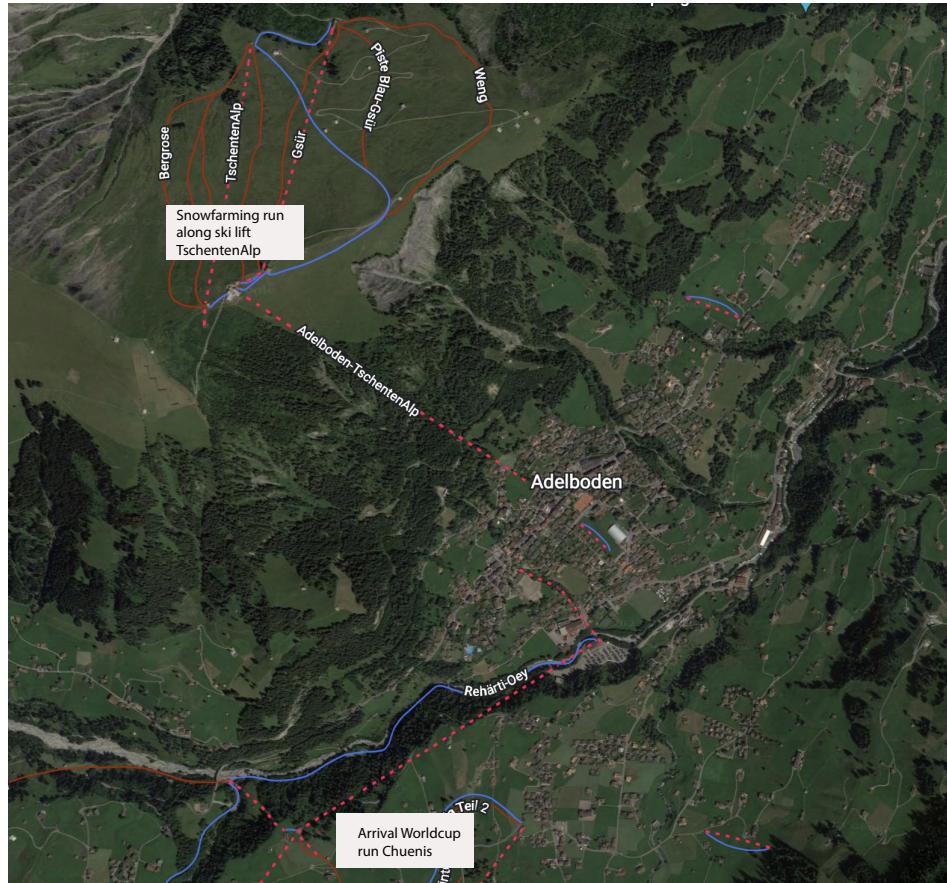


Impacts of snow-farming on alpine soil and vegetation: a case study from the Swiss Alps

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Suppl. S1 Geographical location of the experimental site in the Swiss Alps ($46^{\circ}30'5''N$, $7^{\circ}32'39''E$) near the Adelboden ski resort. Ski lifts are indicated with red dashed lines, and ski runs with red solid lines.



Suppl. S2 Preparation of the snow pile in April 2018 (A), view of the snow pile in June 2018 (B), preparation of the ski slope (C) and ski training session in October 2018 (D). Ferric hydroxide precipitates visible on the border of the snow pile at the end of summer (E).

(A)



(B)



(C)



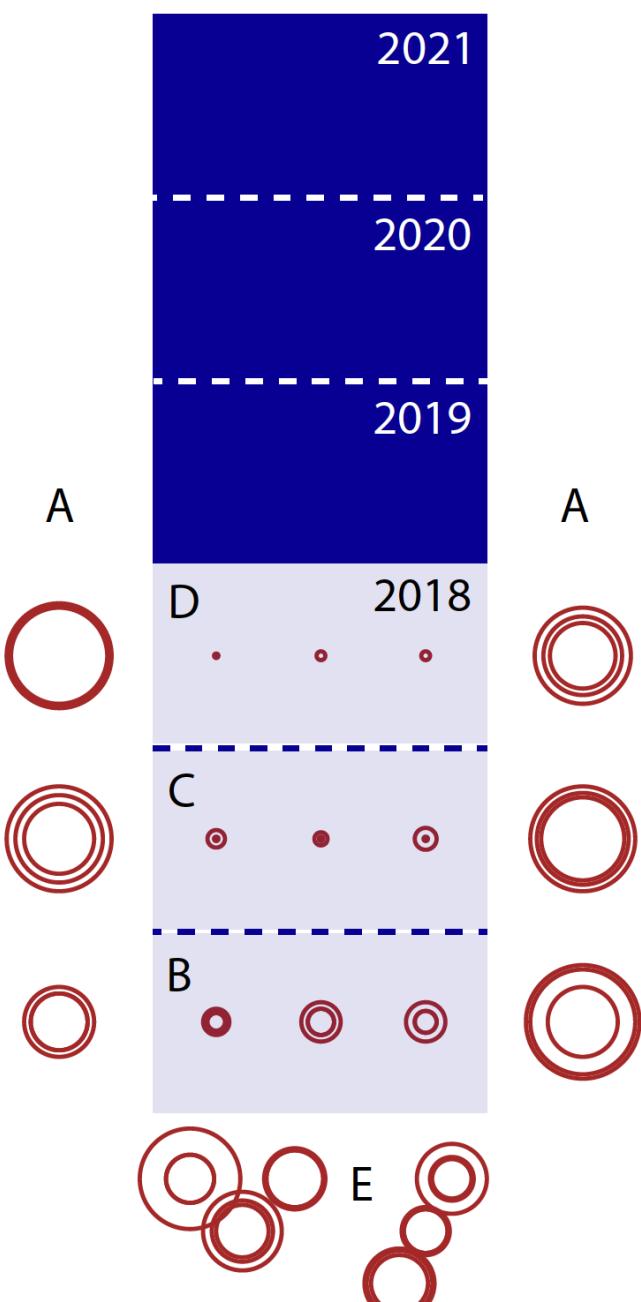
(D)



