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* Department of Bioagricultural Sciences and Pest Management
An Introduction to the Emerald Ash Borer

Photograph by Steven Valley
Emerald ash borer
* Agrilus planipennis

Order Coleoptera (beetles)
Family Buprestidae (metallic wood borers, flatheaded borers)

Photograph by David Cappaert
Photograph by Debbie Miller
Emerald ash borer (EAB) is a green-colored beetle.

...that develops in ash trees (Fraxinus species)...
...and is Native to Asia

Native range of Emerald Ash Borer in Asia.

EAB Native Range
Presence of emerald ash borer has also been reported in adjacent Mongolia and Russia.
Emerald ash borer was accidentally introduced into and has since spread through North America.
Lilac/Ash Borer

*Podosesia syringae*

Order: Lepidoptera
(Moths and butterflies)
Family: Sesiidae (Clearwing borers)
Lilac/Ash Borer does not equal Emerald Ash Borer!

Lilac/ash borer, a clearwing borer moth

Emerald ash borer, a metallic wood borer/flatheaded borer
Emerald ash borer larvae create meandering tunnels in the cambium that produce girdling wounds.

*Note:* Initial attacks are concentrated in the crown of the tree.
Lilac/ash borer larvae create irregular gouging wounds that extend often into the heartwood.

Attacks are concentrated at the lower trunk of the tree.
EAB adults chew through the bark, producing D-shaped exit holes.
Lilac/ash borer emerges from irregularly round holes. The pupal skin is pulled out when the adult emerges.
After emergence emerald ash borer adults feed on ash foliage for a period and eggs mature.
EAB likely will emerge sometime in midMay. Before eggs are laid it will feed on leaves of the tree canopy.

Eggs will be laid in June, perhaps into early July.
Adults of the lilac/ash borer are present in mid-late spring. Most eggs are generally laid in May through early June.

Adult stages of the lilac ash borer do not feed on any parts of the ash tree.
Eggs of both species are laid on the bark of the host tree.
Damage potential to its host

10 – EAB now defines an aggressive tree killing insect in North America.
Damage potential to its host

2, maybe 3 – Lilac/ash borer has far lower ability to seriously damage its host
Emerald ash borer is devastating to all species of ash that are native to North America.
Emerald Ash Borer is an Introduced Species Native to Asia

Native range of Emerald Ash Borer in Asia.

- EAB Native Range
- Presence of emerald ash borer has also been reported in adjacent Mongolia and Russia.

2000 Mile
Why is EAB so destructive to ash trees in North America?

NA ash species lack ability to resist EAB

No EAB Resistance
These trees can’t be saved. They are already dead.

EAB Will Kill All Unprotected Ash
EAB Invasion Wave and Protection Needs

* Assumes doubling of affected ash and EAB yearly during growth
Chestnut blight – Devastated American chestnut in early 1900s, caused by a fungus

Dutch elm disease – Devastated American elm in mid century. Caused by a fungus, vectored by a bark beetle
Definition of Some Terms

• What is meant by the phrase “state is infested by emerald ash borer”
• What does “control” mean when applied to emerald ash borer
• What is the 1X rate of imidacloprid
• What is the definition of “munted”
Southern Alps
Christchurch Cathedral
munited – The official cuss word of Christchurch, New Zealand

munited

adj (1) used to describe severe levels of damage in Christchurch earthquake. (2) used to avoid offending others by saying f**ked in the context above...

Origin, Christchurch NZ February 2011...
Colorado EAB Tree #1

Located near the intersection of 30\textsuperscript{th} and Valmont, Boulder
Trees within 100 yards of EAB Tree #1 showed some dieback and thinning due to EAB injuries.
Present distribution of EAB in North America
Example for discussion: Let’s assume that the area of Boulder within the circle is the limit of current infestation.
Main Points About Emerald Ash Borer in Colorado

• Known infestation presently confined to areas within Boulder City limits
  – In time will spread throughout South Platte drainage
  – Other areas of the state are at no greater risk than before detection

• Treatments are available that will protect individual trees
  – Each treatment option involves decisions balancing costs, environmental hazards, effectiveness and ease of application
Unlike states to the east, Colorado is highly compartmentalized due to its geography.

