% CI	kurtosis	05% CI	95% CI
Spermatophyta	1140	0.004	0.018	0.557	-0.030	0.040	-0.320	0.300
Gymnosperms	55	-0.154	0.041	3.454	-0.320	0.000	1.550	4.180
Pinales	54	**-0.177**	**0.034**	**-0.222**	**-0.340**	-0.020	-2.111	0.500
Cupressales	32	-0.136	0.045	-0.350	0.299	0.070	-1.760	1.340
Angiosperms	1085	0.012	0.019	-0.030	0.461	0.040	-0.440	0.210
Magnoliids	77	**0.431**	**0.045**	**0.061**	**0.290**	0.560	-1.700	0.610
Laurales	38	0.523	0.067	-0.613	0.320	0.710	-2.681	0.330
Lauraceae	35	0.477	0.066	-0.371	0.270	0.670	-2.460	0.600
Magnoliales	38	**0.348**	**0.058**	**0.225**	**0.150**	0.540	-1.770	1.150
Magnoliaceae	33	**0.344**	**0.059**	**0.494**	**0.130**	0.550	-1.551	1.530
Monocots	181	**-0.323**	**0.043**	**-0.198**	**-0.410**	-0.240	-1.540	-0.020
Poales	163	**-0.318**	**0.047**	**-0.256**	**-0.410**	-0.230	-1.630	-0.030
Poaceae	146	**-0.289**	**0.048**	**-0.031**	**-0.390**	-0.190	-1.470	0.230
Eudicots	901	0.079	0.020	0.523	-0.040	0.110	-0.400	0.310
Core Eudicots	824	0.046	0.021	0.601	0.000	0.080	-0.340	0.400
Rosids + Saxifragales	400	**0.136**	**0.033**	**0.168**	**0.070**	0.190	-0.940	0.130
Rosids	386	**0.151**	**0.033**	**0.137**	**0.090**	0.210	-0.970	0.100
Fabids	278	0.245	0.040	-0.228	0.170	0.310	-1.440	-0.170
Rosales	73	-0.013	0.075	0.738	-0.160	0.120	-1.110	1.320
Rosaceae	46	**-0.173**	**0.062**	**-0.297**	**-0.350**	0.000	-2.220	0.520
Fagales	60	-0.025	0.054	4.590	-0.180	**0.120**	**0.027**	**5.270**
Fagaceae	35	-0.082	0.069	0.624	-0.290	0.110	-1.500	1.610
Fabaceae	77	**0.815**	**0.074**	**0.288**	**0.970**	**0.950**	**0.260**	**2.160**
Malpighiales	42	0.106	0.076	1.082	-0.090	0.280	-0.950	1.960
Saxifragales + Rosids	108	-0.090	0.054	0.291	-0.210	0.020	-1.300	0.680
Malvids	100	-0.097	0.056	0.391	-0.220	0.020	-1.250	0.810
Sapindales + Malvales	65	**-0.027**	**0.066**	**-0.599**	**-0.180**	0.110	-2.410	0.030
Sapindales	46	**-0.006**	**0.079**	**-0.424**	**-0.181**	0.170	-2.440	0.410
Sapindaceae	36	**-0.052**	**0.078**	**-0.885**	**-0.016**	0.250	-2.931	0.070
Caryophyllales + Asterids	403	-0.040	0.028	0.840	-0.100	0.020	-0.250	0.800
Caryophyllales	54	**-0.035**	**0.091**	**-0.089**	**-0.200**	0.120	-2.050	0.640
Asterids	349	-0.040	0.029	0.992	-0.110	0.020	-0.140	0.980
Campanuliids	281	0.021	0.032	0.694	-0.050	0.090	-0.510	0.730
Asterales	133	0.009	0.047	1.565	-0.100	**0.110**	**0.070**	**1.860**
Asteraceae	130	0.010	0.047	1.561	-0.100	**0.110**	**0.060**	**1.860**
Lamiids	93	0.112	0.054	0.660	-0.020	0.230	-0.940	1.130
Lamiales	41	0.084	0.080	-0.615	-0.110	0.260	-2.590	0.270
Gentianales	33	0.166	0.079	-0.627	-0.050	0.370	-2.680	0.400
Ericales + Cornales	68	-0.294	0.057	2.139	-0.440	-0.150	-0.310	2.760

Table S6. Plant families included in the analysis and their taxonomic groupings used for this study. Presented are the superorders displayed in Figure 4 as well as the orders analyzed for table S5.

