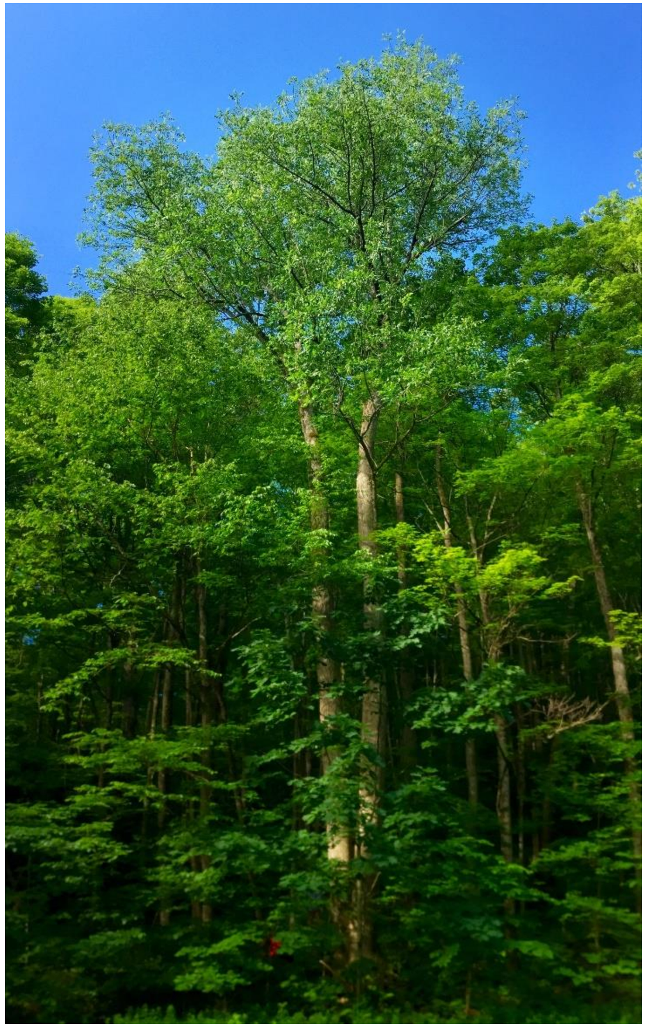
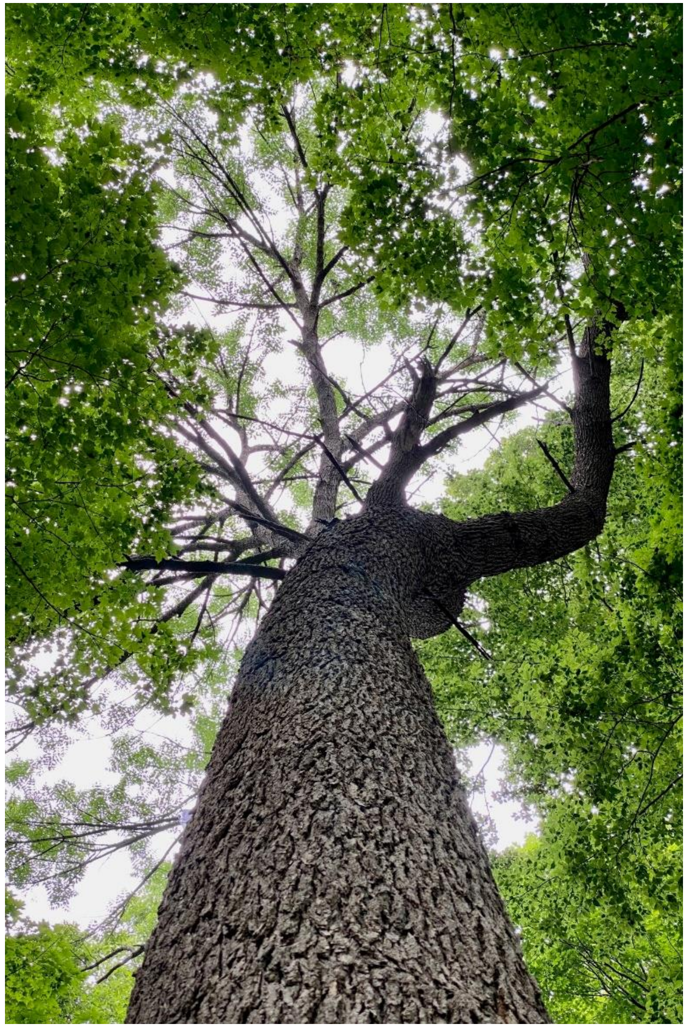
Impacts and Management of Emerald Ash Borer

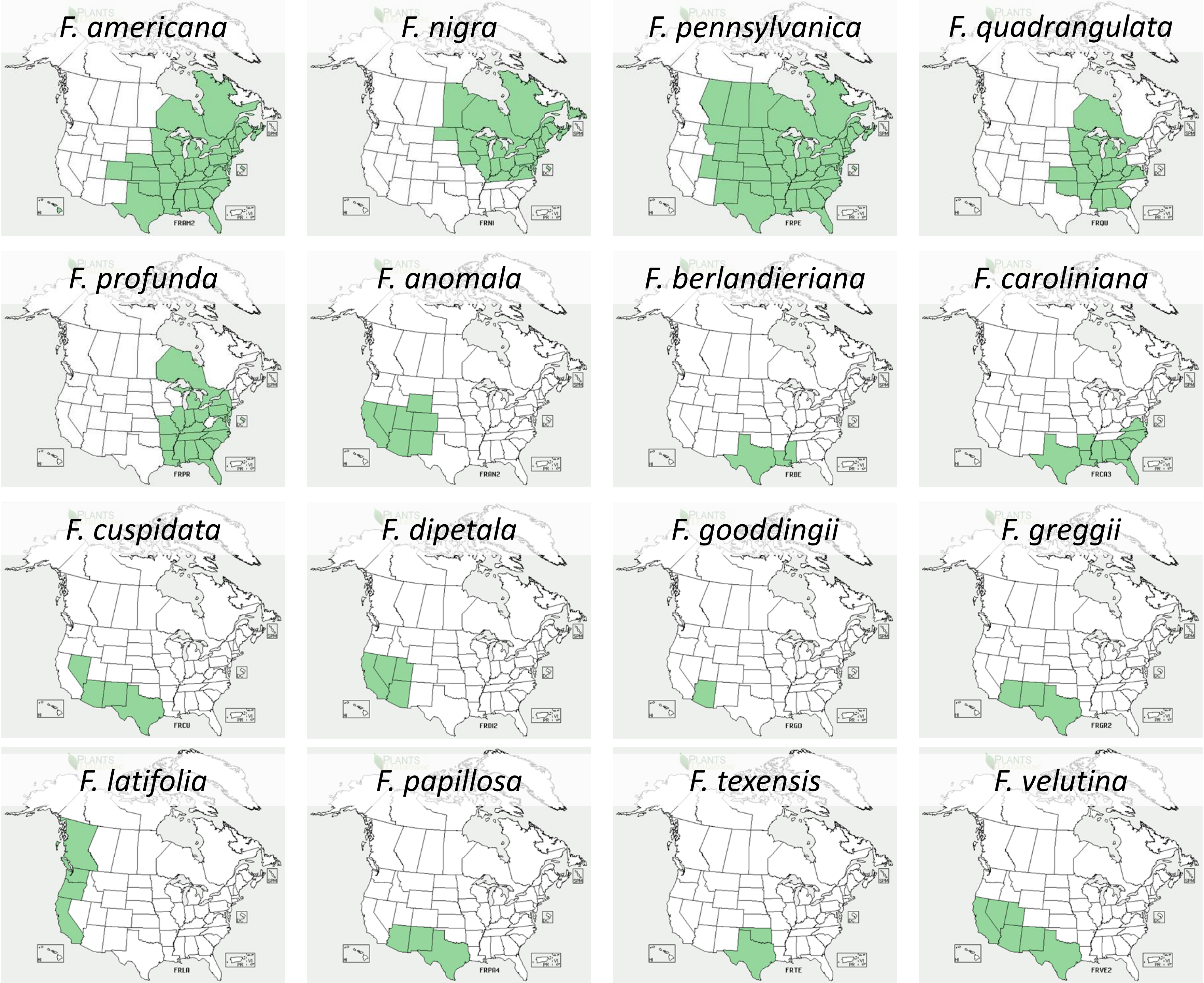
Kathleen Knight, Charlie Flower, Jennifer Koch, Mary Mason, David Carey, Julia Wolf, Aletta Doran, Jason Kilgore, Alex Royo, Brian Hoven, Rachel Kappler, Tim Fox, Josh Wigal, Julia Zick, Justin LaMountain




Ash: Ecologically, Economically, and Culturally Important



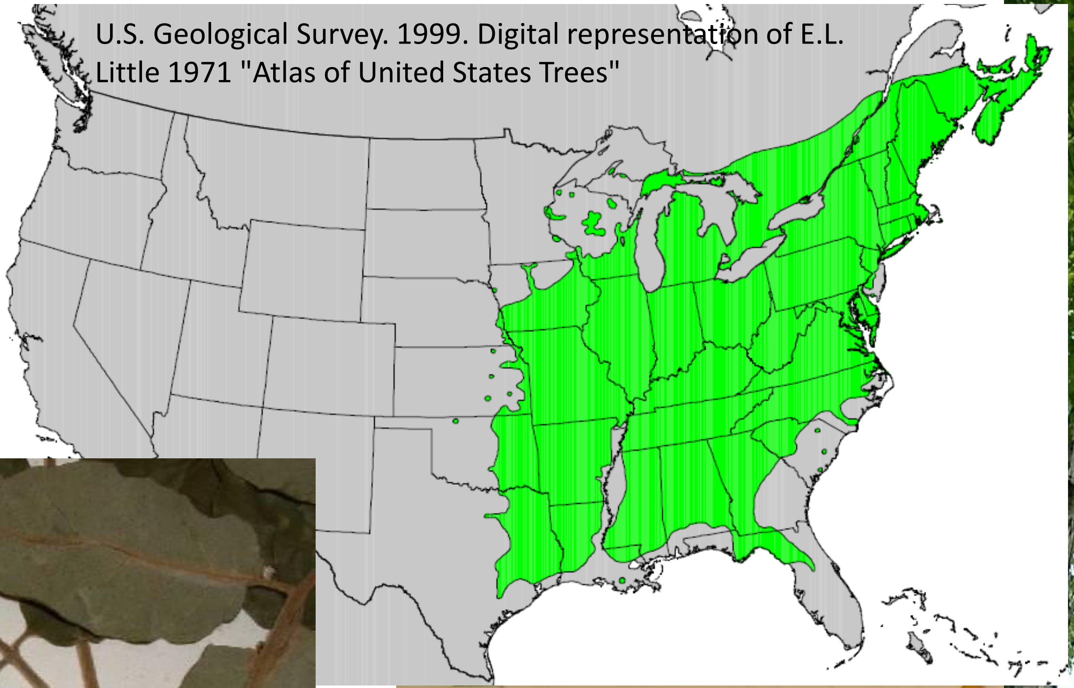




PLANTS Database

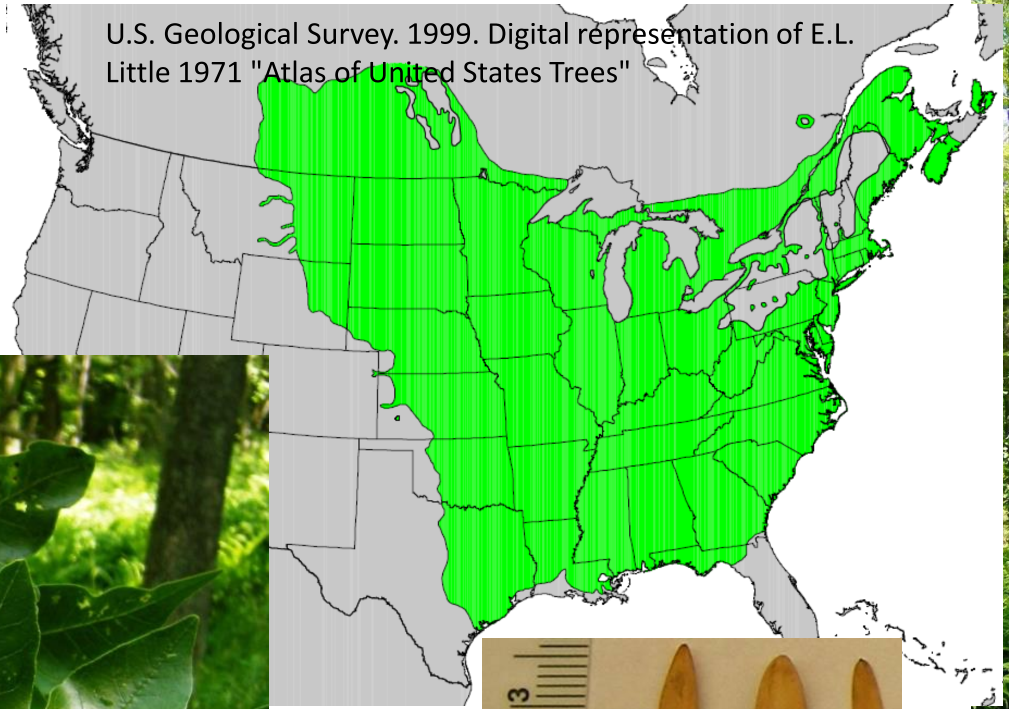
Ash species of the midwest

- White ash (*Fraxinus americana*)

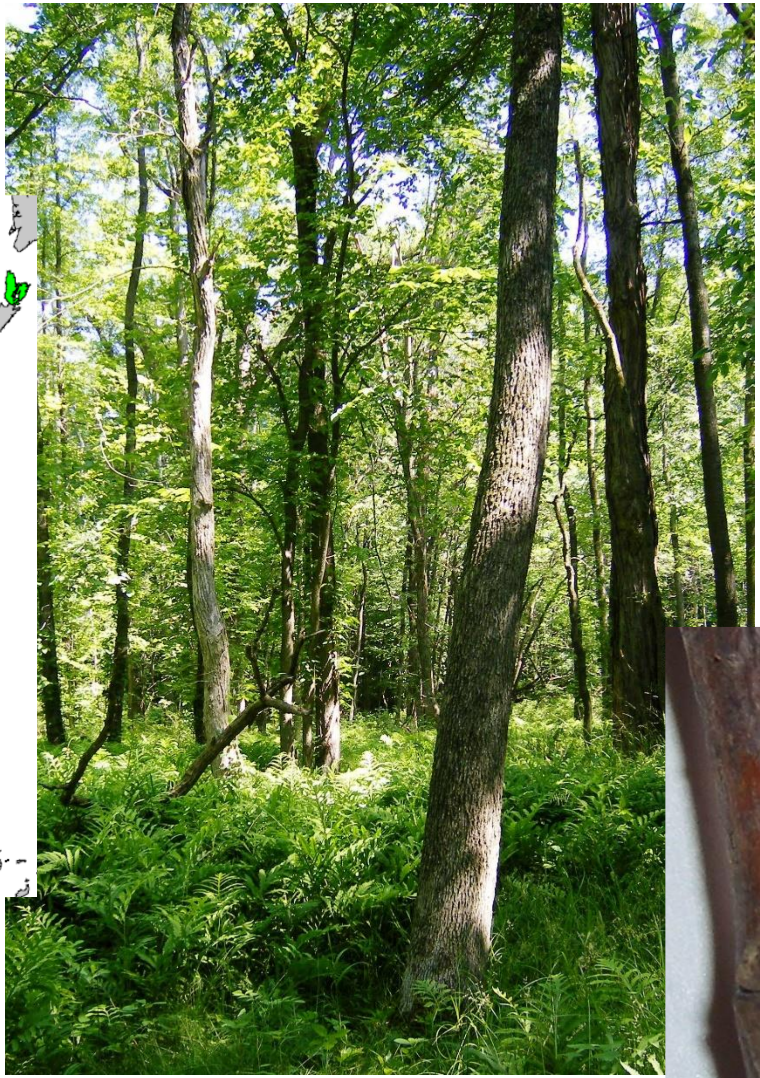


Ash species of the midwest

- Green ash (*Fraxinus pennsylvanica*)

