

Humus forms and soil microbiological parameters in a mountain forest: Upscaling to the slope scale

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Supplementary Materials

Table S1. Input data for linear models of soil C/N ratio and enzyme activities depending on pH values

Site	Soil depth (cm)	Soil horizons covered by the sample	pH H ₂ O (1:10)	Leucine-amino-peptidase activity (nmol MUF g ⁻¹ dry soil h ⁻¹)	Ratio alkaline/acid phospho-monoesterase activity	Soil C/N ratio
N1a-1	5-10	A	4.39	147.9	0.01	26.5
N1a-2	5-10	A	4.47	87.6	0.00	21.3
N1a-3	5-10	AE/Bs	4.54	96.2	0.01	19.3
N1a-4	5-10	AE	4.83	144.7	0.03	16.4
N1a-5	5-10	AE/Bs	4.39	123.7	0.00	19.4
N1b-1	0-5	O/A	4.35	180.4	0.16	25.8
N1b-2	5-10	A/Bs	4.43	54.5	0.00	23.6
N1b-3	0-5	O/A	4.22	141.5	0.01	36.6
N1b-4	5-10	A/Bs	4.67	23.7	0.00	22.5
N1b-5	0-5	O/A	4.43	227.7	0.02	35.1
N1c-1	5-10	AE/Bs	5.23	126.0	0.24	17.8
N1c-2	5-10	AE/Bs	5.29	116.8	0.23	21.7
N1c-3	5-10	AE	5.45	128.5	0.37	17.5
N1c-4	5-10	AE/Bs	5.38	105.6	0.26	17.4
N1c-5	5-10	AE/Bs	4.94	58.7	0.08	18.2
S6a-1	5-10	Ah	5.43	72.7	0.22	22.8
S6a-2	5-10	Ah	5.33	66.4	0.59	21.3
S6a-3	5-10	Ah	4.96	30.6	0.03	17.3
S6a-4	5-10	Ah	5.94	149.1	0.57	21.0
S6a-5	5-10	Ah	5.60	61.0	0.23	19.7
S6b-1	0-5	OF/Ah	6.76	438.6	2.17	15.5
S6b-2	0-5	Ah	6.60	285.8	1.72	18.5
S6b-3	10-15	Bw	6.16	58.9	0.80	13.9
S6b-4	0-5	OF/Ah	6.53	148.5	1.60	14.2
S6b-5	0-5	OF/Ah	6.36	130.6	1.79	18.5
S6c-1	0-5	OF/Ah	5.53	192.4	0.13	22.5
S6c-2	0-5	OF/Ah	5.74	337.5	0.13	22.0
S6c-3	0-5	OF/Ah	5.77	588.3	0.65	19.4
S6c-4	0-5	OF/Ah	5.84	351.8	0.39	19.3
S6c-5	0-5	OF/Ah	5.93	266.2	0.71	20.7
N2a-1	10-15	OH/AE	3.82	50.7	0.00	20.5
N2a-2	10-15	OH/AE	3.87	56.1	0.00	24.2
N2a-3	10-15	OH/AE	3.86	48.5	0.00	21.9
N2a-4	10-15	OH/AE	3.97	57.3	0.00	19.9
N2a-5	10-15	OH/AE	3.81	27.8	0.00	22.2
N2b-1	10-15	AE/Bs	5.07	37.3	0.07	18.1
N2b-2	5-10	AE/Bs	4.94	92.5	0.09	18.8
N2b-3	5-10	AE/Bs	5.17	351.4	0.23	17.4
N2b-4	5-10	AE/Bs	4.89	78.3	0.04	23.6
N2b-5	5-10	AE/Bs	4.63	92.9	0.03	23.8
N2c-1	10-15	AE/C	4.53	38.7	0.00	20.4
N2c-2	10-15	AE/C	4.50	24.6	0.00	18.0
N2c-3	10-15	AE/C	4.75	43.6	0.04	20.1
N2c-4	10-15	AE/C	4.48	19.6	0.00	25.3
N2c-5	10-15	AE/C	4.66	26.0	0.00	20.2

