Supplementary material

The supplementary material includes the following parts:

Part A
Supplementary Tables S1−S5 on results of statistical analyses
Supplementary Figure S1 on soil moisture in the treatment and control site
Supplementary Figure S2 on coarse root traits

Part B
Description on the modelled soil temperature in winter 2021−2022
Includes Table S6 and Figures S3−S6

Table S1. Soil moisture analyzed at 10 cm depth with mixed effect model. The fixed effects in the model were treatment (C = control, T = snow exclusion treatment), season (Summer-Autumn = Jun-Nov, Winter-Spring = Dec-May), and their interaction term. Random effects were moisture tube identity and measurement time. As soil moisture data were non-normally distributed, power of 0.6 transformation was used. Different letters indicate significant differences between least squares means. SE refers to standard error.

Dependent variable	**Effect**	**Mean (SE)**	**Df1**	**Df2**	**P-value**	**F-value**
Soil moisture at 10 cm depth, $(m^3\ m^{-3})^{0.6}$	Treatment		1	162	0.3212	0.99
	C	0.23^a (0.03)				
	T	0.27^a (0.03)				
	Season		1	162	**0.0296**	4.82
	Summer-Autumn	0.26^a (0.02)				
	Winter-Spring	0.23^b (0.02)				
	Treatment x Season		1	162	0.0750	3.21

Table S2. Cumulative daily amplitude (CDA) of sapflow per unit sapwood area (log-transformed) analysed with mixed effect model. The fixed effects in the model were treatment (C = control, T = snow exclusion treatment), species, measurement day (every two weeks in the spring), year and their interaction terms. Random effect was tree identity. As CDA data were non-normally distributed, logarithmic transformation was used. Different letters indicate significant differences between least squares means. SE refers to standard error.

Dependent variable	**Effect**		**Mean (SE)**	**Df1**	**Df2**	**P-value**	**F-value**
CDA, log	Treatment			1	50	**0.0005**	13.83
		C	-0.91[a] (0.10)				
		T	-1.46[b] (0.11)				
	Species			1	50	0.8895	0.02
	Measurement day			2	50	**<0.0001**	134.36
		15.4.	-1.77[a] (0.08)				
		1.5.	-1.11[b] (0.08)				
		15.5.	-0.68[c] (0.09)				
	Year			1	50	**<0.0001**	29.09
		2021	-1.34[a] (0.08)				
		2022	-1.04[b] (0.07)				
	Treatment x Species			1	50	**0.0122**	6.76
		C pine	-1.09[a] (0.13)				
		T pine	-1.26[ab] (0.16)				
		C birch	-0.74[a] (0.13)				
		T birch	-1.66[b] (0.16)				
	Treatment x Measur. day			2	50	0.3818	0.98
	Treatment * Year			1	50	**<0.0001**	21.28
		C 2021	-1.19[ab] (0.11)				
		T 2021	-1.48[c] (0.12)				
		C 2022	-0.64[a] (0.10)				
		T 2022	-1.44[bc] (0.11)				

Table S3. Results on tree growth from mixed effect model. The stem diameter growth is expressed as a percentage change in annual growth when compared to the average annual growth in years 2014-2019. The fixed effects in the model were the treatment (T = snow exclusion treatment, C = control), tree species, year and their interaction terms. The random effect in the model was tree identity. Different letters indicate significant differences between least squares means. SE refers to standard error.

Dependent variable	**Effect**		**Mean (SE)**	**Df1**	**Df2**	**P-value**	**F-value**
Diameter growth, %	Treatment			1	38	0.7815	0.08
	Species			2	38	0.0521	3.20
	Year			2	38	**<0.0001**	14.05
		2021	118^{a} (14)				
		2022	188^{bc} (14)				
		2023	207^{c} (14)				
	Year x Species			4	38	**0.0056**	4.32
		2021 pine	111^{ab} (23)				
		2021 spruce	101^{a} (23)				
		2021 birch	142^{ab} (23)				
		2022 pine	158^{ab} (23)				
		2022 spruce	207^{bc} (23)				
		2022 birch	200^{abc} (23)				
		2023 pine	190^{abc} (23)				
		2023 spruce	280^{c} (23)				
		2023 birch	151^{ab} (23)				
	Species x Treatment			2	38	**0.0026**	6.99
		C pine	173^{ab} (19)				
		T pine	133^{a} (19)				
		C spruce	156^{a} (19)				
		T spruce	236^{b} (19)				
		C birch	178^{ab} (19)				
		T birch	150^{ab} (19)				
	Treatment x Year			2	38	0.3455	1.09

