Ash Tree Breeding and Resistance to the Emerald Ash Borer

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Holden Forests & Gardens

Importance of Ash (*Fraxinus spp*.)

- Used for iconic American products:
    Louisville Slugger baseball bats
    Fender, Taylor guitars (white, green)

- Important timber species *(white)*

- Common landscape & street trees (*white, green*)
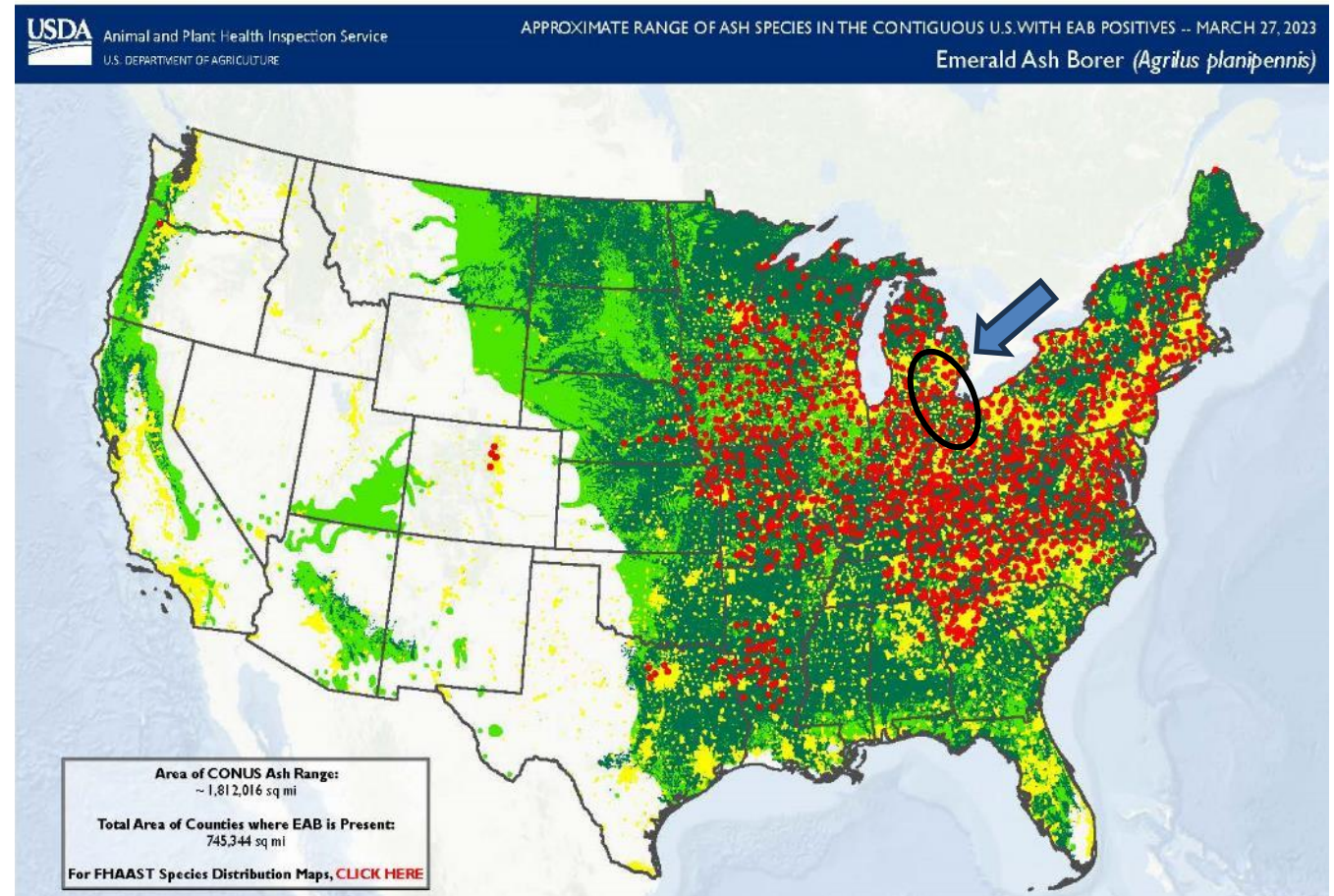

- Ecologically important riparian & wetland forest species (*green, black, pumpkin, Oregon*)

- Regulation of wetland hydrology (*black, green*)
    - *Contribute to climate change, loss of black ash=conversion of >300 million acres of forest to non-forest*

- Agroforestry-one of few species that can survive in Plains states (*green*)
    - *Increase in non-source point of pollution*

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

- 40 % of range of ash infested by EAB

- 9 out of 16 U.S. species are in this range

IUCN Red List (iucn.org):

- 5 species "critically endangered": Green, white, black, blue and pumpkin ash

- Carolina ash "endangered"

- Oregon ash "near threatened"

USDA Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

APPROXIMATE RANGE OF ASH SPECIES IN THE CONTIGUOUS U.S. WITH EAB POSITIVES -- MARCH 27, 2023

Emerald Ash Borer (*Agrilus planipennis*)

Area of CONUS Ash Range:
~ 1,812,016 sq mi

Total Area of Counties where EAB is Present:
745,344 sq mi

For FHAAST Species Distribution Maps, CLICK HERE

- Initial EAB County Detection
- Ash Distribution
- Potential Urban Ash Distribution
- Approximate Range of Ash

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Hope: The Story of Lingering Ash

It all started with ash monitoring plots:

2005-2015:
>3000 ash trees tracked individually
>6000 total trees tracked individually
5 ash species, range of ash densities and habitats
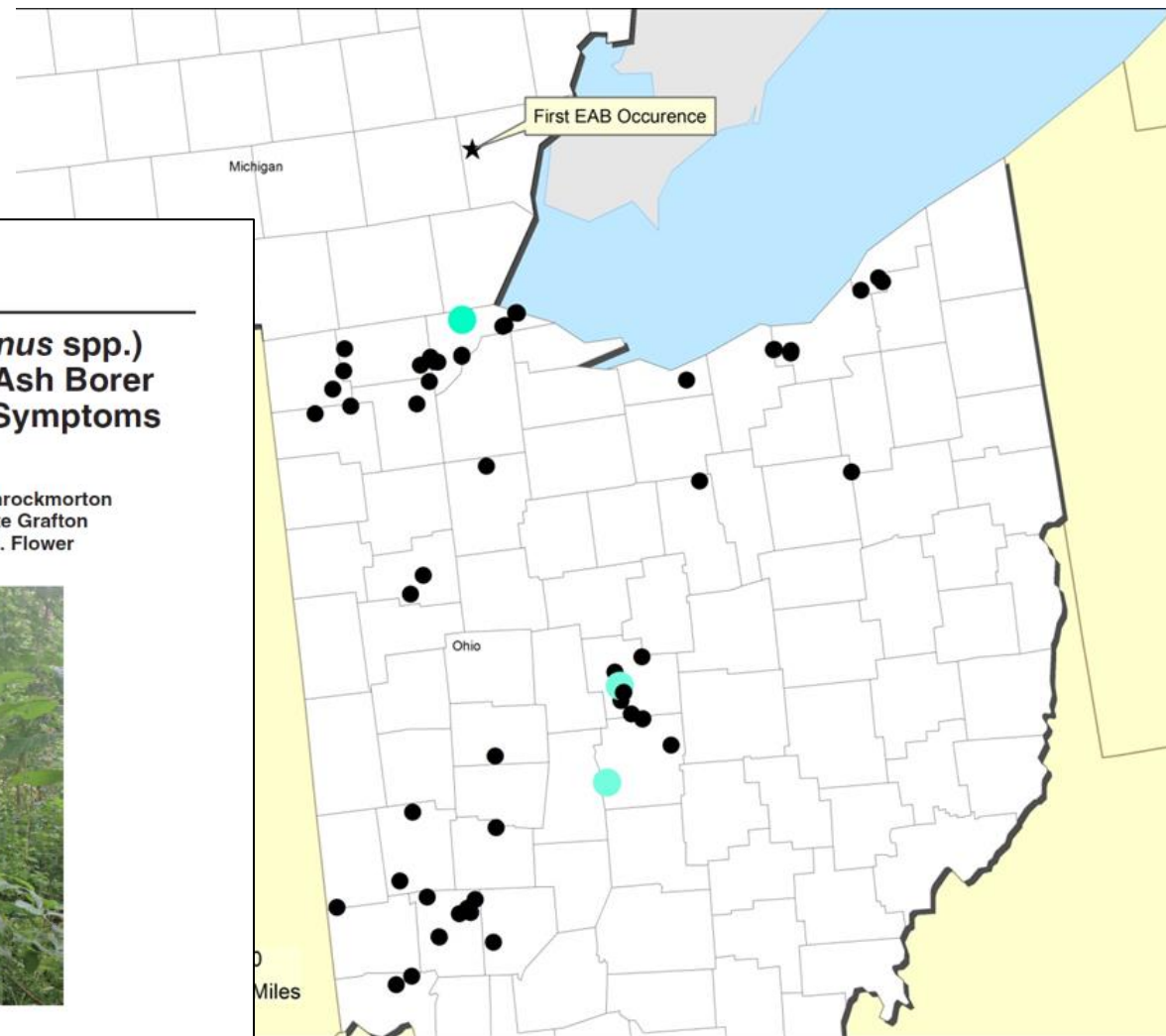
Monitoring Ash (*Fraxinus* spp.) Decline and Emerald Ash Borer (*Agrilus planipennis*) Symptoms in Infested Areas

