USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE



Tree breeding to support forest resilience:

Species in detail – ash and elm

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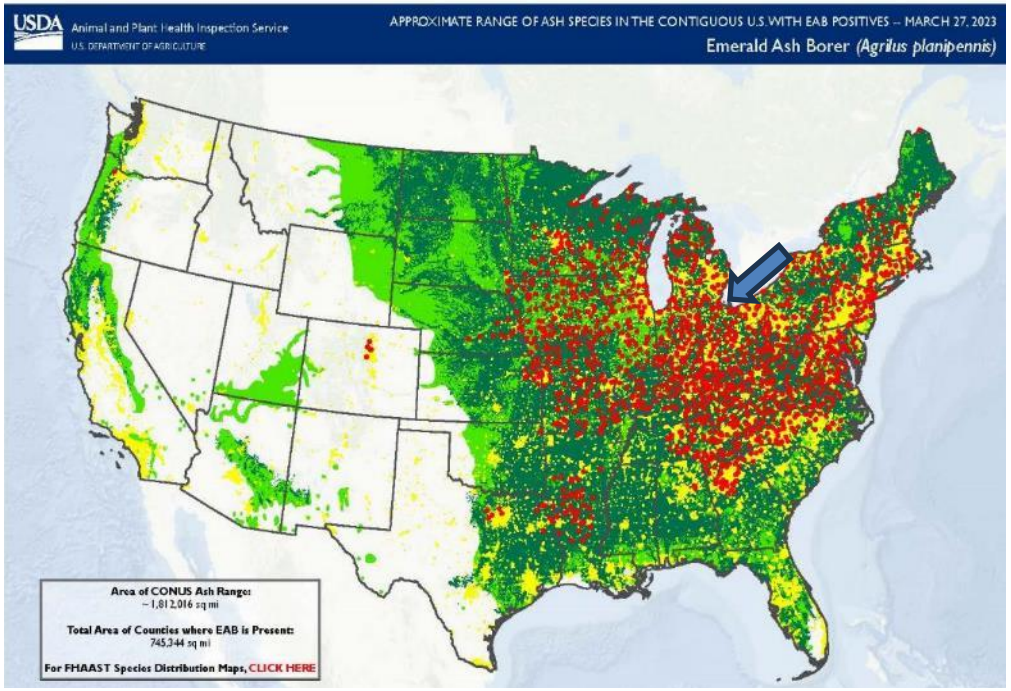
And many partners and collaborators

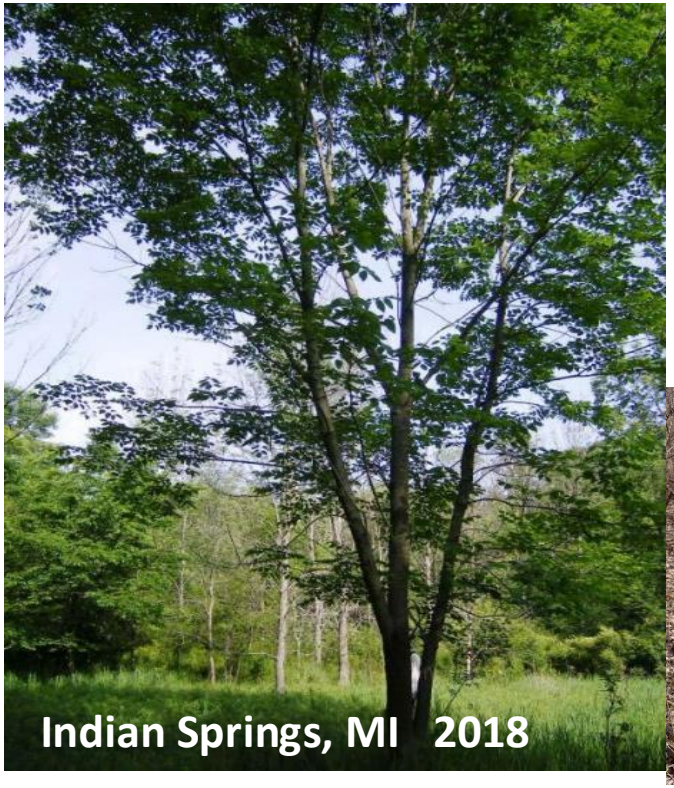
The Threat: Emerald Ash Borer (*Agrilus planipennis*)

- First detected in 2002, Detroit, MI US
- Now 40 % of range infested (Range=~480 billion hectares)
- 9 out of 16 U.S. species in EAB infested areas:
  - *Fraxinus pennsylvanica* (green ash)*
  - *Fraxinus americana* (white ash)*
  - *Fraxinus nigra* (black ash)*
  - *Fraxinus quadrangulata* (blue ash)*
  - *Fraxinus profunda* (pumpkin ash)*
  - *Fraxinus caroliniana* (Carolina ash)**
  - *Fraxinus albicans* (Texas ash)
  - *Fraxinus berlanderia* (Arizona ash)
  - *Fraxinus latifolia* (Oregon ash)***

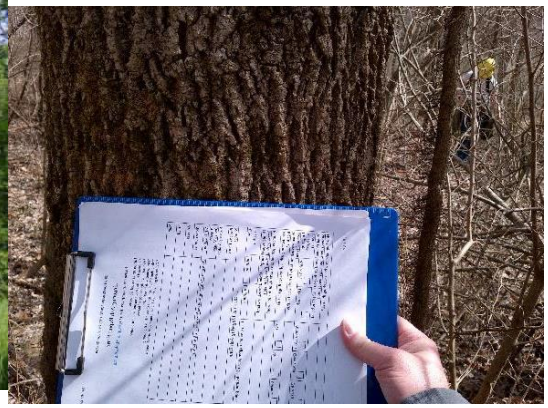
*critically threatened"IUCN red list
**endangered IUCN red list
***near threatened IUCN red list