Table S1. *Continued*

Site	Soil depth (cm)	Soil horizons covered by the sample	pH H ₂ O (1:10)	Leucine-amino-peptidase activity (nmol MUF g ⁻¹ dry soil h ⁻¹)	Ratio alkaline/acid phospho-monoesterase activity	Soil C/N ratio
S7a-1	10-15	Bs	5.93	209.9	1.10	14.0
S7a-2	10-15	Bs/C	5.99	121.9	0.88	14.1
S7a-3	10-15	Bs/C	5.99	131.8	0.94	14.4
S7a-4	10-15	Bs/C	6.00	141.7	0.95	10.8
S7a-5	10-15	Bs	5.81	166.5	0.94	13.2
S7b-1	5-10	AE	5.89	367.5	0.73	19.4
S7b-2	5-10	AE	5.76	187.7	0.60	17.2
S7b-3	5-10	AE	6.15	356.6	0.86	15.7
S7b-4	5-10	AE	5.93	286.5	0.77	18.5
S7b-5	5-10	AE	5.96	213.4	0.81	15.5
S7c-1	5-10	AE	5.80	145.4	0.56	17.8
S7c-2	5-10	AE	5.56	93.4	0.24	16.5
S7c-3	5-10	AE	5.55	97.5	0.33	16.6
S7c-4	5-10	AE	5.58	120.1	0.30	16.5
S7c-5	5-10	AE	5.60	177.9	0.34	14.4
N3a-1	5-10	OF/AE	4.14	NA ¹	NA ¹	25.9
N3a-2	10-15	OF/AE	4.56	71.5	0.03	20.1
N3a-3	10-15	OF/AE	4.55	81.5	0.03	20.7
N3a-4	5-10	OF/Bs	4.39	92.6	0.02	22.2
N3a-5	10-15	E/C	4.48	67.5	0.02	25.6
N3b-1	10-15	OH/C	4.31	86.7	0.02	19.7
N3b-2	5-10	OF(/C)	4.32	0.0	NA ¹	20.1
N3b-3	10-15	OH/C	4.24	70.5	0.01	18.9
N3b-4	10-15	E/C	4.09	100.3	0.01	NA ¹
N3b-5	10-15	E/C	3.95	28.4	0.00	NA ¹
N3c-1	10-15	AE	4.04	57.1	0.02	22.1
N3c-2	10-15	AE	4.06	75.4	0.01	23.5
N3c-3	10-15	AE	4.07	59.2	0.01	19.5
N3c-4	10-15	AE	3.89	98.9	0.01	NA ¹
N3c-5	10-15	AE	4.07	143.1	0.01	25.5
S8a-1	5-10	OF/Bs	5.52	99.5	0.04	21.2
S8a-2	5-10	Ah/Bs	4.98	142.5	0.03	23.8
S8a-3	5-10	OF/Bs	5.62	892.5	0.09	10.9
S8a-4	5-10	Ah/Bs	5.41	260.7	0.06	18.8
S8a-5	5-10	Ah/Bs	5.66	1403.9	0.12	10.9
S8b-1	5-10	OL/OF/AE	5.20	70.4	0.05	17.2
S8b-2	5-10	OL/OF/AE	5.27	100.0	0.05	14.0
S8b-3	5-10	OL/OF/AE	5.03	77.7	0.06	17.2
S8b-4	5-10	OL/OF/AE	5.31	118.9	0.10	18.2
S8b-5	5-10	OL/OF/AE	5.28	86.6	0.08	17.6
S8c-1	0-5	Ah/Bs	5.18	143.0	0.03	23.2
S8c-2	0-5	Ah/BA	5.50	192.6	0.15	17.5
S8c-3	0-5	Ah/Bs	5.35	131.1	0.09	18.8
S8c-4	0-5	Ah/Bs	5.46	133.2	0.10	22.4
S8c-5	0-5	Ah/Bs	5.81	127.2	0.15	18.2

¹ No sample. Sample was omitted in the respective regression model.

Table S2. Input data for linear model of the ratio bacterial / archaeal abundance depending on pH values

Site	Soil depth (cm)	Dominant soil horizons of subsamples	pH H ₂ O (1:10)	Ratio bacterial / archaeal abundance
N1a	5-10	AE/Bs	4.52	4.8
N1b	0-5	O/A	4.45	4.7
N1c	5-10	AE/Bs	5.26	4.0
S6a	5-10	Ah	5.45	29.4
S6b	0-5	OF/Ah	6.58	16.1
S6c	0-5	OF/Ah	5.76	19.1
N2a	10-15	OH/AE	3.87	1.9
N2b	5-10	AE/Bss	4.94	0.5
N2c	10-15	AE/C	4.58	40.2
S7a	10-15	Bs/C	5.94	32.7
S7b	5-10	AE	5.94	660.5
S7c	5-10	AE	5.62	22.0
N3a	10-15	OF/AE	4.53	18.0
N3b	10-15	OH/E/C	4.17	0.1
N3c	10-15	AE	4.03	30.4
S8a	5-10	Ah/Bs	5.44	22.1
S8b	5-10	Ah/Bs	5.22	20.3
S8c	0-5	OL/OF/AE	5.46	24.4

Table S3. Humus forms (according to [40,41]) and pH values sampled at 60 sites in Val di Rabbi (RN1–RN30 at a north-facing slope, RS1–RS30 at a south-facing slope). pH values are means from two replicates

