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Supplement of

Distribution of phosphorus fractions with different plant availability in German forest soils and their relationship with common soil properties and foliar P contents

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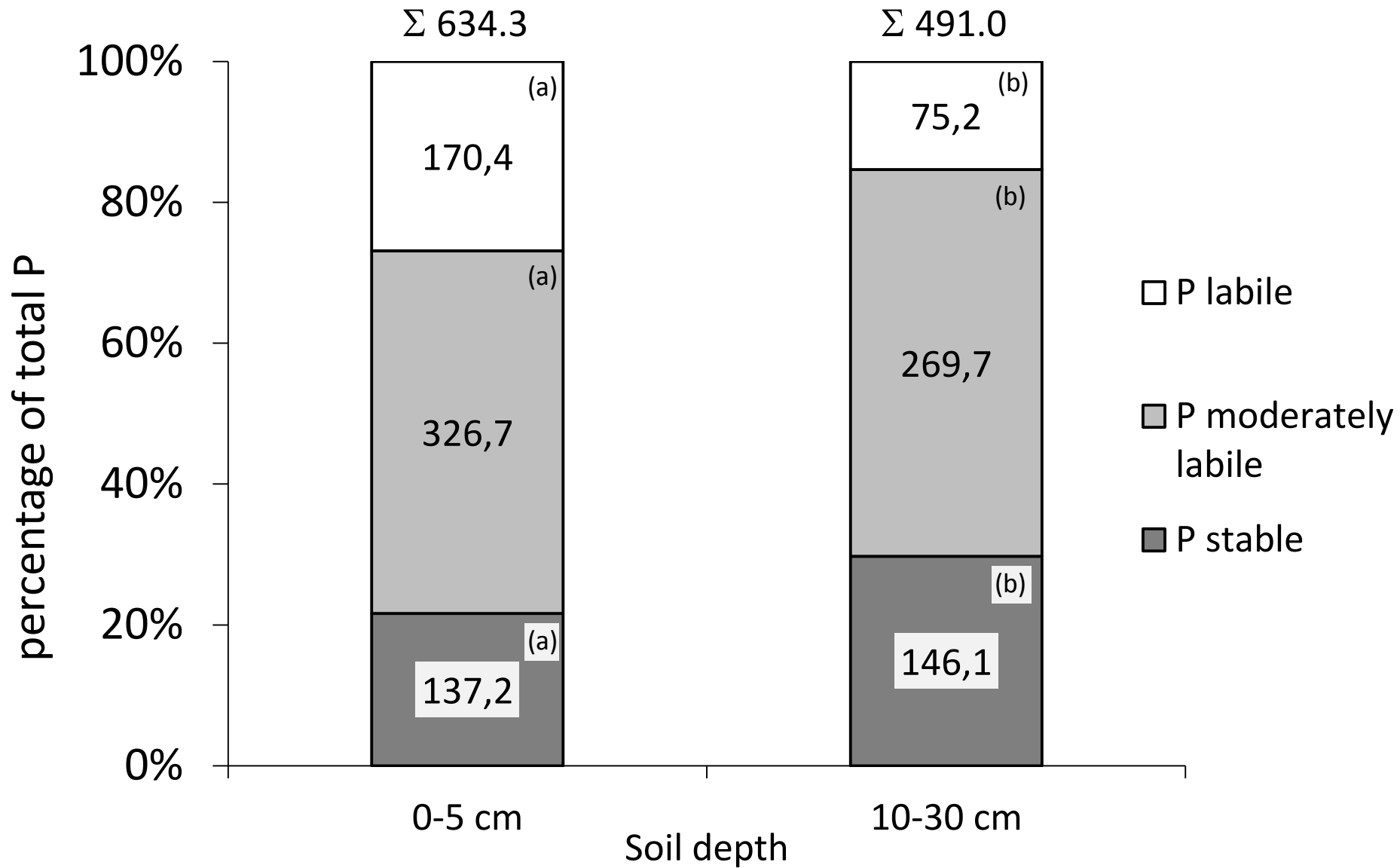


Figure S1: Mean values of P concentration and percentage of total P for all NFSI samples, grouped by depth. Dark grey boxes stable P, light grey boxes moderately labile P, and white boxes labile P, different letters per row showed significant differences in P pools per depths, non-parametric Wilcoxon test, $\alpha < 0.05$.