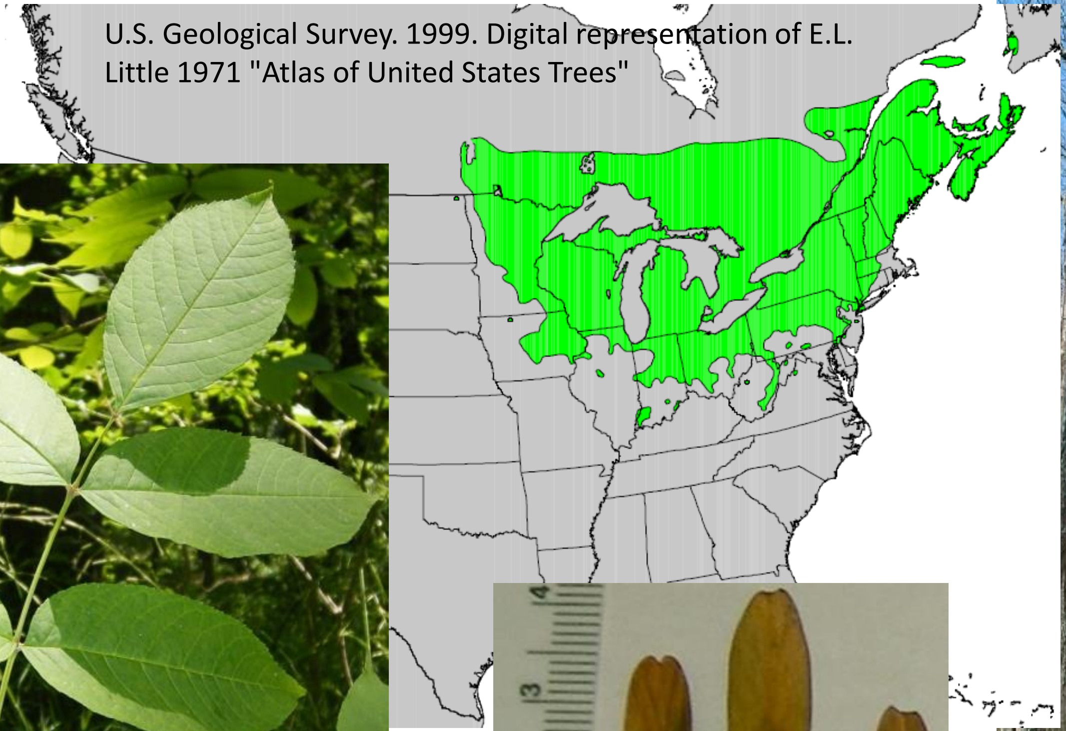


Knight



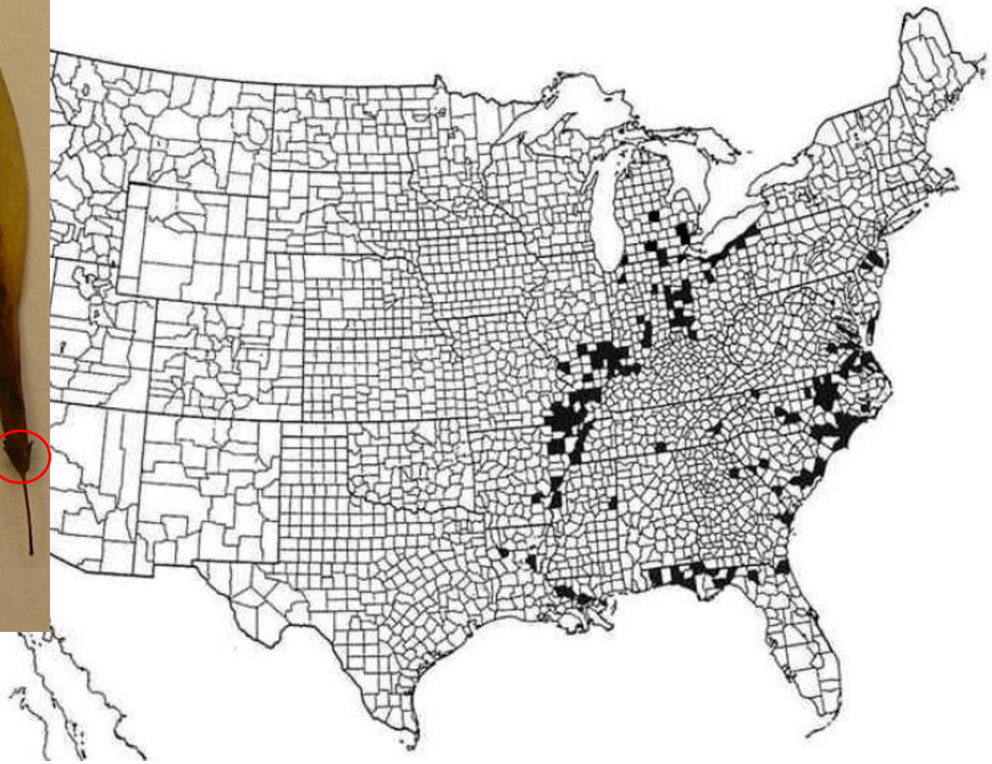
Ash species of the midwest

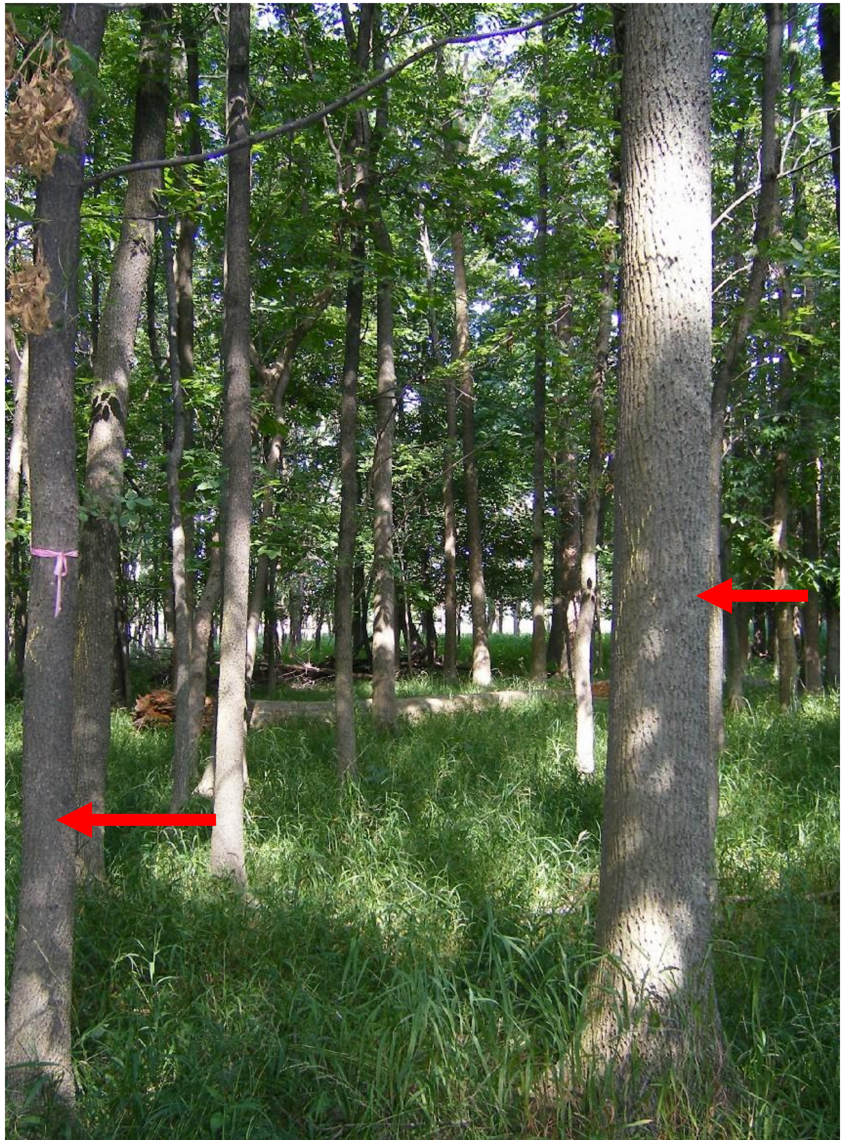
- Black ash (*Fraxinus nigra*)



Ash species of the midwest

- Pumpkin ash (*Fraxinus profunda or Fraxinus tomentosa*)

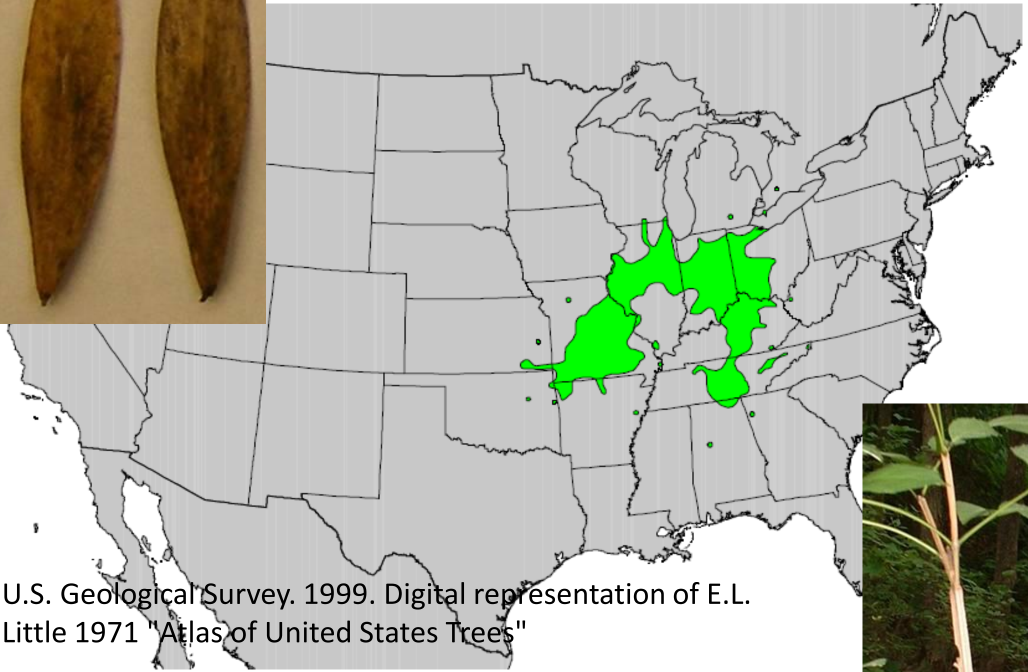




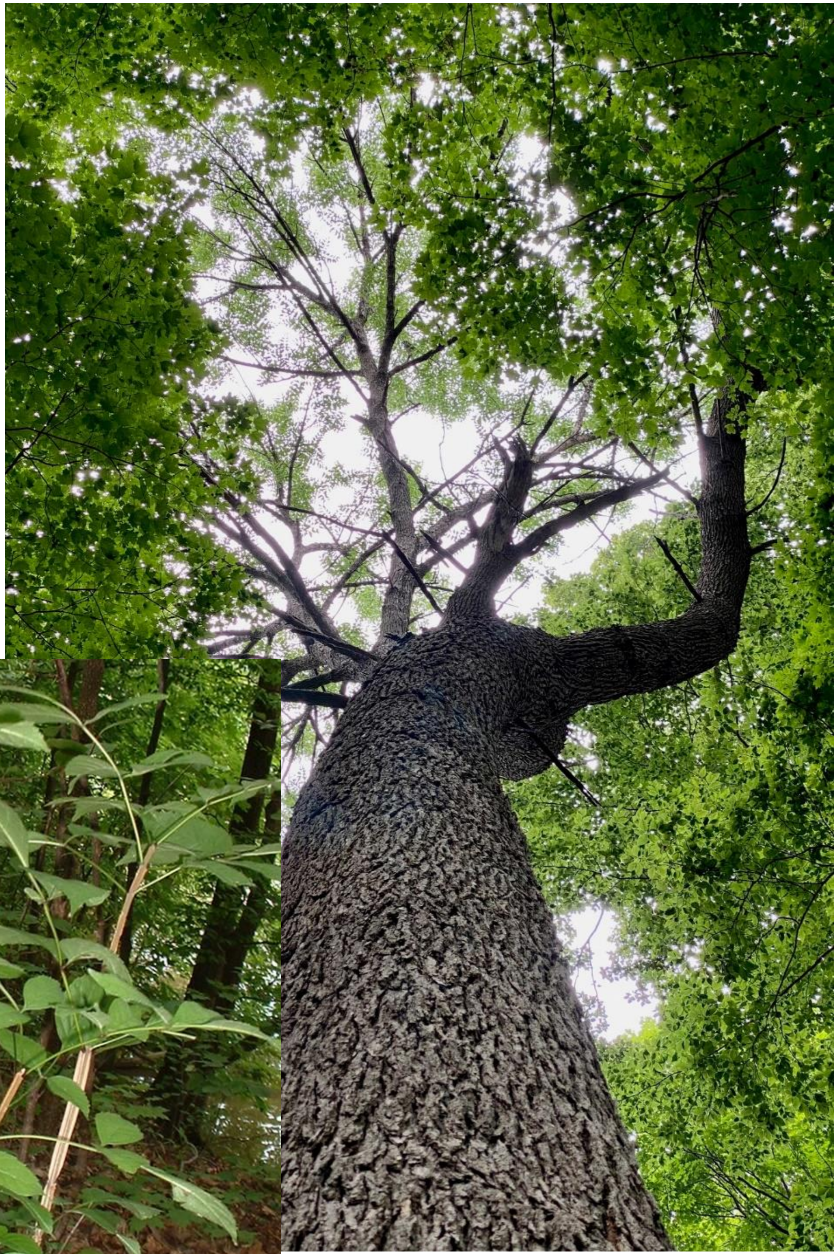
McCormack JS, Bissell JK, & Stine SJ Jr. 1995. The status of *Fraxinus tomentosa* (Oleaceae) with notes on its occurrence in Michigan and Pennsylvania. Castanea 60: 70-78.
With additions from:
Penskar MR. 2004. Special Plant Abstract for *Fraxinus profunda* (pumpkin ash). Michigan Natural Features Inventory. Lansing, MI. 3 pp.
Knight KS. 2007. Unpublished data

Ash species of the midwest

- Blue ash (*Fraxinus quadrangulata*)



U.S. Geological Survey. 1999. Digital representation of E.L. Little 1971 "Atlas of United States Trees"



Ash: Ecologically and Culturally Important Species

- A key niche in northern floodplains: cold tolerance, flood tolerance, & shade tolerance
- Regulate hydrology of wet forest systems
- Sustain biodiversity
- Culturally important to native American tribes
- Economically important

Emerald ash borer (EAB)

