Ecohydrological Evaluation and Management Implications for Black Ash Wetland Ecosystems Threatened by Emerald Ash Borer

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NORTHERN MICHIGAN UNIVERSITY
EARTH, ENVIRONMENTAL AND GEOGRAPHICAL SCIENCES

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Great Lakes RESTORATION

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Emerald Ash Borer Infestation Implications

Emerald Ash Borer (EAB)

Agrilus planipennis Fairmaire (*Coleoptera: Burpestidae*)

- Exotic and invasive beetle
- Larvae bore into and feed on phloem
- Disrupting water and nutrient transport within ash trees (*Fraxinus sp*.)

http://www.emeraldashborer.info/

http://www.esf.edu/extension/ash.htm

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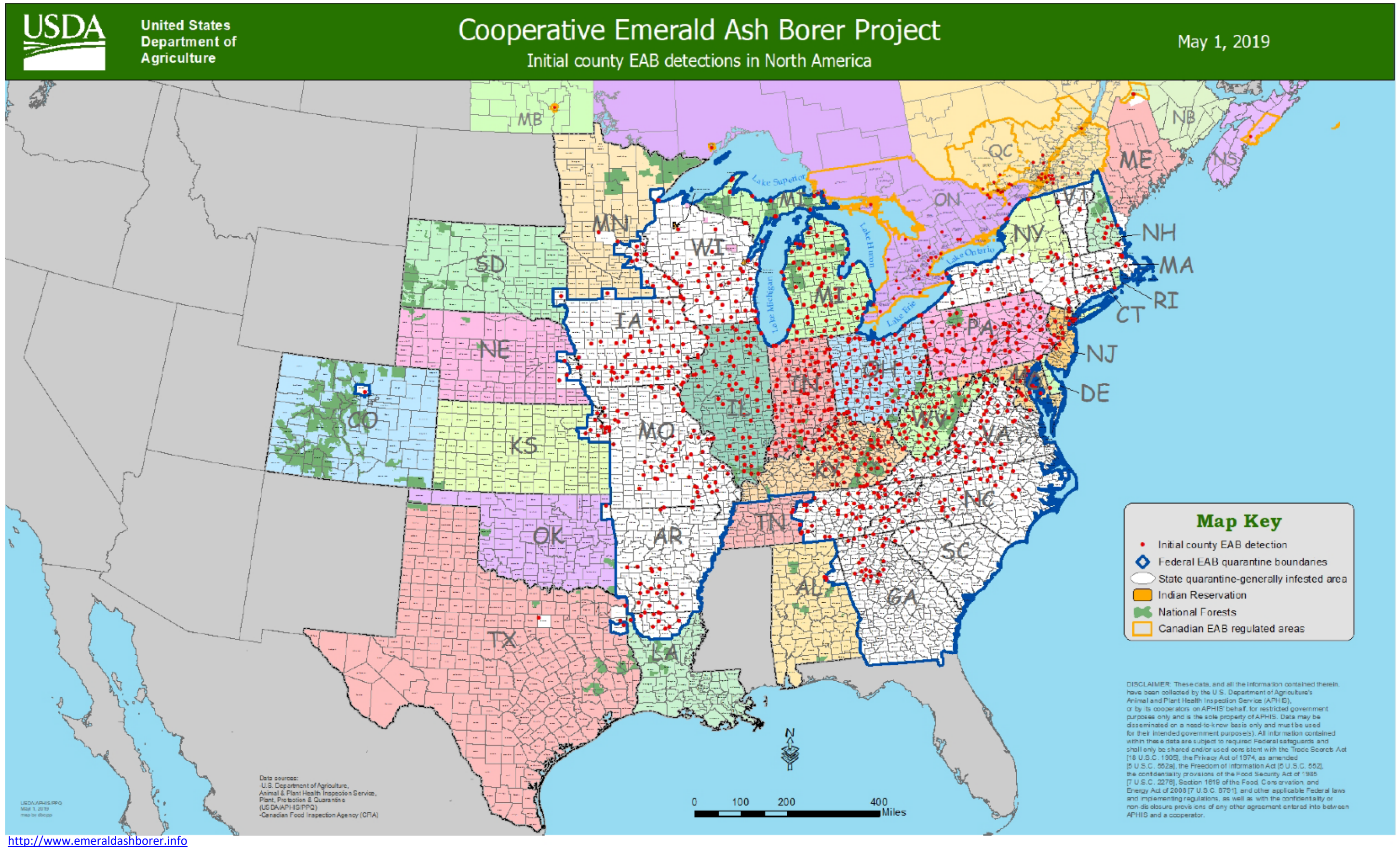
http://labs.russell.wisc.edu/eab/signs-and-symptoms/t