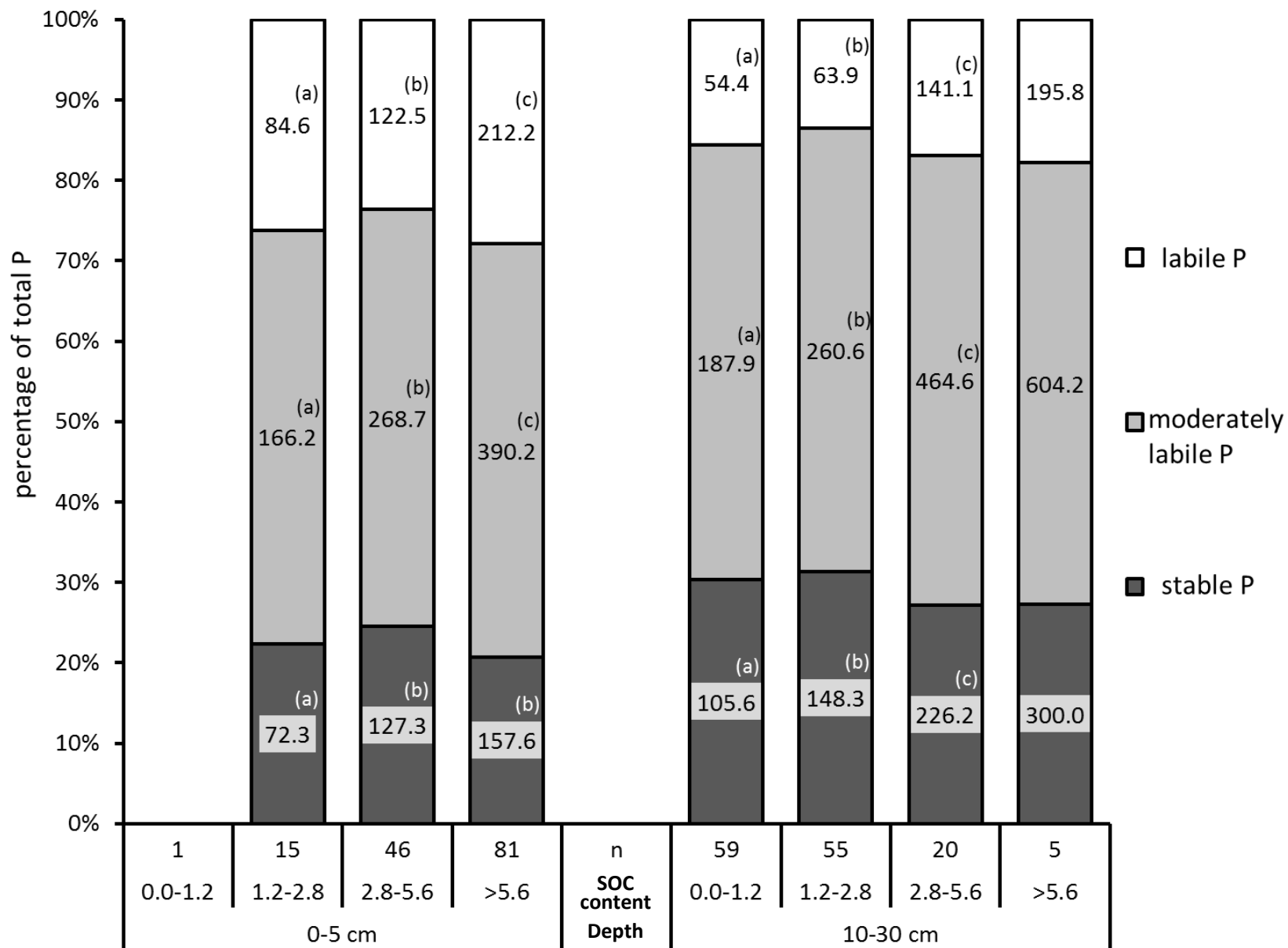


Figure S2: Absolute and relative shares of Hedley P pools and total P (mean values), grouped SOC content in % and depth; different letters per row indicate significant differences in absolute values between SOC classes, non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

