

Biomass partitioning and growth efficiency in four naturally regenerated forest tree species

Article

Accepted Version

Postprint - Appendix

Konopka, B., Pajtik, J., Moravcik, M. and Lukac, M. ORCID: <https://orcid.org/0000-0002-8535-6334> (2010) Biomass partitioning and growth efficiency in four naturally regenerated forest tree species. Basic and Applied Ecology, 11 (3). pp. 234-243. ISSN 1439-1791 doi: 10.1016/j.baae.2010.02.004 Available at <https://centaur.reading.ac.uk/18389/>

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To link to this article DOI: <http://dx.doi.org/10.1016/j.baae.2010.02.004>

Publisher: Elsevier

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Appendix A

Table 1 Site characteristics of selected European beech plots.

Locality	ŠLP I	SLP II	Sekier I	Sekier II	Hrochoť	Kráľová	Zvolen
Altitude (m a.s.l.)	710	675	670	660	620	550	460
Longitude (°) (') (")	19°00'23"	19°03'17"	19°13'26"	19°13'18"	19°17'01"	19°09'36"	19°07'36"
Latitude (°) (') (")	48°37'56"	48°38'45"	48°29'57"	48°29'58"	48°39'30"	48°32'05"	48°33'10"
Exposition	W	SW	N	NW	NW	NW	N
Slope (%)	15	40	50	50	20	20	20
Average annual temperature (°C)	6.8	7.0	6.8	6.8	6.9	7.5	7.9
Annual precipitation (mm)	920	900	826	824	764	766	740
Soil group (FAO)	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol
Geobiocenological unit	<i>Fagetum typicum</i>	<i>Fagetum typicum</i>	<i>Fagetum typicum</i>	<i>Fagetum typicum</i>	<i>Fagetum pauper</i>	<i>Fagetum pauper</i>	<i>Querceto Fagetum</i>
Mean age (years)	9.0	6.0	9.0	4.0	8.0	6.0	3.0
Mean diameter d_0 (mm)	25.0	14.5	20.0	7.0	18.8	12.5	3.5
Mean height (m)	1.71	1.32	2.44	0.54	2.23	1.17	0.58
Canopy closure (%)	75	85	95	70	100	95	95
Basal area ($\text{m}^2 \cdot \text{ha}^{-1}$)	15.08	14.46	31.66	4.39	43.72	38.41	29.70
Number of trees in full canopy (thousand per ha)	36	92	73	146	121	251	783

Table 2 Site characteristics of selected Sessile oak plots

Locality	Antol	Ladzany I	Ladzany II	Krupina I	Krupina II	Žibritov I	Žibritov II
Altitude (m a.s.l.)	560	480	500	460	380	480	480
Longitude (°) (') (")	18°57'18"	18°51'33"	18°50'56"	19°01'21"	19°05'05"	19°01'58"	19°01'42"
Latitude (°) (') (")	48°22'12"	48°17'27"	48°17'33"	48°20'19"	48°22'44"	48°22'46"	48°22'53"
Exposition	E	SW	E	SE	N	S	S
Slope (%)	35	10	5	10	10	20	10
Average annual temperature (°C)	7.6	7.9	7.7	8.3	8.1	7.8	7.7
Annual precipitation (mm)	825	801	823	709	692	763	776
Soil group (FAO)	Cambisol	Luvisol	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol
Geobiocenological unit	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>
Mean age (years)	5.5	12.0	2.5	7.5	1.5	4.0	8.0
Mean diameter d_0 (mm)	13.6	37.9	4.1	18.6	2.7	5.9	17.6
Mean height (m)	1.01	5.07	0.26	2.00	0.16	0.47	2.99
Canopy closure (%)	90	95	75	95	60	80	95
Basal area ($\text{m}^2 \cdot \text{ha}^{-1}$)	16.21	16.95	7.20	24.40	2.65	11.43	13.64
Number of trees in full canopy (thousand per ha)	84	13	428	64	463	289	46