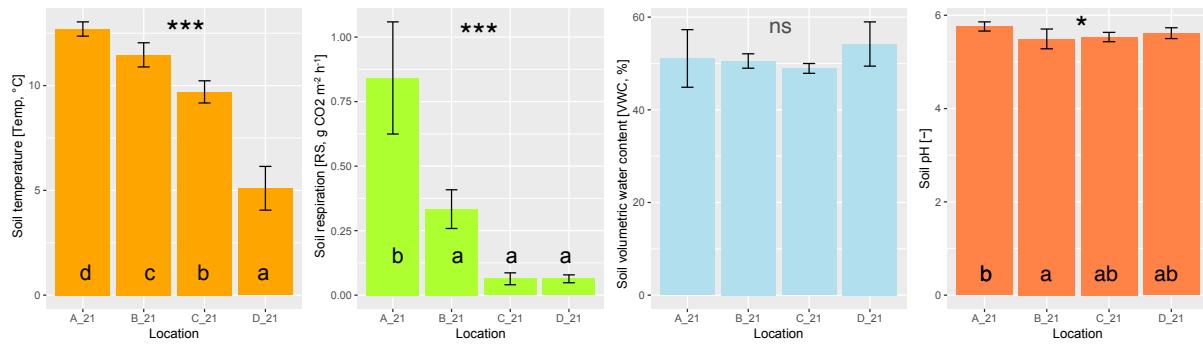
(E)



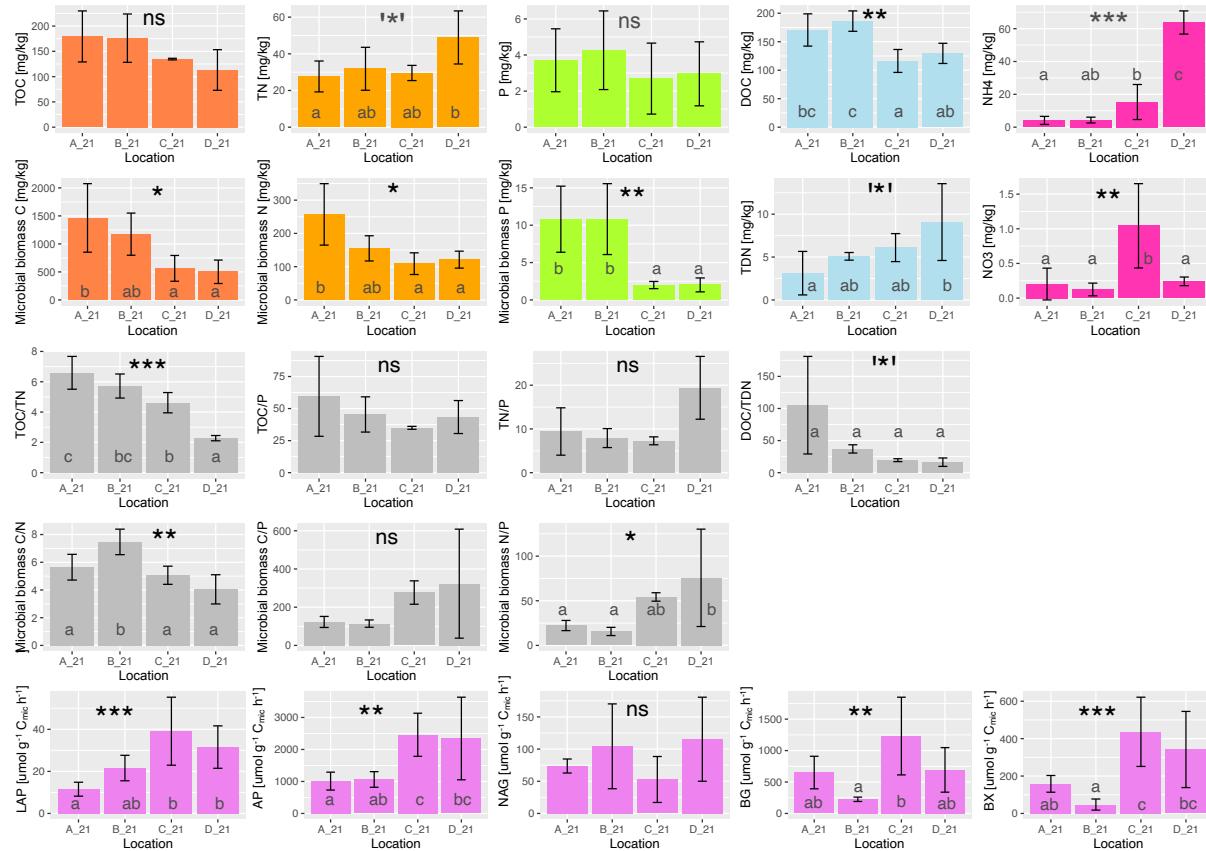
Suppl. S3 Map of plant species richness. Annual records are superimposed as circles proportional to the number of species in each year. Years indicate the upper margin of the snow pile in each year. In locations B, C and D, records were made three times (2019, 2020, 2021), twice (2020, 2021) and only once (2021), respectively. In A and E, records were made in 2018, 2019 and 2020. Refer to Fig. 1 for the experimental design.