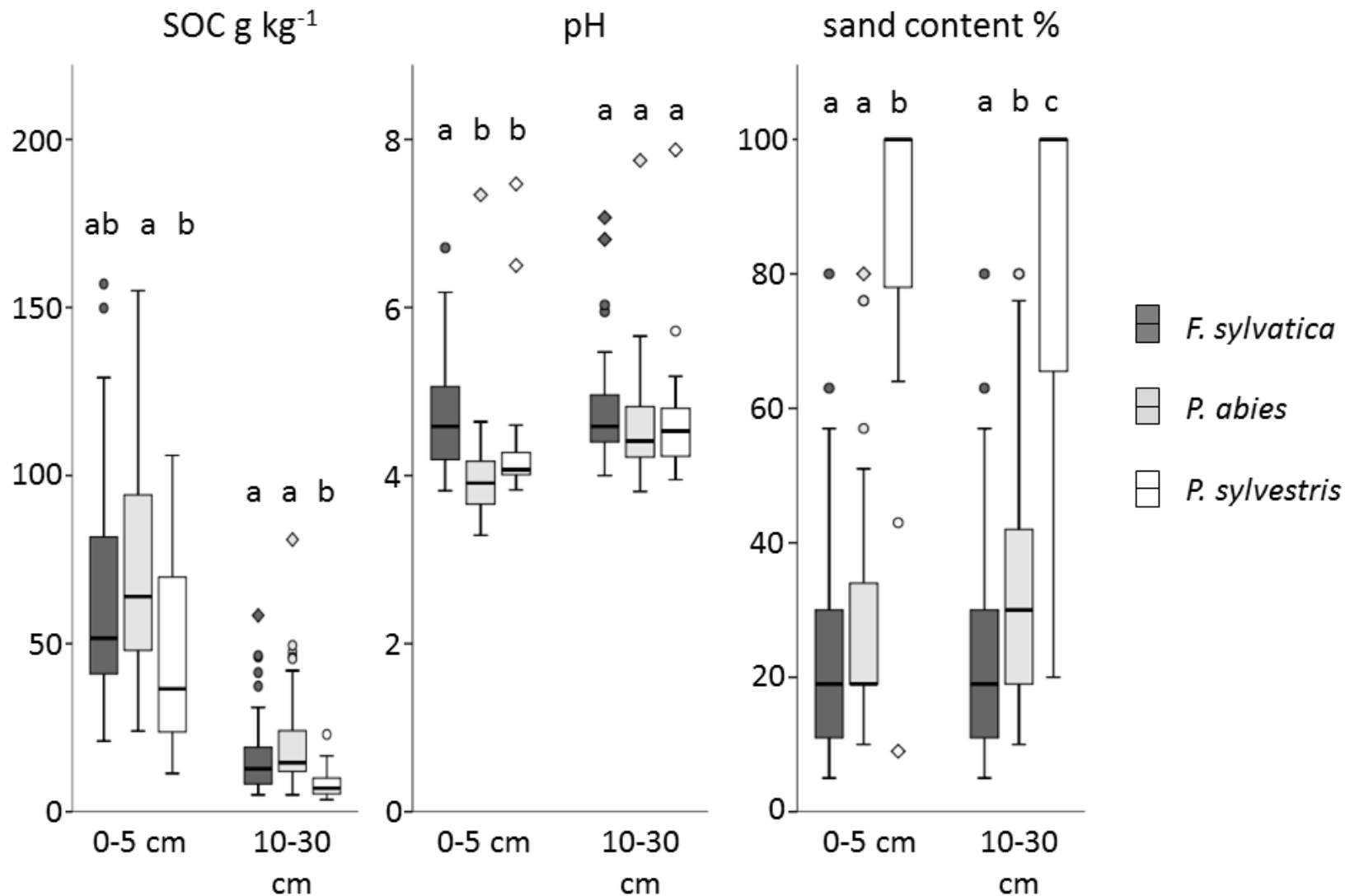


Figure S3: Boxplots of selected soil variables from samples obtained at two depth (0-5 and 10-30 cm) and from sites dominated by three different trees species: *Fagus sylvatica*, *Picea abies*, and *Pinus sylvestris*. Different letters indicate significant differences of soil variables between depths in subject to tree species (non-parametric Mann-Whitney-U-test, $\alpha < 0.05$).

Table S1: Mean values (\pm standard deviation) of Hedley P fractions for all soil samples separated by depth (all values in mg kg⁻¹) and relative shares of P pools to the sum of all Hedley P fractions.

P fraction	P pool	0-5 cm depth		10-30 cm depth		#)
		n = 139 [§])		n = 139 [§])		
		%	mg kg ⁻¹	%	mg kg ⁻¹	
Pi resin			49.9 ±36.9		21.1 ±24.7	***
Pi NaHCO ₃	P labile	26.9 %	33.7 ±40.5	15.3 %	22.5 ±36.7	***
Po NaHCO ₃			86.8 ±57.9		31.7 ±29.6	***
Pi NaOH	P		85.3 ±92.9		96.7 ±106.0	
Po NaOH	moderately labile	51.5 %	194.2 ±136.9	54.9 %	118.2 ±103.2	***
Pi 1M HCl			47.2 ±95.9		54.8 ±137.9	
P HCl _{conc}			96.1 ±99.2		103.5 ±110.0	
	P stable	21.6 %		29.8 %		
Pi residual			41.2 ±30.9		42.5 ±33.5	

#) paired non-parametric Wilcoxon test, *** $\alpha < 0.001$; §) reduced number of samples since not at all sites, both soil depths were not available.

Table S2: Mean values (\pm standard deviation) of Hedley P fractions in soil samples, grouped by soil depth and soil acidity classes as indicated by pH ranges, all values in mg kg^{-1} .