Lingering Ash Exist: singly and clusters



Alum Creek, Oh 2022
R: 'bone yard' of downed dead ash
Below: 2 heathy large ash trees a mile or so away
photos: Dave Carey, USFS



Phenotype Parents and Progeny: EAB Egg Transfer Bioassay

(assess resistance phenotype)

Coffee filter with eggs affixed to bark

Three grafted replicates of each genotype

EAB Egg Bioassay

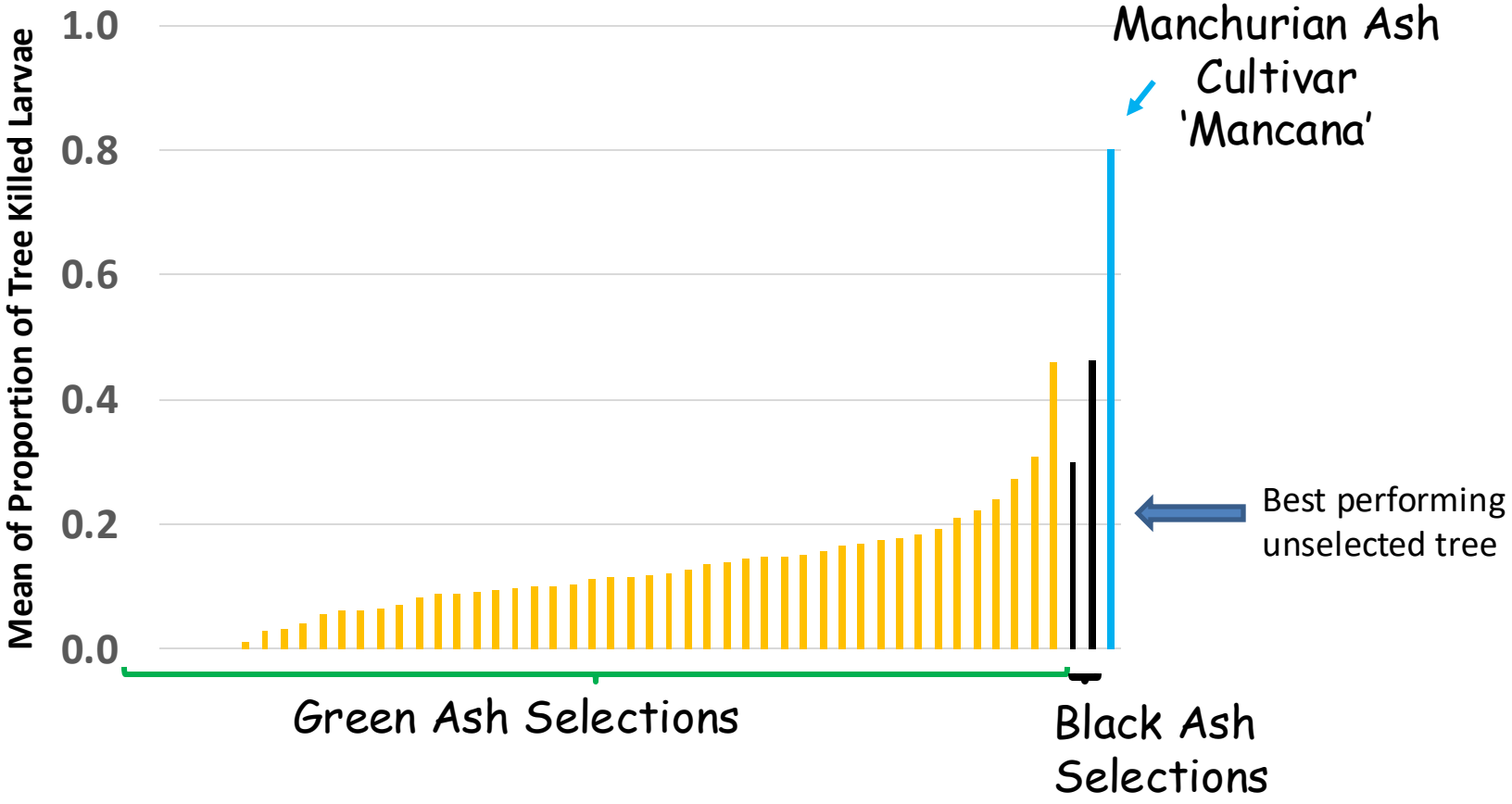
Metrics:

- 2-3 weeks-egg hatched Y/N
- 8 weeks-larval outcome: L1, L2, L3, L4, Host-killed
- Larval weight
- **LA are significantly different from unselected controls**

Healthy larva

Host-killed larva

Lingering ash have a range of Proportion host killed Better than Susceptible but not as good as Asian host