EAB Adult Beetle

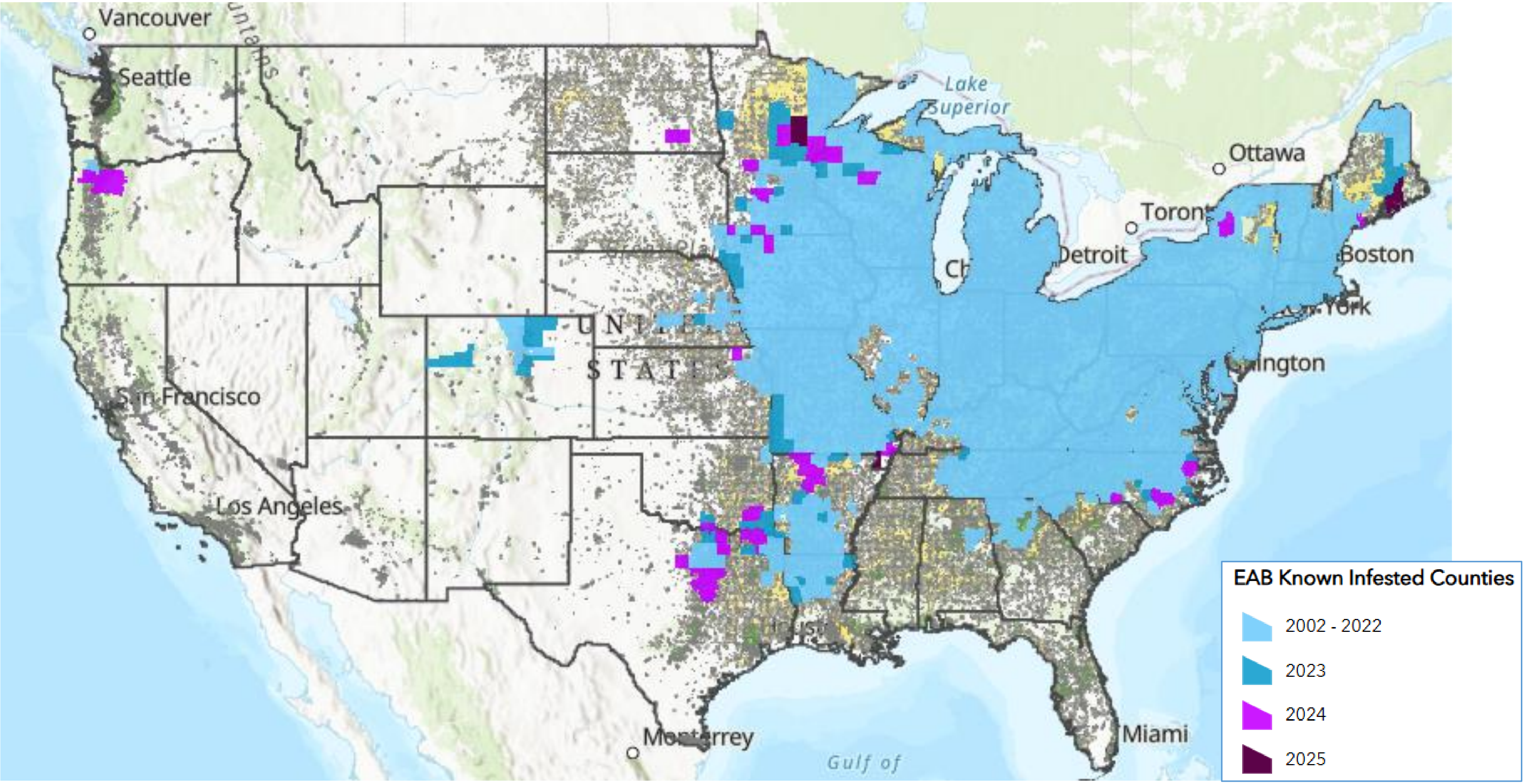
Photo by David Cappaert

EAB Larva

Photo by Pennsylvania DCNR

EAB larval galleries

U.S. EAB Detections



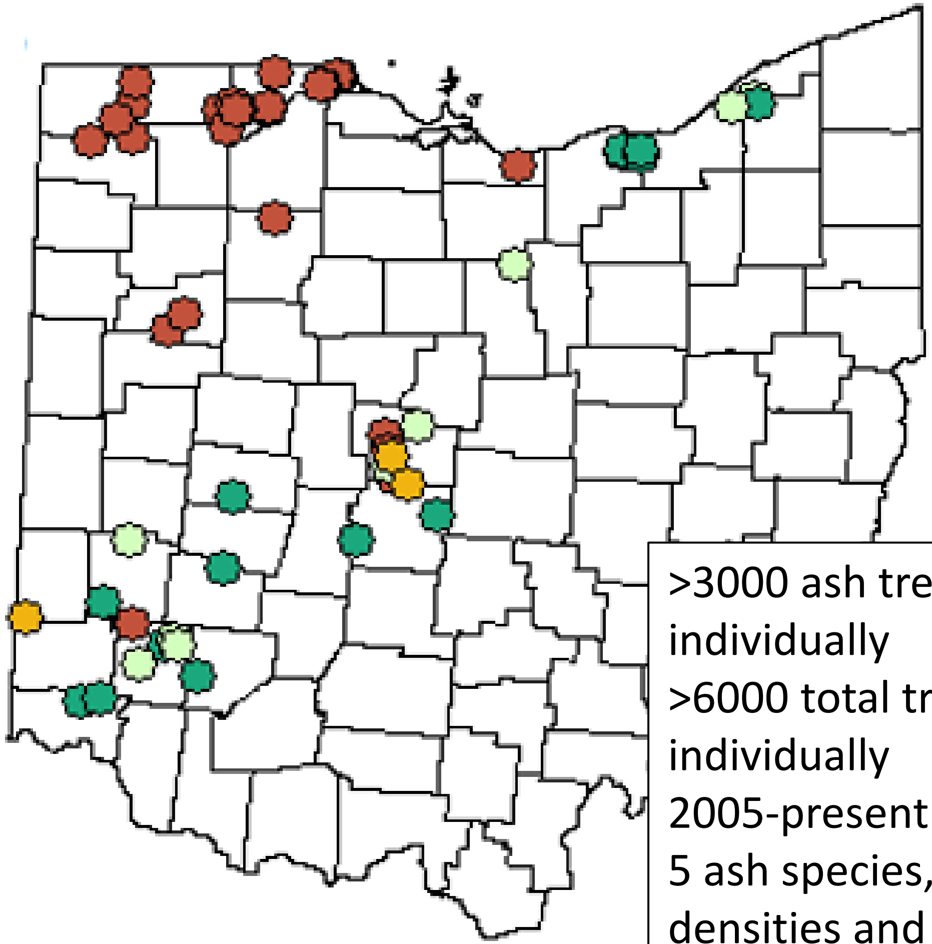
https://www.aphis.usda.gov/plant-pests-diseases/eab/eab-infestation-map

Management of Forests Impacted by EAB

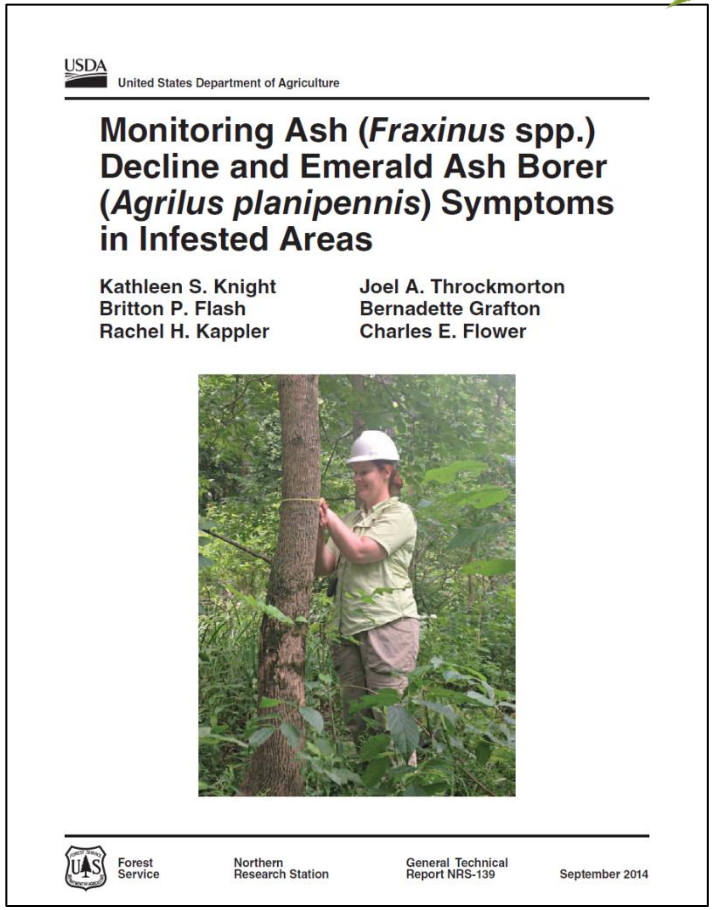
- Understand **impacts** – differ by species and ecosystem
- Understand **long-term dynamics**
- Combine different strategies to achieve specific goals
  - Breeding and restoring ash with resistance to EAB
  - Conserving ash genetics through insecticide treatment or seed collection
  - Releasing biocontrol insects
  - Genetic conservation of ash
  - Restoration to maintain ecosystem function

Ohio EAB Forest Ecosystem Effects Research

Kathleen Knight, Charles Flower, Brian Hoven, Rachel Kappler, Robert Long, Timothy Fox, Josh Wigal, Julia Zick



>3000 ash trees tracked individually
>6000 total trees tracked individually
2005-present
5 ash species, range of ash densities and habitats



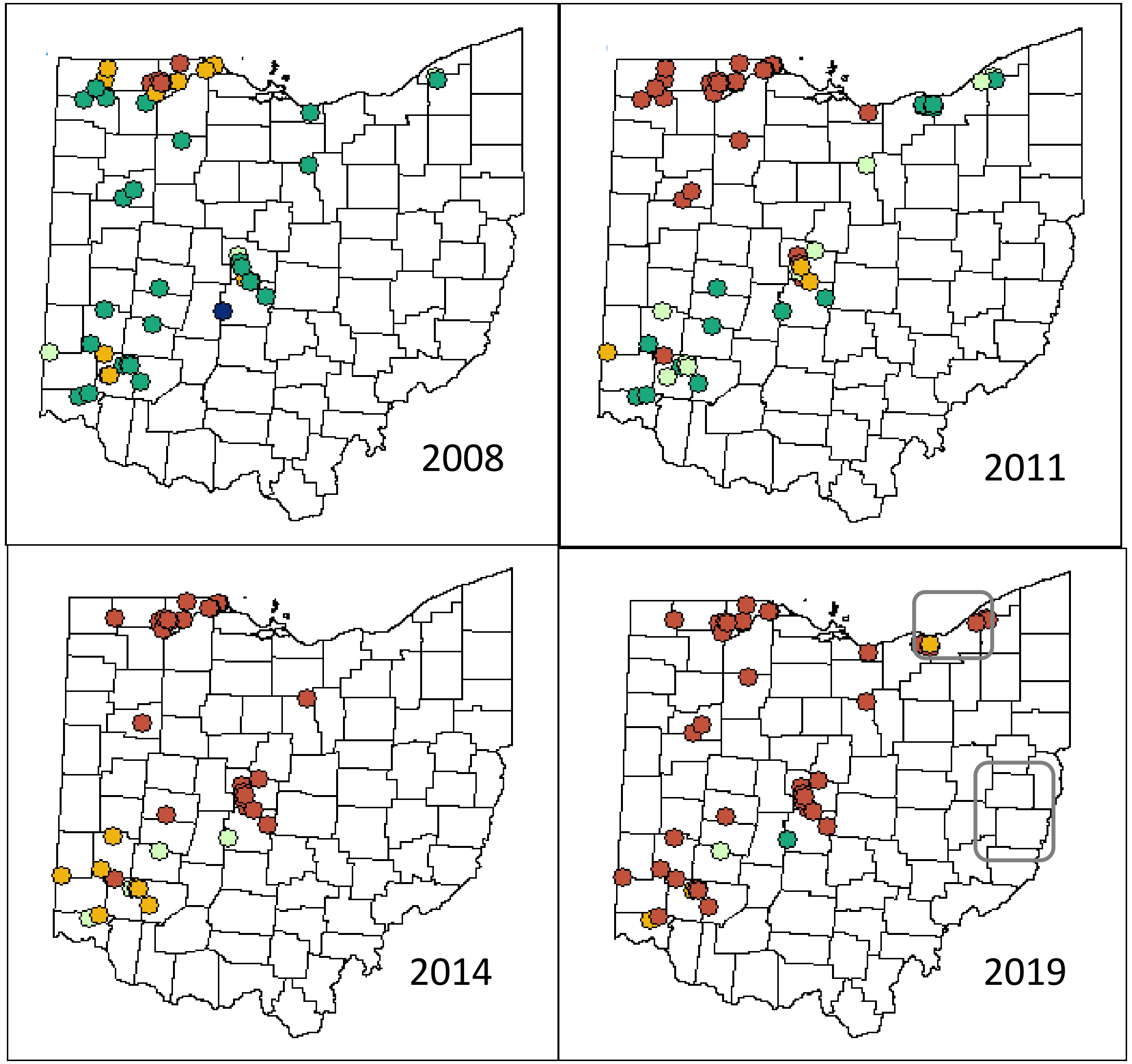
USDA United States Department of Agriculture

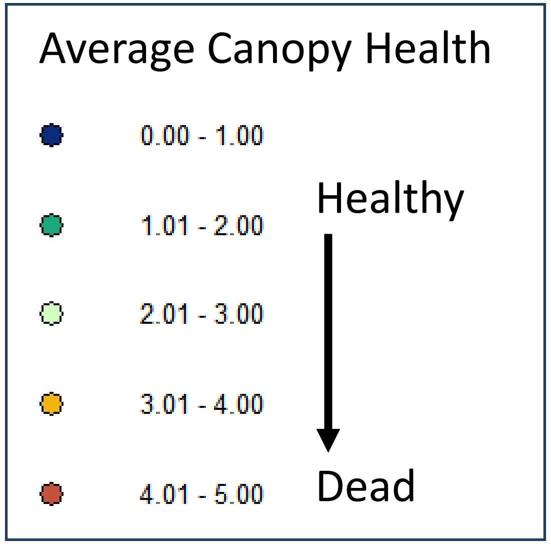
Monitoring Ash (*Fraxinus* spp.) Decline and Emerald Ash Borer (*Agrilus planipennis*) Symptoms in Infested Areas

Kathleen S. Knight
Britton P. Flash
Rachel H. Kappler
Joel A. Throckmorton
Bernadette Grafton
Charles E. Flower

Forest Service | Northern Research Station | General Technical Report NRS-139 | September 2014

Ash mortality in Ohio



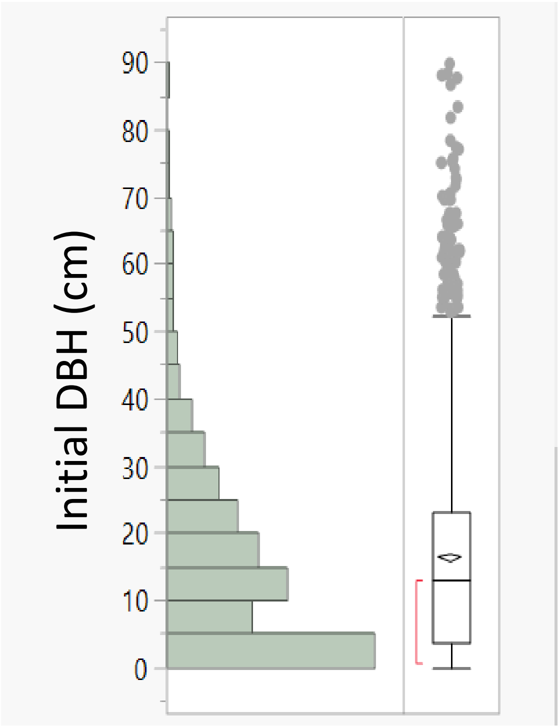


Knight et al. 2023. Ash tree decline and mortality in Ohio and the Allegheny National Forest. Forest Health Monitoring National Status and Trends 2022

