

Zeng, W., Xiang, W., Zhou, B., Ouyang, S., Zeng, Y., Chen, L., Freschet, G. T., Valverde-Barrantes, O. J. and Milcu, A. 2020. Positive tree diversity effect on fine root biomass: via density dependence rather than spatial root partitioning. – Oikos doi: 10.1111/oik.07777

## Appendix 1

Table A1. Forest structure factors of the diameter at breast height (DBH, at 1.3 m above the ground), height (H), basal area (BA), stand density, and Pielou's evenness in the coniferous and evergreen broadleaved mixed forest (PM), deciduous broadleaved forest (CA) and evergreen broadleaved forest (CG).

	PM	CA	CG
Average DBH (cm)	8.5 (4.0–30.8)	10.4 (5.0–37.9)	9.1 (4.0–33.9)
Average height (H) (m)	12.7 (5.6–26.4)	10.0 (6.3–22.9)	10.3 (6.4–24.2)
BA (cm <sup>2</sup> m <sup>-2</sup> )	34.6 (18.6–56.4)	31.6 (15.2–60.0)	32.6 (19.6–54.0)
Stand density (trees ha <sup>-1</sup> )	6103 (2384–12480)	4972 (555–10300)	5024 (1999–11120)
Pielou's evenness	0.78 (0.57–0.96)	0.80 (0.63–1.00)	0.80 (0.67–1.00)

Table A2. Aboveground and belowground-identified species and functional groups in the three forests studied.

Stand type	Functional type	Belowground species	Aboveground species
Conifer and evergreen broadleaved mixed forest	Evergreen coniferous species	<i>Cunninghamia lanceolata</i>	<i>Cunninghamia lanceolata</i>
		<i>Pinus massoniana</i>	<i>Pinus massoniana</i> <i>Pinus elliotti</i>
	Deciduous broadleaved species	<i>Choerospondias axillaris</i>	<i>Choerospondias axillaris</i>
		<i>Diospyros tsangii</i>	<i>Diospyros tsangii</i>
<i>Diospyros kaki</i>		<i>Diospyros kaki</i>	
<i>Liquidambar formosana</i>		<i>Liquidambar formosana</i> <i>Aleurites montana</i> <i>Castanea henryi</i> <i>Quercus fabri</i> <i>Sapium japonicum</i>	
Evergreen broadleaved species	<i>Sassafras tzumu</i>		
	<i>Camellia oleifera</i>	<i>Camellia oleifera</i>	
	<i>Cinnamomum camphora</i>	<i>Cinnamomum camphora</i>	
	<i>Cleyera japonica</i>	<i>Cleyera japonica</i>	
Shrub species	<i>Cyclobalanopsis glauca</i>	<i>Cyclobalanopsis glauca</i>	
	<i>Lithocarpus glaber</i> ;	<i>Lithocarpus glaber</i>	
	<i>Schima superba</i>	<i>Schima superba</i>	
	<i>Symplocos caudata</i>	<i>Symplocos caudata</i> <i>Ilex chinensis</i>	
Shrub species		<i>Platyclusus orientalis</i> <i>Symplocos sumunitia</i>	
		<i>Clerodendrum cwtophyllum</i> Turcz	
		<i>Loropetalum chinense</i> <i>Eurya muricate</i>	

