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Emerald Ash Borer

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Note: all photographs give credit to photographers in their captions

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Virginia Cooperative Extension
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CHAPTER 1

Introduction

SECTION 1

Chapter Objectives

The purpose of this chapter is to provide an introduction to an exotic, invasive tree pest called emerald ash borer (EAB).

Upon completing this chapter, you should be able to:

- Describe EAB introduction to North America
- Identify EAB modes of dispersal
- Explain EAB impacts on infested environments and communities

IMAGE 1.1 EAB adult feeding on ash foliage

Image from Debbie Miller, USDA Forest Service, Bugwood.org

SECTION 2

What is EAB?

The emerald ash borer (*Agrilus planipennis* Fairmaire) is a wood-boring beetle native to eastern Asia and is now **considered the most destructive forest pest ever seen in North America.** Since its discovery in Michigan in 2002, it has killed tens of millions of native ash (*Fraxinus* spp.) trees in the United States and Canada. This destruction has already cost municipalities, property owners, and businesses tens of millions of dollars in damages.

INTERACTIVE 1.1 YouTube video Emerald Ash Borer 3:27

Video by Natural Resources Canada 2012

IMAGE 1.2 Ash trees taken down after EAB infestation

Image from Daniel Herms, The Ohio State University, Bugwood.org

How does EAB kill ash trees?

IMAGE 1.3 EAB larval galleries

Image from Art Wagner, USDA APHIS PPQ, Bugwood.org

Although adult EAB beetles feed on foliage of ash trees, this causes little harm to the tree. It is the EAB larvae that kill ash trees. Larvae feed under the bark on the tree's cambial layer. Feeding disrupts the tree's ability to transport food and nutrients, causing the tree to eventually starve to death. If left unabated, trees usually die within 3-5 years of initial EAB infestation.

IMAGE 1.4 EAB larva in wood

Image from Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

SECTION 4

Where did EAB come from?

The emerald ash borer is native to eastern Russia, northern China, Japan and the Korean peninsula. Before 2002, it had never been found in North America.

ILLUSTRATION 1.1 Map of the native range of the emerald ash borer

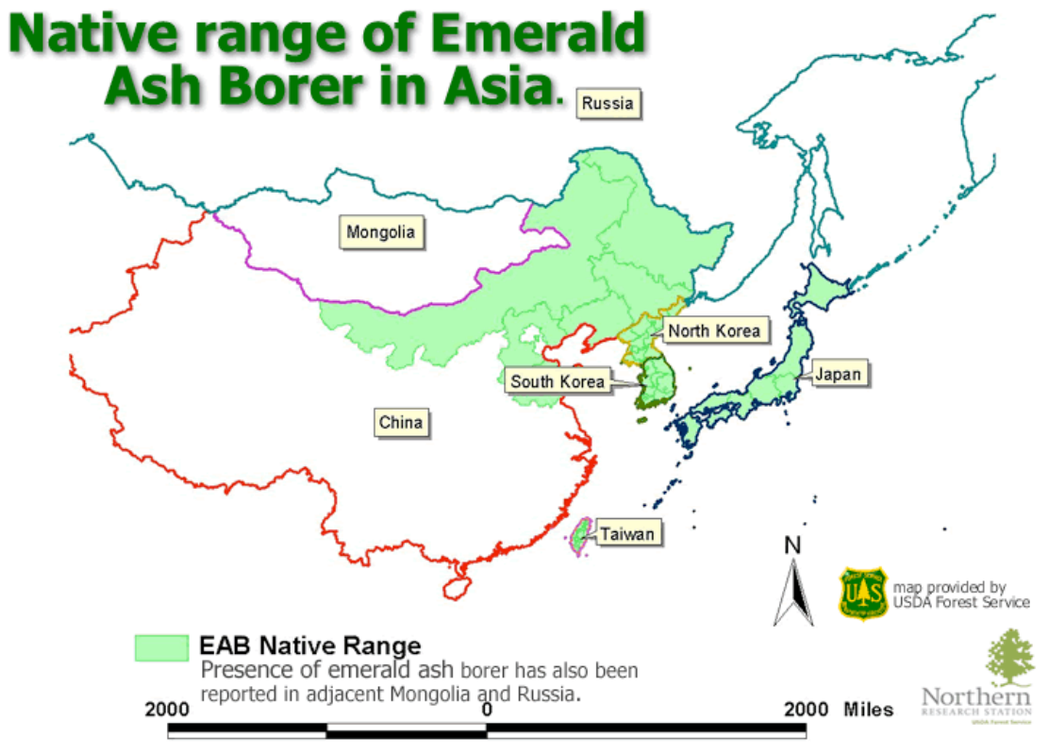


Illustration from the USDA Forest Service

It is believed that EAB entered the United States in the early 1990s in solid-wood packing material used to transport manufactured goods from China. The initial population was small and went unnoticed until 2002 when it was first discovered killing native ash trees in Detroit, Michigan.

IMAGE 1.5 Wooden shipping crates

Image from Bas Kegge, Rotterdam, NL

SECTION 5

Where is EAB now?

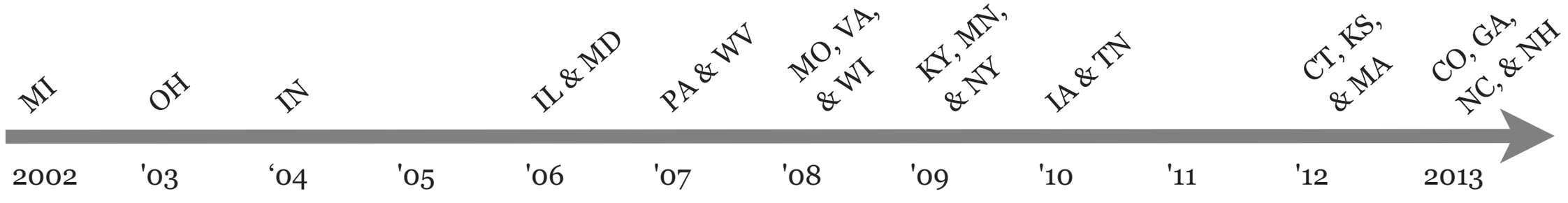
Since its discovery in Michigan in 2002, EAB has been confirmed in 22 other states as well as the Canadian provinces of Ontario and Quebec.