Depth	pH-range	n	Pi Resin [#]	Pi HCO ₃ [#]	Po HCO ₃ [#]	Pi NaOH [#]	Po NaOH [#]	Pi 1M HCl [#]	P HCL _{conc} [#]	P Residual [#]
			mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
			labile P			moderately labile P			stable P	
0-5 cm	> 6.2	6	34.7 \pm 14.1 a	24.1 \pm 11.5 a	28.5 \pm 13.9 a	35.2 \pm 23.9 a	215.3 \pm 156.8 a	48.9 \pm 36.9 ab	262.3 \pm 165.3 a	105.6 \pm 60.5 a
	5.0-6.2	15	40.1 \pm 11.8 a	23.3 \pm 11.7 a	59.6 \pm 33.2 b	79.4 \pm 43.0 ab	217.5 \pm 125.9 a	71.1 \pm 55.1 b	162.7 \pm 108.1 a	67.2 \pm 30.7 ab
	4.2-5.0	43	46.3 \pm 35.2 a	32.4 \pm 33.0 a	77.6 \pm 41.5 b	103.4 \pm 111.0 b	190.5 \pm 108.8 a	70.6 \pm 160.6 b	109.9 \pm 93.5 b	44.6 \pm 27.6 b
	3.0-4.2	80	55.0 \pm 41.0 a	37.3 \pm 48.1 a	101.0 \pm 65.5 c	80.6 \pm 90.9 a	189.2 \pm 150.1 a	30.2 \pm 37.9 a	64.2 \pm 69.6 c	29.8 \pm 16.9 c
10-30 cm	> 6.2	6	19.5 \pm 8.2 a	11.7 \pm 7.9 ab	23.9 \pm 12.7 ab	22.0 \pm 14.1 a	143.7 \pm 148.2 ab	98.7 \pm 79.2 a	278.3 \pm 212.1 a	141.1 \pm 36.8 a
	5.0-6.2	21	19.6 \pm 20.0 a	16.5 \pm 17.9 a	26.9 \pm 18.2 ab	105.6 \pm 108.7 ab	105.5 \pm 86.7 ab	162.4 \pm 316.7 a	178.0 \pm 128.2 a	61.2 \pm 30.7 b
	4.2-5.0	81	22.6 \pm 26.6 a	25.6 \pm 35.0 a	37.0 \pm 34.2 a	112.6 \pm 110.9 b	143.1 \pm 111.6 a	38.7 \pm 48.5 b	95.7 \pm 91.3 b	36.3 \pm 24.3 c
	3.0-4.2	31	18.0 \pm 24.8 a	19.5 \pm 51.2 b	23.3 \pm 22.0 b	65.0 \pm 89.5 a	59.6 \pm 36.9 b	17.2 \pm 19.4 c	42.9 \pm 25.6 c	28.1 \pm 15.0 c

