Emerald Ash Borer Simulation Reveals Ecohydrologic Feedbacks in Black Ash Wetlands

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The Emerald Ash Borer (EAB; *Agrilus planipennis*), is causing devastation to ash trees (*Fraxinus sp.*) throughout North America. Since 2002, the EAB has killed hundreds of millions of trees, but many questions remain regarding the attendant consequences to ecosystem properties of this loss. To explore some of these consequences, we take advantage of an experimental design that simulates EAB-induced mortality and investigate feedbacks between vegetation and hydrology (ecohydrology). This work bridges knowledge gaps on the resilience of ash tree ecosystems and informs managers as they prepare for inevitable EAB infestation.

Study System

Our study systems are black ash wetlands. Black ash (*Fraxinus nigra*) are a major presence in North America with over 8 billion ash trees located in the northern U.S. and Canada. Black ash wetlands are unique in that they predominately occur in monotypic stands (i.e., they represent 75–100% of tree species in an area). These wetlands are characterized by low topographic gradient, lack of understory, and organic soils.

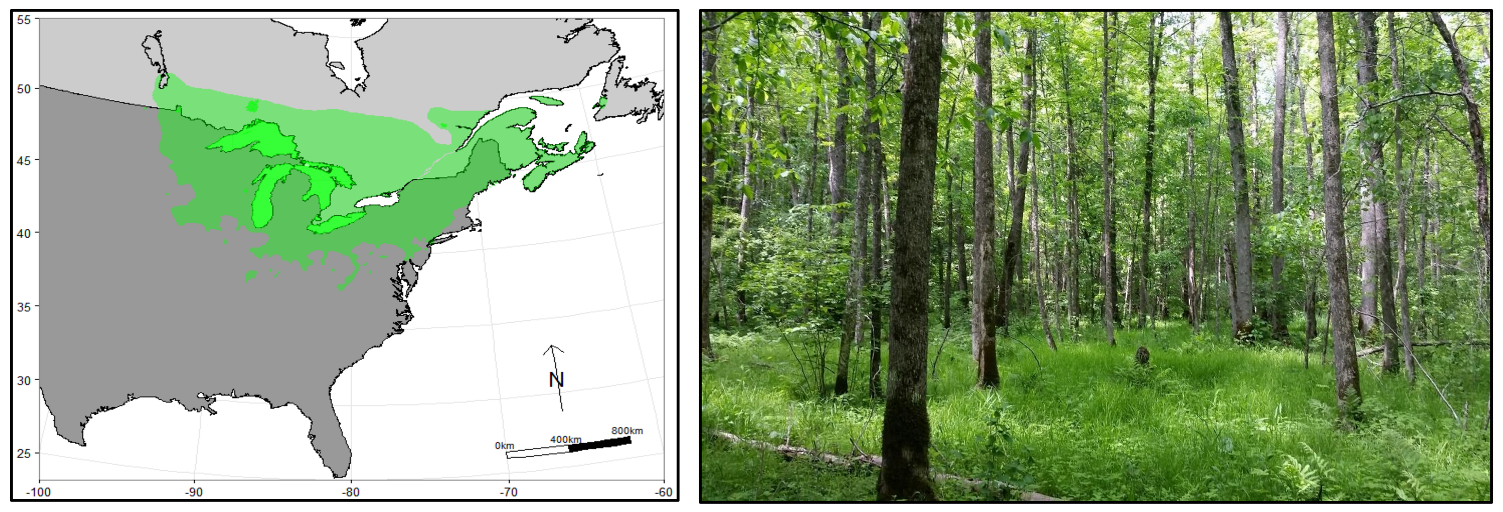


Figure 1. (Left) Extent of black ash habitat range, and (Right) typical black ash wetland in Minnesota during summer 2015.