From 2002 to 2006 EAB was found in Michigan and the adjoining states of Ohio and Indiana. Since then, it has spread to most of the states in the midwest, northeast, and the south Atlantic regions of the United States.

ILLUSTRATION 1.3 Graphic of states and provinces where EAB has been detected (2013)

Illustration from emeraldashborer.info

ILLUSTRATION 1.2 Timeline of when EAB was detected in each state.



SECTION 6

How is EAB spread?

Natural dispersal of EAB is rather slow. An adult beetle can only fly about ½ mile at a time and can travel about 2 miles per year. EAB dispersal is greatly accelerated when people move infested ash articles such as nursery trees, wood products, packing material, logs, or firewood. Because EAB is easily spread by people, many states and localities have enacted quarantines to restrict movement of ash articles.

For more information on quarantined areas by state, visit: http://www.emeraldashborer.info/firewood.cfm

IMAGE 1.6 Don't move firewood sign from Ohio

Image from Amy Stone, Ohio State University Extension

Economic Impacts

Removal and Replacement Costs – Computer simulation studies conducted by Kovacs et al. (2009) estimate that by 2019 EAB is likely to encompass at least 25 states. The cost of removal and replacement of trees in affected communities could reach over $10.7 billion and this estimate doubles when developed land outside communities is considered.

Impacts on Commerce – Many wood products such as flooring, furniture, tool handles, and baseball bats are made from ash, and losses to the ash products industry could be $25 billion in the eastern U.S. alone. The tree nursery industry will also be negatively affected because ash is a very popular landscape tree.

IMAGE 1.7 Ash wood baseball bat

Image from Marc Martindale Wausau, WI

Environmental Impacts

IMAGE 1.8 Dead ash trees create a newly opened canopy

Image from Daniel Herms, The Ohio State University, Bugwood.org

Natural Ecosystems – Native ash trees are key species in many forest ecosystems. Sudden "gaps" in the forest canopy due to ash tree death have been found to increase abundance of invasive plant species and alter insect and amphibian populations.

Urban Forests and Landscapes – Ash trees were widely used to replace landscape elms decimated by Dutch elm disease in the middle of the 20th century. As a result, they are one of the most widely planted urban tree types in the US. Loss of ash trees to EAB not only has an impact on community aesthetics, but also results in decreased environmental benefits such as temperature moderation, improved air quality, stormwater management, carbon sequestration, and more.

IMAGE 1.9 Dead ash tree at office building

Image from Joseph O'Brien, USDA Forest Service, Bugwood.org

SECTION 9

Cultural Impacts

Indigenous peoples of the Great Lakes region use ash wood to craft many items such as baskets, snowshoes, hunting and fishing decoys, and canoe paddles.

Basket weaving traditions are passed on through families, and baskets are often crafted from black ash (*Fraxinus nigra*) splints. The manufacture and sale of these works of art help Native American families sustain their culture and support their communities.

IMAGE 1.10 Black ash baskets by artists Kelly Church (center red basket) and Katie Sickles (2 outer baskets)

Image from Nick Reo, Michigan State University

REVIEW 1.1

Question 1 of 2

Emerald ash borer can spread to uninfested areas by:

- **A.** natural dispersal of flying adult beetles
- **B.** transport of firewood infested with beetle larvae
- **C.** transport of nursery trees infested with beetle larvae
- ✓ **D.** all of the above

◀ Check Answer ▶

SECTION 10

Chapter Summary

- Emerald ash borer is an exotic, invasive pest in North America that kills native ash (*Fraxinus* spp.) trees.
- EAB is native to eastern Asia and was first discovered in North America in 2002.
- Humans are accelerating the spread of EAB by transporting infested ash articles outside its naturalized area.
- The loss of ash trees to EAB has had severe economic, environmental, and cultural consequences.

IMAGE 1.11 Debris from ash trees killed by EAB

Image from David Cappaert, Michigan State University, Bugwood.org

CHAPTER 2

EAB Ecology

SECTION 1

Chapter Objectives

The purpose of this chapter is to review the ecology of an exotic, invasive tree pest called emerald ash borer (EAB).

Upon completing this chapter, you should be able to:

- Describe the taxonomy of EAB
- Identify the physical characteristics of EAB
- Explain the life cycle of EAB
- Name the plant hosts of EAB
- Summarize the variety of EAB natural enemies

IMAGE 2.1 Adult EAB on bark

Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

Taxonomy and Description

IMAGE 2.2 Adult EAB beetle

David Cappaert, Michigan State University, Bugwood.org

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Buprestidae

Genus: Agrilus

Species: planipennis

Binomial name: *Agrilus planipennis* (Fairmaire)

Adults are:

- Iridescent green, wood-boring beetle
- About 1/2” long and 1/6” wide

Larvae are:

- White to cream colored
- About 1 to 1.25” long when fully mature
- Flat headed
- Have bell-shaped segments

Detailed identifying characteristics are discussed in Chapter 3.

IMAGE 2.3 EAB larva

Image from David Cappaert, Michigan State University, Bugwood.org

Life Cycle

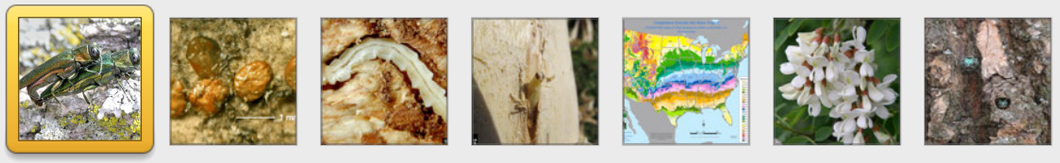
EAB adults are active from April to mid-August, depending on their location. They live for about 3-4 weeks and feed on ash foliage. After mating, females lay 50-100 eggs, one at a time, on and under the bark of ash trees. Initially they place their eggs on branches high in the tree crown, and usually do not target the lower trunk until a tree has been infested for 1-2 years.

