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Lithology- and climate-controlled soil aggregate-size distribution and organic carbon stability in the Peruvian Andes

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Supplement:

Table S1 Bulk soils properties and distribution of fraction weights, C and N in aggregate-size fractions.

Site	Horizon	Depth	C	N	pH	MWD	Gravels in LM	W5	W4	W3	W2	W1	C5	C4	C3	C2	C1	N5	N4	N3	N2	N1
		cm	%	%		mm	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Wet (Cajamarca)																						
LS1	A_{h1}	20	12.51	1.10	6.17	4.22	0.00	29.2	18.6	43.5	7.9	0.7	11.94	11.73	12.25	13.59	12.23	1.06	1.05	1.06	1.24	1.07
	A_{h2}	37	7.20	0.64	6.07	6.42	0.75	51.6	20.2	26.2	2.0	0.0	6.67	8.39	8.05	9.37	10.58	0.61	0.74	0.72	0.83	0.87
	B_t	57	3.73	0.40	6.22	7.99	18.91	68.9	17.4	13.2	0.5	0.0	3.96	4.53	5.19	7.38	6.91	0.40	0.46	0.50	0.68	0.64
LS2	A_{h1}	14	14.84	1.21	5.25	5.33	0.29	41.1	20.4	25.2	8.9	4.1	14.22	14.25	14.66	15.42	11.64	1.15	1.18	1.18	1.27	0.95
	A_{h2}	40	12.65	1.01	5.50	4.80	0.00	34.4	24.0	29.5	9.2	2.9	12.15	12.46	12.60	13.58	10.58	0.95	1.00	1.01	1.11	0.87
	A_{h3}	55	7.67	0.60	5.98	6.37	0.00	50.7	22.3	23.4	3.4	0.2	7.44	8.24	8.34	9.26	7.22	0.57	0.65	0.67	0.73	0.58
	B_{tg}	66	2.41	0.24	6.49	8.72	18.43	77.1	15.6	7.1	0.2	0.0	2.11	2.44	2.90	3.69	2.67	0.22	0.24	0.27	0.33	0.24
LS3	A_p	12	12.63	1.01	5.57	5.64	0.00	44.8	16.3	31.4	6.0	1.3	12.21	11.66	12.43	13.25	12.40	0.99	0.97	0.99	1.10	1.05
	A_{h2}	37	7.47	0.57	6.42	4.97	0.00	36.1	22.4	34.3	6.1	1.0	7.52	7.32	7.17	7.78	8.25	0.57	0.57	0.55	0.63	0.65
	A_{h3}	47	4.59	0.34	6.84	7.66	0.14	65.3	18.2	14.7	1.6	0.3	4.55	5.12	4.81	5.19	5.99	0.32	0.37	0.35	0.40	0.45
	B_{tg}	60	2.37	0.20	6.97	8.30	0.62	73.7	11.6	13.6	1.1	0.0	1.98	2.98	3.17	3.59	4.27	0.18	0.23	0.25	0.27	0.34
AS1	A_p	20	3.30	0.28	4.99	3.76	11.16	29.2	7.9	34.0	23.2	5.6	3.77	3.70	2.32	4.48	6.78	0.30	0.30	0.18	0.39	0.60
	A_{h2}	45	3.46	0.29	4.90	4.00	4.96	29.3	14.8	34.1	17.0	4.8	3.83	3.79	2.82	4.19	7.48	0.32	0.32	0.25	0.36	0.65
	A_{h3}	68	2.97	0.26	5.00	3.80	17.00	26.4	16.1	39.3	14.0	4.2	3.06	2.83	2.21	3.47	5.93	0.25	0.24	0.19	0.30	0.55
AS2	A_p	20	9.24	0.67	5.03	2.89	9.14	18.4	13.9	39.2	21.1	7.0	9.82	9.70	7.53	8.77	14.28	0.68	0.69	0.52	0.63	1.01
