Relationships between aboveground and belowground biomass stock – a case study from mountain area temperate forests in the northern Carpathians

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OBJECTIVES

(1) estimate the soil organic matter (SOM) stock in mountain temperate forests in the Western Carpathians

(2) estimate fine roots biomass (FRB) in soils under three tree species (beech, spruce, fir)

(3) assess the relationship between aboveground biomass (AGB), SOM stocks and FRB for beech-, spruce- and fir-dominated forests

(4) assess the effects of selected abiotic factors (i.e. elevation, aspect, slope, mean annual air temperature, mean annual precipitation) on SOM and FRB stocks found in beech-, spruce- and fir-dominated forests in the Western Carpathians

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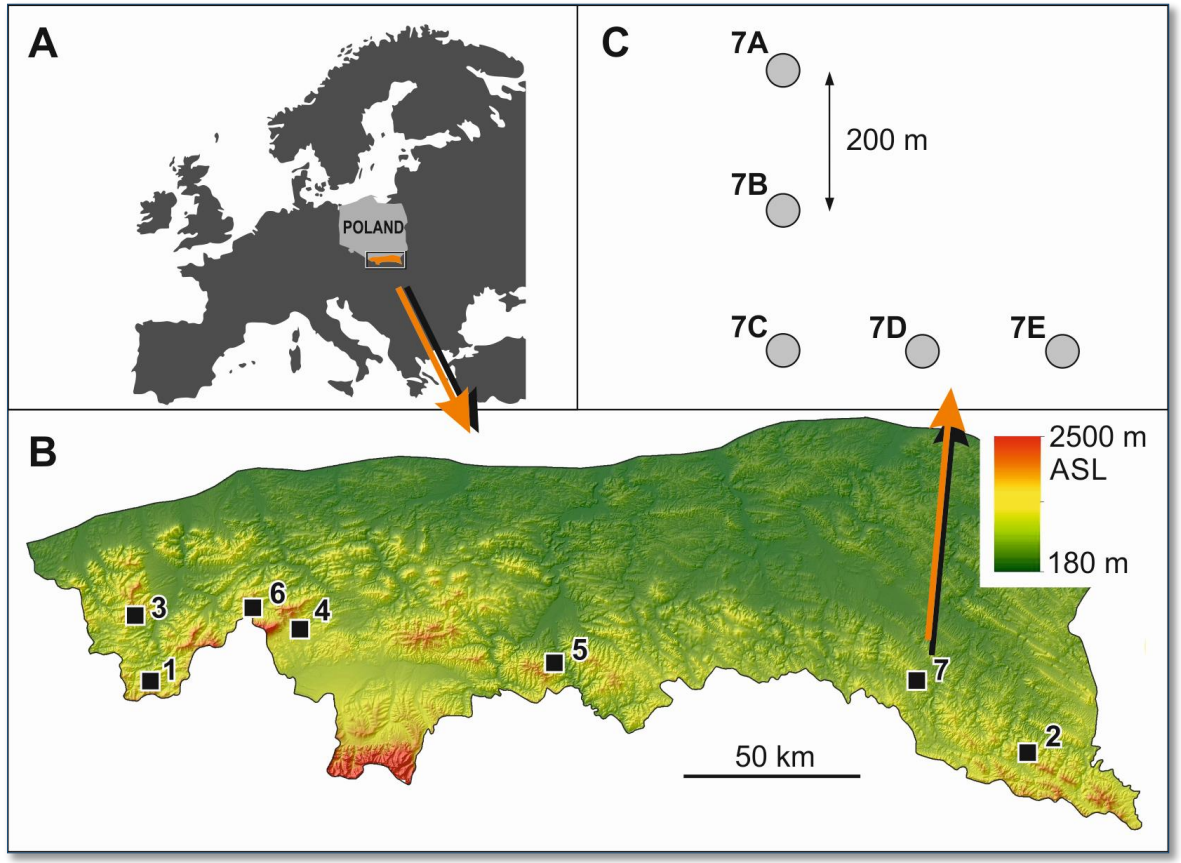
STUDY AREA



