

## Ericoid shrub encroachment shifts aboveground–belowground linkages in three peatlands across Europe and western Siberia

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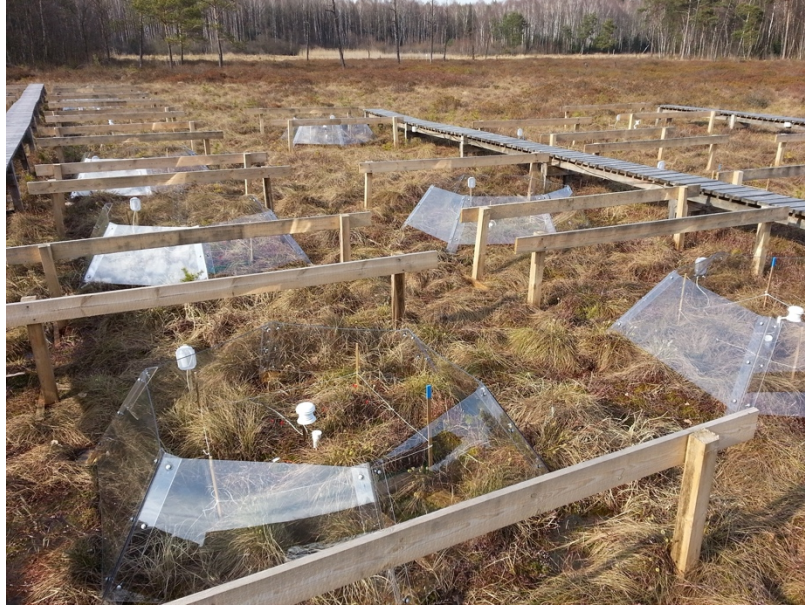
### Supplementary Material

**Suppl. S1** Geographical map (a) showing the locations of the study sites (Google Earth), indicating mean annual values of monthly average temperature [Tave], monthly maximum temperature [Tmax], monthly precipitation sum [P], and monthly average vapour pressure [VP] (data from WorldClim; <https://www.worldclim.org>). Experimental site in Linje, Poland (b). Example of different amounts of *Andromeda polifolia* cover in plots in Mukhrino, Siberia (c). Map lines delineate study areas and do not necessarily depict accepted national boundaries.

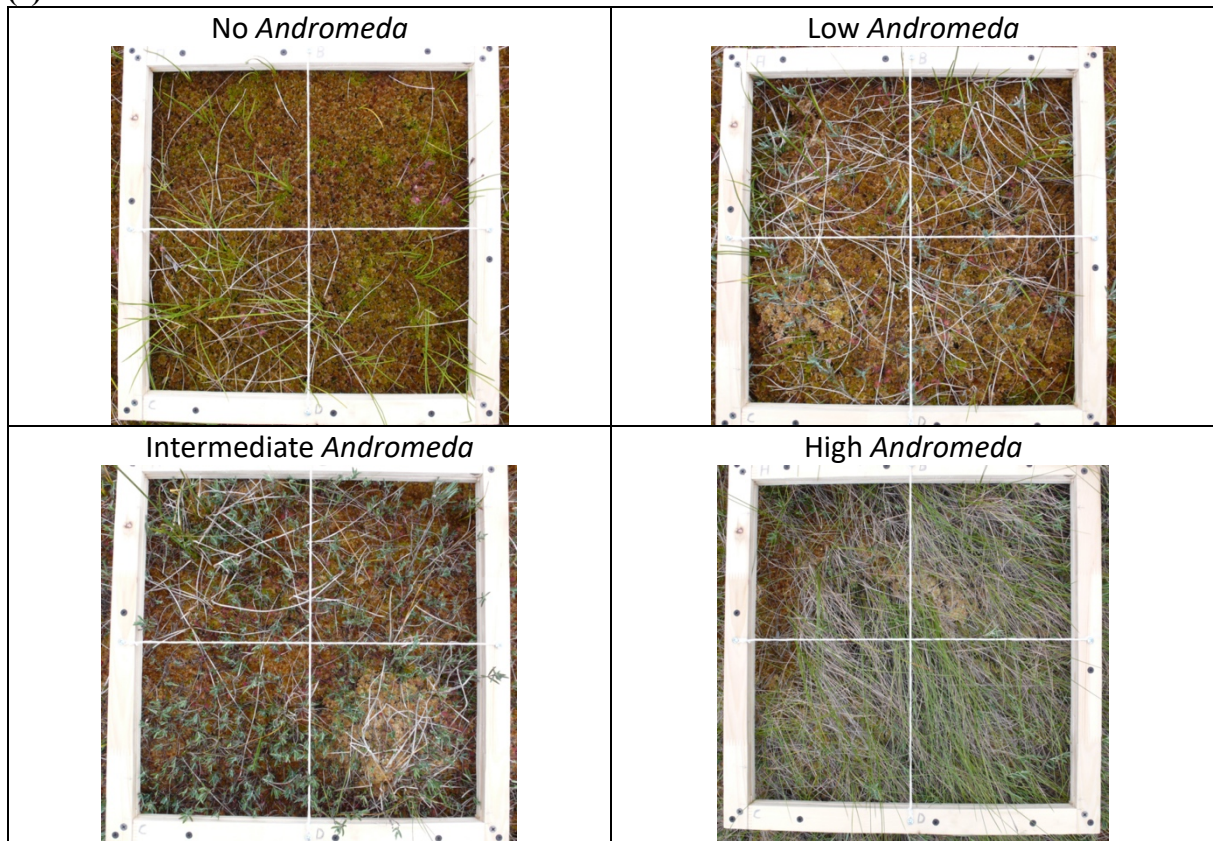
(a)