Stand type	Functional type	Belowground species	Aboveground species
			<i>Gardenia jasminoides</i> <i>Litsea cubeba</i> <i>Rhododendron mariesii</i> <i>Syzygium buxifolium</i> <i>Vaccinium bracteatum</i>
		<i>Magnolia liliflora</i>	
		<i>Aleurites montana</i> <i>Choerospondias axillaris</i> <i>Diospyros kaki</i>	<i>Aleurites montana</i> <i>Choerospondias axillaris</i> <i>Diospyros kaki</i>
	Deciduous broadleaved species	<i>Diospyros tsangii</i> <i>Ilex purpurea</i> <i>Liquidambar formosana</i> <i>Vernicia fordii</i>	<i>Diospyros tsangii</i> <i>Ilex purpurea</i> <i>Liquidambar formosana</i> <i>Vernicia fordii</i> <i>Castanea henryi</i> <i>Vaccinium bracteatum</i>
Deciduous broadleaved forest		<i>Davidia involucrata</i> Baill <i>Quercus fabri</i> <i>Sassafras tzumu</i>	
	Evergreen broadleaved species	<i>Camellia oleifera</i> <i>Cleyera japonica</i> <i>Cinnamomum camphora</i> <i>Cyclobalanopsis glauca</i> <i>Lithocarpus glaber</i> <i>Symplocos stellaris</i>	<i>Camellia oleifera</i> <i>Cleyera japonica</i> <i>Cinnamomum camphora</i> <i>Cyclobalanopsis glauca</i> <i>Lithocarpus glaber</i> <i>Symplocos stellaris</i> <i>Photinia davidsoniae</i>
	Shrub species	<i>Symplocos caudata</i> <i>Alangium kurzii</i> <i>Gardenia jasminoides</i>	<i>Alangium kurzii</i> <i>Gardenia jasminoides</i>

Stand type	Functional type	Belowground species	Aboveground species
		<i>Loropetalum chinense</i> <i>Litsea cubeba</i> <i>Rhododendron</i>	<i>Loropetalum chinense</i> <i>Litsea cubeba</i> <i>Rhododendron</i> <i>Clerodendrum cwtophyllum</i> Turcz <i>Eurya muricate</i> <i>Ficus heteromorpha</i> <i>Photinia beauverdiana</i> <i>Rhododendron mariesii</i> <i>Syzygium buxifolium</i>
		<i>Rubus buergeri</i>	
	Evergreen coniferous species	<i>Cunninghamia lanceolata</i> <i>Pinus massoniana</i>	<i>Cunninghamia lanceolata</i> <i>Pinus massoniana</i>
		<i>Castanea henryi</i>	<i>Castanea henryi</i>
		<i>Choerospondias axillaris</i> <i>Diospyros tsangii</i> <i>Liquidambar formosana</i> <i>Quercus fabri</i> <i>Sassafras tzumu</i>	<i>Choerospondias axillaris</i> <i>Diospyros tsangii</i> <i>Liquidambar formosana</i> <i>Quercus fabri</i> <i>Sassafras tzumu</i> <i>Aleurites montana</i> <i>Castanea mollissima</i> <i>Dalbergia hupeana</i> <i>Diospyros kaki</i> <i>Sapium japonicum</i>
Evergreen broadleaved forest	Deciduous broadleaved species		
		<i>Cleyera japonica</i> <i>Cyclobalanopsis glauca</i> <i>Cinnamomum camphora</i> <i>Elacocarpus japonicus</i>	<i>Cleyera japonica</i> <i>Cyclobalanopsis glauca</i> <i>Cinnamomum camphora</i> <i>Elacocarpus japonicus</i>

Stand type	Functional type	Belowground species	Aboveground species
		<i>Ilex purpurea</i> <i>Lithocarpus glaber</i> <i>Symplocos stellaris</i> <i>Symplocos caudata</i>	<i>Ilex purpurea</i> <i>Lithocarpus glaber</i> <i>Symplocos stellaris</i> <i>Symplocos caudata</i> <i>Cupressus funebris</i> <i>Photinia davidsoniae</i> <i>Schima superba</i>
		<i>Alangium kurzii</i> <i>Eurya muricate</i> <i>Litsea cubeba</i> <i>Loropetalum chinense</i>	<i>Alangium kurzii</i> <i>Eurya muricate</i> <i>Litsea cubeba</i> <i>Loropetalum chinense</i> <i>Clerodendrum cwtophyllum</i> Turcz <i>Rhododendron</i> <i>Rhododendron mariesii</i> <i>Syzygium buxifolium</i> <i>Vaccinium bracteatum</i>
	Shrub species	<i>Celastrus orbiculatus</i> <i>Magnolia liliflora</i> <i>Ulmus parvifolia</i>	

Table A3. Loadings of species richness and fine root biomass ( $\text{g m}^{-2}$ ) of each subplot.