EAB eggs are about the size of a pinhead and hatch 7-10 days after being deposited. After hatching, EAB larvae bore into the bark and feed on the tree's phloem and cambium, eventually growing to about 1-1.25" in length. **The larval stage is most lethal to the tree because its feeding disrupts the tree's flow of food and nutrients.** Tree death occurs within 3-5 years.

After feeding throughout the growing season, EAB larvae overwinter under the bark and pupate the following spring. In colder regions, the life cycle may take two years to complete.

GALLERY 2.1 EAB life cycle

EAB adults mating. Adults are active from April to August. They live for about 3-4 weeks and feed on ash foliage. Image from David Cappaert, Michigan State University, Bugwood.org



The pupal stage, which occurs under the bark of the host tree, begins in spring and lasts about 28 days. EAB adult emergence typically coincides with blooming of black locust (*Robinia peseudoacacia*). Because their heads are flat on top, EAB adults create D-shaped holes in the bark as they emerge from pupation. These holes are about 1/8" wide.

Review 2.1

Question 1 of 3

Which is the most lethal stage of EAB?

Check Answer

TAXONOMY AND LIFE CYCLE SUMMARY		
STAGE	**DURATION**	**COMMENT**
Egg	7-10 days	On and underneath bark
Larva	Typically 9-10 months	Underneath bark; most damaging stage to ash trees
Pupa	28 days	Underneath bark in spring following over-wintering
Adult	3-4 weeks	Emerge when black locust bloom

SECTION 4

Hosts of EAB in its Native Range

EAB is not a very serious pest in its native range of East Asia because trees there have co-evolved with the pest and developed natural resistance to it. There are also more natural enemies of EAB in Asia that keep EAB populations in check.

Manchurian ash (*F. mandshurica*), Chinese ash (*F. chinensis*), and Korean ash (*F. rhynchophylla*) are native hosts for EAB in Asia. In Japan, EAB has also been reported on Manchurian walnut (*Juglans mandshurica*), Japanese wingnut (*Pterocarya rhoifolia*), and Japanese elm (*Ulmus davidiana* var. *japonica*).

IMAGE 2.4 Manchurian ash

Image from USDA-NRCS PLANTS Database / Herman, D.E., et al. 1996. North Dakota tree Handbook. USDA NRCS ND State Soil Conservation Committee; NDSU Extension and Western Area Power Administration, Bismarck

Hosts of EAB in its Introduced Range

Because native ash trees in North America did not co-evolve with EAB, these species have not developed resistance to the pest. Even healthy trees are vulnerable to infestation. In North America, EAB is capable of infesting all native ash trees (*Fraxinus* spp.). Fortunately, it has not been observed infesting any other types of trees.

ILLUSTRATION 2.1 Distribution of native ash trees in the United States and where EAB has been found (as of August 2013).