#) different letters within columns and per depth indicate significant differences between the pH-classes; non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

Table S3: Mean value (\pm standard deviation) for Hedley P pools of all soil samples, grouped by soil depth and pH-value, all values in mg kg^{-1} .

Depth	pH-range	n	P			Pi extractable [#] mg k ⁻¹	Po extractable [#] mg k ⁻¹					
			labile [#] mg k ⁻¹	moderately labile [#] mg k ⁻¹	stable [#] mg k ⁻¹							
0-5 cm	> 6.2	6	87.3 \pm 41.9	a	299.3 \pm 210.2	a	367.9 \pm 199.0	a	142.8 \pm 74.6	a	243.8 \pm 186.5	a
	5.0-6.2	15	123.1 \pm 43.5	a	368.0 \pm 184.2	a	230.0 \pm 122.8	a	214.0 \pm 112.8	a	214.0 \pm 112.8	a
	4.2-5.0	43	156.3 \pm 86.8	b	364.5 \pm 324.6	a	154.4 \pm 117.6	b	252.7 \pm 308.8	a	268.1 \pm 148.1	a
	3.0-4.2	80	193.3 \pm 138.2	b	300.0 \pm 248.7	a	93.9 \pm 79.4	c	203.1 \pm 195.6	a	290.2 \pm 212.2	a
10-30 cm	> 6.2	6	55.2 \pm 26.0	ab	264.4 \pm 161.9	a	419.4 \pm 211.1	a	151.9 \pm 86.8	a	167.6 \pm 158.9	ab
	5.0-6.2	21	62.9 \pm 42.7	ab	373.5 \pm 488.3	a	239.3 \pm 152.1	b	304.1 \pm 455.3	a	132.4 \pm 104.4	ab
	4.2-5.0	81	85.1 \pm 83.4	a	294.4 \pm 216.9	a	132.0 \pm 108.7	c	199.5 \pm 187.5	a	180.1 \pm 142.9	a
	3.0-4.2	31	60.8 \pm 88.8	b	141.8 \pm 135.0	b	71.0 \pm 30.9	d	119.7 \pm 174.8	b	82.9 \pm 55.2	b

#) different letters indicate significant differences between the pH-classes, valid per column and per depth, non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

Table S4: Mean values (\pm standard deviation) of Hedley P fractions of all analyzed NFSI samples, grouped by depth and SOC content, all values in mg kg⁻¹.