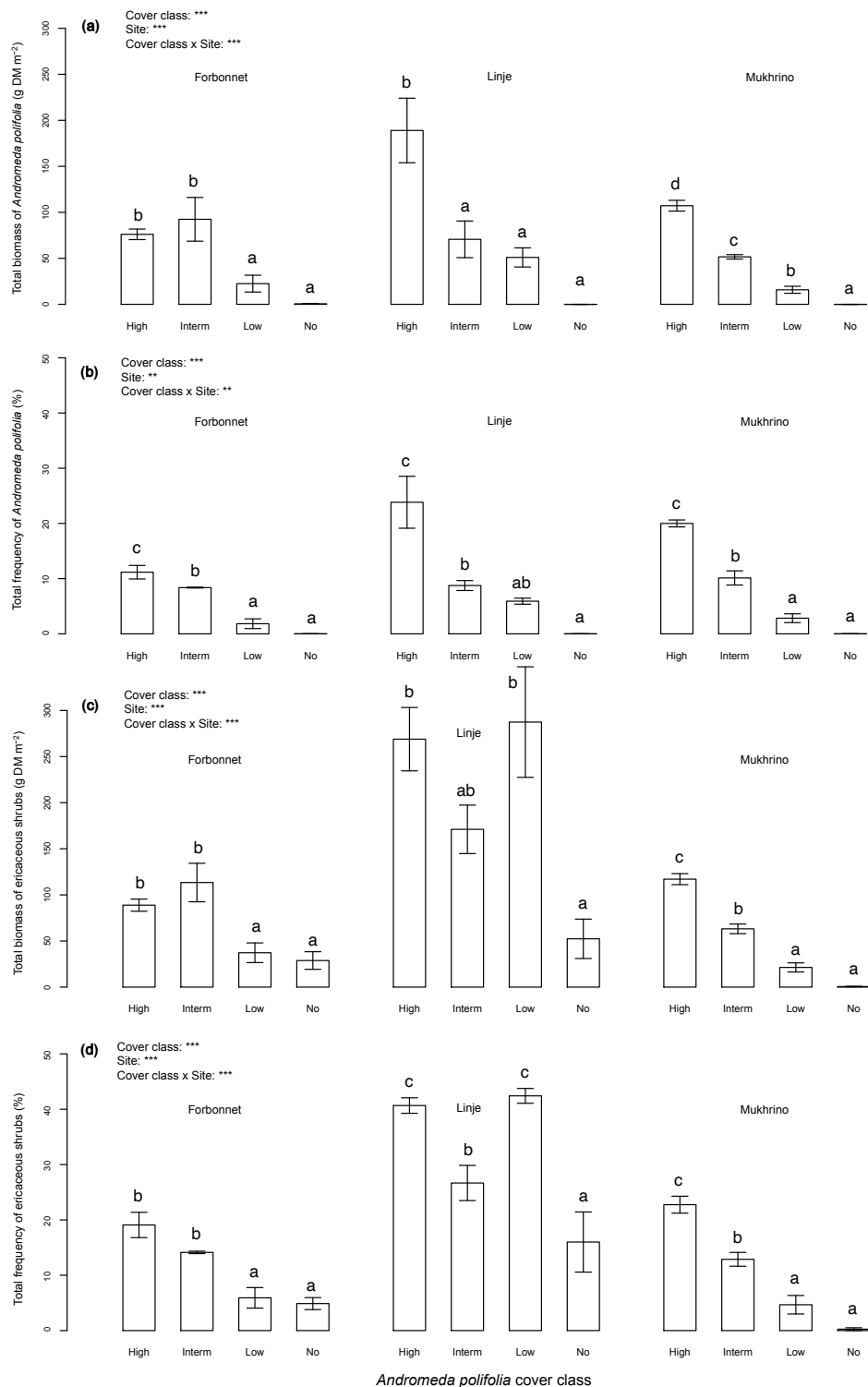
(b)