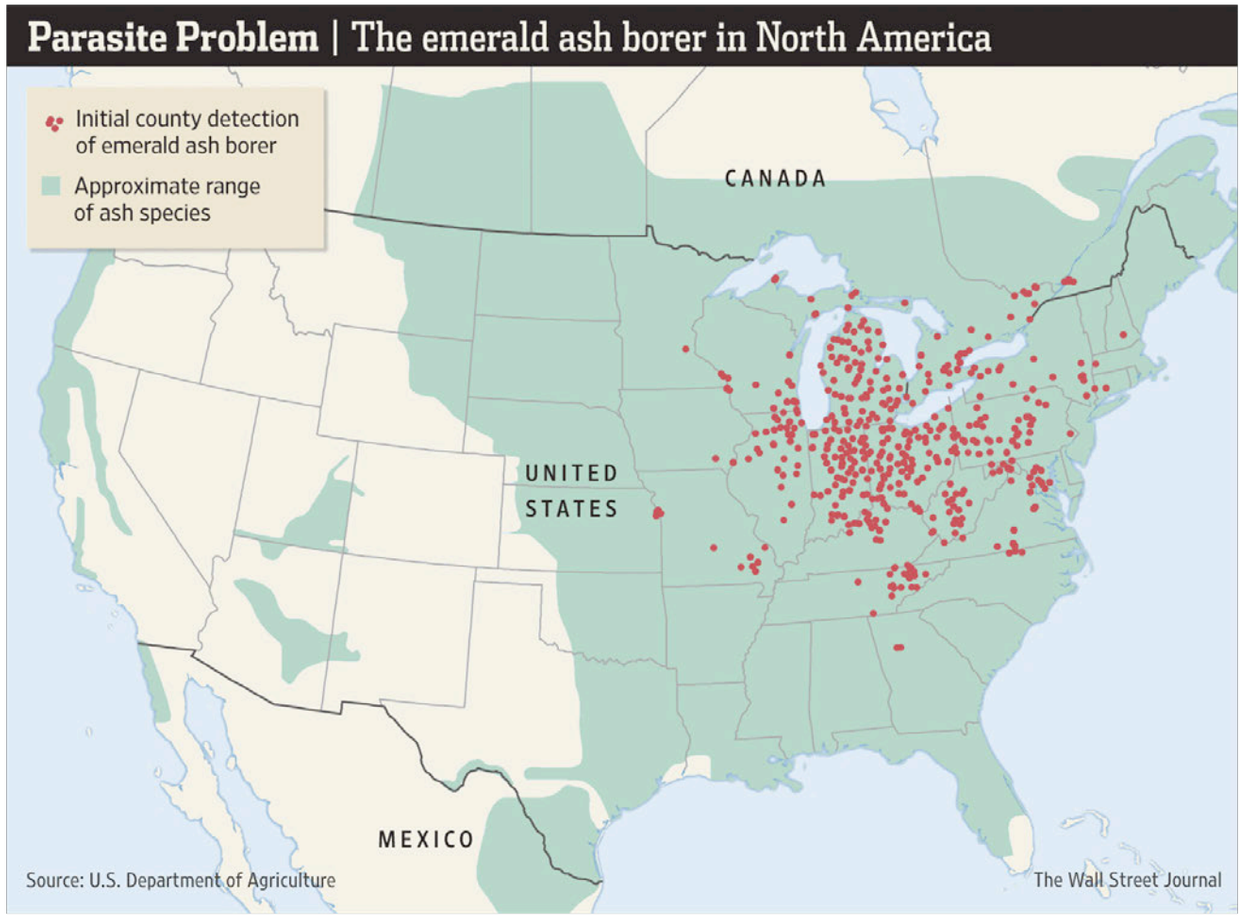


Illustration from the Wall Street Journal

The most common ash trees in the eastern US are:

- green ash (*F. pennsylvanica*)
- white ash (*F. americana*)
- black ash (*F. nigra*)
- blue ash (*F. quadrangulata*)

Although ash trees are a minor component in most native forests, they can be locally abundant in certain forest types and have been heavily planted in urban forests throughout the Midwest.

IMAGE 2.5 Green ash leaves

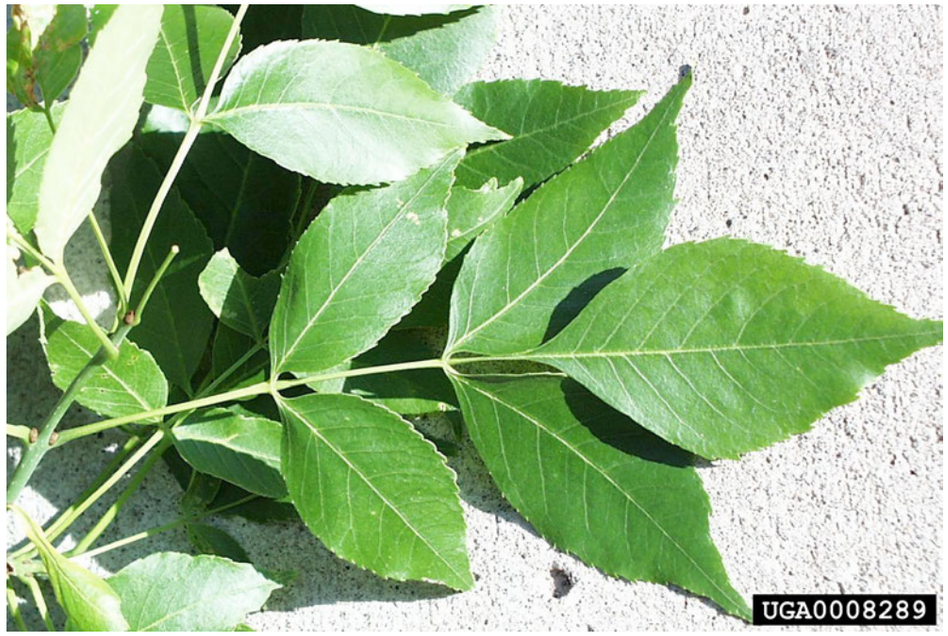


Image from Paul Wray, Iowa State University, Bugwood.org

SECTION 6

Natural Enemies and Population Controls

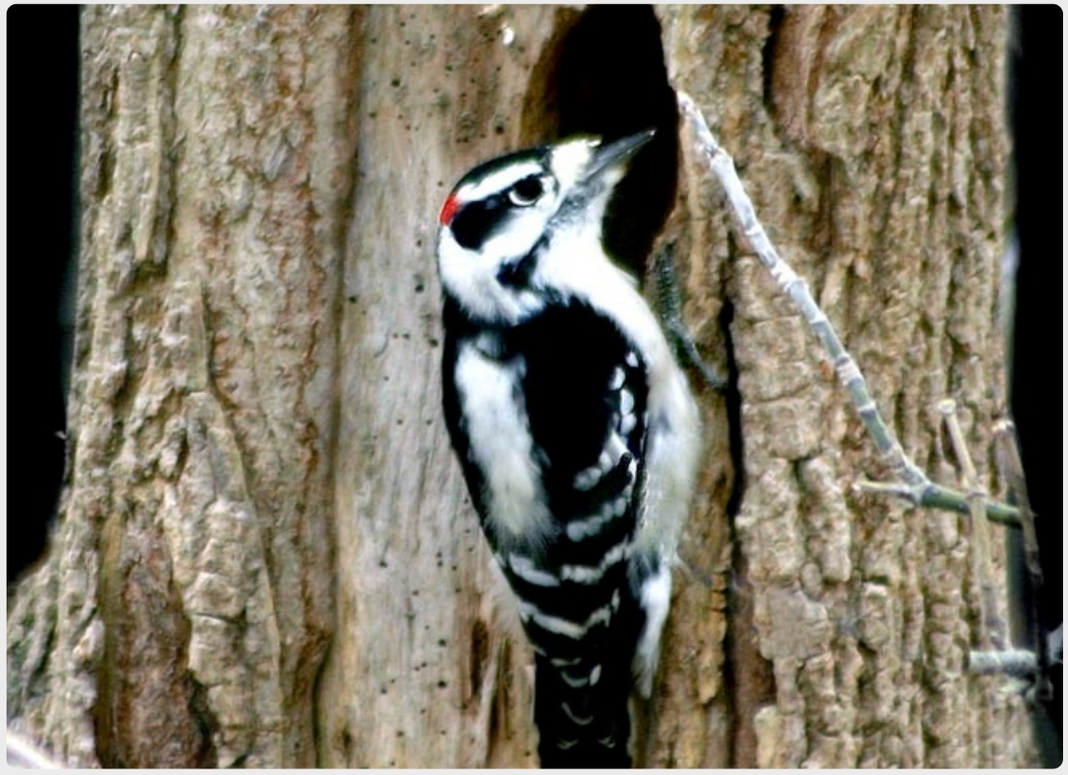
EAB larvae are a favorite food of woodpeckers. Infested trees often are riddled with holes and detached bark from woodpeckers foraging on larvae.