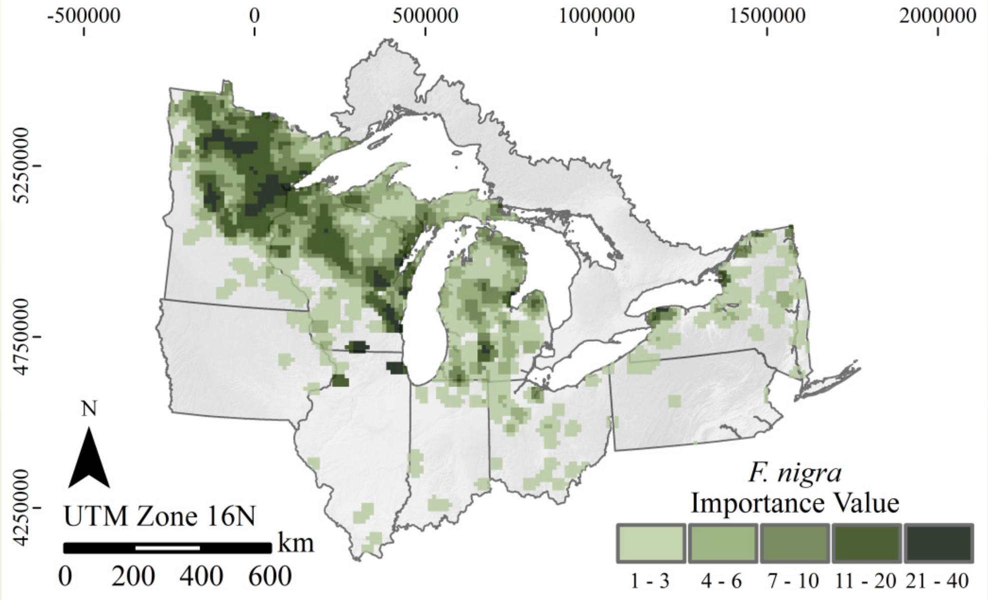
EAB Detection: 2002 - 2019

Current EAB: 35 U.S. States & 5 Canadian Provinces

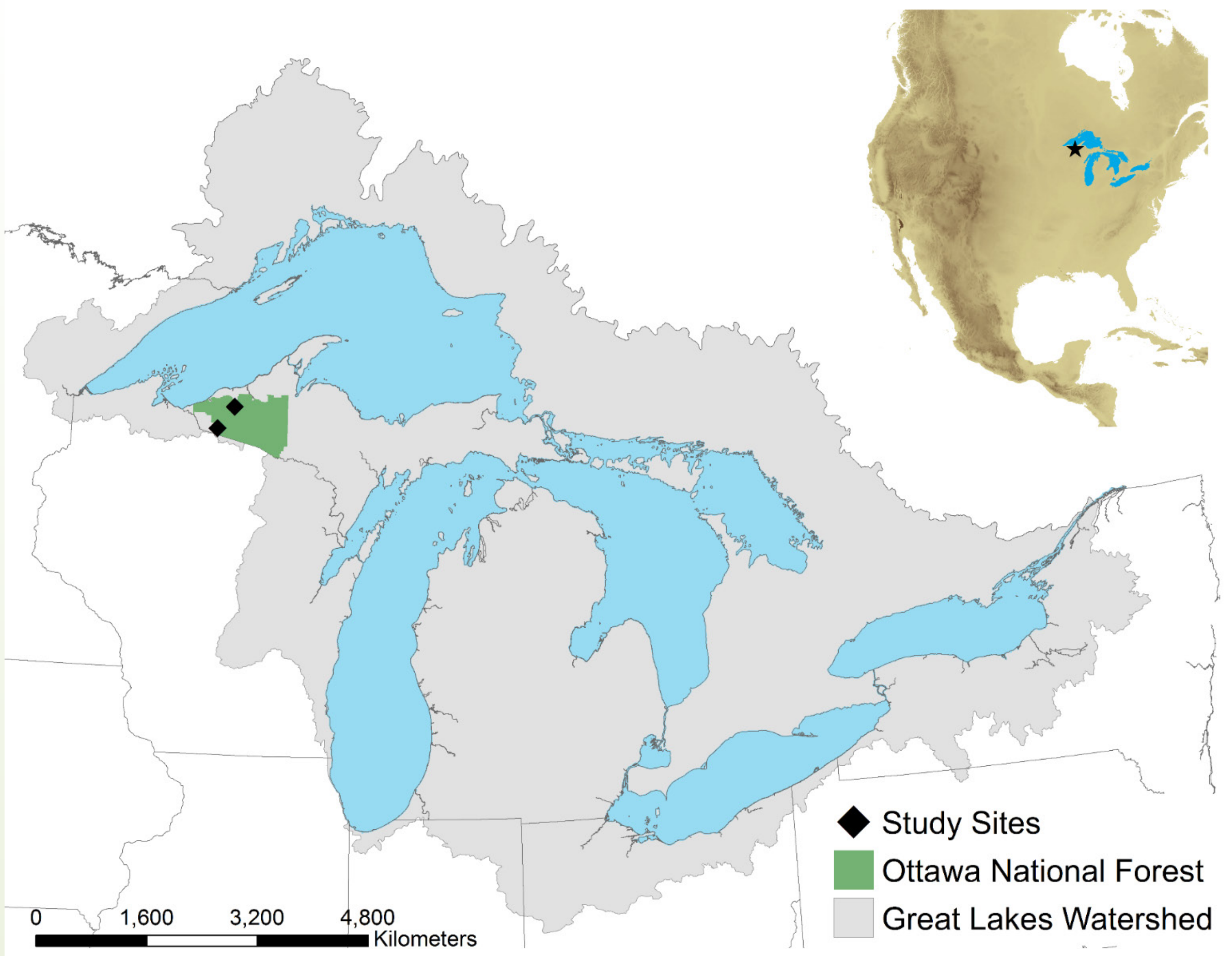


http://www.emeraldashborer.info

- Killed hundreds of millions of ash trees



Study Area Overview



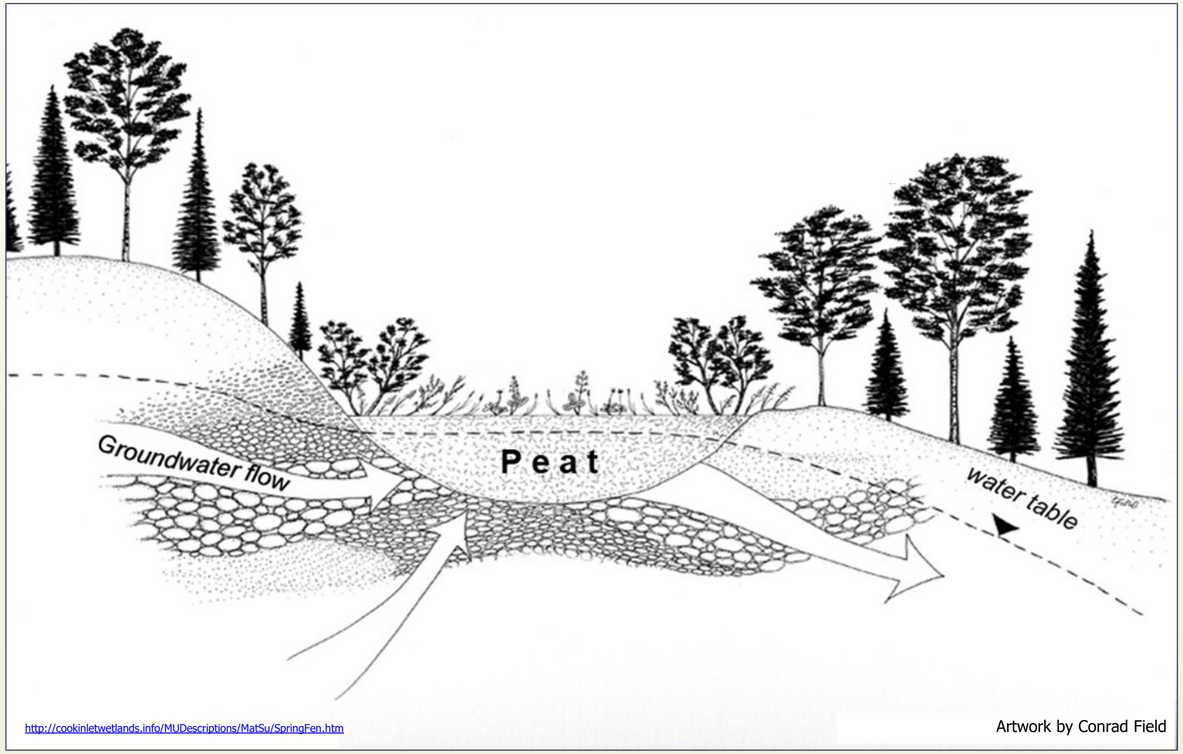
Ottawa National Forest

Michigan's Upper Peninsula contains 56,000 ha of wetlands

- 18,000 ha of deciduous forested wetlands
  - 70% of wetlands dominated by black ash (*Fraxinus nigra*)

Depressional Black Ash Wetlands

- Headwater wetlands
- Histosol & histic mineral soils
- 0.25 – 1.25 ha



- 66% black ash basal area
  - Yellow birch and red maple
- *Carex* species highest occurrence and greatest percent cover

Research Objectives & Management Implications

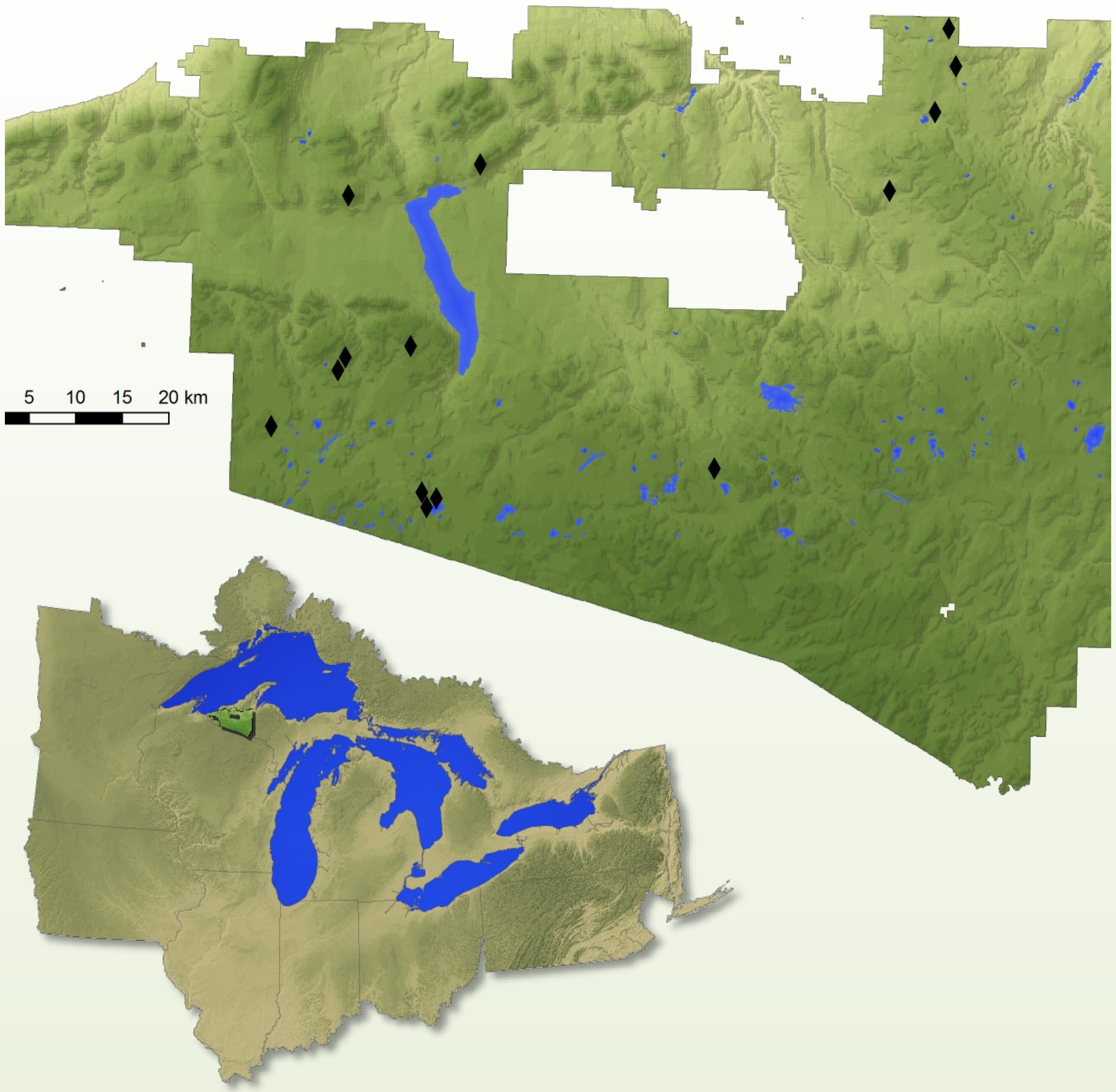
Research Objectives

- Groundwater connectivity, source water contributions & site transpiration

<u>Responses to simulated EAB infestation</u>

- Water table fluctuations
- Quantify water, carbon and nitrogen loads
- Residual vegetation growth and regeneration
- Planted alternative species growth & survival

Study Area and Experimental Design

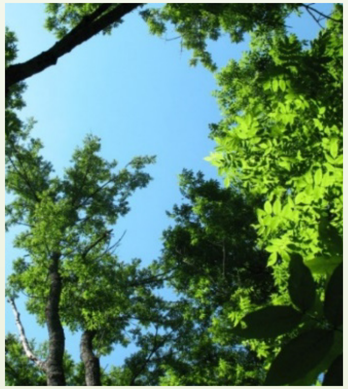


14 wetlands with 3 treatments

- Control
- Girdle (girdle ash stems ≥ 1″ DBH)
- Ash-Cut (hand-fell ash stems ≥ 1″ DBH)