Study site	Coordinates	Elevation range min-max (m a.s.l.)	MAT (°C)	MAP (mm)
1	49°26'54"N 19°03'05"E	701-808	5.1	1127
2	49°11'30"N 22°28'12"E	940-1067	4.6	1068
3	49°38'01"N 18°58'36"E	768-887	5.2	1103
4	49°34'28"N 19°41'09"E	706-753	5.5	978
5	49°29'27"N 20°36'35'E	575-658	6.3	1021
6	49°37'44"N 19°28'30"E	836-937	4.8	1134
7	49°25'10"N 22°01'56"E	602-624	6.1	870

At each study site (1-7) 5 study plots (12 m radius) from National Forest Inventory taken under consideration.

One soil pit at each study site (profile labeled 'C') was excavated to the lithic contact (7 reference pedons); in other study plots soil pits were excavated to approx. 50 cm (25 pedons).

Each plot classified based on dominating AGB species (> 75% of total AGB*)
*AGB – live woody tree biomass

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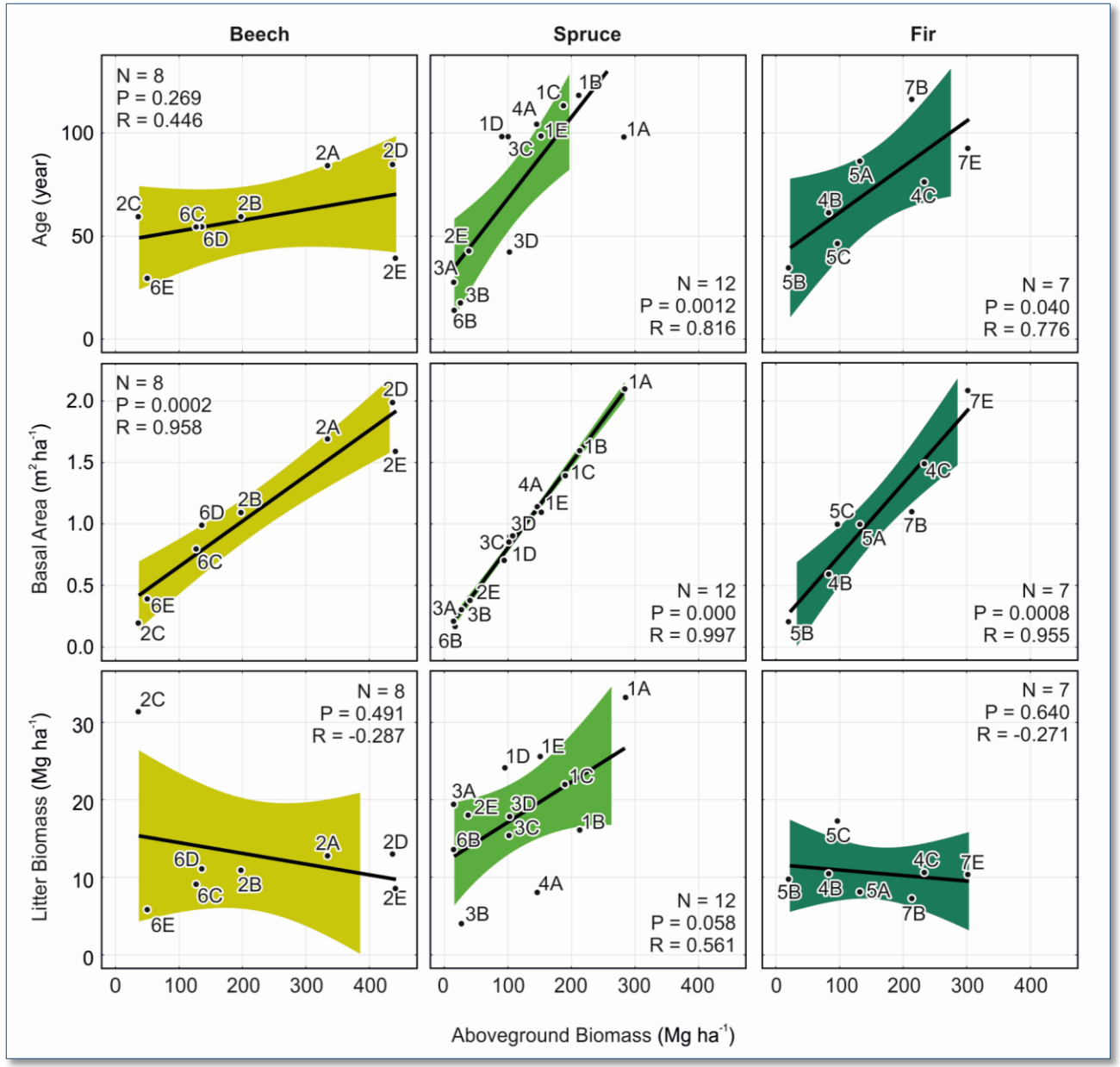
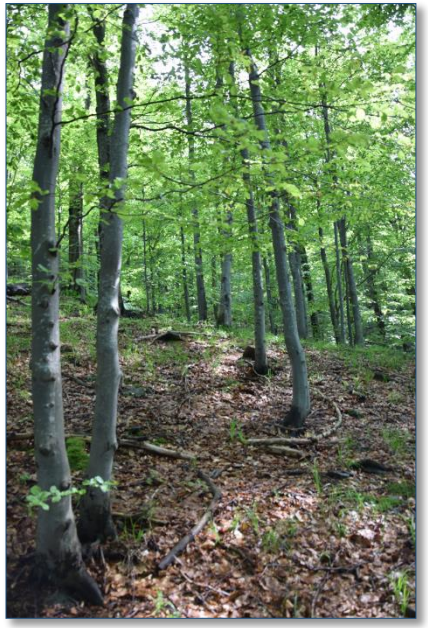
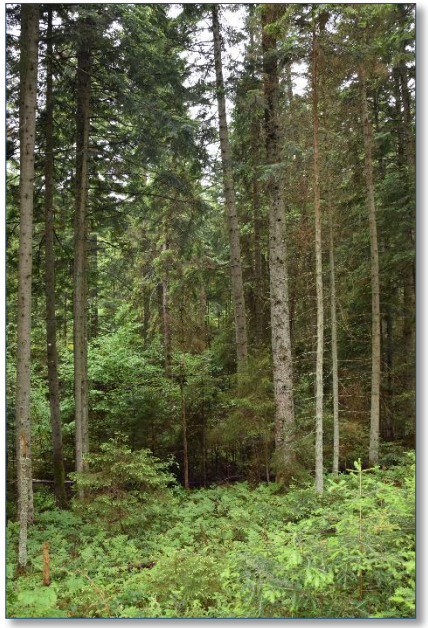
RESULTS

Aboveground biomass



The highest values were identified for beech-dominated forests (more than ~440 Mg ha^{-1}), while the lowest values in beech-dominated stands were less than 40 Mg ha^{-1}. The AGB stock in spruce-dominated stands ranged from ~15 to ~280 Mg ha^{-1}. Among the fir stands, AGB stock varied from ~20 Mg ha^{-1} to ~300 Mg ha^{-1}.