Replicated Clone Test to Confirm EAB-Resistance

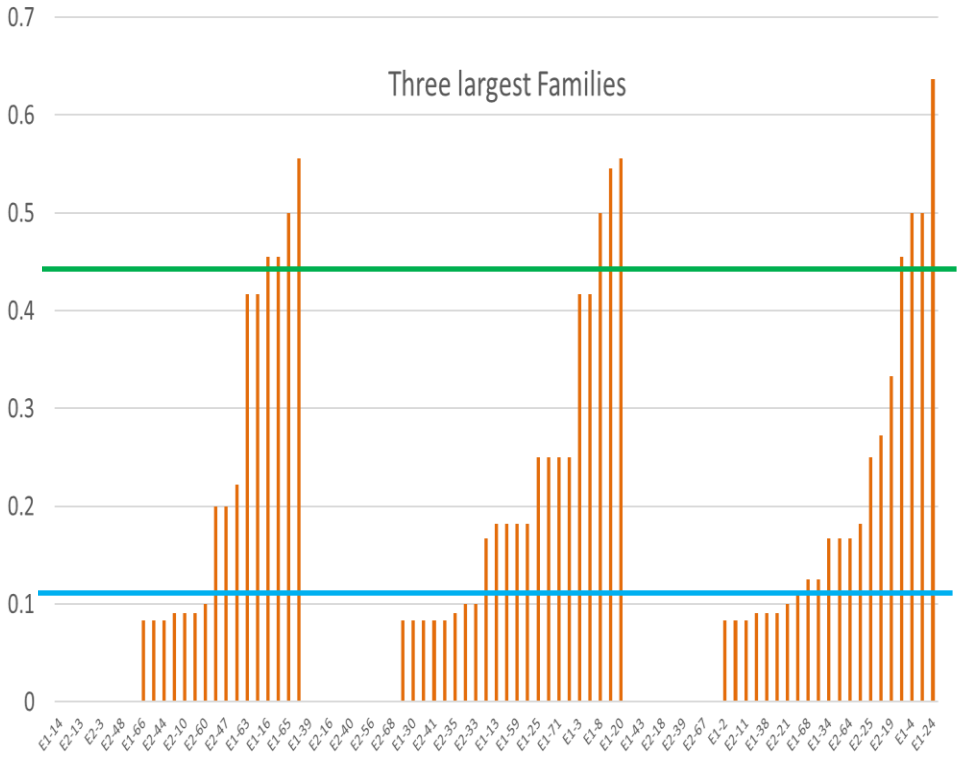
- 2 Locations
- 40 lingering green ash
- 8 lingering white ash

- Bioassay to Field correlation

- Will become improved seed orchard

Making and Testing Lingering x Lingering Families

- Will become 2nd generation seed orchard

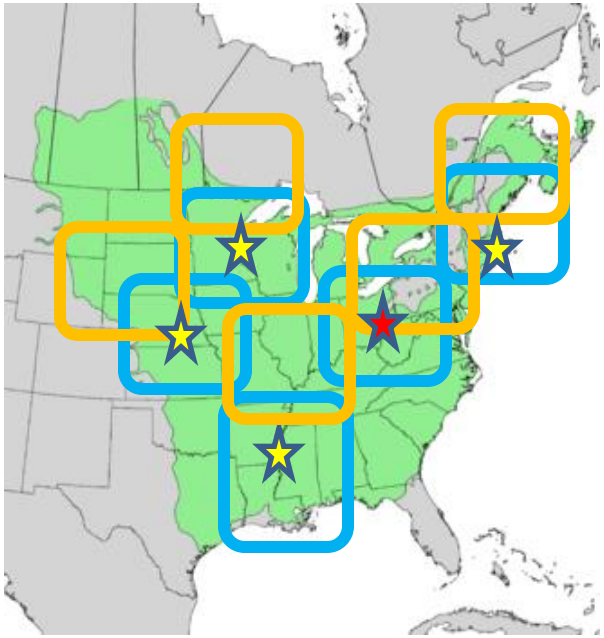


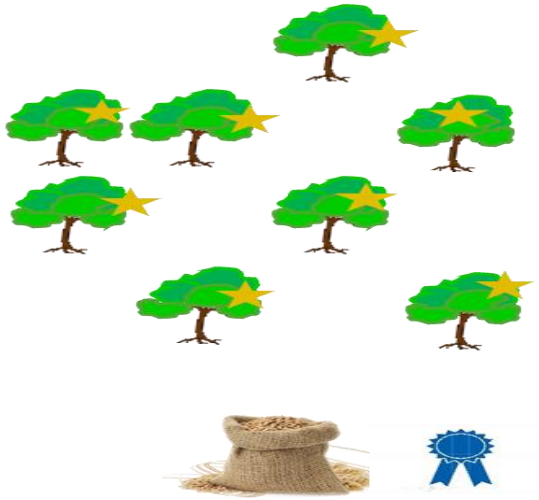
One bar per seedling, proportion host killed.
Blue line is best control parent,
green line is best LA parent.

Breeding for Range-Wide Forest Restoration

Heritability and other calculations of genetic control support continued breeding!

			estimate
Humans	height		0.8
Google says: "natural populations"			0.1-0.2
Green ash: parents	Tree killed larvae	r	0.15
Green ash: seedlings	Tree killed larvae	h^2	0.63
Green ash: grafted seedlings	Tree killed larvae	r	0.87





seed orchard

current climate-based population

future climate-based seed zone

Repeat for each area/population

- Capture genetic diversity
- Adaptive capacity
- Partners!

Black Ash Story

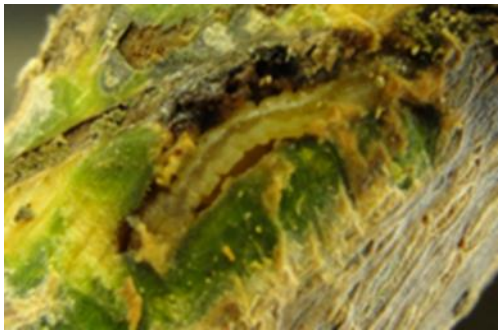
- Same story?
  - lingering black ash do exist
  - unselected black ash will kill a proportion of EAB larvae equal to lingering green ash (more than unselected green ash)

- With some twists?
  - Tree killed at lower EAB attack density?
  - looks to have a different response in bioassay

➢ So ….