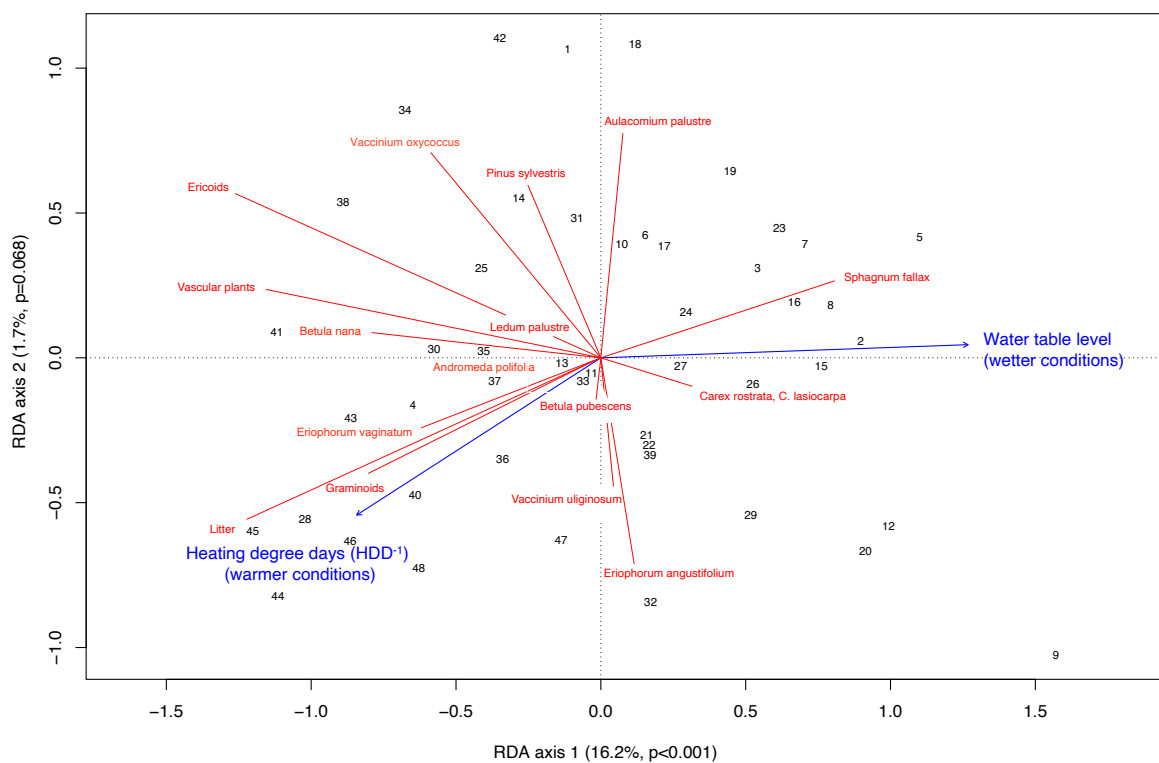
(c)



**Suppl. S2** Total biomass (grams of dry matter per square metre, g DM m<sup>-2</sup>; a) and total relative frequency (%) of *Andromeda polifolia*; total biomass (c) and total relative frequency (d) of all ericaceous species in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three peatland sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 statistical differences in pairwise comparisons (Tukey post-hoc tests) (see also Table 1 for complete results of tests).