Sites	Elevation a.s.l. (m)	Ground cover type (percentage at site)	Humus form	pH in A horizon H ₂ O (1:10)
RN1	1215	Grass (100%)	Amphimull (AMU)	6.06
RN2	1211	Grass (100%)	Mullartiger Moder (MOM)	5.18
RN3	1244	Grass (100%)	Rohhumusartiger Moder (MRA)	4.88
RN4	1270	Moss (100%)	Amphimull (AMU)	5.20
RN5	1278	Litter (70%)	Amphimull (AMU)	5.25
		Fern (30%)	F-Mull (MUO)	4.96
RN6	1298	Litter (50%)	Hagerhumus (HMO)	5.11
		Grass (50%)	Rohhumusartiger Moder (MRA)	4.41
RN7	1309	Grass (100%)	Rohhumusartiger Moder (MRA)	4.82
RN8	1340	Litter (100%)	Rohhumusartiger Moder (MRA)	4.63
RN9	1362	Grass (100%)	Graswurzelfilz-Moder (GMO)	5.00
RN10	1411	Grass (80%)	Amphimull (AMU)	4.62
		Litter (20%)	Amphimull (AMU)	¹
RN11	1437	Litter (50%)	Rohhumusartiger Moder (MRA)	4.41
		Grass (50%)	Mullartiger Moder (MOM)	4.84
RN12	1442	Grass (80%)	Mullartiger Moder (MOM)	4.48
		Litter (20%)	Rohhumusartiger Moder (MRA)	4.45
RN13	1480	Litter (100%)	Rohhumusartiger Moder (MRA)	4.42
RN14	1496	Grass (70%)	Rohhumusartiger Moder (MRR)	4.39
		Litter (30%)	Rohhumusartiger Moder (MRA)	4.64
RN15	1523	Grass (90%)	Rohhumusartiger Moder (MRR)	4.72
		Litter (10%)	Rohhumusartiger Moder (MRR)	4.45
RN16	1540	Grass (100%)	Rohhumusartiger Moder (MRR)	4.80
RN17	1622	Grass (100%)	Rohhumusartiger Moder (MRR)	4.20
RN18	1648	Grass (100%)	Typischer Moder (MOA)	4.25
RN19	1704	Grass (80%)	Rohhumusartiger Moder (MRA)	4.69
		Litter (20%)	Rohhumusartiger Moder (MRR)	4.58
RN20	1735	Grass (100%)	Rohhumusartiger Moder (MRR)	4.73
RN21	1757	Grass (100%)	Rohhumusartiger Moder (MRR)	4.17
RN22	1805	Grass (100%)	Rohhumusartiger Moder (MRA)	4.24
RN23	1849	Grass (100%)	Rohhumusartiger Moder (MRR)	4.46
RN24	1893	Shrubs (100%)	Rohhumus (ROR)	4.22
RN25	1895	Grass (80%)	Mullartiger Moder (MOM)	4.66
		Shrubs (20%)	Rohhumusartiger Moder (MRA)	4.71
RN26	1908	Grass (100%)	Rohhumusartiger Moder (MRA)	4.74
RN27	1915	Grass (100%)	Rohhumusartiger Moder (MRR)	4.02
RN28	1957	Grass (100%)	Rohhumusartiger Moder (MRR)	4.52
RN29	1964	Grass (80%)	Mullartiger Moder (MOM)	4.71
		Shrubs (20%)	Typischer Moder (MOR)	4.68
RN30	2007	Shrubs (100%)	Rohhumus (ROR)	4.05

¹ No pH sample was taken under litter at site RN10. For modelling, the pH sample under grass was weighted with 1.0 (instead of 0.8) at this site.

Table S3. Continued

Sites	Elevation a.s.l. (m)	Ground cover type (percentage at site)	Humus form	pH in A horizon H ₂ O (1:10)
RS1	1229	Grass (100%)	F-Mull (MUO)	5.70
RS2	1310	Grass (100%)	Typischer Moder (MOA)	5.80
RS3	1329	Litter (100%)	Amphimull (AMU)	4.43
RS4	1391	Grass (60%)	Rohhumusartiger Moder (MRA)	4.74
		Litter (40%)	Amphimull (AMU)	4.77
RS5	1415	Grass (100%)	Amphimull (AMU)	5.79
RS6	1421	Grass (100%)	F-Mull (MUO)	5.36
RS7	1459	Litter (70%)	Mullartiger Moder (MOM)	4.67
		Grass (30%)	F-Mull (MUO)	5.36
RS8	1502	Grass (70%)	Rohhumusartiger Moder (MRA)	4.90
		Litter (30%)	Amphimull (AMU)	4.90
RS9	1523	Grass (100%)	Amphimull (AMU)	5.45
RS10	1553	Grass (100%)	F-Mull (MUO)	5.95
RS11	1590	Grass (100%)	Mullartiger Moder (MOM)	5.39
RS12	1621	Litter (60%)	Mullartiger Moder (MOM)	5.05
		Moss (40%)	Mullartiger Moder (MOM)	4.46
RS13	1677	Grass (100%)	Mullartiger Moder (MOM)	5.30
RS14	1719	Grass (100%)	Rohhumusartiger Moder (MRA)	4.61
RS15	1728	Grass (50%)	Rohhumusartiger Moder (MRA)	4.73
		Litter (40%)	Hagerhumus (HMO)	4.92
		Moss (10%)	Rohhumusartiger Moder (MRA)	4.47
RS16	1783	Litter (60%)	Rohhumusartiger Moder (MRA)	4.62
		Grass (40%)	Rohhumusartiger Moder (MRR)	4.74
RS17	1827	Litter (60%)	Rohhumus (ROA)	4.73
		Grass (30%)	F-Mull (MUO)	5.34
		Moss (10%)	Rohhumus (ROA)	²
RS18	1892	Grass (100%)	Rohhumusartiger Moder (MRA)	4.72
RS19	1908	Grass (60%)	Rohhumusartiger Moder (MRA)	4.39
		Litter (40%)	Rohhumusartiger Moder (MRR)	4.72
RS20	1952	Grass (100%)	F-Mull (MUO)	5.30
RS21	1945	Litter (50%)	Rohhumusartiger Moder (MRA)	4.51
		Grass (50%)	F-Mull (MUO)	5.08
RS22	1967	Grass (100%)	Mullartiger Moder (MOM)	5.15
RS23	2010	Grass (100%)	F-Mull (MUO)	5.02
RS24	2029	Shrubs (60%)	Typischer Moder (MOR)	4.94 and 4.98 ³
		Grass (40%)	Typischer Moder (MOA)	
RS25	2059	Shrubs (80%)	Rohhumus (ROR)	4.75
		Grass (20%)	Rohhumusartiger Moder (MRA)	4.95
RS26	2090	Grass (100%)	Rohhumusartiger Moder (MRA)	5.95
RS27	2130	Shrubs (50%)	Rohhumusartiger Moder (MRA)	4.51
		Grass (50%)	Typischer Moder (MOA)	4.73
RS28	2147	Shrubs (70%)	Rohhumusartiger Moder (MRR)	4.46
		Grass (30%)	Typischer Moder (MOA)	4.92
RS29	2158	Shrubs (80%)	Rohhumusartiger Moder (MRR)	4.61
		Grass (20%)	Typischer Moder (MOA)	5.05
RS30	2212	Shrubs (80%)	Rohhumus (ROR)	4.54
		Grass (20%)	Rohhumusartiger Moder (MRA)	4.86

² No pH sample was taken under moss at site RS17. For modelling, the pH samples under litter and grass were weighted with 2/3 (instead of 0.6) and 1/3 (instead of 0.3) at this site.

