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Estimating sub-canopy evapotranspiration and resistances from small-scale, forested wetlands in the sub-humid Boreal Plain

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Forested wetlands in the Western Boreal Plain are long-term carbon sinks and increase runoff from local to regional scales. They are hence vital for water security and maintaining downstream and adjacent ecosystems. However, processes occurring in individual wetland systems and their translation into larger-scale functions are not fully understood. Small-scale (< 1 ha), forested wetlands (SFW) of similar or equal function are likely found throughout the region. Given that their size and vegetation can lead to misclassification as uplands, the (cumulative) role of these small wetlands in providing water to adjacent and downstream systems is currently unknown, and they hence represent unstudied Boreal Plain landscape features.
Further, research on northern peatlands suggests possible state-shifts (e.g. from carbon sink to source) in the future. Yet, it has not been established to what extent SWF could be affected by high-latitude warming from projected climate change or natural (e.g. wildfire) and human disturbances (e.g. resource extraction, agriculture).

The ecohydrological functioning of SFW depends on their ability to export water in a sub-humid climate. Hence assessing their water balance dynamics is a crucial first step. Evapotranspiration (ET) is generally the dominate water efflux in Boreal Plain wetlands, with sub-canopy ET (i.e. from ground, standing water, moss and herb layer) being a major sub-component. A combination of automated chamber (n = 6) ET and atmometer-based (n = 3) potential ET (pET) measurements were used in the 2016 growing season to assess spatially-explicit sub-canopy ET at an exemplary SWF. Given the structural complexity (multiple shrub layers and high tree density) and its limited size, this allowed us to circumvent issues that may have arisen with eddy covariance approaches due to difficulties of delineating flux footprints and unfavorable boundary layer conditions. Daily, growing season actual ET (aET) in 2016 averaged 0.90 mm (sd = 0.50 mm) from the sub-canopy and was highly variable, following micrometeorological conditions, soil moisture and water table dynamics. Linear relationships between atmometer and chamber measurements allowed estimating daily sub-canopy ET for the 2017 growing season, averaging 1.1 mm (1.0 – 1.2 mm 95 % CI). Mismatches between high atmospheric demand (pET) and low aET hint at reduced water losses, allowing these systems to maintain their wetland functioning during drier times, e.g. as is typically found for moss communities in boreal peatlands. To elucidate ET-reducing mechanisms, we investigated the role of bulk, surface and aerodynamic resistances in relation to micrometeorological and hydro(pedo)logical dynamics. Atmometers were calibrated, allowing an estimate of “bulk” aerodynamic resistance for the sub-canopy environment, while chamber fluxes were partitioned into evaporation and transpiration. Across multiple dry days, sub-canopy resistances increased by approximately 50 %, effectively reducing water losses to the atmosphere.

The use of chambers and atmometers was effective for assessing sub-canopy ET and resistances in an SWF of the Western Boreal Plain. It has useful implications for constraining other measurement and modelling approaches, yet additional research on the spatio-temporal variability of estimated parameters is necessary.