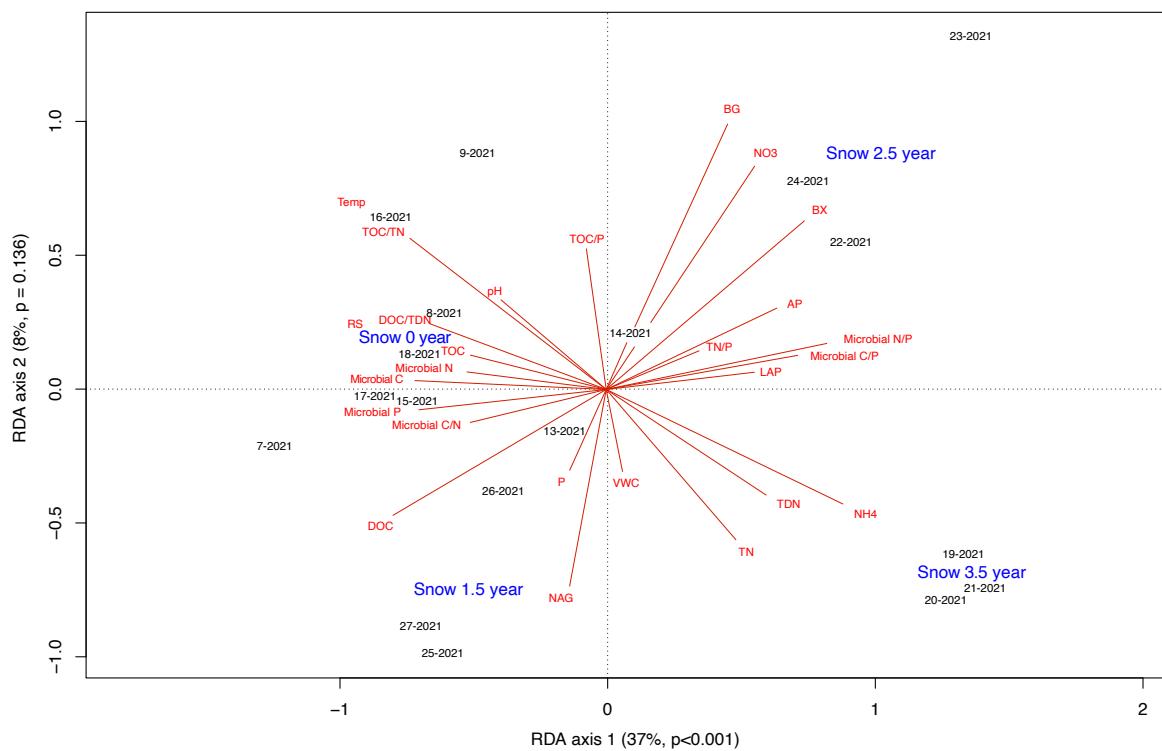
Suppl. S4 Mean \pm SD of soil temperature, respiration, moisture and pH in 2021. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3). The statistical significance of the differences between locations are indicated with: ns not significant ($p \geq 0.1$); ** $0.05 \leq p < 0.1$; * $0.01 \leq p < 0.05$; ** $0.001 \leq p < 0.01$; *** $p < 0.001$. Different letters indicate pairwise comparisons (Tukey post-hoc tests).



