

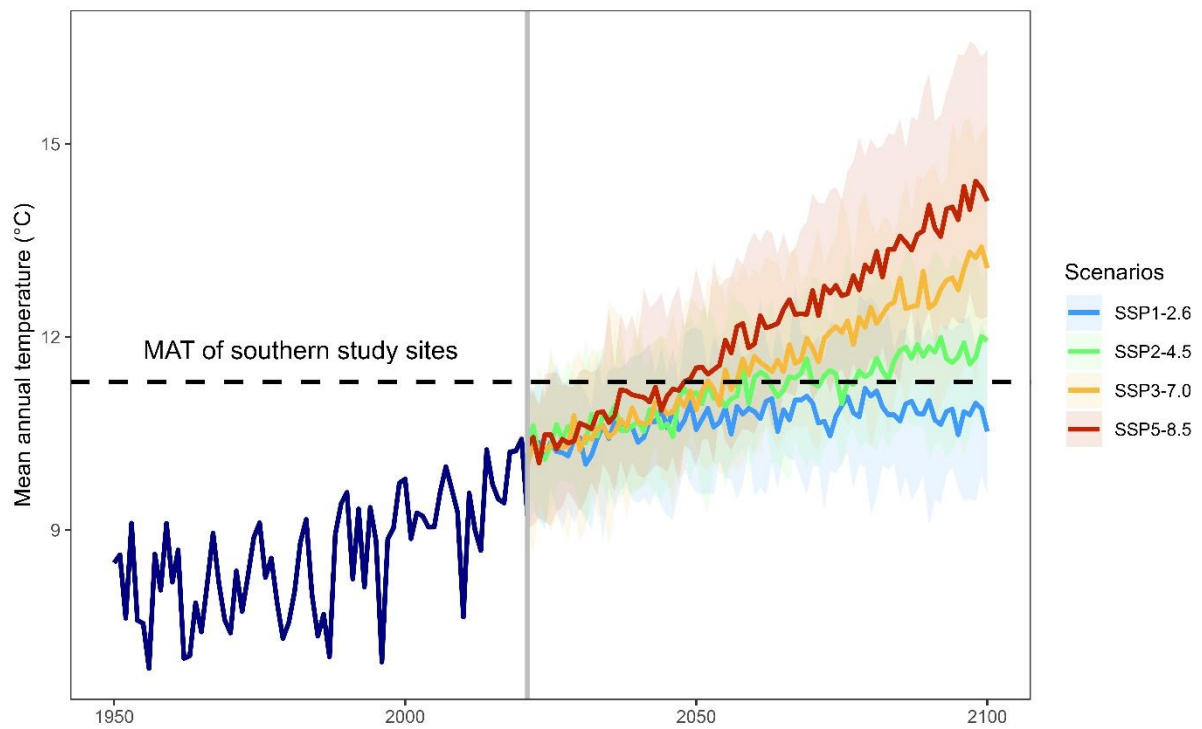


Figure S1: Mean annual temperature (MAT) of the northern study region up to 2021 (DWD Climate Data Center), with projections until 2100 based on different climate scenarios (IPCC 2023) for Lower Saxony (World Bank Climate Change Knowledge Portal). The horizontal dashed line represents the MAT of the southern study region for 1991–2020 (DWD Climate Data Center).