Timeline

- Baseline conditions, 2011-2012
- Treatments applied, Winter 2012-13

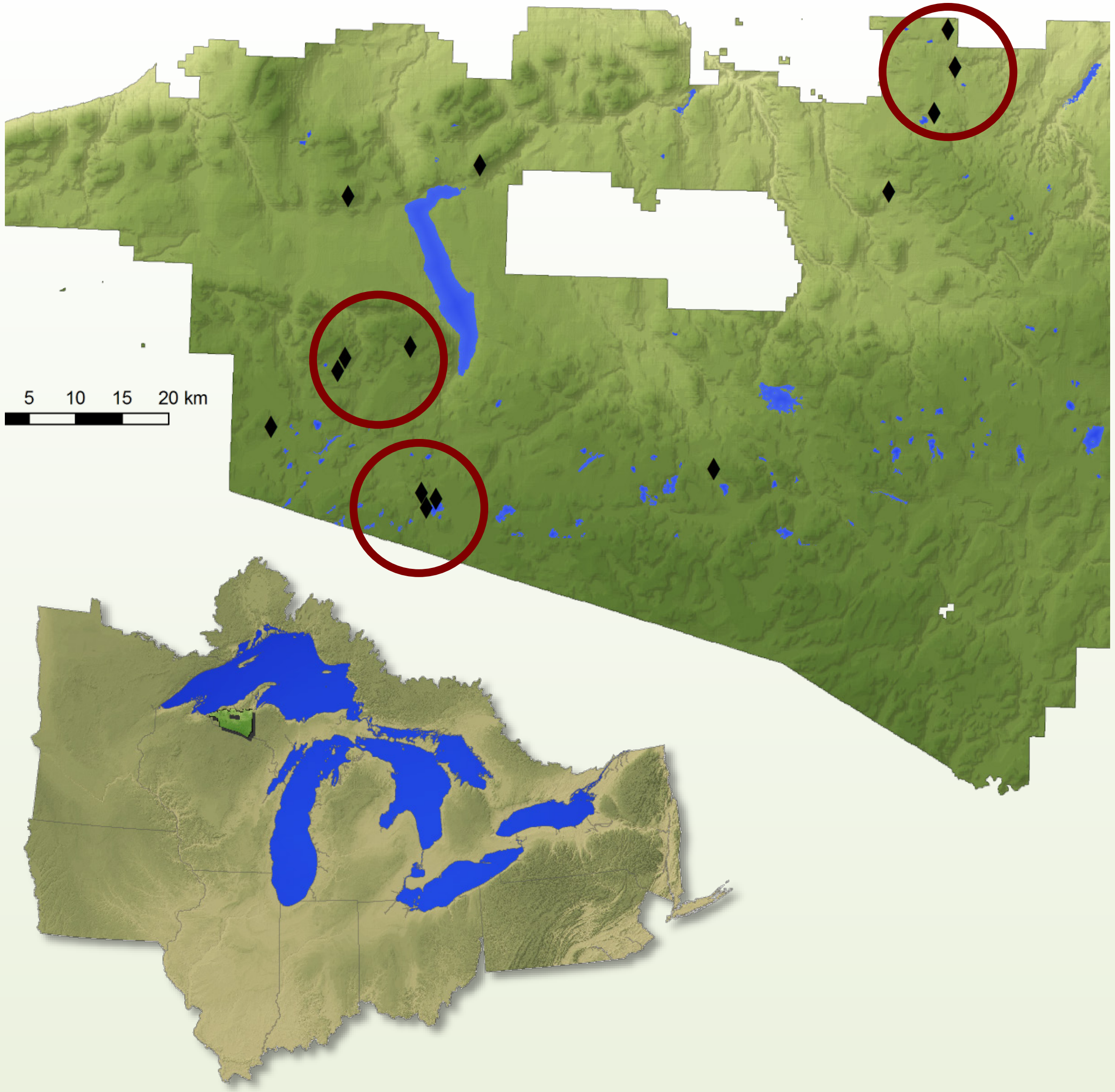


Control

Girdle

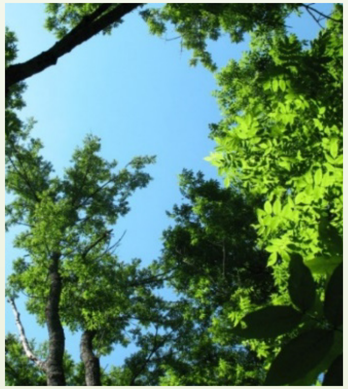
Ash-Cut

Study Area and Experimental Design



9 wetlands with 3 treatments

- Source water contributions
- Water level monitoring
- Sap flux estimation for canopy species
- Residual vegetation growth and regeneration