³ The labels of ground cover types got lost for pH samples at site RS24.

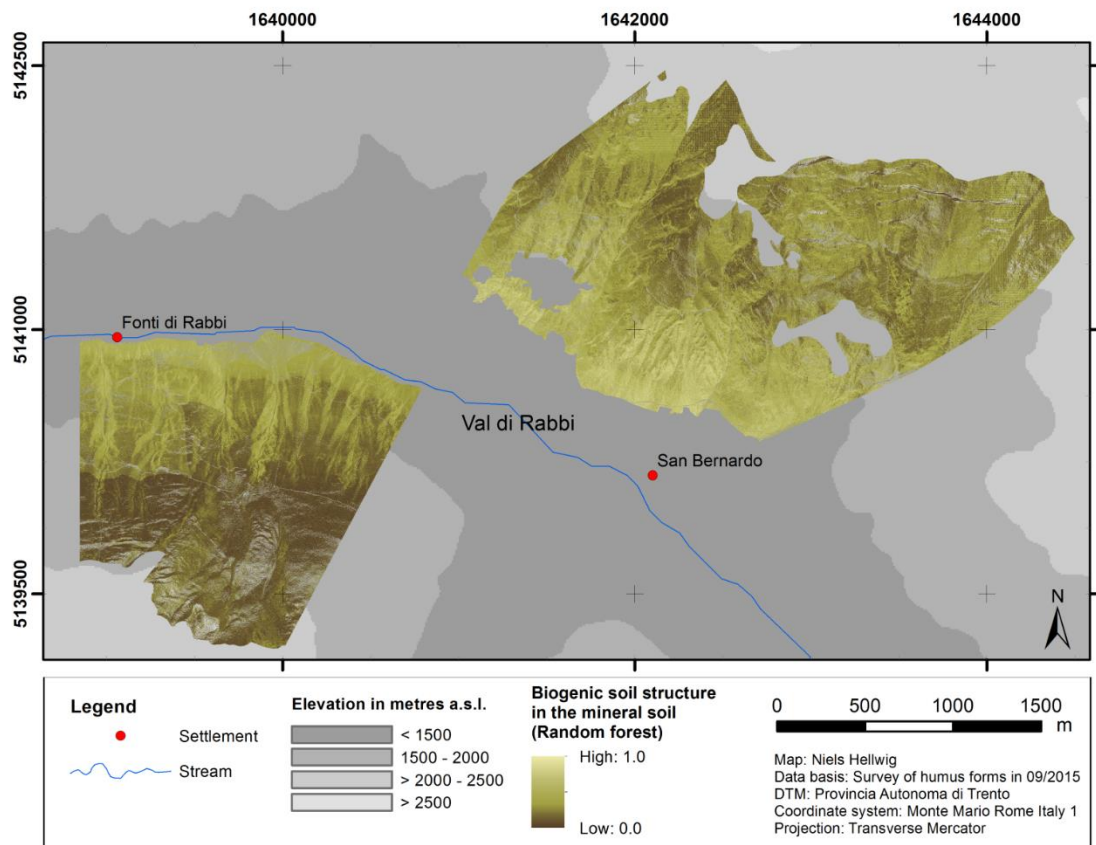


Figure S1. Results of the random forest model for the biogenic soil structure in the mineral soil

