



Supplement of

Availability of labile carbon controls the temperature-dependent response of soil organic matter decomposition in alpine soils

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Figure S1. Incubation setup: A 2-l glass jar containing a Petri dish filled with 50 g of soil material, a brown vial containing NaOH solution to trap the respired CO₂ and a smaller clear vial containing water to keep a constant humidity within the jar.

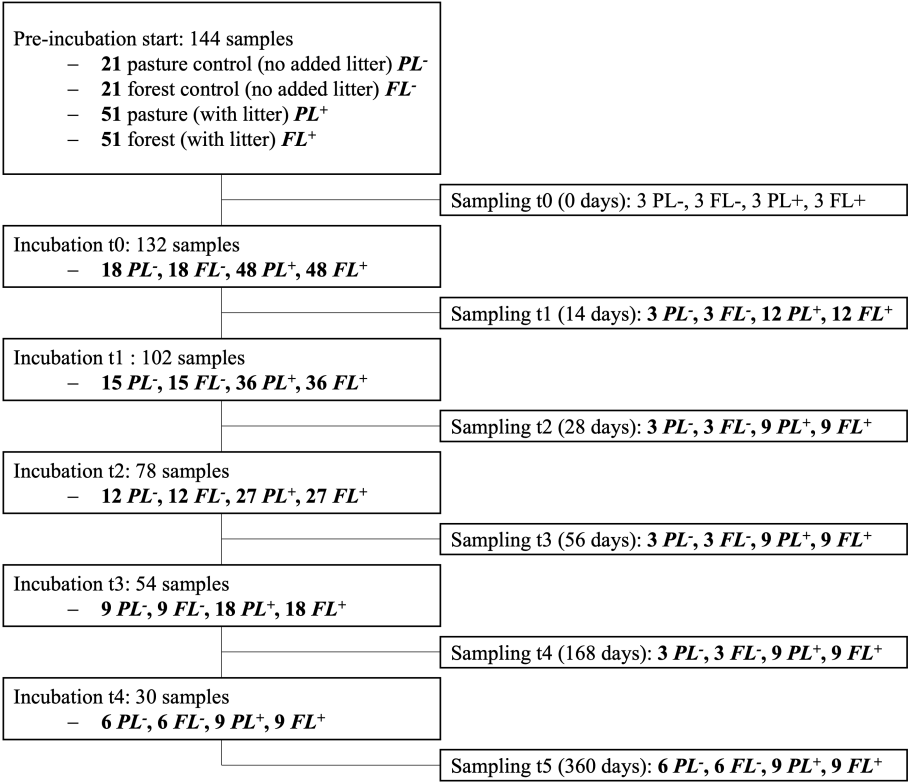


Figure S2. Incubation flowchart illustrating sample progression over time. The left side represents the number of samples remaining in incubation, while the right side denotes the sampling time points (0, 14, 28, 56, 168, and 360 days) and the number of samples collected from each treatment group. **P** refers to pasture, **F** to forest, **L**⁻ to samples without litter, and **L**⁺ to samples with litter.

Table S1. Overview of incubation experiment parameters and measured soil properties. The table includes sample number, replicate, incubation temperature, vegetation type (P = Pasture, F = Forest), sample type (L- = no litter, L+ = with litter addition), and incubation duration. Measured parameters include total organic carbon (TOC) and total nitrogen (TN) concentrations, the carbon-to-nitrogen (C/N) ratio, and $\delta^{13}\text{C}$ values (‰ vs. VPDB).

Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
133	A	12.5	P	L+	0	5.80	0.52	11.11	526.94
133	B	12.5	P	L+	0	5.92	0.53	11.15	565.02
134	A	16.5	P	L+	0	5.92	0.55	10.70	532.11
134	B	16.5	P	L+	0	5.87	0.53	11.05	503.86
135	A	20.5	P	L+	0	5.69	0.52	10.94	411.33
135	B	20.5	P	L+	0	5.42	0.49	11.03	397.92
136	A	12.5	F	L+	0	5.14	0.38	13.55	488.41
136	B	12.5	F	L+	0	5.31	0.39	13.58	528.03
137	A	16.5	F	L+	0	5.40	0.39	13.86	532.11
137	B	16.5	F	L+	0	5.34	0.42	12.71	520.85
138	A	20.5	F	L+	0	5.35	0.39	13.86	370.78
138	B	20.5	F	L+	0	5.39	0.40	13.38	383.55
139	A	12.5	P	L-	0	4.41	0.46	9.66	-26.77
139	B	12.5	P	L-	0	4.72	0.49	9.61	-26.73
140	A	16.5	P	L-	0	4.45	0.46	9.64	-26.77
140	B	16.5	P	L-	0	4.56	0.48	9.53	-26.75
141	A	20.5	P	L-	0	4.57	0.47	9.75	-26.66
141	B	20.5	P	L-	0	4.57	0.49	9.40	-26.60
142	A	12.5	F	L-	0	4.55	0.35	12.97	-25.78
142	B	12.5	F	L-	0	4.23	0.34	12.58	-25.91
143	A	16.5	F	L-	0	4.19	0.34	12.48	-25.84
143	B	16.5	F	L-	0	4.51	0.34	13.26	-25.99
144	A	20.5	F	L-	0	4.28	0.34	12.72	-25.75
144	B	20.5	F	L-	0	4.52	0.35	12.97	-25.77
1	A	12.5	P	L+	14	4.74	0.51	9.34	293.04
1	B	12.5	P	L+	14	4.83	0.53	9.14	325.39
2	A	12.5	P	L+	14	5.02	0.53	9.39	311.21
2	B	12.5	P	L+	14	5.08	0.56	9.06	297.56
3	A	12.5	P	L+	14	5.13	0.52	9.80	325.25
3	B	12.5	P	L+	14	5.06	0.54	9.35	332.62
4	A	12.5	P	L+	14	5.01	0.53	9.47	302.97
4	B	12.5	P	L+	14	5.23	0.56	9.30	328.49
5	A	16.5	P	L+	14	5.05	0.51	9.99	290.06
5	B	16.5	P	L+	14	5.24	0.56	9.40	311.00
6	A	16.5	P	L+	14	4.89	0.53	9.18	327.51
6	B	16.5	P	L+	14	4.78	0.51	9.33	306.28
7	A	16.5	P	L+	14	5.18	0.56	9.28	327.06
7	B	16.5	P	L+	14	4.71	0.51	9.24	295.07
8	A	16.5	P	L+	14	5.05	0.55	9.17	251.67
8	B	16.5	P	L+	14	4.93	0.53	9.28	270.66
9	A	20.5	P	L+	14	5.02	0.52	9.69	286.34
9	B	20.5	P	L+	14	5.28	0.57	9.24	302.53
10	A	20.5	P	L+	14	5.07	0.58	8.71	294.63
10	B	20.5	P	L+	14	5.18	0.59	8.78	264.14