Experimental Setup

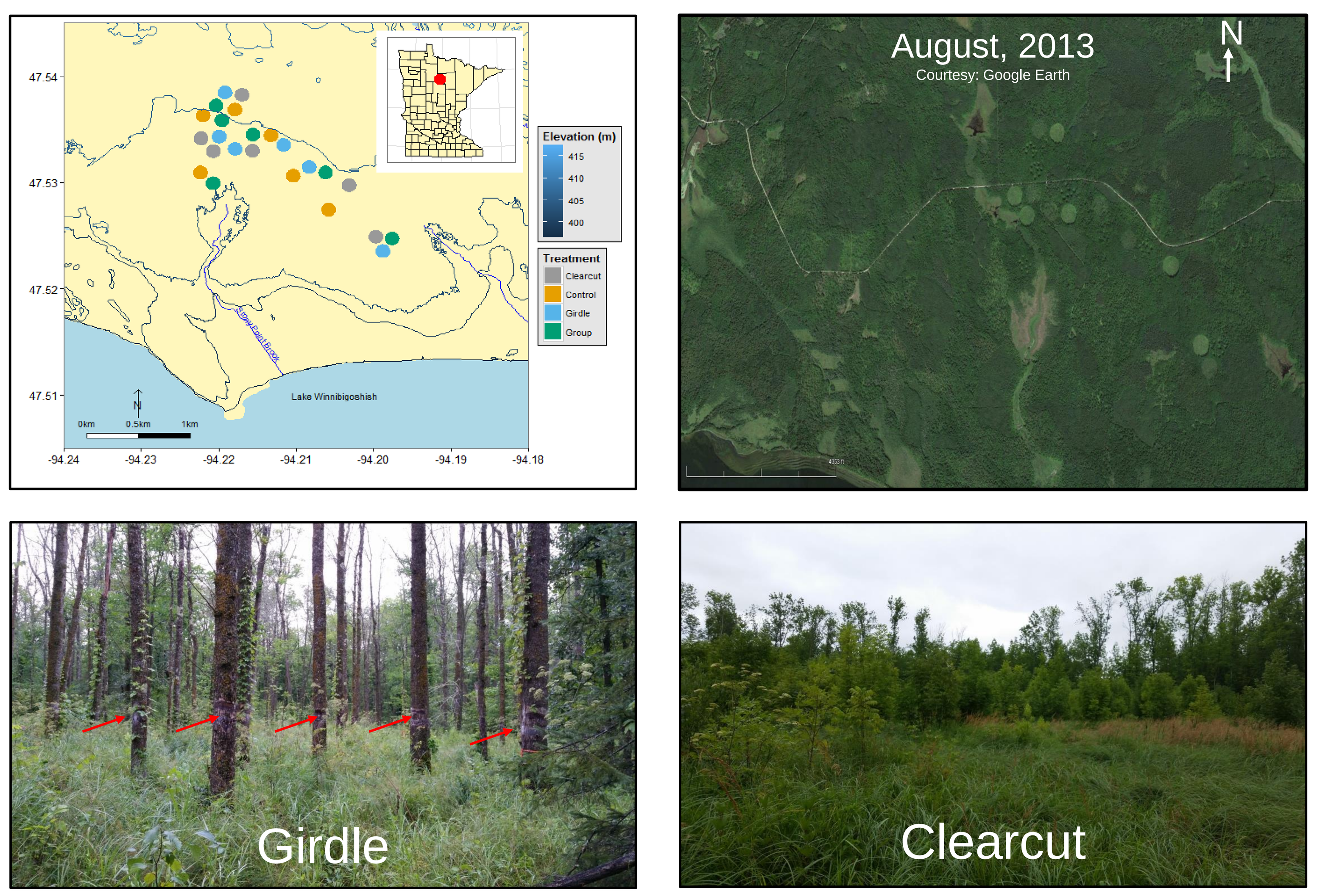


Figure 2. (Clockwise from top-left) Randomized block design with 4 treatments in color; aerial imagery of site after treatments were implemented; ground-view of clearcut treatment; ground-view of girdle treatment with arrows pointing to girdling locations on trees. Girdle treatments simulate EAB infestation, as the beetle girdles trees by boring through and feeding on phloem. Clearcut and group-selection (no photo) treatments represent preemptive management strategies to remove black ash before the EAB arrives.