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

First EAB Occurence
Michigan
Ohio
Miles

EAB Population Dynamics also Monitored

(slide by Kathleen Knight)

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EAB population dynamics
As EAB populations peak, ash mortality accelerates

Slide by Kathleen Knight
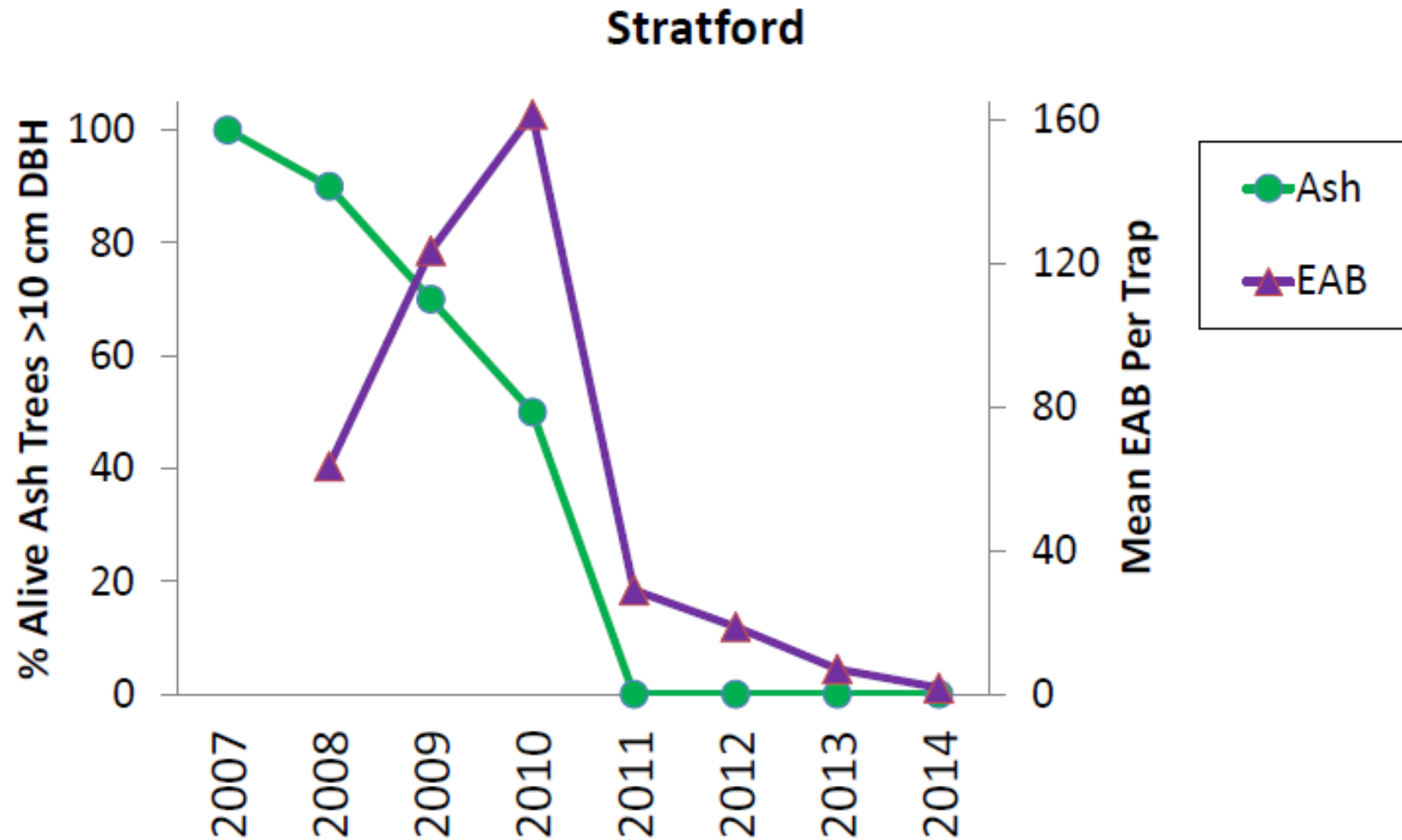
But ALL of the ash trees didn't die!

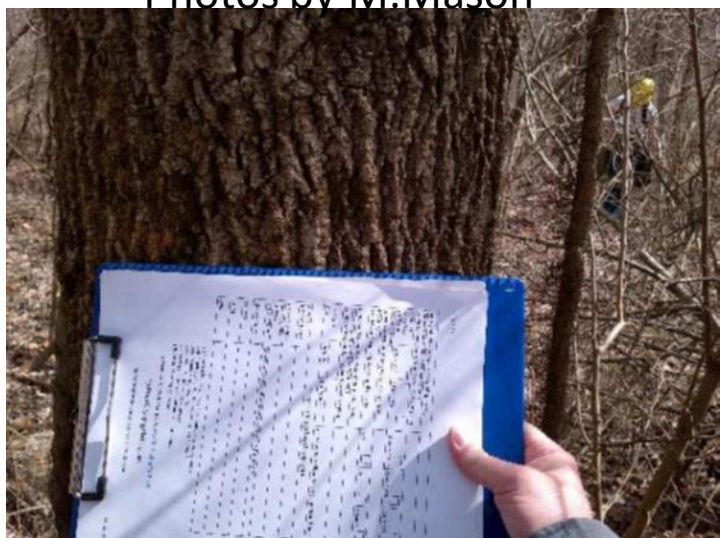"Lingering" ash trees found both individually and in clusters:

Photos by M.Mason
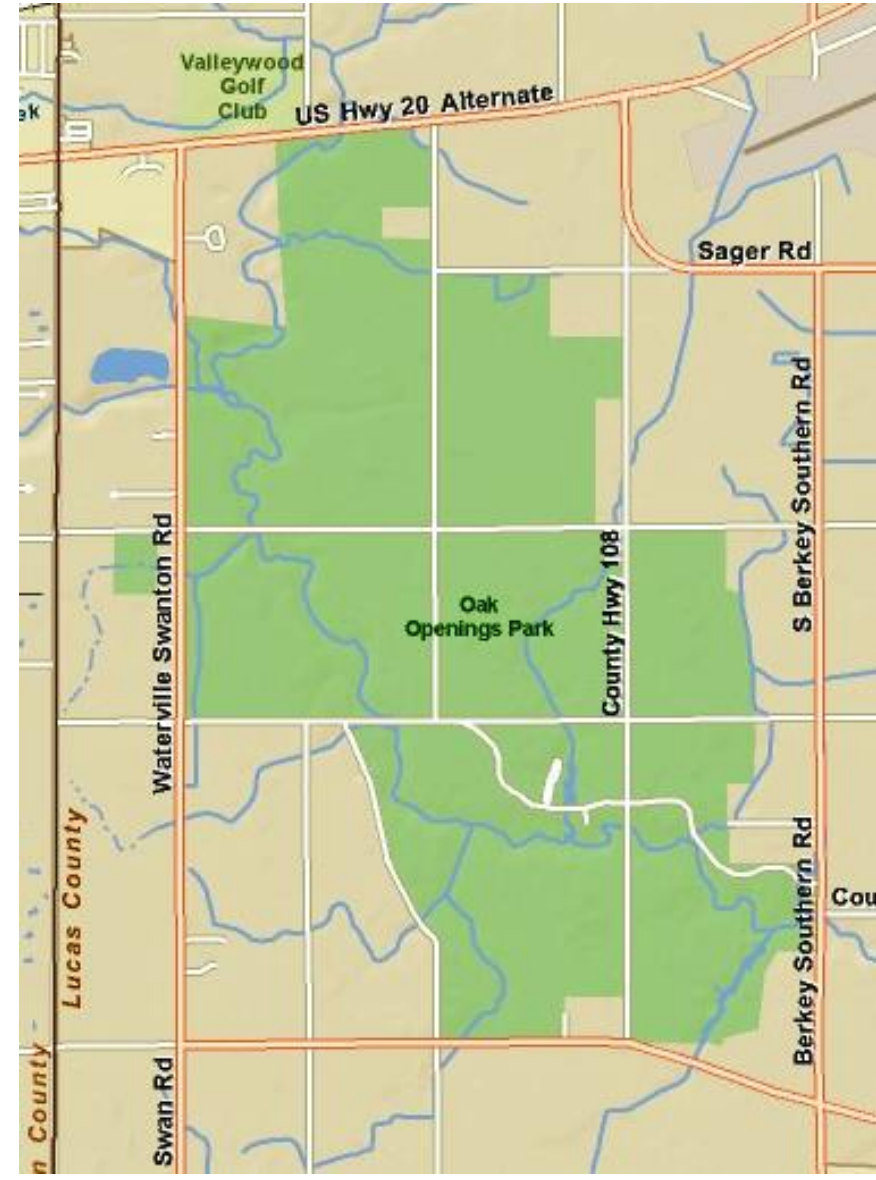

Photo by J. Koch

Photo by K. Knight

And don't appear to be 'escapes'

Lingering Ash "Cluster": 2010 Survey of Swan Creek Floodplain
(in Oak Openings Park near Toledo, OH)

Estimated 11,000
ash trees had died

(From K. Knight)

Live ash

- Found 284 live ash (2.6 %)

- 108 of these ash trees had
  Healthy canopies (1%)!!!

- Continued monitoring:
  - Trees with healthy canopies
    tended to survive over time

  - Declining trees tended to die

  - Even healthy trees are weakened
    so can die from other causes

  - *EAB persisting at low levels and
    may continue attacking trees*
    (lingering and regeneration if present)

Photo by
K. Knight

What does resistance look like?

Partially resistant trees may simply live longer than susceptible trees (and may be further improved through breeding!)

Susceptible   **Partial Resistance**   **Resistant**

(Common)   (Rare)   (Extremely Rare)

Dead   **Healing bole**   **Healthy bole**

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Criteria for Selection of Lingering Ash for Resistance Testing:

Full Crown
(fine twigs intact)

- Natural forest long infested by EAB

- Large enough to have been infested during peak EAB

- Healthy canopy

- Alive at least 2 years after mortality rate leveled off

Winter Photos

Healing Bole
(not 'immune'))

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Criteria for Selection of Lingering Ash for Resistance Testing:
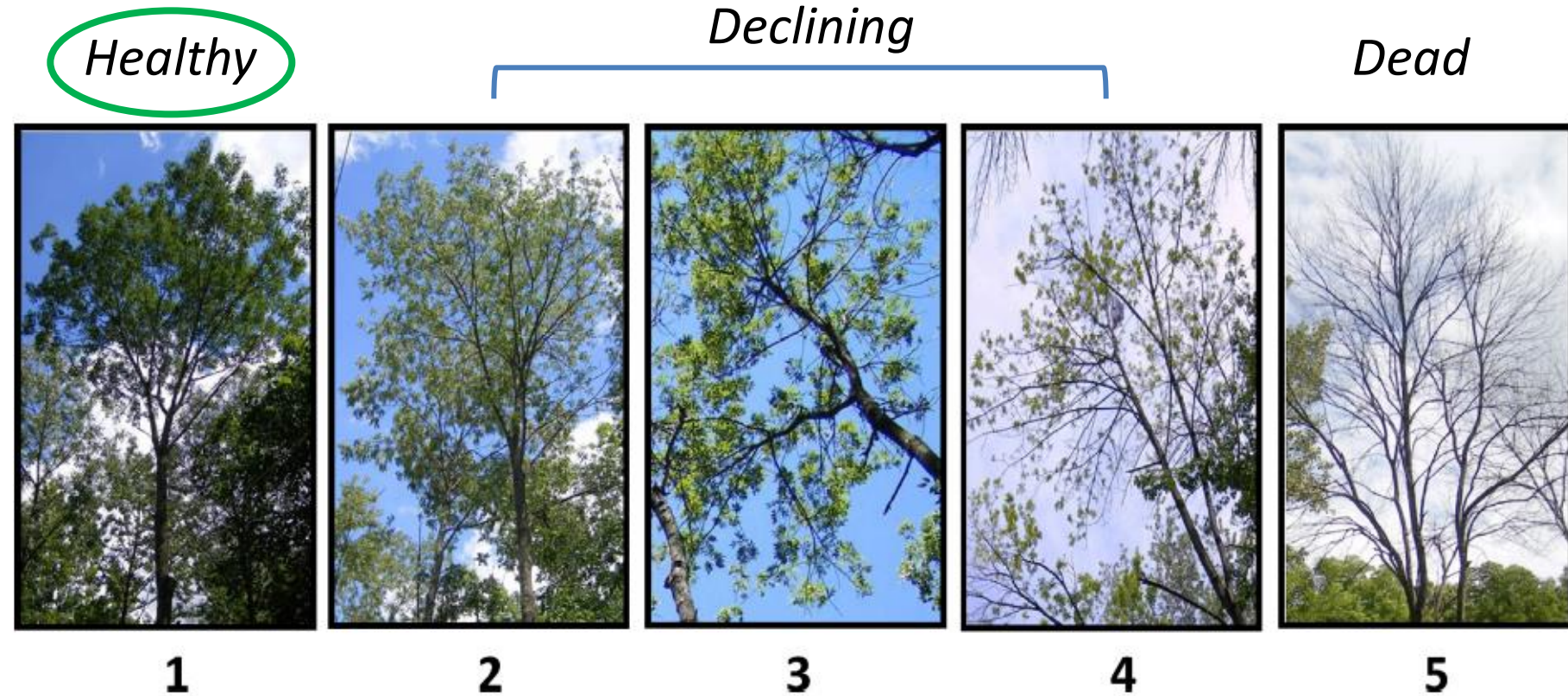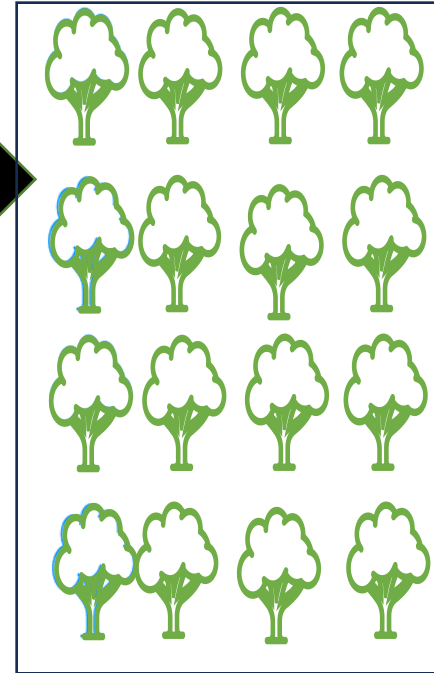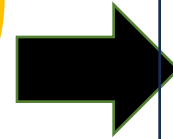