Table S4. Results on tree fine root growth from mixed effect models. The fixed effect in the models was the treatment: T = snow exclusion treatment, C = control. The random effect in the model was plot identity. As root growth data was non-normally distributed, power of 0.5 transformation was used. Different letters indicate significant differences between least squares means. SE refers to standard error.

Dependent variable	**Effect**		**Mean (SE)**	**Df1**	**Df2**	**P-value**	**F-value**
Root growth in dry mass, $(g\ m^{-2})^{0.5}$	Treatment			1	12	0.0763	3.76
		C	7.90^{a} (1.44)				
		T	3.95^{a} (1.44)				

Table S5. Results on dwarf shrubs from mixed effect models. The fixed effect in the models was the treatment: T = snow exclusion treatment, C = control, E = extra control in very close proximity of the snow exclusion area. The random effect in the model was plot identity within each treatment. As data on elongation growth, diameter growth and number of dead ramets were non-normally distributed, logarithmic 11 transformation was used. Different letters indicate significant differences between least squares means. SE refers to standard error.

Dependent variable	**Effect**		**Estimate (SE)**	**Df1**	**Df2**	**P-value**	**F-value**
Dry mass of 10 leaves, g	Treatment			2	53	**<0.0001**	12.19
		T	0.076^{a} (0.004)				
		C	0.045^{b} (0.004)				
		E	0.059^{b} (0.004)				
Leaf area, cm^2	Treatment			2	53	**<0.0001**	27.42
		T	1.91^{a} (0.08)				
		C	1.07^{b} (0.08)				
		E	1.31^{b} (0.08)				
SLA, g cm^{-2}	Treatment			2	53	0.0510	3.15
		T	0.0040^{a} (0.0001)				
		C	0.0042^{a} (0.0001)				
		E	0.0045^{b} (0.0001)				
Elongation growth, log(cm)	Treatment			2	53	**<0.0001**	13.63
		T	1.62^{a} (0.13)				
		C	0.69^{b} (0.13)				
		E	1.18^{c} (0.13)				
Diameter growth in year 2021, log(µm)	Treatment			2	50	0.4202	0.88
		T	5.31^{a} (0.13)				
		C	5.09^{a} (0.13)				
		E	5.29^{a} (0.13)				
Diameter growth in year 2022, log(µm)	Treatment			2	50	0.2481	1.43
		T	4.78^{a} (0.19)				
		C	4.32^{a} (0.19)				
		E	4.55^{a} (0.20)				
Dead ramets, log(no m^{-2})	Treatment			2	10	**0.0006**	17.13
		T	2.50^{a} (0.26)				
		C	0.53^{b} (0.26)				
		E	0.00^{b} (0.63)				