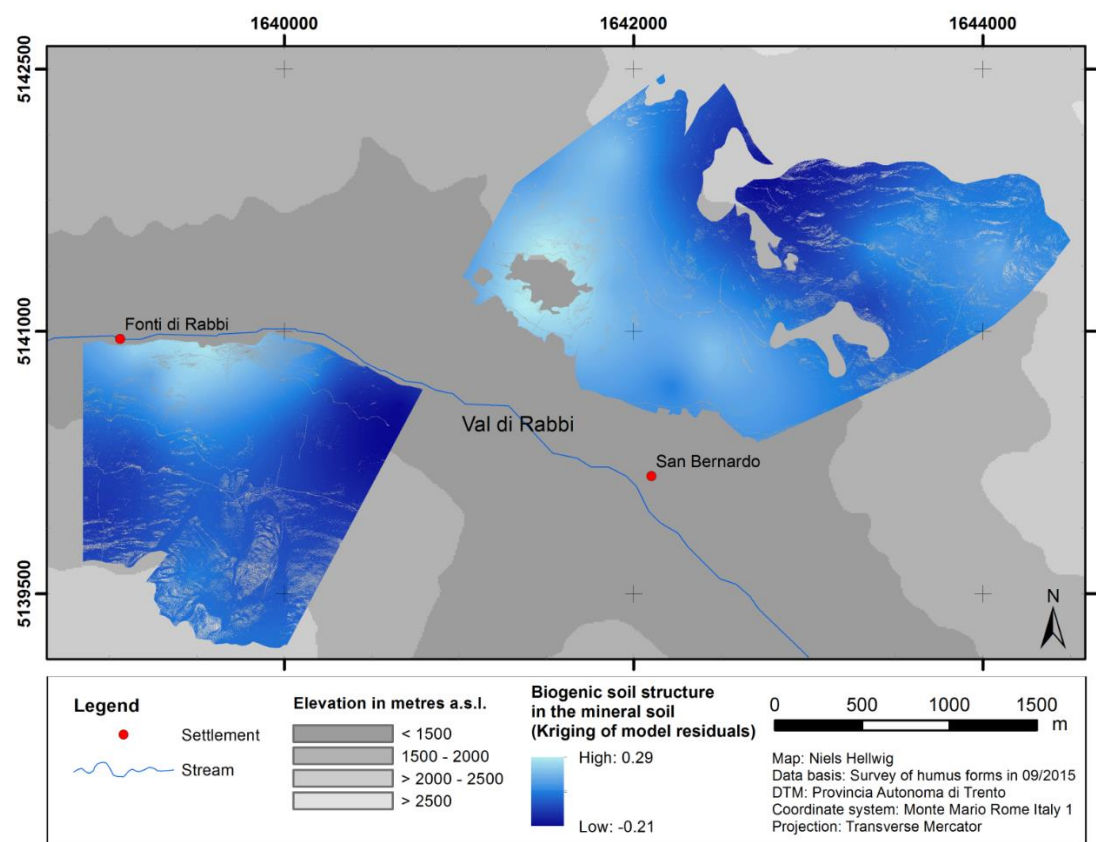


Figure S2. Results of the kriging procedure of the model residuals for the biogenic soil structure in the mineral soil

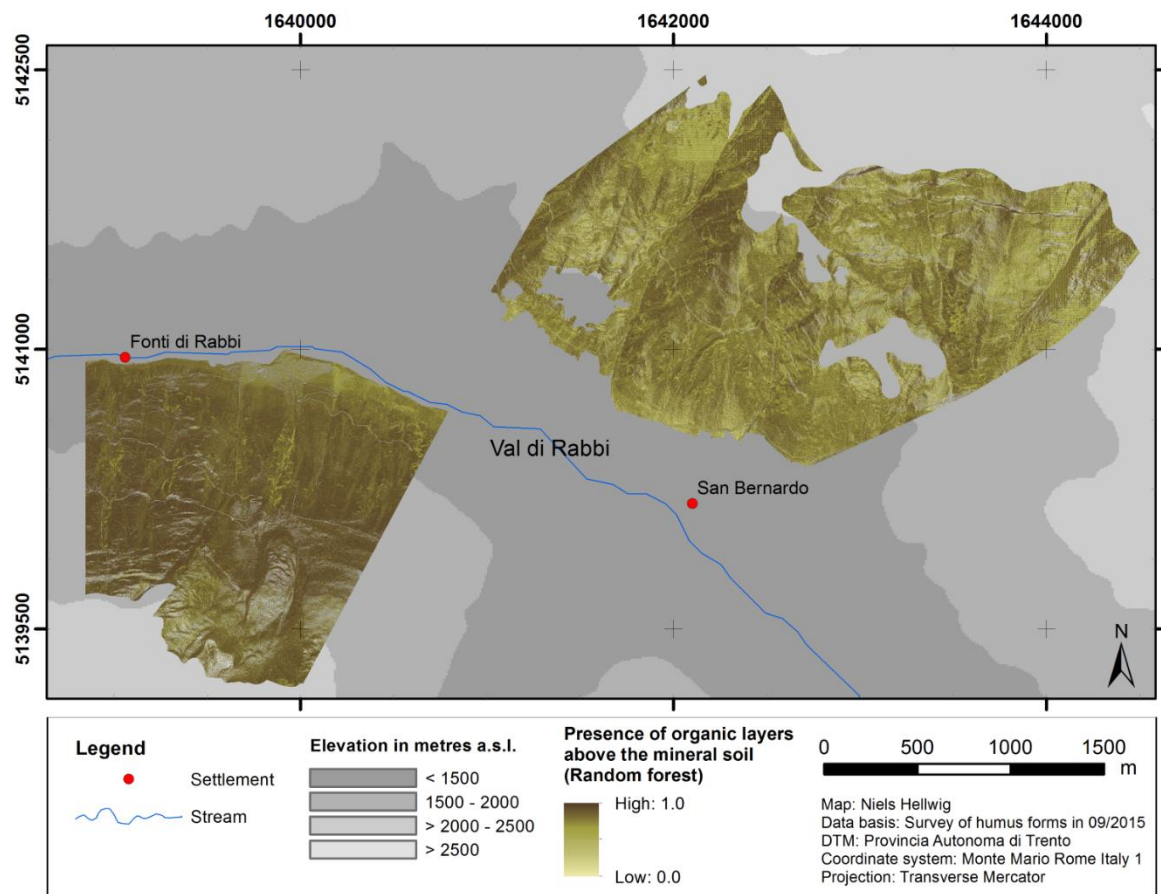


Figure S3. Results of the random forest model for the presence of organic layers above the mineral soil