Different Responses to EAB Between Species

Green ash
- Often no response
- Doesn't kill



Black ash
- rigorous defense response
- Doesn't always kill larve
- Not limited

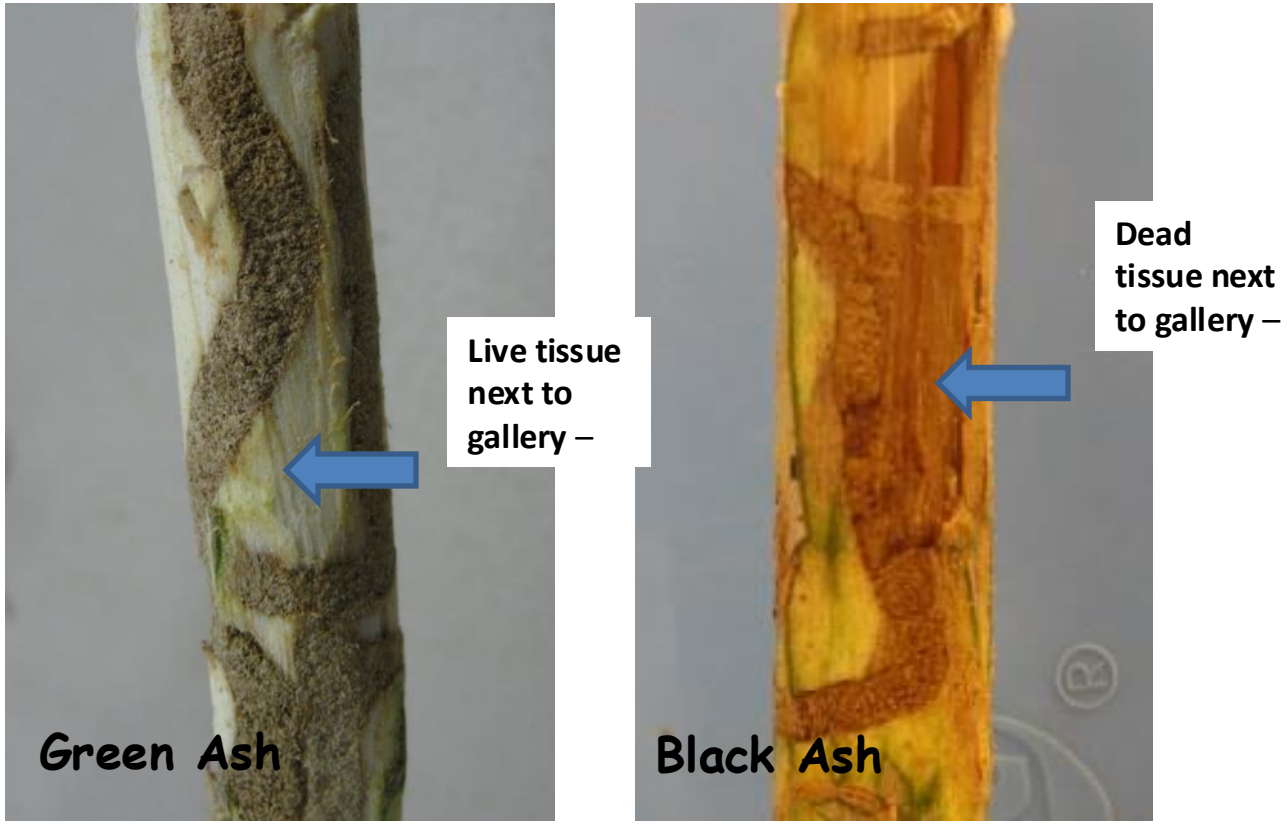
Manchurian ash
- rapid response
- Quick, effective response
- limited

Black ash: High tree killed larvae doesn't always = better survival

defense response can, in some cases, become detrimental to the tree

Field data & bioassays:
It takes fewer larvae to kill some black ash

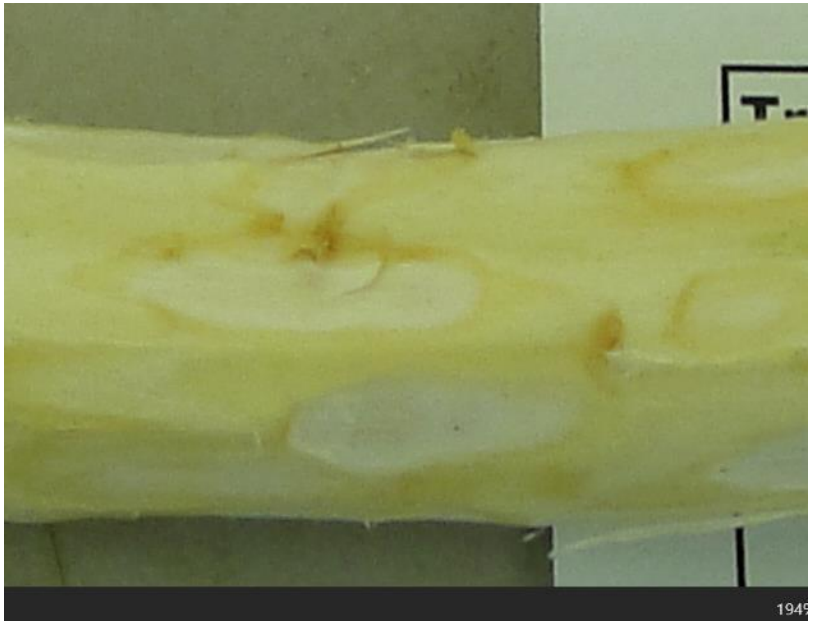
Need to screen for
larval kill
&
lack of
detrimental defenses