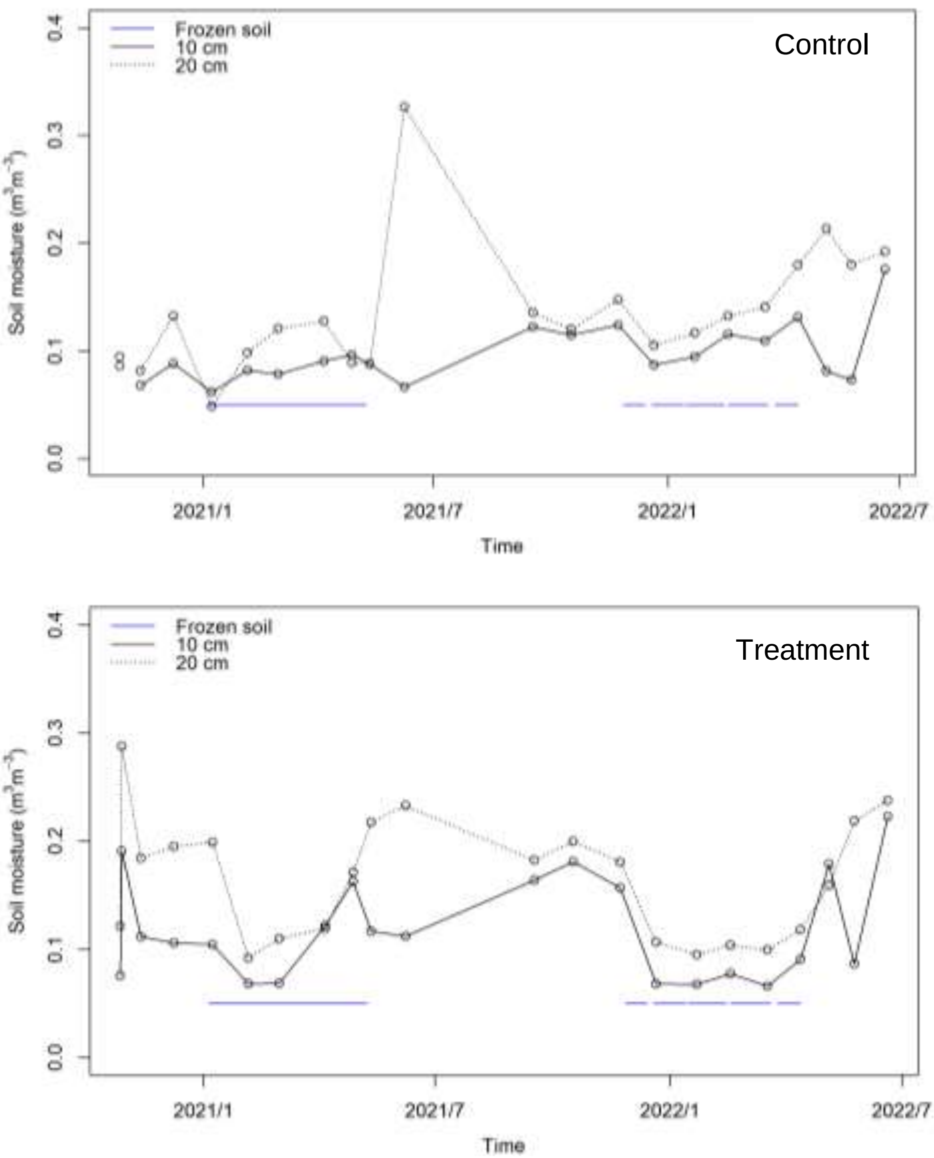

Figure S1. Average soil moisture in the control (above) and snow-exclusion treatment (below) at 10 cm and 20 cm depths. Periods with frozen humus layer in the treatment are shown with blue lines.