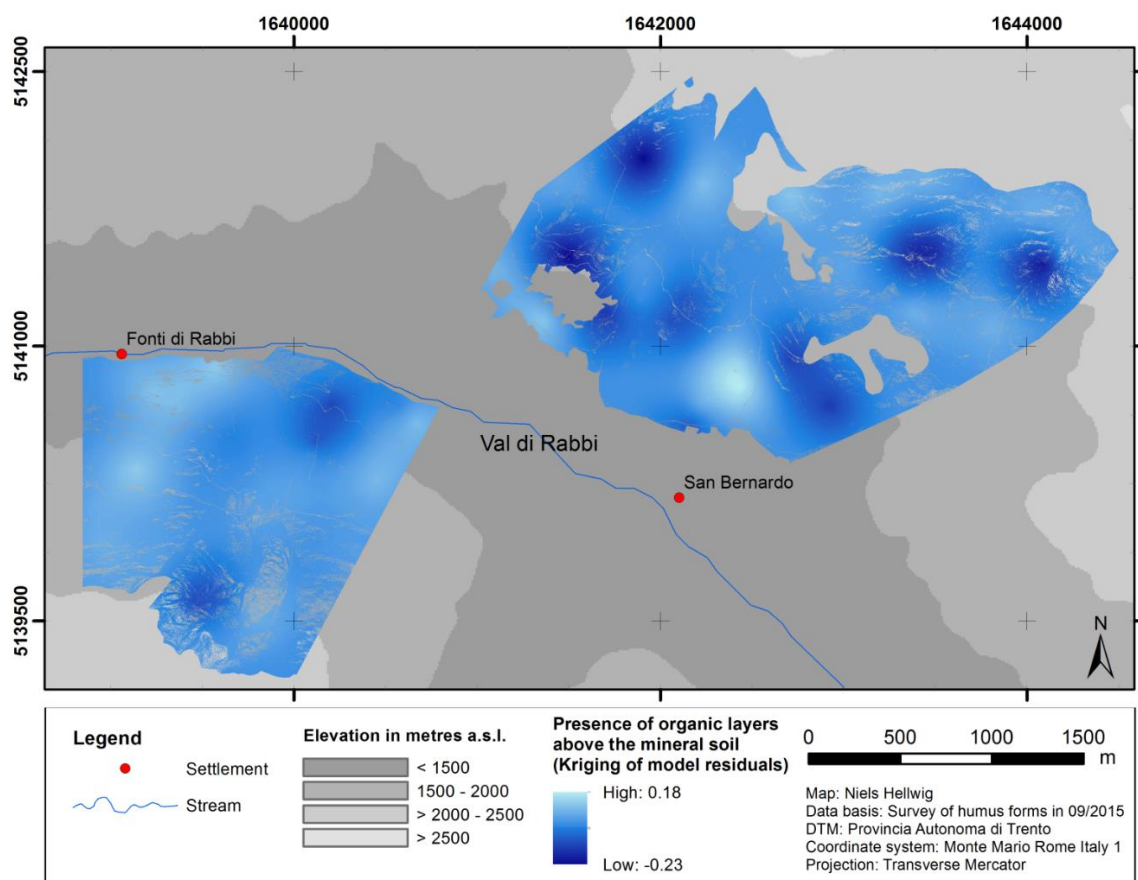


Figure S4. Results of the kriging procedure of the model residuals for the presence of organic layers above the mineral soil

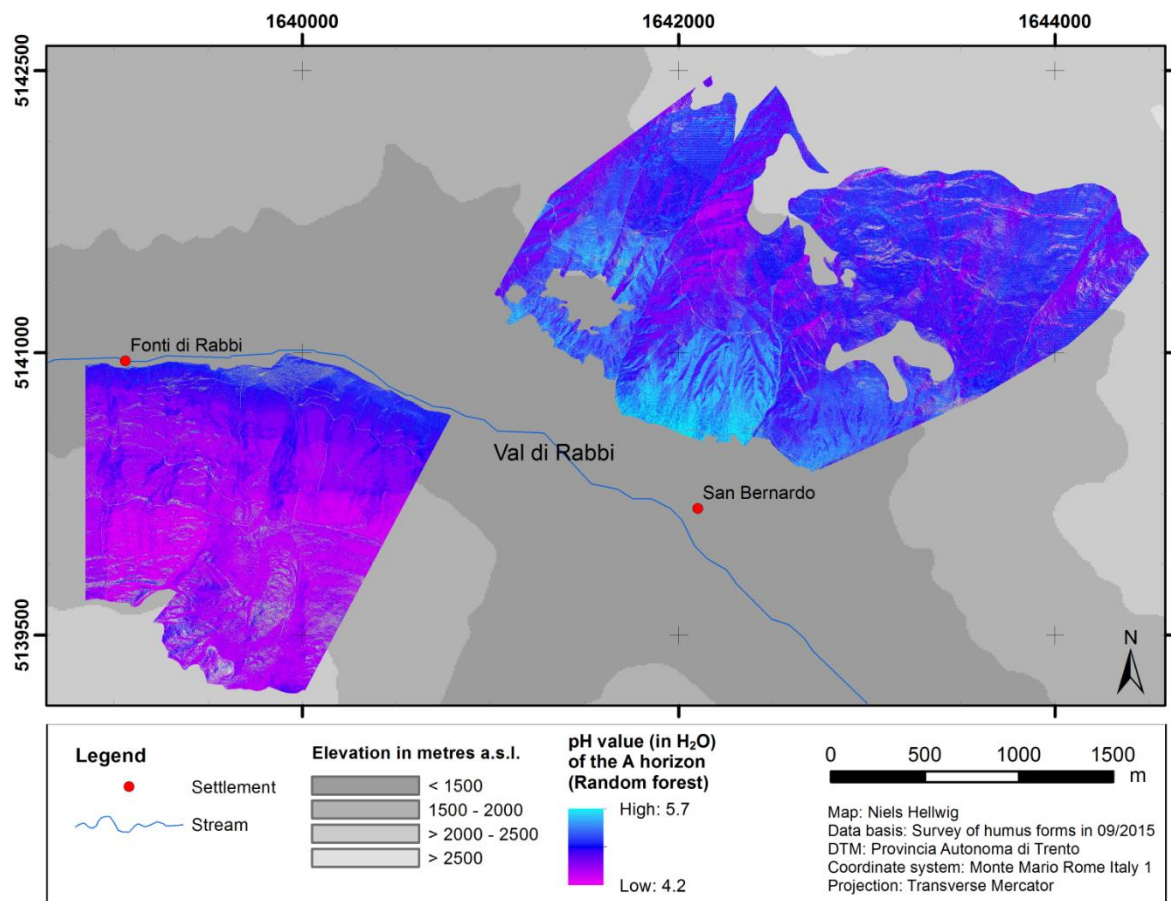


Figure S5. Results of the random forest model for the topsoil acidity.