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RESULTS

Soils morphology and properties (7 reference pedons)

Depth	Horizon	Sand	Silt	Clay	Texture[3]	SOC	C/N	pH
(cm)		(%)				(%)		(H_2O)
Profile 1C. Epidystric Cambisol (Humic, Loamic)								
2-0	Oi	n.a.	n.a.	n.a.	n.a.	24.03	21	4.25
0-14	A	n.a.	n.a.	n.a.	n.a.	3.92	9	4.29
14-64	Bw	33	20	47	L	2.12	10	4.56
64-98	BC	33	20	47	L	1.59	9	4.90
98-(125)	C	-	-	-	-	1.68	n.a.	5.32
Profile 2C. Orthodystric Endoskeletic Endogleyic Cambisol (Humic, Loamic)								
0-3	Oa	n.a.	n.a.	n.a.	n.a.	21.52	25	4.28
3-10	A	n.a.	n.a.	n.a.	n.a.	4.28	10	4.24
10-30	AB	42	20	38	L	2.99	11	4.76
30-55	Bw	42	20	38	L	2.34	12	4.62
55-73	BC	n.a.	n.a.	n.a.	n.a.	1.73	11	4.64
73- (90)	C	n.a.	n.a.	n.a.	n.a.	1.20	n.a.	4.78
Profile 3C. Dystric Orthoskeletic Cambisol (Loamic)								
4-0	Oa	n.a.	n.a.	n.a.	n.a.	25.76	21	3.68
0-5	Ah	n.a.	n.a.	n.a.	n.a.	6.16	19	3.58
5-23	Bw	48	19	33	L	3.72	18	3.86
23-(45)	BC	n.a.	n.a.	n.a.	n.a.	1.92	n.a.	4.01
Profile 4C. Epidystric Katogleyic Cambisol (Humic, Loamic)								
3-0	Oi	n.a.	n.a.	n.a.	n.a.	34.31	20	4.38
0-7	A	n.a.	n.a.	n.a.	n.a.	2.22	12	4.42
7-15	AB	n.a.	n.a.	n.a.	n.a.	1.52	12	4.49
15-45	Bw	14	25	61	SiL	1.25	12	4.75
45-50	Bwg1	14	25	61	SiL	0.70	14	4.88
50-80	Bwg2	14	25	61	SiL	0.39	6	5.11
80-(100)	BC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5.21

Depth	Horizon	Sand	Silt	Clay	Texture[3]	SOC	C/N	pH
(cm)		(%)				(%)		(H_2O)
Profile 5C. Orthodystric Cambisol (Loamic)								
3-0	Oi	n.a.	n.a.	n.a.	n.a.	39.45	29	4.39
0-7	A	n.a.	n.a.	n.a.	n.a.	3.43	18	4.09
7-16	AB	n.a.	n.a.	n.a.	n.a.	1.30	13	4.20
16-27	Bw1	53	22	25	SL	1.24	13	4.31
27-48	Bw2	53	22	25	SL	0.69	8	4.13
48-82	BC	53	22	25	SL	n.a.	n.a.	n.a.
82- (111)	C	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Profile 6C. Orthodystric Cambisol (Humic, Loamic)								
3-0	Oa	n.a.	n.a.	n.a.	n.a.	45.17	23	4.72
0-12	A	n.a.	n.a.	n.a.	n.a.	3.88	13	4.12
12-20	AB	n.a.	n.a.	n.a.	n.a.	1.77	13	4.15
20-38	Bw1	40	26	34	L	1.53	12	4.28
38-60	Bw2	40	26	34	L	1.59	13	4.41
60-70	BC	40	26	34	L	1.15	15	4.49
70-(105)	C	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Profile 7C. Orthoeutric Cambisol (Humic, Loamic)								
3-0	Oa	n.a.	n.a.	n.a.	n.a.	39.35	32	4.81
0-28	A	n.a.	n.a.	n.a.	n.a.	1.99	10	6.01
28-63	Bw	3	21	76	SiL	1.14	9	6.39
63-(90)	BC	3	21	76	SiL	0.75	8	6.88