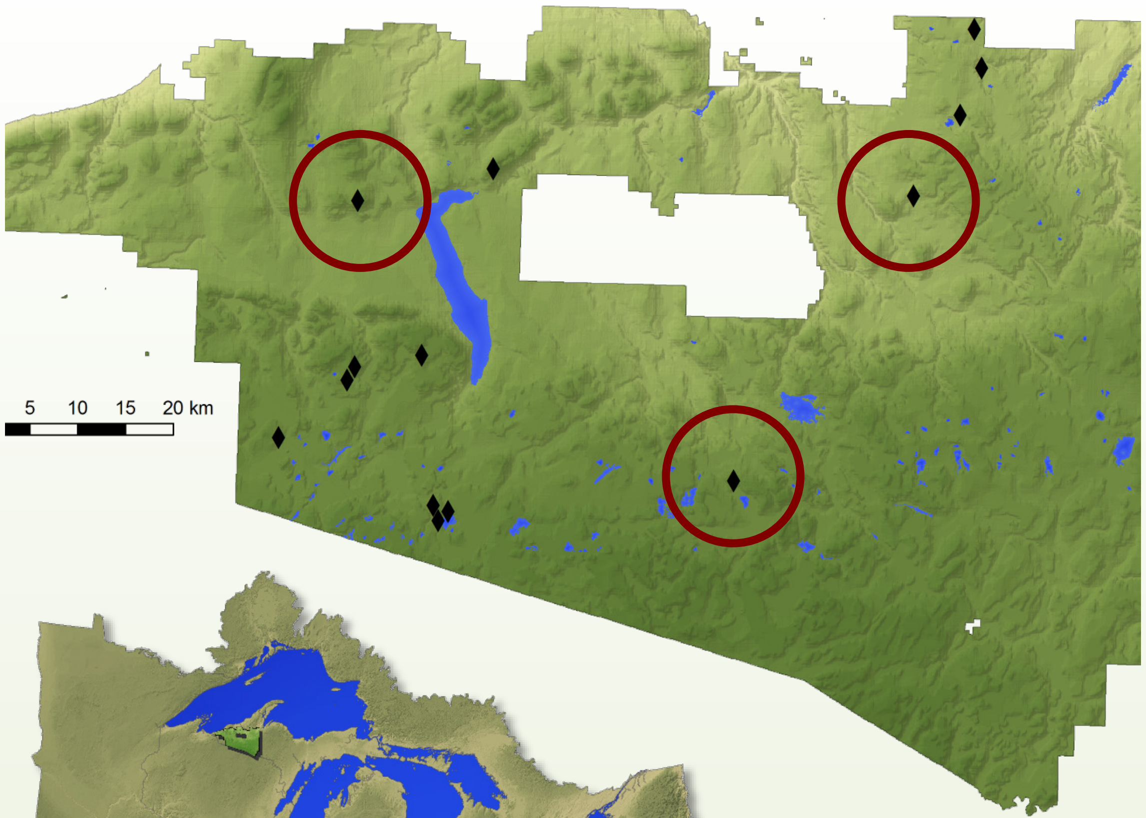


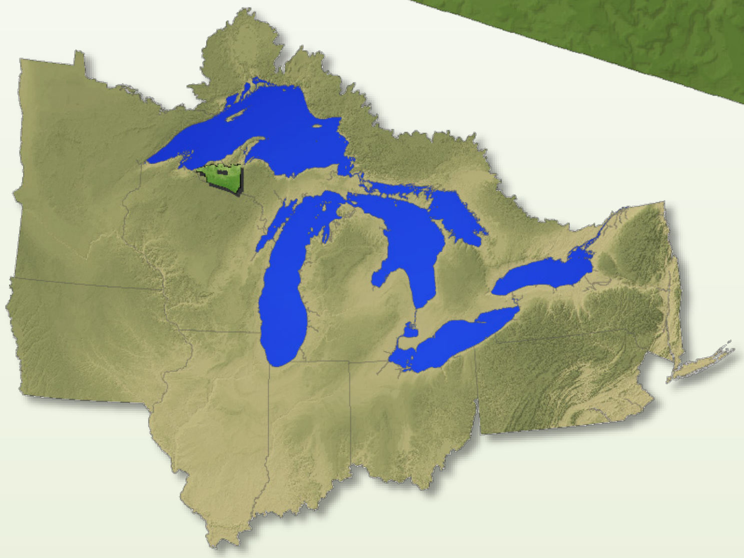
Control

Girdle

Ash-Cut

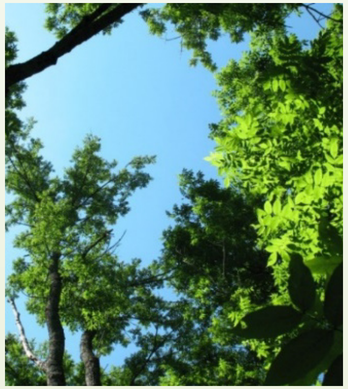
Study Area and Experimental Design





3 wetlands with 3 treatments

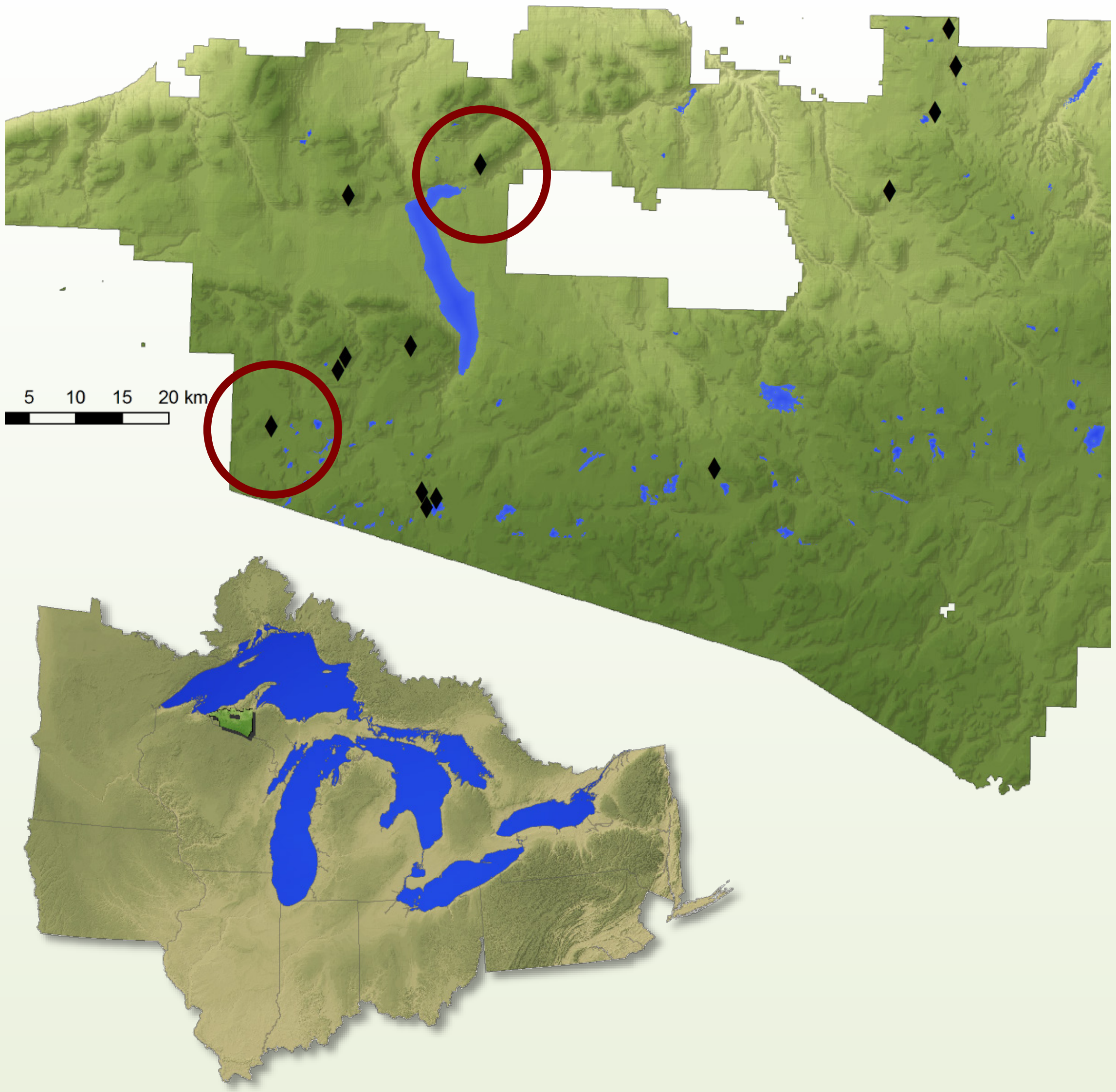
- Planted 1800 alternative species seedling growth and survival
- Paired hummock & hollow planting design


Control


Girdle


Ash-Cut

Study Area and Experimental Design



Paired watershed study with control and ash-cut treatments

- Water yield
- DOC & TDN exports
- Soil decomposition & chemistry

Control

Ash-Cut

Results: Physical Soil Properties

Soil Depth (cm)	Sample Size	Average Bulk Density	95% Conf. Interval	Est. K_{sat} (cm/s)	Mineral Soil (K_{sat}) Equivalent
0-15	10	0.09	0.03	1×10^{-3}	Sand
15-30	12	0.16	0.02	1×10^{-4}	Loam
30-50	15	0.23	0.02	1×10^{-5}	Clay

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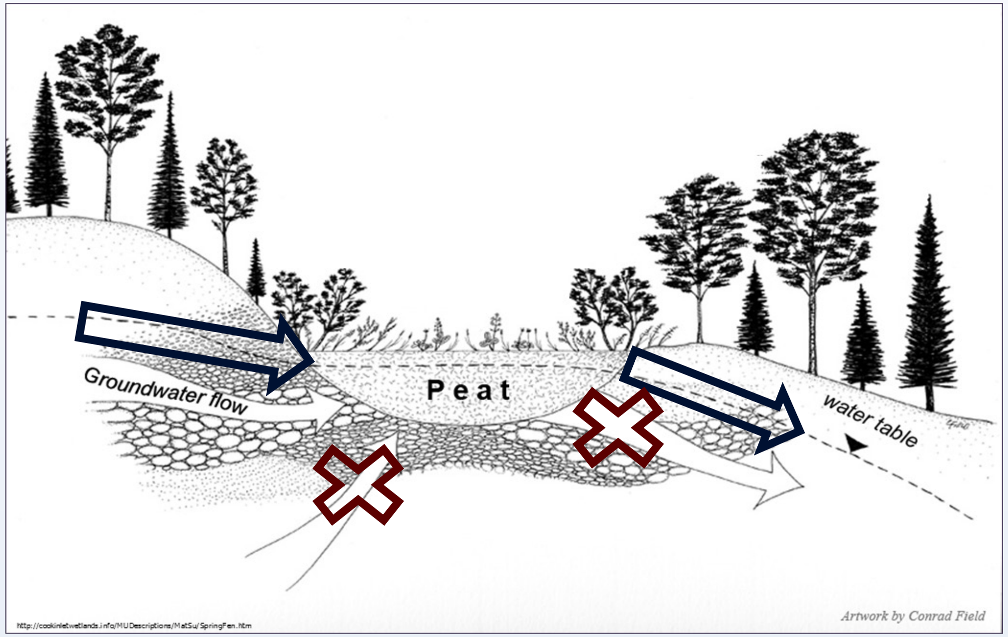
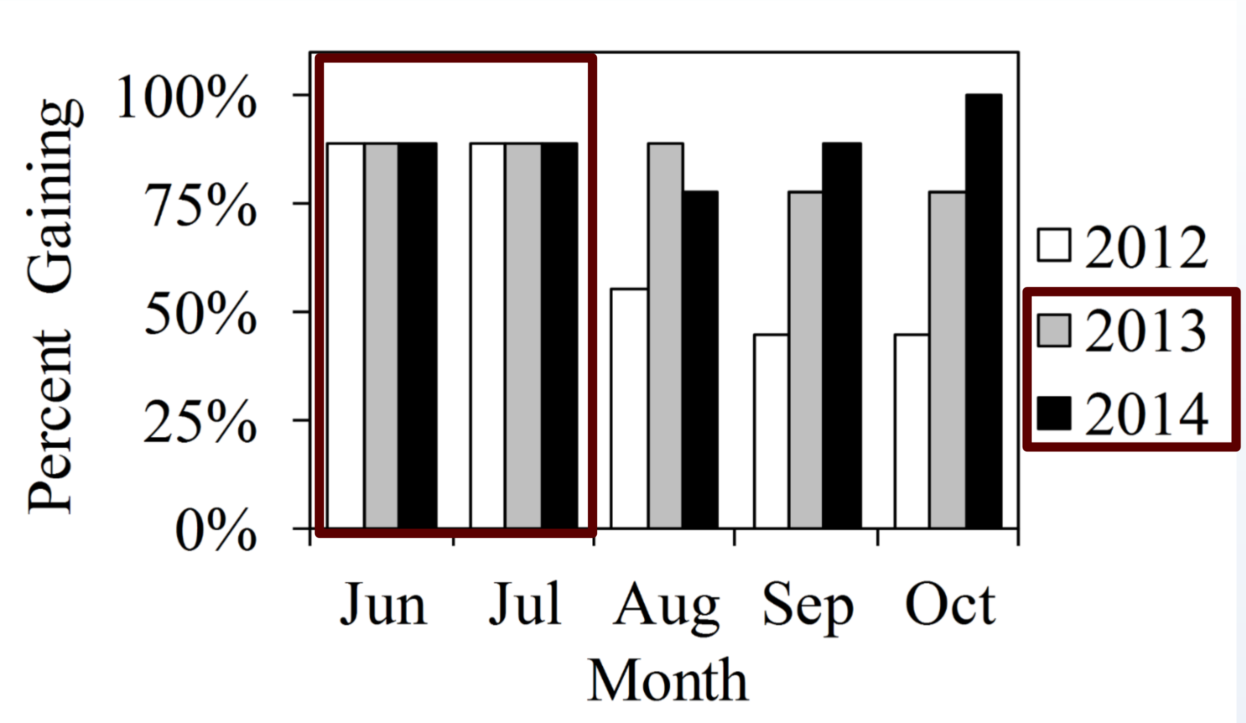