Table 3 Site characteristics of selected Scots pine plots

Locality	Kopčany I	Zolná	Kováčová	Kišovce	Žiar n/Hr.	Levoča	Kopčany II
Altitude (m a.s.l.)	165	430	380	640	380	620	165
Longitude (°) (') (")	17°04'55"	19°13'21"	19°04'24"	20°22'24"	18°52'33"	20°30'52"	17°04'50"
Latitude (°) (') (")	48°45'16"	48°37'11"	48°35'38"	49°01'43"	48°36'11"	49°01'07"	48°45'19"
Exposition	flat	SE	E	S	E	NE	flat
Slope (%)	0	5	15	20	15	10	0
Average annual temperature (°C)	9.9	7.7	8.0	6.2	8.2	6.2	9.9
Annual precipitation (mm)	606	714	744	639	776	644	606
Soil group (FAO)	Regosol	Luvisol	Luvisol	Leptosol	Cambisol	Cambisol	Regosol
Geobiocenological unit	<i>Carpineto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Fageto Quercetum</i>	<i>Piceeto Pinetum inferiorum</i>	<i>Fageto Quercetum</i>	<i>Pinetum dealpinum superiorum</i>	<i>Carpineto Quercetum</i>
Mean age (years)	3.0	5.0	5.0	6.0	6.0	8.0	8.0
Mean diameter d_0 (mm)	14.9	28.6	37.4	21.2	43.6	41.3	36.9
Mean height (m)	0.68	1.33	1.50	1.31	2.20	2.63	3.02
Canopy closure (%)	82	92	75	77	85	90	100
Basal area ($m^2 \cdot ha^{-1}$)	12.56	23.99	18.23	14.77	26.47	31.14	55.66
Number of trees in full canopy (thousand per ha)	70	31	16	36	18	19	43

Table 4 Site characteristics of selected Norway spruce plots

Locality	Poľana I	Poľana II	Drakšiar I	Drakšiar II	Bacúch	Č. Váh I	Č. Váh II
Altitude (m a.s.l.)	985	790	625	635	840	820	830
Longitude (°) (') (")	19°31'05"	19°32'15"	19°47'29"	19°47'37"	19°49'00"	19°57'52"	19°57'54"
Latitude (°) (') (")	48°38'31"	48°38'32"	48°50'58"	48°50'59"	48°54'05"	48°59'04"	48°59'03"
Exposition	E	SW	SW	SW	S	NE	NE
Average annual temperature (°C)	5.3	6.0	6.3	6.3	4.8	5.0	5.0
Annual precipitation (mm)	982	902	865	867	1021	865	865
Slope (%)	20	10	5	5	45	60	20
Soil group (FAO)	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol	Cambisol	Podsol
Geobiocenological unit	<i>Fagetum typicum</i>	<i>Fagetum typicum</i>	<i>Abieto Fagetum inferiorum</i>	<i>Abieto Fagetum inferiorum</i>	<i>Abieto Fagetum superiorum</i>	<i>Fagetum abietino-piceosum</i>	<i>Fagetum abietino-piceosum</i>
Mean age (years)	9.0	4.0	4.5	7.0	1.5	9.5	8.5
Mean diameter d_0 (mm)	25.7	5.2	11.6	15.6	4.6	24.5	17.2
Mean height (m)	2.13	0.34	0.68	0.92	0.22	1.81	1.29
Canopy closure (%)	95	80	80	70	30	90	95
Basal area ($m^2 \cdot ha^{-1}$)	28.5	4.7	8.8	10.7	1.5	28.4	34.2
Number of trees in full canopy (thousand per ha)	58	279	104	80	293	67	155

Table 5 European beech; regression coefficients b_0 , b_1 , b_2 , their standard errors (S.E.), p-value (P), coefficient of determination (R^2), mean squared error (MSE), logarithmic transformation bias λ and its standard deviation (S.D.) for Eqs. (1)-(3)