The current infestation is an infestation of the South Platte River drainage, *not the State of Colorado*. 
Emerald Ash Borer has become established within in the South Platte River Drainage of Colorado – not the entire state of Colorado!
Within the next five years, emerald ash borer will move out of Boulder into the surrounding counties.
Over time the South Platte River Drainage will be colonized by emerald ash borer
Most of Colorado is no more – nor less – at risk of infestation by Emerald Ash Borer. EAB will be a problem due to Boulder infestation.
How far away is emerald ash borer from your community?
How far away is emerald ash borer from your community?

One truckload
Example for discussion: Let’s assume that the area of Boulder within the circle is the limit of current infestation.
Where are we now with the EAB in Boulder?

Management Phase

Aggressive    Maintenance

Affected Ash

EAB

Percentage of Maximum

0% 20% 40% 60% 80% 100%

Time (Years)

5 9 13

Cusp    Crest    Post Crest

* Assumes doubling of affected ash and EAB yearly during growth
What to Do in 2014?

• Boulder residents in High Risk areas need to make EAB treatment decisions now

• Everyone in Colorado should renew vigilance in detection of EAB infestations

• Communities within the South Platte drainage need to make long-term plans for EAB management now

• Revisit the Colorado situation this time next year (and every year)
Control Options for Management of Emerald Ash Borer
One good thing about emerald ash borer –

We have learned a lot about insect control
Emerald Ash Borer Control Options

• Soil applications with systemic insecticides
  – imidacloprid, dinotefuran

• Non-invasive trunk sprays of systemic insecticides
  – dinotefuran

• Trunk injections of systemic insecticides
  – Emamectin benzoate (TREE-Age), azadirachtin (TreeAzin), imidacloprid
Important note regarding EAB control

Present controls can allow trees to recover if EAB-induced crown thinning has not exceeded 30-50%
Target Life Stages for EAB Treatments

- Adults as they feed on foliage
- Young larvae that tunnel in the phloem and cambium
Emerald Ash Borer Insecticides

- **Imidacloprid** (Merit, Xytect, Criterion, etc.)
  - Soil drench, possible trunk injection
- **Dinotefuran** (Safari, Zylam, Transtect)
  - Basal trunk spray, possible soil drench
- **Emamectin benzoate** (TREE-Age)
  - Trunk injection only
- **Azadirachtin** (TreeAzin)
  - Trunk injection only
Soil Treatment Options for EAB

• Imidacloprid
  – Merit, Xylect, Criterion, Zenith, Bandit……
    • 75WSP and 2F formulations
  – Several retail formulations now available
    • Typically 1.47% liquid formulations

• Dinotefuran
  – Safari, Zylam, Transtect
Soil application option – imidacloprid applied as drench or injection
Over-the-Counter Imidacloprid Formulations
Primary method of imidacloprid application – soil applications for root uptake
Optimal Application – Soil drench within 18-24 inches of the Trunk

Yes

No?
Soil Injection Patterns

A circle of 40-ft diameter (i.e., 40-ft canopy spread) covers 1250 sq ft.

Bird's eye views from above the tree looking through the canopy to the ground. The dark spot represents the trunk, while the irregular grey line represents the border of the canopy (the drip line).

Injections are made at each "X" spaced apart every 2.5-feet. Rings are also spaced apart by 2.5-feet.

**************************
Injections can be very useful to bypass mulch or fabric barriers.

Injections also prevent the presence of surface residue of the applied insecticide.
Soil applications of systemic insecticides should not be made if there are flowering plants at the application site.
Modifying DBH-based rates by tree size
What rate of use for imidacloprid soil treatments?

