Analyzing Transpiration in Replacement Trees Following Emerald Ash Borer Infestation

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Introduction

The invasive emerald ash borer (*Agrilus planipennis*) poses an immediate threat to black ash (*Fraxinus nigra*) wetland forests across the U.S. Black ash is an important mediator of hydrological dynamics in such systems - they serve to lower the water table and prevent transition to cattail dominated wetlands. Given their unique ecohydrological niche, die-off via emerald ash borer stands to disrupt the hydrological processes of these wetlands. This study aims to provide transpiration data on tree species that may potentially replace black ash to mitigate changes in the hydrology of these sites.

Site Description

This study was performed in Cloquet, MN on the Fond du Lac reservation beginning July 9th, 2018. A single site was selected in a black ash dominated stand on a wetland area. At this site, ten trees were fitted with thermal dissipation probes. Tree species monitored include two black ash (*Fraxinus nigra*), two red maple (*Acer rubrum*), two paper birch (*Betula papyrifera*), two mountain ash (*Sorbus americana*), one balsam fir (*Abies balsamea*), and one mountain maple (*Acer spicatum*).

Analysis

Raw data from thermal dissipation probes were converted into sap flux density using the Granier (1985) equation.

$$F_d = 118.9 \cdot 10^{-6}\, K^{1.231}$$

Black ash trees are ring porous which requires a different equation to account for a different structure of the xylem. The Herbst et al. (2007) equation was used here.

$$F_d = 2.023 \cdot 10^{-3} \cdot K^2 + 4.28 \cdot 10^{-4} \cdot K$$

The ring porous structure of black ash creates narrow areas of active xylem which can lead to underestimates of sap flux. This was corrected for using the Clearwater er al. (1999) equation.

$$\Delta T_{SW} = \frac{\Delta T - b\Delta T_m}{a}$$

Results

Most trees had sap flux densities varying in the same range. Balsam fir had low sap flux density as expected for a conifer and mountain maple had high sap flux density possibly due to the young age of the specimen. Black ash sap flux density was in the same range as other species when the Granier (1985) equation was used, but was much greater when using other equations. When compared at the tree level, black ash had about 1/4 the sap flow that other species of similar DBH had when using the Granier (1985) equation. When using the Herbst et al. (2007) equation, black ash had about 4 times the sap flux that of other species of similar DBH at the tree level. Studies have shown that the Granier (1985) equation underestimates transpiration in ring-porous trees (Herbst et al., 2007). However, subsequent studies have had varying success using equations designed for ring-porous trees (Telander et al., 2015; Shannon et al., 2018). Based on these findings, we suggest that black ash transpiration is closer to values found from the Herbst et al. (2007) equation but that the result from this equation requires further investigation.

Table 1. Mean sap flux density and maximum flux in a day.

Species	n	Mean Sap Flux Density $m^3\ m^{-2}\ day^{-1}$ (S.D.)	Maximum Flux in a Day $m^3\ m^{-2}\ day^{-1}$
Red Maple	2	1.21 (.26)	1.80
Paper Birch	2	1.40 (.28)	2.15
Mountain Ash	1	1.66 (.27)	2.00
Balsam Fir	1	1.02 (.41)	1.60
Mountain Maple	1	1.72 (.44)	2.74
Black Ash (Granier)	2	1.51 (.24)	2.00
Black Ash (Granier + Clearwater)	1	8.19 (1.70)	11.26
Black Ash (Herbst)	2	14.97 (3.20)	24.43
Black Ash (Herbst + Clearwater)	1	214.41 (68.77)	345.53

