Moss Uncovered: Discoveries to Date and the Road Ahead

Authors: The indomitable Moss team — charting the squishy frontiers of science to unearth the secrets of SPRUCE

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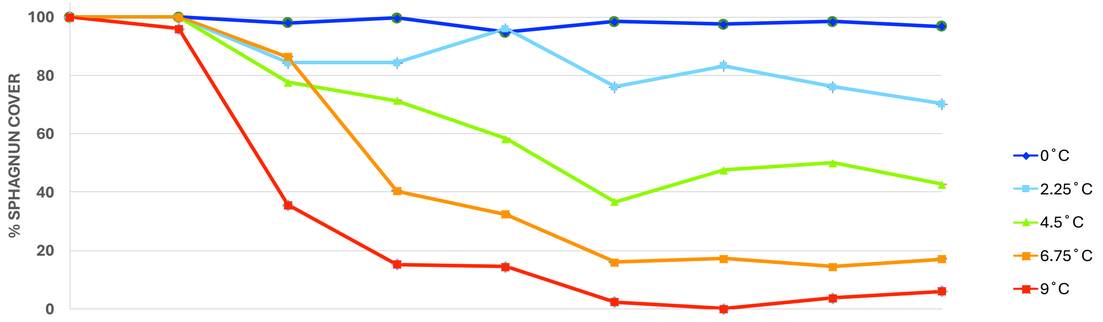
Warming Increases *Sphagnum* mortality, Possible CO2 Effect Emerging

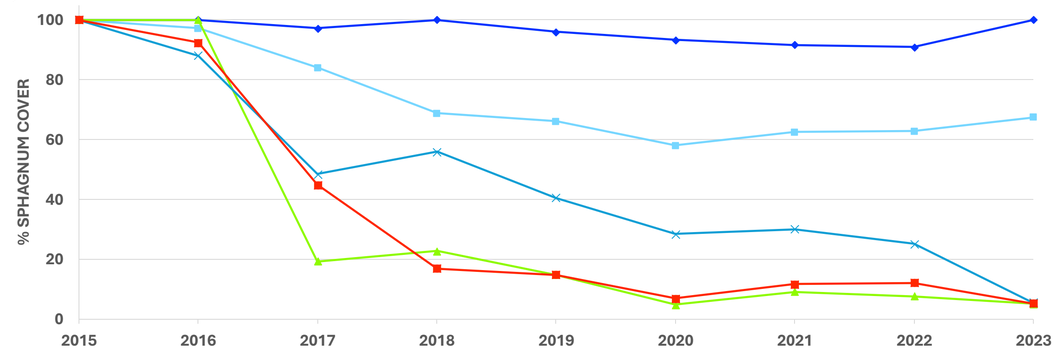
High levels of experimental warming resulted in substantial and sustained declines in *Sphagnum* cover, with the +9.0°C treatment showing near-total loss by year 4. Intermediate warming treatments (+4.5°C and +6.75°C) exhibited progressive declines over time, while the ambient and +2.25°C treatments maintained relatively stable cover (Norby et al. 2023).

A) Ambient CO2

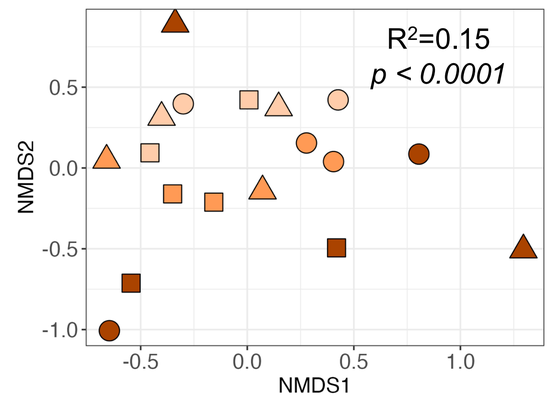


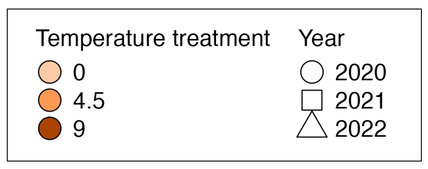
These results suggest a strong temperature sensitivity of *Sphagnum* persistence, particularly beyond a warming threshold of ~2.5°C. Elevated CO_2 shows a similar trend, although there may be a developing CO2 by warming effect emerging in later years (Norby et al. 2023).