Species richness	Fine root biomass	Species richness	Fine root biomass	Species richness	Fine root biomass
1	46.38	5	447.04	7	281.40
1	137.59	5	234.04	7	238.72
2	234.43	5	253.06	7	316.72
2	189.95	5	158.25	7	323.14
2	295.42	5	125.37	7	154.76
2	213.24	5	64.01	7	525.52
2	189.41	5	109.23	7	316.99
3	143.17	5	183.05	7	231.68
3	248.49	5	323.06	7	377.24
3	96.39	5	163.66	8	233.80
3	212.40	5	207.53	8	343.52
3	281.67	5	201.75	8	367.13
3	234.92	6	278.34	8	412.79
3	310.30	6	414.03	8	100.09
3	331.48	6	270.17	8	302.41
3	376.38	6	295.91	8	317.65
3	328.11	6	340.83	8	253.25
4	146.32	6	307.91	9	221.12
4	188.77	6	360.64	9	347.10
4	156.24	6	360.94	9	111.55
4	176.76	6	197.67	9	303.24
4	353.76	6	278.39	9	265.82
4	75.97	6	249.47	10	257.17
4	143.23	6	286.40	10	244.93
4	264.49	6	355.32	11	338.62
4	200.70	6	299.28	11	232.33
4	346.60	6	378.48	11	264.90
4	253.34	7	329.52	12	167.01
5	237.91	7	276.78	12	168.03
5	298.80	7	301.72		
5	111.99	7	266.33		

Table A4. Effects of aboveground tree species richness and total soil organic carbon (C), nitrogen (N) and phosphorus (P) contents and their interactions on the inverse CV of fine root biomass within soil depth of 0-10 cm (n = 91). Variance explained by the fixed effects represents the marginal  $r^2$  ( $mr^2$ ) whereas the variance explained by the entire model, including both fixed and random effects represents the conditional  $r^2$  ( $cr^2$ ).

Source	numDF	denDF	F-value	p -value
(Intercept)	1	72	3054.32	<.0001
Species richness	1	72	0.21	0.6425
N	1	72	1.48	0.2256
P	1	72	0.78	0.3757
C	1	72	0.25	0.6157
Species richness: N	1	72	1.16	0.2829
Species richness: P	1	72	0.02	0.8653
N: P	1	72	0.07	0.7931
N: C	1	72	0.13	0.7124
P: C	1	72	0.06	0.7933
Species richness: N :P	1	72	3.93	0.0490
N: P: C	1	72	4.48	0.0357
	$mr^2=0.2791$		$cr^2=0.2791$	

Table A5. Statistical results of univariate models testing the impact of diameter at breast height (DBH, at 1.3m above the ground), height (H), basal area (BA), stand density, Pielou's evenness on fine root biomass (n = 91). DF represents the degrees of freedom and Sum Sq represents the sum of squares.

Source	DF	Sum Sq	F-value	p-value
DBH	1	105	0.01	0.911
H	1	1600	0.19	0.662
BA	1	242	0.03	0.865
Stand density	1	74974	9.82	0.004*
Pielou's evenness	1	1027	0.12	0.728

Asterisks indicate level of significance for each index (\*p < 0.05)

Table S6. Effects of tree density, *C. glauca* and species richness and their interactions, on fine root biomass (n = 91). Variance explained by the fixed effects represents the marginal  $r^2$  ( $mr^2$ ) whereas the variance explained by the entire model, including both fixed and random effects represents the conditional  $r^2$  ( $cr^2$ ).

Source	numDF	denDF	F-value	p-value
(Intercept)	1	82	998.58	<.0001
Stand density	1	82	9.97	0.0021
<i>C. glauca</i>	1	82	9.03	0.0036
Species richness	1	82	1.04	0.3076
Stand density: species richness	1	82	4.21	0.0384
	$mr^2=0.1567$		$cr^2=0.1567$	