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Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
11	A	20.5	P	L+	14	5.00	0.57	8.82	283.08
11	B	20.5	P	L+	14	4.98	0.57	8.67	282.83
12	A	20.5	P	L+	14	4.91	0.56	8.77	250.63
12	B	20.5	P	L+	14	5.15	0.57	9.02	255.79
49	A	12.5	P	L-	14	4.58	0.47	9.72	-26.37
49	B	12.5	P	L-	14	4.61	0.47	9.78	-26.56
55	A	16.5	P	L-	14	4.58	0.47	9.64	-26.65
55	B	16.5	P	L-	14	4.67	0.49	9.57	-26.54
61	A	20.5	P	L-	14	4.34	0.45	9.57	-26.69
61	B	20.5	P	L-	14	4.25	0.44	9.59	-26.61
67	A	12.5	F	L+	14	4.94	0.42	11.90	376.39
67	B	12.5	F	L+	14	5.32	0.47	11.26	382.63
68	A	12.5	F	L+	14	5.11	0.44	11.57	352.30
68	B	12.5	F	L+	14	4.89	0.44	11.15	339.61
69	A	12.5	F	L+	14	5.11	0.43	11.79	368.44
69	B	12.5	F	L+	14	4.91	0.44	11.19	370.35
70	A	12.5	F	L+	14	5.00	0.42	11.83	351.05
70	B	12.5	F	L+	14	4.71	0.41	11.39	363.57
71	A	16.5	F	L+	14	4.72	0.40	11.73	298.25
71	B	16.5	F	L+	14	5.01	0.42	11.81	307.45
72	A	16.5	F	L+	14	5.09	0.43	11.78	301.26
72	B	16.5	F	L+	14	5.06	0.43	11.82	321.63
73	A	16.5	F	L+	14	5.11	0.43	11.97	295.59
73	B	16.5	F	L+	14	5.06	0.45	11.36	318.60
74	A	16.5	F	L+	14	4.88	0.43	11.34	304.14
74	B	16.5	F	L+	14	4.87	0.42	11.65	309.18
75	A	20.5	F	L+	14	4.64	0.42	11.13	274.22
75	B	20.5	F	L+	14	5.12	0.44	11.60	265.65
76	A	20.5	F	L+	14	5.43	0.47	11.59	317.33
76	B	20.5	F	L+	14	4.98	0.44	11.20	310.71
77	A	20.5	F	L+	14	4.91	0.44	11.14	276.67
77	B	20.5	F	L+	14	4.67	0.42	10.99	279.66
78	A	20.5	F	L+	14	4.90	0.44	11.05	291.93
78	B	20.5	F	L+	14	4.89	0.46	10.61	297.70
115	A	12.5	F	L-	14	4.41	0.34	13.02	-25.70
115	B	12.5	F	L-	14	4.54	0.34	13.28	-25.69
121	A	16.5	F	L-	14	4.67	0.36	12.87	-25.90
121	B	16.5	F	L-	14	4.05	0.32	12.47	-25.75
127	A	20.5	F	L-	14	4.42	0.34	12.95	-25.76
127	B	20.5	F	L-	14	4.43	0.34	12.92	-25.79
13	A	12.5	P	L+	28	4.94	0.58	8.59	329.44
13	B	12.5	P	L+	28	5.25	0.61	8.65	298.57
14	A	12.5	P	L+	28	5.04	0.59	8.48	283.27
14	B	12.5	P	L+	28	4.98	0.58	8.62	282.29
15	A	12.5	P	L+	28	5.12	0.54	9.55	278.72
15	B	12.5	P	L+	28	5.20	0.55	9.47	285.28
17	A	16.5	P	L+	28	4.84	0.55	8.75	220.36
17	B	16.5	P	L+	28	4.99	0.58	8.64	230.86
18	A	16.5	P	L+	28	4.72	0.55	8.62	253.13