Summer Photos (from Kathleen Knight)

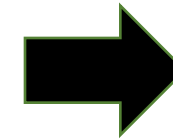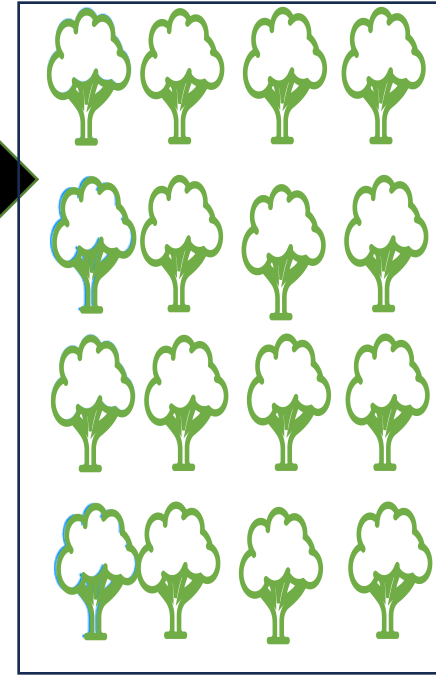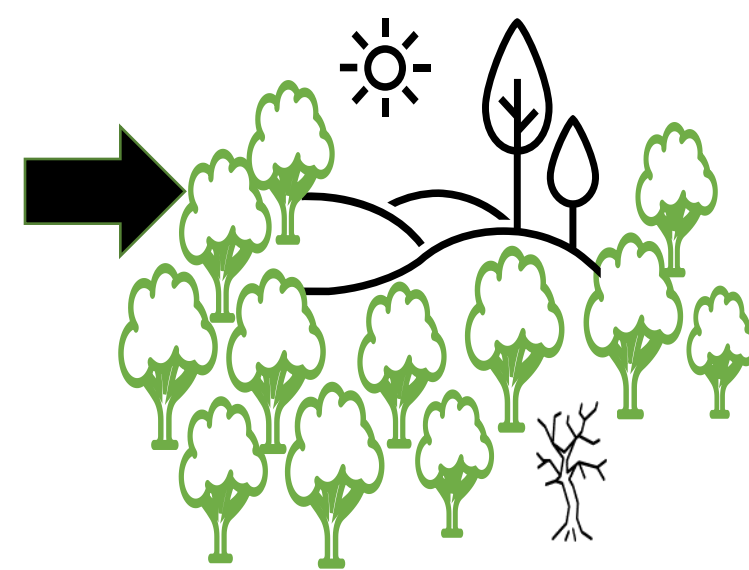# Resistance Breeding General Process
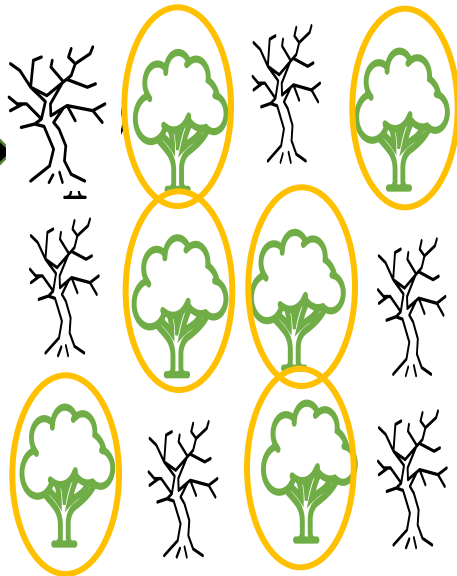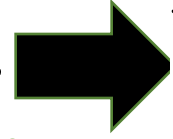
Collect: seed or scion from lingering ash

Field testing: Select best trees

Seed orchards: put best trees together, produce better seed!

Forest restoration goal: self-sustaining populations that can continue to evolve

Resistance Breeding General Process

Collect: seed or scion from lingering ash

Seedling/graft test for resistance: reduce number of trees in field tests

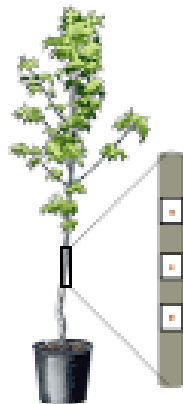**Field testing:** select best trees

Seed orchards: put best trees together, produce better seed!

Forest restoration goal: self-sustaining populations that can continue to evolve

Test for Resistance
(EAB egg bioassay)

8 wk
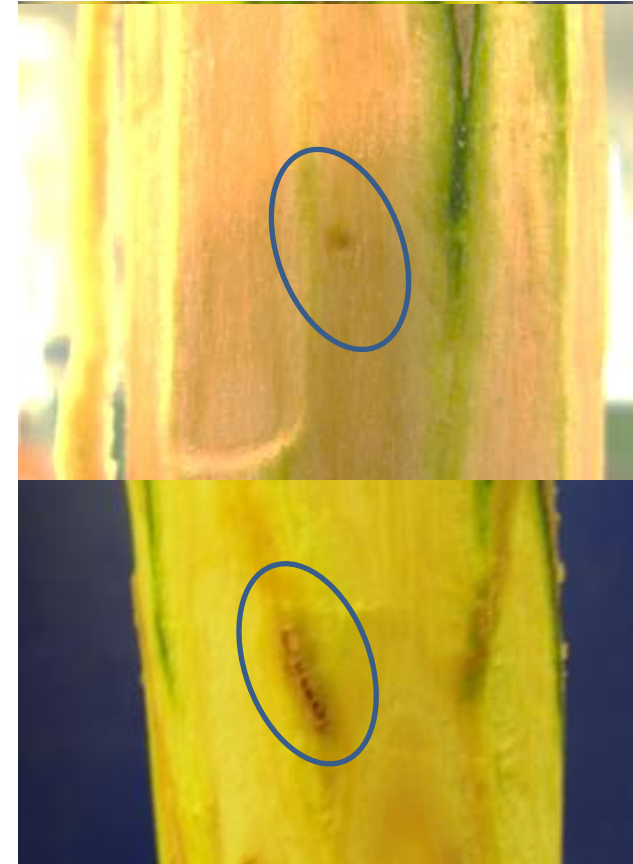
Coffee filter with eggs affixed to bark

Healthy larva

Host-killed larva

Better Trees kill more Larvae!