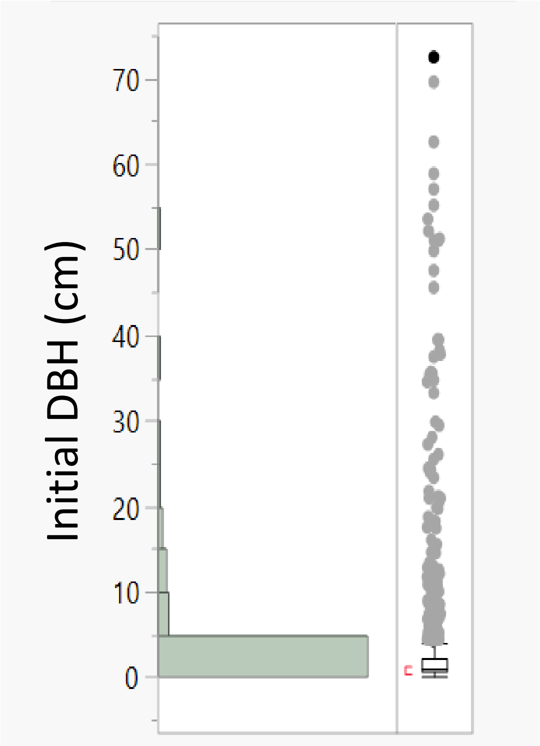
Diameter distribution of trees that survived EAB

- Extreme mortality of larger ash trees
- Species differences
- Very few large surviving black ash
- Almost all surviving ash >30cm is blue ash

2007



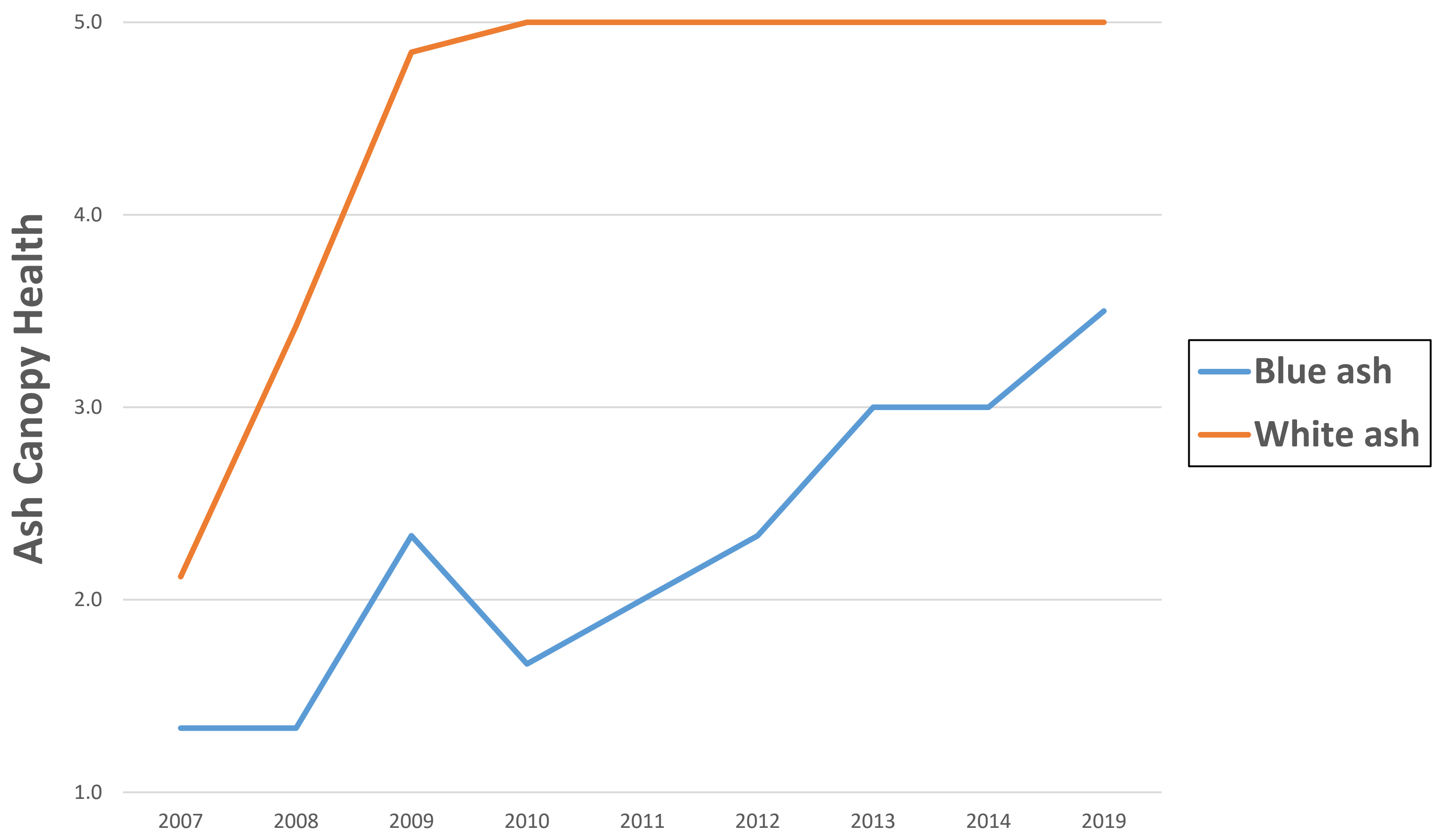
2019



Blue ash mortality

Species	Number of trees	Mean initial d.b.h.	Mean canopy health rating, 2019[a]	Dead, 2019
		cm		*percent*
White ash (*Fraxinus americana*)	529	24.1	5.0	98.6
Black ash (*F. nigra*)	80	20.5	4.7	91.8
Green ash (*F. pennsylvanica*)	391	25.9	4.9	95.8
Blue ash (*F. quadrangulata*)	60	28.1	2.9	28.3

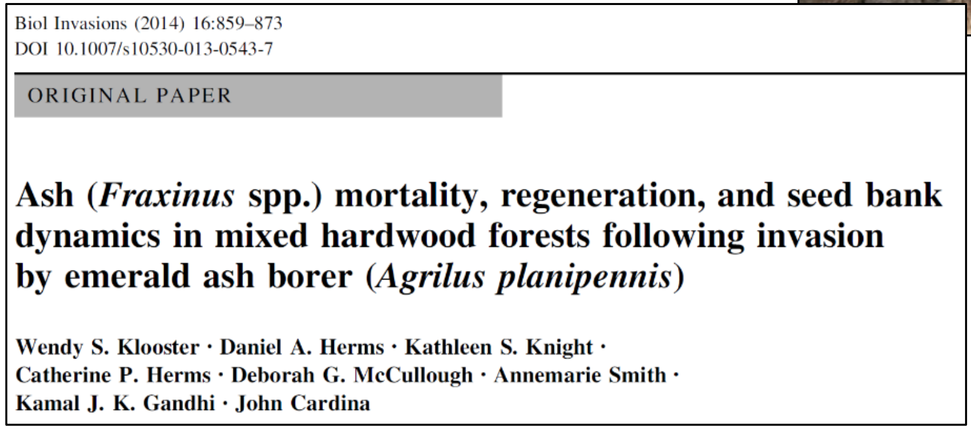
Blue ash mortality



Of six sites with blue ash, four have graphs that look like this, where the white ash dies first, then the blue ash slowly declines and dies.
At the other two sites, the blue ash have stayed healthy so far.
This shows the value of long-term data.

Ash regeneration

- Seedlings and saplings too small for EAB remain and grow
- Seed bank is short-lived
  - Mast years 2008, 2018
  - New seedlings appear for 2-3 years



Biol Invasions (2014) 16:859–873
DOI 10.1007/s10530-013-0543-7

ORIGINAL PAPER

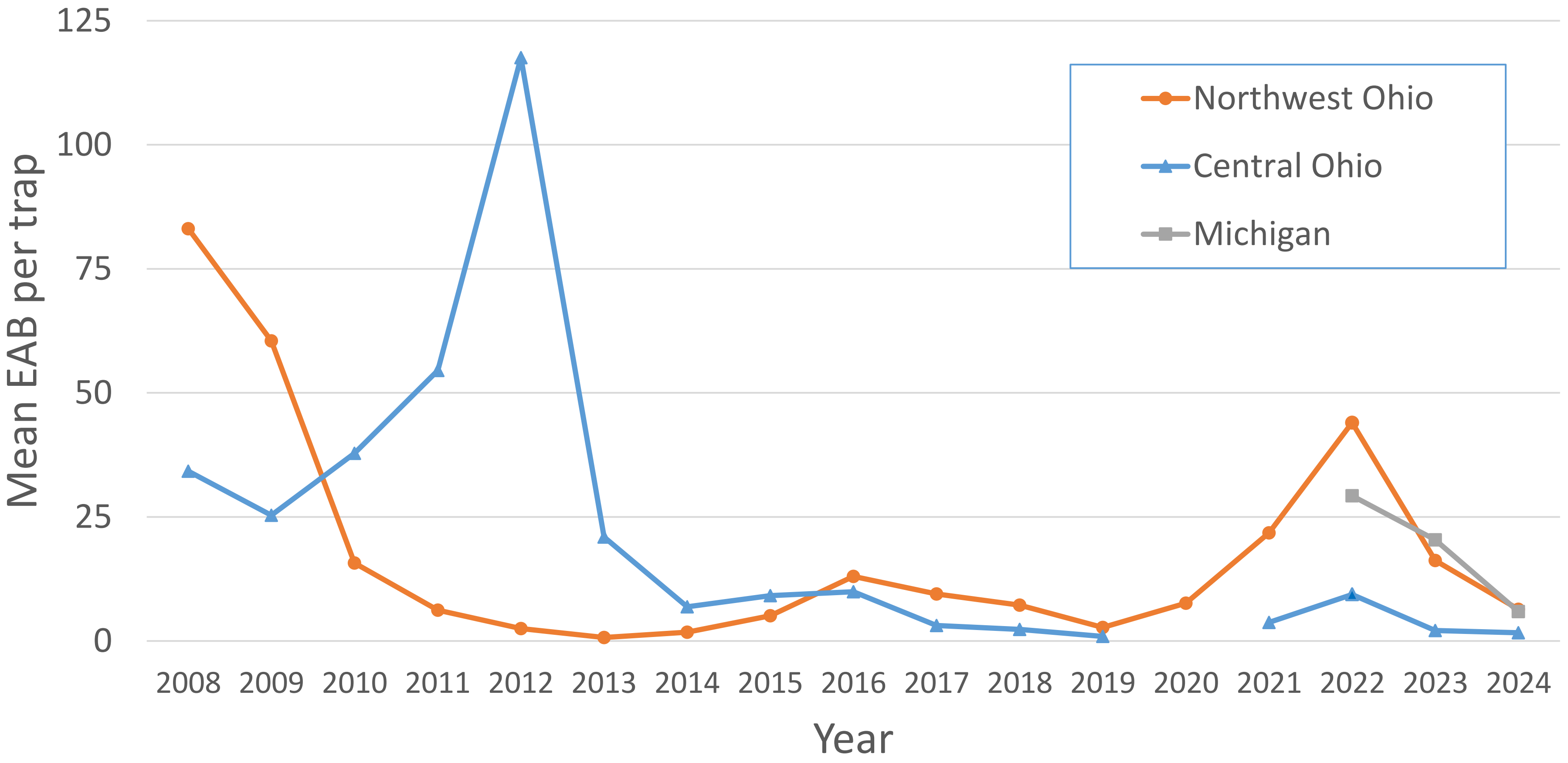
Ash (*Fraxinus* spp.) mortality, regeneration, and seed bank dynamics in mixed hardwood forests following invasion by emerald ash borer (*Agrilus planipennis*)

Wendy S. Klooster · Daniel A. Herms · Kathleen S. Knight · Catherine P. Herms · Deborah G. McCullough · Annemarie Smith · Kamal J. K. Gandhi · John Cardina

EAB Population Dynamics

- Counts of EAB on purple panel traps

EAB Population Dynamics



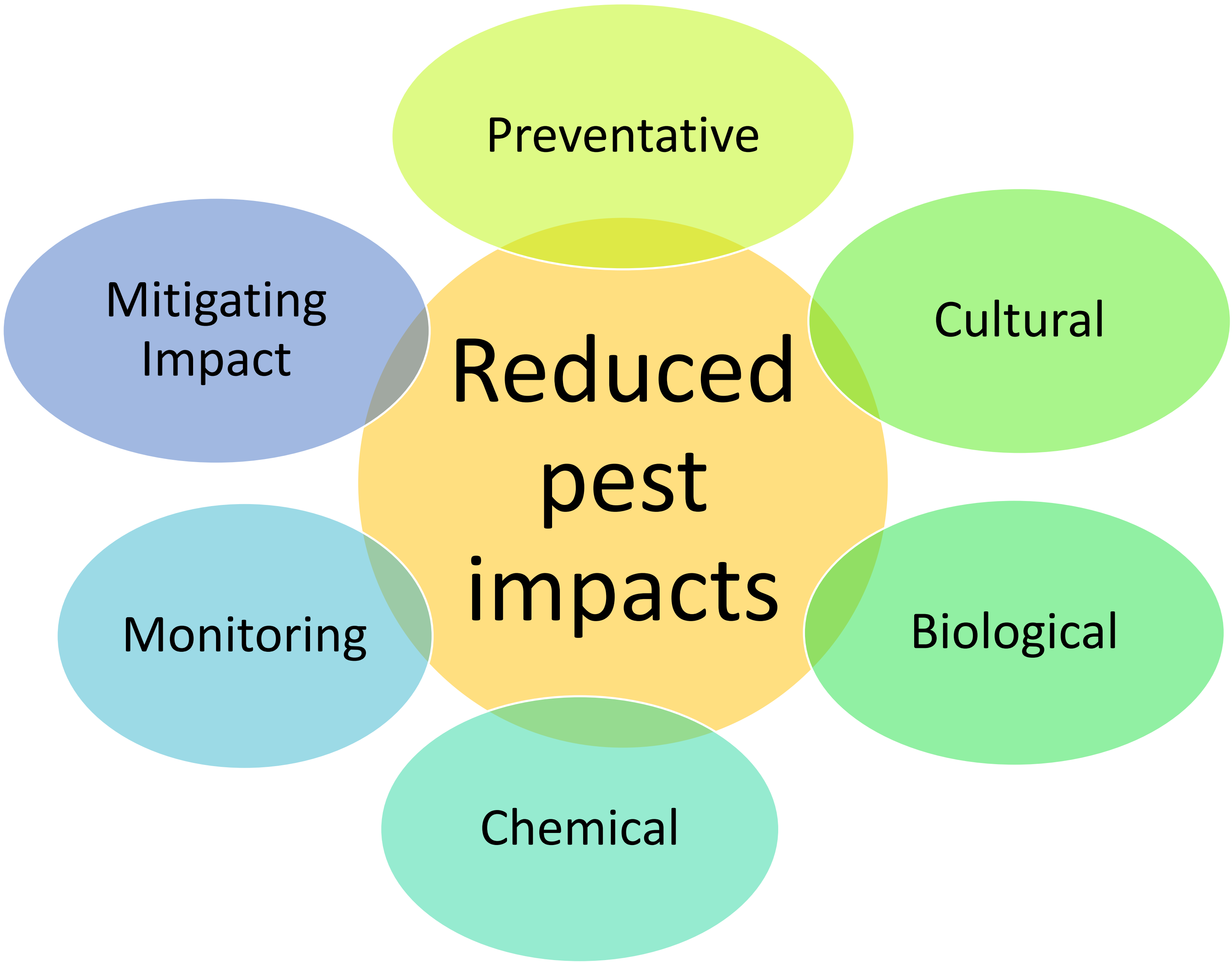
Surviving ash

- A small percent of the large trees survive at some sites
- We have identified many healthy green and white ash 4-10 in DBH as well as much larger healthy blue ash
- Healthy large surviving ash may have rare genetic traits that make them resistant to EAB
- Many smaller ash that were too small for EAB during the first wave remain and grow
- Ash mortality during second wave of EAB

Management Implications – EAB Impacts

- Ash mortality and EAB population dynamics follow a predictable pattern, allowing for planning of management actions (e.g., underplanting, removal of hazard trees, treatment of invasives)
- EAB remains a threat
- Most ash trees >4 in DBH die, though there are some rare large trees that survive

So how can we respond to invasive pests like EAB?