The native wasps *Antanycolus hicoriae* and *Cerceris fumipennis* predate EAB. These species capture EAB beetles and carry them to their nest where their larvae parasitize the carcasses. It is possible to monitor for EAB simply by examining the wasps' nests for carcasses of the pest. Although useful for detection, these wasps do not kill enough EAB to effectively suppress its population.

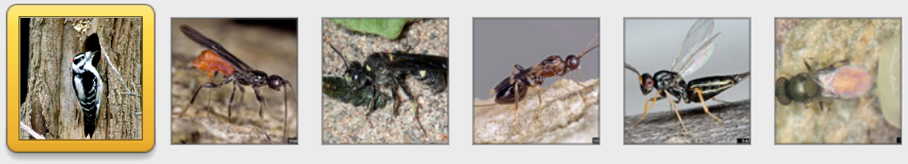
Scientists are researching Asian wasps that parasitize EAB in its natural range, including:

- *Spathius agrili*: parasitizes larvae
- *Tetrastichus planipennis*: parasitizes larvae
- *Oobius agrili*: parasitizes eggs

GALLERY 2.2 Natural enemies and population controls of EAB



Downy woodpecker - *Picoides pubescens*. Image from David Cappaert, Michigan State University, Bugwood.org



Research is also being conducted on a fungus (*Beuveria bassiana*) that kills EAB adults when they ingest it.

To learn more about biological control of EAB, visit: http://www.emeraldashborer.info/biocontrol.cfm

REVIEW 2.2

Question 1 of 2

What tree genus in North America is commonly infested by EAB?

- **A.** *Quercus* (oak)
- **B.** *Fraxinus* (ash)
- **C.** *Ulmus* (elm)

◀ Check Answer ▶

Chapter Summary

There are four main life stages for EAB: egg, larva, pupa and adult.

- Adult EAB emerge from trees in late spring and early summer.
- The larval stage is the deadliest to ash trees because larva feed on the tree's phloem and cambium, which disrupts the flow of food and nutrients.
- In North America, EAB is capable of infesting all plants in the *Fraxinus* genus.
- The most common *Fraxinus* species include white, green, blue and black ash.

Image 2.6 EAB damage in Ann Arbor, MI

Image from Steven Katovich, USDA Forest Service, Bugwood.org

- Natural enemies to EAB include woodpeckers, certain native and Asian wasps, and the fungus *Beuveria bassiana*. These enemies have not been found to appreciably suppress EAB populations.

CHAPTER 3

EAB Identification and Hosts

SECTION 1

Chapter Objectives

The purpose of this chapter is to introduce basic facts needed to identify an exotic, invasive tree pest called emerald ash borer (EAB).

Upon completing this chapter, you should be able to:

- Identify EAB larvae and adults
- Identify native ash species that are hosts of EAB
- Recognize signs of EAB infestation
- Recognize symptoms of EAB infestation

IMAGE 3.1 Adult EAB feeding on ash leaf
Image from USDA-APHIS

Adult and Larval EAB Identification

Adults

- Are metallic green in color with bronze undertones
- Have large, alien-like eyes
- About 1/2” long and 1/6” wide, approximately the size of a tic-tac candy or a little larger.
- Feed on ash leaves from April to August

Larvae

- Are “flat headed” and have body segments resembling nested bells
- Feed during warm months and then overwinter under ash tree bark

GALLERY 3.1 Adult and larval EAB identification

EAB adult with wings spread. Image from David Cappeart, Michgan State University, Bugwood.org

- Can be found by stripping the bark from infested branches and trunks
- Created S-shaped galleries beneath the bark that fill with frass (sawdust-like excrement) as they feed on the cambium

To see the EAB “Unwanted” poster with life cycle, tap here.

EAB Look-alikes

Several wood-boring beetles native to North America are closely related to EAB. Two that are also pests of native trees are:

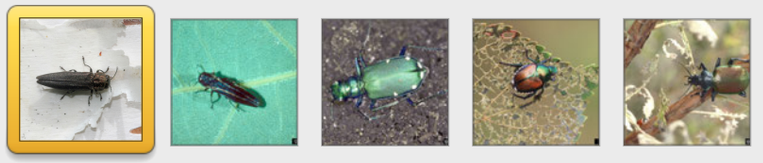
- Bronze birch borer (*Agrilus anxius*)
- Two-lined chestnut borer (*Agrilus bilineatus*) They are similar in size and shape to EAB, but are colored differently and attack different tree hosts.

Other insects that resemble EAB include:

- Six-spotted tiger beetle (*Cicindela sexguttata*)- one of the most commonly mistaken insects for EAB
- Japanese beetle (*Popillia japonica*)
- Caterpillar hunter (*Calosoma scrutator*)

GALLERY 3.2 EAB look-alikes

Bronze birch borer adult. Image from Whitney Cranshaw, Colorado State University, Bugwood.org



For more information on EAB look-alikes, tap here.

To view an EAB look-alikes poster, tap here.

REVIEW 3.1

Question 1 of 3

What color and size are adult EAB?