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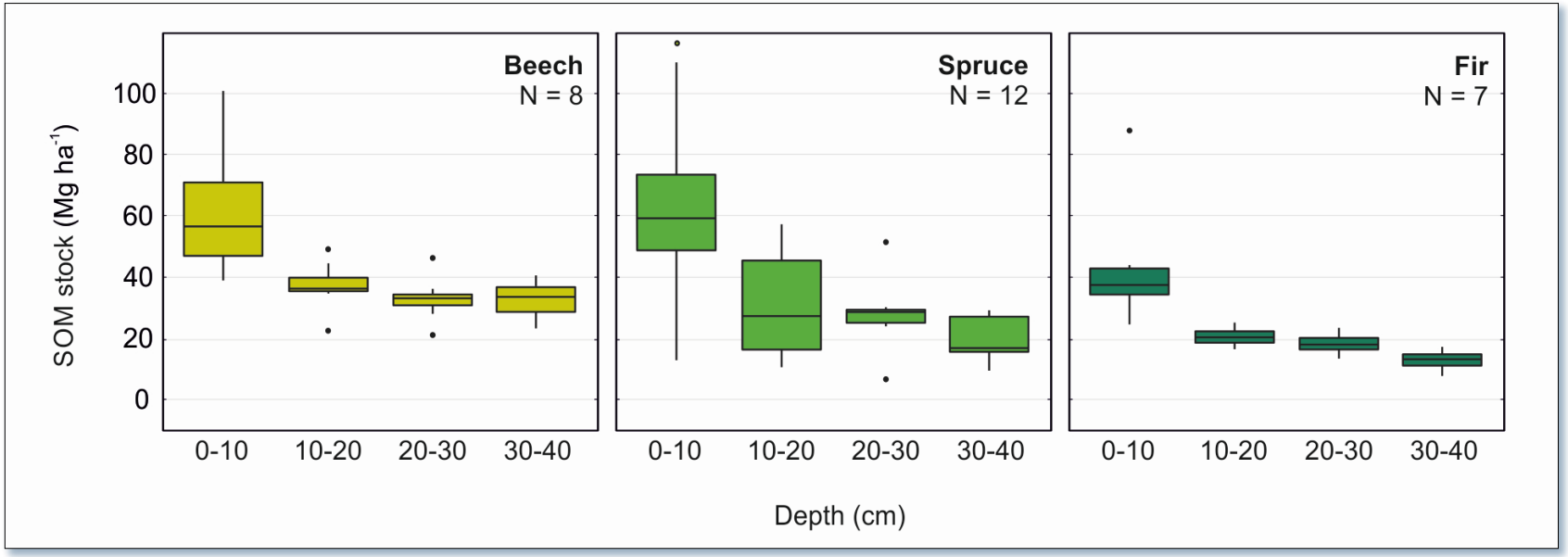
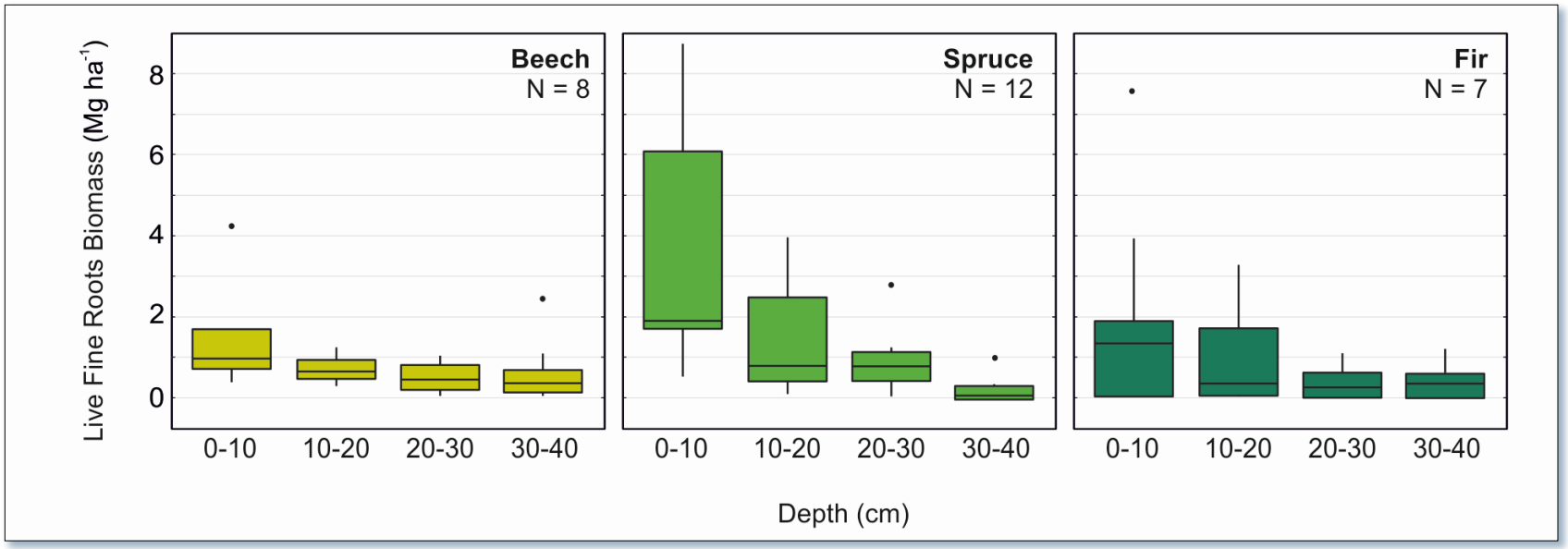
RESULTS Soil Organic Matter Stock and Fine Roots Biomass