Preventative
Mitigating Impact
Cultural
Reduced pest impacts
Monitoring
Biological
Chemical

Preventative

Slow or prevent spread

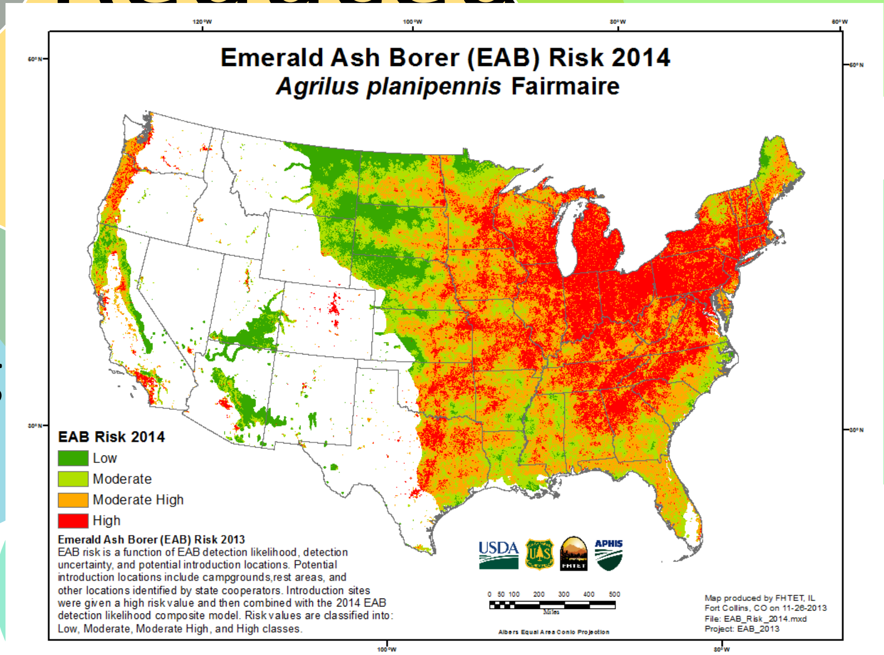
Risk assessment

Mitigating

Reduced

Cultural

Monitoring



Cultural

Resistance breeding

Silvicultural practices

Biological

Preventative

Leluthia - Robert Kula


Oobius - Deborah Miller


Tetrastichus - David Cappaert

Impacts

Monitoring

Chemical

Biocontrol

Introduced or native parasitoids or predators

tative

Cultural

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st
acts

Biological

Chemical

Insecticide

Mitigating Impact

Re

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Monitoring

Monitoring EAB

Monitoring host

Monitoring impacts

Chemical

Mitigating Impact

Restoration

Ex-situ and In-situ genetic conservation

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United States Department of Agriculture

Forest Service

Northern Research Station

General Technical Report NRS-55

USDA

Methods for Collecting Ash (*Fraxinus* spp.) Seeds

Kathleen S. Knight
Robert P. Karrfalt
Mary E. Mason

forests

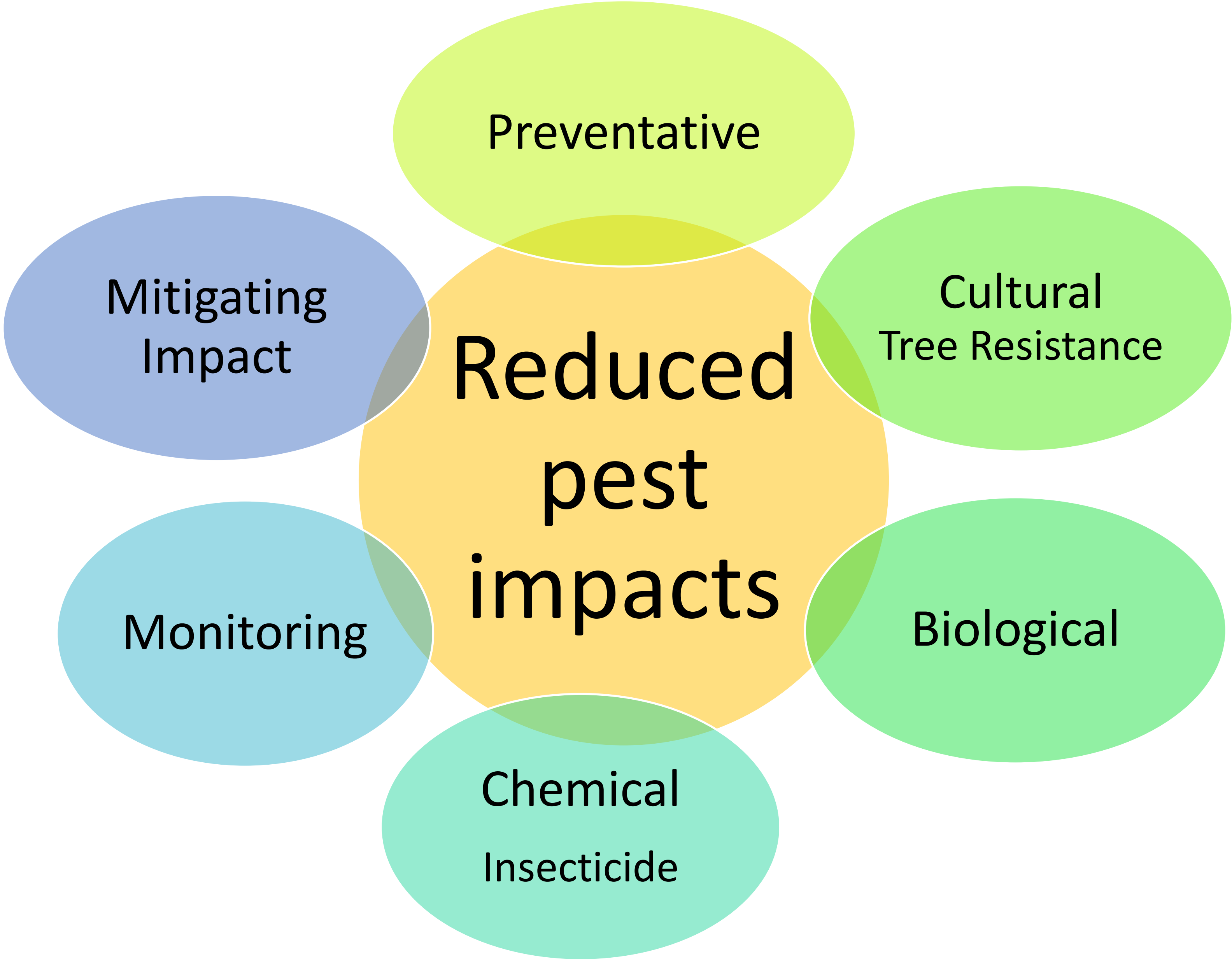
MDPI

http://www.mdpi.com/journal/forests

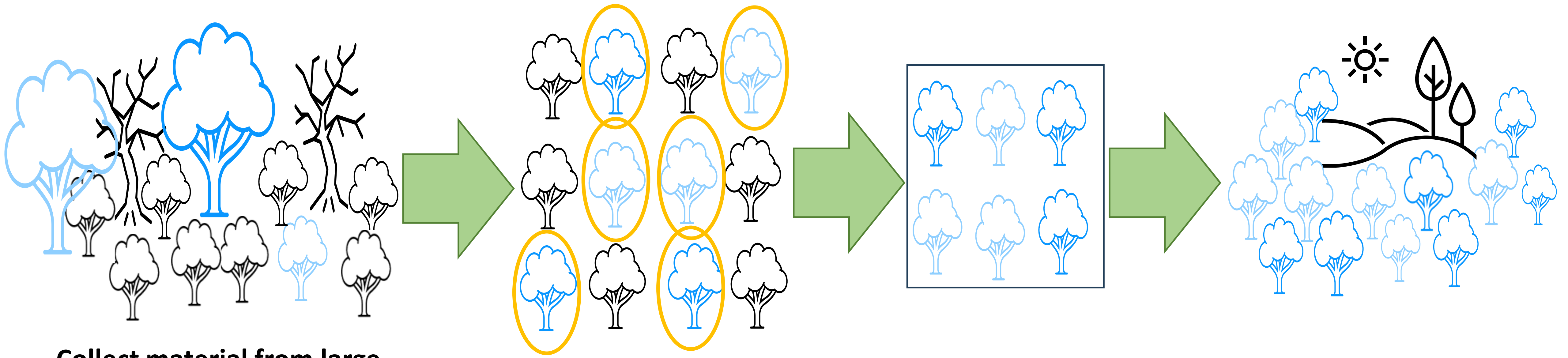
Article

Optimizing Conservation Strategies for a Threatened Tree Species: In Situ Conservation of White Ash (*Fraxinus americana* L.) Genetic Diversity through Insecticide Treatment

Charles E. Flower [1,2,*], Jeremie B. Fant [3], Sean Hoban [4], Kathleen S. Knight [1], Laura Steger [3], Elijah Aubihl [5], Miquel A. Gonzalez-Meler [2], Stephen Forry [6], Andrea Hille [6] and Alejandro A. Royo [7]


Preventative
Mitigating Impact
Cultural
Tree Resistance
Reduced pest impacts
Monitoring
Biological
Chemical
Insecticide

Tree Breeding General Process



Collect material from large survivor trees

Testing to identify resistant individuals

Locally adapted seed orchard

Reforestation

Selection & propagation of "lingering ash"

"Lingering ash" Criteria:

- Area long infested by EAB
- Large enough to have been infested during peak EAB
- Healthy canopy, at least 2 years after mortality rate leveled off

Once selected, trees are propagated and "moved" into the program:

Hot callous grafting

Grafted replicates for experiments & archive

Archive plot (Clone bank)

Pollinations

Test for resistance: lingering green ash selections

EAB egg bioassay

Healthy larva　　Host-killed larva

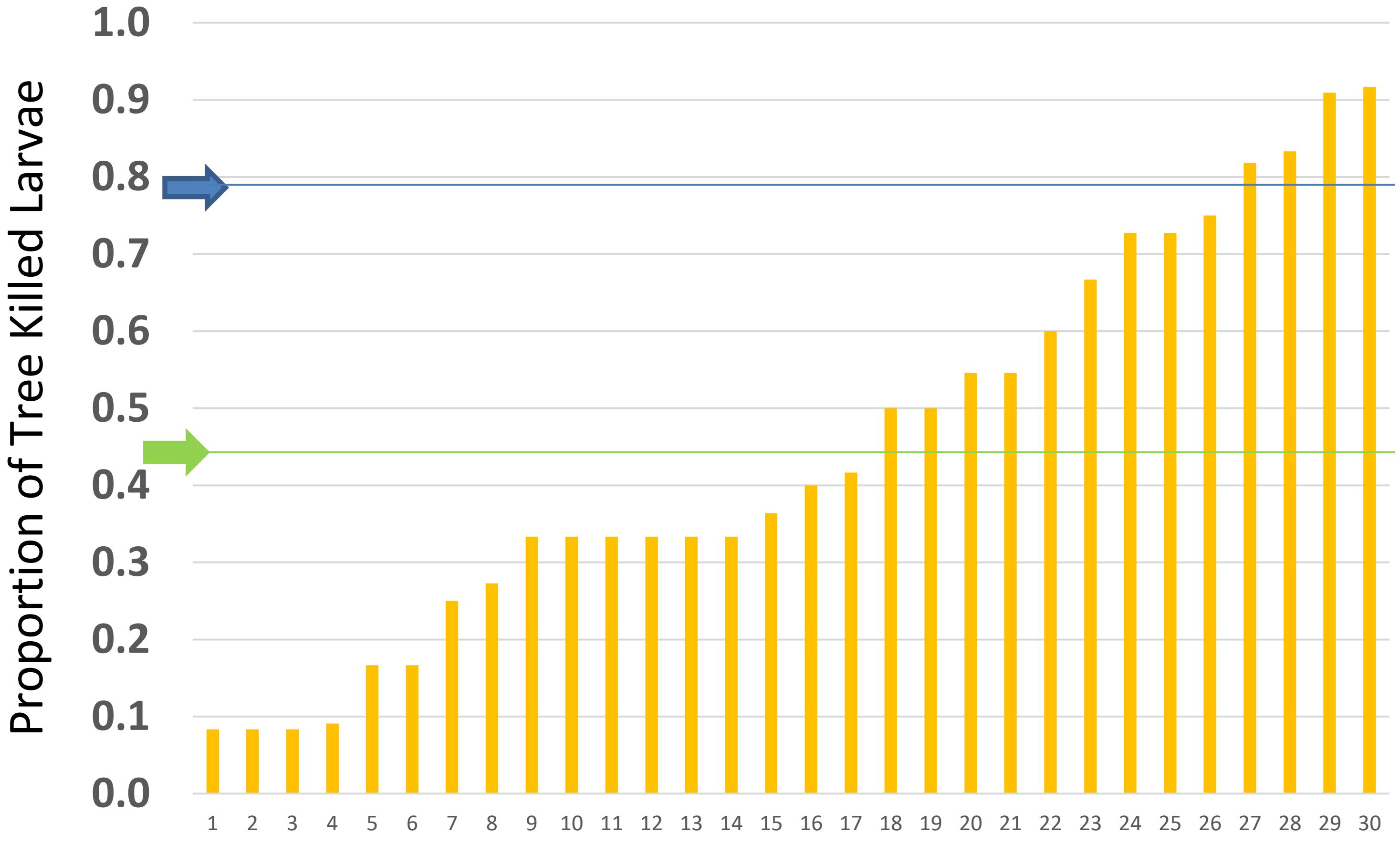
- Not all lingering ash have resistance (~50 %)
- Best lingering 45 % larvae killed
- Best susceptible 12 % killed, average 5 %
- Top 10 lingering ash average 19 % larvae killed
  - Enough to allow tree to live longer
  - Still at risk of death

Field Trials

- Confirm bioassay indicative of field performance
- Assess environmental impacts on resistance

Test for resistance: lingering ash x lingering ash seedlings

Example seedling family



Breeding increases resistance!

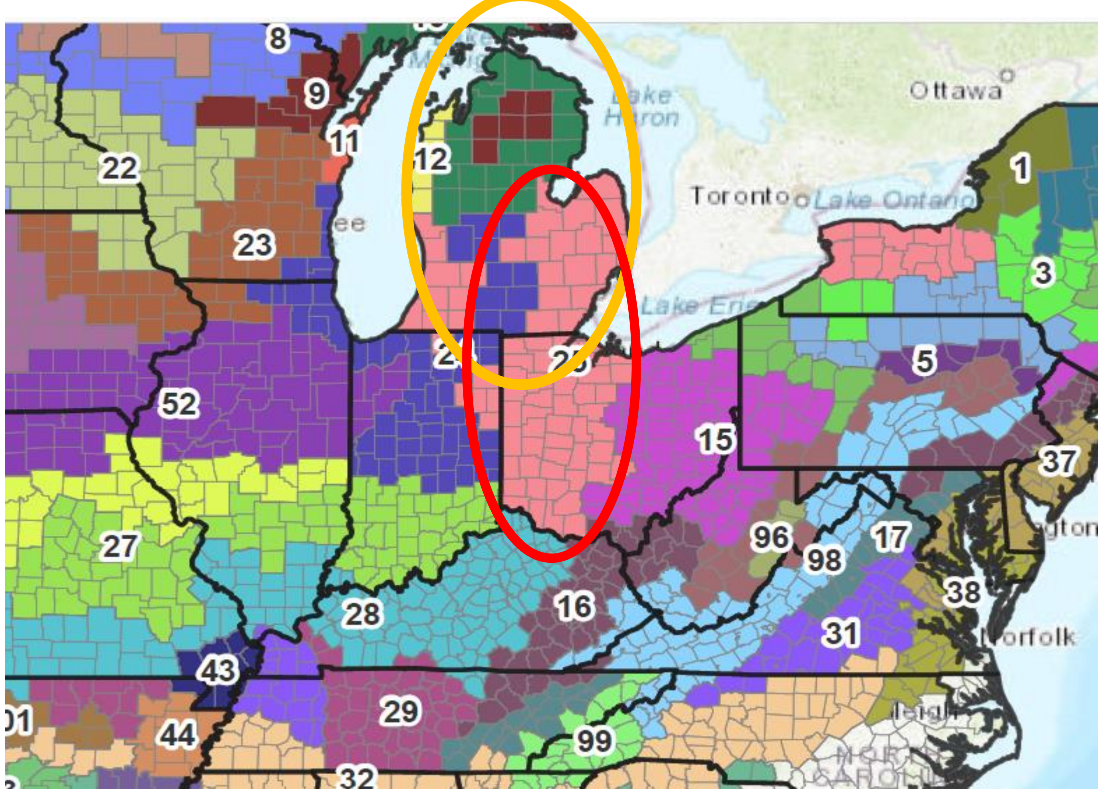
- 855 seedlings (27 families) screened
- This family:
  - 40 % of seedlings were more resistant than parents
  - 4 seedlings as resistant as Asian ash species
- Select best seedlings/trees!