Breeding Increases Frequency & Amount of Resistance (Based on bioassay data)
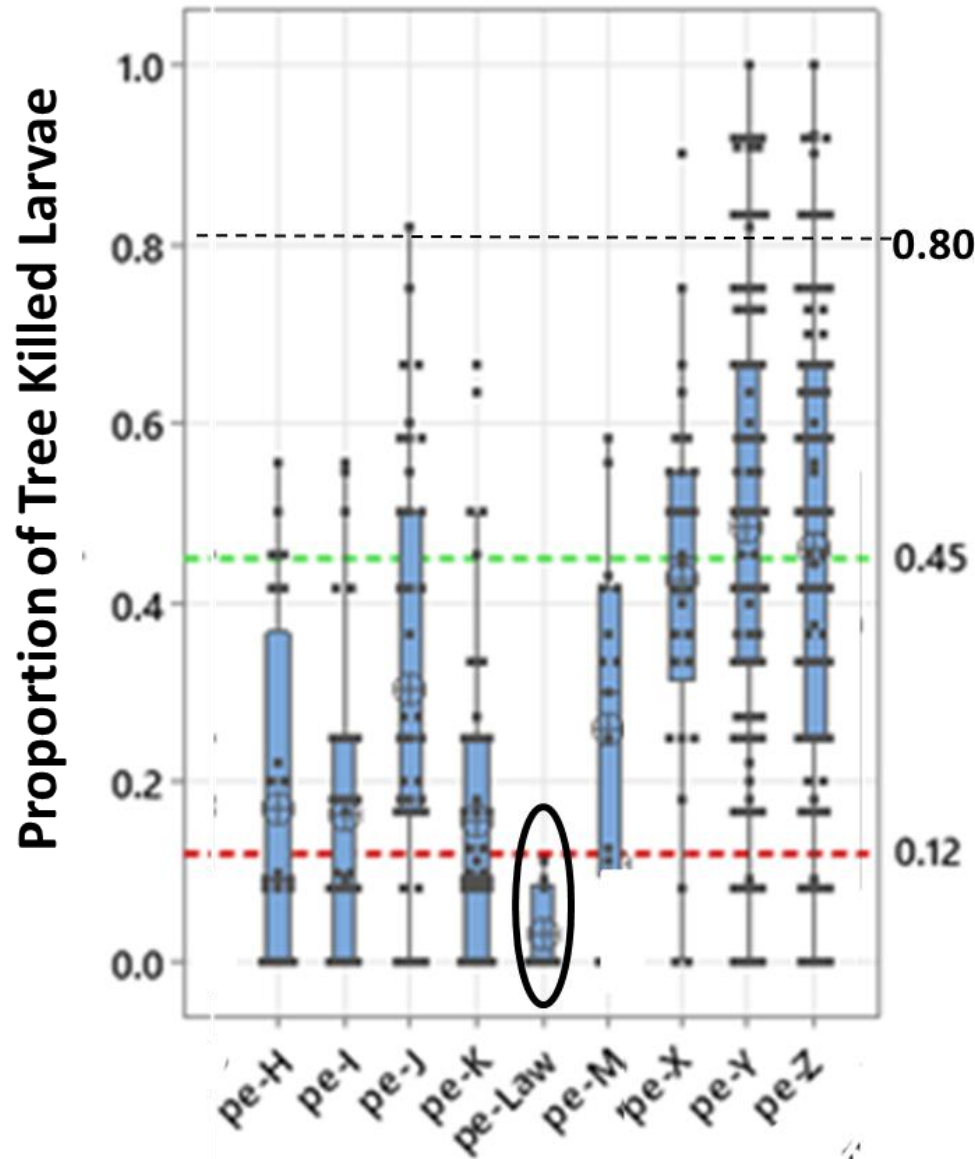
Manchurian ash cultivar: resistant control
(~40 % of families have seedlings at or above 80 % kill)

Best performing lingering green ash field selection
(~80 % of families have seedlings at or above 45 % kill)

Best performing unselected/susceptible seedling
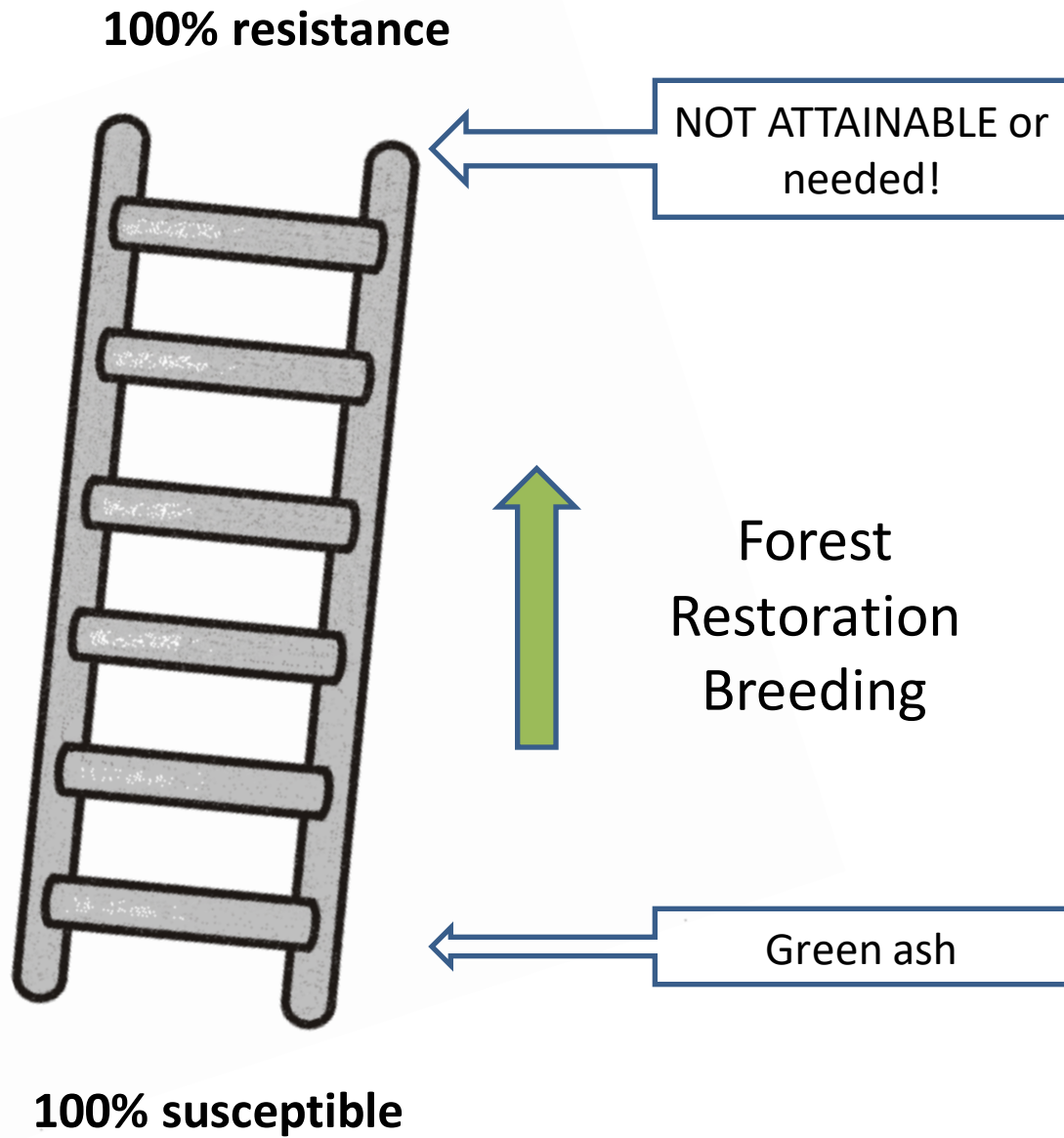
Lingering X Lingering Ash
Seedling Families

100% resistance

NOT ATTAINABLE or needed!

The Resistance "Ladder"
100% resistance (immunity) NOT the goal.