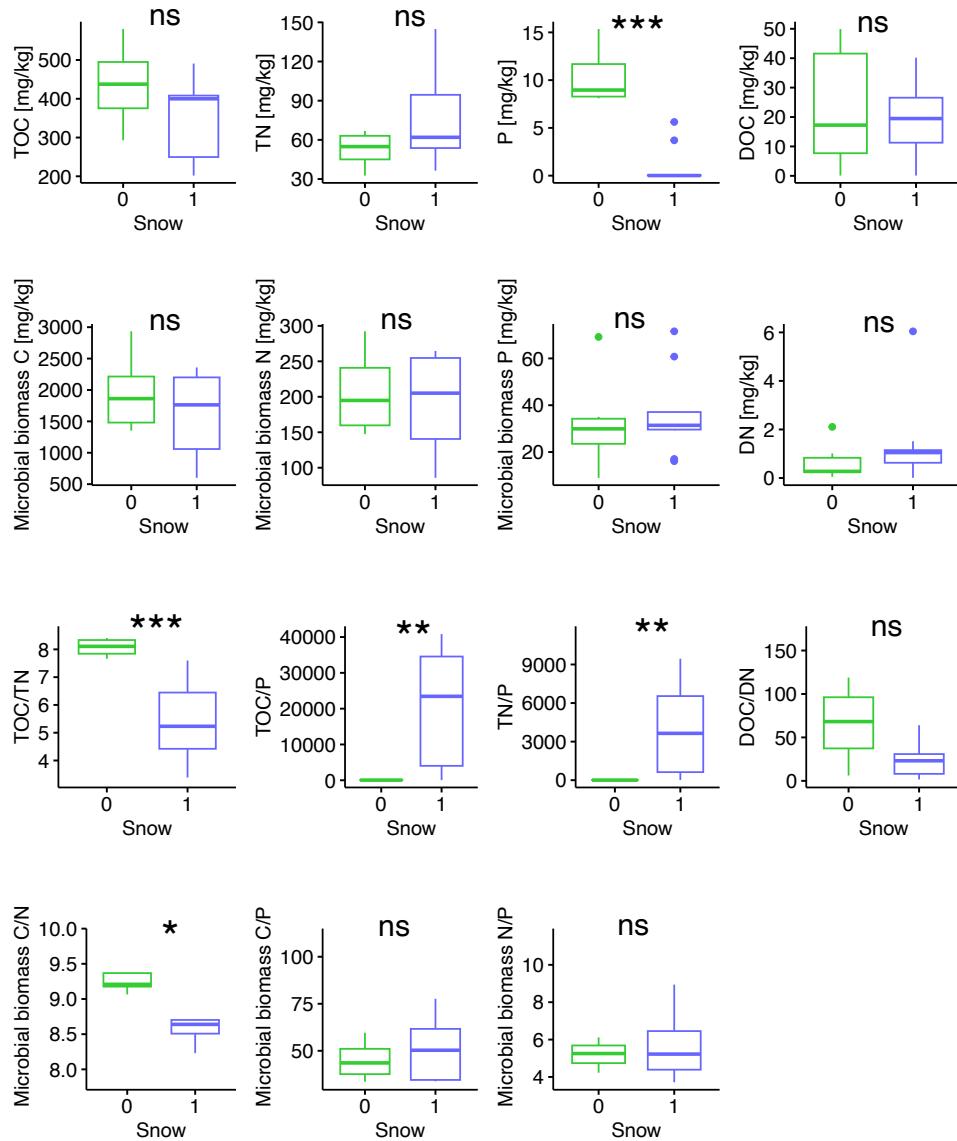
Suppl. S5 Mean \pm SD of soil biogeochemical properties in 2021. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3). The statistical significance of the differences between locations are indicated with: ns not significant ($p \geq 0.1$); ** $0.05 \leq p < 0.1$; * $0.01 \leq p < 0.05$; *** $0.001 \leq p < 0.01$; **** $p < 0.001$. Different letters indicate pairwise comparisons (Tukey post-hoc tests). Enzymes are leucine-aminopeptidase (LAP), acid phosphatase (AP), β -N-acetyl glucosaminidase (NAG), β -glucosidase (BG) and β -xylosidase (BX). See abbreviations of other variables in Table 1.



Suppl. S6 Scatterplot of the redundancy analysis (RDA) of plots in locations A, B, C, D and E in 2021 ($N = 18$), described by biogeochemical variables. Plot numbers are indicated with the year of sampling. Explanatory variable is the duration of compressed snow cover on the plots and includes the different recovery periods: 1.5 years of cover with a recovery period of 3 vegetation seasons in B (plots 25, 26, 27), 2.5 years of cover with a recovery period of 2 vegetation seasons in C (plots 22, 23, 24), and 3.5 years of cover with a recovery period of 1 vegetation season in D (plots 19, 20, 21). Control plots, without compressed snow, were positioned at locations A (left and right side of the snow pile: plots 7, 8, 9, 16, 17, 18) and E (drier run-off area: plots 13, 14, 15). The overall model is significant, with $p < 0.001$. The explanatory variable snow cover explains 51% of the variability and is significant ($p < 0.001$). See abbreviations for variables in Table 1.