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Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
18	B	16.5	P	L+	28	4.80	0.56	8.64	263.44
19	A	16.5	P	L+	28	4.98	0.57	8.72	271.27
19	B	16.5	P	L+	28	4.81	0.55	8.71	277.40
21	A	20.5	P	L+	28	4.90	0.51	9.51	265.85
21	B	20.5	P	L+	28	4.96	0.55	9.03	247.11
22	A	20.5	P	L+	28	4.77	0.51	9.43	210.26
22	B	20.5	P	L+	28	4.99	0.52	9.63	212.31
23	A	20.5	P	L+	28	4.90	0.52	9.44	248.89
23	B	20.5	P	L+	28	4.93	0.52	9.55	253.74
50	A	12.5	P	L-	28	4.75	0.48	9.84	-26.62
50	B	12.5	P	L-	28	4.57	0.47	9.80	-26.56
56	A	16.5	P	L-	28	4.52	0.48	9.51	-26.55
56	B	16.5	P	L-	28	4.36	0.46	9.54	-26.67
62	A	20.5	P	L-	28	4.57	0.48	9.45	-26.53
62	B	20.5	P	L-	28	4.45	0.47	9.41	-26.68
79	A	12.5	F	L+	28	4.80	0.45	10.60	307.62
79	B	12.5	F	L+	28	4.80	0.44	10.95	311.78
80	A	12.5	F	L+	28	4.61	0.43	10.71	298.02
80	B	12.5	F	L+	28	5.00	0.48	10.37	319.32
81	A	12.5	F	L+	28	4.98	0.45	11.05	288.54
81	B	12.5	F	L+	28	4.90	0.45	10.98	308.89
83	A	16.5	F	L+	28	5.08	0.50	10.16	273.48
83	B	16.5	F	L+	28	4.96	0.45	11.05	271.37
84	A	16.5	F	L+	28	4.96	0.46	10.77	280.88
84	B	16.5	F	L+	28	5.00	0.46	10.93	275.73
85	A	16.5	F	L+	28	4.80	0.44	10.80	278.34
85	B	16.5	F	L+	28	5.04	0.45	11.21	265.79
87	A	20.5	F	L+	28	5.21	0.41	12.69	246.40
87	B	20.5	F	L+	28	4.72	0.40	11.90	274.25
88	A	20.5	F	L+	28	5.07	0.42	11.99	269.54
88	B	20.5	F	L+	28	4.78	0.44	10.77	269.69
89	A	20.5	F	L+	28	4.77	0.42	11.42	242.51
89	B	20.5	F	L+	28	4.74	0.42	11.16	256.93
116	A	12.5	F	L-	28	4.45	0.35	12.65	-25.72
116	B	12.5	F	L-	28	4.25	0.33	12.90	-25.71
122	A	16.5	F	L-	28	3.93	0.32	12.26	-25.77
122	B	16.5	F	L-	28	4.22	0.33	12.97	-25.67
128	A	20.5	F	L-	28	4.00	0.32	12.71	-25.48
128	B	20.5	F	L-	28	4.52	0.35	12.96	-25.85
16	A	12.5	P	L+	56	4.88	0.58	8.39	248.72
16	B	12.5	P	L+	56	4.87	0.57	8.55	255.01
20	A	16.5	P	L+	56	4.85	0.58	8.40	244.72
20	B	16.5	P	L+	56	5.14	0.55	9.39	250.12
24	A	20.5	P	L+	56	4.78	0.54	8.82	231.68
24	B	20.5	P	L+	56	4.94	0.54	9.14	239.64
25	A	12.5	P	L+	56	4.69	0.54	8.62	229.94
25	B	12.5	P	L+	56	5.11	0.60	8.53	257.47
26	A	12.5	P	L+	56	4.83	0.56	8.63	255.43
26	B	12.5	P	L+	56	5.01	0.60	8.41	251.91

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Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
29	A	16.5	P	L+	56	5.14	0.61	8.43	262.85
29	B	16.5	P	L+	56	5.13	0.52	9.91	258.37
30	A	16.5	P	L+	56	4.86	0.52	9.27	242.75
30	B	16.5	P	L+	56	4.86	0.53	9.09	239.44
33	A	20.5	P	L+	56	4.73	0.50	9.54	234.68
33	B	20.5	P	L+	56	4.86	0.52	9.33	239.29
34	A	20.5	P	L+	56	4.71	0.52	9.00	211.55
34	B	20.5	P	L+	56	5.07	0.55	9.22	215.71
51	A	12.5	P	L-	56	4.50	0.47	9.51	-26.58
51	B	12.5	P	L-	56	4.42	0.47	9.34	-26.50
57	A	16.5	P	L-	56	4.58	0.48	9.46	-26.61
57	B	16.5	P	L-	56	4.54	0.48	9.51	-26.66
63	A	20.5	P	L-	56	4.52	0.47	9.52	-26.68
63	B	20.5	P	L-	56	4.42	0.47	9.38	-26.61
82	A	12.5	F	L+	56	5.01	0.46	10.93	275.77
82	B	12.5	F	L+	56	5.09	0.50	10.23	283.44
86	A	16.5	F	L+	56	5.00	0.48	10.49	245.42
86	B	16.5	F	L+	56	5.01	0.41	12.20	250.33
90	A	20.5	F	L+	56	4.81	0.41	11.74	232.21
90	B	20.5	F	L+	56	5.06	0.41	12.22	251.38
91	A	12.5	F	L+	56	4.90	0.43	11.46	297.77
91	B	12.5	F	L+	56	4.85	0.46	10.60	319.55
92	A	12.5	F	L+	56	5.25	0.48	10.96	283.06
92	B	12.5	F	L+	56	4.99	0.46	10.73	288.41
95	A	16.5	F	L+	56	5.13	0.42	12.16	242.70
95	B	16.5	F	L+	56	4.72	0.39	12.23	278.69
96	A	16.5	F	L+	56	4.79	0.40	12.01	264.48
96	B	16.5	F	L+	56	4.96	0.42	11.68	241.90
99	A	20.5	F	L+	56	4.69	0.39	12.12	239.80
99	B	20.5	F	L+	56	4.66	0.43	10.77	245.28
100	A	20.5	F	L+	56	4.68	0.40	11.75	241.98
100	B	20.5	F	L+	56	4.98	0.41	12.07	239.86
117	A	12.5	F	L-	56	4.24	0.34	12.61	-25.80
117	B	12.5	F	L-	56	4.54	0.35	13.14	-25.72
123	A	16.5	F	L-	56	4.50	0.35	12.84	-25.89
123	B	16.5	F	L-	56	4.52	0.35	12.98	-25.79
129	A	20.5	F	L-	56	4.29	0.34	12.64	-25.86
129	B	20.5	F	L-	56	4.38	0.33	13.17	-25.83
27	A	12.5	P	L+	168	5.20	0.53	9.75	227.38
27	B	12.5	P	L+	168	5.06	0.52	9.82	233.21
28	A	12.5	P	L+	168	4.77	0.52	9.24	227.65
28	B	12.5	P	L+	168	4.78	0.53	8.97	237.95
31	A	16.5	P	L+	168	4.82	0.52	9.34	212.12
31	B	16.5	P	L+	168	4.95	0.52	9.61	214.25
32	A	16.5	P	L+	168	4.94	0.53	9.29	181.40
32	B	16.5	P	L+	168	4.77	0.52	9.25	189.36
35	A	20.5	P	L+	168	4.98	0.57	8.74	189.08
35	B	20.5	P	L+	168	4.73	0.55	8.59	197.79
36	A	20.5	P	L+	168	4.83	0.52	9.38	189.69