Black ash: bioassay host killed larvae without reaction

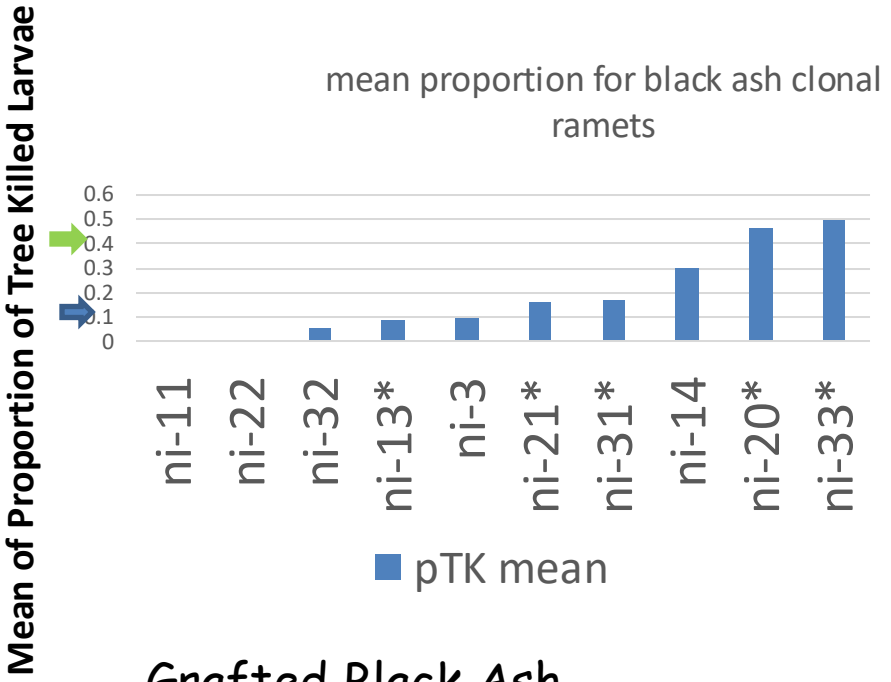
- Lingering black ash are out there, but likely harder to find

BB8 Ni-Mohawk TK L1

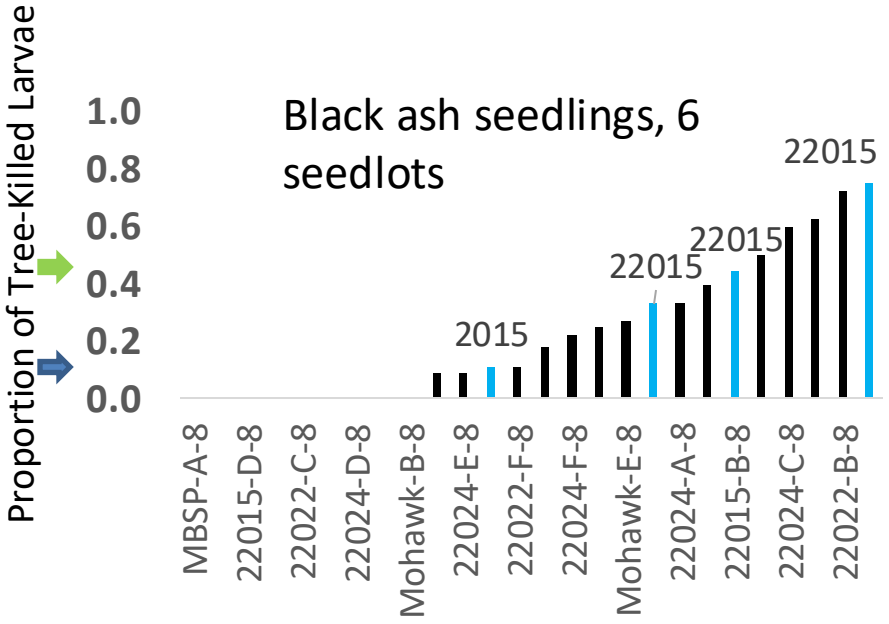


BB8 Ni-22015 TK L1

Lingering Black Ash: they exist as individual trees and within unselected families



Grafted Black Ash, unselected and Lingering (*)



Unselected Seedling Black Ash seedlings

Blue arrow best unselected green ash, green arrow best green LA

Opportunity to Develop Accelerated Breeding Strategy: Plant EAB-Resistant Black Ash Before EAB Arrives

(Proactive Breeding)

- **Instead of waiting for >95 % of black ash to die, we can collect and screen Wild seed now!**

Breeding Options:

- Pre-EAB: establish genetically diverse gardens on multiple sites
  1. **Reserve** 1-2 gardens to protect from EAB with insecticides
  2. **Sacrifice** 1-2 gardens and select surviving seedlings
- Post-EAB:
  - Identify **lingering ash**
  - Monitor seedlings

Recent presentation with more detail:
RNGR.NET
Search: Mary Mason
Will pull up presentation from Oct 2024

USDA

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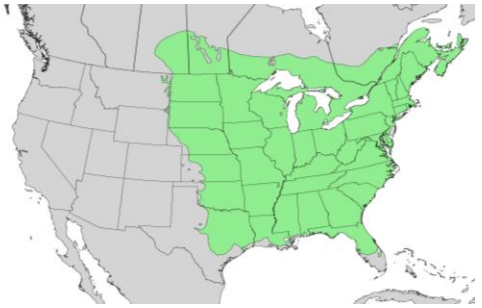
Manton Foundation
Tree Species in Peril

American elm (*Ulmus americana*)

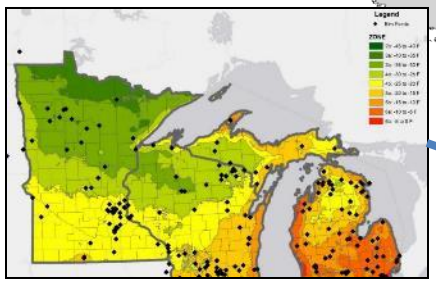


U Geological Survey. 1999. Digital representation of E.L. Little 1971 "Atlas of United States Trees"