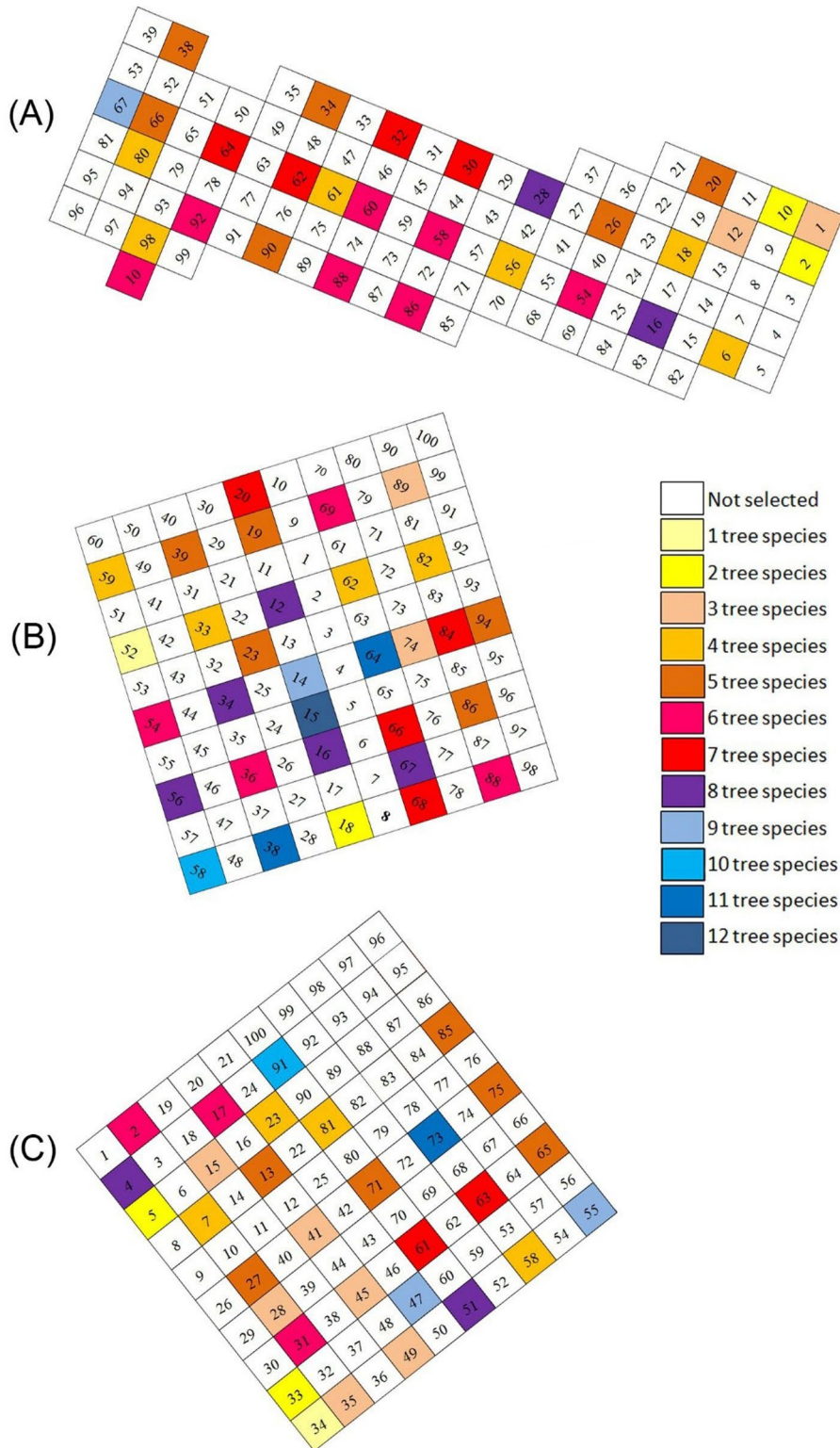


Figure A1. Map of experimental plots: (A) map for PM forest, (B) map for CA forest and (C) map for CG forest.