Goals of Forest Restoration Breeding:

- Maintain genetic diversity

- Resilience to adapt to changing climate, future pests, pathogens

- Retain regional adaptive traits

- Survival rate sufficient to continue to evolve/natural selection

Forest Restoration Breeding

Green ash

100% susceptible

- Confirm bioassay indicative of field performance

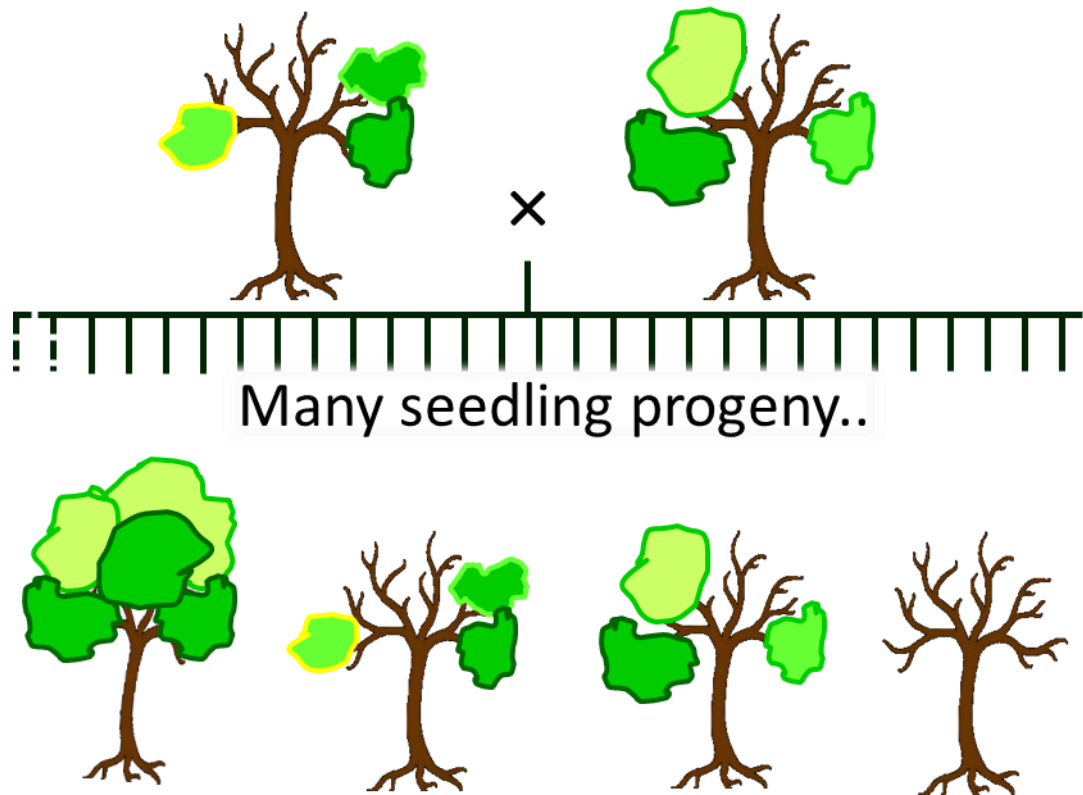- Assess environmental impacts on resistance

Grafted replicates of select lingering ash parents

Seedling progeny of lingering ash parents

Heritability: how much progeny (children) resemble their parents
The influence of genetics vs other factors on the expression of resistance

Many seedling progeny..

**Heritability
(0 is lowest, 1 is highest)**

- Human height = 0.8

- Natural populations = 0.1 – 0.2

- Green ash seedlings = 0.63 – 0.87
  (bioassays/# larvae killed in
    773 progeny, 27 families)

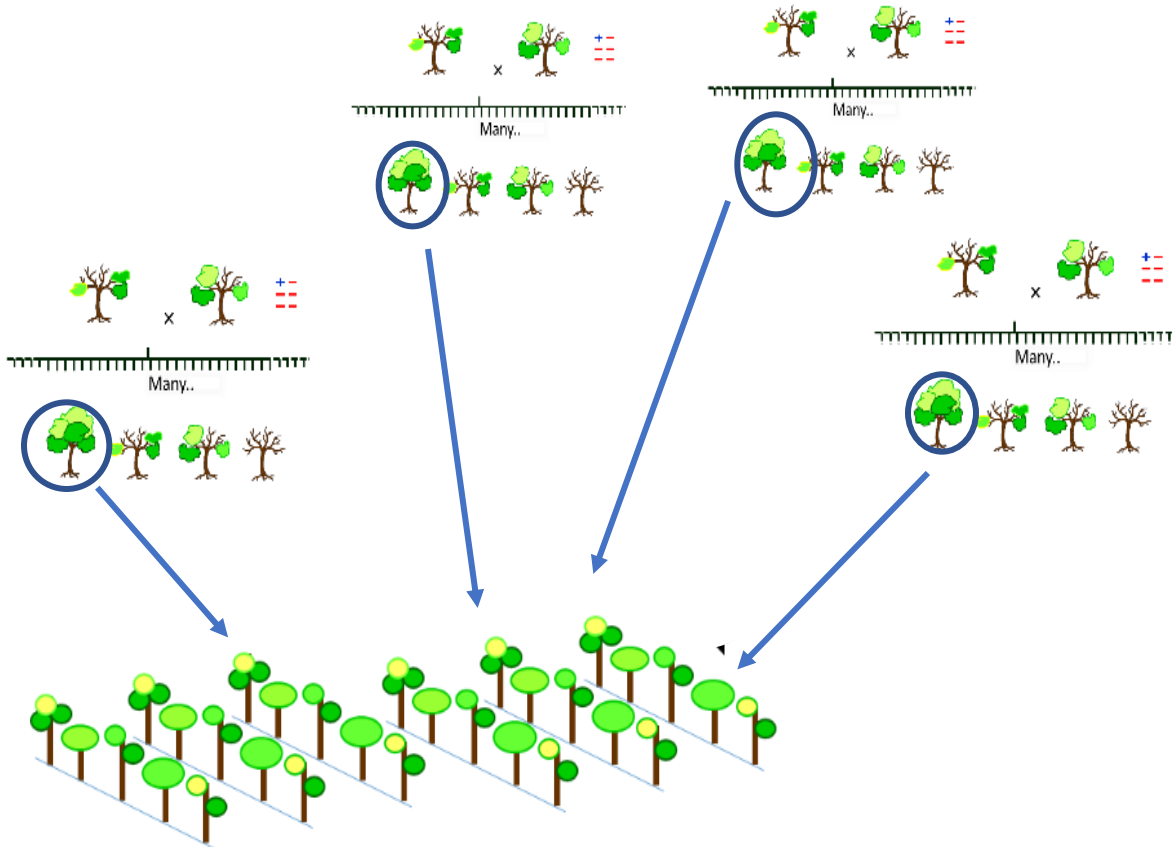- High enough to suggest breeding
  will work!

- Breeding combines best genes from each parent
- Further improvement with each generation

Bring best trees together, Get better seed!

Lingering ash x lingering ash seedling seed orchard – appropriate for planting in Eastern OH, southern MI, western IN

Process must be repeated across the range with new genotypes!

Breeding is part of Integrated Pest Management!

⬆Host-Resistance **+⬇Insect Population**
(selection & breeding) **(biocontrol)**

= Sustainable ash resources
in North America

"parasitism (biocontrol)…<u>coupled with moderate to high levels of host plant resistance</u> should permit survival and regeneration of ash…"
(Duan et al. in Biology and Control of EAB FHTET-2014-09)

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How can you help?

- Watch for and preserve lingering ash
- Submit them to a database
  - Treesnap   https://treesnap.org/
  - Monitoring and Managing Ash (MaMA) http://www.monitoringash.org/
- Great Lakes Basin Forest Health Collaborative
  - https://holdenfg.org/great-lakes-basin-forest-health-collaborative/
  - Coordinator:Rachel Kappler rkappler@holdenfg.org
    - training
    - networking partners to establish breeding programs
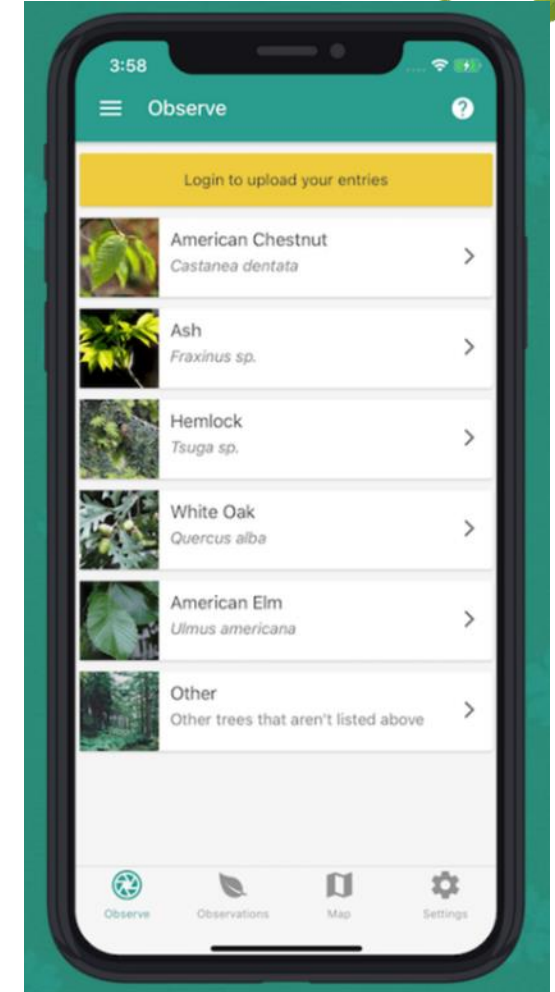
Lingering Ash Criteria