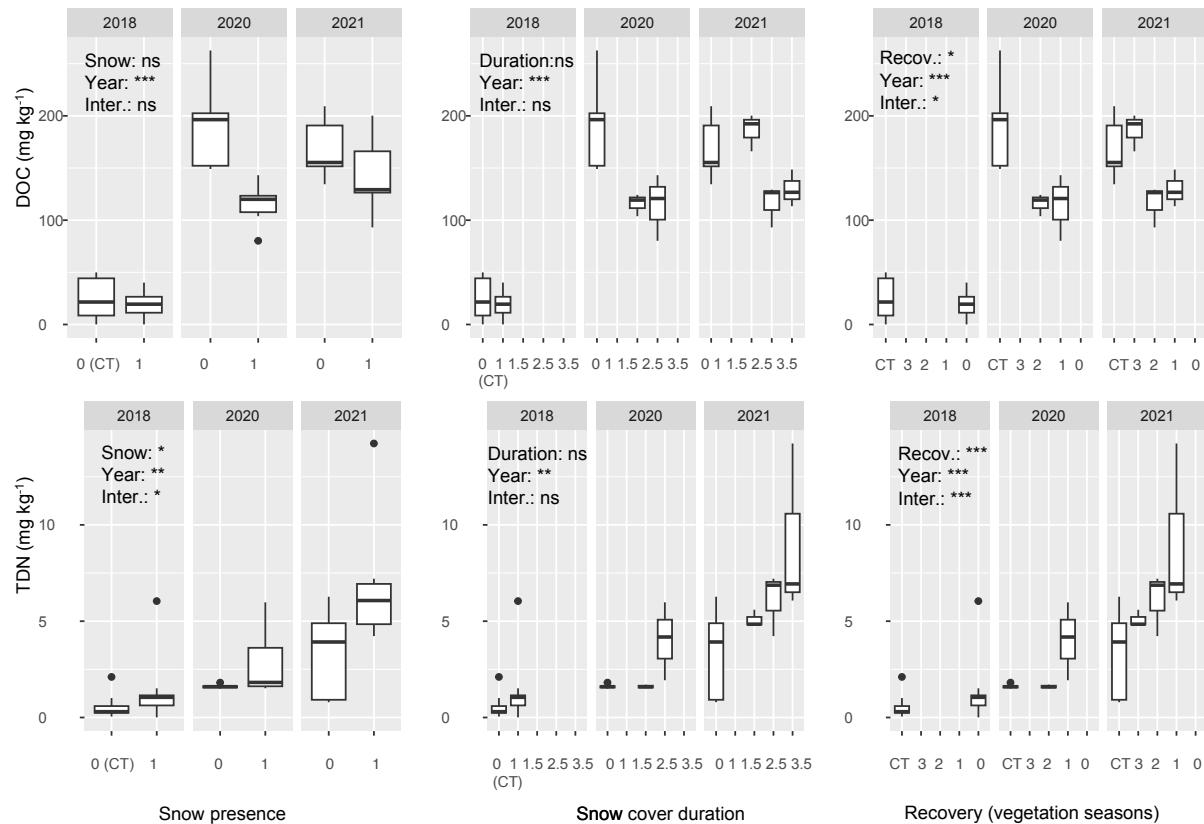
Suppl. S7 Mean \pm SD of soil biogeochemical properties in 2018, in control plots (A, no compressed snow cover, N = 6; “Snow 0”) and in plots sampled underneath the snow pile, after 1 year of cover (B, C and D, N = 9; “Snow 1”). Significant differences are indicated with: ns not significant ($p \geq 0.1$); * $0.05 \leq p < 0.1$; * $0.01 \leq p < 0.05$; ** $0.001 \leq p < 0.01$; *** $p < 0.001$. See abbreviations for variables in Table 1.



Suppl. S8 Significance of soil biogeochemical properties across the 3 years of the study (2018, 2020 and 2021), according to the presence of compressed snow, the compressed snow cover duration, and the number of vegetation seasons of recovery after snow cover. P-values from linear mixed-effects models are given with: '*' $0.05 \leq p < 0.1$; '*' $0.01 \leq p < 0.05$; '** $0.001 \leq p < 0.01$; *** $p < 0.001$.