Indicates highest % killed from lingering ash selections

Indicated % killed by Manchurian ash resistant control

First improved green ash seed orchards

www.EasternSeedZones.com



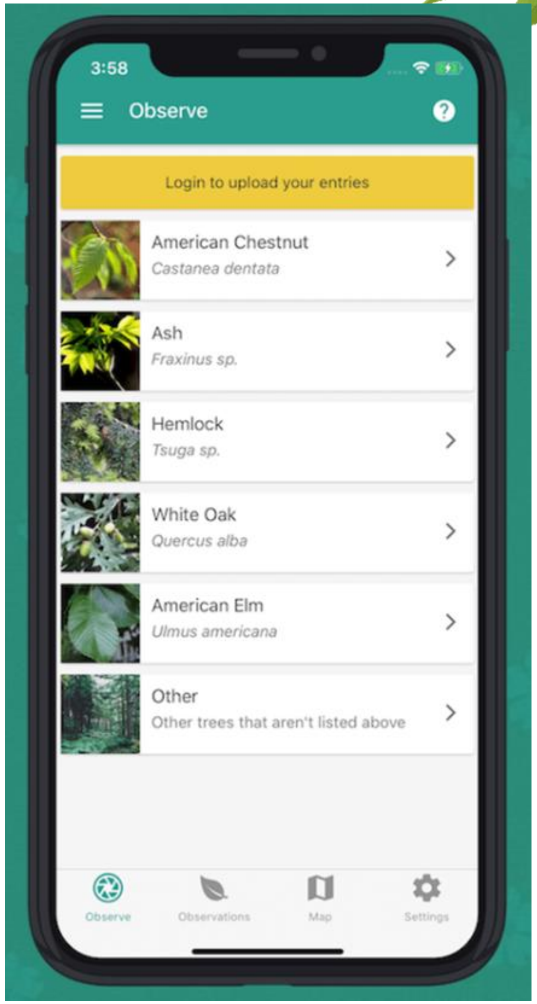
1st lingering ash selections clonal orchard
- Best of 40 green ash will be kept
- Seed production ~ 12-15 years

Lingering ash x lingering ash seedling orchard
- 600 trees from 31 families
- Best trees will be kept
- Seed production ~ 15-20 years

*Need to replicate the whole process
(Select, test, seed orchard)
To produce seed adapted to other zones

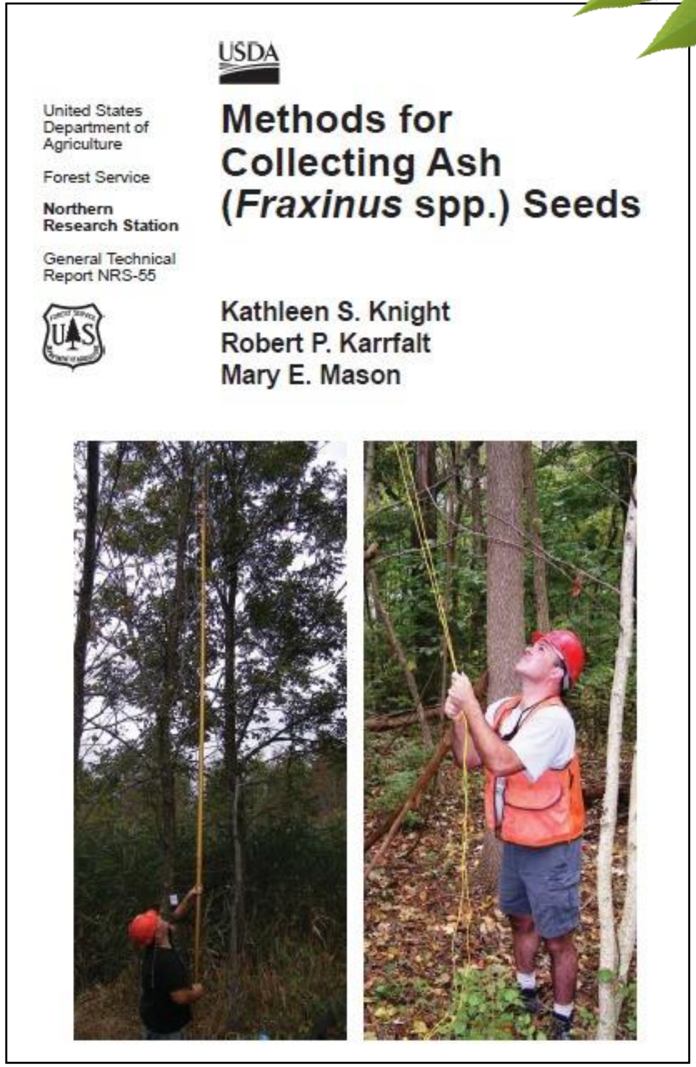
How can you help?

- Watch for large survivor ash trees!
- Submit them to a database
  - Treesnap https://treesnap.org/



Genetic Conservation

- Preserve the genetic diversity of ash before it's killed by EAB
- Ex-situ genetic conservation: seed collection
- In-situ genetic conservation: insecticide protection


USDA

United States Department of Agriculture

Forest Service

Northern Research Station

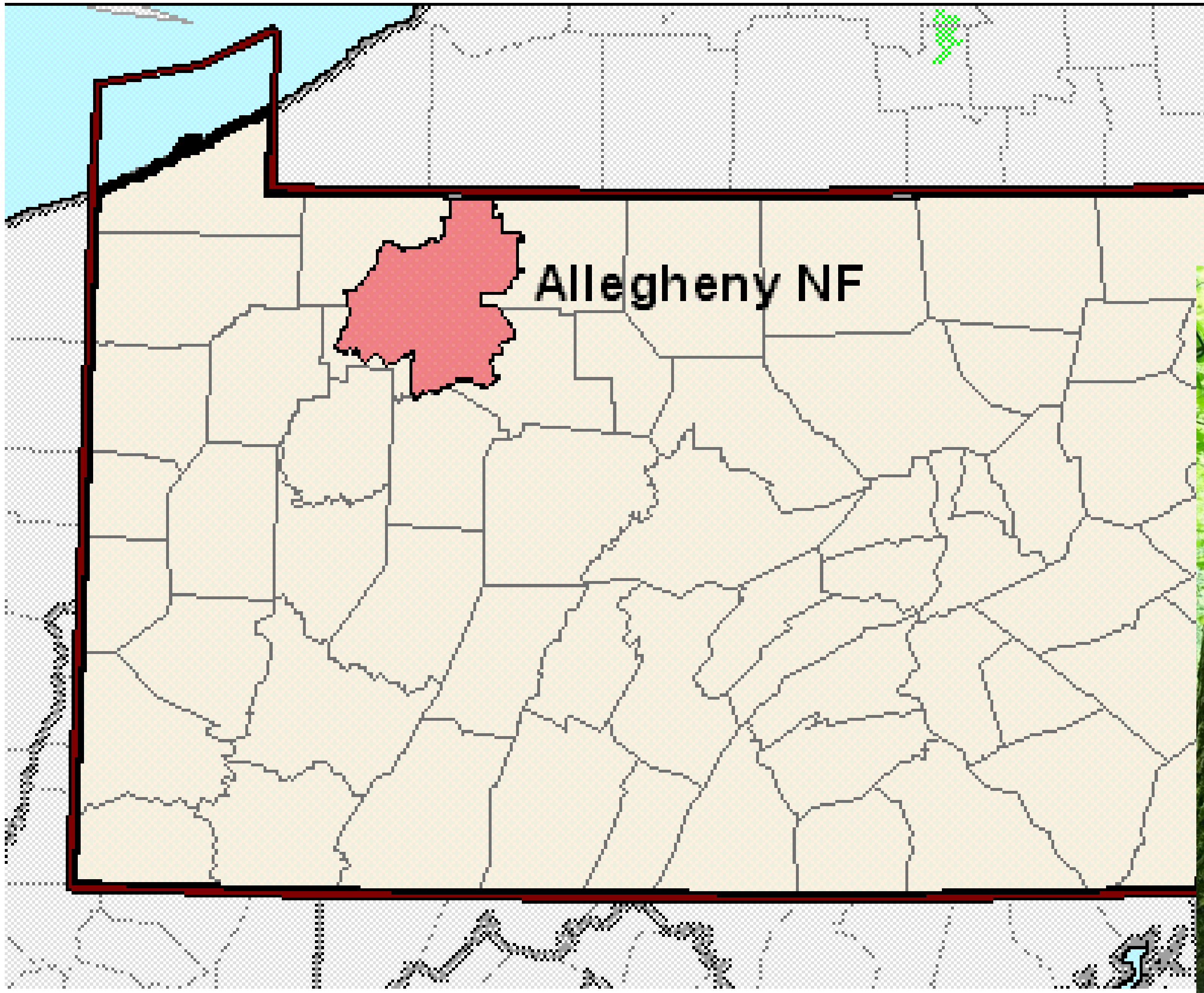
General Technical Report NRS-55

Methods for Collecting Ash (*Fraxinus* spp.) Seeds

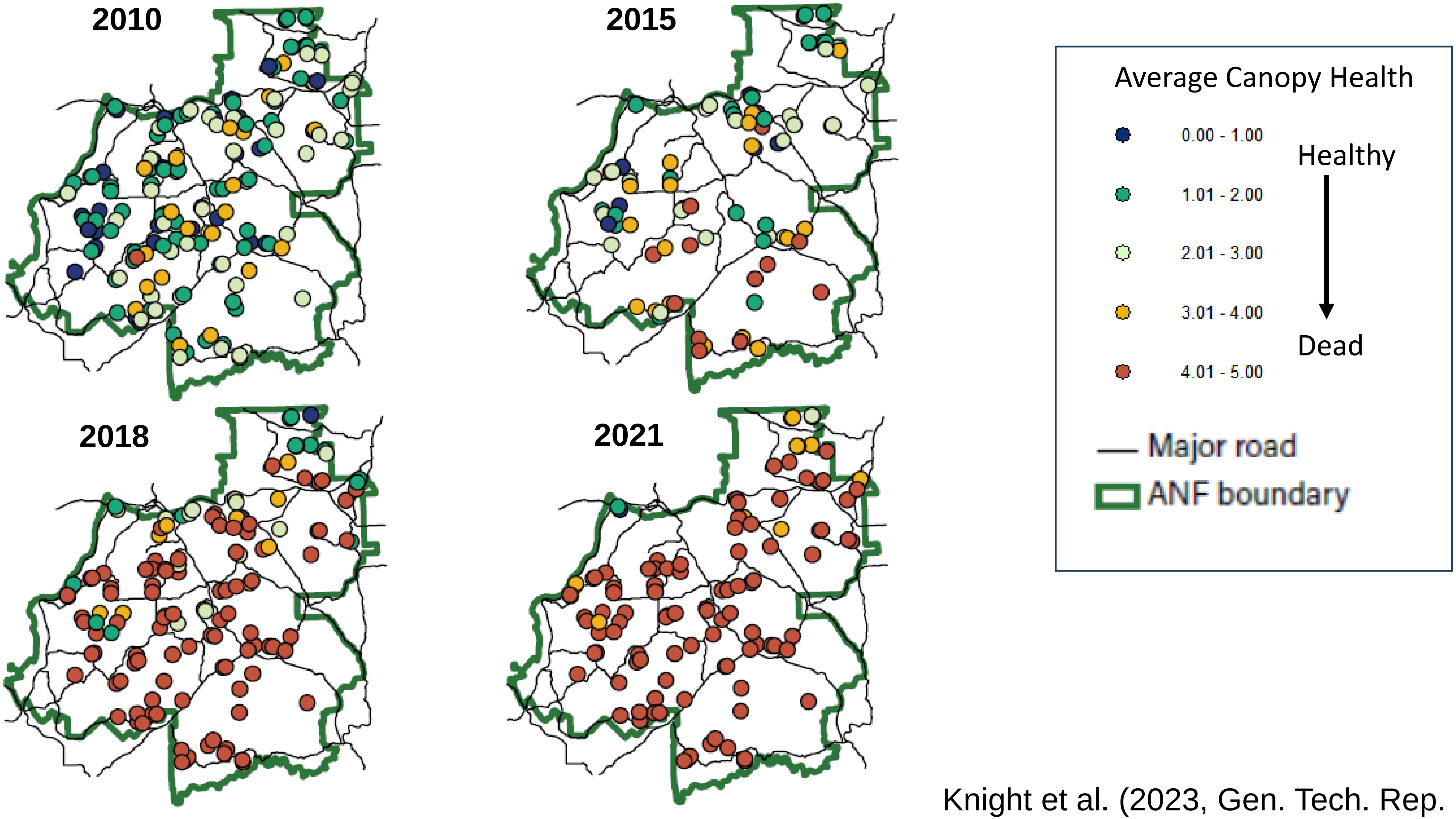
Kathleen S. Knight
Robert P. Karrfalt
Mary E. Mason

Allegheny National Forest (ANF):
Northern Unglaciated Allegheny Plateau

Collaborators and monitoring crew leaders:
Kathleen Knight
Alex Royo
Charlie Flower
Jason Kilgore
Justin LaMountain
Rachel Kappler
Eli Aubuhl
Dawlton Nelson
Steve Forry
Andrea Hille
Bill Oldland
Danielle Kelley



Ash canopy condition across the ANF



Knight et al. (2023, Gen. Tech. Rep. SRS-273)

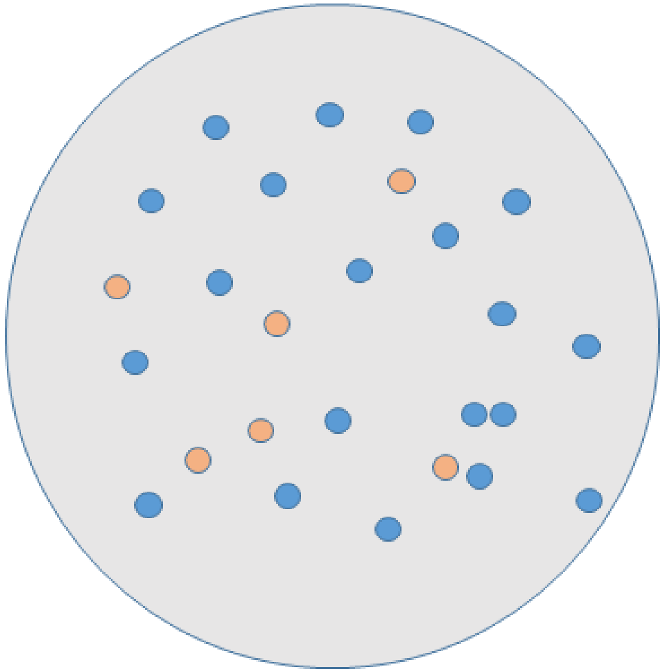
ANF Ash Insecticide Treatment for Genetic Conservation

27 plots
3.14 ha (100 m radius) (7.76 acre)
20 trees treated in each plot

TREE-äge
(emamectin benzoate)