- ✓ **A.** metallic green and ½” long
- **B.** lime green and 1” long
- **C.** metallic brown and 1/2” long
- **D.** metallic green and 1” long

◀ Check Answer ▶

EAB Identification Summary

- EAB adults and larvae have distinguishing characters that aid with their identification
- Adults are metallic green and about ½" long. They are active from April to August
- Larvae can be found beneath the bark in late summer through late winter, have bell- shaped body segments, and have a tiny, flattened head

IMAGE 3.2 Adult EAB

Image from Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

IMAGE 3.3 EAB larvae

Image from David Cappaert, Michigan State University, Bugwood.org

Vulnerable Plant Species

If given no other choice, EAB adults have been known to feed on the foliage of several genera within the olive family (Oleaceae: *Chionanthus, Forestiera, Forsythia, Fraxinus, Ligustrum, Syringa*). However, EAB has only reproduced on native ash trees in North America (*Fraxinus* spp.).

White ash (*F. americana*) and green ash (*F. pennsylvanica*) are most frequently planted in urban areas. Other important species include blue ash (*F. quadangulata*) and black ash (*F. nigra*).

IMAGE 3.4 Mature ash tree

Image from David Cappaert, Michigan State University, Bugwood.org

SECTION 6

Characteristics of Ash Trees

- Ash trees have oppositely arranged twigs and leaves
- They are a large deciduous trees reaching mature heights of 50-100', typically having a broad, rounded crown
- Leaves are pinnately compound with 5-9 leaflets
- Bark of mature green and white ash trees has a distinct diamond-shaped pattern
- Ash seed (samaras) are oar-shaped 1-3" long and hang in clusters from summer through early winter (female trees only)

GALLERY 3.3 Characteristics of ash trees

Green ash leaves. Image from Keith Kanoti, Maine Forest Service, Bugwood.org



Ash Tree Look-Alikes

The following trees have pinnately compound leaves like *Fraxinus* and are common in urban areas, BUT…

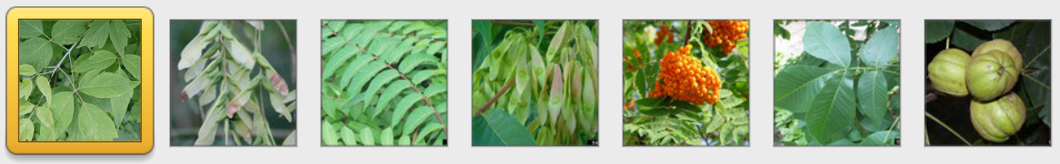
- Boxelder (*Acer negundo*) has 3-5 leaflets and samaras are in pairs
- Tree-of-heaven (*Ailanthus altissima*) has 10-41 leaflets, alternate branching, and samaras have seed in the center of the wing
- European mountain-ash (*Sorbus aucuparia*) is not a true ash species, it has alternate branching and orange berries

These native North American trees also have pinnately compound leaves like ash trees, BUT…

- Black walnut (*Juglans nigra*) and
- Hickory (*Carya* spp.) both have alternate branching and produce large, spherical fruits

GALLERY 3.4 Ash tree look-alikes

Boxelder leaves. Image from Robert Vidéki, Doronicum Kft., Bugwood.org



For more information on ash look-alikes, tap here.

REVIEW 3.2

Question 1 of 3

What are the two most commonly planted species of ash in the US?

- **A.** red and black
- **B.** yellow and orange
- ✓ **C.** green and white
- **D.** blue and yellow

Check Answer

Ash Identification Summary

All ash (*Fraxinus* spp.) trees in North America are vulnerable to attack by EAB.

Key characteristics of ash trees include:

- Is a large-maturing, deciduous tree
- Opposite branching with pinnately compound leaves
- Green and white ash have a distinct diamond-shaped pattern in mature bark
- Oar-shaped seeds (samaras) that hang in clusters on female trees

Some tree species are commonly mistaken for ash. Pay close attention to leaf form, branch arrangement, and fruit type when determining if a tree is truly an ash.

IMAGE 3.5 White ash with fall color

Image from Richard Webb, Self-employed horticulturist, Bugwood.org

Symptoms and Signs of an EAB Infestation

Symptoms are host responses to pest infestation. It can take 2-3 years for an infested tree to show noticeable symptoms of EAB attack. By then, it is often too late to save the tree due to extensive injury to the vascular system.

In the crown – thinning of foliage and branch dieback that starts high in the crown and progresses downward

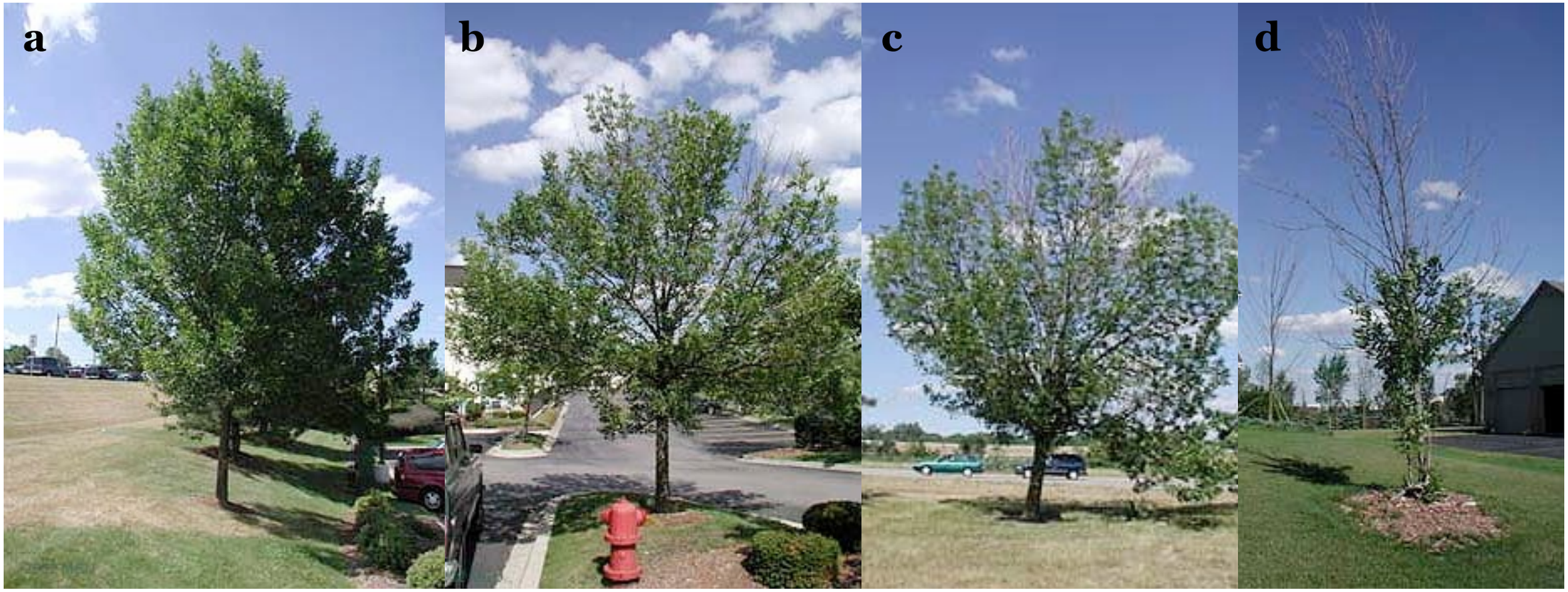
At the base of the tree – epicormic shoots (also called witches' broom) may be present

