Supplementary Material

Text S1. Analysis of additional structure-related soil properties

To further evaluate the robustness of the four-cluster classification, the same correlation analysis as for K_{sat} was conducted for bulk density (ρ_{bulk}) and water content at 100 cm suction (θ_{100}). The latter is a structure-related property that provides indirect information on the abundance of structural pores and the resulting air-filled porosity of the soil. Strong relationships were obtained for both properties within the same four clusters (Figure S1), yielding coefficients of determination of $R^2 = 0.88$ for ρ_{bulk} and $R^2 = 0.79$ for θ_{100}, respectively. The consistency of these relationships across three independent structure-related properties provides additional support for the validity of the proposed classification.

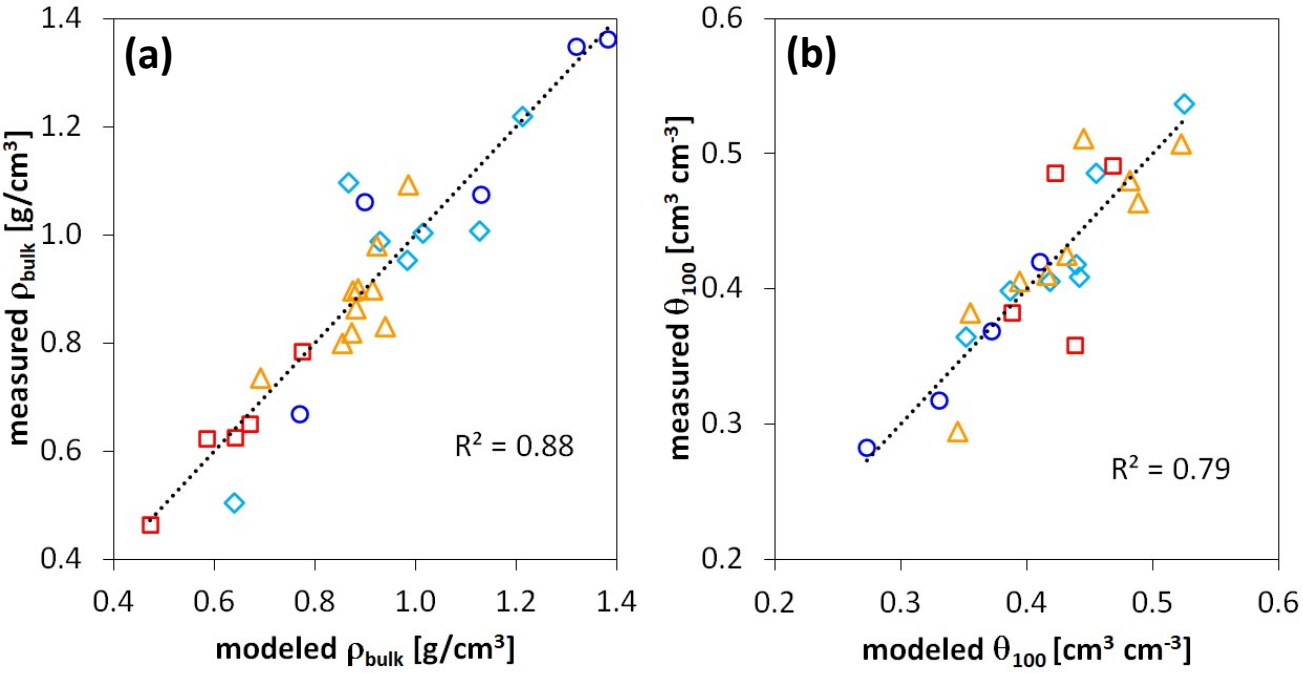

Figure S1. Modeling of bulk density (a) and water content at 100 cm suction (b) using the same clusters as applied to the analysis of K_{sat}. Note that in (b), measurements were available for only 24 of the 27 topsoils. Red squares represent soils of the strongly acidic subdomain, orange triangles the near-neutral subdomain, and light and dark blue symbols the two moderately acidic subdomains, respectively.

Table S1. Overview of the 27 forest sites including mean annual temperature, annual precipitation, and altitude. Climate data were extracted from Frehner et al. (2011) and represent long-term averages.

Site ID	Mean Annual Temperature [°C]	Annual Precipitation [mm]	Altitude [m a.s.l.]
18747	9.1	1087.2	464
O18152	9.0	1143.0	603
O18157	9.0	1150.2	639
O18679	9.1	1097.6	492
O1826	9.1	1089.2	467
18676	9.2	1079.6	431
18784	8.8	1161.3	628
17244	9.0	1113.3	443
17283	8.9	1126.8	435
22b-66	9.6	1294.6	672
18387	9.1	1109.2	459
18737	9.1	1081.3	492
18732	9.1	1073.8	467
21102	9.2	1113.1	453
P1678	9.1	1059.0	540
K252	7.7	1264.5	791
P1346	8.7	1102.3	576
P370	8.5	1129.5	631
P265	8.5	1164.9	673
HW	8.8	1073.9	572
K126	7.5	1277.0	803
W	8.2	1180.9	682
395W	5.0	1548.7	1415
2624	4.2	1506.8	1502
350	9.0	1121.9	520
1528	8.9	1130.3	517
L	7.6	784.9	1040

Table S2. Overview of the forest sites including sampling date, assigned soil moisture measuring station, measuring depth, suction values at the time of sampling (expressed in cbar and hPa), and the distance between each sampling site and its corresponding measuring station. Distances represent the straight-line distance between the sampling location and the associated measuring station.