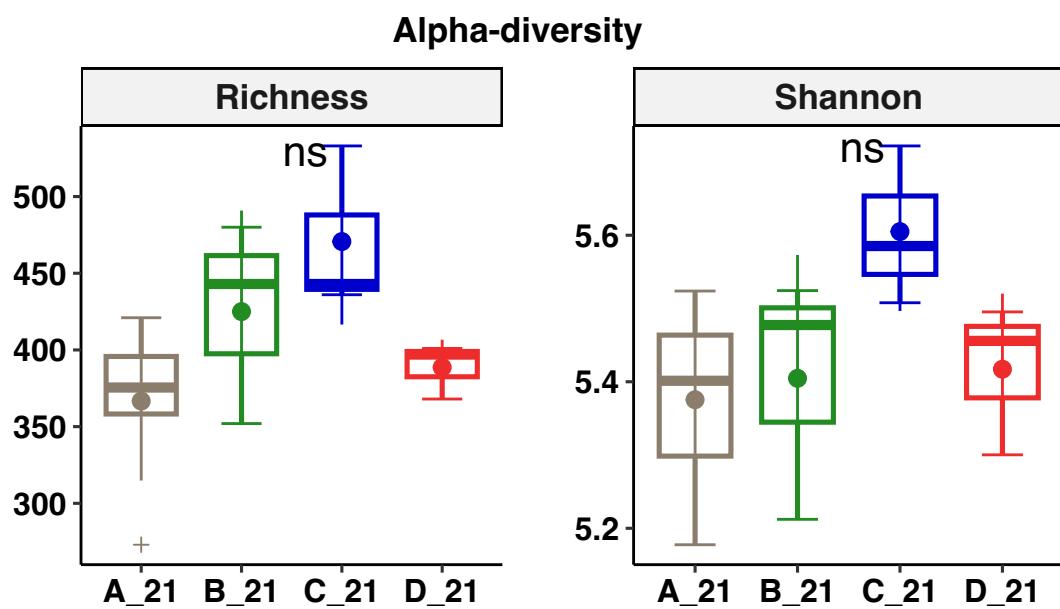
Response variable	Snow cover (presence)			Duration of snow cover (years)			Recovery (growing seasons)		
	Snow	Year	Snow x Year	Duration	Year	Duration x Year	Recovery	Year	Recovery x Year
Soil physical properties									
pH	0,1398	0,2335	0,1404	0,0133	*	0,2417	0,0133	*	0,4860
Temperature (Temp)	0,5505	0,4469	0,5487	0,1555	0,7417	0,1546	0,0000	***	0,0000
Respiration (RS)	0,0020	**	0,0000	***	0,0020	**	0,0404	*	0,0008
Volumetric water content (VWC)	0,0219	*	0,0015	**	0,0219	*	0,2483	0,0384	*
Soil biochemical properties									
Soil available P (P)	0,0000	***	0,0000	***	0,0000	***	0,0000	***	0,4721
Total organic C (TOC)	0,1468	0,0000	***	0,1470	0,0193	*	0,0000	***	0,7262
Total N (TN)	0,2309	0,0003	***	0,2318	0,0335	*	0,0001	***	0,0336
Microbial P	0,0017	**	0,0093	**	0,0016	**	0,1112	0,0048	**
Microbial C	0,4845	0,0236	*	0,4839	0,5340		0,0042	**	0,5346
Microbial N	0,0019	**	0,0547	0,0019	**	0,1893	0,0701	0,1886	0,0005
Water soluble organic C (DOC)	0,1770	0,0000	***	0,1763	0,6045		0,0000	***	0,6033
Total dissolved N (TDN)	0,0185	*	0,0015	**	0,0184	*	0,1075	0,0041	**
Ammonium (NH_4^+)	0,0769	0,8428	0,0772	0,0015	**	0,9953	0,0015	**	0,9075
Nitrate (NO_3^-)	0,0675	0,0001	***	0,0676	0,0001	***	0,0001	***	0,0045
DOC/TDN	0,5891	0,2007	0,5876	0,8342	0,1394	0,8352	0,3143	0,4976	0,3134
TOC/TN	0,0834	0,0002	***	0,0838	0,0004	***	0,0000	***	0,0004
TOC/P	0,0000	***	0,9080	0,0000	***	0,0000	***	0,0000	***
TN/P	0,0000	***	0,8011	0,0000	***	0,0000	***	0,0000	***
Microbial C/N	0,5144	0,0000	***	0,5144	0,1210		0,0000	***	0,1210
Microbial C/P	0,0142	*	0,5328	0,0141	*	0,0010	**	0,8676	0,0010
Microbial N/P	0,0023	**	0,1143	0,0023	**	0,0174	*	0,1826	0,0173

Suppl. S9 Mean \pm SD of selected soil stoichiometric variables measured across the 3 years of the study (2018, 2020 and 2021) using plots in locations A, B, C, D and E, according to the presence of compressed snow, the compressed snow cover duration, and the number of vegetation seasons of recovery after snow cover. Box plots are given for dissolved organic carbon (DOC) and dissolved nitrogen (TDN). Control plots (CT) are from locations A and E. For other variables and their statistical significance see Suppl. S8. P-values from linear mixed-effects models are indicated with : ns not significant ($p \geq 0.1$); ** $0.05 \leq p < 0.1$; * $0.01 \leq p < 0.05$; *** $0.001 \leq p < 0.01$; *** $p < 0.001$.