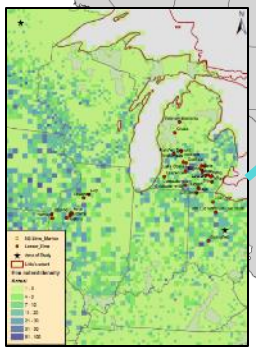
- Intermediate to shade tolerant
- Intermediate in flood tolerance
- Fast growing
- Tolerates a wide range of environmental conditions

Identify additional DED-tolerant American elms: Survivor elm populations

Cold-Hardy Lake States
~38 accessions, Zone 2b to 4a

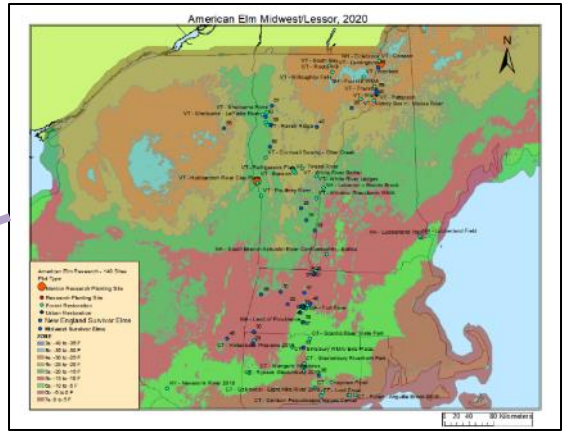


Upper Mississippi
Zone 4b to 5b



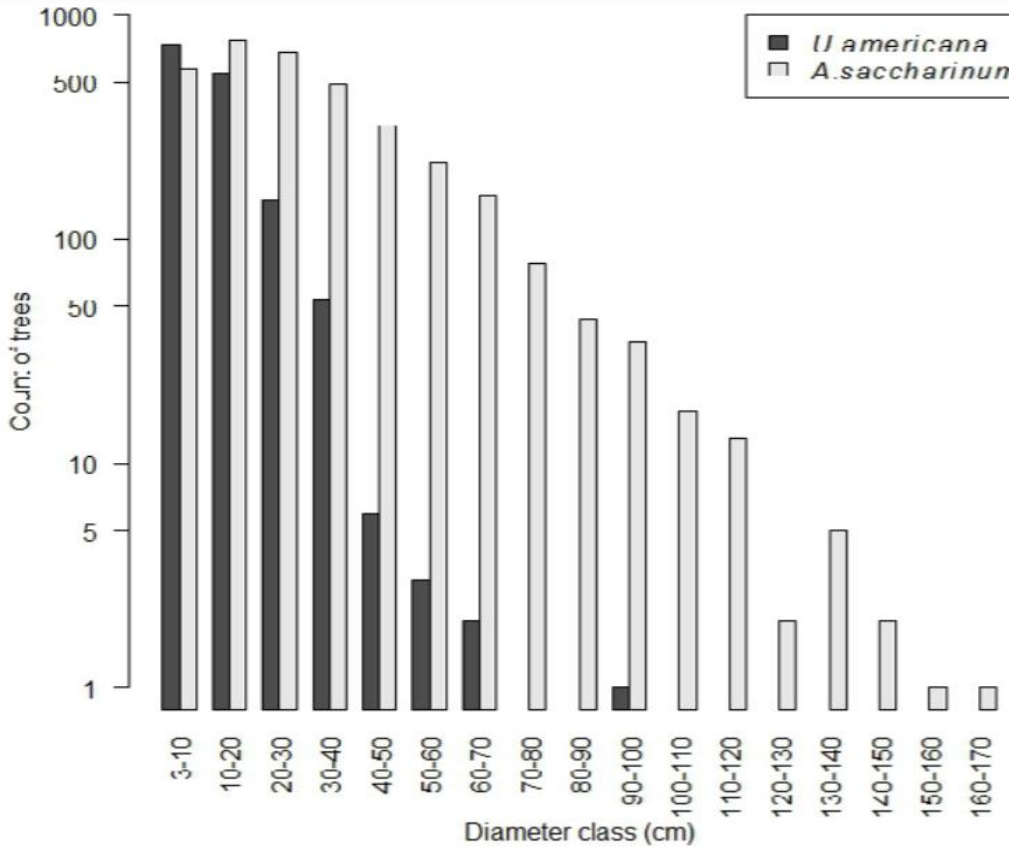
Lower Midwest
~40 accessions
Zone 5b and
6a