Fine Roots Biomass and Soil Organic Matter stocks (0-40 cm depth) at each plot type.

Plot type	average	max	min	Q1	Q3
FRB_beech	3.2	5.5	1.2	1.2	4.1
SOM_beech	162.9	213.3	128.5	147.6	170.1
FRB_spruce	3.4	10.2	0.0	1.5	3.9
SOM_spruce	140.9	224.5	56.6	124.2	162.6
FRB_fir	6.5	13.8	1.2	2.3	11.0
SOM_fir	95.5	143.3	78.6	79.3	97.6

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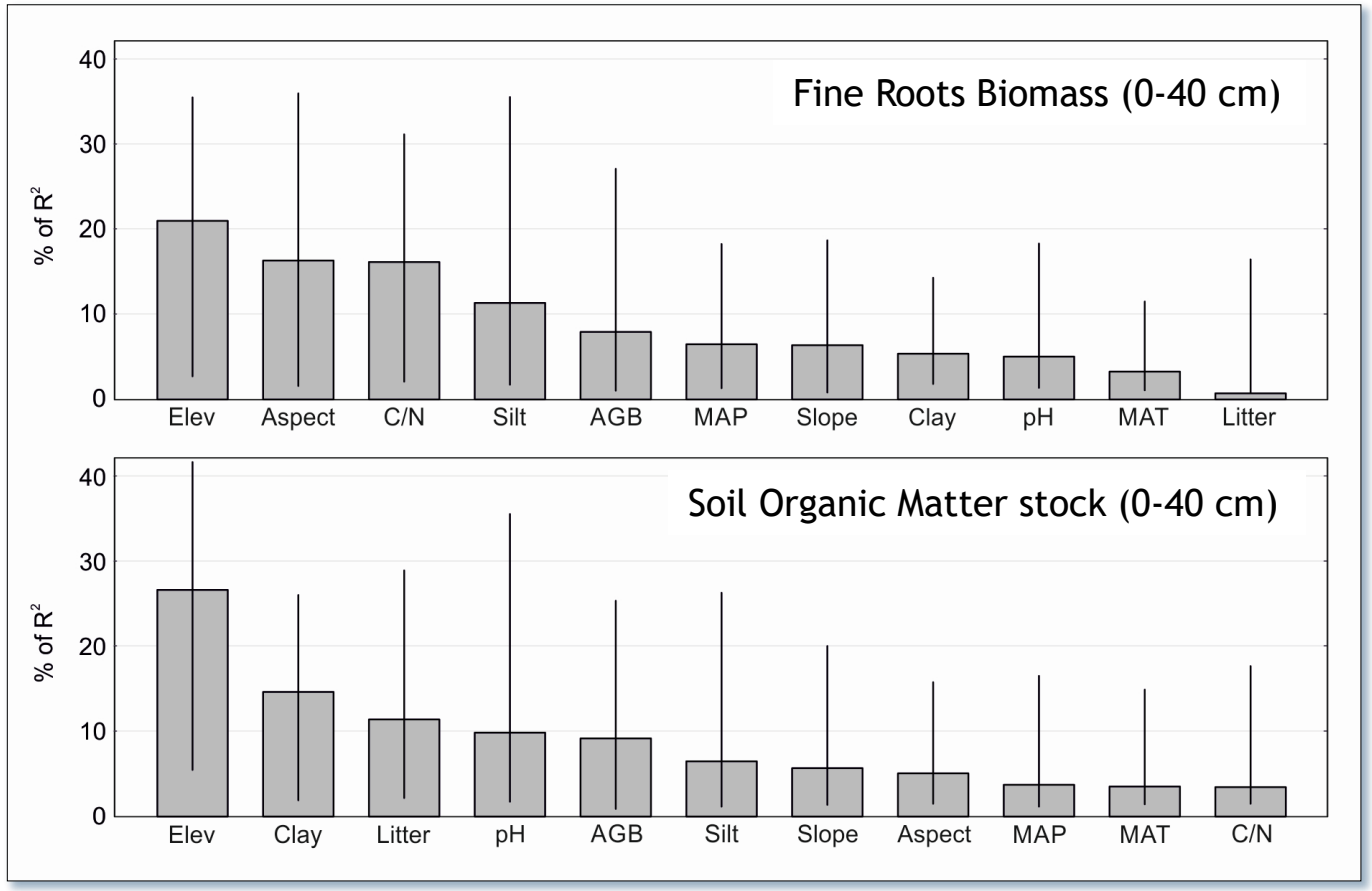
RESULTS



Relative importance of predictors with 95% bootstrap confidence intervals (LMG method, metrics are normalized to sum 100%):
A) Fine Roots Biomass 0-40 cm (R2 = 54.44%,);
B) Soil Organic Matter stock 0-40 cm (R2 = 54.79%).

Assesing relationships between aboveground biommass and belowground biomass (soil organic matter stock and fine roots biomass) and selected abiotic factors

Predictors group	Detailed data	Abbreviations
Aboveground biomass stock	Live woody tree biomass	AGB
	Litter mass	litter
Soil properties	Silt content	Silt
	Clay content	Clay
	pH	pH
	C/N	C/N
Abiotic factors	Elevation	Elev
	Aspect	Aspect
	Slope	Slope
	Mean annual precipitation	MAP
	Mean annual air temperature	MAT

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CONCLUSIONS

- the largest amount of biomass both aboveground and belowground was found in beech-dominated forests

- no statistically significant correlations were noted between aboveground biomass (live woody tree biomass from the forest inventory) and belowground biomass (soil organic matter and fine roots) found under beech-, spruce- and fir-dominated stands (i.e. secondary succession) atop Cambisols in the studied humid mountain-type area

- belowground biomass (i.e. SOM and FRB) is affected for the most part by abiotic factors such as morphologic position, climatic conditions, and soil properties

- we recommend using the results of multiple, fine-scale studies on the environmental background (i.e. biotic and abiotic factors) and forest management history for biomass and carbon modelling. Employing the same models may be an erroneous strategy for different study sites because of local environmental factors that strongly determine aboveground and belowground biomass stock

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