	A_{h2}	45	7.38	0.52	4.96	2.93	18.10	17.7	15.9	42.8	19.3	4.3	8.01	7.52	6.81	9.24	12.68	0.56	0.52	0.47	0.68	0.88
AS3	A_{h1}	15	9.38	0.66	5.54	3.79	9.26	24.4	23.9	32.8	14.1	4.4	10.83	9.83	8.34	10.43	12.28	0.78	0.68	0.58	0.74	0.91
	A_{h2}	35	5.90	0.43	5.26	3.08	43.10	18.6	19.4	37.7	17.3	6.9	7.15	5.67	5.16	7.95	10.01	0.52	0.42	0.37	0.60	0.72
Dry (Carhuaz)																						
LS1	A_{h1}	22	3.62	0.33	5.21	3.72	8.95	21.8	28.9	35.6	9.8	3.6	4.35	3.59	3.87	3.27	3.85	0.39	0.34	0.34	0.32	0.37
	A_{h2}	42	2.34	0.25	5.11	5.99	7.18	48.8	16.9	23.7	8.1	2.5	2.15	2.33	2.39	2.43	2.60	0.26	0.27	0.27	0.27	0.28
	B_t	56	1.99	0.24	5.02	7.35	10.48	63.4	13.9	17.9	4.0	0.9	1.82	1.96	1.95	2.05	2.61	0.27	0.25	0.26	0.25	0.30
LS2	A_{h1}	21	2.95	0.32	5.85	6.18	9.53	49.1	22.0	22.5	5.0	1.3	2.86	3.07	3.11	3.01	3.82	0.33	0.34	0.35	0.34	0.44
	A_{h2}	34	1.39	0.20	5.58	6.72	7.13	55.3	19.3	20.5	3.7	1.1	1.22	1.35	1.34	1.45	1.92	0.21	0.21	0.22	0.20	0.27
	B_{tg}	54	0.77	0.17	5.74	7.70	0.00	66.2	17.0	13.7	2.3	0.8	0.64	0.71	0.72	0.94	1.01	0.17	0.18	0.17	0.19	0.20
LS3	A_{h1}	21	4.29	0.40	5.02	5.00	6.89	37.2	21.2	30.0	9.0	2.4	3.98	3.77	4.69	4.67	4.70	0.39	0.37	0.44	0.45	0.48
	A_{h2}	42	2.62	0.27	4.95	4.43	15.21	29.9	25.4	34.6	7.7	2.4	2.79	2.60	2.71	2.58	3.48	0.31	0.29	0.28	0.26	0.38
	A_{h3}	62	2.05	0.24	5.11	4.52	11.89	28.6	33.6	30.2	5.8	1.8	2.03	2.02	2.05	2.11	2.70	0.25	0.26	0.24	0.26	0.31
	B_{tg}	73	1.69	0.22	5.25	4.44	22.56	28.3	30.7	34.1	5.4	1.4	1.72	1.74	1.74	2.09	2.27	0.23	0.23	0.22	0.25	0.30
AS1	A_{h1}	19	7.27	0.54	5.49	1.62	57.95	7.3	9.2	43.1	27.5	12.8	7.18	6.97	5.62	7.69	8.97	0.46	0.51	0.43	0.63	0.76
	A_{h2}	44	6.66	0.48	5.26	2.43	44.45	14.4	12.6	38.8	21.2	12.9	6.32	5.25	4.41	6.26	8.93	0.47	0.40	0.33	0.49	0.70
AS2	A_{h1}	10	4.62	0.32	5.63	2.03	55.76	8.3	15.3	51.6	20.8	3.6	5.83	5.41	5.96	5.74	6.45	0.40	0.38	0.38	0.42	0.50
	AC	15	1.98	0.14	5.82	1.20	80.25	1.0	9.6	64.9	18.5	6.0	2.69	2.52	1.93	2.80	4.69	0.20	0.19	0.14	0.20	0.35
	$2A_{bh}$	60	4.40	0.31	5.24	2.90	31.46	16.3	16.8	50.9	13.6	2.3	5.40	4.31	4.10	5.66	6.41	0.38	0.30	0.29	0.42	0.49
AS3	A_{h1}	19	4.81	0.32	4.83	1.90	33.58	10.9	4.2	50.2	24.2	10.0	6.27	5.60	5.63	4.29	8.96	0.42	0.33	0.35	0.31	0.65
	A_{h2}	50	4.40	0.30	4.78	1.01	77.88	1.6	6.7	49.8	27.9	13.7	7.11	5.17	6.98	5.04	8.24	0.47	0.35	0.43	0.37	0.63