Eq.	Tree compartment	b_0	S.E.	P	b_1	S.E.	P	b_2	S.E.	P	R^2	MSE	λ	S.D.
(1)	Stem	-4.034	0.164	<0.001	2.852	0.063	<0.001				0.923	0.167	1.0836	0.438
	Branches	-5.982	0.218	<0.001	3.117	0.084	<0.001				0.891	0.295	1.142	0.592
	Leaves	-3.750	0.183	<0.001	2.375	0.071	<0.001				0.871	0.207	1.102	0.486
	Roots	-2.960	0.179	<0.001	2.361	0.069	<0.001				0.874	0.199	1.098	0.495
	Aboveground	-3.288	0.144	<0.001	2.777	0.056	<0.001				0.937	0.129	1.063	0.364
	Whole tree	-2.521	0.132	<0.001	2.639	0.051	<0.001				0.941	0.108	1.053	0.336
(2)	Stem	3.108	0.043	<0.001	2.302	0.073	<0.001				0.854	0.318	1.166	0.672
	Branches	1.833	0.069	<0.001	2.324	0.117	<0.001				0.703	0.803	1.474	1.671
	Leaves	2.206	0.058	<0.001	1.712	0.098	<0.001				0.643	0.573	1.308	1.068
	Roots	2.964	0.061	<0.001	1.651	0.102	<0.001				0.607	0.620	1.298	0.949
	Aboveground	3.669	0.048	<0.001	2.161	0.082	<0.001				0.806	0.396	1.216	0.855
	Whole tree	4.094	0.050	<0.001	2.000	0.085	<0.001				0.767	0.427	1.226	0.853
(3)	Stem	-1.530	0.163	<0.001	1.848	0.065	<0.001	1.015	0.054	<0.001	0.975	0.054	1.026	0.222
	Branches	-4.768	0.364	<0.001	2.630	0.144	<0.001	0.423	0.121	<0.001	0.901	0.270	1.130	0.560
	Leaves	-3.286	0.317	<0.001	2.188	0.126	<0.001	0.188	0.105	0.076	0.873	0.205	1.100	0.479
	Roots	-2.898	0.314	<0.001	2.336	0.124	<0.001	0.025	0.104	0.809	0.874	0.200	1.098	0.493
	Aboveground	-1.486	0.186	<0.001	2.054	0.074	<0.001	0.731	0.062	<0.001	0.966	0.070	1.034	0.266
	Whole tree	-1.236	0.197	<0.001	2.124	0.078	<0.001	0.521	0.065	<0.001	0.957	0.079	1.038	0.285

Table 6 Sessile oak; regression coefficients b_0 , b_1 , b_2 , their standard errors (S.E.), p-value (P), coefficient of determination (R^2), mean squared error (MSE), logarithmic transformation bias λ and its standard deviation (S.D.) for Eqs. (1)-(3)

Eq.	Tree compartment	b_0	S.E.	P	b_1	S.E.	P	b_2	S.E.	P	R^2	MSE	λ	S.D.
(1)	Stem	-4.311	0.224	<0.001	2.959	0.071	<0.001				0.942	0.240	1.121	0.544
	Branches	-6.025	0.215	<0.001	2.963	0.068	<0.001				0.947	0.221	1.107	0.496
	Leaves	-5.954	0.221	<0.001	2.768	0.070	<0.001				0.936	0.234	1.106	0.459
	Roots	-1.954	0.150	<0.001	2.066	0.046	<0.001				0.941	0.124	1.065	0.401
	Aboveground	-3.952	0.206	<0.001	2.931	0.065	<0.001				0.950	0.203	1.099	0.469
	Whole tree	-2.612	0.175	<0.001	2.646	0.005	<0.001				0.956	0.146	1.070	0.382
(2)	Stem	3.471	0.045	<0.001	2.516	0.046	<0.001				0.965	0.147	1.074	0.419
	Branches	1.839	0.086	<0.001	2.388	0.089	<0.001				0.871	0.535	1.271	0.896
	Leaves	1.370	0.074	<0.001	2.269	0.077	<0.001				0.891	0.398	1.190	0.700
	Roots	3.511	0.053	<0.001	1.719	0.051	<0.001				0.898	0.213	1.112	0.553
	Aboveground	3.769	0.050	<0.001	2.468	0.052	<0.001				0.954	0.186	1.095	0.483
	Whole tree	4.369	0.051	<0.001	2.207	0.053	<0.001				0.942	0.189	1.099	0.503
(3)	Stem	-0.066	0.170	0.698	1.324	0.063	<0.001	1.491	0.053	<0.001	0.993	0.029	1.014	0.171
	Branches	-4.263	0.432	<0.001	2.284	0.161	<0.001	0.619	0.135	<0.001	0.956	0.186	1.092	0.473
	Leaves	-3.577	0.412	<0.001	1.852	0.153	<0.001	0.835	0.129	<0.001	0.954	0.169	1.077	0.399
	Roots	-0.226	0.289	0.436	1.398	0.107	<0.001	0.611	0.091	<0.001	0.956	0.092	1.047	0.333
	Aboveground	-0.201	0.194	0.303	1.486	0.072	<0.001	1.317	0.061	<0.001	0.991	0.038	1.019	0.199
	Whole tree	0.389	0.201	0.056	1.490	0.075	<0.001	1.054	0.063	<0.001	0.989	0.040	1.020	0.209