• 1X rate = 1.4 grams active ingredient/inch trunk diameter

• Rates of use allowed in label directions
  – 75 WP formulation - 1X/application
  – 2F and 75WSP formulations - 1X up to 15 inches diameter; 2X in larger trees
  – Retail nursery formulations – 1/2X
    • Limited to single application/year
Area increases as the square of the width (diameter)

Example: A circle that is 2 ft. wide has an area 4X greater than a circle of 1 ft. diameter

Bottom line: Larger trees have proportionately much greater volume than do smaller trees. Insecticides rates based on DBH will be more diluted in larger trees.
Use of High or Low Rates of Imidacloprid?

Low Rates (1X, 1/2X)
- Smaller trees
- EAB populations low, moderate
- Spring applications

High Rates (2X)
- Large trees
- High EAB populations present (peak outbreak phase)
- Fall applications
Modifying DBH-based rates by tree size
All Systemics Need Water

- Soil drench
- Trunk sprays
- Trunk injection

Water carries the pesticide
Conditions Optimizing Uptake and Distribution of Systemic Insecticides

- Soil is moist (but not saturated!)
- Soil temperatures are above 45°F
- Ambient air temperatures are between 40°F-90°F

In other words, conditions are most favorable to transpiration.
What are the Trade-offs with Fall Applications vs. Spring Applications?
Take home message to me: Spring applications are more efficient in the use of soil applied imidacloprid than is a fall application to ash (a deciduous tree).
White pine weevil and imidacloprid soil treatments
Adults mate and lay eggs in early to mid-spring.
Pupation occurs within ‘chip cocoons’
Imidacloprid Soil Drenches?

Some activity likely with fall applications.

Spring applications do not allow sufficient time for uptake.
Another consideration with fall vs. spring applications of systemic insecticides?

Effects on potential residues present in nectar and pollen
Pollinators and Systemic Treatments
Ash is Wind Pollinated and Dioecious

Male flowers (with pollen)

Female flowers (no pollen)
Is Ash Pollen from EAB Treated Trees a Threat to Bees?

Present evidence from the midwest suggests that ash pollen is collected infrequently and does not constitute a biologically significant source of possible neoniciotinoid exposure.
Wind pollinated plants can be used as significant pollen sources by honey bees.
Flowering ash (*Fraxinus ornus*), native to southern Europe, is an important pollen source for honey bees in Europe.
Study planned to start in 2014

Survey of pollen collected by honey bees

Question to answer:
What are the important pollen sources used by honey bees in Colorado?
Top honey bee-visited plants include: most Sedums, most thistles, catmint, *Gaillardia*, most *Agastache*, Blue mist spirea, Russian sage, fruit trees, linden, golden raintree ........
My greatest concern about neonicotinoids and woody plants - Lindens
THE NEW EPA BEE ADVISORY BOX
On EPA’s new and strengthened pesticide label to protect pollinators

PROTECTION OF POLLINATORS

APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon in the Directions for Use for each product. This product can kill bees and other insect pollinators.

Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar. Bees and other insect pollinators can be exposed to this pesticide from:
- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.

When Using This Product, Take Steps To:
- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
- Minimize drift of this product onto bees or to off-site pollinator attractive habitat. Drift of this product onto bees can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at: http://pesticidestewardship.org/pollinatorprotection/Pages/default.aspx

Pesticide incidents (for example, bee kills) should immediately be reported to the state/local lead agency. For contact information for your state/tribe, go to: www.catppuc.org. Pesticide incidents can also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beeskit@epa.gov

Alerts users to separate restrictions on the label. These prohibit certain pesticide use when bees are present.

The new bee icon helps signal the pesticide’s potential hazard to bees.

Makes clear that pesticide products can kill bees and pollinators.

Bees are often present and foraging when plants and trees flower. EPA’s new label makes it clear that pesticides cannot be applied until all petals have fallen.