For more information on EAB signs and symptoms, tap here.

IMAGE 3.6 Late-stage EAB infestation showing branch dieback and epicormic sprouting

Image from Daniel Herms, The Ohio State University, Bugwood.org

IMAGE 3.7 Stages of canopy thinning. From left to right: a) healthy ash tree, b) initial decline: light thinning, c) intermediate decline: pronounced thinning and some dieback, and d) advanced decline: pronounced dieback and sprouting.



Images from David Roberts, Michigan State University

To see a tree canopy thinning scale (Smitley et al. 2008) tap here.

Signs are physical clues of a pest that are unrelated to host responses to the pest. Signs of EAB infestation in branches and trunks include:

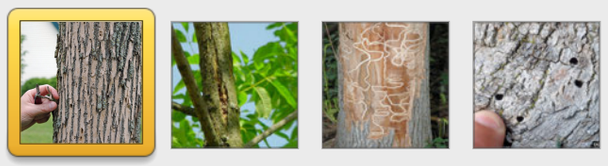
- Woodpecker damage
- Splitting of the bark on young trees
- S-shaped larval feeding galleries beneath the bark
- D-shaped holes in the bark following adult beetle emergence

INTERACTIVE 3.1 YouTube video EAB Identification 3:05

Video by Backyard Farmer with the University of Nebraska Lincoln (2009)

GALLERY 3.5 EAB signs

Flaking of outer bark by woodpecker foraging. Image from Art Wagner, USDA APHIS PPQ, Bugwood.org



REVIEW 3.3

Signs and symptoms of an EAB infestation include:

- **A.** D-shaped holes in the bark
- **B.** thinning canopy
- **C.** woodpecker damage
- ✓ **D.** all of the above

Check Answer

Chapter Summary

Emerald Ash Borer:

- Adults are metallic green and about ½” long. They are active from April-August.
- Larvae are found beneath the bark from mid-summer through late-winter, have bell shaped segments and a tiny, flattened head.

Ash Trees:

- Opposite branching with pinnately compound leaves
- A distinct diamond-shaped pattern in mature bark of green and white ash
- Oar-shaped seeds (samaras) 1-3” long that hang in clusters on female trees

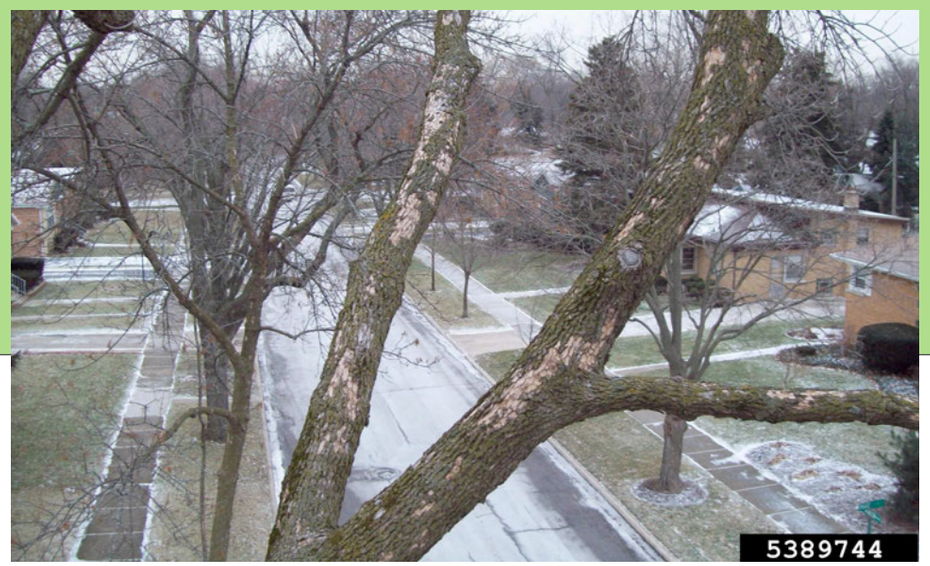


Image 3.8 Woodpecker damage on an infested ash
Image from Jim Tresouthick, Village of Home-wood, Bugwood.org

Signs and Symptoms:

- Foliage thinning and branch dieback in tree crown
- Epicormic shoots at base of tree
- Woodpecker foraging damage on branches and trunks
- Splitting of the bark on young trees
- S-shaped feeding galleries beneath the bark
- D-shaped exit holes

Chapter 4

EAB Monitoring

SECTION 1

Chapter Objectives

This chapter will provide an overview of the procedures and practices used to monitor ash trees for EAB infestation and explain how citizen-monitors should respond upon discovering a suspected EAB infestation.