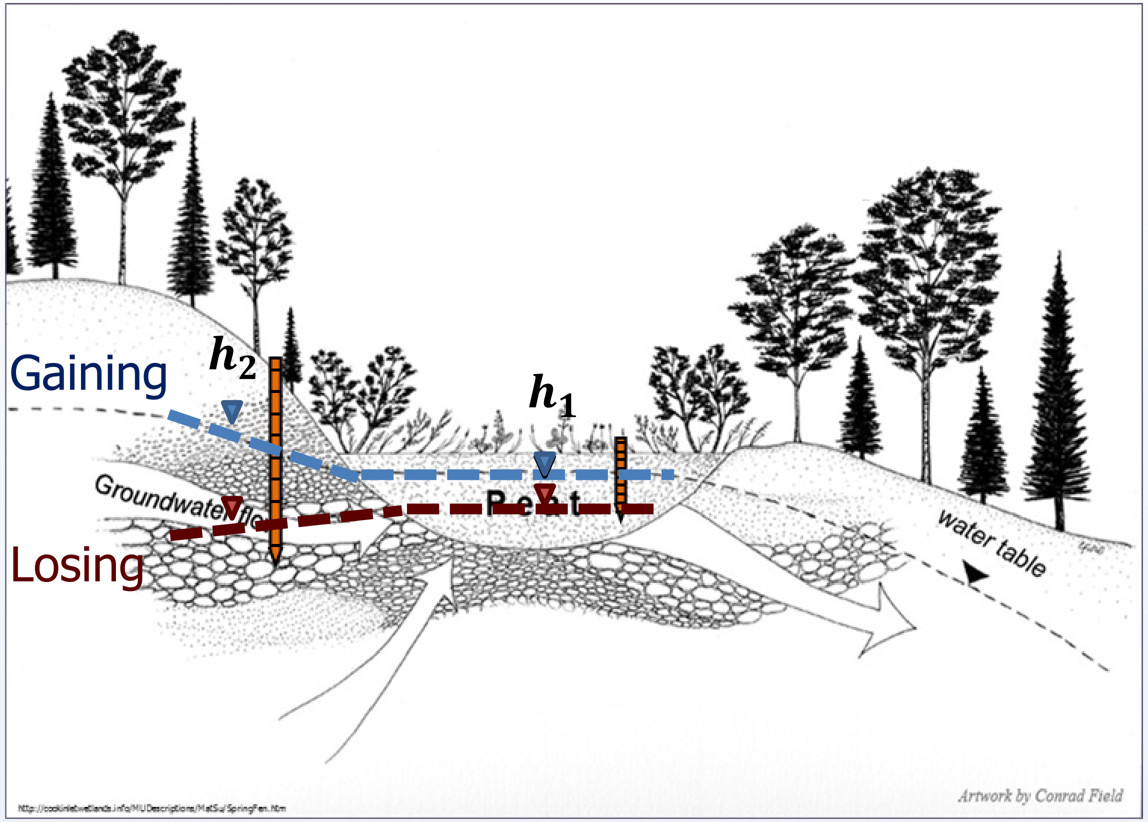
Chimner et al. 2012

Results: Hydraulic Gradient

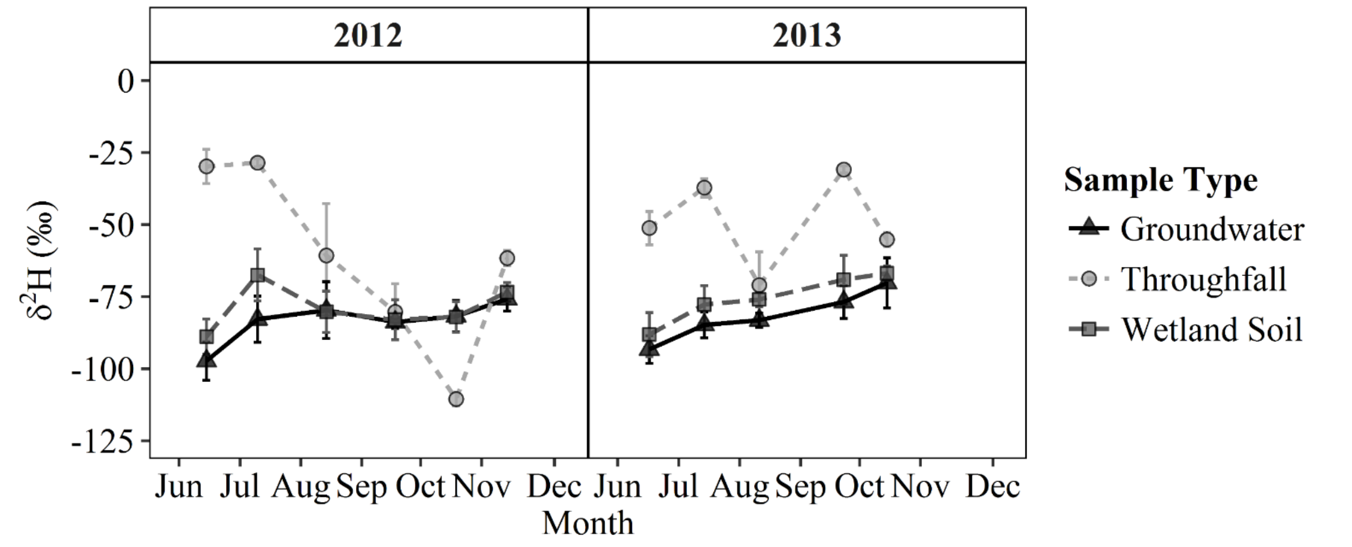
Persistent gaining conditions detected

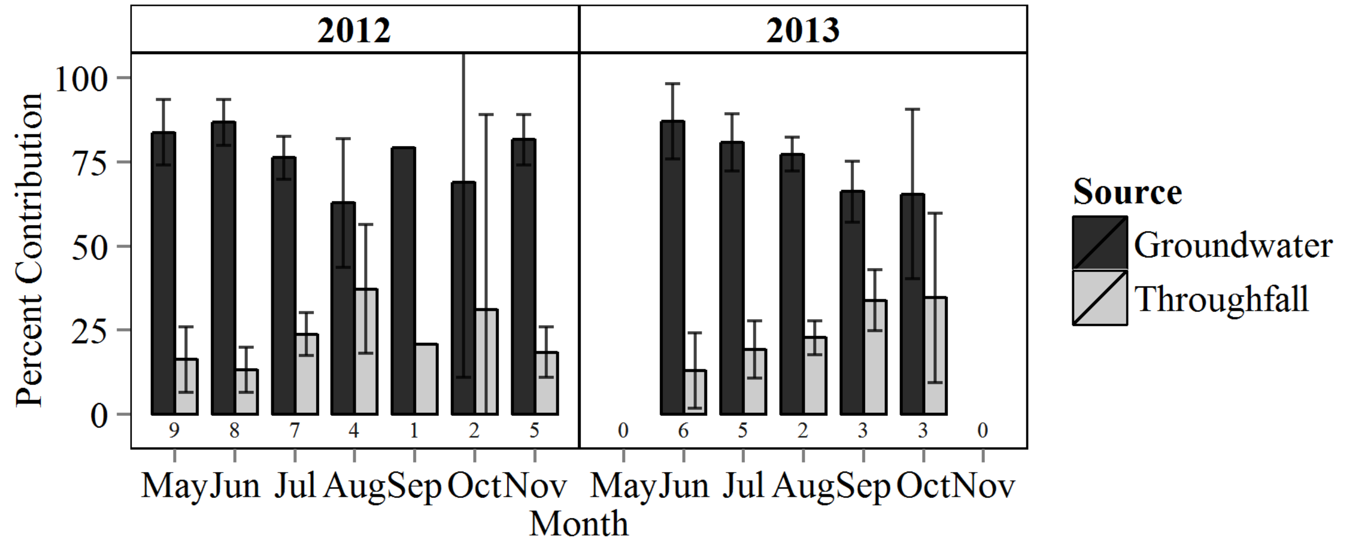


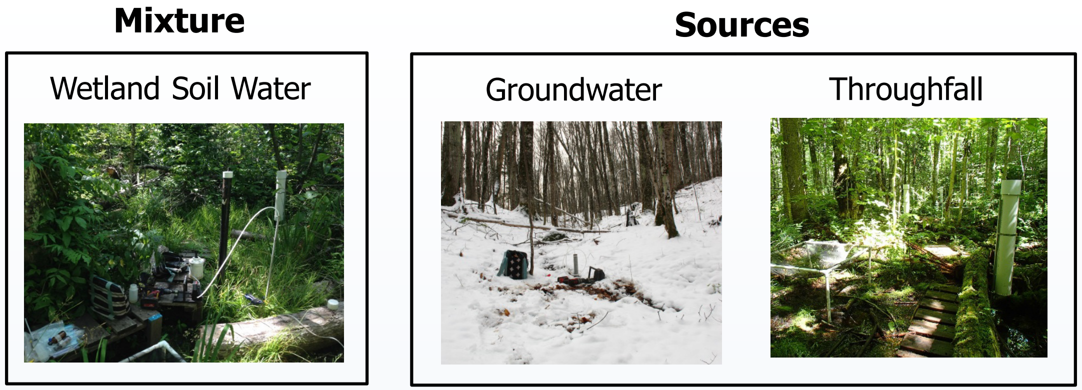
Van Grinsven et al. 2017



Results: Water Isotope Signatures







Wetland soil water δ^2H signatures were similar to groundwater

Black ash wetlands predominantly supplied by groundwater

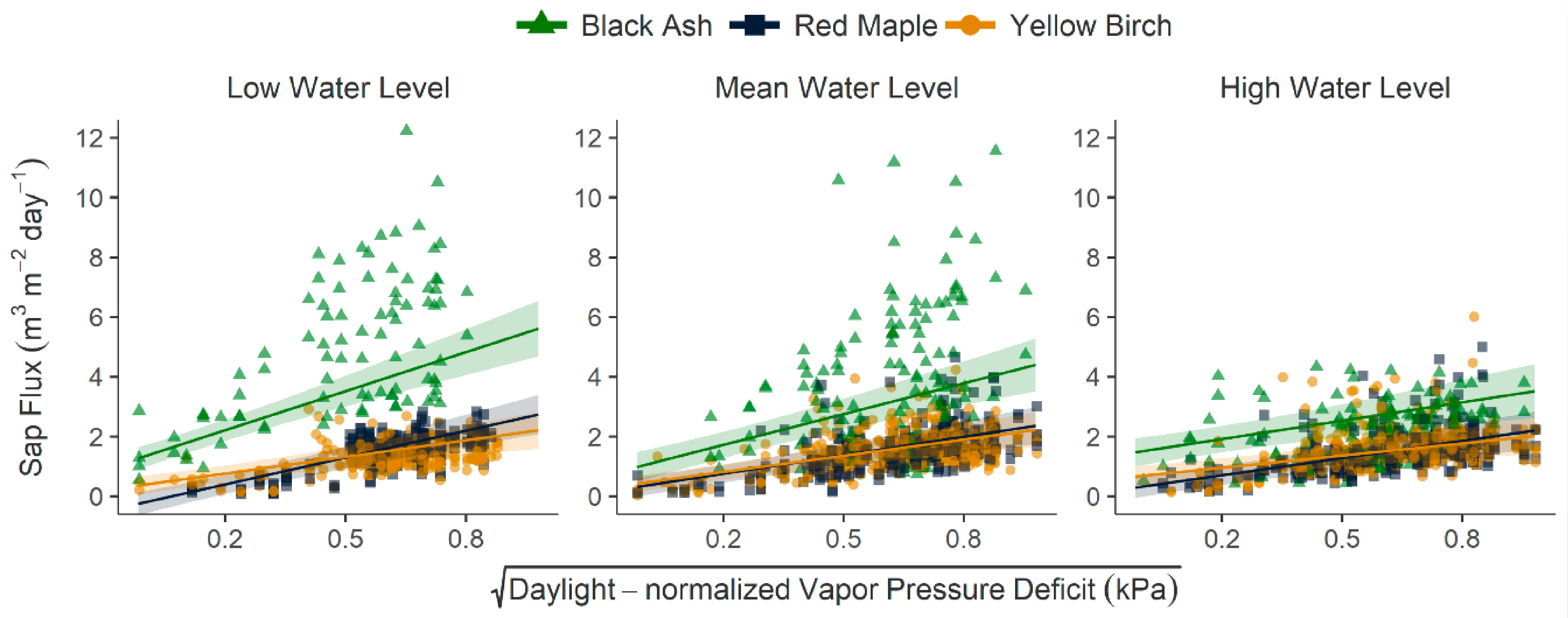
- 75% Mean Contribution

Van Grinsven et al. 2017