Table 7 Scots pine; regression coefficients b_0 , b_1 , b_2 , their standard errors (S.E.), p -value (P), coefficient of determination (R^2), mean squared error (MSE), logarithmic transformation bias λ and its standard deviation (S.D.) for Eqs. (1)-(3)

Eq.	Tree compartment	b_0	S.E.	P	b_1	S.E.	P	b_2	S.E.	P	R^2	MSE	λ	S.D.
(1)	Stem	-3.143	0.122	<0.001	2.480	0.038	<0.001				0.960	0.131	1.067	0.395
	Branches	-3.985	0.125	<0.001	2.515	0.039	<0.001				0.960	0.138	1.072	0.435
	Needles	-1.961	0.144	<0.001	2.014	0.045	<0.001				0.920	0.183	1.089	0.456
	Roots	-3.628	0.130	<0.001	2.236	0.041	<0.001				0.946	0.149	1.079	0.479
	Aboveground	-1.698	0.097	<0.001	2.290	0.030	<0.001				0.970	0.083	1.041	0.306
	Whole tree	-1.531	0.089	<0.001	2.278	0.028	<0.001				0.975	0.069	1.035	0.282
(2)	Stem	3.958	0.043	<0.001	2.389	0.057	<0.001				0.912	0.293	1.156	0.648
	Branches	3.246	0.062	<0.001	2.304	0.081	<0.001				0.824	0.601	1.323	1.003
	Needles	3.843	0.060	<0.001	1.805	0.078	<0.001				0.755	0.560	1.273	0.852
	Roots	2.824	0.067	<0.001	1.965	0.087	<0.001				0.745	0.694	1.387	1.173
	Aboveground	4.880	0.050	<0.001	2.134	0.065	<0.001				0.862	0.388	1.200	0.725
	Whole tree	5.013	0.051	<0.001	2.108	0.066	<0.001				0.854	0.402	1.209	0.752
(3)	Stem	-0.702	0.152	<0.001	1.618	0.052	<0.001	0.944	0.052	<0.001	0.987	0.045	1.023	0.231
	Branches	-3.184	0.257	<0.001	2.232	0.089	<0.001	0.310	0.088	<0.001	0.962	0.129	1.066	0.403
	Needles	-1.901	0.307	<0.001	1.993	0.106	<0.001	0.024	0.105	0.822	0.920	0.184	1.089	0.457
	Roots	-4.105	0.273	<0.001	2.405	0.094	<0.001	-0.184	0.093	0.050	0.947	0.146	1.078	0.487
	Aboveground	-0.466	0.177	0.009	1.856	0.061	<0.001	0.476	0.060	<0.001	0.978	0.061	1.031	0.269
	Whole tree	-0.502	0.167	0.003	1.914	0.057	<0.001	0.398	0.057	<0.001	0.980	0.054	1.028	0.253

Table 8 Norway spruce; regression coefficients b_0 , b_1 , b_2 , their standard errors (S.E.), p -value (P), coefficient of determination (R^2), mean squared error (MSE), logarithmic transformation bias λ and its standard deviation (S.D.) for Eqs. (1)-(3)

