USDA Forest Service

UrbanForest Connections

Second Wednesdays | 1:00 – 2:00 pm ET
www.fs.fed.us/research/urban-webinars

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EMERALD ASH BORER: STATUS, MANAGEMENT OPTIONS, AND COST CALCULATORS

Deborah McCullough
Professor
Michigan State University

Cliff Sadof
Professor
Purdue University

Richard Hauer
Professor
University of Wisconsin – Stevens Point
Emerald Ash Borer: Kicking Ash Across North America

Dr. Deborah G. McCullough, Professor
Dept. of Entomology & Dept. of Forestry
Michigan State University
Special thanks to:

**MSU:** Andrea Anulewicz, Jacob Borney, Chenin Limback, Molly Robinett, Sara Tanis, Andrew Tluczek

**Washburn University:** Rodrigo Mercader

**USFS:** Therese Poland, Nathan Siegert

**Funding:** USDA Forest Service, USDA ARS, ARRA, MSU Project GREEEN
July 2002: *Agrilus planipennis* first identified as cause of ash decline in Detroit, MI & Windsor, Ontario.

March 2015: EAB present in 25 states & 2 provinces.
Many EAB “outlier” sites originated from transport of infested ash nursery trees, logs or firewood. Firewood remains a concern.
Hundreds of millions of ash trees in urban, rural, forest & riparian areas have been killed by EAB.
EAB Management in the U.S.

- Detection surveys continue
- Quarantine regulates transport of ash trees, logs & wood from infested areas.
- No overall national EAB strategy
- Landowners, foresters, municipalities must deal with EAB on their own.
- Economic costs are staggering.
EAB is already the most destructive & economically costly forest insect to ever invade the U.S.

**Annualized marginal damages in $ millions**

<table>
<thead>
<tr>
<th></th>
<th>Government</th>
<th>Households</th>
<th>Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Federal</td>
<td>Local</td>
<td>Spent</td>
</tr>
<tr>
<td>EAB</td>
<td>38</td>
<td>850</td>
<td>350</td>
</tr>
<tr>
<td>Gypsy moth</td>
<td>33</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td>Hemlock adelgid</td>
<td>4</td>
<td>66</td>
<td>44</td>
</tr>
</tbody>
</table>

*Kovacs et al. 2010. Ecological Economics
Questions we can address....

Which trees are most likely to be infested by EAB first?

Are there any resistant ash species?

When should I begin treating landscape ash trees?

Are systemic insecticide products effective?

What about biological control?

What tactics might go into an IPM program for EAB?
Host Preference & Resistance: Which trees are likely to be attacked by EAB first? Does resistance to EAB vary among *Fraxinus* species?

Continental US: 16 native ash species; Ash are also common in landscapes

Michigan: 4 major ash species: Green, White, Black & Blue ash
Beetles select hosts & leaf-feed throughout life span.
Females lay eggs between bouts of feeding & resting.
Adults feed on ash foliage for 2-3 weeks before females begin to lay eggs. *Note: This provides a key opportunity to control adults before eggs are produced.*
Larvae must survive & develop – no choice of hosts.

Larvae feed on phloem & cambium, mid summer to fall. Complete 4 instars. Most larvae overwinter as prepupae in outer sapwood or outer bark. Pupate in spring.

L2, L3 & L4 larvae in Sept.

PP larva

Pupation

Adult
Ash trees stressed by girdling are highly attractive to adult EAB. In low density sites, 5 to 20 times more larvae on girdled trees than on nearby healthy trees. Girdled trees can be used for detection, survey & as trap trees.

Adult EAB prefer sunny conditions. More beetle activity on trees fully exposed to sun than on edge trees. Edge trees are more attractive than shaded trees.
Not all North American ash species are equally attractive or vulnerable to EAB.
EAB host preference & host resistance vary among North American ash species.

**Green Ash (F. pennsylvanica)**
Grows in 44 states on a wide range of sites; often on heavy soils; common landscape & riparian species.

**White Ash (F. americana)**
Grows in 34 states, often in mixed stands on upland, fertile sites; timber valued; common landscape tree
Green ash (*F. pennsylvanica*) is consistently less resistant & more preferred by EAB than white ash (*F. americana*). [Street trees, Plantation, Forested sites]
EAB host preference: green ash vs white ash

- **Street trees**: EAB preferentially attacks green ash over white ash trees when planted together.

- **Plantations**: EAB strongly prefers green ash over white ash trees & girdled trees over healthy trees.

### Street trees

<table>
<thead>
<tr>
<th>Year</th>
<th>Green exits</th>
<th>White exits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>2004</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>2005</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

### Plantation - 2010

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. larvae per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girdle</td>
<td>White: 50, Green: 350</td>
</tr>
<tr>
<td>Control</td>
<td>White: 10, Green: 250</td>
</tr>
</tbody>
</table>
Green ash forest conditions: 3 stages of the EAB invasion

**Core:** Southeast MI, near EAB origin

**Crest:** Central MI: peak EAB density

**Cusp:** Southwest MI: EAB recent

Surveyed EAB density, overstory trees & regeneration in 2010 & 2011 (8 sites per invasion stage).