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Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
36	B	20.5	P	L+	168	4.80	0.50	9.69	196.10
37	A	12.5	P	L+	168	5.17	0.53	9.78	231.85
37	B	12.5	P	L+	168	5.04	0.56	8.93	223.01
41	A	16.5	P	L+	168	4.71	0.52	9.04	196.60
41	B	16.5	P	L+	168	4.77	0.53	9.08	195.10
45	A	20.5	P	L+	168	4.62	0.49	9.38	137.43
45	B	20.5	P	L+	168	4.63	0.52	8.96	138.61
52	A	12.5	P	L-	168	4.42	0.47	9.34	-26.63
52	B	12.5	P	L-	168	4.43	0.48	9.32	-26.57
58	A	16.5	P	L-	168	4.76	0.51	9.31	-26.63
58	B	16.5	P	L-	168	4.53	0.49	9.26	-26.64
64	A	20.5	P	L-	168	4.45	0.48	9.32	-26.67
64	B	20.5	P	L-	168	4.30	0.47	9.06	-26.51
93	A	12.5	F	L+	168	4.73	0.40	11.74	229.32
93	B	12.5	F	L+	168	5.06	0.41	12.23	245.17
94	A	12.5	F	L+	168	5.04	0.40	12.49	250.33
94	B	12.5	F	L+	168	5.10	0.43	11.94	230.15
97	A	16.5	F	L+	168	4.70	0.35	13.44	184.39
97	B	16.5	F	L+	168	4.43	0.33	13.36	198.99
98	A	16.5	F	L+	168	4.98	0.42	11.96	203.78
98	B	16.5	F	L+	168	4.74	0.40	11.93	217.10
101	A	20.5	F	L+	168	4.56	0.39	11.63	206.16
101	B	20.5	F	L+	168	4.76	0.40	11.76	191.10
102	A	20.5	F	L+	168	4.59	0.41	11.14	201.42
102	B	20.5	F	L+	168	4.68	0.43	11.02	206.49
103	A	12.5	F	L+	168	4.89	0.40	12.30	252.46
103	B	12.5	F	L+	168	4.75	0.40	11.96	244.41
107	A	16.5	F	L+	168	5.05	0.42	12.14	206.37
107	B	16.5	F	L+	168	4.72	0.40	11.70	210.03
111	A	20.5	F	L+	168	4.72	0.40	11.88	208.87
111	B	20.5	F	L+	168	4.84	0.43	11.23	203.52
118	A	12.5	F	L-	168	4.81	0.35	13.82	-25.91
118	B	12.5	F	L-	168	3.89	0.33	11.79	-25.72
124	A	16.5	F	L-	168	4.47	0.35	12.70	-25.88
124	B	16.5	F	L-	168	4.22	0.34	12.33	-25.74
130	A	20.5	F	L-	168	4.08	0.34	12.13	-25.88
130	B	20.5	F	L-	168	4.58	0.35	13.05	-25.89
38	A	12.5	P	L+	360	4.88	0.50	9.68	207.84
38	B	12.5	P	L+	360	4.81	0.50	9.59	203.36
39	A	12.5	P	L+	360	5.07	0.53	9.55	213.46
39	B	12.5	P	L+	360	5.19	0.56	9.22	195.88
40	A	12.5	P	L+	360	4.65	0.49	9.40	202.20
40	B	12.5	P	L+	360	4.87	0.51	9.49	218.98
42	A	16.5	P	L+	360	4.69	0.49	9.52	179.50
42	B	16.5	P	L+	360	4.64	0.49	9.41	171.13
43	A	16.5	P	L+	360	5.01	0.53	9.42	169.92
43	B	16.5	P	L+	360	4.69	0.54	8.70	170.92
44	A	16.5	P	L+	360	4.81	0.50	9.66	192.64
44	B	16.5	P	L+	360	4.37	0.46	9.59	162.46