New England Connecticut River



26 accessions, Zone 2b to
5b

Survivor elm on the landscape



Christian Marks, 2017

Collect scion and seeds of survivor trees

Elm propagation techniques: vegetative production

New scion is grafted onto existing rootstock

Cuttings are taken from grafted material and new clones are generated

Elm propagation techniques: vegetative production

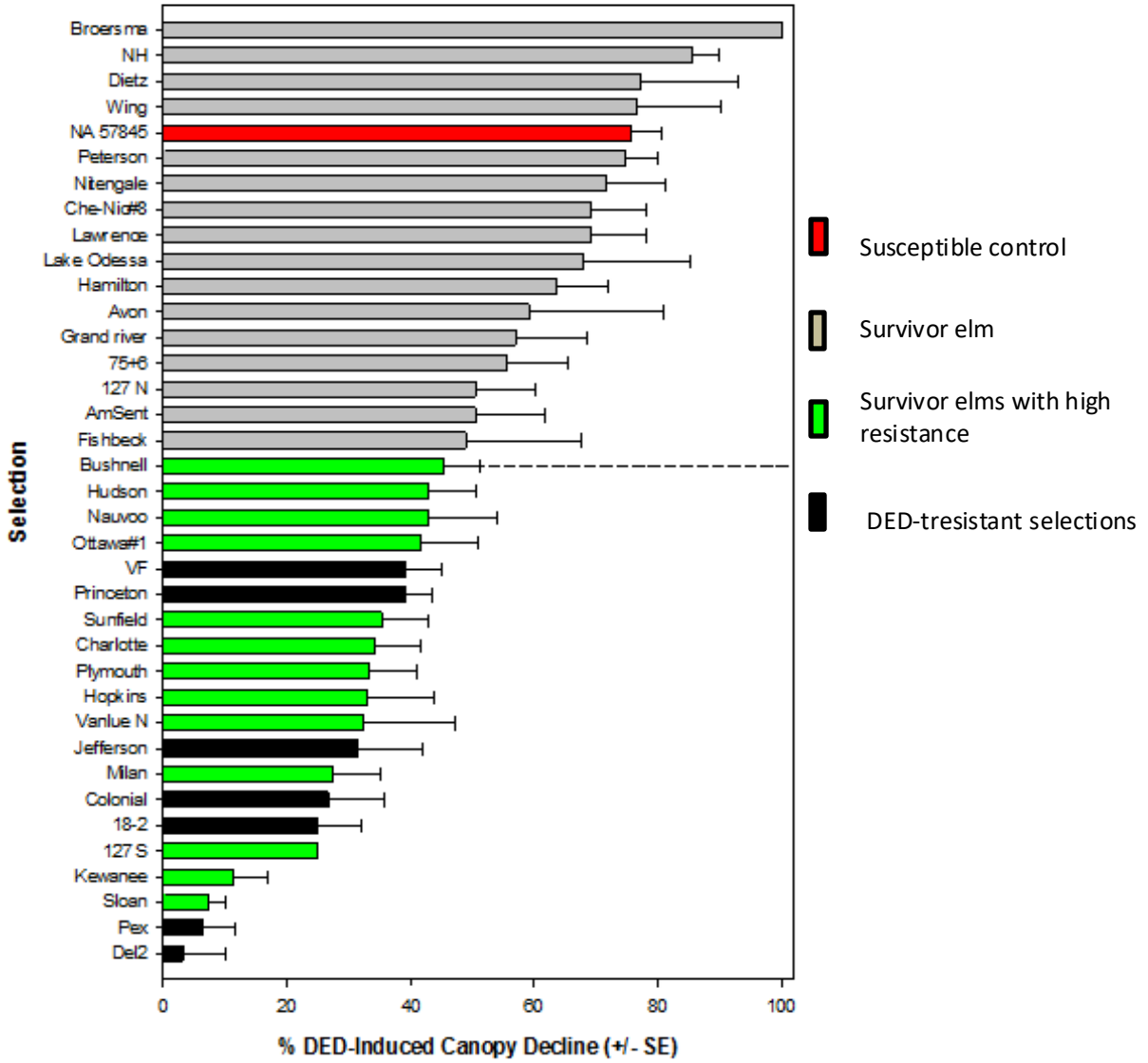
From softwood cuttings to clonal trees in field trials

Inoculation with DED fungus

Rate canopy decline post-inoculation

DED inoculation trial results

Clones of 29 survivor American elms were planted in complete replicate blocks in Delaware, OH and inoculated with DED 10 years after planting.



Elm restoration in New England

- Work established by Christian Marks while at TNC
- Have clones and/or progeny of over 50 large survivor elms from New England
- 2 plantings in VT (Benson, Lemington)
- 2 plantings in central OH

Elm restoration in New England

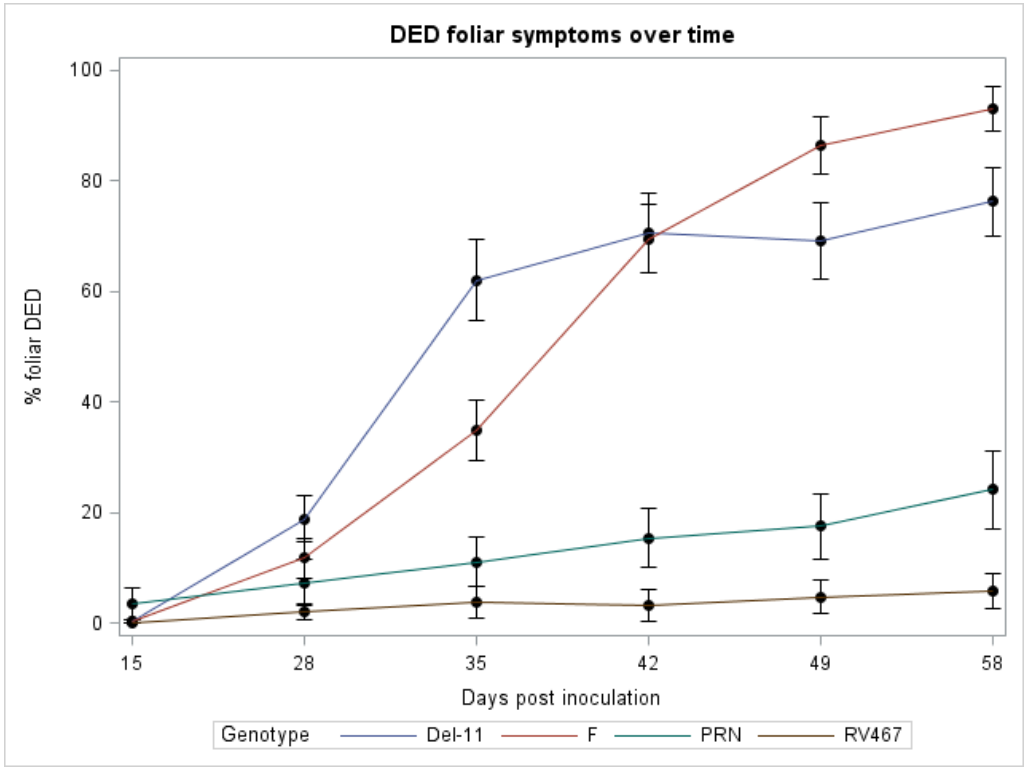
Inoculating >3000 New England survivor elm progeny and clones in OH trials spring 2025