Results: Sap Flux Estimation

Black ash sap flux was 80–160% higher than non-black ash at all water levels

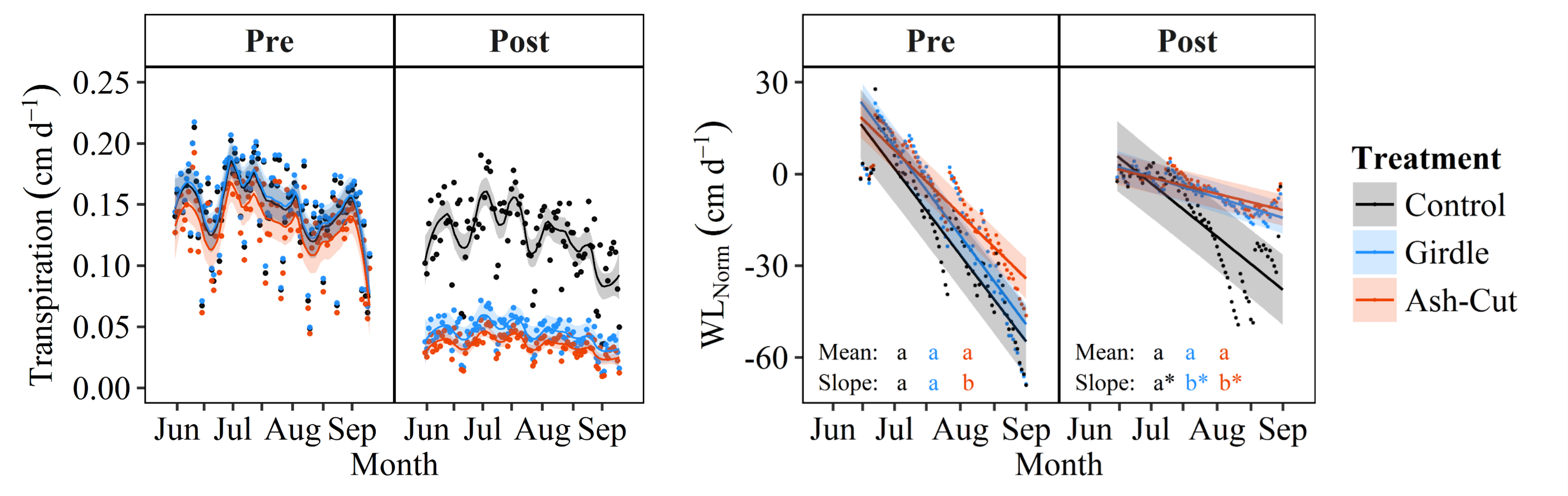
- Black ash sap flux was 45% higher at lowest water levels



Shannon et al. 2018

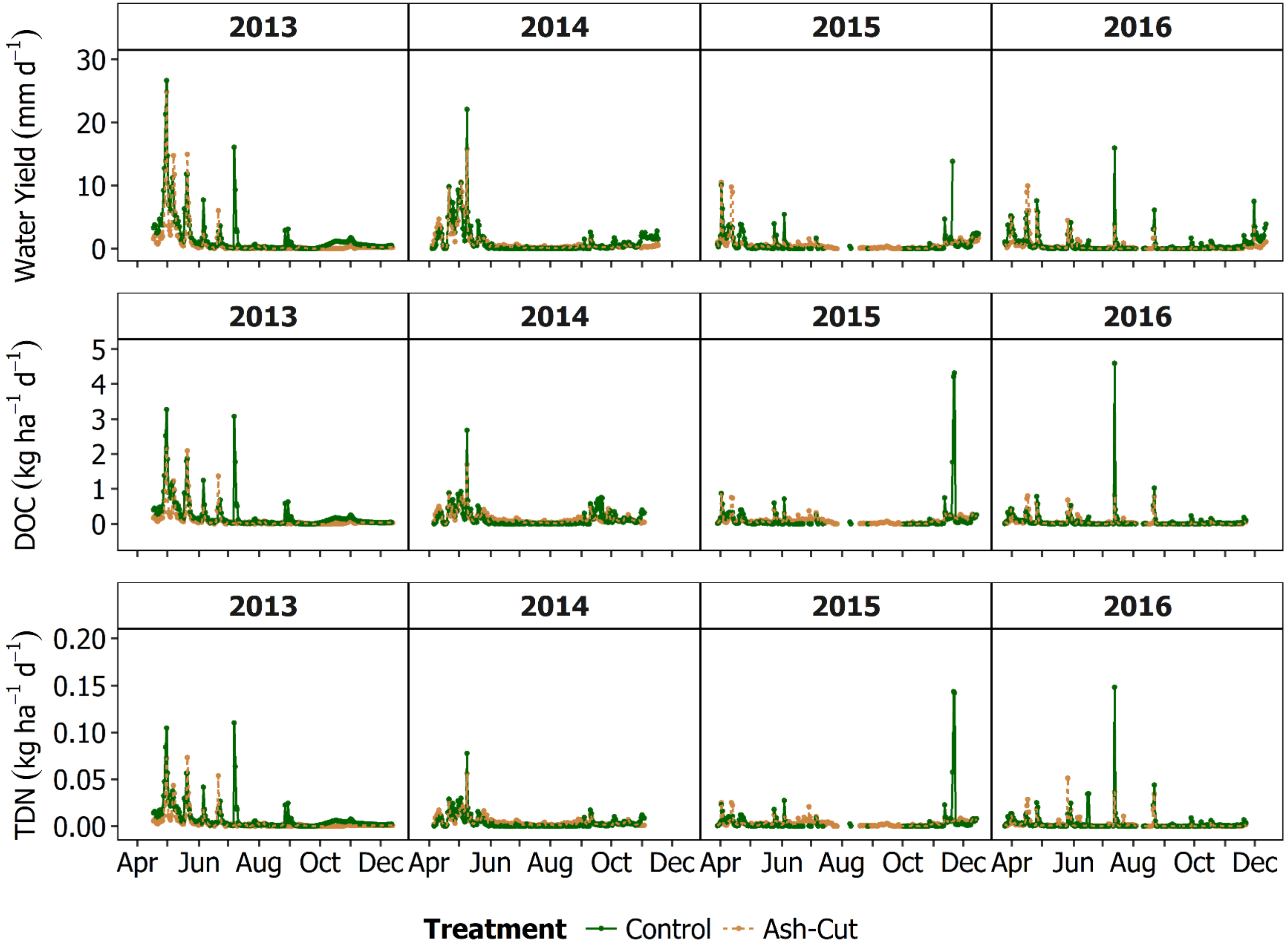
Results: Site Transpiration and Water Tables

- 70% reduction in site transpiration attributed to removal of black ash
- Significantly lower water table drawdown rates & higher water levels detected in treated sites during post-treatment growing season