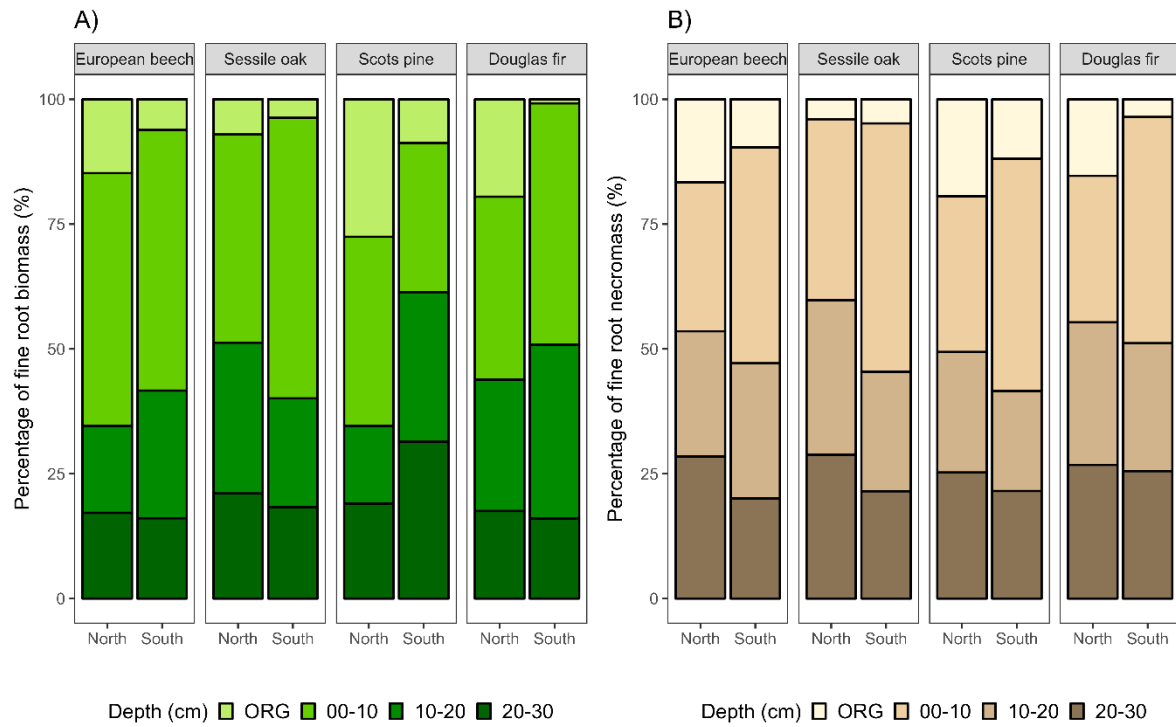


Figure S2: Fine root A) biomass and B) necromass distribution expressed as percentages in the four depth layers for all species in both regions.

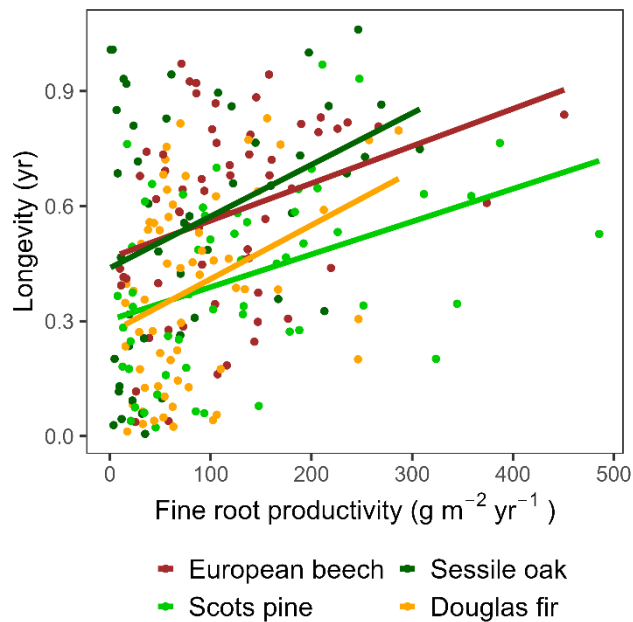


Figure S3: Relation between fine root longevity and fine root productivity for the four species. Spearman rank correlation coefficients are as follows: beech ($\rho = 0.33$, $p = 0.01$), oak ($\rho = 0.37$, $p = 0.01$), pine ($\rho = 0.40$, $p = 0.002$), and Douglas fir ($\rho = 0.36$, $p = 0.004$).