Wetland Hydrology

Figure 3. PVC wells used to observe water table depth that are equipped with high-resolution (0.4 cm) pressure transducers that measures water table at 15-minute intervals.

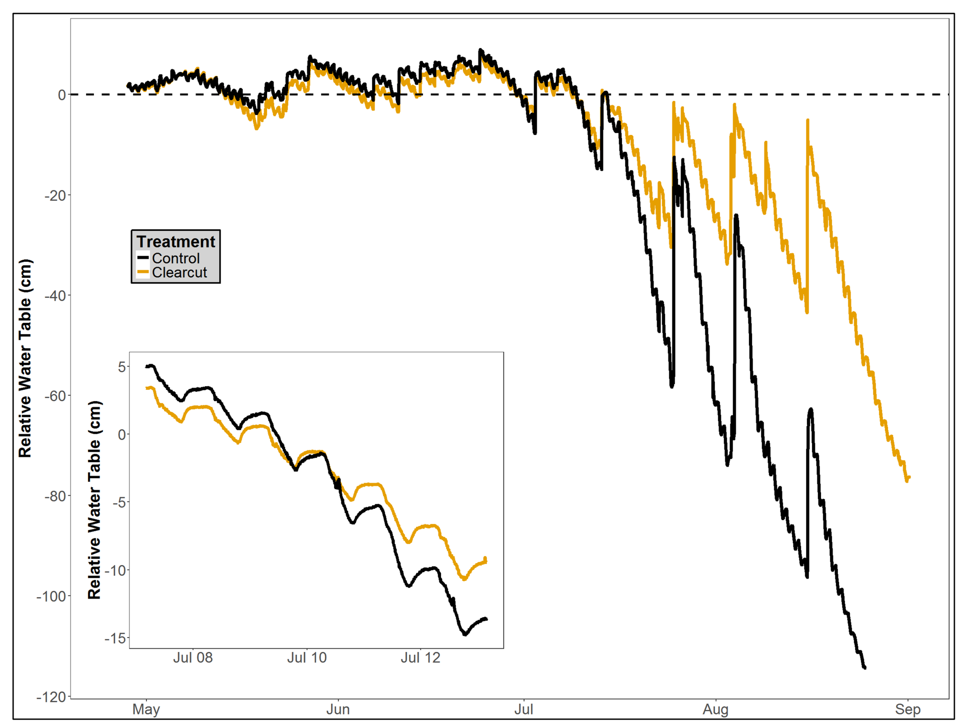
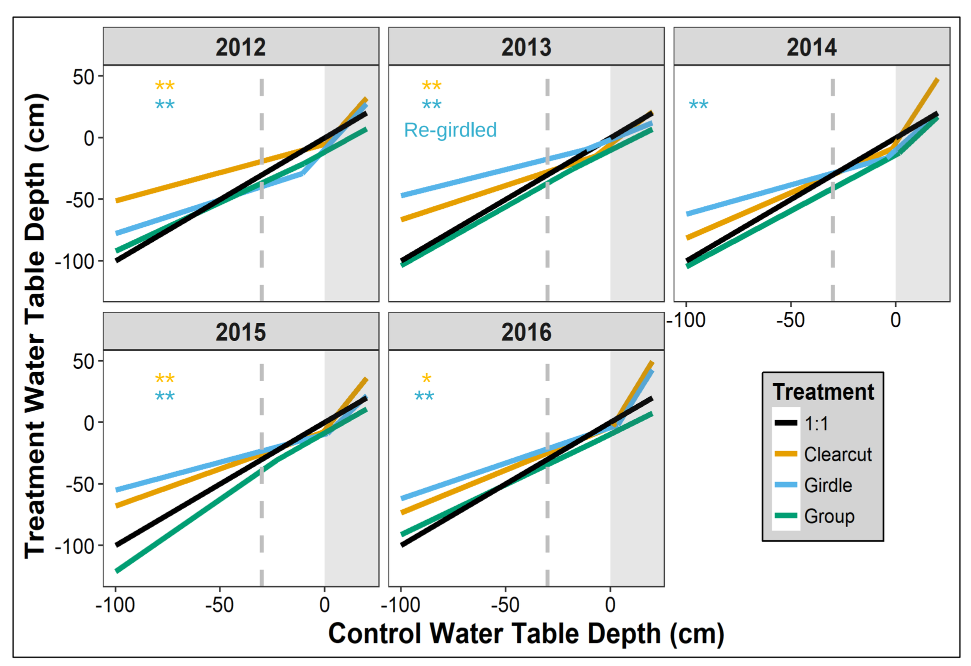