LS: limestone soil, AS: acid igneous rock soil, Wet: the wet site, Dry: the dry site, MWD: mean weight diameter, LM: large macroaggregates (>2 mm), W: weight percentage, C: organic carbon content, N: nitrogen content, -5: fractions >5 mm, -4: fraction 2-5 mm, -3: fraction 0.25-2 mm, -2: fraction 0.063-0.25 mm, -1: fraction <0.063 mm.

Table S2 SOC concentrations and bulk densities every 10 cm.

Depth	SOC content	Bulk density	Bulk density corrected for stones	Depth	SOC content	Bulk density	Bulk density corrected for stones	Depth	SOC content	Bulk density	Bulk density corrected for stones
cm	%	g cm^{-1}	g cm^{-1}	cm	%	g cm^{-1}	g cm^{-1}	cm	%	g cm^{-1}	g cm^{-1}
Wet-LS1				**Wet-LS2**				**Wet-LS3**			
10	14.69	0.51	0.51	10	13.72	0.75	0.75	10	11.33	0.71	0.71
20	13.46	0.58	0.58	20	14.41	0.78	0.78	20	9.56	0.78	0.78
30	10.18	0.76	0.75	30	11.43	0.84	0.84	30	9.33	0.76	0.75
40	6.48	0.89	0.88	40	8.99	0.87	0.87	40	6.22	0.89	0.89
50	5.29	1.02	1.01	50	6.45	0.99	0.98	50	4.31	1.06	1.05
60	3.33	1.14	1.10	60	3.28	1.19	0.70	60	2.25	1.28	1.27
				70	1.00	1.37	1.32				
Average	8.91	0.82	0.81	Average	8.47	0.97	0.89	Average	7.17	0.91	0.91
Wet-AS1				**Wet-AS2**				**Wet-AS3**			
10	3.84	1.16	1.09	10	8.97	0.78	0.77	10	9.57	0.73	0.71
20	3.34	1.15	1.13	20	8.81	0.75	0.75	20	7.43	0.80	0.72
30	3.93	1.09	1.09	30	7.37	0.85	0.78	30	5.70	0.87	0.82
40	4.11	0.99	0.99	40	4.97	0.83	0.65	40	5.14	0.84	0.77
50	3.23	1.16	0.91	50	0.95	1.05	0.50	50	0.55	1.16	1.09
60	2.74	1.08	1.01								
70	1.67	1.05	0.85								
Average	3.27	1.10	1.01	Average	6.21	0.85	0.69	Average	5.68	0.88	0.82
Dry-LS1				**Dry-LS2**				**Dry-LS3**			
10	4.95	0.96	0.94	10	4.08	1.08	0.97	10	5.05	0.95	0.92
20	2.56	1.01	0.97	20	2.14	1.07	1.02	20	3.34	1.08	1.05
30	2.32	0.99	0.96	30	1.51	1.16	1.09	30	2.78	1.09	1.05
40	2.17	1.08	1.08	40	0.99	1.29	1.21	40	2.38	1.07	1.03
50	1.96	1.04	1.01	50	0.57	1.28	1.28	50	2.11	1.11	1.08
60	1.47	1.22	1.19	60	0.66	1.25	1.25	60	2.09	1.16	1.09
								70	1.69	1.19	1.15
Average	2.57	1.05	1.03	Average	1.66	1.19	1.14	Average	2.78	1.09	1.05
Dry-AS1				**Dry-AS2**				**Dry-AS3**			
10	6.88	0.74	0.48	10	5.19	0.73	0.68	10	4.88	0.99	0.85
20	5.46	0.87	0.64	20	2.78	1.13	0.89	20	4.77	0.70	0.62
30	5.37	0.78	0.74	30	3.48	1.04	0.74	30	4.88	0.72	0.69
40	2.29	0.96	0.75	40	4.31	0.81	0.73	40	5.45	0.78	0.69
50	0.91	1.21	1.18	50	4.08	0.84	0.78	50	4.48	1.09	0.77
60	0.98	1.28	1.25	60	4.59	1.03	0.77				
				70	0.51	1.59	1.25				
Average	3.65	0.97	0.84	Average	3.56	1.03	0.83	Average	4.89	0.86	0.72

Wet: the wet site, Dry: the dry stie, LS: limestone soil, AS: acidic igneous bedrock soils