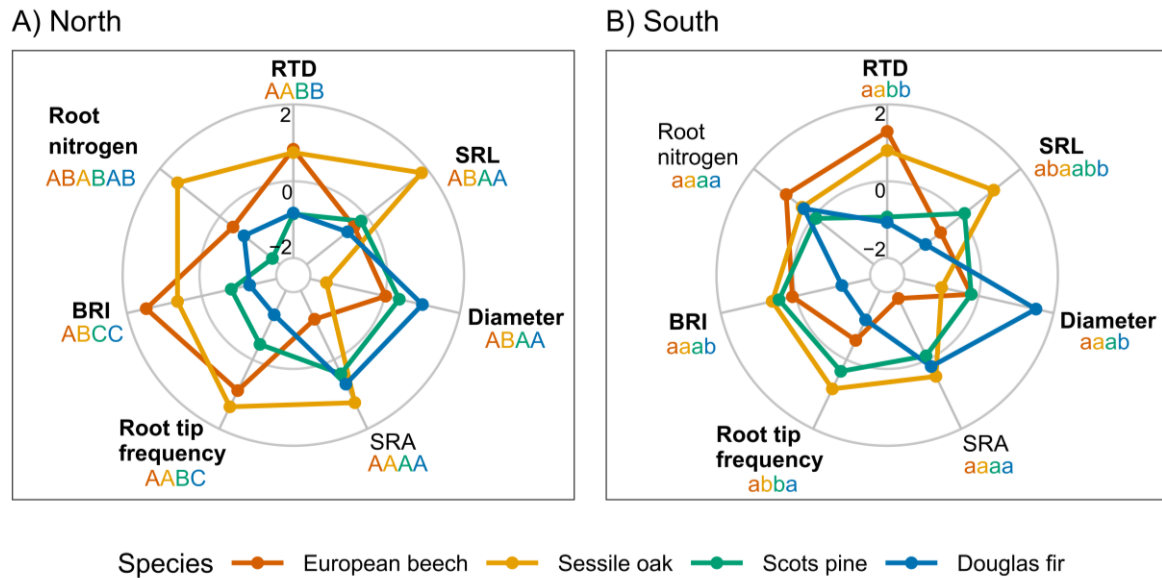


Figure S4: Comparison of standardized marginal means of morphological root traits across species for A) the northern and B) the southern region. Root traits with significant differences between species are indicated in bold and letters show pairwise comparisons. Abbreviations for the root traits can be found in Table 3.