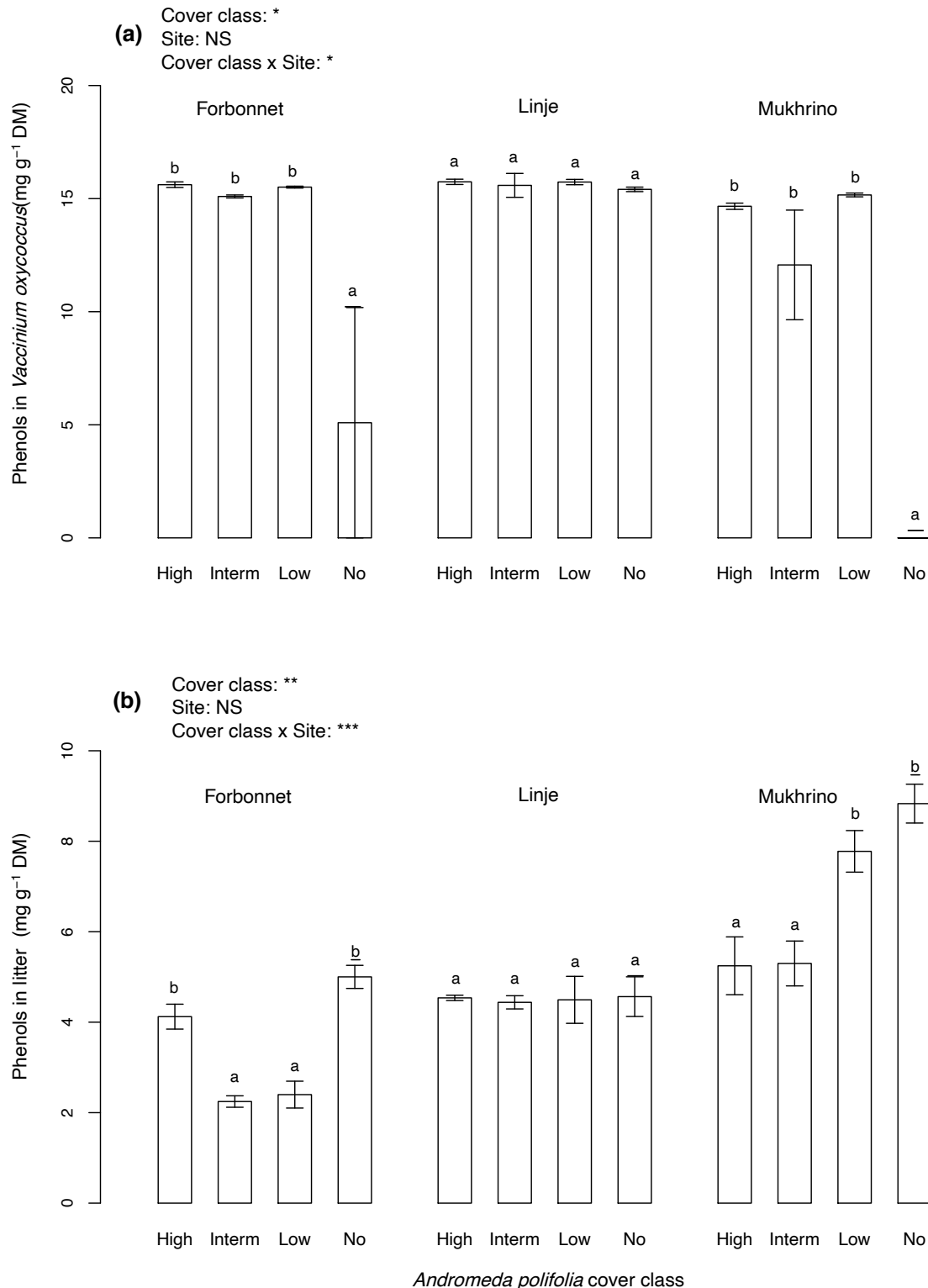


**Suppl. S3** Redundancy analysis (RDA) showing the relationship between vegetation in the plots of the manipulative experiment in Linje, Poland (years 2013 and 2014) and water table level and heating degree days (HDD) measured within each plot (N=24). For clarity, in the graphical representation HDDs were multiplied by -1 ( $\text{HDD}^{-1}$ ) so that the arrow points towards warmer conditions. Species descriptors are frequencies assessed with the needle point-intercept method. The explanatory variables explained 17.9% of the variability. The overall model was significant ( $p < 0.001$ ), with the first RDA axis ( $p < 0.001$ ) representing 16.2% of the variance and the second RDA axis (marginally significant,  $p = 0.068$ ) only 1.7%. Explanatory variables are the water table level ( $p < 0.001$ ) and  $\text{HDD}^{-1}$  (marginally significant,  $p = 0.065$ ). Ericoids comprises *Andromeda polifolia*, *Vaccinium oxycoccus*, *Betula nana* and *Ledum palustre*.