Depth	SOC content	n	Pi Resin [#]	Pi HCO ₃ [#]	Po HCO ₃ [#]	Pi NaOH [#]	Po NaOH [#]	Pi 1M HCl [#]	P HCL _{conc} [#]	P Residual [#]
	%		mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹
			labile P			moderately labile P			stable P	
0-5 cm	0.0-1.2	1	30.9	41.0	18.3	27.8	25.7	4.0	8.0	4.3
	1.2-2.8	15	28.4 ±27.1 a	22.6 ±30.8 a	33.7 ±22.9 a	56.0 ±76.9 a	77.3 ±67.6 a	32.9 ±40.5 a	49.6 ±58.7 a	22.7 ±15.6 a
	2.8-5.6	46	40.0 ±28.1 b	24.5 ±25.7 a	58.1 ±26.0 b	77.8 ±100.3 b	132.0 ±66.8 b	58.9 ±156.9 a	86.6 ±96.1 b	40.7 ±28.0 b
	>5.6	81	58.9 ±39.9 c	41.1 ±48.1 b	112.1 ±60.9 c	96.7 ±92.5 b	249.1 ±146.9 c	44.4 ±48.4 a	112.0 ±105.8 b	44.1 ±33.9 b
10-30 cm	0.0-1.2	59	18.9 ±23.6 a	19.2 ±23.1 ac	16.3 ±9.4 a	81.8 ±72.5 a	64.5 ±49.7 a	41.6 ±64.3 a	71.6 ±82.4 a	34.0 ±26.2 a
	1.2-2.8	55	17.9 ±20.1 a	15.6 ±23.0 a	30.4 ±15.3 b	81.9 ±91.5 a	107.1 ±67.7 b	71.6 ±209.2 a	104.2 ±103.5 a	45.7 ±34.0 ab
	2.8-5.6	20	32.5 ±30.8 b	42.6 ±63.8 b	66.1 ±35.7 c	159.4 ±135.7 b	255.0 ±99.2 c	50.2 ±37.6 b	166.6 ±115.9 b	59.6 ±39.0 b
	>5.6	5	39.1 ±43.8	60.0 ±90.9	96.7 ±71.8	203.0 ±273.1	349.5 ±141.6	51.6 ±33.2	235.5 ±241.7	64.4 ±55.9

#) different letters indicate significant differences between SOC content classes, valid per column and per depth, non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

Table S5: Mean (\pm standard deviation) value for Hedley P pools of all soil samples, grouped by soil depth and SOC content (%), all values in mg kg⁻¹.

Depth	SOC content	n	P labile [#]	P moderately labile [#]	P stable [#]	Pi extractable [#]	Po extractable [#]
	%		mg k ⁻¹	mg k ⁻¹	mg k ⁻¹	mg k ⁻¹	mg k ⁻¹
0-5 cm	0.0-1.2	1	90.3	57.5	12.3	103.8	44.0
	1.2-2.9	15	84.6 \pm 77.0 a	166.2 \pm 170.1 a	72.3 \pm 69.1 a	139.8 \pm 157.1 a	110.9 \pm 87.3 a
	2.9-5.8	46	122.5 \pm 63.2 b	268.7 \pm 303.9 b	127.3 \pm 117.8 b	201.1 \pm 290.7 a	190.1 \pm 83.8 b
	>5.8	81	212.2 \pm 128.3 c	390.2 \pm 240.7 c	157.6 \pm 126.9 b	241.1 \pm 194.6 b	361.2 \pm 194.8 c
10-30 cm	0.0-1.2	59	54.4 \pm 49.0 a	187.9 \pm 153.7 a	105.6 \pm 103.2 a	161.6 \pm 147.0 a	80.7 \pm 57.3 a
	1.2-2.9	55	63.9 \pm 47.4 b	260.6 \pm 320.5 ac	148.3 \pm 124.1 ac	186.9 \pm 304.7 a	137.5 \pm 78.1 b
	2.9-5.8	20	141.1 \pm 111.4 c	464.6 \pm 200.8 b	226.2 \pm 134.1 b	284.7 \pm 226.9 b	321.1 \pm 125.2 c
	>5.8	5	195.8 \pm 200.1 c	604.2 \pm 375.6 bc	300.0 \pm 296.8 bc	353.8 \pm 425.6 ab	446.3 \pm 192.9 c

#) different letters indicate significant differences between the pH classes, valid per column and per depth, non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

Table S6: Mean values (\pm standard deviation) of Hedley P fractions of NFSI samples, grouped by soil depth and soil texture, all values in mg kg⁻¹