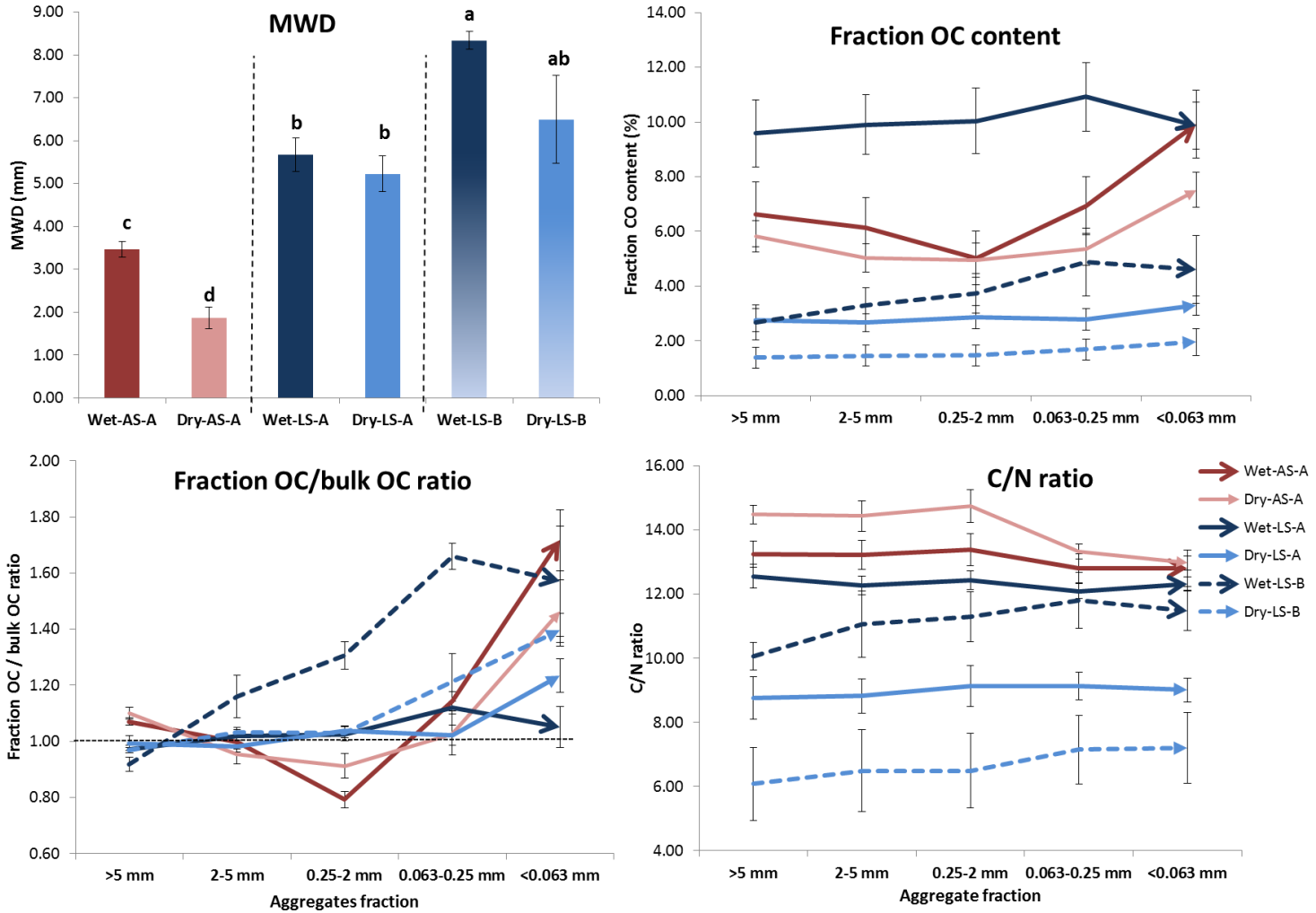

Fig. S1 Mean weight diameters (MWD) of soil horizons and properties of aggregate size fractions. N=3 for each horizon. Arrows indicate decreasing aggregate sizes**.** Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizons, B: B horizons, fraction OC content: organic carbon contents of aggregate-size fractions.