 Warns users that direct contact and ingestion could harm pollinators. EPA is working with beekeepers, growers, pesticide companies, and others to advance pesticide management practices.

Highlights the importance of avoiding drift. Sometimes, wind can cause pesticides to drift to new areas and can cause bee kills.

The science says that there are many causes for a decline in pollinator health, including pesticide exposure. EPA’s new label will help protect pollinators.

Read EPA’s new and strengthened label requirements: http://go.usa.gov/jHH4
Neonicotinoids and Pollinators: Bottom Line

Avoid applications to plants *that bees visit* that are in bloom – *or soon will be in bloom*.
Another consideration with fall vs. spring applications of systemic insecticides?

Applications of insecticides after bloom will produce lower risk of exposure to pesticides that may migrate into pollen, nectar.
Imidacloprid - Maximum Use per area Limitations

• **Maximum use allowed** is 0.4 lbs imidacloprid/acre/year
  - This involves all uses (homeowners, municipal, various tree care companies, etc.)

• **Equivalent uses**
  - 1X rate – **Allows treatment of ash trees of ca. 126 cumulative inches of trunk diameter**
  - 2X rate – **allows treatment of ash trees of ca. 63 inches of cumulative trunk diameter**
Soil drench with dinotefuran (Safari, Zylam, Transtect)
Basal trunk spray with dinotefuran (Safari, Zylam)
Relative Water Solubility of Neonicotinoids:

### Water Solubility (Active Ingredient)

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Water Solubility (A.I. per liter)</th>
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<tbody>
<tr>
<td>Clothianidin (Celero)</td>
<td>327</td>
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<tr>
<td>Imidacloprid (Marathon)</td>
<td>500</td>
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<td>2950</td>
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**Information sources**

- Clothianidin (Celero), Acetamiprid (Tristar), Dinotefuran (Safari) – EPA Pesticide Fact Sheet
- Imidacloprid (Marathon), thiamethoxam (Flagship) – MSDS for Products

Slide information courtesy J. Chamberlin
$K_{oc}$ Values of Neonicotinoids:

- Clothianidin: 166
- Imidacloprid: 440
- Acetamiprid: 267
- Thiamethoxam: 245
- Dinofuran: 26

Source Data: EPA Pesticide Fact Sheets
Basal Trunk Sprays of Dinotefuran

- Enters tree through thin areas of bark
- Can be expected to reach peak levels in foliage in about 2-3 weeks
- Adjuvant? – May help some to increase deposition into trunk fissures, slow drying
All Systemics Need Water

- Soil drench
- Trunk sprays
- Trunk injection

Water carries the pesticide
Dinotefuran Trunk Sprays

Advantages

- Ease of application
- Does not require tree wounding
- Rapid uptake following application
- Limited area receiving surface residues
- Applied after bloom (of ash)
Target pest of dinotefuran trunk sprays

Flatheaded borers

Roundheaded borers
Target pest of dinotefuran trunk sprays

Adelgids (woolly aphids of conifers)
Target pest of dinotefuran trunk sprays

Scale insects (both armored and soft)
Natural Enemies of Pine Needle Scale

Lady beetles that specialize in armored scales (*Coccidophilus* spp., *Chilochoerus* spp.)
Natural Enemies of Pine Needle Scale

Parasitic Wasps
Whole tree sprays produce surface residues on all foliage. Natural enemies are killed. Natural controls are wasted.

Treatment area limited to bark of lower trunk. Impacts on natural enemies is minimalized.
All Systemics Need Water

- Soil drench
- Trunk sprays
- Trunk injection

Water carries the pesticide
Relative Water Solubility of Neonicotinoids:

**Water Solubility (Active Ingredient)**

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Slide information courtesy J. Chamberlin
Dinotefuran - Maximum Use per area
Limitations

• **Maximum use allowed is 0.54 lbs dinotefuran/acre/year**
  – This involves all uses (homeowners, municipal, various tree care companies, etc.)

