

## **Emerald Ash Borer:** **Host Plant Resistance Research**

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## **Millions of dead ash trees (and counting)**



### **Host Impact:**

Larvae feed under bark; disrupt transport of water, nutrients, carbohydrates.

All major ash species are susceptible (white, green, black, blue, pumpkin).

Healthy trees killed within 1-3 years of first symptoms.

Trees of all size are colonized: 1/2 inch samplings to the largest mature trees.



### **Objectives:**

1. Patterns of ash mortality in forests.
2. Does forest composition affect susceptibility to invasion?
3. Overview of host plant resistance research from a coevolutionary perspective.

## **Huron River Watershed**



- 33 forested stands
- 3 plots (0.1 ha) / stand

## Huron River Watershed



White Ash

Green Ash

Black Ash

>50% Species Dominance

Increasing Moisture Gradient

Smith (2006)

## Ash Decline Rating Scale



1

2

3

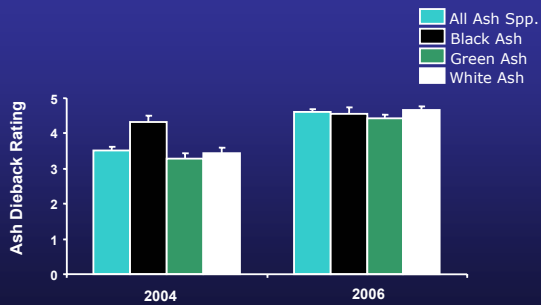
4

5

No decline

Death

## Tree Decline Advanced from 2004 to 2006



## Ash Decline Rating Scale



1

2

3

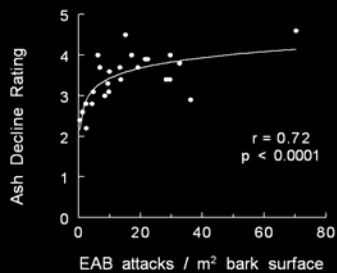
4

5

No decline

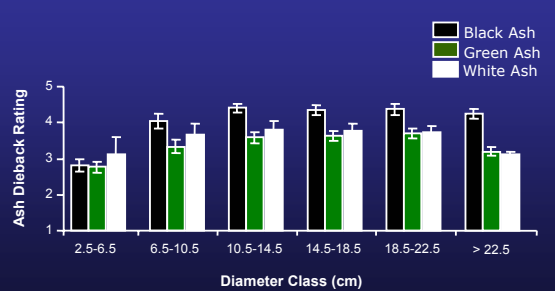
Death

As EAB attack density intensity increased, ash decline intensified



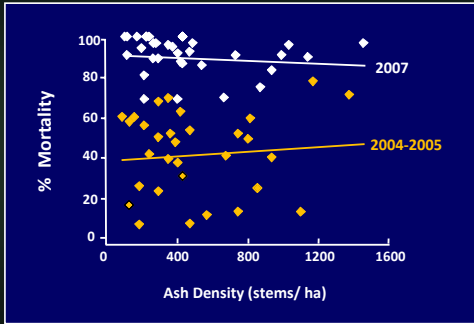
Annemarie Smith, 2006

## Ash Dieback by Species and Size Class



Annemarie Smith, 2006

No relationship between ash density and EAB-induced mortality



A. Smith, K. Gandhi, and D. Herms, Ohio State Univ.

No relationship between ash decline or mortality and:

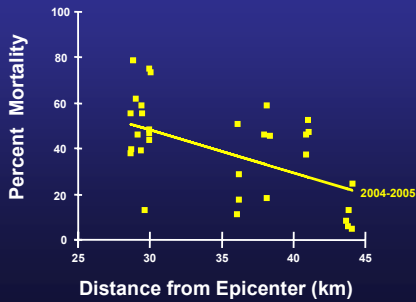
- Ash density
- Ash basal area
- Relative dominance of ash
- Relative density of ash
- Stand density
- Stand basal area
- Any measure of species diversity.



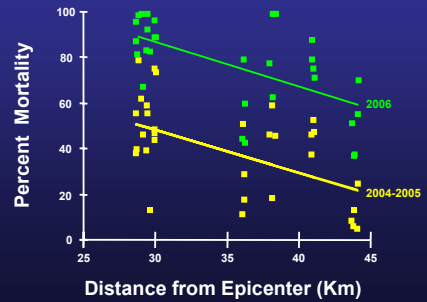
Suggests limited potential for EAB-proofing via silviculture

Annemarie Smith, 2006

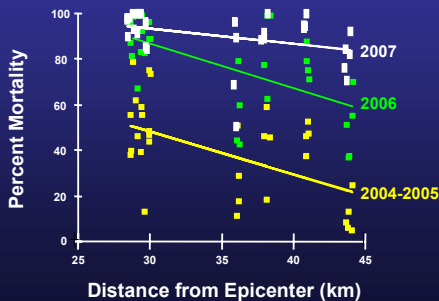
Mortality declined 2% with each km from epicenter



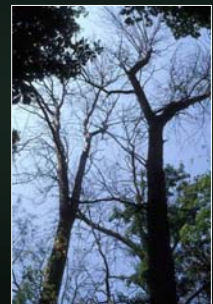
Mortality increased 30% per year, with no change in slope



Slope no longer significant, as vast majority of trees are dead



Why are North American ash trees being devastated by an insect that is not a pest in Asia?