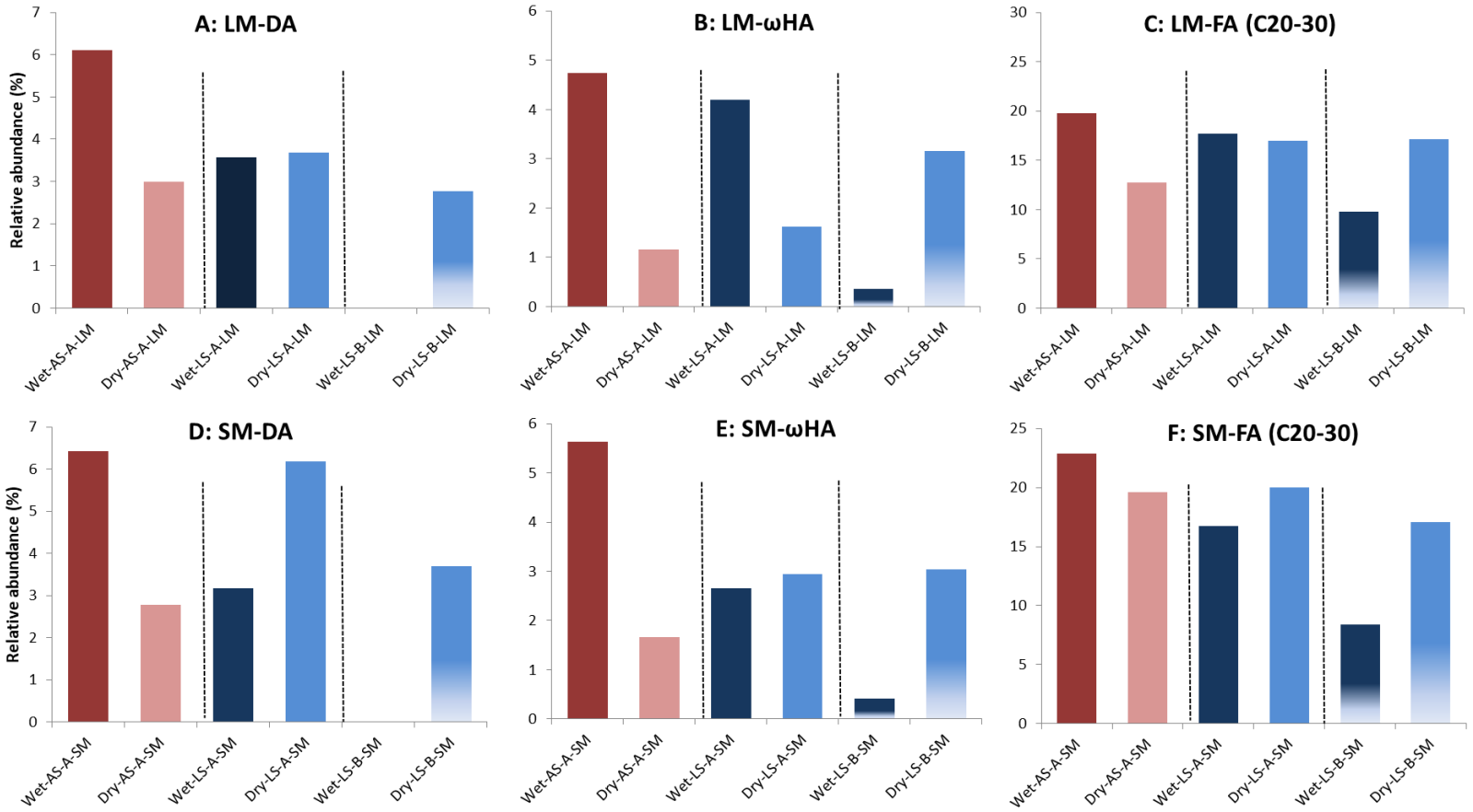

Fig. S2 Relative abundances of α, ω-dioic acids (DA), ω-hydroxyl alkanoic acid (ω-HA) and long-chain fatty acids (FA) in aggregate fractions before the incubation. Pyrolysis-gas chromatography / mass spectrometry (GC/MS) was applied to estimate the molecular composition of the soil organic matter. Briefly, milled soil samples were hydrolyzed and methylated using tetra-methyl-ammonium hydroxide (25 % in water). Afterward, a Curie-point pyrolyzer was used for sample pyrolysis. Helium was used as the carrier gas. Initial temperature was kept at 40 °C for 1 min, followed by heating at the rate of 7 °C min^{-1} until 320 °C sustaining for 15 min. The products of the pyrolysis were analyzed by the GC/MS system. Relative abundance of each compound was calculated as the peak area of the compound divided by the sum of peak areas of all identified compounds. Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizons, B: B horizons, LM: large macroaggregates (>2 mm), SM: small macroaggregates (0.25-2 mm).