Van Grinsven et al. 2017

Results: Water, DOC & TDN Loads



Daily exports normalized using watershed area for comparison

Streamflow: mm d^{-1}

DOC: kg ha^{-1} d^{-1}

TDN: kg ha^{-1} d^{-1}

Control

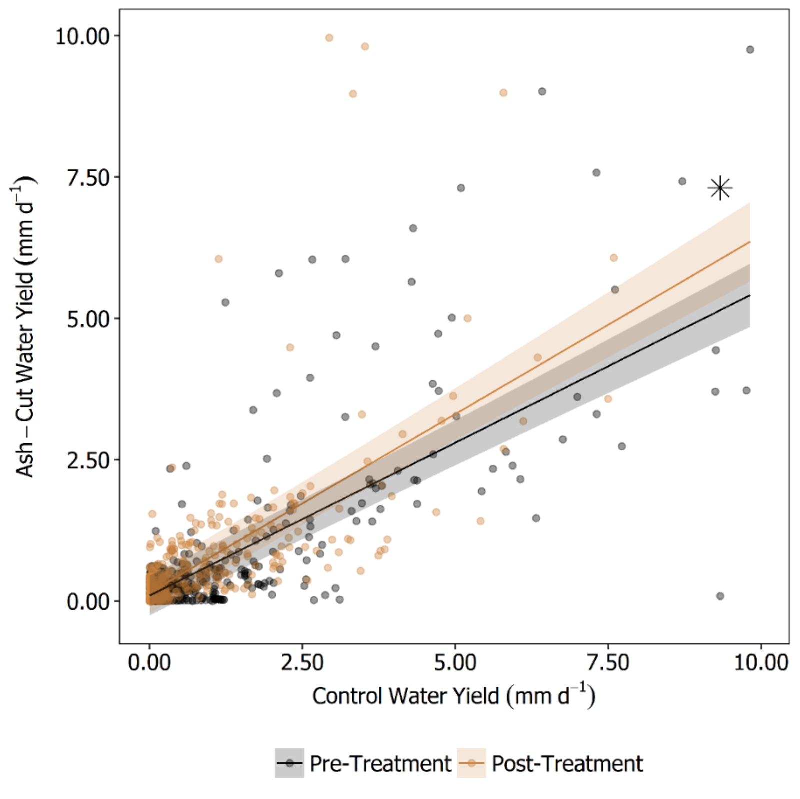
Ash-Cut

Results: Water, DOC & TDN Load Responses

Water Yield

Post-treatment Ash-Cut mean: 0.12 mm d^{-1}

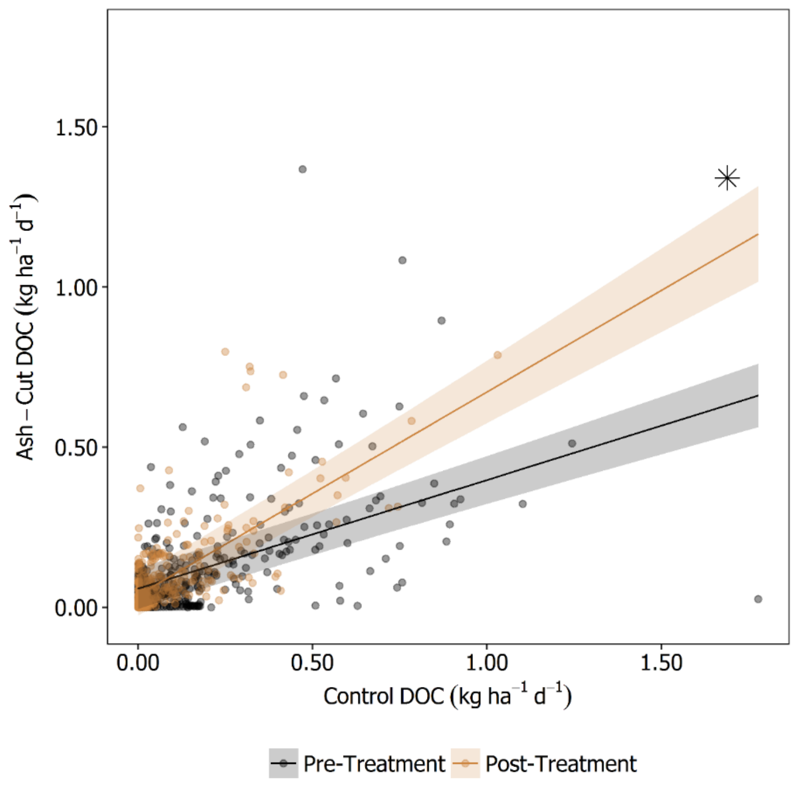
- 44% greater than Control



DOC Load

Post-treatment Ash-Cut mean: 0.02 kg ha^{-1} d^{-1}

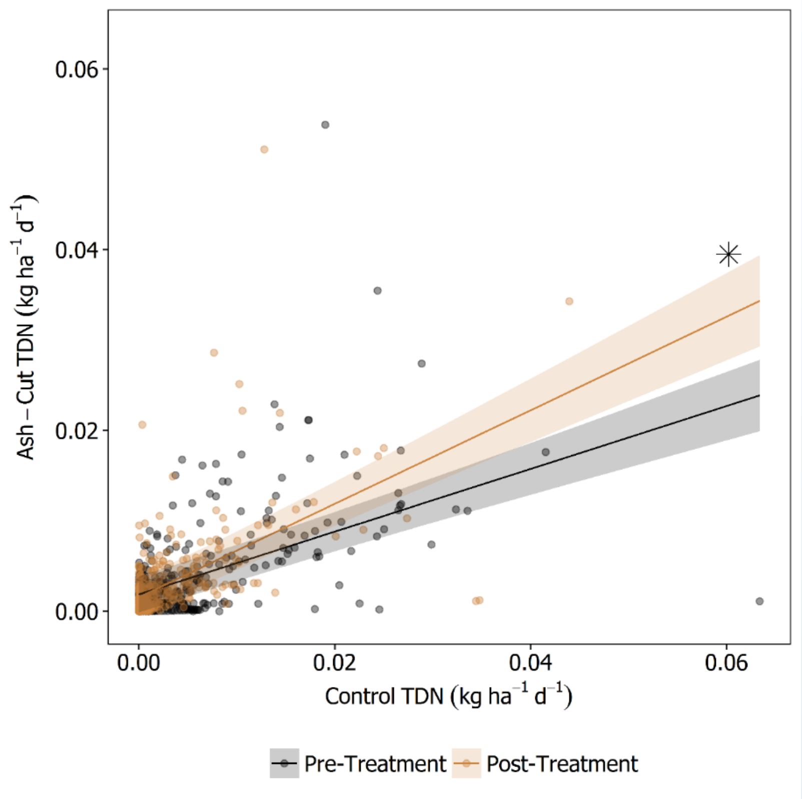
- 114% greater than Control



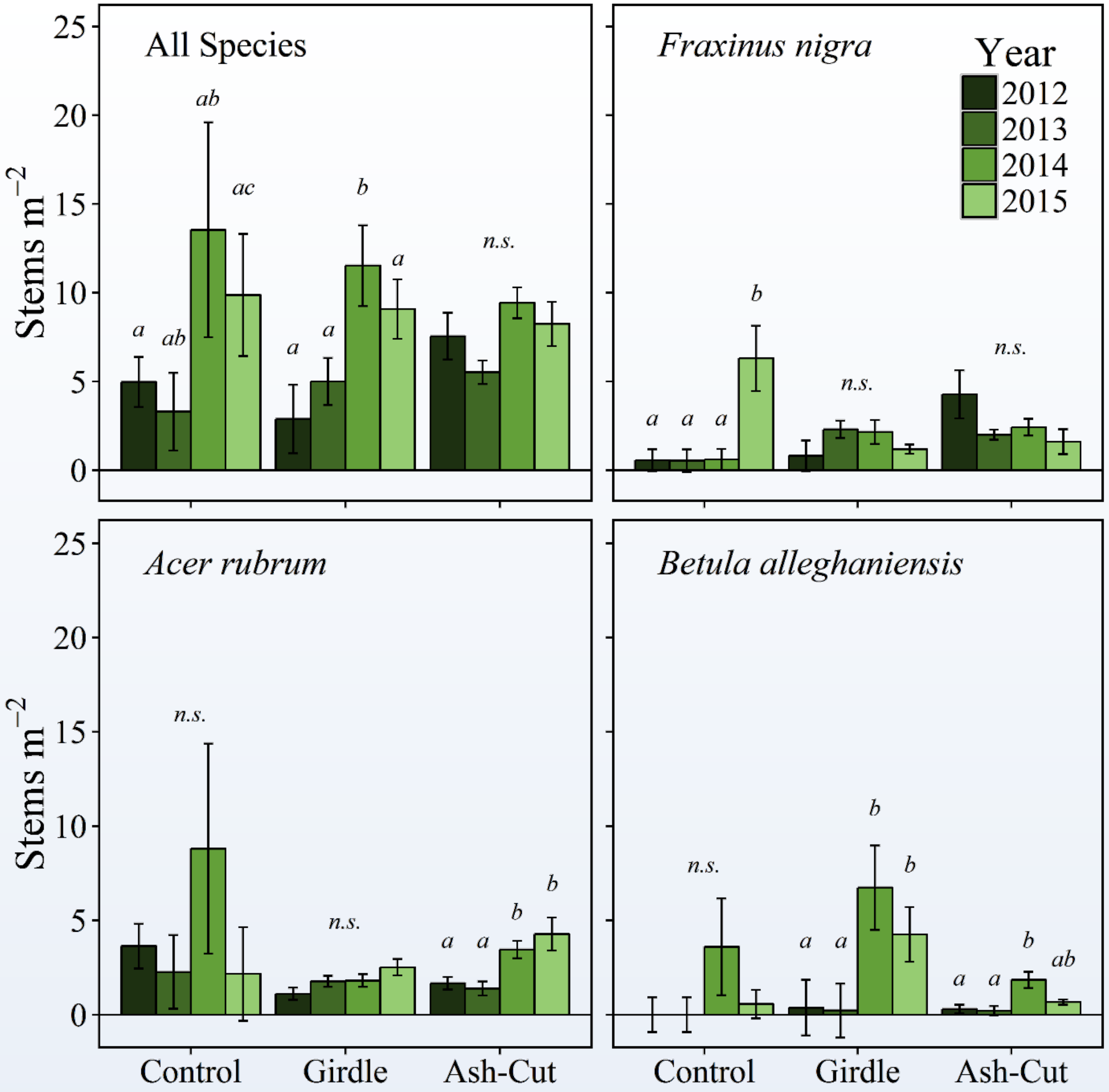
TDN Load

Post-treatment Ash-Cut mean: 6.4 x 10^{-4} kg ha^{-1} d^{-1}

- 105% greater than Control



Results: Residual Species Regeneration



Davis et al. 2016

Increased red maple & reduced black ash seedlings in treated sites

- Water levels not preventing natural regen.