## Hypotheses generated from bronze birch borer research.



David G. Nielsen, The Ohio State University / OARDC



## 20 year study of variation in birch resistance to bronze birch borer

Nielsen and Herms, In prep.

7 species, 200 reps / species, 1400 trees total:

### North American:

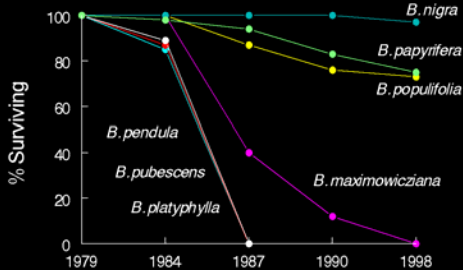
*B. nigra*  
*B. papyrifera*  
*B. populifolia*

### Exotic species:

*B. pendula*  
*B. pubescens*  
*B. platyphylla*  
*B. maximowicziana*



## 20 Year Record of Birch Mortality from Bronze Birch Borer



### North American species:

*B. nigra* 3%  
*B. papyrifera* 27%  
*B. populifolia* 25%

### Exotic species:

*B. pendula* 100%  
*B. pubescens* 100%  
*B. platyphylla* 100%  
*B. maximowicziana* 100%

**Conclusion:** no evolutionary history, no resistance.

## EAB Host Plant Resistance Research Program:

1. Identify resistant germplasm via inter- and intra-specific comparisons in common gardens: E. Rebek & D. Smitley (Michigan State University)
2. Identify biochemical mechanisms of resistance: E. Bonello (OSU) & D. Cipollini (Wright State University)
3. Identify resistance genes and markers via comparative proteomics: J. Whitehill & E. Bonello (OSU), and J. Koch (USDA Forest Service)
4. Interspecific hybridization and backcrossing to generate resistant genotypes (e.g. chestnut blight program): J. Koch (USDA Forest Service)

## Experimental Ash Plantation in Michigan:

Comparative study of susceptibility to EAB

### North American:

*F. pennsylvanica*  
*F. americana*

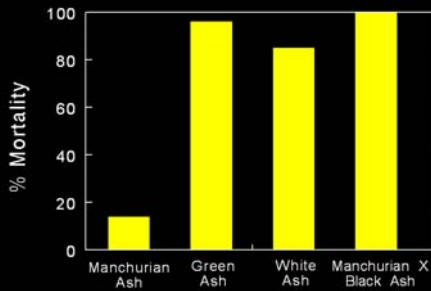
Asian: *F. mandshurica*

### North American – Asian Hybrid:

*F. nigra* x *F. mandshurica*



Manchurian ash is highly resistant;  
North American ashes are very susceptible.



Rebek et al. 2008. *Environ. Entomol.* 37:242-246

Stress effects on resistance to wood-borers:  
*a priori* predictions.

Coevolutionary history: stress decreases resistance.

No coevolutionary history: stress has no effect.

### Predictions

Stress increases susceptibility of Manchurian ash to EAB; no effect on resistance to native clearwing borers

Stress has no effect on susceptibility of white and green ash to EAB; increases susceptibility to native clearwing borers

Stress predicted to decrease bronze birch borer resistance of native paper birch (*B. papyrifera*)



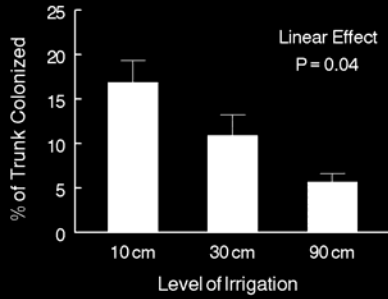
### Experimental plots:



Experimental approach: manipulate water availability, create simulated outbreak.



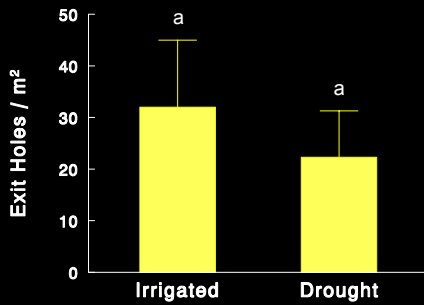
Drought stress increased bronze birch borer colonization



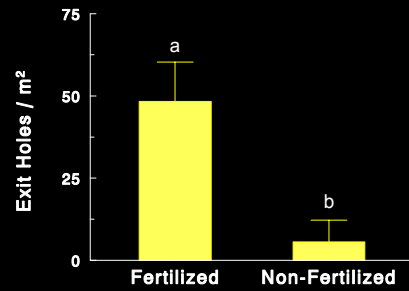
Stress predicted to have little effect on bronze birch borer resistance of European white birch (*B. pendula*)