B) Elevated CO2



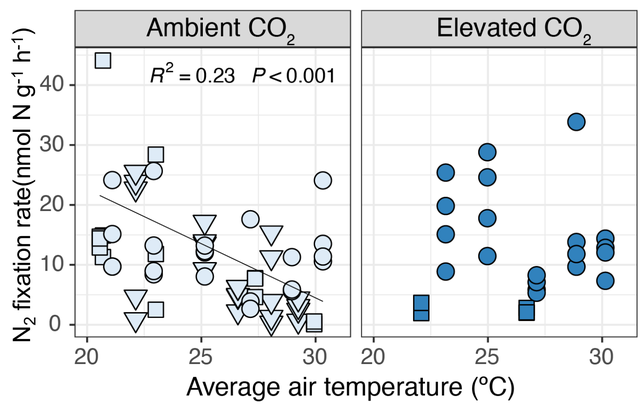
Shifts in the *Sphagnum* microbiome can drive ecological feedbacks related to nitrogen and carbon cycling

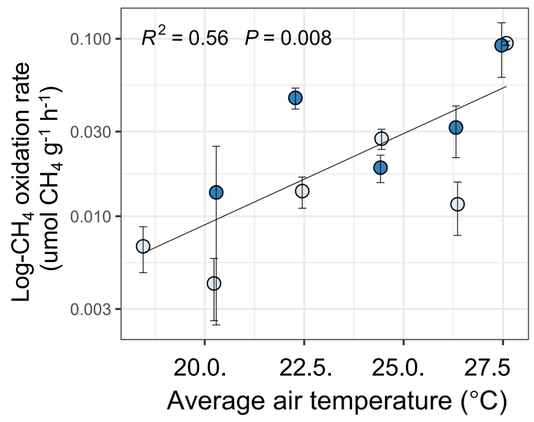




Using genome-centric metagenomics, we found that the composition of the *Sphagnum* microbiome is significantly altered by warming at SPRUCE.

Changes in microbial composition are accompanied by shifting rates of activity. Warming slows down N_2 fixation in *Sphagnum* tissue under ambient CO_2. However, this trend is disrupted under warming + elevated CO_2. In contrast, CH_4 oxidation rates increase with temperature, irrespective of CO_2 conditions.