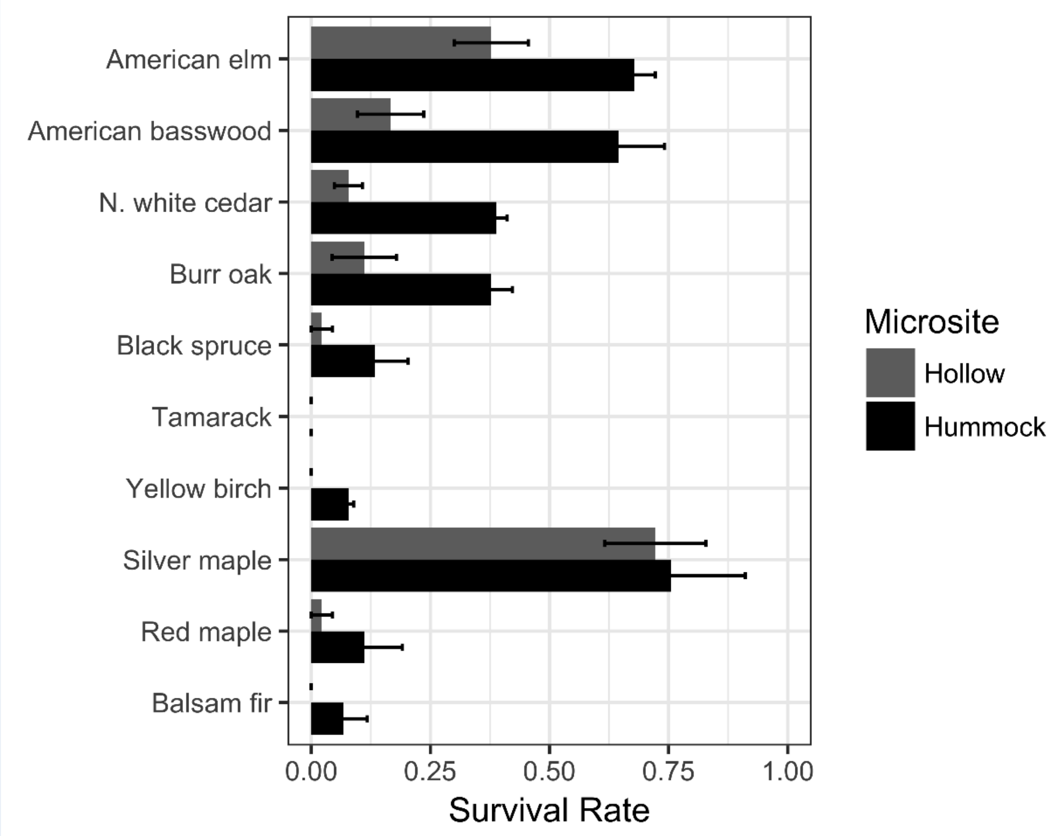
No overall change in canopy growth rate or canopy and sapling basal areas

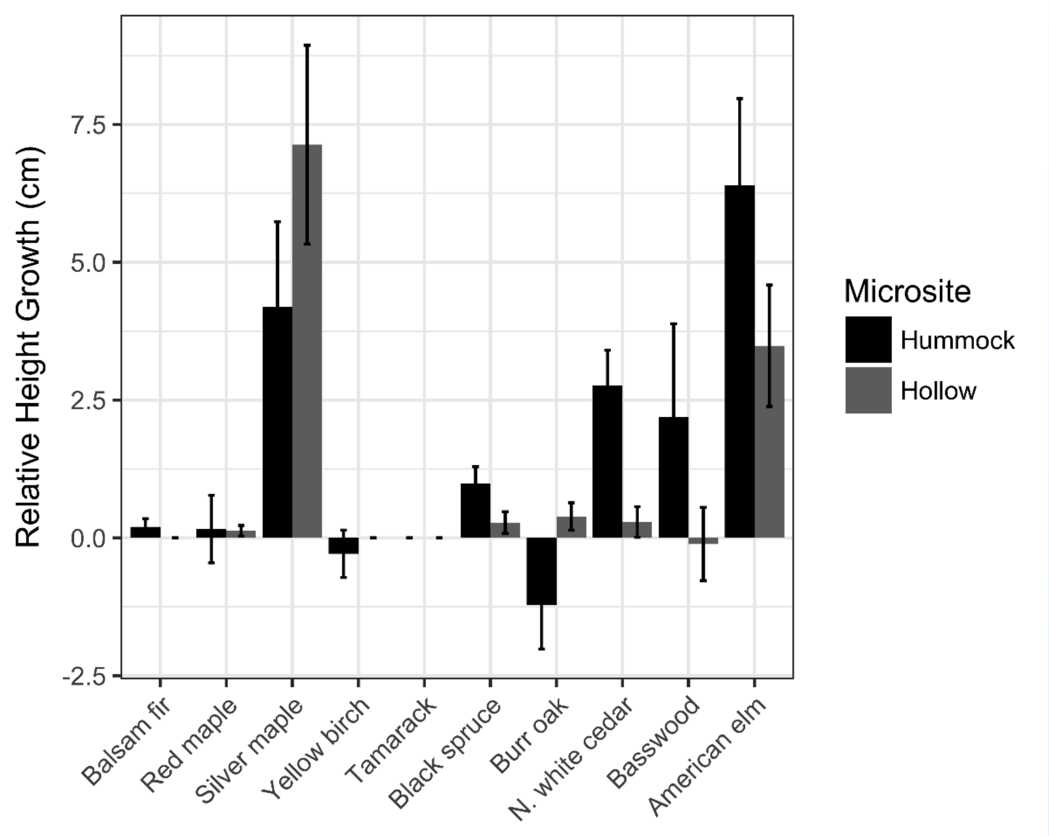
- Non-ash overstory mortality was significant in some sites

Results: Planted Alternative Species

American elm, basswood, silver maple, and northern white cedar are suitable options for species transition and retaining forested wetlands

- Plantings should be focused on natural hummocks within the wetlands





Bolton et al. 2018

Conclusions: Response to simulated EAB Infestation

Persistently gaining groundwater conditions

- 75% groundwater contributions

Significantly smaller rates of drawdown in treated sites

- Due to significant decrease in transpiration

Mean water table positions were significantly higher in treated sites during the end of the growing season

Significantly higher post-treatment mean: water yield (+ 44%), DOC load (+ 114%) and TDN load (+ 105%)

Management Implications

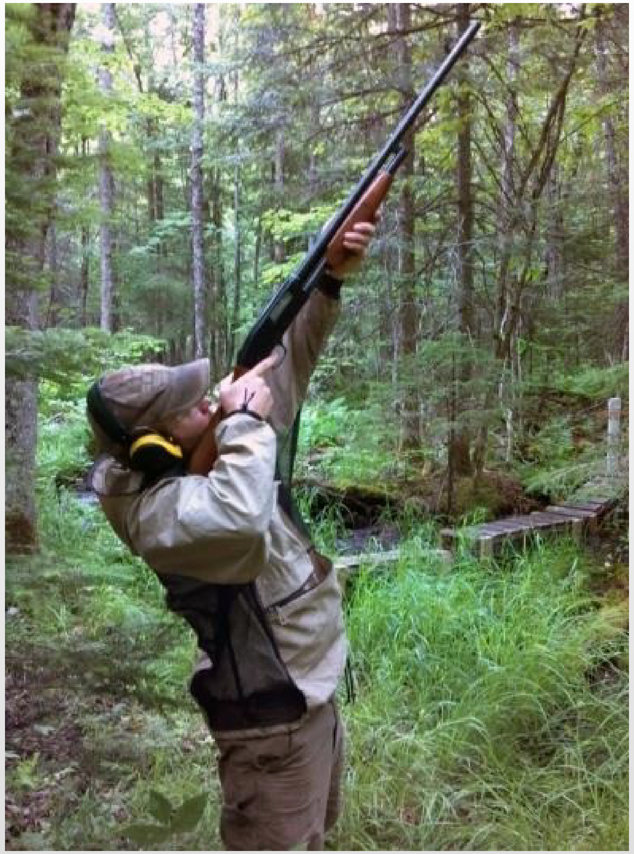
Post-treatment water levels are not inhibiting recruitment and regeneration of red maple

- No change in canopy growth rate or canopy and sapling basal areas
  - Based upon 3 years of post-treatment monitoring

American elm, basswood, silver maple, and northern white cedar are suitable mitigation and management options

- Plantings should be focused on natural hummocks within the wetlands

Thank You



Davis et al. 2016