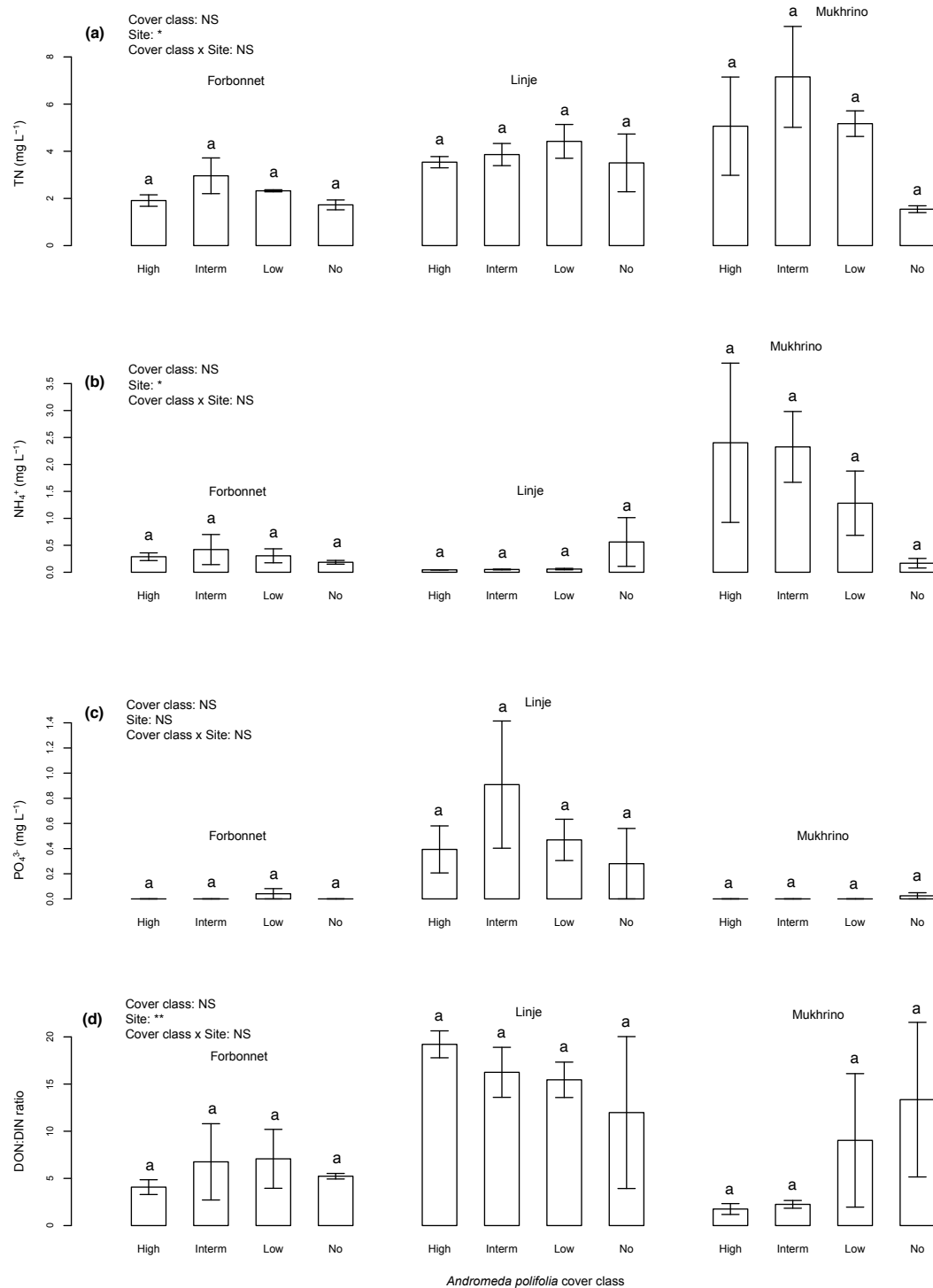




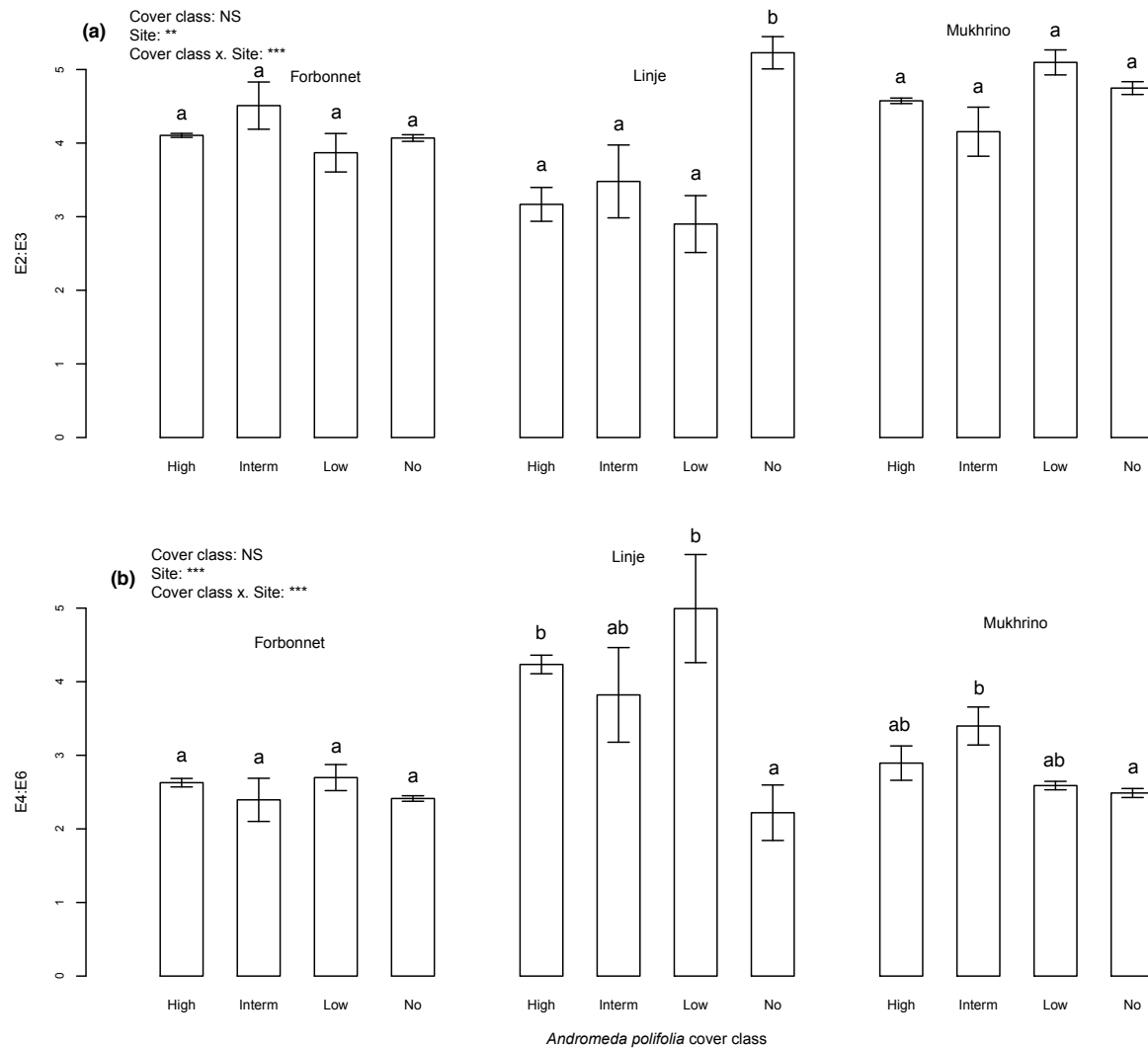
**Suppl. S4** Phenols in *Vaccinium oxycoccus* (a) and in litter (b) in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).