Figure 4. Typical annual trend of groundwater levels in a black ash wetland. Early season inundation (water tables above ground surface, which is indicated by the dashed line at 0 cm) is followed by summer drawdown due to evapotranspiration (ET). Inset shows diel patterns of water table levels indicative of ET.

Water Table Effects of Forest Loss



2011 = Pretreatment year
2012 = Treatments applied
2013 = Girdle treatments re-girdled due to incomplete girdling

Figure 5. Average water table response across 6 blocks. Asterisks represent slopes significantly different from the 1:1 line (*, $p < 0.05$; **, $p < 0.01$). Breakpoints center on ground surface in the control (shading). Clearcut treatments appear to have a slightly faster recovery to pre-disturbance hydrology on average than girdle treatments, but both treatments maintain elevated water tables even after 5 years. Dashed vertical grey line represents estimated rooting depth of 30 cm. The greatest differences in water table are below this depth.

Assessing the Mechanism: Evapotranspiration

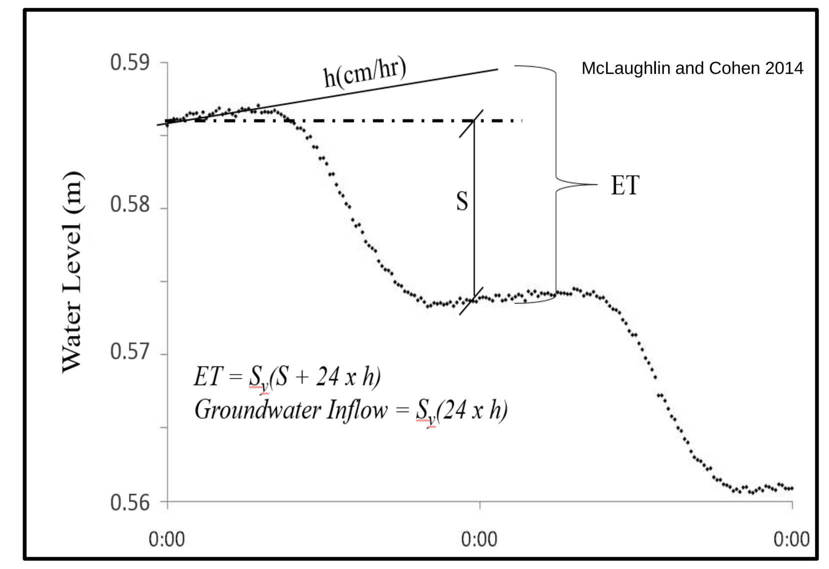


Figure 6. We measure whole system evapotranspiration (ET) through analysis of diel water level patterns. We attribute the change in storage (S) over the course of a day to net groundwater flow and ET. We account for groundwater flow with nighttime-recovery slopes (h).