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Sample number	Replicate	Temperature [°C]	Vegetation	Type	Incubation duration [d]	TOC concentration [%]	TN concentration [%]	C/N ratio	$\delta^{13}\text{C}$ [‰ vs. VPDB]
46	A	20.5	P	L+	360	4.71	0.54	8.80	142.88
46	B	20.5	P	L+	360	4.72	0.55	8.52	139.64
47	A	20.5	P	L+	360	4.67	0.52	8.96	148.37
47	B	20.5	P	L+	360	4.61	0.53	8.61	149.10
48	A	20.5	P	L+	360	4.59	0.53	8.71	173.34
48	B	20.5	P	L+	360	4.84	0.55	8.77	185.34
53	A	12.5	P	L-	360	4.58	0.48	9.53	-26.70
53	B	12.5	P	L-	360	4.25	0.45	9.39	-26.69
54	A	12.5	P	L-	360	4.77	0.51	9.27	-26.68
54	B	12.5	P	L-	360	4.30	0.48	9.01	-26.64
59	A	16.5	P	L-	360	4.10	0.44	9.23	-26.72
59	B	16.5	P	L-	360	4.37	0.47	9.21	-26.67
60	A	16.5	P	L-	360	4.61	0.50	9.22	-26.71
60	B	16.5	P	L-	360	4.14	0.45	9.22	-26.66
65	A	20.5	P	L-	360	4.48	0.48	9.40	-26.67
65	B	20.5	P	L-	360	4.29	0.47	9.17	-26.69
66	A	20.5	P	L-	360	4.40	0.48	9.25	-26.48
66	B	20.5	P	L-	360	4.45	0.49	9.13	-26.68
104	A	12.5	F	L+	360	4.62	0.38	12.22	233.09
104	B	12.5	F	L+	360	4.53	0.37	12.08	232.51
105	A	12.5	F	L+	360	4.61	0.39	11.97	233.23
105	B	12.5	F	L+	360	4.73	0.38	12.38	254.17
106	A	12.5	F	L+	360	5.06	0.41	12.35	225.30
106	B	12.5	F	L+	360	4.69	0.40	11.74	209.30
108	A	16.5	F	L+	360	4.43	0.38	11.80	168.50
108	B	16.5	F	L+	360	4.90	0.39	12.58	187.77
109	A	16.5	F	L+	360	4.97	0.39	12.73	167.07
109	B	16.5	F	L+	360	4.85	0.39	12.42	166.48
110	A	16.5	F	L+	360	4.62	0.36	12.91	187.33
110	B	16.5	F	L+	360	4.61	0.37	12.50	189.20
112	A	20.5	F	L+	360	4.39	0.42	10.46	160.01
112	B	20.5	F	L+	360	5.11	0.45	11.35	151.03
113	A	20.5	F	L+	360	4.67	0.39	12.12	155.10
113	B	20.5	F	L+	360	4.99	0.41	12.21	157.37
114	A	20.5	F	L+	360	4.36	0.35	12.63	163.92
114	B	20.5	F	L+	360	4.26	0.33	12.77	157.20
119	A	12.5	F	L-	360	4.24	0.34	12.49	-25.69
119	B	12.5	F	L-	360	3.90	0.32	12.03	-25.70
120	A	12.5	F	L-	360	4.04	0.33	12.20	-25.75
120	B	12.5	F	L-	360	4.21	0.33	12.81	-25.80
125	A	16.5	F	L-	360	4.26	0.33	12.73	-26.08
125	B	16.5	F	L-	360	4.36	0.35	12.30	-25.72
126	A	16.5	F	L-	360	4.24	0.35	11.98	-25.91
126	B	16.5	F	L-	360	4.02	0.34	12.00	-25.68
131	A	20.5	F	L-	360	4.19	0.35	11.93	-25.88
131	B	20.5	F	L-	360	3.94	0.34	11.49	-25.80
132	A	20.5	F	L-	360	3.34	0.30	11.27	-25.69
132	B	20.5	F	L-	360	4.28	0.34	12.52	-26.10

Table S2. Decomposition constants of APE for L⁺ soils and the different incubation conditions. The table presents the decomposition constant (*k*) and its standard error (SE) for two incubation durations (early phase 0–28 days and 0–360 days), expressed in per day and per year units.

Temperature	Vegetation	<i>k</i> (0–28 days) [d ^{−1}]	SE <i>k</i> (0–28 days) [d ^{−1}]	<i>k</i> (0–360 days) [d ^{−1}]	SE <i>k</i> (0–360 days) [d ^{−1}]	<i>k</i> (0–360 days) [d ^{−1}]	SE <i>k</i> (0–360 days) [d ^{−1}]
12.5	Forest	4.2 × 10 ^{−3}	1.4 × 10 ^{−5}	1.4 × 10 ^{−6}	6.5 × 10 ^{−9}	4.9 × 10 ^{−4}	2.4 × 10 ^{−6}
12.5	Pasture	5.1 × 10 ^{−3}	3.1 × 10 ^{−5}	1.6 × 10 ^{−6}	4.5 × 10 ^{−9}	5.8 × 10 ^{−4}	1.6 × 10 ^{−6}
16.5	Forest	5.1 × 10 ^{−3}	0.9 × 10 ^{−5}	1.7 × 10 ^{−6}	6.7 × 10 ^{−9}	6.2 × 10 ^{−4}	2.4 × 10 ^{−6}
16.5	Pasture	6.2 × 10 ^{−3}	4.6 × 10 ^{−5}	1.8 × 10 ^{−6}	6.6 × 10 ^{−9}	6.6 × 10 ^{−4}	2.4 × 10 ^{−6}
20.5	Forest	5.5 × 10 ^{−3}	2.4 × 10 ^{−5}	1.8 × 10 ^{−6}	2.8 × 10 ^{−9}	6.7 × 10 ^{−4}	1.0 × 10 ^{−6}
20.5	Pasture	6.6 × 10 ^{−3}	5.0 × 10 ^{−5}	1.9 × 10 ^{−6}	12.6 × 10 ^{−9}	7.0 × 10 ^{−4}	4.6 × 10 ^{−6}

Table S3. Lignin phenol concentrations in soil samples under different incubation conditions. The table includes sample number, incubation temperature (Temp.), vegetation type (Veg.; P = pasture, F = forest), sample type (L- = no litter, L+ = with litter addition), and incubation duration (Inc. Dur.), along with measured concentrations of individual lignin-derived phenols. The abbreviations for the phenols used here are the following: V = Vanillin, VAc = Vanillic acid, AV = Acetovanillone, SyAl = Syringaldehyde, SyAc = Syringic acid, AS = Acetosyringone, CAc = Coumaric acid, FAc = Ferulic acid, SaAl = Salicylaldehyde, SaAc = Salicylic acid, P = Piceol.