Average percent of green ash basal area alive varied among EAB invasion stages (n=8 sites per stage).

<table>
<thead>
<tr>
<th></th>
<th>Core</th>
<th>Crest</th>
<th>Cusp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>8%</td>
<td>63%</td>
<td>95%</td>
</tr>
<tr>
<td>2011</td>
<td>5%</td>
<td>45%</td>
<td>85%</td>
</tr>
</tbody>
</table>

No new ash seedlings in Core areas in either year
White ash forest conditions: Preliminary data from 28 sites in EAB Core areas surveyed in 2014.

- White ash mortality ranged from <10% to 100% of trees.
- In 20 of 28 sites, at least 50% of the white ash phloem is alive; trees remain healthy or are recovering.
EAB Host Preference & Ash Resistance

- Beetles like it hot & bright! Trees in sunny locations usually colonized before shaded trees.
- EAB are strongly attracted to girdled trees or trees stressed by other problems.
- Black ash: highly preferred & very vulnerable host.
- EAB preferentially attacks green ash over white ash. Long-term persistence of white ash in forests - ???
- Strong EAB preference for white ash over blue ash trees when both species occur together.
- Blue ash is the most resistant host EAB has encountered in North America; Will likely survive the EAB invasion.
Watch most vulnerable trees for early evidence of EAB

- Monitor stressed ash, especially green or black ash trees & focus on open-grown or edge trees.
- Woodpecker attacks & EAB exit holes are typically the first signs of EAB. The first woodpecks & EAB exit holes are usually in the upper canopy – look up!
Questions we can address....

Which trees are most likely to be infested by EAB first?

Are there any resistant ash species?

When should I begin treating landscape ash trees?

Are systemic insecticide products effective?

What about biological control?

What tactics might go into an IPM program for EAB?
When should I begin treating ash trees?

Ideally, you’d know EAB distribution & where you are in relation to the EAB Invasion Wave.

Problems: Detection difficult; Long range EAB dispersal
EAB detection, delimitation & survey is very difficult

Determining EAB distribution is complicated by:

1. No long range pheromones.
2. Girdled & debarked ash effective, but not often used.
3. Canopy traps & lures are not highly effective.
4. Surveys end once county or state found to be infested.

**APHIS canopy trap**  **Double-decker trap**  **Girdled trees - debarked**
Long distance dispersal: Most females lay eggs within 100 meters of emergence point. But a few females (maybe 1-5%?) disperse 0.5 to 3 (?) miles. Long range dispersal is unpredictable. Leads to patchy distribution.

Siegert et al. 2010.
Actual EAB distribution is probably at least 2-3 miles beyond our detection threshold.

New satellite populations usually “simmer” for 4+ years before any tree decline becomes apparent.

If ash trees are left untreated, rates of ash decline & mortality will increase at an exponential rate; most ash trees in a given area die during a 3-4 year period.

McCullough & Mercader 2012; Mercader et al. 2012.
Once EAB populations build, expect high rates of ash decline & mortality to occur over a 3-4 year period.

Landscape ash in Toledo, OH before & after EAB

June 2006

August 2009

Photos courtesy of D. Herms, OSU
Must assume landscape ash trees not protected with effective insecticides will be killed by EAB.

- Dead or dying landscape trees reduce property values.
- Dead ash decay & become hazards.
- Tree removal is costly & unpleasant.
When is it too late to begin treating trees?

Once canopy transparency or canopy dieback >60%, trees are not likely to recover *(MSU 2009-2014 data).* Obvious symptoms of EAB on the lower trunk indicate trees are too infested to transport systemic insecticides.

- Bark crack & WP hole at eye level
- Severe canopy decline
- Epicormic sprouts on trunk
True EAB distribution is always further than we think!

If EAB is detected in your county or within a 15-30 mile radius & if you want to protect at least some ash trees, consider your options & develop a plan – soon...
Questions we can address....

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Are systemic insecticide products effective?

What about biological control?

What tactics might go into an IPM program for EAB?
### Relatively new systemic insecticide options

<table>
<thead>
<tr>
<th>Products (active ingredient)</th>
<th>Treat</th>
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<tbody>
<tr>
<td>TREE-äge - trunk injection (emamectin benzoate)</td>
<td>2-3 years</td>
</tr>
<tr>
<td>TreeAzin - trunk injection (azadirachtin)</td>
<td>1-2 years</td>
</tr>
<tr>
<td>Azasol - trunk injection (azadirachtin)</td>
<td>1-2 years</td>
</tr>
<tr>
<td>Safari – basal trunk spray (dinotefuran)</td>
<td>1 year</td>
</tr>
<tr>
<td>Imidacloprid products - 2x rate soil drench or soil injection</td>
<td>1 year</td>
</tr>
</tbody>
</table>
Emamectin benzoate (TREE-äge): Trunk injection applied in May or early June provides up to 3 years of nearly 100% EAB control, even at lowest application rates.

