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Environmental controls of Picea mariana water use in a boreal subarctic peatland

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Black spruce (Picea mariana) dominated peat plateaus are an important component of northwestern Canada's heterogeneousboreal landscape. Threats to these ecosystems, including permafrost thaw and wetland expansion, could impact hydrological fluxes therefore, it is essential to understand the factors affecting the hydraulic function of black spruce in these rapidly changing landscapes. Sap velocity (V_s, cm·hr^{-1}) is the movement of water and minerals through tree stems during the growth period and can be used as an indicator for plant water use and the quantification of tree transpiration. Here, we identified the meteorological variables driving daytime and nighttime V_s in Picea mariana (black spruce) trees growing across a 21 hectare (20 m^2 grid) subarctic boreal peatland complex underlain with discontinuous permafrost, ~630 km west of Yellowknife, Northwest Territories (61°18'N, 121°18'W; ForestGEO Plot). For two consecutive growing seasons (2017 and 2018), eighteen black spruce trees were instrumented with sap flow sensors using the heat-ratio method to measure V_s. Meteorological variables including vapor pressure deficit (VPD) and photosynthetically active radiation (PAR) accounted for 57 and 73% of the variance in daytime mean V_s in 2017 and 2018, respectively, while VPD, PAR and air temperature accounted for 26 and 40% of V_s variance at night. VPD and PAR were the strongest meteorological drivers of black spruce V_s in the ForestGEO Plot. An increase in either variable corresponded to an increase in V_s across various time periods (day/nighttime). In addition, we investigated how daytime seasonal mean/maximum V_s for black spruce was affected by local environmental factors including fibric layer depth, organic matter decomposition, black spruce density, black spruce basal area, phosphorus supply rate (P) and soil water content (SWC) when physiological traits of black spruce, including diameter at breast height and crown area, were considered as covariables. It was hypothesised that stand density and basal area would affect V_s, but results indicated that only P and SWC had a (weak) influence on black spruce Vs. The variables P and SWC had a greater influence on the amplitude (seasonal daily maximum) of V_s over the sampling period. Overstory vegetation in Canada's Northwestern boreal forest is important for the terrestrial water cycle through tree water storage, and transpiration, therefore the quantification of black spruce transpiration and an improved understanding of the environmental controls of black spruce V_s in boreal peatlands would be a natural next step for this research.