Eq.	Tree compartment	b_0	S.E.	P	b_1	S.E.	P	b_2	S.E.	P	R^2	MSE	λ	S.D.
(1)	Stem	-3.084	0.069	<0.001	2.459	0.024	<0.001				0.986	0.090	1.046	0.324
	Branches	-3.452	0.099	<0.001	2.482	0.035	<0.001				0.971	0.185	1.093	0.488
	Needles	-2.589	0.099	<0.001	2.317	0.035	<0.001				0.967	0.185	1.082	0.397
	Roots	-2.460	0.070	<0.001	2.114	0.025	<0.001				0.980	0.095	1.046	0.309
	Aboveground	-1.842	0.069	<0.001	2.398	0.024	<0.001				0.985	0.088	1.043	0.296
	Whole tree	-1.432	0.060	<0.001	2.333	0.021	<0.001				0.988	0.067	1.033	0.258
(2)	Stem	4.010	0.035	<0.001	2.398	0.033	<0.001				0.972	0.178	1.092	0.484
	Branches	3.704	0.056	<0.001	2.376	0.054	<0.001				0.930	0.453	1.245	0.921
	Needles	4.090	0.058	<0.001	2.200	0.055	<0.001				0.914	0.486	1.232	0.816
	Roots	3.640	0.052	<0.001	2.004	0.049	<0.001				0.919	0.386	1.198	0.748
	Aboveground	5.072	0.047	<0.001	2.307	0.044	<0.001				0.949	0.308	1.160	0.684
	Whole tree	5.304	0.047	<0.001	2.239	0.044	<0.001				0.948	0.300	1.157	0.676
(3)	Stem	-0.469	0.201		1.555	0.070	<0.001	0.913	0.068	<0.001	0.994	0.041	1.020	0.205
	Branches	-2.553	0.417	<0.001	2.171	0.144	<0.001	0.313	0.141	0.028	0.972	0.180	1.089	0.460
	Needles	-2.487	0.426	<0.001	2.282	0.147	<0.001	0.036	0.144	0.805	0.967	0.186	1.082	0.396
	Roots	-2.869	0.304	<0.001	2.254	0.105	<0.001	-0.142	0.103	0.169	0.980	0.094	1.045	0.306
	Aboveground	-0.696	0.281	0.014	2.002	0.097	<0.001	0.400	0.095	<0.001	0.987	0.079	1.037	0.274
	Whole tree	-0.579	0.251	0.023	2.039	0.087	<0.001	0.297	0.085	<0.001	0.989	0.062	1.030	0.248

Fig. 1 Biomass allocation coefficients based on tree height (m) at three levels of height increment of 0.1, 0.3 and 0.5 m per annum.

Fig. 2 Inter-specific comparison of growth efficiency of stem (GE I, g g^{-1}) and woody biomass (GE II, g g^{-1}) at medium range height increment (0.3 m y^{-1}).

Fig. 3 Growth efficiency of stem (GE I, g g^{-1}) and woody biomass (GE II, g g^{-1} , left axis) at three levels height (h, m) increment and dry foliage biomass (DW, g, right axis).