**OSU study (2006-2009)**

Azadirachtin (TreeAzin, Azasol)

Applied as trunk injection; May or early June.

Different mode of action: will not kill adult EAB but may reduce viable egg production. Also appears to control young larvae (disrupts molting).

MSU 2-year study: TreeAzin was highly effective when applied annually. Somewhat less effective after 2 years.
Some neonicotinoid products (but not all) can effectively protect landscape ash trees.

**Imidacloprid (many products):** Usually applied as soil drench; some can be trunk injected. Must apply annually. Product efficacy varies greatly; 2x products more effective.

**Dinotefuran (Safari):** Usually applied as a basal trunk spray for EAB; Must apply annually; Generally effective, especially on small trees.
Information on insecticides for EAB control & ash protection is available free at www.emeraldashborer.info

Multi-state extension bulletins

Frequently Asked Questions Regarding Potential Side Effects of Systemic Insecticides Used To Control Emerald Ash Borer

Daniel A. Herms, Assistant Extension Entomologist, Department of Entomology, University of Minnesota
Cynthia A. Herms, Professor, Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University
Deborah G. McCullough, Professor, Department of Entomology and Department of Forestry, Michigan State University

What systemic insecticides are commonly used to protect ash trees from emerald ash borer (EAB)?

Gunnar H. W. Jorgensen, Extension Entomologist, University of Minnesota

Coalition for Urban Ash Tree Conservation - Emerald Ash Borer Management Statement

We the undersigned strongly endorse ash tree conservation as a fundamental component of integrated programs to manage emerald ash borer (EAB) in residential and municipal landscapes. Cost-effective, environmentally sound EAB management protocols are now available that can preserve ash trees through good EAB management and healthy canopy function. Used in association with tree inventories and strategic removal of unhealthy ash, tree conservation will help retain maximum integrity and value of urban forests. This integrated approach to urban EAB management is supported by university scientists with expertise in EAB management, commercial arborists, municipal foresters, public works officials, and non-governmental organizations (NGOs).

Emerald ash borer has killed millions of ash trees since its discovery in 2002 and the number of dead ash is increasing rapidly. Ash species are abundant in planned and natural

Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

Daniel A. Herms, Deborah G. McCullough, David R. Smithey, Clifford S. Sadowski, Whitney Griswold
Which trees are most likely to be infested by EAB first?

Are there any resistant ash species?

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What about biological control?

What tactics might go into an IPM program for EAB?
Woodpecker Predation

WP holes are often the first sign of EAB; Flecking occurs on heavily infested trees.

WPs usually prey on late instar EAB larvae & prepupae in winter & early spring.

WP predation is a major source of EAB mortality but rates are highly variable.

No evidence that WPs can slow EAB population growth or rate of ash mortality.
Native Parasitoids

- Native parasitoids, particularly *Atanycolus cappaerti*, are increasingly common.
- Native parasitoids are clearly learning to search ash trees for EAB larvae.
- Highest parasitism rates usually in heavily infested trees.
- Potentially more important in the Core, behind the EAB invasion wave?
Asian parasitoids - Classical biocontrol for EAB

USDA APHIS, USFS & ARS are spending $ millions on 3 Chinese parasitoids. First releases were in MI in 2007. APHIS released >280,000 wasps annually since 2012.

- Oobius agrili (egg parasitoid)
- Spathius agrili
- Tetrastichus planipennisi
Biocontrol agents: Compatible with TREE-äge & other systemic insecticides. No evidence that predators & parasitoids can slow EAB population growth & the rate of ash mortality. Biocontrol may be more important in Core areas, behind the invasion wave – yet to be determined.

**Asian parasitoids**

- *Spathius sp.*
- *Atanycolus cappaerti*
- *Tetrastichus sp.*
Questions we can address....

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Are there any resistant ash species?
When should I begin treating landscape ash trees?
Are systemic insecticide products effective?
What about biological control?
What tactics might go into an IPM program for EAB?
Integrated management of EAB increasing in urban areas; Neighborhood, municipal & regional efforts underway

✓ Inventory ash trees (size, species, condition).
✓ Identify trees to protect & trees that should be replaced.
✓ Trees destined for removal can be girdled in spring & used as trap trees. Intermixing girdled & treated trees likely to be an especially effective control tactic.
✓ Treat valuable trees at 2-3 year intervals (TREE-äge).
✓ Consider classical biocontrol with Asian parasitoids.
We can protect ash trees from EAB. Whether we can save the forest remains unknown.