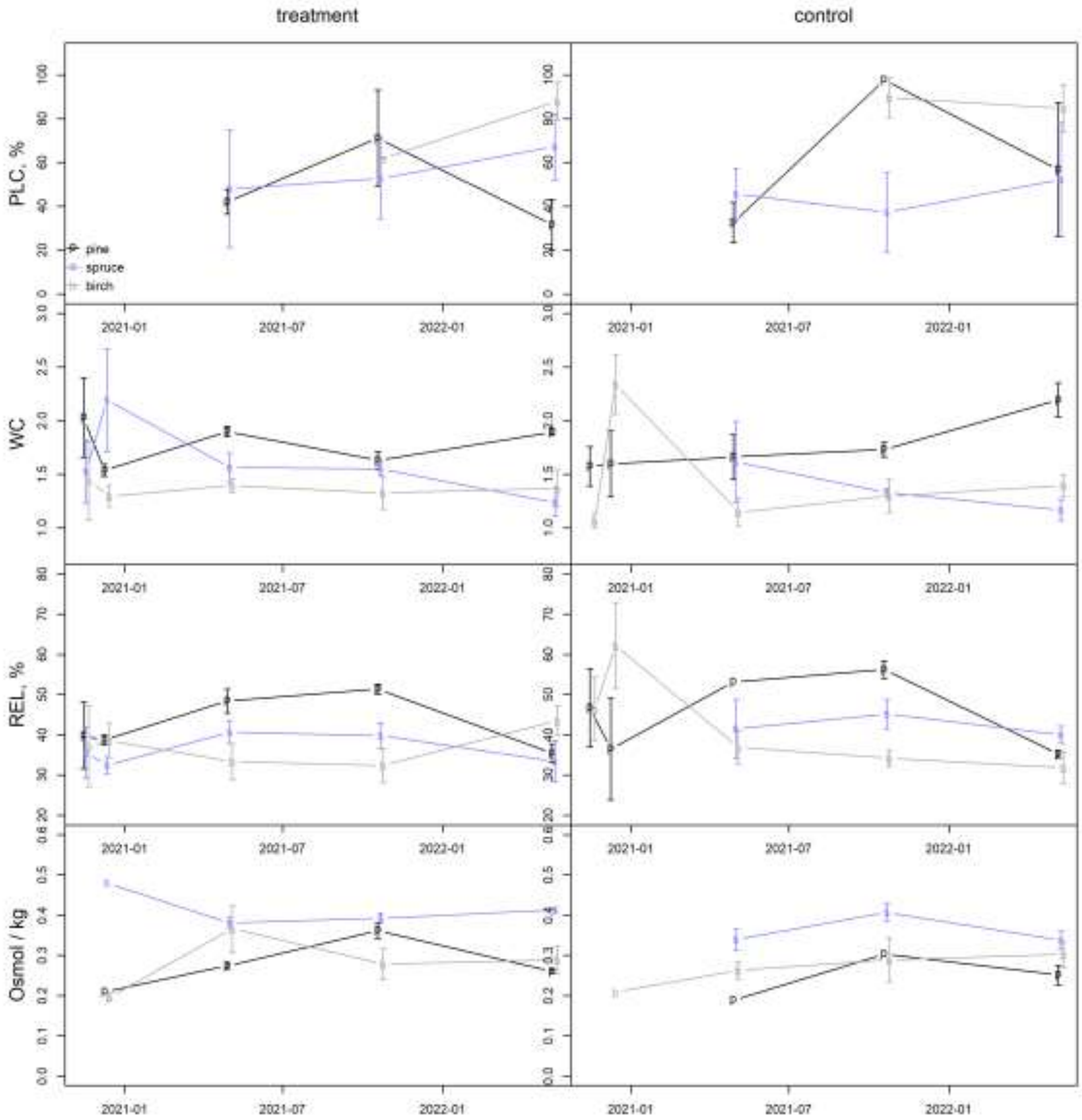

Figure S2. Coarse root percentage loss of hydraulic conductance (PLC), water content (kg_{H20} $kg_{dry\_mass}^{-1}$), relative electrical conductivity, and root bark osmolality shown separately for the treatment and control sites and for pine (black line), spruce (blue line) and birch (grey line).

Modelled soil temperature in winter 2021−2022

Mineral and humus soil temperature was simulated for the second studied winter of 2021-2022 due to missing data. First, the mean temperature of mineral soil and humus soil was calculated for the first winter of 2020-2021 for both the control and the treatment site using data from the DS1921G temperature loggers. With the data from each site, mean temperatures of mineral and humus layer were then compared against each of the root temperature measurements conducted at that site with thermocouples. Mean soil temperatures were compared to root thermocouple measurements using linear regression, from which goodness of fit parameter R^2 was obtained (Table 1). The linear regression was performed in R using the function 'lm()' and the model was formulated as the following:

$W_1 \sim T_1$

Where W_1 is the mean soil temperature and T_1 is the root temperature. For each soil layer of both sites, we selected the root thermocouple measurement that had the best fit with the soil temperature data and no missing data (Figures 1-4). These selected root thermocouple measurements were then used to simulate soil temperature in mineral and humus layers using parameters obtained from the linear regression tests:

$W_2 = a + T_1 * b$

Where W_2 is the simulated mineral or humus soil temperature for winter 2021-2022, a is the intercept and b is the slope of the linear regression model.

Table S6. Results of linear regression tests between mean soil temperature and each root thermocouple (TC) at both sites and for both soil layers. Root thermocouple measurements selected for simulation purposes are marked with star (*), see Fig. 1−4.