Depth	Soil texture	n	Pi Resin [#]	Pi HCO ₃ [#]	Po HCO ₃ [#]	Pi NaOH [#]	Po NaOH [#]	Pi 1M HCl [#]	P HCL _{conc} [#]	P Residual [#]
			mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹	mg kg ⁻¹
			labile P			moderately labile P			stable P	
0-5 cm	sand	21	22.7 ±13.8 a	15.9 ±15.0 a	39.6 ±27.3 a	16.9 ±13.5 a	55.5 ±34.3 a	4.8 ±4.5 a	16.7 ±9.2 a	15.6 ±10.4 a
	loam	37	49.8 ±35.2 b	35.0 ±62.2 ab	87.5 ±50.2 b	73.5 ±100.6 b	153.6 ±94.0 b	30.7 ±32.0 b	49.8 ±27.7 b	29.4 ±16.7 b
	silt	71	57.3 ±40.6 b	39.0 ±34.0 c	103.7 ±61.8 b	111.3 ±96.7 c	242.6 ±136.0 c	66.9 ±130.4 c	120.9 ±93.7 c	48.1 ±30.4 c
	clay	15	47.5 ±22.4 b	30.3 ±17.7 bc	63.0 ±41.0 a	91.1 ±73.0 bc	242.9 ±158.2 c	56.6 ±42.7 c	205.9 ±157.0 c	73.9 ±40.4 d
10-30 cm	sand	22	17.9 ±23.3 a	32.3 ±59.7 a	18.9 ±21.0 a	55.0 ±87.9 a	38.7 ±35.5 a	7.7 ±10.0 a	17.8 ±12.0 a	17.4 ±15.1 a
	loam	42	21.5 ±29.3 a	24.0 ±41.2 a	36.9 ±38.2 b	103.2 ±127.0 b	133.4 ±110.2 b	30.6 ±23.9 b	59.9 ±29.7 b	29.8 ±17.9 b
	silt	60	20.1 ±21.9 ab	17.7 ±20.4 a	33.3 ±27.1 b	109.9 ±100.6 b	134.4 ±103.3 b	86.0 ±204.5 bc	137.2 ±115.1 c	47.9 ±24.0 c
	clay	16	27.8 ±24.7 b	22.9 ±32.8 a	29.4 ±18.3 b	87.5 ±82.2 ab	126.9 ±106.7 b	66.2 ±47.0 c	209.7 ±159.6 c	90.2 ±55.8 d

#) different letters indicate significant differences between main texture classes, valid per column and per depth, non-parametric Mann-Whitney-U-test, $\alpha < 0.05$.

Table S7: Results of linear regression models for Hedley P pools and P fractions, by soil variables in 10-30 cm soil depth, model quality and standardized regression coefficients.

depth 10-30 cm	n = 139	predictor variables		
		SCO mg kg ⁻¹	sand %	pH
target	<i>r</i> ² #	standardized regression coefficients [§]		
log P labile	<i>0.26</i>	<i>0.495</i>	<i>-0.155</i>	<i>-0.176</i>
log P moderately labile	0.43	0.469	-0.434	-0.250
log P stable	0.62	0.156	-0.637	0.239
log pi resin	<i>0.10</i>	<i>0.265</i>	<i>-0.164</i>	
log Pi HCO ₃	<i>0.09</i>	<i>0.305</i>		
log Po HCO ₃	0.41	0.589	-0.213	-0.324
log Pi NaOH	<i>0.23</i>	<i>0.242</i>	<i>-0.407</i>	<i>-0.302</i>
log Po NaOH	0.54	0.564	-0.436	-0.224
log Pi 1M HCl	<i>0.37</i>		<i>-0.531</i>	<i>0.188</i>
log P HCL conc	0.55	0.173	-0.576	0.213
log P residual	0.47		-0.580	0.231

adjusted *r*², P pools or P fractions with model performance *r*² below 0.4 are shown in italics. § significant predictors (*p* < 0.05, F-Test) are shown, strongest predictor are presented in bold.