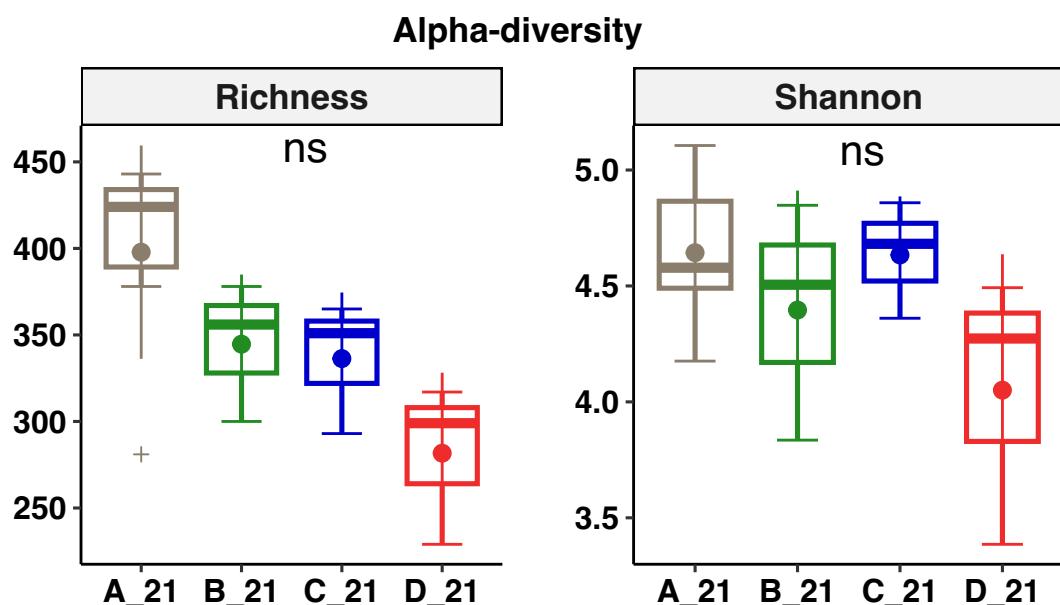


Suppl. S10 Mean \pm SD of bacterial (A) and fungal (B) alpha-diversity (richness and Shannon) in the different locations. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3). ns means no significant difference between locations.