To be considered for resistance testing

- >95% mortality of mature ash has occurred in the area at least 2 years ago (or 4 years past & 50 % mortality)
- Location is in natural woodland area
- Large enough to be preferred by EAB during peak infestation (trunk size)
- Has healthy canopy
  (assessed between June & September)

Not all lingering ash trees are resistant, but all resistant trees are lingering ash (~50 % are resistant based on bioassay)

Identification & Selection of "Lingering" Ash"
(importance of monitoring plots)

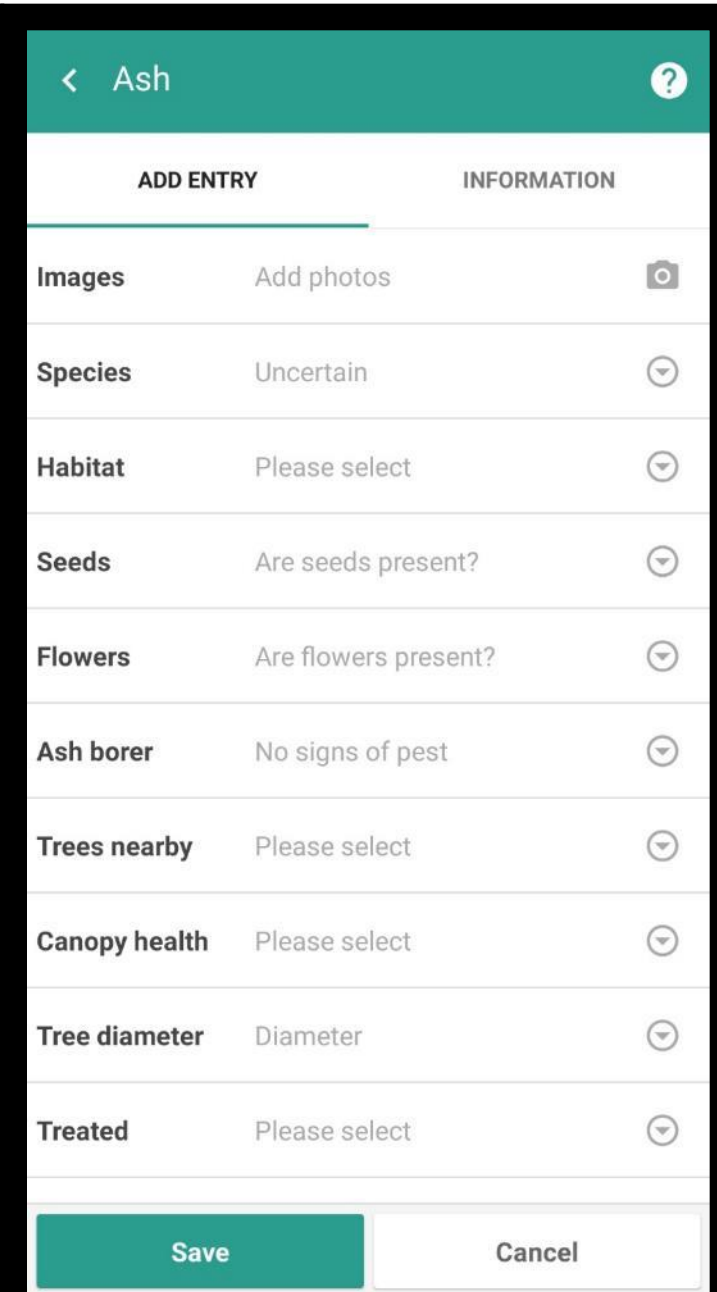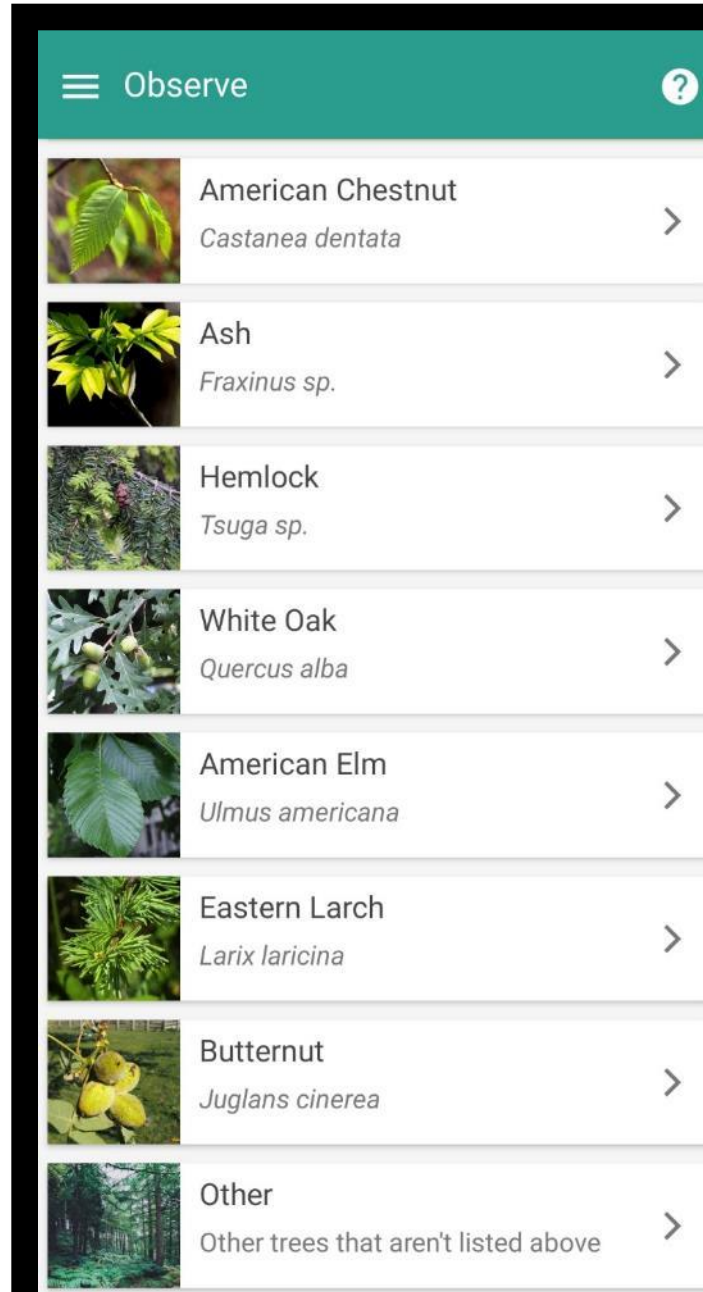

Stratford
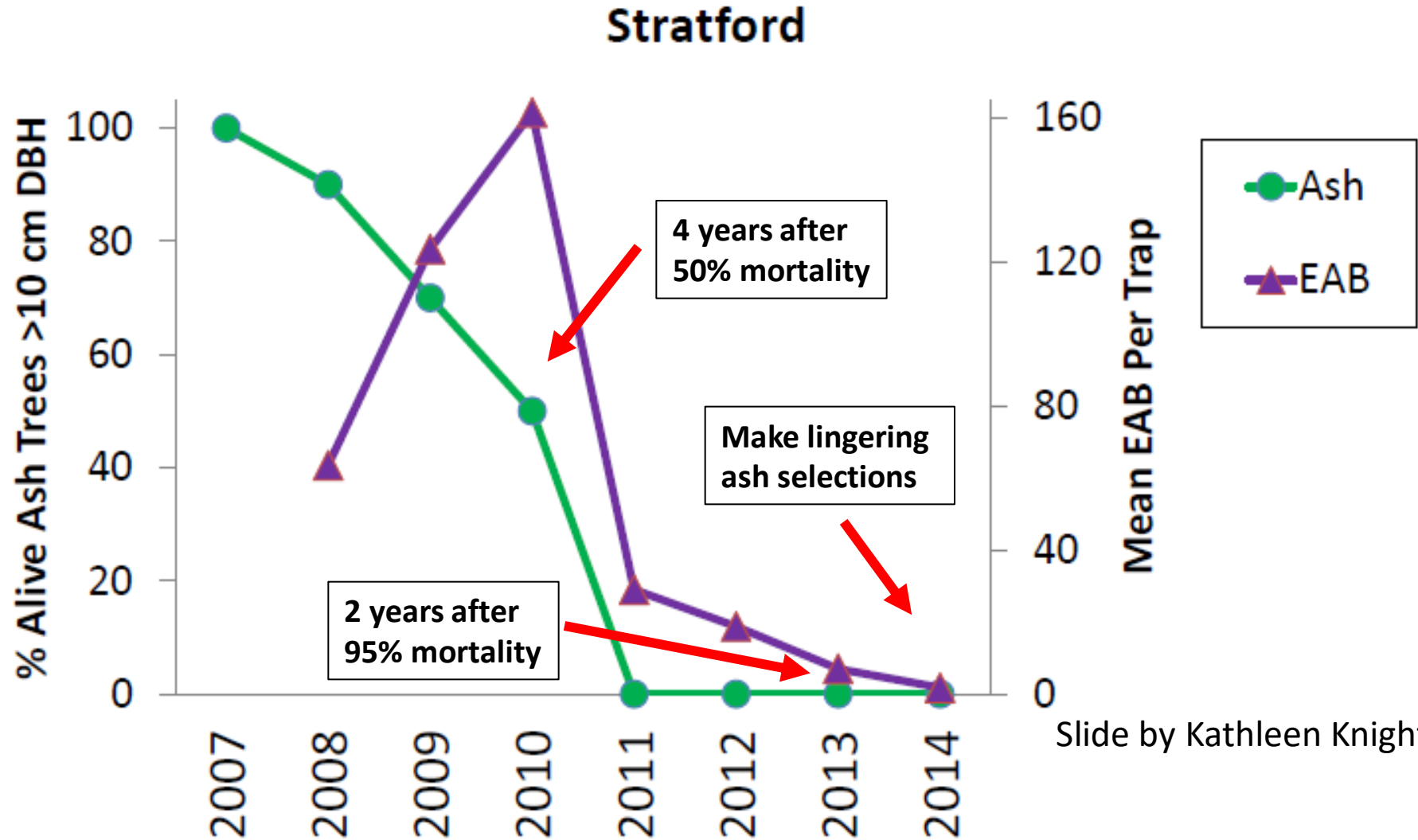
Slide by Kathleen Knight

TreeSnap app

Smart phone app for recording individual trees of various tree species.

Each species listed is part of different projects

USFS & I use this to search & verify new reported lingering ash trees for the breeding program

Managing & Monitoring Ash (MaMA) projects

- Monitoringash.org

- Use Anecdata app projects to keep track of ash/EAB progression across time

  - Ash/EAB survey – assess presence or absence of EAB per individual tree

  - Monitoring plot network – create ash plot(s) to record EAB symptoms over time

  - Lingering ash search – report lingering ash in areas where monitoring plots indicate it is time to look for healthy ash surrounded by dead ash

- Able to get assistance from professionals and citizen scientists

Ash action table (from monitoringash.org)

Pre-infestation EAB not yet present	Early infestation Some EAB signs; some dead ash along w/ healthy and declining trees	Mid-infestation Widespread EAB signs; higher ash mortality; few healthy trees	Late infestation Ash largely dead, with remainder very unhealthy except for *very rare* lingering ash
Assess ash presence/importance			
Decide which trees to be treated vs. cut vs. left for mortality monitoring/lingering ash detection			
Identify sites where mitigation needed (for invasive plants, hydrological changes, etc.)			
Document infestation onset			
Establish/use mortality monitoring plots; detect when thresholds reached			
		Record, report, protect potential lingering ash	
©2017 - 2018 Ecological Research Institute			Find/mark lingering ash, report for possible scion collection, possibly collect their seed