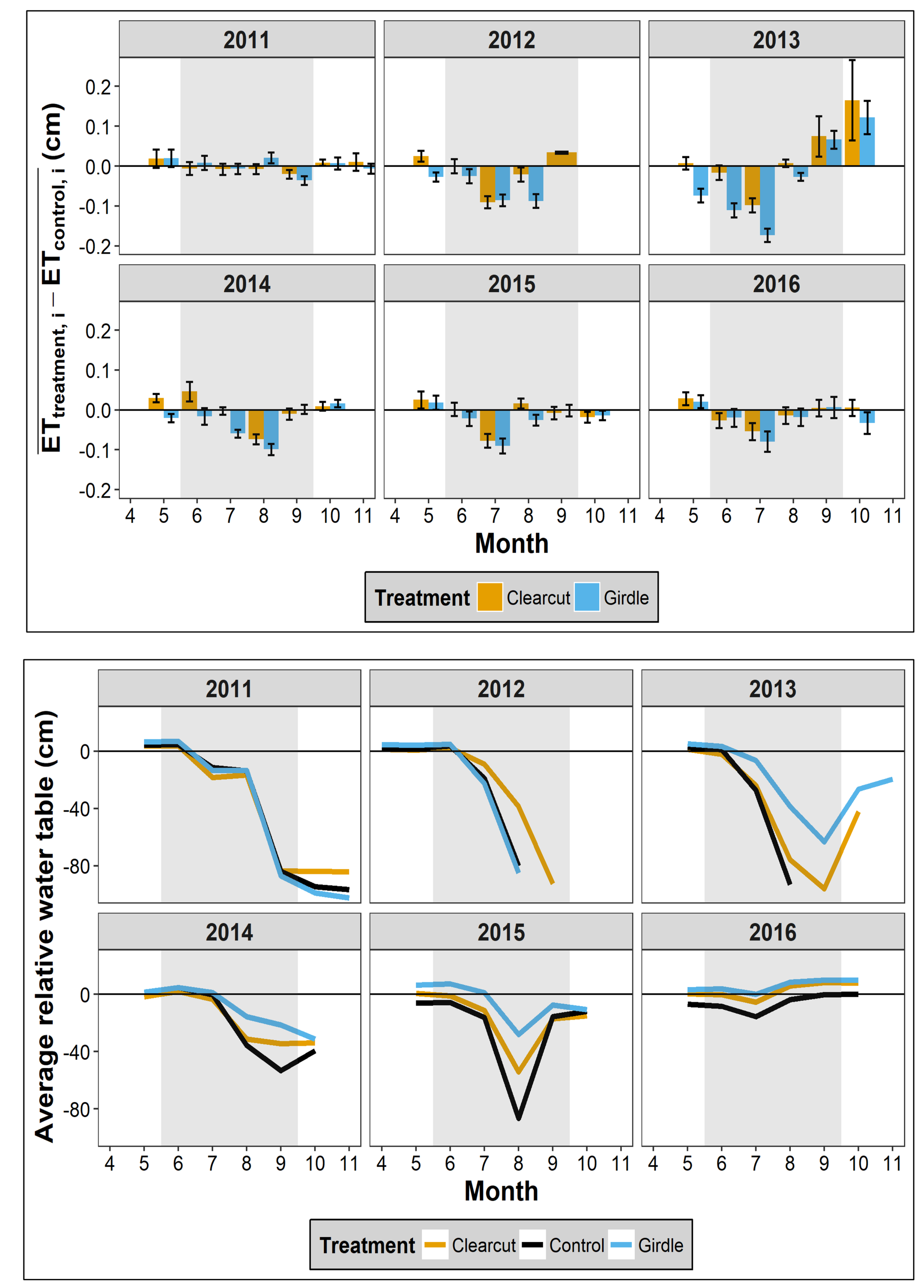


Figure 7. (Top) Sum of mean daily differences by month between controls and treatments, averaged across blocks. Bars are standard errors. Generally, ET in controls is much greater than treatments during mid-summer, but these differences are muted or even reversed in late spring and fall, especially for clearcuts. Shading indicates leaf-on season. (Bottom) Average monthly water table for block 1. Monthly values are missing when water tables were below recording depth. When water tables are similar among control and treatments, differences in daily ET are smallest.

Ecohydrologic Feedbacks Control Response