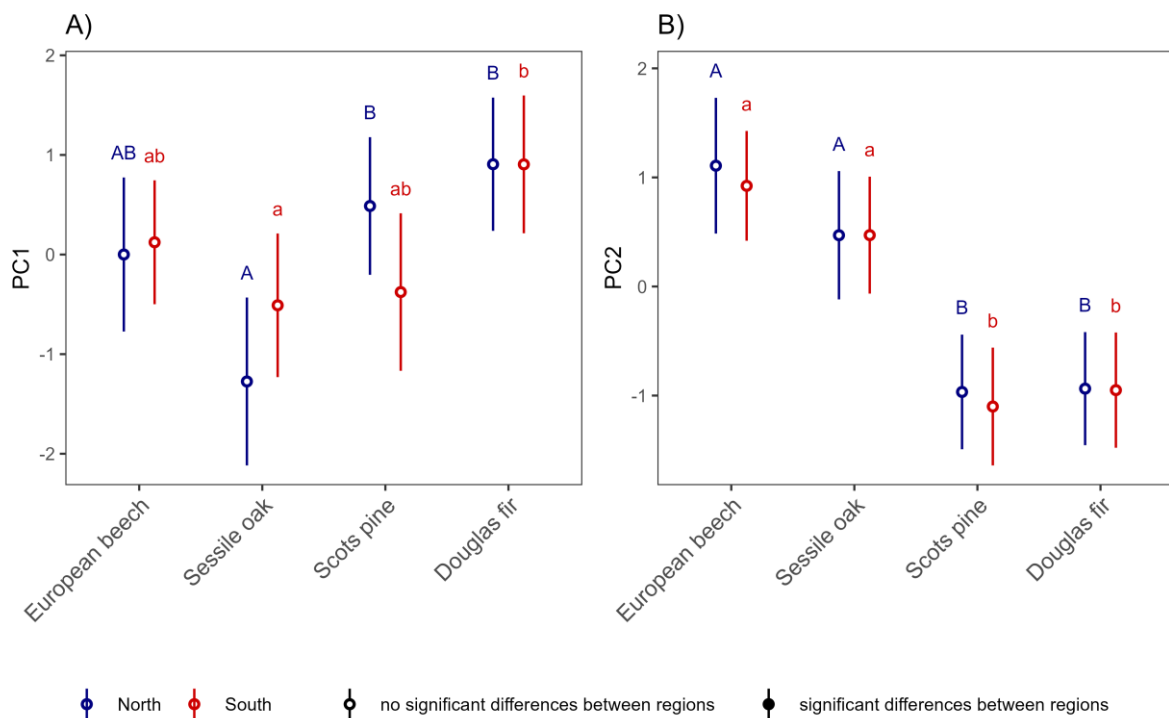


Figure S5: A) Root length and B) root area index of the four species in the two regions. Given are estimated marginal means and 95% confidence intervals. Filled circles indicate significant differences between regions for a given species. Different letters indicate significant differences among species within the same region: Uppercase letters for the northern region and lowercase letters for the southern region.

Table S1: Soil properties of the 24 study sites for two depths (5 cm, 20 cm; means of 3 replicate soil samples each). Water capacity – storage capacity for plant-available water.

Species	Region	Depth (cm)	Plot	pH (H ₂ O)	C/N (g g ⁻¹)	N (mg g ⁻¹)	CEC (μmol _c g ⁻¹)	Base saturation (%)	Sand content (%)	Silt content (%)	Clay content (%)	Water capacity (cm ³ cm ⁻³)
European beech	North	5	1	4.35	23.4	0.96	27.9	9.0	75	22	3	0.22
			2	4.44	22.0	0.63	37.6	9.1	82	15	3	0.19
			3	4.38	21.9	0.56	27.1	11.5	69	27	4	0.23
		20	1	4.90	22.0	0.56	21.8	7.6	75	18	7	0.22
			2	4.93	22.3	0.48	19.6	4.2	87	10	3	0.15
			3	4.89	24.4	0.42	24.4	6.4	69	27	4	0.22
	South	5	1	4.92	13.9	0.69	19.4	7.2	85	10	5	0.17
			2	4.79	14.4	0.85	19.2	6.0	88	10	3	0.15
			3	4.86	13.5	0.84	16.4	6.8	84	10	6	0.18
		20	1	4.99	12.3	0.57	11.9	8.0	89	8	4	0.14
			2	5.06	12.9	0.56	10.5	8.6	89	7	4	0.14
			3	5.03	12.1	0.63	13.9	6.3	86	8	6	0.17
Sessile oak	North	5	1	4.58	19.2	0.64	26.8	12.2	76	20	4	0.22
			2	4.50	18.9	0.53	23.9	12.6	78	18	4	0.20
			3	4.49	18.9	0.78	26.3	10.5	67	26	7	0.23
		20	1	4.92	20.6	0.36	12.6	13.4	77	17	5	0.21
			2	4.88	18.9	0.41	14.0	10.1	76	19	5	0.21
			3	4.96	17.6	0.41	12.0	10.1	65	28	7	0.23
	South	5	1	5.26	16.4	1.21	28.8	22.9	75	20	5	0.22
			2	4.98	16.4	1.02	33.7	18.2	78	16	6	0.21
			3	5.21	15.2	1.67	27.8	28.3	65	28	6	0.25
		20	1	5.72	12.0	0.50	14.7	36.7	76	20	5	0.21
			2	5.54	12.3	0.38	12.3	17.4	76	18	6	0.21
			3	5.55	13.5	0.61	13.3	22.5	67	22	11	0.23
Scots pine	North	5	1	4.13	28.7	0.81	32.3	17.8	76	20	4	0.22
			2	4.14	24.7	0.68	39.7	22.4	86	12	3	0.16
			3	4.35	21.9	1.32	36.9	36.0	78	17	5	0.23
		20	1	4.92	25.3	0.50	22.3	10.4	78	17	6	0.21
			2	4.89	23.3	0.49	16.3	5.4	86	7	7	0.16
			3	4.83	24.7	0.84	24.9	6.9	76	19	5	0.22
	South	5	1	4.14	23.2	0.69	23.6	14.9	87	10	3	0.15
			2	4.12	23.8	0.95	28.2	15.8	85	12	3	0.17
			3	4.17	24.7	0.79	29.2	13.5	87	11	2	0.15
		20	1	4.40	19.1	0.57	21.2	7.8	84	12	3	0.18
			2	4.46	17.4	0.66	19.4	6.8	85	11	4	0.17
			3	4.47	21.5	0.36	29.6	7.2	90	9	1	0.11
Douglas fir	North	5	1	4.47	20.2	1.55	39.9	3.7	71	23	6	0.25
			2	4.48	21.7	1.52	42.0	4.3	78	15	6	0.23
			3	4.46	23.0	0.46	43.5	3.2	72	23	5	0.22
		20	1	4.78	15.6	1.23	21.0	4.1	71	23	6	0.25
			2	4.67	23.7	0.85	27.0	3.5	77	18	5	0.22
			3	4.70	18.8	0.11	25.3	3.3	87	12	1	0.13
	South	5	1	4.86	14.4	1.88	27.3	22.7	70	22	7	0.25
			2	5.04	13.6	1.15	28.1	23.5	62	29	9	0.24
			3	5.17	14.0	1.19	23.4	30.6	77	17	6	0.22
		20	1	5.26	14.6	1.08	23.6	13.9	72	20	7	0.23
			2	5.16	15.9	0.72	23.9	14.1	70	21	9	0.22
			3	5.22	13.5	0.60	19.9	9.6	76	19	6	0.21