Sample Nr.	Temp. [°C]	Veg.	Type	Inc. Dur. [d]	V [µg g ⁻¹]	VAc [µg g ⁻¹]	AV [µg g ⁻¹]	SaAl [µg g ⁻¹]	SyAc [µg g ⁻¹]	AS [µg g ⁻¹]	CAc [µg g ⁻¹]	FAc [µg g ⁻¹]	SaAl [µg g ⁻¹]	SaAc [µg g ⁻¹]	P [µg g ⁻¹]
258B21TS1	12.5	P	L+	14	233.8	114.0	65.3	176.9	120.9	74.9	206.4	225.1	71.9	39.5	5.2
258B21TS2	12.5	P	L+	14	285.9	95.6	87.8	208.4	138.2	89.0	180.4	190.1	51.1	13.2	2.6
258B21TS3	12.5	P	L+	14	255.0	100.2	73.0	197.9	138.2	78.8	213.7	232.7	52.0	16.8	4.4
258B21TS4	12.5	P	L+	14	275.1	123.1	70.8	168.7	147.0	65.9	217.0	237.3	75.1	49.0	19.0
258B21TS5	16.5	P	L+	14	265.1	97.3	84.1	182.2	88.8	88.8	167.7	194.4	51.8	17.5	38.9
258B21TS9	20.5	P	L+	14	291.1	109.2	101.0	202.1	168.8	55.0	175.1	205.0	36.1	31.3	38.8
258B21TS13	12.5	P	L+	28	289.8	108.0	93.0	195.5	137.1	73.3	178.5	200.9	48.9	10.1	43.0
258B21TS16	12.5	P	L+	56	279.6	104.5	88.4	186.8	118.4	51.3	146.0	175.0	42.8	9.3	40.3
258B21TS17	16.5	P	L+	28	308.7	116.6	103.7	200.8	141.7	47.2	136.5	152.3	41.7	8.9	44.9
258B21TS20	16.5	P	L+	56	267.9	101.8	82.6	182.2	114.5	44.4	146.6	179.0	33.6	7.3	37.0
258B21TS21	20.5	P	L+	28	276.8	114.1	99.4	185.8	137.2	54.7	125.2	153.9	37.2	10.6	41.4
258B21TS24	20.5	P	L+	56	280.1	111.7	87.6	188.8	123.4	52.6	157.3	184.2	36.3	7.4	40.5
258B21TS27	12.5	P	L+	168	303.8	116.1	98.9	196.0	114.1	38.5	112.3	138.0	36.7	6.0	42.7
258B21TS31	16.5	P	L+	168	253.4	100.3	85.0	176.7	99.4	40.2	115.9	148.6	32.6	7.1	36.2
258B21TS35	20.5	P	L+	168	315.2	122.4	108.5	183.9	140.4	64.4	82.5	90.8	57.1	14.3	49.2
258B21TS38	12.5	P	L+	360	206.0	84.7	61.8	161.8	78.8	25.0	155.7	178.5	15.9	28.5	24.5
258B21TS42	16.5	P	L+	360	248.1	153.1	89.9	186.9	101.5	13.4	145.3	149.5	28.6	29.1	33.8
258B21TS46	20.5	P	L+	360	255.7	51.8	95.3	202.1	84.4	88.4	134.6	140.4	20.0	28.4	31.7
258B21TS49	12.5	P	L-	14	280.2	121.4	96.7	209.2	144.0	72.3	234.1	253.6	38.3	9.8	43.9
258B21TS50	12.5	P	L-	28	255.3	100.8	78.8	194.5	125.2	54.6	243.3	266.3	32.2	7.2	38.6
258B21TS51	12.5	P	L-	56	260.2	100.7	95.9	155.0	160.0	154.6	117.7	113.1	85.6	55.8	50.1
258B21TS52	12.5	P	L-	168	267.0	85.1	83.2	158.2	91.1	70.8	98.8	116.7	44.7	9.0	42.8
258B21TS53	12.5	P	L-	360	156.0	85.9	53.1	131.6	78.8	35.7	148.7	169.1	21.6	25.1	23.6
258B21TS54	12.5	P	L-	360	223.7	94.0	71.5	176.1	84.3	29.9	156.1	174.2	19.4	14.7	28.9
258B21TS55	16.5	P	L-	14	229.7	96.9	67.6	171.5	128.9	124.1	256.3	279.6	97.1	90.1	37.8
258B21TS56	16.5	P	L-	56	288.8	101.3	93.2	183.5	111.9	83.2	129.9	136.9	57.3	31.5	47.7
258B21TS57	16.5	P	L-	28	290.3	120.2	96.4	216.1	145.2	65.6	233.4	253.3	38.1	7.7	46.4
258B21TS58	16.5	P	L-	168	172.3	81.3	70.4	122.7	138.2	94.1	139.3	162.5	33.5	17.6	34.9
258B21TS59	16.5	P	L-	360	223.8	90.2	74.7	168.9	86.6	34.1	151.7	161.8	19.4	10.8	29.2
258B21TS60	16.5	P	L-	360	269.8	129.5	101.6	187.7	104.5	52.3	113.5	75.0	47.3	21.5	44.6
258B21TS61	20.5	P	L-	14	289.0	117.0	93.9	213.6	145.3	89.2	234.2	252.4	57.8	16.2	45.8
258B21TS62	20.5	P	L-	28	190.3	186.7	89.9	76.9	129.3	40.1	210.4	209.5	69.1	39.4	48.3
258B21TS63	20.5	P	L-	56	279.4	101.3	96.6	170.9	111.3	72.7	95.9	94.8	52.0	28.9	48.9
258B21TS64	20.5	P	L-	168	205.5	85.9	66.7	142.3	101.9	64.9	113.5	137.3	42.1	0.2	36.2
258B21TS65	20.5	P	L-	360	205.0	106.1	81.9	157.6	99.2	49.3	126.7	127.3	26.8	12.4	32.9
258B21TS66	20.5	P	L-	360	294.4	45.1	113.1	197.8	107.0	130.5	115.7	94.6	41.4	22.5	44.5
258B21TS67	12.5	F	L+	14	666.9	231.3	177.9	68.4	45.9	26.5	140.7	128.0	61.3	8.1	21.2
258B21TS71	16.5	F	L+	14	656.2	28.8	180.9	61.8	55.4	146.0	129.5	136.3	47.1	5.4	45.5
258B21TS75	20.5	F	L+	14	651.8	28.0	210.3	66.8	61.8	140.0	111.0	117.1	45.0	7.2	44.9
258B21TS79	12.5	F	L+	28	617.6	28.3	183.9	59.5	42.2	151.5	117.3	128.6	52.5	10.2	43.6
258B21TS82	12.5	F	L+	56	719.6	29.1	204.2	67.2	60.2	152.5	122.8	126.9	50.4	5.9	48.9
258B21TS83	16.5	F	L+	28	736.6	28.7	224.3	65.2	41.1	123.7	107.5	107.0	38.6	4.1	49.6