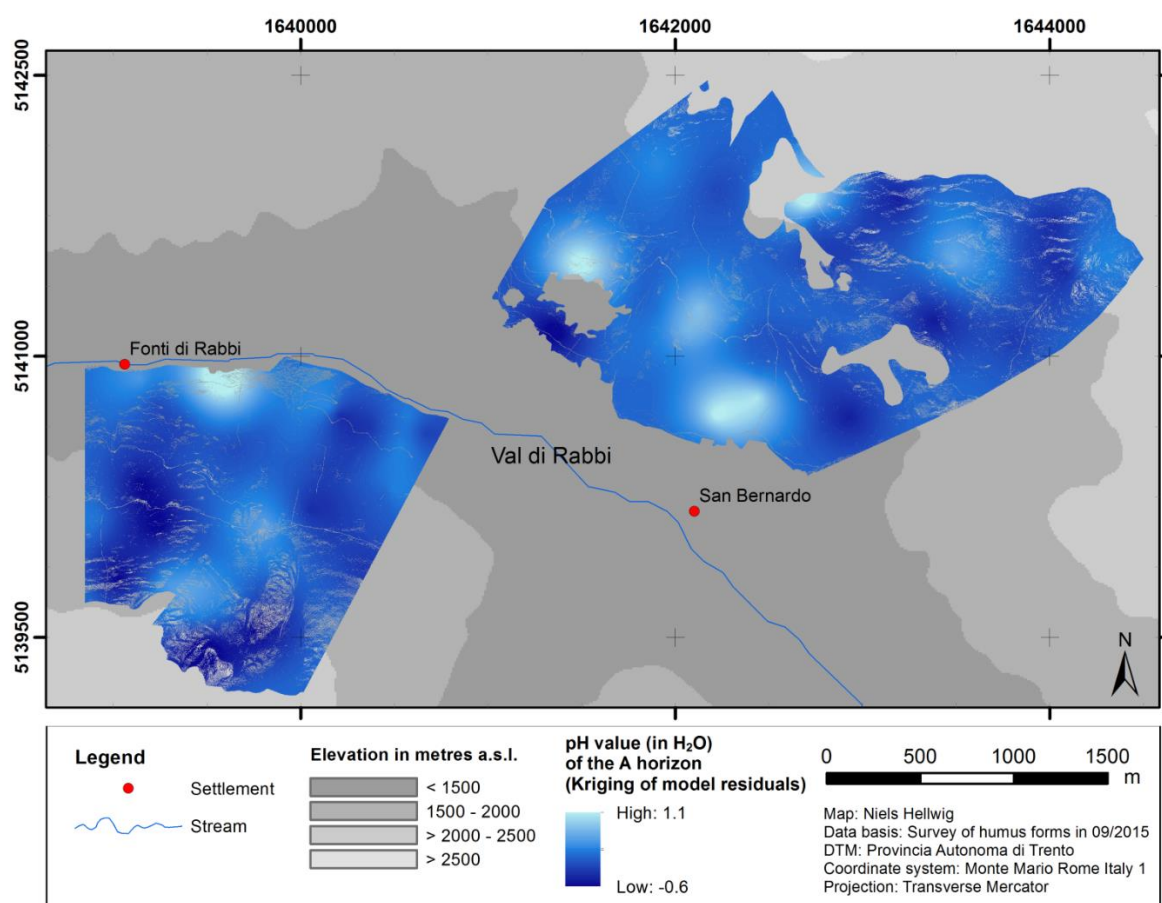


Figure S6. Results of the kriging procedure of the model residuals for the topsoil acidity