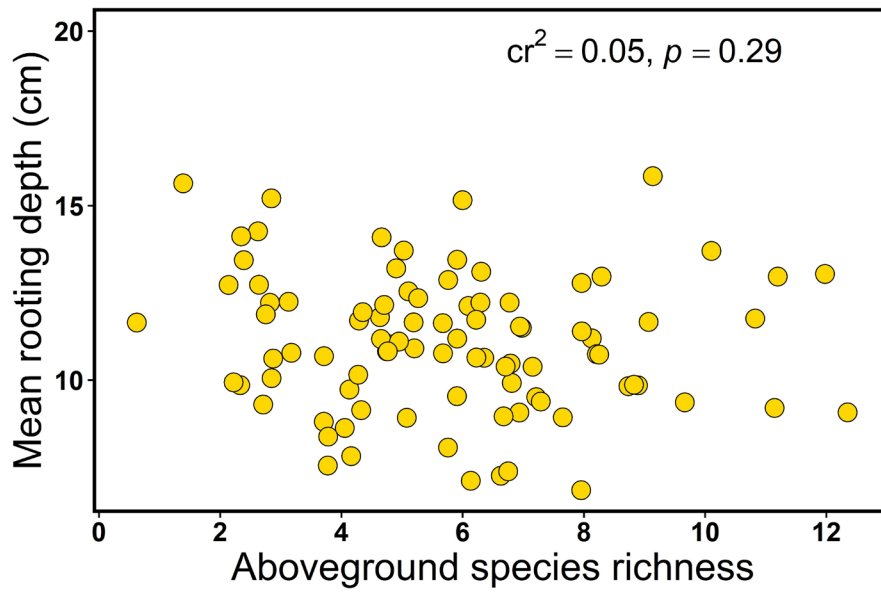


Figure A2. Relationships between aboveground species richness and mean rooting depth in all samples from all forests ( $n = 91$ ). Variance explained by the entire model, including both fixed and random effects represents the conditional  $r^2$  ( $cr^2$ ).