Testing Associational Protection

27 treated plots
22-215 ash per plot
20 treated ash per plot



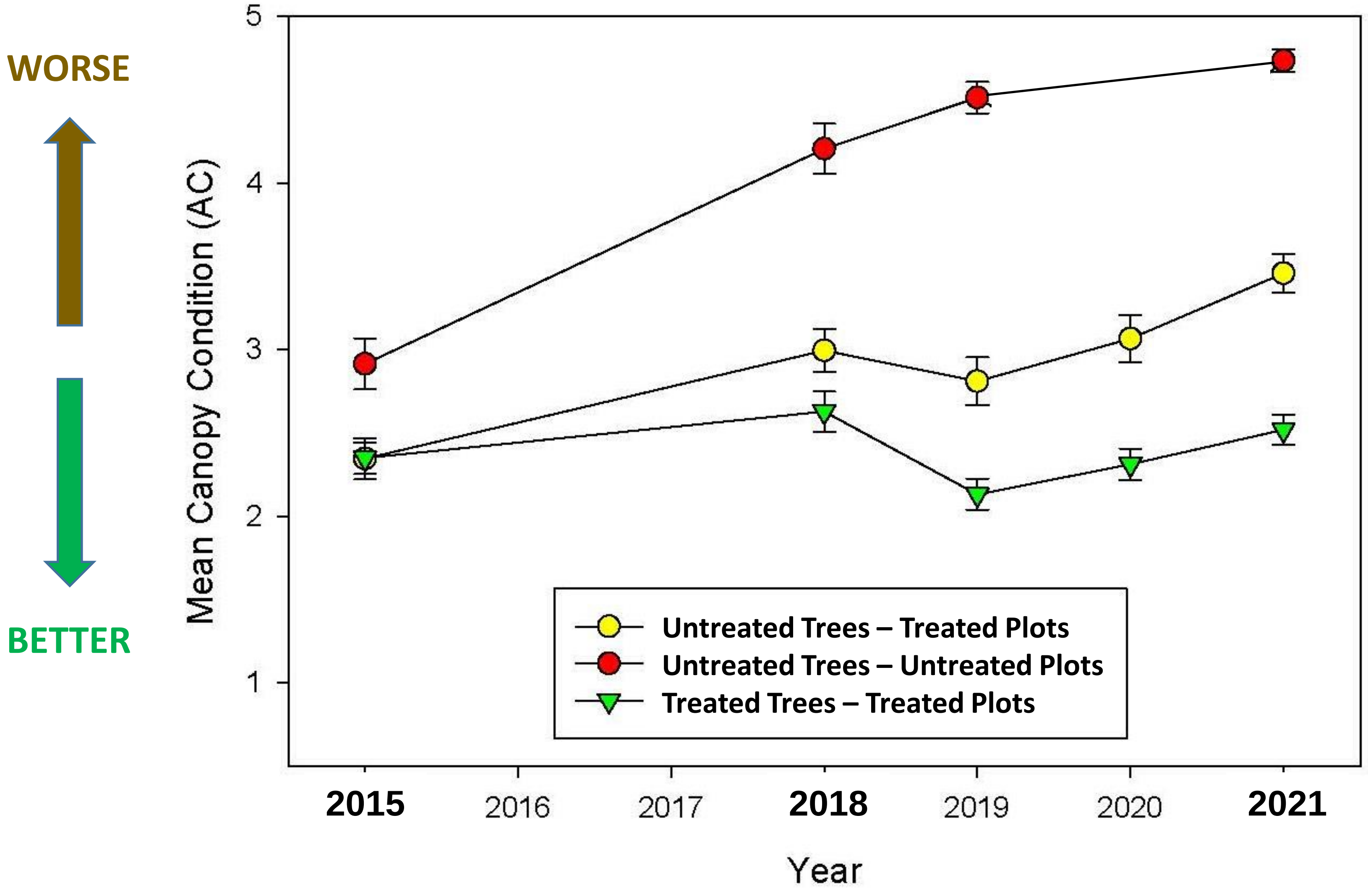
Example plot with 26 ash trees
-- 20 treated trees (blue dots)
-- 6 untreated trees (orange dots)

Testing Associational Protection

Several studies have demonstrated protection of untreated trees with nearby treated trees in a variety of contexts

- **Mercader et al. 2015** – Michigan SLAM
- **O'Brien 2017** – Ohio metroparks
- **de Andrade et al. 2020** – Maryland and Washington D.C. neighbor proximity
- **Sadof et al. 2021** – Indiana urban SLAM
- **Mwangola et al. 2023** – Minnesota urban street trees
- **Duan et al. 2023** – Connecticut and Massachusetts forests, no effect detected

Testing Associational Protection



Untreated trees in treated plots have better canopy condition than control trees

W=263, P=1.007E-14

Insecticide treatment for genetic conservation

- Conserved 97% of genetic diversity of white ash at the ANF
- Maximize efficiency by treating many unique populations with at least 10 trees per population
- Insecticide is most successful in trees that are healthy at the time of treatment
- Insecticide treatment provides protection for untreated nearby trees.

Ash Floodplain Restoration

Challenges:

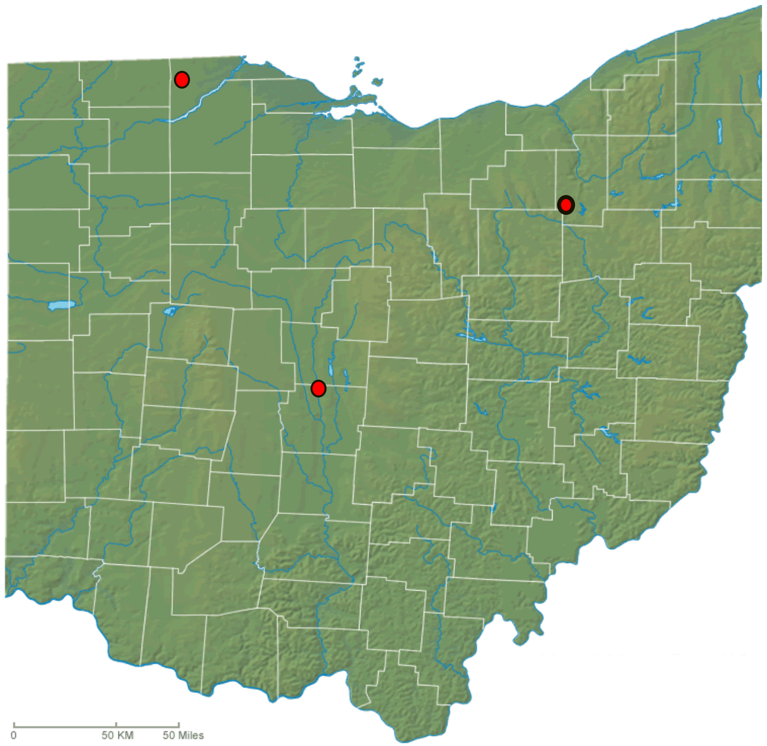
- Flooding
- Deer Browse
- Shade
- Competing vegetation

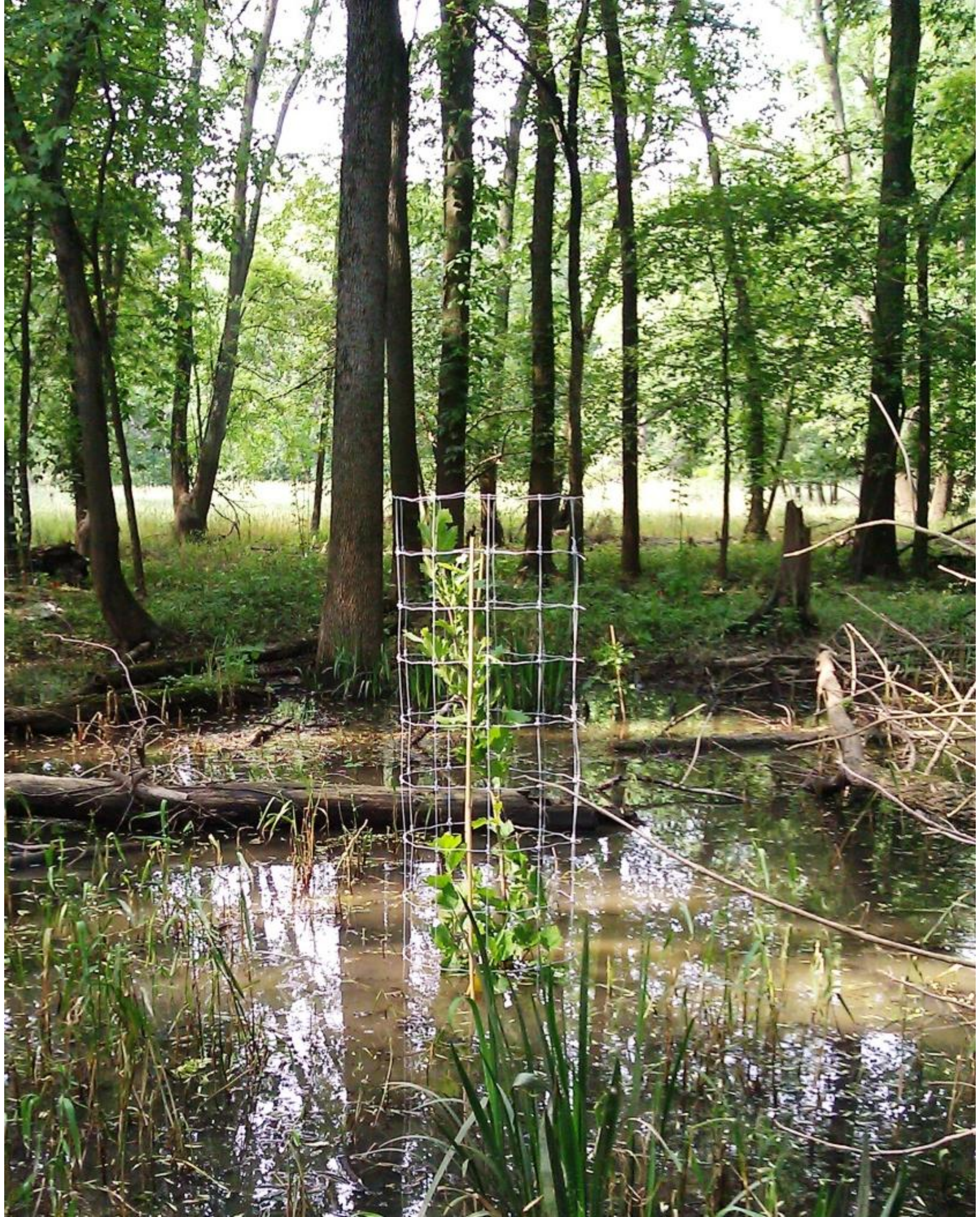
What factors affect the growth and survival of planted tree seedlings?

Best planting strategy?

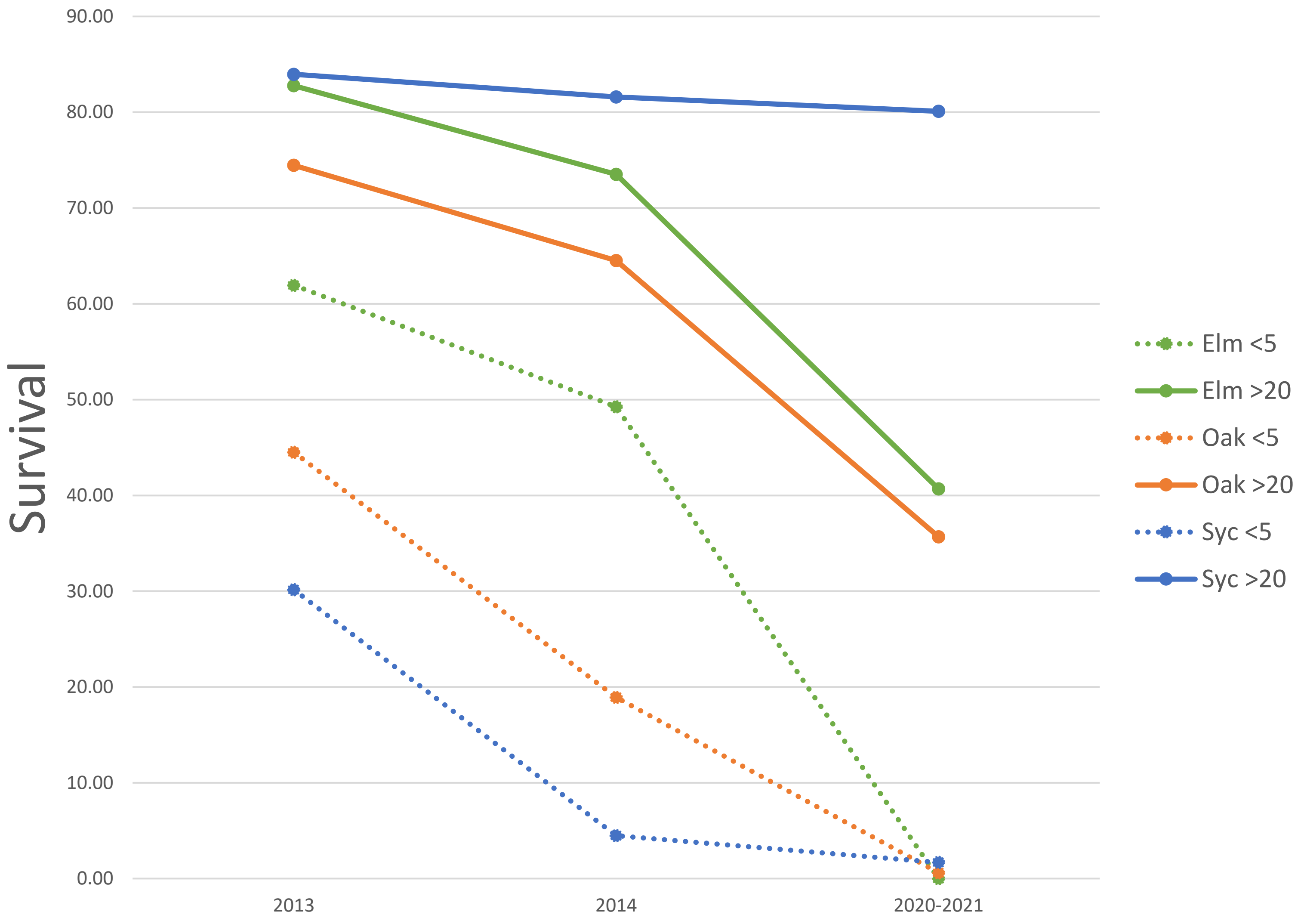
Ash Floodplain Restoration Experiment

- What factors affect the growth and survival of planted tree seedlings in Ohio floodplains impacted by EAB?
    - Tree species - elm, pin oak, sycamore
    - Initial size - Small trees vs. large trees
    - Herbivory by deer – cage vs. no cage for large trees
    - Light – canopy openness above seedling