Have refined a potted elm assay

Goal: To accelerate the identification of tolerant genotypes and reduce expenses

Inoculating one-year old elm with DED

60 dpi foliar symptoms

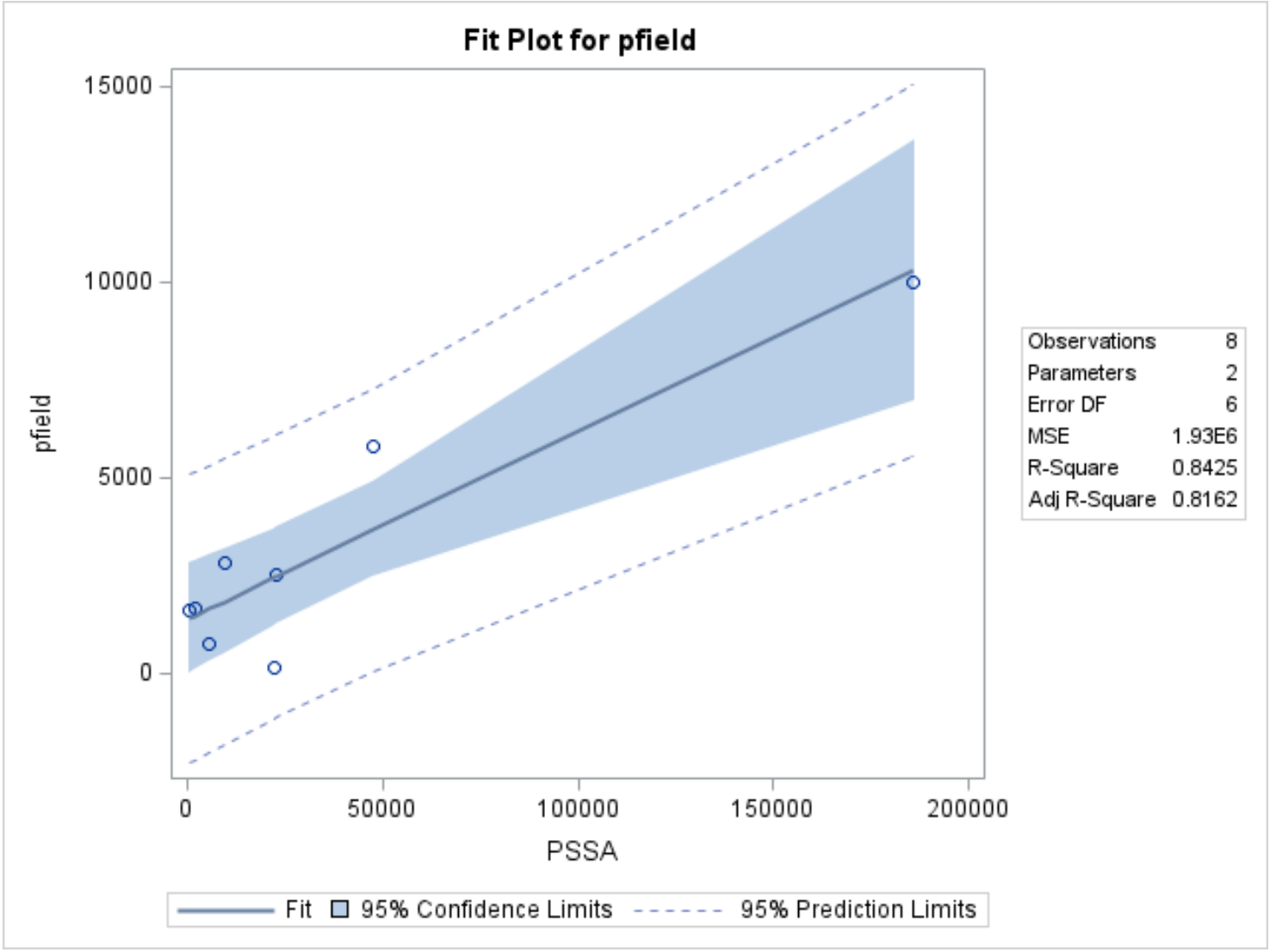


Susceptible controls

Resistant controls

Susceptible elm (left) and resistant elm (right)

Comparing potted assay with field trial ratings of resistance



Testing other tools to phenotype survivor elms

- Near-infrared spectroscopy
  - A. Conrad, C. Flower, NRS; C. Rosa, A. Miller, Penn State University
- Hyperspectral/multispectral imaging
  - J.Jian, X. Wei, S. Fei, Purdue University, A. Conrad, C. Flower, NRS
- Transcriptomics
  - C. Rosa, A. Miller, Penn State University; C. Flower, NRS

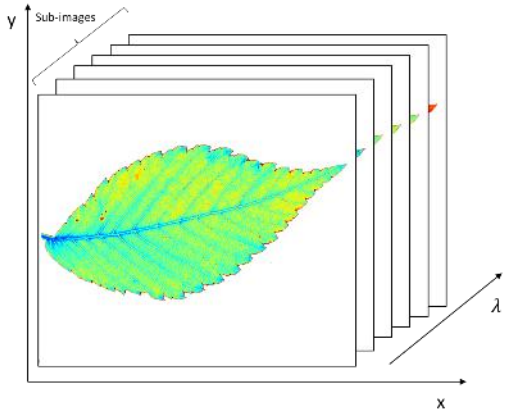


Image credit: J. Jian, X. Wei, Purdue University

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