Family	Order	Superorder
Acanthaceae	Lamiales	Asterids
Actinidiaceae	Ericales	Asterids
Adoxaceae	Dipsacales	Asterids
Alismataceae	Alistamatales	Monocots
Altingiaceae	Saxifragales	Rosids
Amaranthaceae	Caryophyllales	Asterids
Amaryllidaceae	Asparagales	Monocots
Anacardiaceae	Sapindales	Rosids
Annonaceae	Magnoliales	Magnoliids
Apiaceae	Asterales	Asterids
Apocynaceae	Gentianales	Asterids
Aquifoliaceae	Aquifoliales	Asterids
Araceae	Alistamatales	Monocots
Araliaceae	Apiales	Asterids
Araucariaceae	Pinales	Gymnosperms
Arecaceae	Arecales	Monocots
Asparagaceae	Asparagales	Monocots
Asteliaceae	Asparagales	Monocots
Asteraceae	Asterales	Asterids
Atherospermataceae	Laurales	Magnoliids
Balsaminaceae	Ericales	Asterids
Berberidaceae	Ranunculales	Basal Angiosperms
Betulaceae	Fagales	Rosids
Bignoniaceae	Lamiales	Asterids
Boraginaceae	Boraginales	Asterids
Brassicaceae	Brassicales	Rosids
Burseraceae	Sapindales	Rosids
Calycanthaceae	Laurales	Magnoliids
Campanulaceae	Asterales	Asterids
Cannabaceae	Rosales	Rosids
Caprifoliaceae	Dipsacales	Asterids
Caricaceae	Brassicales	Rosids
Caryophyllaceae	Caryophyllales	Asterids
Celastraceae	Celastrales	Rosids
Cercidiphyllaceae	Saxifragales	Rosids
Chloranthaceae	Chloranthales	Magnoliids
Chrysobalanaceae	Malpighiales	Rosids
Cistaceae	Malvales	Rosids
Clusiaceae	Malpighiales	Rosids
Combretaceae	Myrtales	Rosids
Commelinaceae	Commelinales	Monocots
Convolvulaceae	Asterales	Asterids
Coriariaceae	Cucurbitales	Rosids
Cornaceae	Cornales	Asterids
Corynocarpaceae	Cucurbitales	Rosids
Cucurbitaceae	Cucurbitales	Rosids
Cunoniaceae	Oxalidales	Rosids
Cupressaceae	Cupressales	Gymnosperms