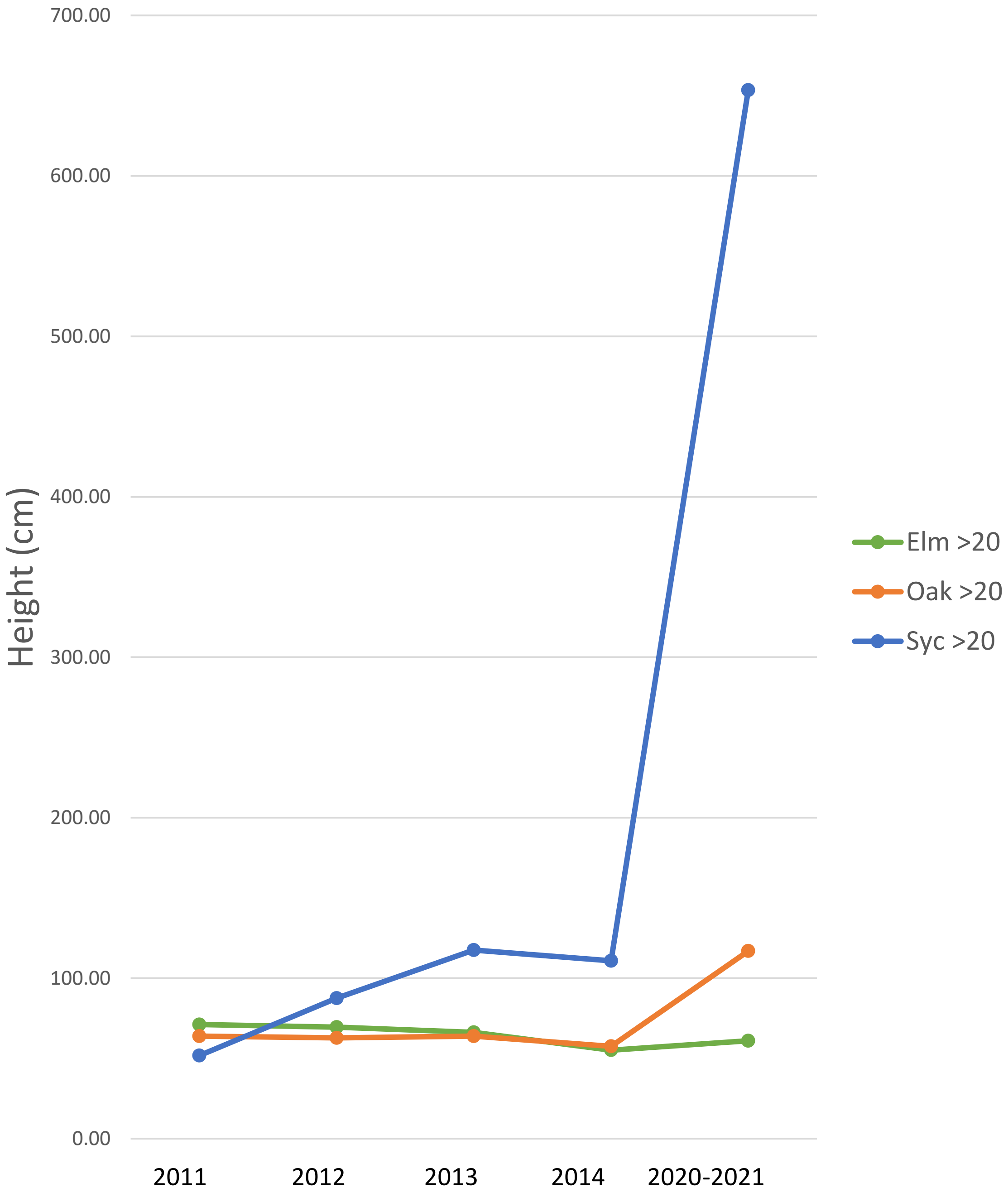


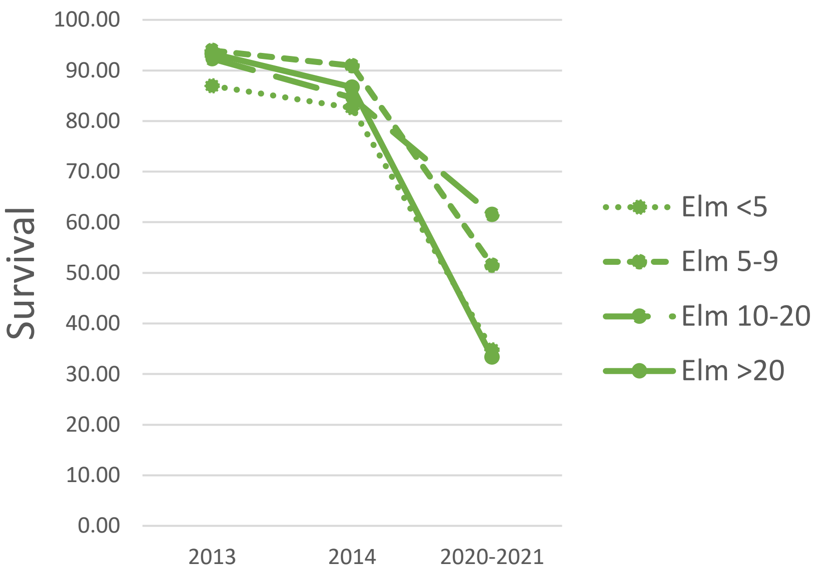
Survival: Small trees with no fence at low and high light

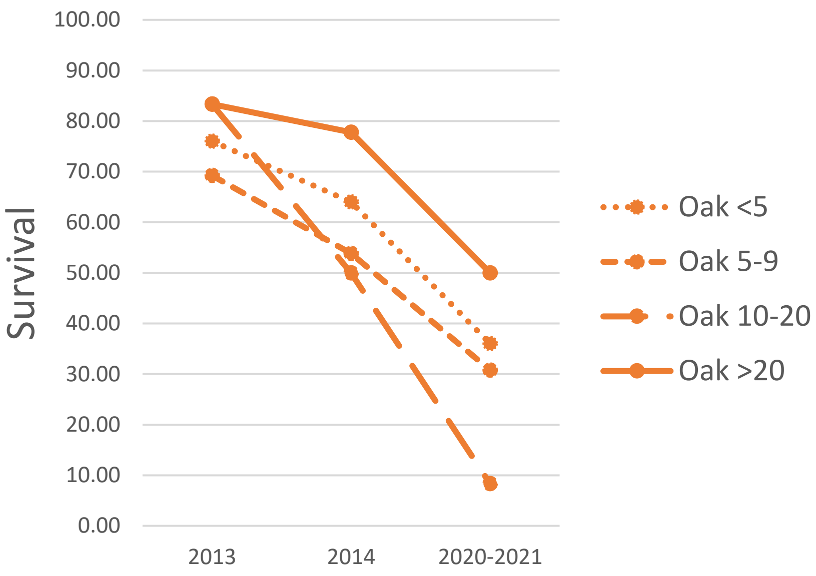


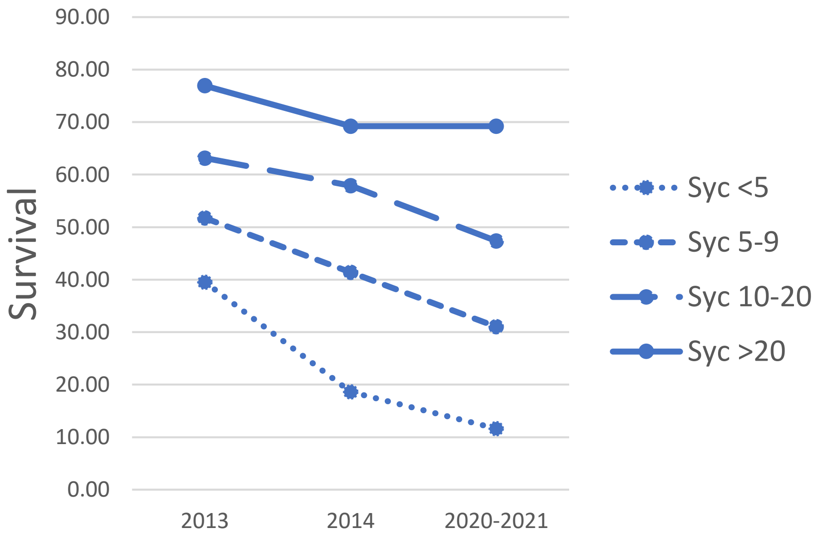
Growth: Small Trees No Fence



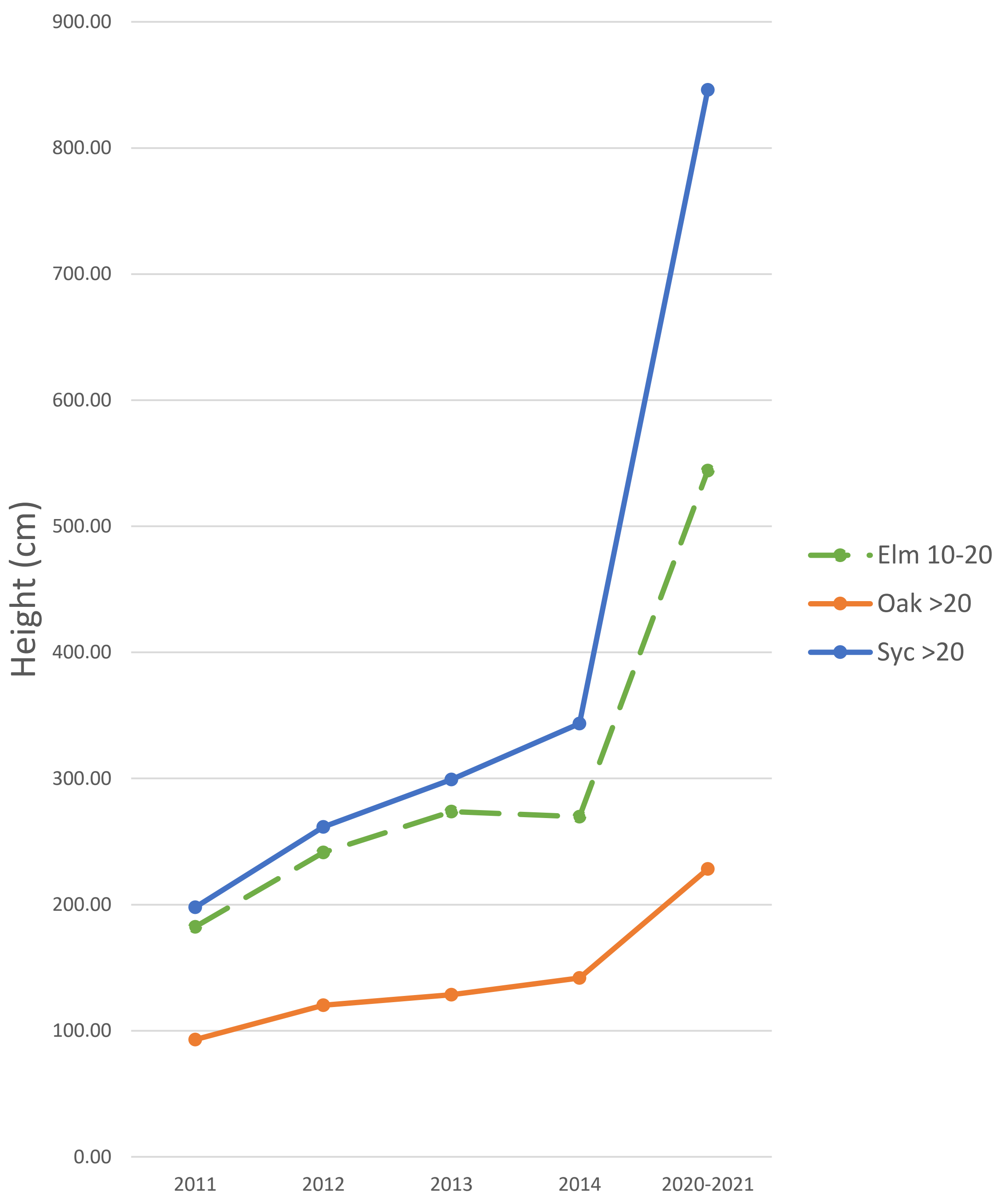
Survival: Large trees with fence at four light levels





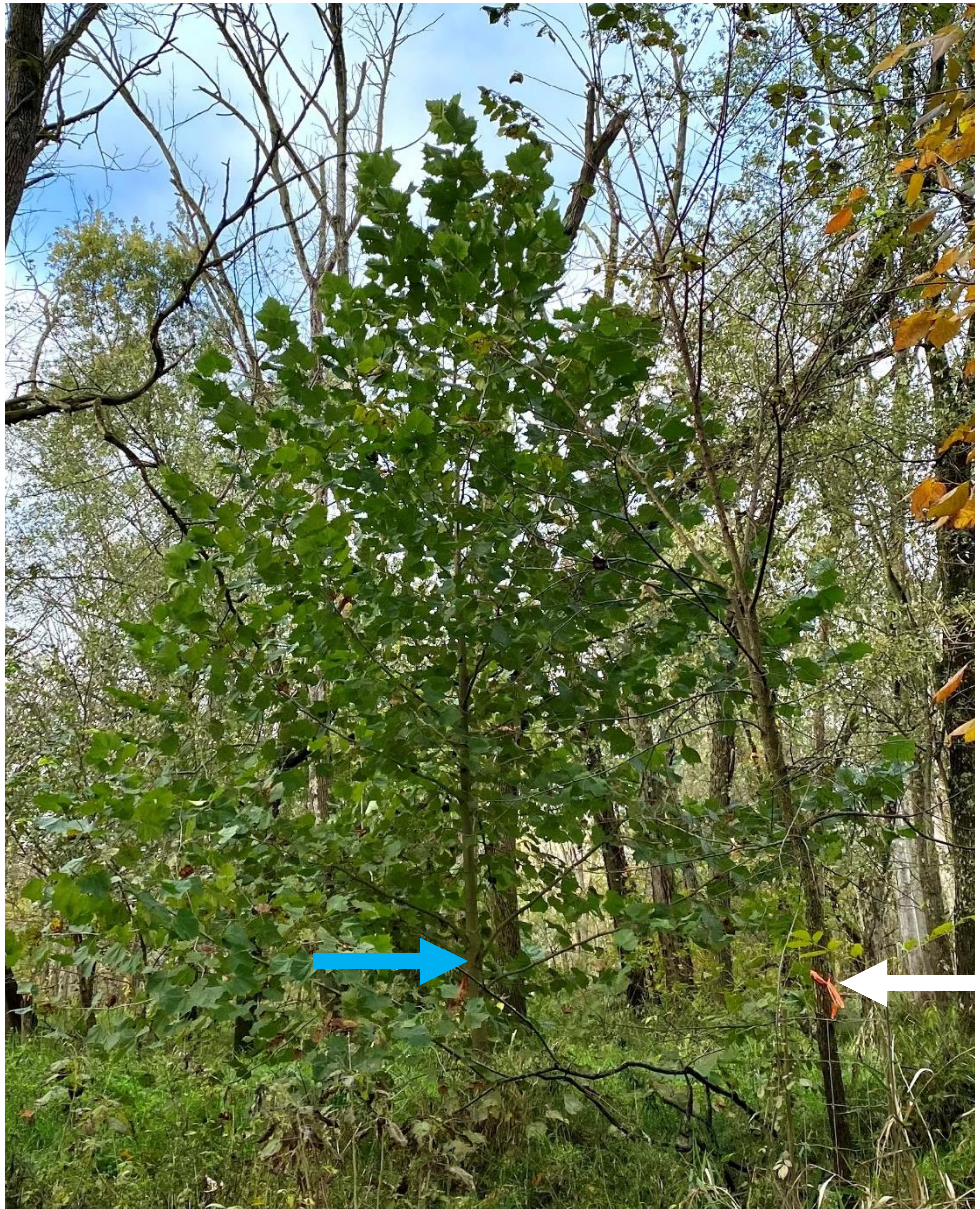


Growth: Large Trees Fenced



Ash Floodplain Restoration - Management Implications

- DED-tolerant elm and pin oak performed well in ash floodplain restoration plantings when protected from deer
- Sycamore performs extremely well in moderate to high light, with or without deer protection
- Plant other species to preserve or restore function in floodplains impacted by EAB



Conclusions

- Understanding impacts on forest ecosystems and long-term population dynamics allows for management planning
- Management strategies can reduce impacts

Acknowledgements

Funding sources

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FIVE RIVERS METROPARKS

OHIO DEPARTMENT OF NATURAL RESOURCES

Great Parks of Hamilton County

THE OHIO STATE UNIVERSITY

UNIVERSITY OF NOTRE DAME

DNR Indiana Department of Natural Resources

PRESERVATION PARKS DELAWARE COUNTY

DCNR

US Army Corps of Engineers®

And many teams of summer interns!

Thank you!

Kathleen.S.Knight@usda.gov