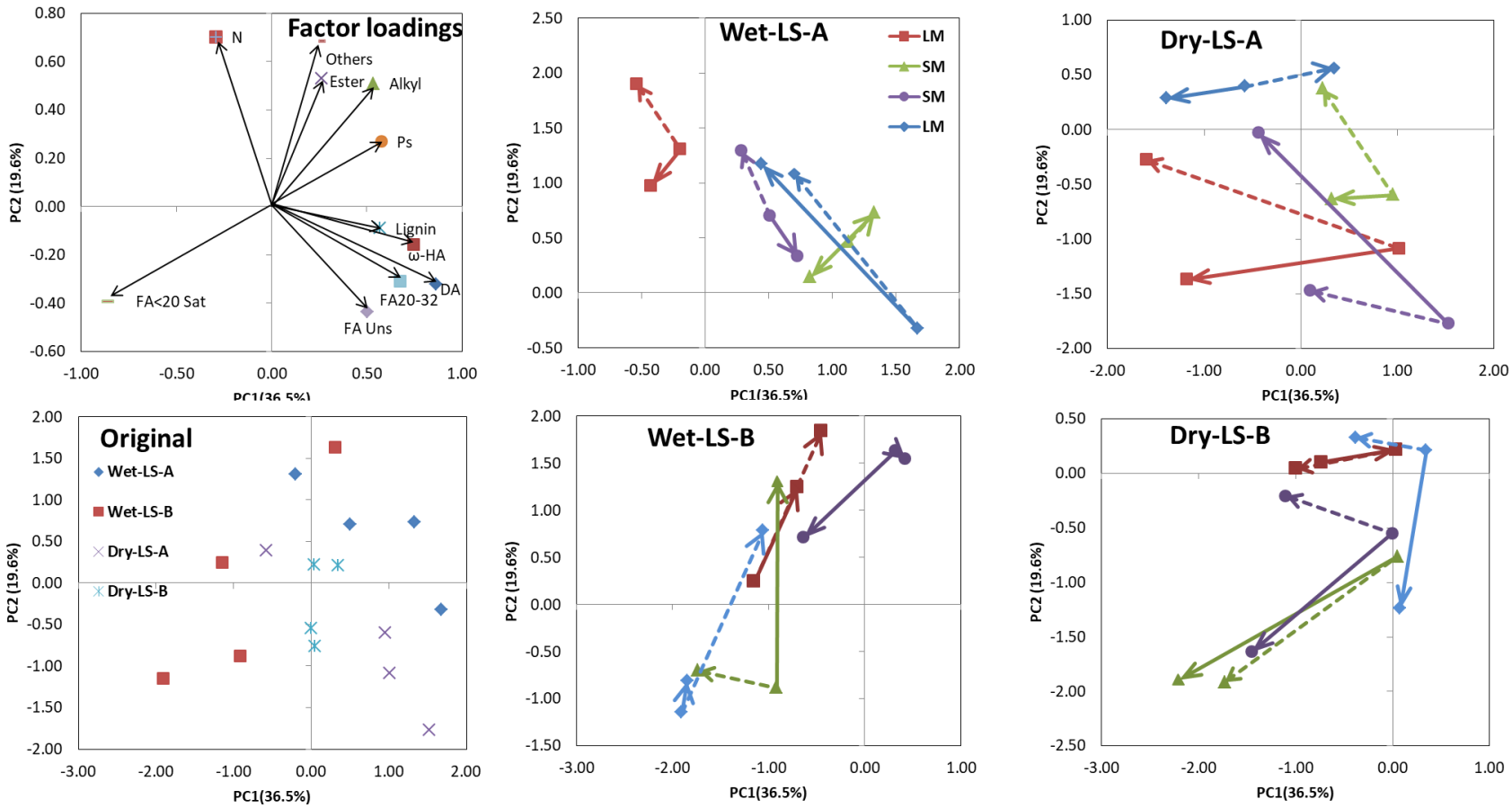

Fig. S3 Principal component analysis indicating changes in organic matter chemical composition after a 76-day incubation. DA: α, ω-dioic acid, ω-HA: ω-hydroxyl alkanoic acid, Alkyl: *n*-alkanes and *n*-alkenes, Ps: polysaccharides, N: nitrogen containing compounds, FA<20 Sat: saturated fatty acids with <20 carbon atoms, FA Uns: unsaturated fatty acids, FA20-32: saturated fatty acids with 20-32 carbon atoms, Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizon, B: B horizon. Arrows in solid line mean relative abundance change after incubation of intact aggregates; arrows in dotted line mean relative abundance change after incubation of crushed aggregates. Pyrolysis-gas chromatography / mass spectrometry (GC/MS) analysis was applied for the organic matter molecular composition. The analysis is described in Fig. S2.