Cyperaceae	Poales	Monocots
Daphniphyllaceae	Saxifragales	Rosids
Dioscoreaceae	Dioscoreales	Monocots
Dipterocarpaceae	Malvales	Rosids
Ebenaceae	Ericales	Asterids
Elaeagnaceae	Ericales	Asterids
Elaeocarpaceae	Oxalidales	Rosids
Ephedraceae	Pinales	Gymnosperms
Ericaceae	Ericales	Asterids
Euphorbiaceae	Malpighiales	Rosids
Eupteleaceae	Ranunculales	Basal Angiosperms
Fabaceae	Fabales	Rosids
Fagaceae	Fabales	Rosids
Gentianaceae	Gentianales	Asterids
Geraniaceae	Geraniales	Rosids
Ginkgoaceae	Ginkgoales	Gymnosperms
Gnetaceae	Gnetales	Gymnosperms
Griseliniaceae	Cornales	Asterids
Hamamelidaceae	Saxifragales	Rosids
Hydrangeaceae	Cornales	Asterids
Hypericaceae	Malpighiales	Rosids
Icacinaceae	Icacinales	Asterids
Iridaceae	Asparagales	Monocots
Iteaceae	Saxifragales	Rosids
Juglandaceae	Fagales	Rosids
Juncaceae	Poales	Monocots
Juncaginaceae	Alistamatales	Monocots
Lamiaceae	Lamiales	Asterids
Lardizabalaceae	Ranunculales	Basal Angiosperms
Lauraceae	Laurales	Magnoliids
Lecythidaceae	Ericales	Asterids
Liliaceae	Liliales	Monocots
Linaceae	Malpighiales	Rosids
Lythraceae	Myrtales	Rosids
Magnoliaceae	Magnoliales	Magnoliids
Malpighiaceae	Malpighiales	Rosids
Malvaceae	Malvales	Rosids
Melanthiaceae	Liliales	Monocots
Melastomataceae	Myrtales	Rosids
Meliaceae	Sapindales	Rosids
Monimiaceae	Laurales	Magnoliids
Moraceae	Rosales	Rosids
Moringaceae	Brassicales	Rosids
Myricaceae	Fagales	Rosids
Myristicaceae	Magnoliales	Magnoliids
Myrtaceae	Myrtales	Rosids
Nitrariaceae	Sapindales	Rosids
Nothofagaceae	Fagales	Rosids
Nyctaginaceae	Caryophyllales	Asterids
Oleaceae	Lamiales	Asterids
Onagraceae	Myrtales	Rosids

Orobanchaceae	Fagales	Rosids
Pandaceae	Pandanales	Monocots
Paracryphiaceae	Paracryphiales	Asterids
Pennantiaceae	Apiales	Asterids
Pentaphylacaceae	Ericales	Asterids
Phyllanthaceae	Malpighiales	Rosids
Pinaceae	Pinales	Gymnosperms
Pittosporaceae	Apiales	Asterids
Plantaginaceae	Lamiales	Asterids
Platanaceae	Proteales	Basal Angiosperms
Plumbaginaceae	Asterales	Asterids
Poaceae	Poales	Monocots
Podocarpaceae	Cupressales	Gymnosperms
Polemoniaceae	Asterales	Asterids
Polygalaceae	Caryophyllales	Asterids
Polygonaceae	Caryophyllales	Asterids
Portulacaceae	Caryophyllales	Asterids
Primulaceae	Ericales	Asterids
Proteaceae	Proteales	Basal Angiosperms
Ranunculaceae	Ranunculales	Basal Angiosperms
Rhamnaceae	Rosales	Rosids
Rhipogonaceae	Liliales	Monocots
Rhizophoraceae	Malpighiales	Rosids
Rosaceae	Rosales	Rosids
Rousseaceae	Asterales	Asterids
Rubiaceae	Gentianales	Asterids
Rutaceae	Sapindales	Rosids
Salicaceae	Malpighiales	Rosids
Santalaceae	Santalales	Asterids
Sapindaceae	Sapindales	Rosids
Sapotaceae	Ericales	Asterids
Saxifragaceae	Saxifragales	Rosids
Schoepfiaceae	Santalales	Asterids
Scrophulariaceae	Lamiales	Asterids
Simaroubaceae	Sapindales	Rosids
Smilacaceae	Liliales	Monocots
Solanaceae	Solanales	Asterids
Styracaceae	Ericales	Asterids
Tamaricaceae	Caryophyllales	Asterids
Taxaceae	Cupressales	Gymnosperms
Theaceae	Ericales	Asterids
Thymelaeaceae	Malvales	Rosids
Ulmaceae	Rosales	Rosids
Urticaceae	Rosales	Rosids
Verbenaceae	Lamiales	Asterids
Violaceae	Malpighiales	Rosids
Vitaceae	Vitales	Rosids
Winteraceae	Canellales	Magnoliids
Zingiberaceae	Zingiberales	Monocots
Zygophyllaceae	Zygophyllales	Rosids

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