Ecophysiology of woody plants in an ombrotrophic spruce bog – potential impacts with climate change

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Background/Question/Methods

In the southern boreal forest, ombrotrophic bogs are operating at the edge of their climate envelope. Future increases in temperature (T) and [CO_2] may force a change of state in these ecosystems through impacts on physiology, or through shifts in water table depth caused by enhanced evapotranspiration. The proposed SPRUCE climate change experiment (http://mnspruce.ornl.gov/) will expose large plots in a Minnesota bog to T x [CO_2] treatments. We have begun examining current plant water relations and gas exchange of woody species at the site to assess physiological and environmental controls on response thresholds. Predawn and diel patterns of plant water potential (ψ) were measured on various woody species, including *Ledum groenlandicum*, *Chamaedaphne calyculata, Kalmia polifolia, Vaccinium sp., Larix laricina, Pinus strobus and Picea mariana*. Plant water use as sap flow was investigated in shrubs and 5–40 year-old *P. mariana* trees using energy balance and thermal dissipation techniques. Pressure-volume (P-V) curves were generated for spruce to determine the threshold for loss of specific leaf conductivity under drying conditions. Foliar gas exchange measurements including light and [CO_2] response curves, and diel patterns of assimilation and conductance were conducted in order to differentiate species foliar physiological responses to altered environmental conditions.

Results/Conclusions

Specific leaf conductivity of spruce declined as seasonal drought stress increased beyond ψ= -1.2 MPa, with the turgor loss point reached by -2.2 MPa. Summer mid-day water potentials in small spruce and large spruce trees approached this turgor loss point, even as conditions were mild, cloudy and wet. Spruce ψ was generally lower than other species, although *Ledum* could also experience low midday ψ (>-2.0 MPa).This suggests that under current environmental conditions foliar water stress may be limiting gas exchange in spruce, and that trees are operating close to a point of hydraulic failure. The largest sap flux occurred in *Vaccinium* (>3000 kg m^{-2} day^{-1}), followed by *Chamaedaphne*, *Picea* and *Ledum* (1000-2000 kg m^{-2} day^{-1}). Net photosynthesis rates varied 3-fold between species, with woody shrubs showing a lower light-compensation point (≤500 μmol m^{-2} s^{-1} PAR) than overstory trees (>1500 μmol m^{-2} s^{-1} PAR). Some shrub species approached [CO_2] saturation at higher concentrations than did tree species, which could suggest a competitive advantage in a high [CO_2] atmosphere. Along with a likely reduction in water table depth under warming treatments, and without rapid hydraulic adjustment (i.e, foliar loss, increased rooting at depth), our research suggests a potential for future shifts in species composition.