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Sample Nr.	Temp. [°C]	Veg. Type		Inc. Dur. [d]	V [µg g ⁻¹]	VAc [µg g ⁻¹]	AV [µg g ⁻¹]	SAI [µg g ⁻¹]	SyAc [µg g ⁻¹]	AS [µg g ⁻¹]	CAC [µg g ⁻¹]	FAc [µg g ⁻¹]	SaAI [µg g ⁻¹]	SaAc [µg g ⁻¹]	P [µg g ⁻¹]
258B21TS86	16.5	F	L+	56	656.8	29.1	199.1	62.2	42.7	141.9	109.8	115.0	44.8	6.1	45.3
258B21TS87	20.5	F	L+	28	698.9	233.8	220.2	67.6	68.9	244.3	109.8	108.4	185.7	130.8	58.4
258B21TS90	20.5	F	L+	56	597.6	28.5	189.7	57.2	48.5	150.2	117.9	115.1	40.1	4.9	46.3
258B21TS93	12.5	F	L+	168	713.3	23.3	204.5	60.2	23.4	157.0	97.9	99.7	52.9	6.7	49.6
258B21TS97	16.5	F	L+	168	707.2	24.1	205.6	62.0	39.3	189.5	111.5	115.3	62.3	9.0	51.9
258B21TS101	20.5	F	L+	168	605.4	29.8	176.9	55.6	58.8	208.4	108.2	109.0	61.2	13.9	47.0
258B21TS104	12.5	F	L+	360	599.2	30.5	186.1	62.4	47.9	140.5	118.9	33.7	38.6	7.6	39.4
258B21TS108	16.5	F	L+	360	552.7	46.3	138.6	58.7	37.5	101.0	101.6	55.6	35.6	6.2	38.8
258B21TS112	20.5	F	L+	360	537.1	33.2	168.6	57.9	33.7	72.9	101.3	97.1	22.1	5.9	33.7
258B21TS115	12.5	F	L-	14	638.5	9.6	176.0	47.0	66.9	359.7	185.0	134.7	156.2	112.9	50.4
258B21TS116	12.5	F	L-	28	629.0	20.5	180.8	49.0	54.5	140.8	148.5	133.5	37.7	22.9	47.8
258B21TS117	12.5	F	L-	56	645.1	21.5	181.4	42.8	42.4	174.8	95.7	78.3	47.7	6.2	50.0
258B21TS118	12.5	F	L-	168	842.5	28.8	247.8	49.2	55.5	298.2	74.8	29.0	89.1	12.4	71.3
258B21TS119	12.5	F	L-	360	303.8	116.1	98.9	196.0	114.1	38.5	112.3	138.0	36.7	6.0	42.7
258B21TS120	12.5	F	L-	360	513.1	25.4	135.1	39.8	25.2	105.5	96.6	82.6	33.2	6.6	35.7
258B21TS121	16.5	F	L-	14	561.1	22.8	207.6	54.0	62.4	264.2	161.7	141.6	82.1	12.8	56.9
258B21TS122	16.5	F	L-	28	682.3	24.0	199.7	53.5	58.2	217.2	160.0	146.7	66.1	9.0	52.7
258B21TS123	16.5	F	L-	56	684.0	22.5	196.6	42.9	45.5	202.9	95.8	21.5	61.7	14.5	52.5
258B21TS124	16.5	F	L-	168	673.7	38.0	208.8	44.5	52.2	209.9	97.1	73.6	69.7	10.1	55.8
258B21TS125	16.5	F	L-	360	463.3	34.9	134.4	36.2	31.4	86.0	111.4	76.0	22.7	18.7	33.7
258B21TS126	16.5	F	L-	360	657.9	51.5	195.4	48.4	36.0	116.6	123.0	82.3	40.8	7.9	45.7
258B21TS127	20.5	F	L-	14	667.7	136.0	190.1	51.4	60.0	64.0	162.2	137.2	51.3	23.7	52.5
258B21TS128	20.5	F	L-	28	729.1	16.8	209.0	50.9	58.7	287.2	149.1	125.5	98.8	21.8	57.3
258B21TS129	20.5	F	L-	56	658.5	21.7	193.1	39.5	48.0	198.1	84.3	67.4	52.6	4.4	54.8
258B21TS130	20.5	F	L-	168	680.6	23.9	198.0	41.9	41.4	241.6	84.9	71.6	75.3	13.0	52.3
258B21TS131	20.5	F	L-	360	572.3	35.7	181.8	42.1	32.3	88.0	100.2	73.8	25.6	20.5	38.3
258B21TS132	20.5	F	L-	360	551.8	28.1	205.4	40.1	28.8	61.7	72.7	54.8	17.9	18.7	37.8
258B21TS133	12.5	P	L+	0	312.8	129.1	106.3	213.1	154.4	86.8	181.7	236.8	65.0	14.0	47.9
258B21TS134	16.5	P	L+	0	325.8	124.0	109.5	209.5	147.7	69.2	154.9	195.8	51.0	4.9	50.6
258B21TS135	20.5	P	L+	0	261.2	105.3	85.7	192.3	123.1	76.8	188.3	263.1	51.4	13.5	41.6
258B21TS136	12.5	F	L+	0	699.4	37.4	201.3	72.8	59.4	217.1	144.6	192.1	70.6	6.5	53.5
258B21TS137	16.5	F	L+	0	723.6	39.4	224.5	67.9	92.2	243.5	149.6	190.3	63.0	4.8	61.2
258B21TS138	20.5	F	L+	0	711.2	36.7	211.9	68.2	56.8	174.5	130.2	163.6	52.0	4.7	56.5
258B21TS139	12.5	P	L-	0	268.6	118.7	95.8	181.3	157.7	73.9	172.4	157.2	39.0	28.7	46.9
258B21TS140	16.5	P	L-	0	257.9	108.5	92.6	173.9	161.1	87.7	172.1	156.5	44.3	5.6	46.5
258B21TS141	20.5	P	L-	0	267.9	94.6	87.4	168.2	100.5	77.4	115.4	120.0	52.6	9.1	42.4
258B21TS142	12.5	F	L-	0	680.7	32.4	211.4	51.4	44.7	167.6	112.3	85.4	48.9	5.1	50.1
258B21TS143	16.5	F	L-	0	686.8	34.1	211.4	46.7	56.1	293.6	123.8	86.4	75.6	11.1	57.6
258B21TS144	20.5	F	L-	0	624.5	24.5	170.7	41.3	44.1	210.4	98.6	20.2	62.7	8.1	50.3