Table S2: Statistics of the linear mixed effects models (Type III Analysis of Variance Table with Satterthwaite's method) for the fixed effects and their interaction. Significant *p*-values are given in bold.

	F	<i>p</i> -value
Fine root biomass		
Species	20.86	<0.001
Region	23.58	<0.001
Species:region	2.45	0.10
Fine root necromass		
Species	21.82	<0.001
Region	157.17	<0.001
Species:region	11.94	<0.001
Live dead ratio		
Species	23.85	<0.001
Region	0.00	1.00
Species:region	0.91	0.46
Fine root production		
Species	10.36	<0.001
Region	39.37	<0.001
Species:region	14.322	<0.001
Longevity		
Species	4.54	0.02
Region	1.84	0.19
Species:region	3.18	0.05
RTD		
Species	42.15	<0.001
Region	0.09	0.77
Species:region	0.79	0.52
SRL		
Species	10.29	0.001
Region	0.80	0.39
Species:region	0.47	0.71
Diameter		
Species	37.40	<0.001
Region	0.18	0.68
Species:region	2.71	0.08
SRA		
Species	5.24	0.01
Region	1.86	0.19
Species:region	0.02	0.99
Root tip frequency		
Species	47.51	<0.001
Region	3.15	0.08
Species:region	9.65	<0.001
BRI		
Species	66.22	<0.001
Region	0.10	0.75
Species:region	18.76	<0.001
Root nitrogen		
Species	3.64	0.04
Region	4.16	0.06
Species:region	2,23	0.14
PC1		
Species	9.01	<0.001
Region	0.02	0.98
Species:region	1.73	0.16
PC2		
Species	32.57	<0.001
Region	0.21	0.65
Species:region	0.06	0.98

Table S3: Spearman rank correlations between fine root traits and stand and soil characteristics. Given are correlation coefficients and p -values. Significant p -values are printed in bold.

	Biomass		Necromass		Production		Longevity	
	ρ	p	ρ	p	ρ	p	ρ	p
Stand characteristics								
Basal area	0.09	0.673	0.31	0.146	0.07	0.762	0.01	0.956
N stems per ha	0.02	0.930	0.27	0.203	0.45	0.029	0.19	0.373
Age	0.41	0.049	0.09	0.674	-0.01	0.958	0.17	0.425
Soil characteristics								
pH (H ₂ O)	0.09	0.691	-0.27	0.208	0.05	0.806	-0.13	0.553
C/N	0.00	0.992	0.42	0.042	0.17	0.431	0.11	0.598
CEC ($\mu\text{molc g}^{-1}$)	0.01	0.972	0.19	0.373	0.16	0.441	0.17	0.439
Base saturation	-0.40	0.054	-0.60	0.002	-0.41	0.048	-0.21	0.312
Water capacity	0.22	0.298	0.16	0.451	0.31	0.147	-0.18	0.396