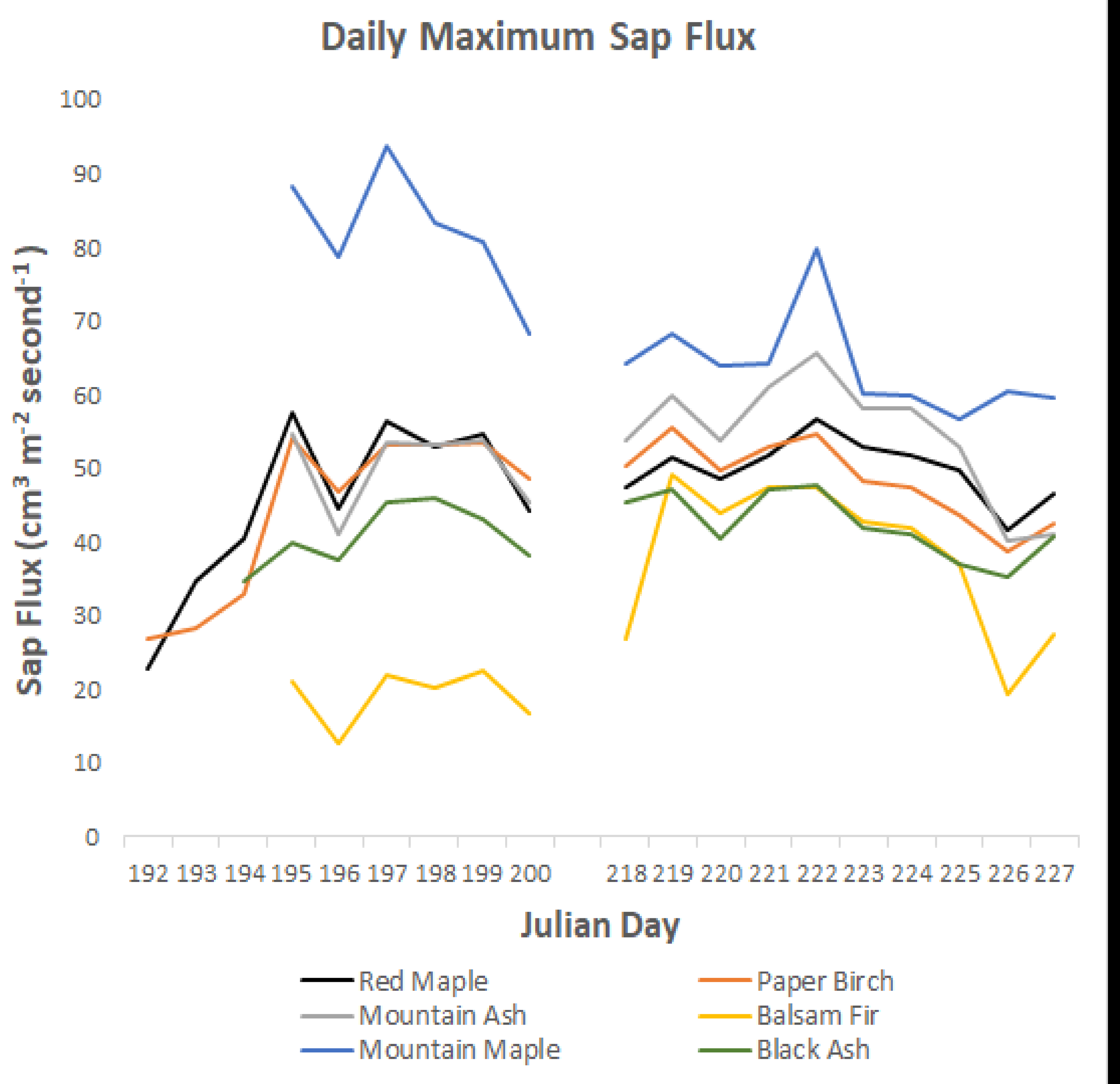

Figure 1. Daily maximum sap flux values for each species as determined using the Granier (1985) equation.

Conclusions

- Sap flux density in black ash is 5-8 times greater than that of other species studied but this difference is smaller at the tree level
- Further research is needed to provide a better method for quantifying transpiration in black ash
- Black ash have greater levels of transpiration than those of other trees studied and their loss from the emerald ash borer could alter the hydrology of black ash stands with significant consequences

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