Site	Soil layer	Species	TC	R^2	Intercept	Slope	
control	humus	birch	2	0.88	1.04	0.81	
control	humus	birch	4	0.81	1.12	0.85	
control	humus	birch	5	0.97	0.70	0.91	*
control	humus	Pine	7	0.94	1.21	0.80	
control	mineral	birch	2	0.77	1.52	0.75	
control	mineral	birch	4	0.74	1.58	0.80	
control	mineral	birch	5	0.94	1.15	0.89	*
control	mineral	Pine	7	0.92	1.64	0.78	
treatment	humus	birch	1	0.87	0.13	0.61	
treatment	humus	birch	3	0.86	0.21	0.75	
treatment	humus	birch	6	0.91	0.15	0.76	
treatment	humus	Pine	2	0.95	0.01	0.83	*
treatment	humus	Pine	4	0.89	0.21	0.68	
treatment	humus	Pine	5	0.97	-0.27	0.85	
treatment	mineral	birch	1	0.61	0.54	0.46	
treatment	mineral	birch	3	0.65	0.63	0.58	
treatment	mineral	birch	6	0.68	0.57	0.59	
treatment	mineral	Pine	2	0.77	0.49	0.66	*
treatment	mineral	Pine	4	0.63	0.61	0.51	
treatment	mineral	Pine	5	0.83	0.26	0.70	

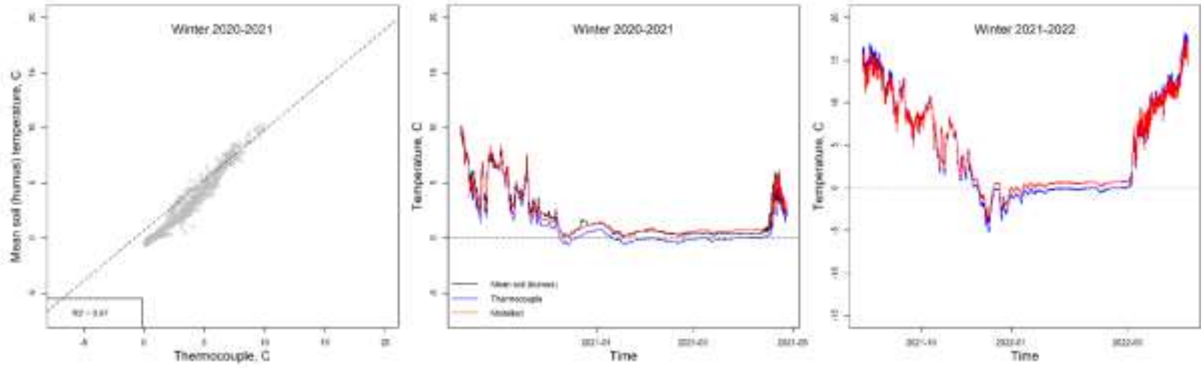

Figure S3. Linear regression test (left) used to obtain model parameters for the simulated soil temperature of the humus soil layer of the control site. The middle sub-plot shows validation period of the model and right sub-plot shows testing period of the model.