Site ID	Sampling Date	Measuring Station	Depth [cm]	Suction [cbar]	Suction [hPa]	Distance Station [m]
18747	24.09.2024	Stüsslingen	20	6.33	63.33	2722
O18152	08.08.2024	Stüsslingen	20	25.17	251.72	4892
O18157	08.08.2024	Stüsslingen	20	25.17	251.72	5041
O18679	08.08.2024	Stüsslingen	20	25.17	251.72	4073
O1826	08.08.2024	Stüsslingen	20	25.17	251.72	3913
18676	24.09.2024	Stüsslingen	20	6.33	63.33	4144
18784	25.09.2024	Aetigkofen	20	3.31	33.11	957
17244	24.09.2024	Fulenbach	20	4.15	41.46	3477
17283	24.09.2024	Fulenbach	20	4.15	41.46	2422
22b-66	25.09.2024	Bellach	20	2.27	22.65	7325
18387	24.09.2024	Dulliken	20	4.68	46.79	1792
18737	24.09.2024	Stüsslingen	20	6.33	63.33	1015
18732	24.09.2024	Stüsslingen	20	6.33	63.33	1405
21102	25.09.2024	Aetigkofen	20	3.31	33.11	6832
P1678	04.07.2024	Zollikofen	20	13.83	138.26	8987
K252	04.07.2024	Zollikofen	20	13.83	138.26	10624
P1346	04.07.2024	Zollikofen	20	13.83	138.26	8672
P370	27.06.2024	Zollikofen	20	6.32	63.24	7331
P265	27.06.2024	Zollikofen	20	6.32	63.24	9412
HW	14.05.2024	Zollikofen	20	6.49	64.86	723
K126	04.07.2024	Treiten	20	6.72	67.22	11203
W	24.08.2023	Zollikofen	20	52.28	522.84	10112
395W	16.05.2025	Langnau	20	6.77	67.65	20020
2624	16.05.2025	Ättenberg	20	1.96	19.63	8233
350	14.05.2025	Aetigkofen	20	13.76	137.60	5182
1528	20.09.2024	Schupfart	20	7.29	72.86	2687
L	30.06.2024	Vouvry	20	2.19	21.89	39965

Table S3. Criteria used to assign VESS scores (Johannes et al., 2020). Smaller scores indicate better structural quality, while greater scores reflect increasing structural degradation.

VESS Score	Size	Shape	Resistance	Structure	Porosity	Roots and Color
Sq1 (very good)	Mostly < 6 mm	Crumbly; Small rounded aggregates	Readily crumbles with fingers	Large aggregates composed of smaller ones; held by roots	High intra–aggregate porosity	Roots within aggregates
Sq2 (good)	2 mm $-$ 7 cm	Rounded aggregates, no clods present	Aggregates easy to break	Opening reveals some smaller aggregates and rough surface structure	High intra-aggregate porosity	Roots within aggregates
Sq3 (moderate)	2 mm $-$ 7 cm; Less than 30% $<$ 1 cm	Mixture of various sizes of rounded aggregates	Most aggregates break with one hand	Opening reveals faces that are more or less rough	Small intra-aggregate porosity	Few roots, mostly within aggregates
Sq4 (poor)	Mostly $>$ 10 cm; Less than 30% $<$ 7 cm	Sub-angular clods with possible sharp edges	Requires considerable effort to break with one hand	Opening a clod reveals rather flat faces	Very small intra-aggregate porosity	Roots usually clustered in macropores and cracks
Sq5 (very poor)	Mostly $>$ 10 cm	Angular clods, sharp-edged and non-porous	Difficult to break up	Opening a clod reveals flat angular faces	No intra-aggregate porosity	Anaerobic zones with gray-blue color possible

Table S4. Minimum and maximum values of the soil properties within each of the four clusters to predict saturated hydraulic conductivity. Values represent the median of typically four replicate soil samples per site

Cluster	pH		Sand		Clay		SOC		SOC:Clay ratio		VESS score	
	[-]		[%]		[%]		[%]		[-]		[-]	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
a)	4.4	5.0	53.5	78	8.1	20.4	1.1	5.8	0.07	0.56	1	2.5
b)	3.8	5.2	17.8	43.5	19.2	42.9	0.1	6.5	0.005	0.19	1	3
c)	4.9	7.2	6.4	29.3	15.3	77.3	2.9	11.5	0.07	0.29	1	2.9
d)	3.4	3.8	17.2	54.5	16.2	21.9	5.9	15.5	0.37	0.83	1	3