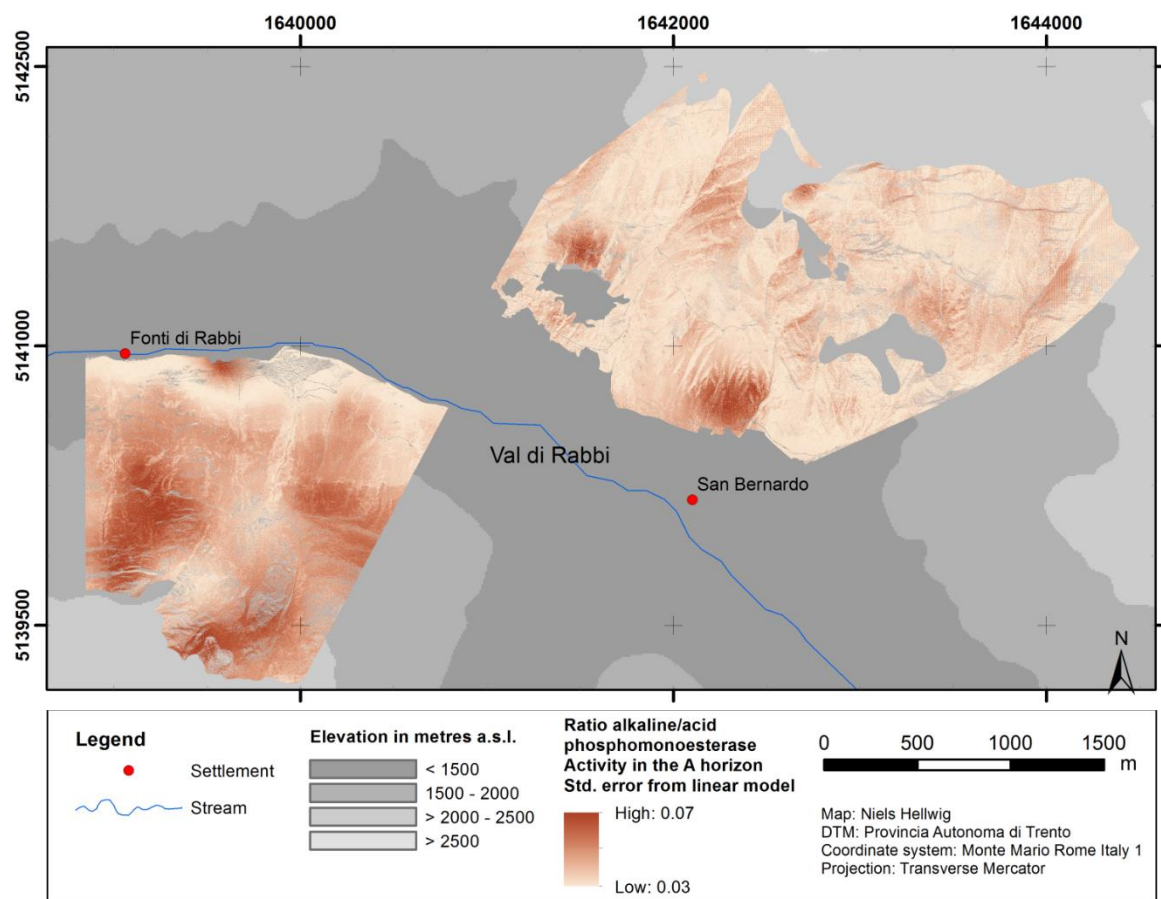


Figure S7. Standard error of predictions from linear model of the ratio alkaline/acid phosphomonoesterase activity as a function of the pH value

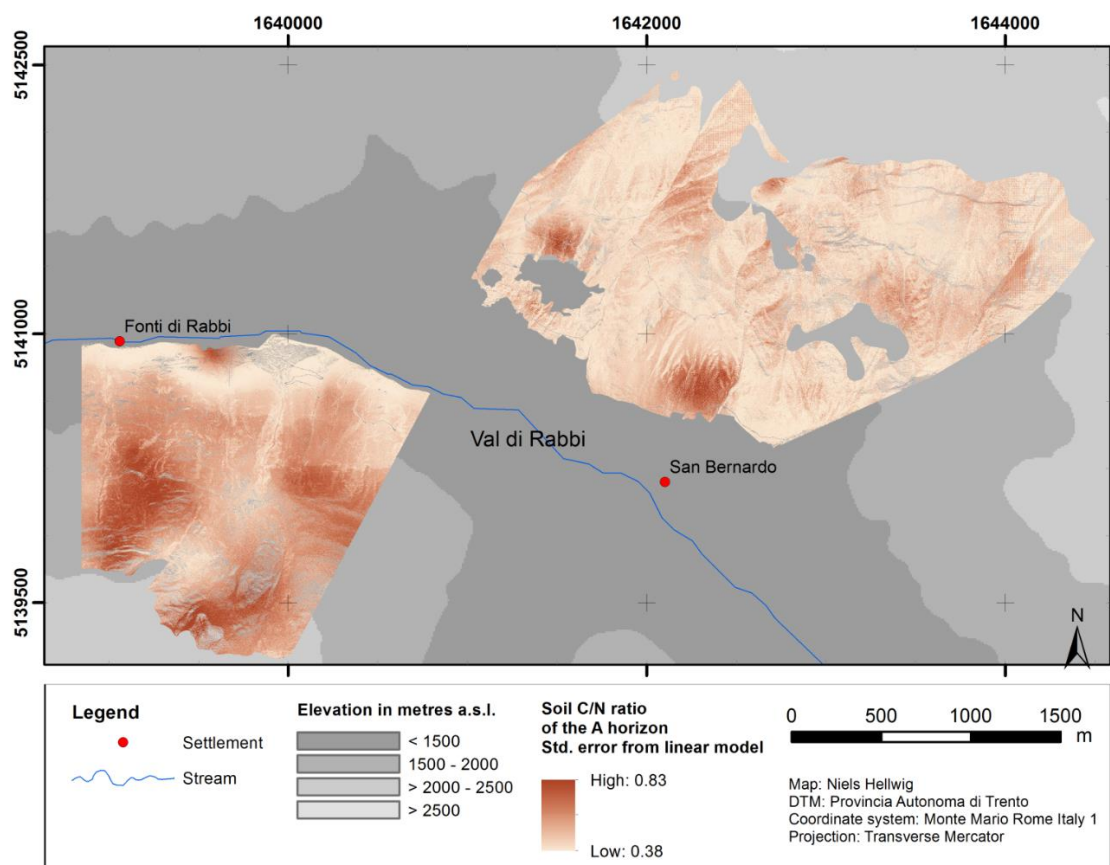


Figure S8. Standard error of predictions from linear model of the soil C/N ratio as a function of the pH value