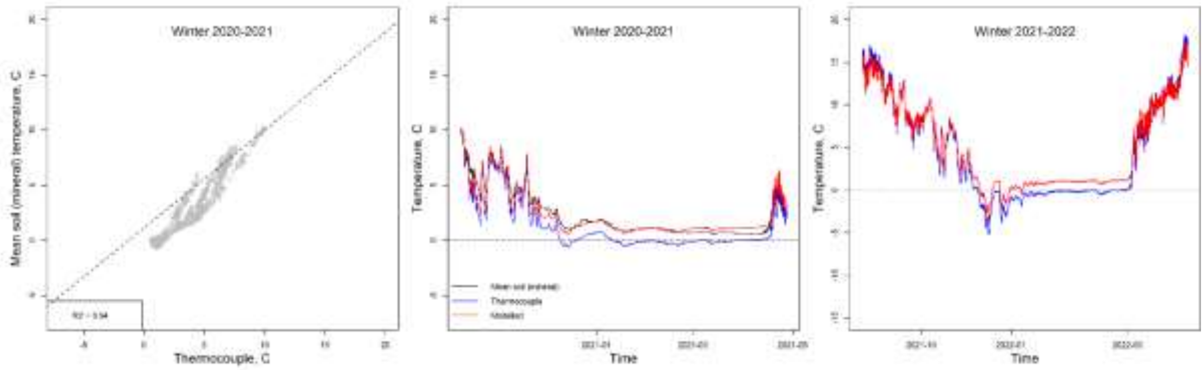

Figure S4. Linear regression test (left) used to obtain model parameters for the simulated soil temperature of the mineral soil layer of the control site. The middle sub-plot shows validation period of the model and right sub-plot shows testing period of the model.

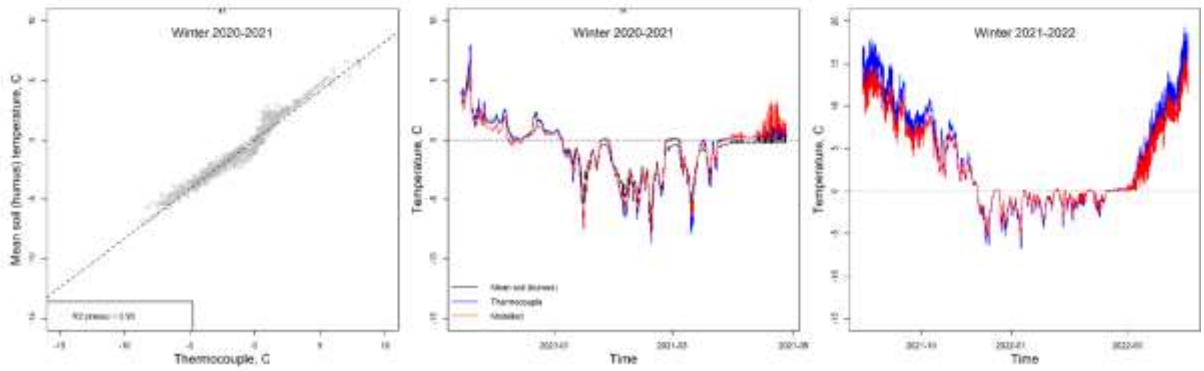

Figure S5. Linear regression test (left) used to obtain model parameters for the simulated soil temperature of the humus soil layer of the treatment site. The middle sub-plot shows validation period of the model and right sub-plot shows testing period of the model.

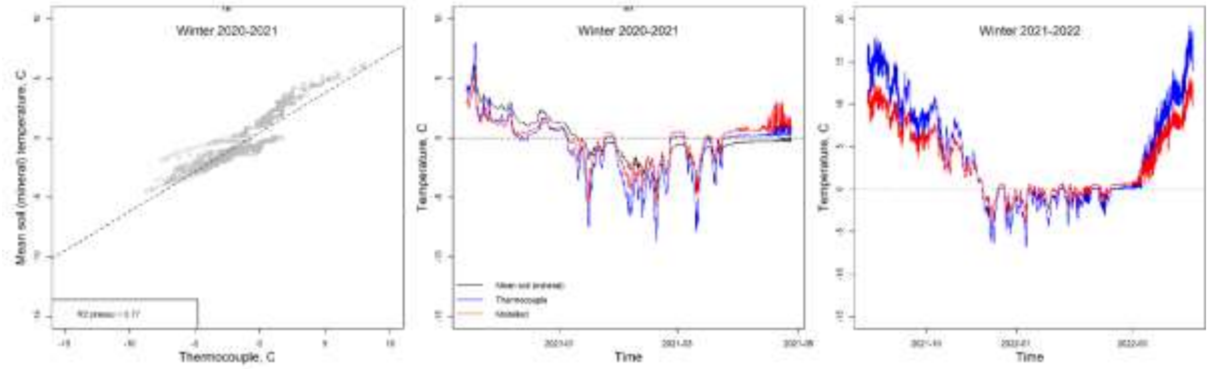

Figure S6. Linear regression test (left) used to obtain model parameters for the simulated soil temperature of the mineral soil layer of the treatment site. The middle sub-plot shows validation period of the model and right sub-plot shows testing period of the model.