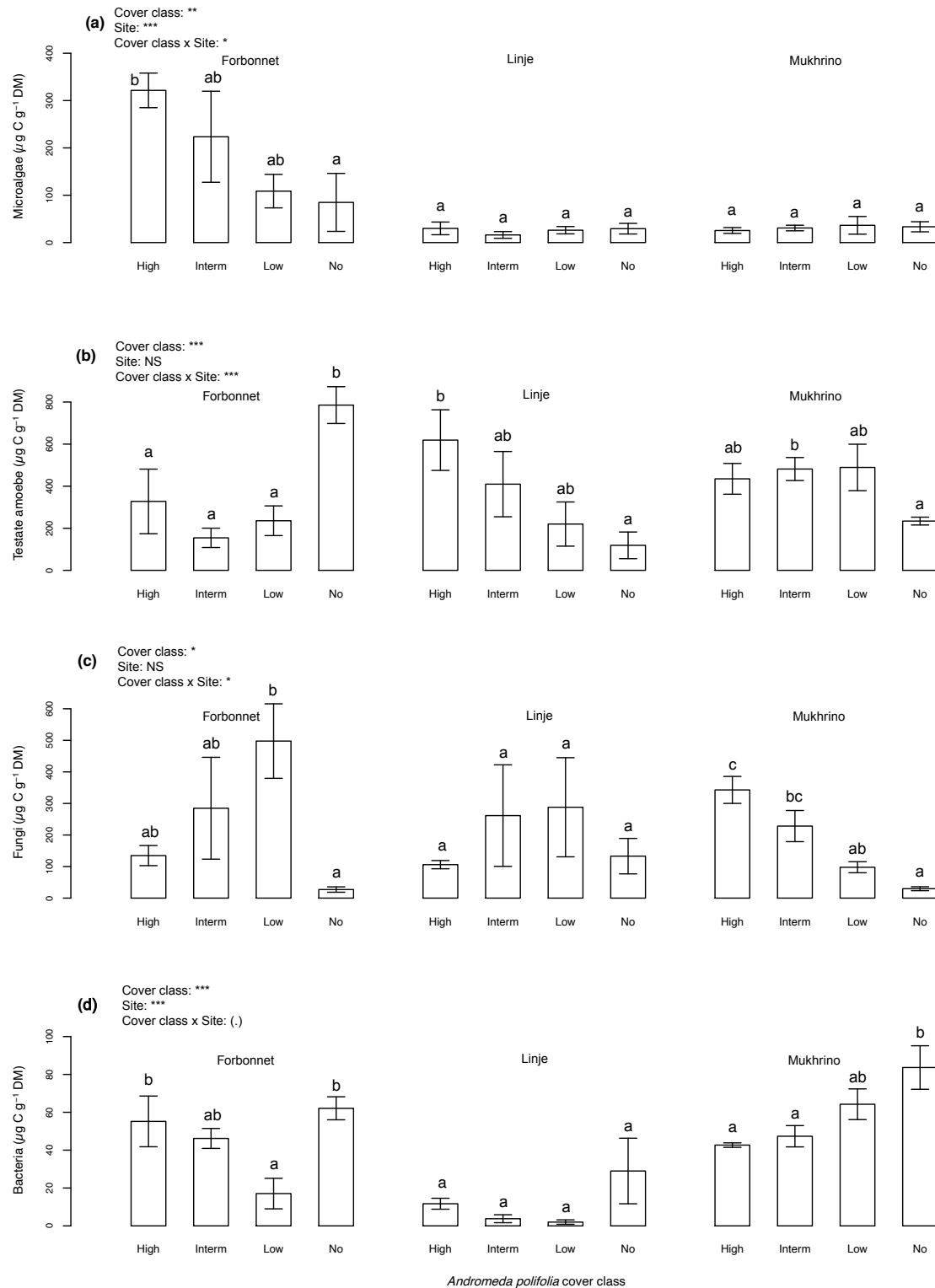
**Suppl. S5** Peat pore water concentrations of total nitrogen (TN; a), ammonium ( $\text{NH}_4^+$ ; b), phosphate ( $\text{PO}_4^{3-}$ ; c) and dissolved organic nitrogen to dissolved inorganic nitrogen ratio (DON:DIN; d) in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).



**Suppl. S6** Peat pore water absorbance ratios E2:E3 (a) and E4:E5 (b) in the different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).