Fig. 1

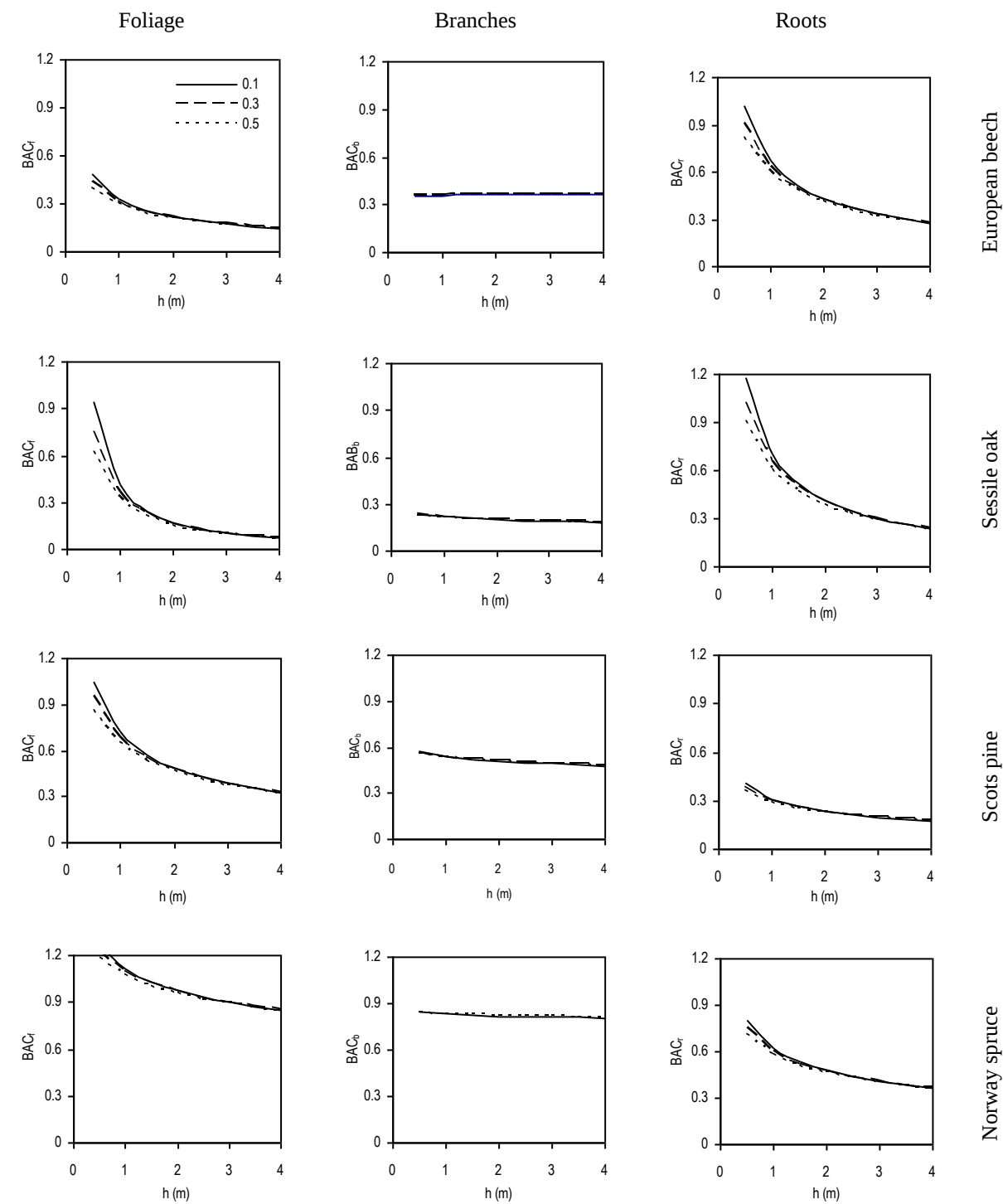


Fig. 2

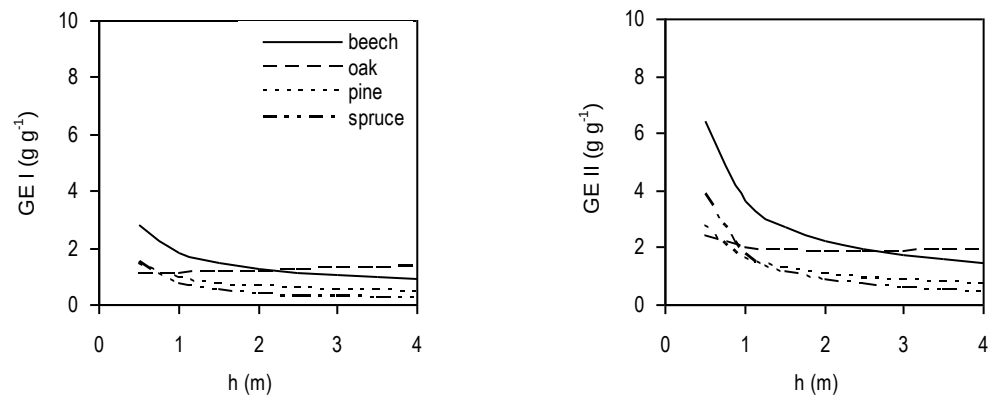


Fig. 3