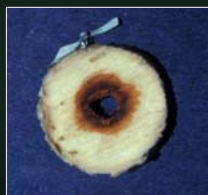
Drought stress had no effect on level of bronze birch borer attack



Fertilization dramatically increased bronze birch borer attack



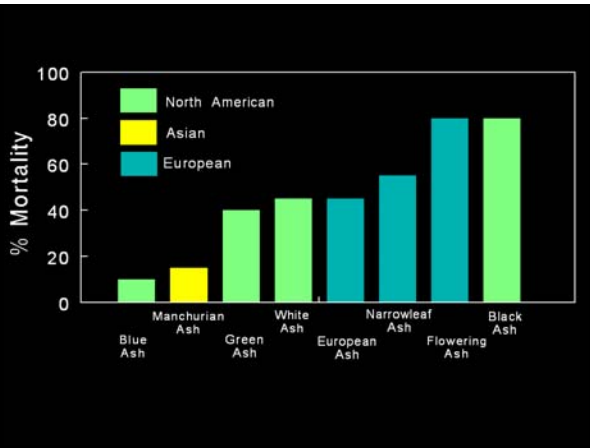
Rapid wound-induced periderm (callus) formation and secondary metabolite accumulation as integrated resistance mechanisms.



Common Garden II

- North American:
  - F. pennsylvanica*
  - F. americana*
  - F. quadrangulata*
  - F. nigra*
  - F. latifolia*
- Asian:
  - F. mandshurica*,
  - F. chinensis*
- European:
  - F. ornus*
  - F. excelsior*
  - F. oxycarpa*

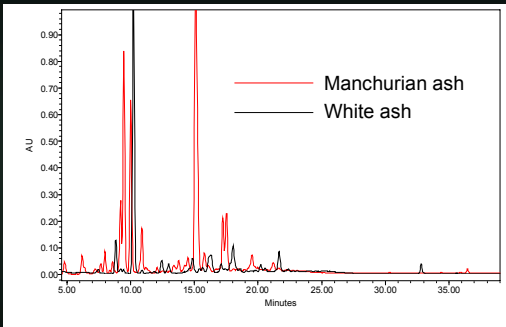




### Constitutive and wound-induced defensive chemistry of ash.



### Phenolic profile of white and Manchurian ash phloem



Eyles et al. 2007. *J. Chem. Ecol.* 33:1430-1448

### Proteomics and Biochemical Approaches to Understanding Resistance to EAB

Justin Whitehill

#### Biochemical Approach

HPLC and spectrophotometric methods

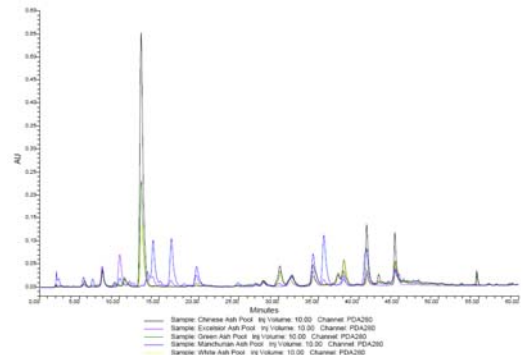
#### Proteomics Approach

2-DE and DIGE (Differential gel electrophoresis)

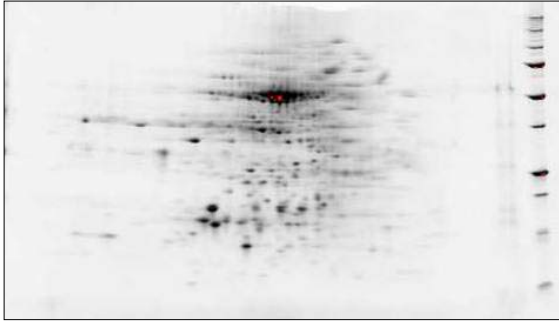
### City of Bowling Green EAB Resistance Study



### HPLC Profiles of Induced Responses of Susceptible and Resistant Ash



## 2-DE of Manchurian Ash Phloem Proteins



## Conclusions:

1. 100% ash mortality in all size classes.
2. Little potential for silvicultural management.
3. Manchurian ash is a source of resistance genes.
4. HPR research in support of breeding program is underway.

## Defense free space:

Documented examples of low host resistance where coevolutionary history is lacking.

- Bronze birch borer and Eurasian birches
- Emerald ash borer and N.A. ashes
- Hemlock wooly adelgid and N.A. hemlocks
- Balsam wooly adelgid and N.A. firs
- Beech bark scale and N.A. beech
- White pine weevil and Eurasian spruces
- Pine needle scale and Eurasian pines
- Grape phylloxera and European grape
- American chestnut and chestnut blight
- Dutch elm disease and N.A. elms



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