Monitoring and Managing Ash (MaMA)
monitoringash.org

In NY/New England, used to ID where/when to search for lingering ash, based on

➢ EAB detection data to predict when/where 95% EAB-induced mortality will be reached

➢ Actual mortality data from MaMA's citizen science projects

Scion already collected from some trees reported through the MaMA Lingering Ash Search project

Lingering white ash

Lingering black ash

Lingering green ash

MaMA's citizen-science projects are all on the *Anecdata.org* platform

MaMA Ash/EAB Surveys
Add Observation

For more information,
visit www.MonitoringAsh.org or email
outreach@monitoringash.org

MaMA Monitoring Plots Network
Add Observation

MaMA RAMA Rapid Ash Mortality Assessment
20

MaMA Lingering Ash Search
Add Observation

Anecdata™

Great Lakes Basin Forest Health Collaborative
Focus on Pests & Diseases

Emerald ash borer

Hemlock woolly adelgid

Beech leaf & bark disease

Dutch Elm Disease

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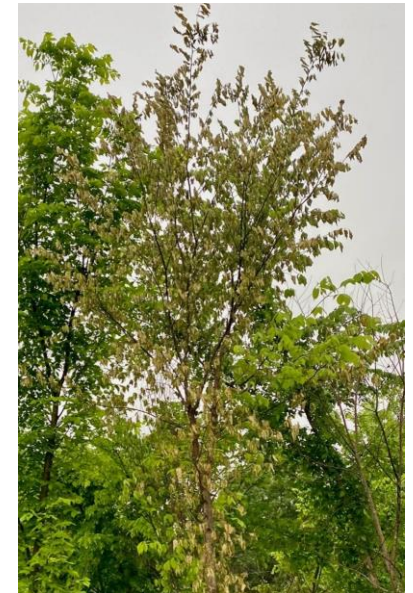
Mission: to expand resistance breeding activities of threatened species through training & partnerships

Great Lakes Basin Forest Health Collaborative

Network of Partners:

- May include federal/state/local agencies, non-profits, citizen scientists & private landowners

- Partners share resources, tasks & updates

- I Keep Partners Up to Date on Research & Activities

- I Train Partners on Breeding Activities

  - Monitoring, Propagating, Growing

  - Hands on and Webinar based

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FORESTS &
GARDENS

Summary

- EAB is a severe threat to our North American ash species

- Monitoring allowed us to observe natural selection (identify"lingering ash")

- FS researchers developed methods to identify, propagate and test ash trees for resistance to EAB – BREEDING WORKS!

- Together we can maintain ash as a healthy part of our forests

- *Need partners to help in all aspects of establishing improved seed orchards across the range of our ash species!!*

HOLDEN FORESTS & GARDENS

Thank You!
Questions?

Jennifer.Koch@usda.gov

rkappler@holdenfg.org

Holden Forests & Gardens webpage:

holdenfg.org/great-lakes-basin-forest-health-collaborative/