Table S4. Statistical significance (*p*-values) of total organic carbon (TOC) differences between temperature treatments on individual days during the incubation period. Values represent pairwise comparisons of two temperatures, with significant differences (*p* <0.05) highlighted.

Total organic carbon			
Pasture L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.78	0.98	0.47
14	0.66	0.06	0.03
28	0.22	0.33	0.56
56	0.21	0.93	0.29
168	0.30	0.64	0.20
360	0.36	0.62	0.47
Forest L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.88	0.97	0.83
14	0.78	0.60	0.86
28	0.27	0.79	0.61
56	0.58	0.77	0.14
168	0.99	0.97	0.96
360	0.30	0.52	0.28
Pasture L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.37	0.16	0.64
14	0.97	0.02	0.02
28	0.33	0.04	<0.01
56	0.07	<0.01	0.73
168	0.46	0.26	0.48
360	0.52	<0.01	<0.01
Forest L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.30	0.32	0.94
14	0.77	0.60	0.74
28	0.11	0.74	0.36
56	0.37	0.05	0.23
168	0.20	0.02	0.46
360	0.84	0.65	0.57

Table S5. Statistical significance (*p*-values) of total organic carbon (TOC) isotope composition ($\delta^{13}\text{C}$) differences between temperature treatments on individual days during the incubation period. Values represent pairwise comparisons of two temperatures, with significant differences (*p* <0.05) highlighted.

TOC isotopic composition d13C			
Pasture L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.87	0.09	0.12
14	0.39	0.29	0.52
28	0.83	0.88	0.99
56	0.19	0.18	0.93
168	0.43	0.91	0.65
360	0.53	0.43	0.33
Forest L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.56	0.40	0.28
14	0.34	0.13	0.63
28	0.91	0.82	0.80
56	0.34	0.26	0.97
168	0.98	0.56	0.48
360	0.33	0.24	0.87
Pasture L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.37	0.06	0.04
14	0.14	<0.01	0.11
28	<0.01	<0.01	0.35
56	0.99	<0.01	<0.01
168	<0.01	<0.01	0.11
360	<0.01	<0.01	0.07
Forest L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.52	0.07	<0.01
14	<0.01	<0.01	0.03
28	<0.01	<0.01	0.04
56	<0.01	<0.01	0.11
168	<0.01	<0.01	0.92
360	<0.01	<0.01	<0.02

Table S6. Statistical significance (*p*-values) of total nitrogen (TN) differences between temperature treatments on individual days during the incubation period. Values represent pairwise comparisons of two temperatures, with significant differences (*p* <0.05) highlighted.

Total nitrogen			
Pasture L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.88	0.87	0.63
14	0.36	0.13	0.06
28	0.58	0.74	0.39
56	0.26	0.77	0.19
168	0.25	0.50	0.26
360	0.47	0.77	0.51
Forest L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.58	0.92	0.58
14	0.88	0.39	0.95
28	0.35	0.72	0.69
56	0.30	0.48	0.15
168	0.55	0.75	0.74
360	0.10	0.88	0.45
Pasture L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.36	0.37	0.19
14	0.72	<0.01	<0.01
28	0.29	<0.01	<0.01
56	0.21	<0.01	0.2
168	0.20	0.58	0.85
360	0.34	0.14	0.03
Forest L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.39	0.47	0.61
14	0.30	0.39	0.04
28	0.38	0.01	<0.01
56	0.02	<0.01	0.48
168	0.22	0.67	0.17
360	0.25	0.91	0.56

Table S7. Statistical significance (p-values) of carbon to nitrogen ratio differences between temperature treatments on individual days during the incubation period. Values represent pairwise comparisons of two temperatures, with significant differences (p <0.05) highlighted.

Carbon to nitrogen ratio			
Pasture L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.50	0.79	0.97
14	0.09	0.10	0.65
28	0.01	<0.01	0.08
56	0.64	0.83	0.76
168	0.32	0.49	0.60
360	0.52	0.63	0.80
Forest L-	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.85	0.80	0.95
14	0.21	0.34	0.41
28	0.73	0.78	0.65
56	0.92	0.94	0.99
168	0.82	0.87	0.90
360	0.62	0.14	0.23
Pasture L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.37	0.16	0.64
14	0.97	0.02	0.02
28	0.33	0.04	<0.01
56	0.07	<0.01	0.73
168	0.46	0.26	0.48
360	0.52	<0.01	<0.01
Forest L+	Temperatures		
Incubation duration [d]	12.5 °C to 16.5 °C	12.5 °C to 20.5 °C	16.5 °C to 20.5 °C
0	0.71	0.85	0.66
14	0.22	0.04	<0.01
28	0.82	0.02	0.03
56	0.02	<0.01	0.97
168	0.38	<0.01	0.03
360	0.08	0.61	0.19