• **Equivalent uses**
  – **Basal trunk sprays** – ca. 75-100 inches cumulative trunk diameter/acre/year
  – **Soil drench** – ca. 100 inches cumulative trunk diameter/acre/year
Dinotefuran Trunk Sprays

**Advantages**
- Ease of application
- Does not require tree wounding
- Rapid uptake following application
- Applied after bloom (of ash)

**Disadvantages**
- Requires annual application
- Use likely limited to trees without thick bark
- Higher cost
- High leaching potential if put into soil
Trunk injection with emamectin benzoate (TREE-age)
Target pests of emamectin benzoate (TREE-age) trunk injections

Flatheaded borers

Roundheaded borers
TREE-age has consistently provided two years of control of EAB

Adults as they feed on foliage

Young larvae that tunnel in the phloem and cambium
Clearwing borers

Bark beetles

Target pests of emamectin benzoate (TREE-age) trunk injections
Experience with trunk injections and emamectin benzoate
Mountain pine beetle adults make coordinated mass attack on trees to overwhelm tree defenses.
A central gallery is excavated under the bark.

After mating, the female lays eggs along the gallery.
A blue stain fungus that is carried into the tree with the beetle colonizes the gallery
TREE-age Trunk Injections

Advantages

• Can consistently provide 2 years control
• Provides lilac/ash borer control
• Applications can be made at many times during the season
• No maximum use/area limitation

Disadvantages

• Involves trunk wounding
• Requires skill in proper application
• High cost
• Restricted Use Pesticide
Trunk injection with azadiractin (TreeAzin)

Some efficacy and tree wounding issues are unresolved at present.
Target pests of TreeAzin trunk injections

Flatheaded borers

Leaf feeding caterpillars

Elm leaf beetle

Sawflies
TreeAzin Trunk Injections

Advantages

• Natural product with low environmental impact and good public perception
• No maximum use/acre limitation
Neem

• Extracted from seeds of the neem tree, *Azadirachta indica*

• Active Ingredients: *Azadirachtin* primarily, oil fractions have some uses.
Azadirachtin *indica*, the source of neem
Neem Has Many Human Pharmaceutical Uses

- Tooth care
- Diuretic
- Burn ointments
Neem

- **Active insecticidal ingredient**: azadirachtin
- **Mode of Action**: Various – insect growth regulator, feeding deterrent, repellent
- **Current Status**: Broadly labeled for food crop and ornamental plant protection
TreeAzin Trunk Injections

**Advantages**
- Natural product with low environmental impact and good public perception
- No maximum use/acre limitation

**Disadvantages**
- Involves trunk wounding
- Likely requires annual application
  - Some evidence of 2nd year activity
- High cost
Trunk Injections Produce Wounds

Tissue discoloration from drilling

Old AceCap Injection in Cottonwood
Concerns - Trunk Wounding and Injections

• Wounding will have to occur annually (TreeAzin, imidacloprid) or every other year (TREE-age)
• Relatively slow growth of regional ash may result in slow wound closure
Good News: There is reported good incidence of wound closure from injections in the MidWest

“wound closure rates are strongly dependent on tree health as expressed by ring growth.”

Problem? – Ash trees in the western states grow much slower than in the Midwest and have much lower rates of ring growth.
What to Do in 2014?

• Boulder residents in High Risk areas need to make EAB treatment decisions *now*

• Everyone in Colorado should renew vigilance in detection of EAB infestations

• Communities within the South Platte drainage need to make long-term plans for EAB management *now*

• Revisit the Colorado situation this time next year (and every year)
Entertaining visitors from the East this year? – Tell them you will provide all the firewood they need.
Monterey cypress – hedge plant of choice
TREE TRIMMING
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* Department of Bioagricultural Sciences and Pest Management