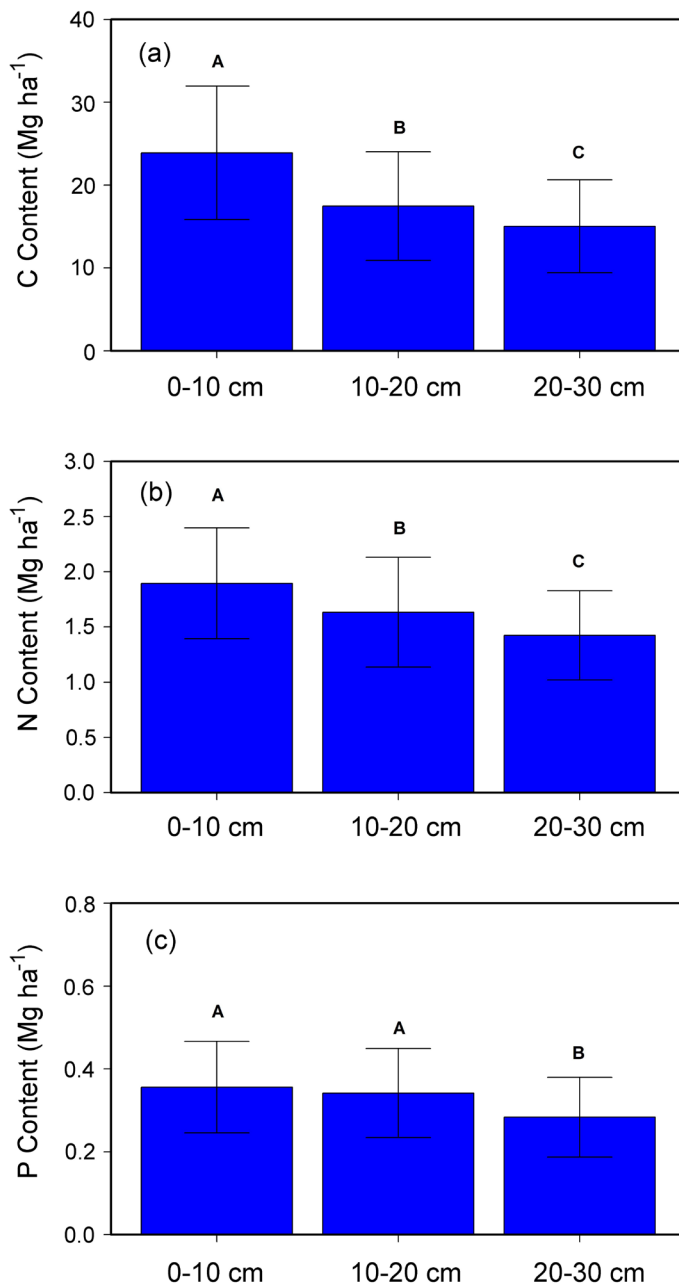


Figure A3. Soil organic carbon (C) (a), nitrogen (N) (b) and phosphorus (P) (c) contents (mean  $\pm$  SE) by soil depth (0-10, 10-20 and 20-30 cm) in all samples from all forests ( $n = 91$  for each soil depth). Different capital letters indicate a significant difference at  $p < 0.05$  (\*) (Tukey-Kramer honestly significant difference test).

## Supplementary note

SEM for fine root biomass based on tree species richness (richness), soil carbon (C), nitrogen (N) and phosphorus (P) concentrations, stand density (density), forest types (type) and fine root biomass (biomass).

```
#####
```

```
> model='
+ Soil=~ C+N+P
+ biomass~density+Soil+type
+ biomass~~ richness
+ Soil~~ richness + density
+ density~~ richness
+ richness ~ type
+ Soil ~ type
+ density ~ type
+ '
> model.fit <- sem(model, data=M1111, meanstructure=TRUE)
> summary(model.fit, rsq=T,standardized=TRUE, fit.measures=TRUE)
```

lavaan 0.6-5 ended normally after 182 iterations

Estimator	ML
Optimization method	NLMINB
Number of free parameters	25

Model test user model:

Test statistic	4.565
Degrees of freedom	8
p-value (Chi-square)	0.803

Model test baseline model:

Test statistic	131.538
Degrees of freedom	21
p-value	0.000

User model versus Baseline model:

Comparative fit index (CFI)	1.00
Tucker-Lewis index (TLI)	1.082

Loglikelihood and information criteria:

Loglikelihood user model (H0)	-1298.603
Loglikelihood unrestricted model (H1)	-1264.320

Akaike (AIC)	2647.206
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Bayesian (BIC) 2709.422  
 Sample-size adjusted Bayesian (BIC) 2630.526

Root mean square error of approximation:

RMSEA 0.000  
 90 Percent confidence interval - lower 0.000  
 90 Percent confidence interval - upper 0.1080  
 P-value RMSEA  $\leq$  0.05 0.884

Standardized root mean square residual:

SRMR 0.036

Parameter estimates:

Information Expected  
 Information saturated (h1) model Structured  
 Standard errors Standard

Latent variables:

	Estimate	SE	z	P(> z )	Std.all
Soil= $\sim$					
C	1.000				0.658
N	0.121	0.042	2.854	0.004	1.145
P	0.009	0.003	2.713	0.007	0.251

Regression:

	Estimate	SE	z	P(> z )	Std.all
biomass $\sim$					
density	0.878	0.313	2.807	0.005	0.287
Soil	1.866	1.497	1.247	0.212	0.105
type	-2.205	8.202	-0.269	0.788	-0.028
Soil $\sim$					
richness	-0.019	0.153	-0.123	0.902	-0.012
density	0.016	0.019	0.853	0.393	0.093
richness $\sim$					
types	-0.097	0.310	-0.314	0.754	-0.033
soil $\sim$					
types	-0.478	0.452	-1.058	0.290	-0.107
density $\sim$					
types	-5.007	2.722	-1.840	0.070	-0.171

Covariances:

	Estimate	SE	z	P(> z )	Std.all
biomass $\sim$					

richness	29.106	13.99	2.080	0.038	0.198
density					
SR	23.697	5.843	4.056	0.001	0.476

Variiances:

	Estimate	SE	z	P(> z )	Std.all
C	17.451	5.080	3.435	0.001	0.567
N	-0.046	0.064	-0.72	0.472	-0.311
P	0.015	0.002	6.644	<0.001	0.937
biomass	3796.451	567.5	6.689	<0.001	0.896
density	5.669	0.850	6.672	<0.001	0.999
SR	436.943	65.50	6.671	<0.001	0.963
Soil	13.009	5.523	2.355	0.019	0.977

R-Square:

	Estimate
biomass	0.104