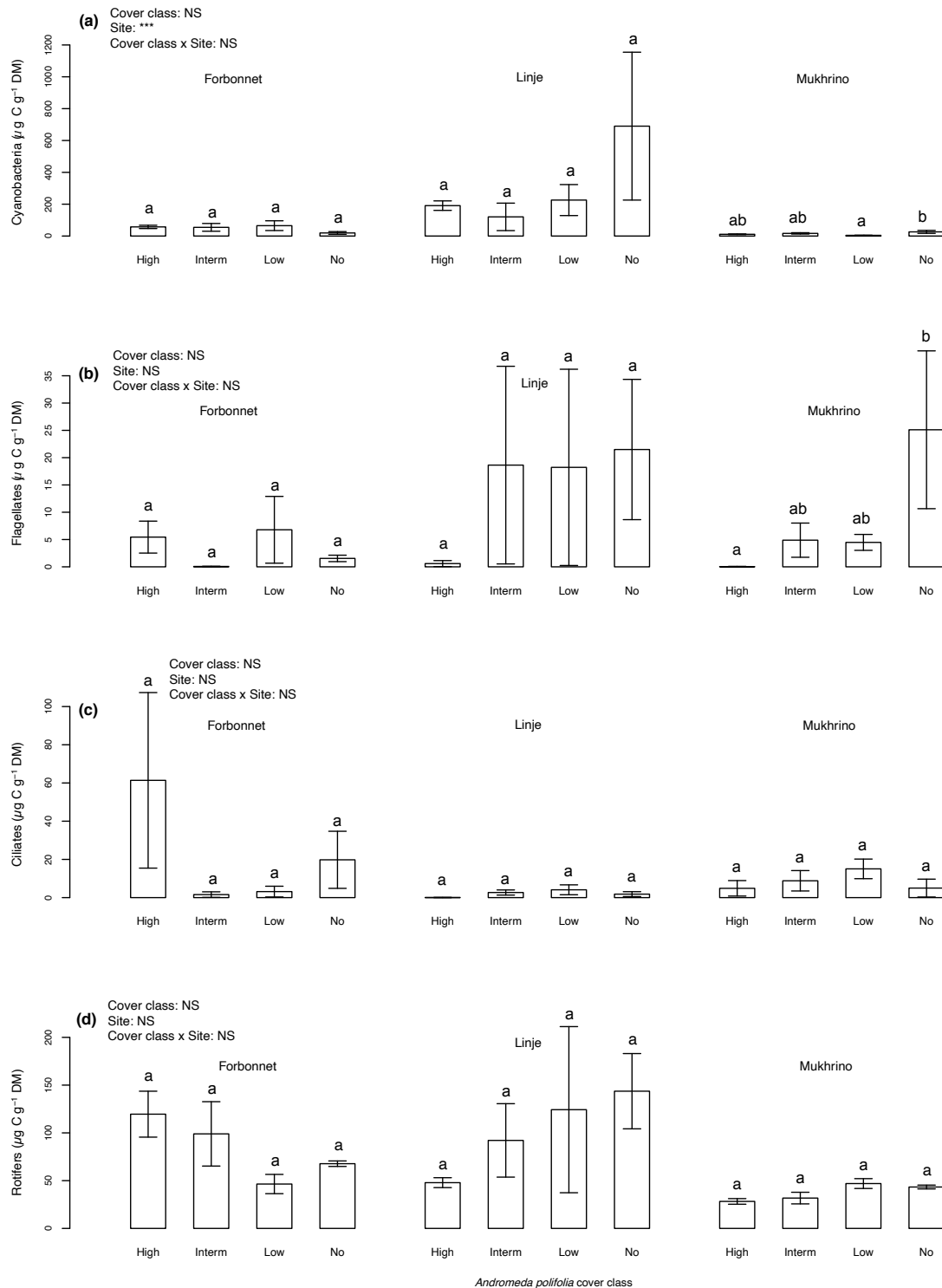


**Suppl. S7** Microbial groups of microalgae (a), testate amoebae (b), fungi (c) and bacteria (D) in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).

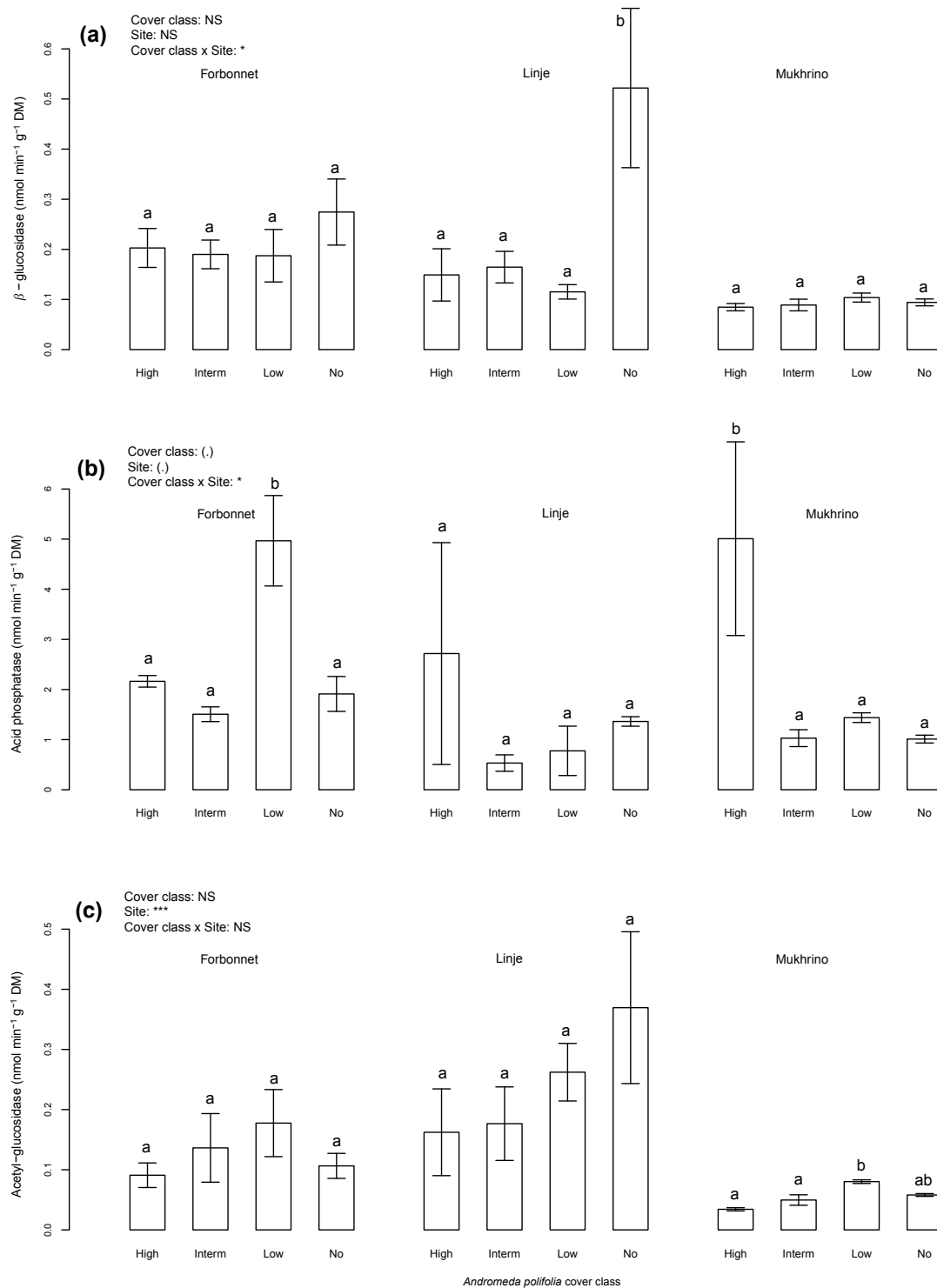




**Suppl. S8** Microbial groups of cyanobacteria (a), flagellates (b), ciliates (c) and rotifers (d) in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).



