Plant water relations in an ombrotrophic bog (SPRUCE S1) - partitioning water use and stress tolerance among components

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The SPRUCE climate change experiment (http://mnspruce.ornl.gov/) in Northern Minnesota, USA, will expose 13-m diameter plots of an ombrotrophic Picea mariana - Ericaceous shrub - Sphagnum bog to long-term temperature × CO₂ treatments. We have examined baseline plant water relations of plant species at the site to assess seasonal patterns of water use and correlate to carbon uptake through photosynthesis. Sap flow was investigated in shrubs and 5-40 year-old black spruce and larch trees using energy balance or thermal dissipation techniques (TDP). TDP probes were calibrated in situ, by measuring water uptake from cut trees. Water release curves were created for sphagnum mosses, which lack stomata, and related to response thresholds for photosynthesis. Predawn and diel patterns of plant water potential (\(\psi\)) were also measured seasonally. While the heat balance technique was able to measure sap flow in small diameter stems (e.g., 2-3 mm), early morning thermal gradients and high sap flow conditions both produced artifacts in the data that required filtering and interpolation. Sap flow (per unit sapwood area) was greater in several of the Ericaceous shrubs than in spruce trees. In the trees, sap flow began by late May and was fairly constant over the season until declining in mid-September (larch foliar senescence) and ceasing as temperatures dropped below zero. Midday spruce \(\psi\) was generally lower than other species, although Ledum could also experience low \(\psi\) (-2.0 MPa). Laboratory measurements of specific leaf conductivity of spruce declined as drought stress increased beyond -1.2 MPa, with the average turgor loss point reached by -2.4 MPa, slightly lower than the turgor loss point of larch (-1.9 MPa). Summer mid-day water potentials in spruce and larch trees approached this turgor loss point. Warming and CO₂ treatments will likely force a change of community composition within this ecosystem due to treatment effects on water availability, and resultant differential water stress among the species. We anticipate being able to capture this response through targeted physiological measurements and more integrated approaches such as chamber-based estimates of system transpiration, changes in soil water content, and through analysis of hydrologic budgets. Insights generated through these studies will be used to improve our understanding of peatland response and resiliency to a changing climate and models of those systems at local to global scales.