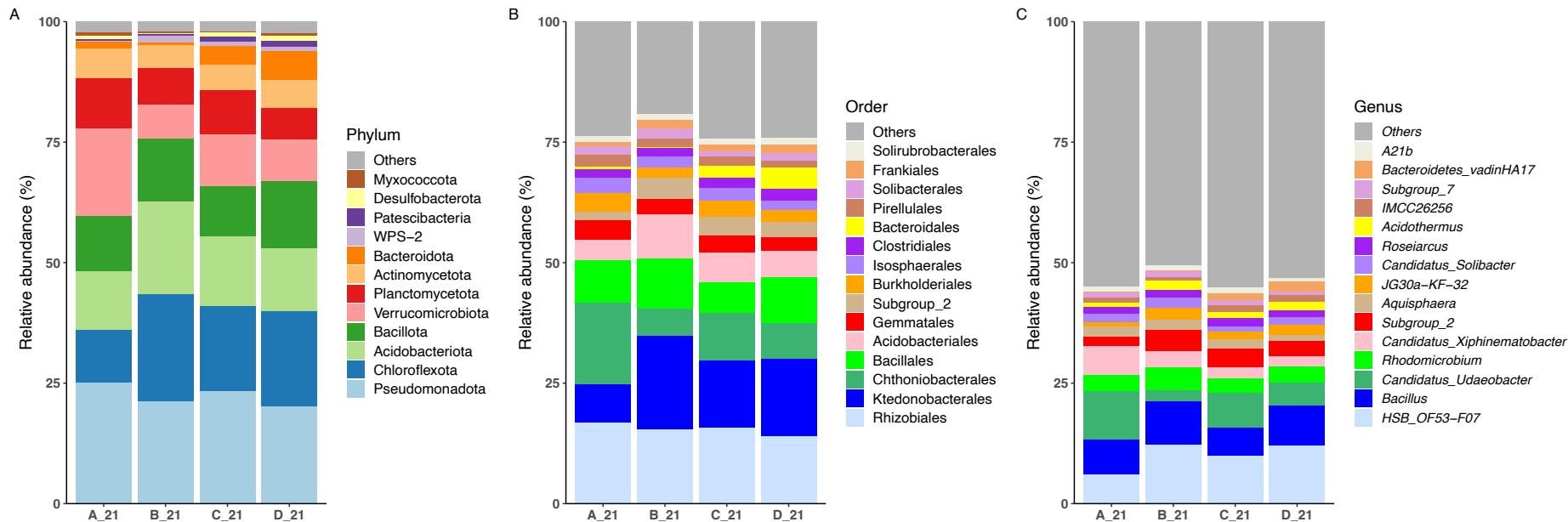
A



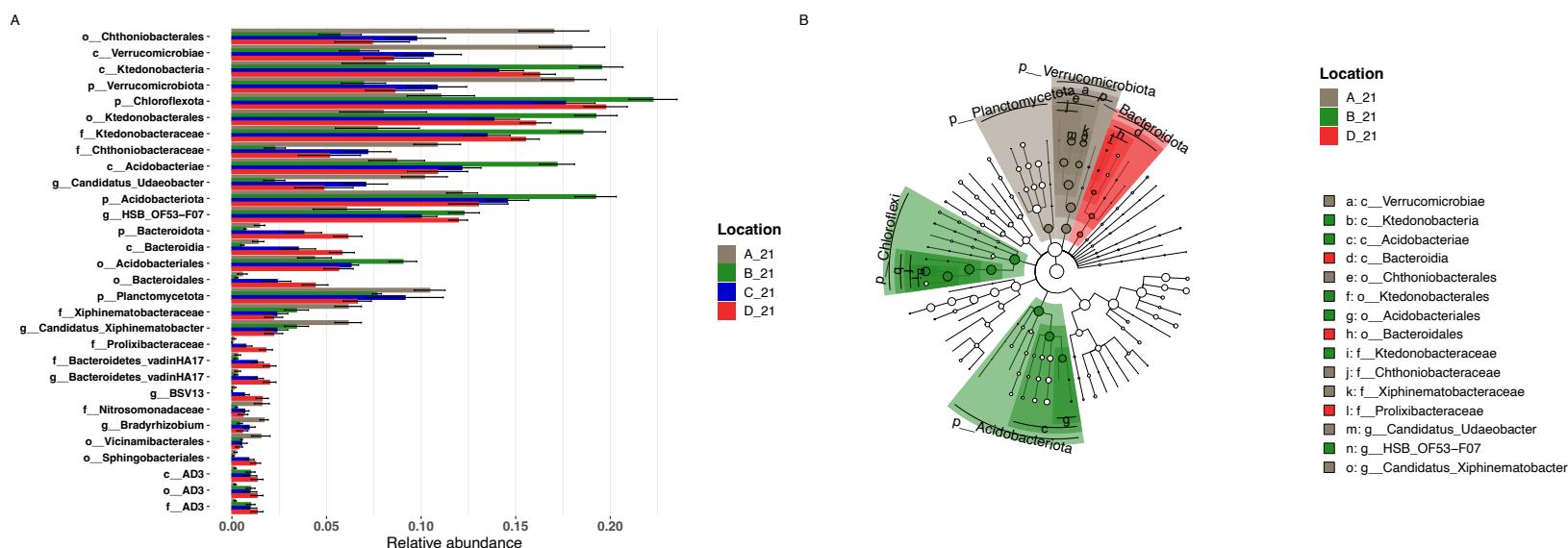
B



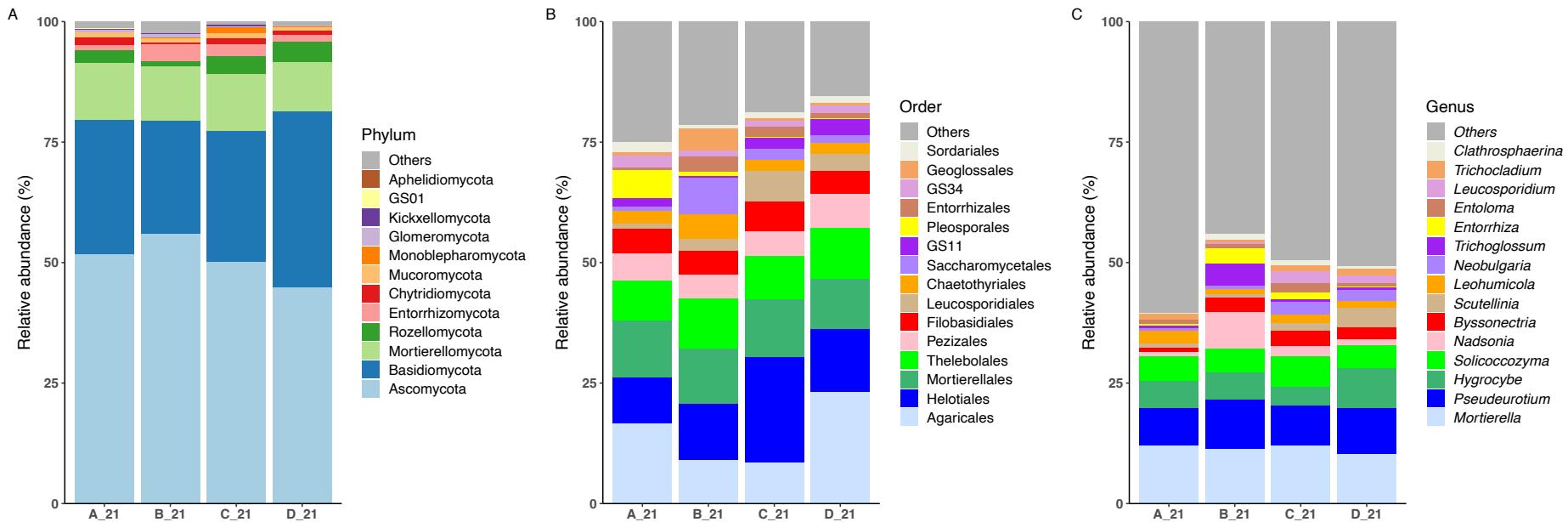
Suppl. S11 Relative abundance of phyla (A), orders (B) and genera (C) in the soil bacterial communities in the different locations. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3).



Suppl. S12 Potential bacterial indicator taxa detected by LEfSe analysis. (A) Barplot of the 30 selected bacterial taxa with the highest abundances. (B) Cladogram indicating the phylogenetic distribution of the 200 most-abundant taxa. Circles indicate phylogenetic levels (from domain to species) in reverse order. Each circle's diameter is proportional to the taxon's abundance. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3).



Suppl. S13 Relative abundance of phyla (A), orders (B) and genera (C) in soil fungal communities in the different locations. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3).



Suppl. S14 Potential fungal indicator taxa detected by LEfSe analysis. (A) Barplot of the 30 selected fungal taxa with the highest abundances. (B) Cladogram indicating the phylogenetic distribution of the 200 most-abundant taxa. Circles indicate phylogenetic levels (from domain to species) in reverse order. Each circle's diameter is proportional to the taxon's abundance. Locations are indicated with capital letters, followed by the year of sampling (A: control plots, N = 6; B: compressed snow cover for 1.5 years and 3 vegetation seasons of recovery, N = 3; C: compressed snow cover for 2.5 years and 2 vegetation seasons of recovery, N = 3; D: compressed snow cover for 3.5 years and 1 vegetation season of recovery, N = 3).