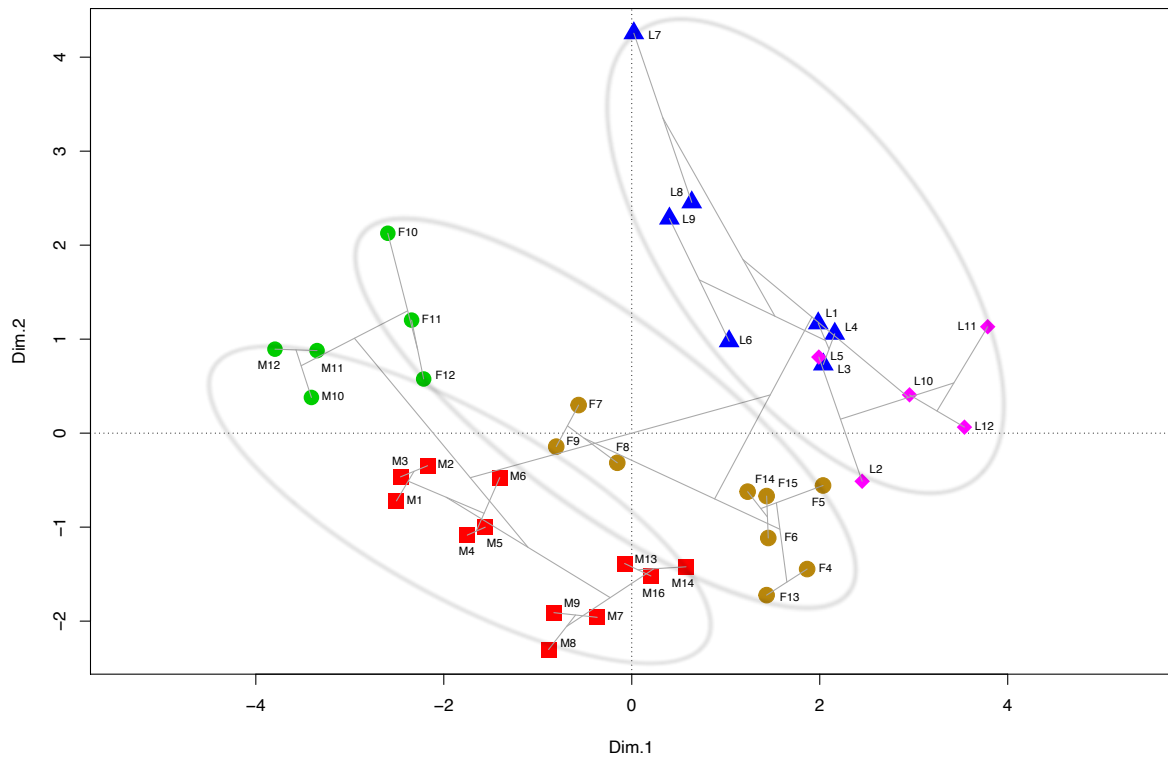
**Suppl. S9**  $\beta$ -glucosidase (a), acid phosphatase (b), and acetyl-glucosidase (c) enzymatic activities in different cover classes of the ericaceous shrub *Andromeda polifolia* in each of the three sites (Forbonnet in France, Linje in Poland, and Mukhrino in Siberia). Each bar represents the mean value  $\pm$  SE. The statistical significance of cover class, site, and their interaction is 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 significant differences in pairwise comparisons (Tukey post-hoc tests) (see Table 1 for complete results of tests).



**Suppl. S10** Multiple factorial analysis (MFA) of all plots (N=39) in the three peatland sites sampled along a gradient of increasing cover of the ericaceous shrub *Andromeda polifolia*, described by biogeochemical response variables. Factorial maps of plots (a) and of groups of variables in subtables illustrated in the correlation circle (b). Subtables contain variables of plant frequencies, biomass of vascular plants and litter, peat pore water chemistry, enzymatic activities in peat, phenols in vascular plants and litter, and microorganisms in *Sphagnum* mosses. The first dimension of the ordination represents 29.5% of the variability, and the second dimension 13.8%. On the factorial map of plots, sites are indicated with letters F (Forbonnet in France), L (Linje in Poland), and M (Mukhrino in Siberia), followed by the plot number. Different colours represent the grouping resulting from a Ward clustering, and ellipses delineate the three sites. On the factorial map of groups of variables, E2:E3 is the absorbance ratio in pore water at 254 and 365 nm; E4:E6 is the absorbance ratio in pore water at 465 and 665 nm; DON:DIN is the ratio dissolved organic N to dissolved inorganic N; DOC: dissolved organic carbon; TN: dissolved N.

The global multivariate approach with the MFA analysis using all biogeochemical variables indicates a strong gradient along axis 1, with correlated variables of plant species frequencies, such as *Eriophorum vaginatum*, *Vaccinium oxycoccus*, *Betula nana*, *Andromeda polifolia* and *Calluna vulgaris*, on the right side of the scatter plot opposed to the frequencies of *Sphagnum balticum*, *Sphagnum fallax*, *Scheuchzeria palustris* and *Carex limosa* on the left side (descriptor's factorial map). Accordingly, total vascular plant biomass is higher on the right side of axis 1, as is phenol concentration in vascular plant biomass. This gradient overlaps with that of peat pore water chemistry, with conductivity, nitrate, nitrite, phenols, DOC and E4:E6 on the right side of the scatter plot and E2:E3 and pH on the left side. The fungi:bacteria ratio is higher on the right side of axis 1 and is opposed to bacteria. Other variables, particularly enzyme activities and several microorganisms, point along axis 2. As seen in the sample's factorial map, the three sites do not overlap and have some distinct characteristics, despite following a similar overall gradient as described above. This might be related to the different climate conditions in the three sites and their potential influence on some biogeochemical properties.

(a)



(b)