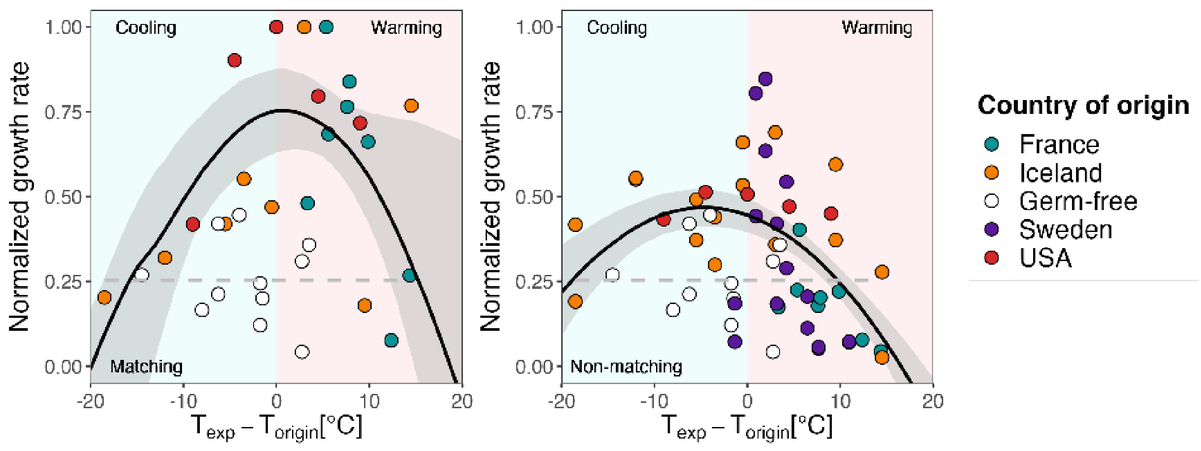




Microbiome Can Enhance Plant Heat Tolerance and Species/Genotype is Important for Receiving Microbial Benefits

Sphagnum growth responses to temperature were strongly influenced by microbiome origin and host–microbe matching.

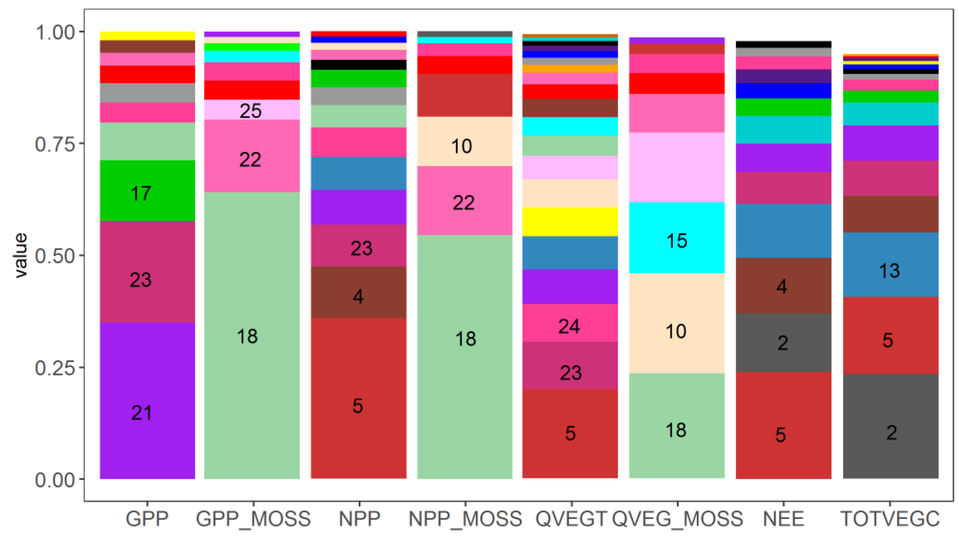
Peak growth rates occurred when recipient Sphagnum species were paired with microbiomes derived from the same host species and exposed to temperatures similar to the microbiome's native thermal environment. Matched host–microbiome pairs exhibited up to 250% higher growth than germ-free controls and outperformed non-matched pairs by approximately 50% (Živković et al. 2025).



These results reveal that thermal acclimation in Sphagnum is enhanced by species-specific host–microbiome associations and by microbial pre-adaptation to temperature. This specificity and thermal history dependence suggest that microbiome composition and host genetics are critical factors in determining peatland moss resilience to climate warming (Živković et al. 2025).

Traits related to photosynthesis, respiration, and inter-PFT interactions strongly influence ELM-SPRUCE outputs

- GPP and GPP_moss are most sensitive to three parameters: flnr, leafcn, and slatop for Picea and moss, respectively.
- NPP, QVEGT, and NEE show high sensitivity to br_mr (base rate of maintenance respiration) and q10_mr (its temperature sensitivity).
- crit_onset_gdd (spring phenology trigger) strongly influences NPP and NEE.



- leafcn_moss and npt_moss are key drivers of NPP_moss and QVEG_moss.
- Vegetation mortality (r_mort) notably impacts TOTVEGC and NEE.
- Cross-PFT influence observed: e.g., leafcn_shrub affects GPP_moss, highlighting inter-PFT competition (Hanson et. Al 2025).

Acknowledgements

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