Upon completing this chapter, you should be able to:

- Explain the importance of early detection of EAB infestation to minimizing its spread and its impacts on forest resources
- Describe the tools and techniques used to monitor ash trees for EAB infestation
- Perform a visual inspection of a vulnerable ash tree and document your observations
- Explain how and where to report a suspected EAB infestation

IMAGE 4.1 Ash street trees

Image from Eric Wiseman, Virginia Tech

SECTION 2

Monitoring for Early Detection and Rapid Response

A fundamental practice for managing any invasive pest is **monitoring** –periodic, systematic inspection of vulnerable trees to detect and document pest activity. Effective monitoring is crucial for early detection and rapid response to an EAB outbreak in a community. The prospect of monitoring trees for EAB infestation in an entire community is a formidable challenge. Over the last few years, federal and state agencies have deployed extensive EAB surveying programs throughout the eastern U.S. in an effort to rapidly detect outbreaks.

IMAGE 4.2 Urban forester examines an ash tree

Image from John Cox, mysuburbanlife.com

SECTION 3

Monitoring

EAB can be spread long distances by human activity. In addition, government resources for surveying for EAB are limited, so the likelihood of a localized outbreak going undetected is very high. Additional monitoring by citizens and green industry professionals can increase the odds of detecting a local EAB outbreak quickly.

One example of citizen monitoring is the **Forest Pest First Detector program** from the University of Minnesota Extension. Citizens are trained to identify infestations and educate their communities. This has significantly increased the capacity of Minnesota communities to monitor for EAB.

IMAGE 4.3 Citizen monitoring

Image from Michigan Department of Agriculture, Bugwood.org

For more information on branch sampling detection method tap here.

REVIEW 4.1

What is monitoring?

- **A.** educating people about a pest activity
- **B.** periodic, systematic inspection to detect and document pest activity
- **C.** taking pictures of pest infestations

Check Answer

SECTION 4

Where to Look for EAB

For EAB monitoring to be efficient and productive, it is important to know where vulnerable ash trees are located.

Many communities possess a **tree inventory** – a database containing information about the location and characteristics of individual public trees – that can be used to identify vulnerable trees and facilitate EAB monitoring efforts. With information about the quantity and location of vulnerable ash trees in a community, a systematic monitoring program can be developed to inspect trees on a periodic basis.

Communities lacking a tree inventory can quickly locate vulnerable ash trees using a **windshield survey**, in which a team of trained assessors drives slowly along select streets and records tree locations (a GPS unit is very helpful) for follow-up inspection by monitors traveling on foot. Volunteers trained in ash species identification and data collection can also be organized to conduct an on-the-ground, **ash-only inventory** to locate and document vulnerable ash trees for later inspection by monitors.

IMAGE 4.4 Tree inventory photograph

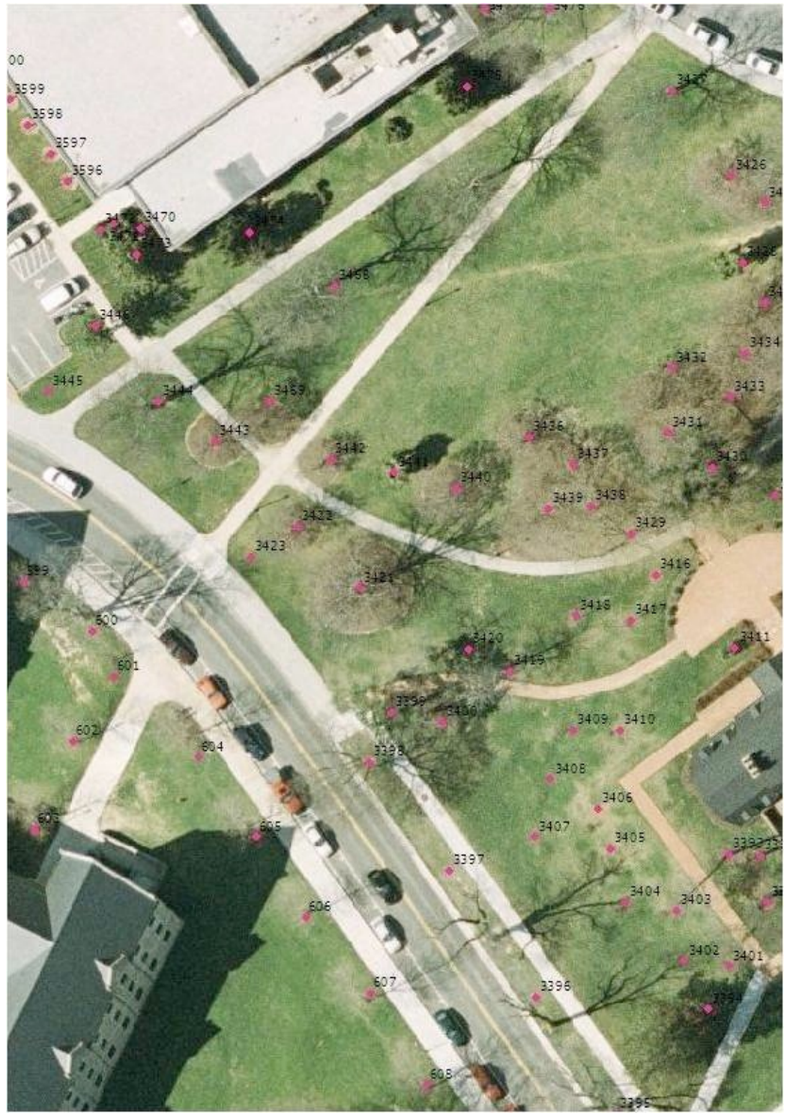


Image from Eric Wiseman, Virginia Tech

SECTION 5

When to Look for EAB

EAB can be detected in infested trees year-round. However, monitoring efforts are generally most efficient during the growing season. There are several reasons for this:

- It is easier to positively identify vulnerable ash species when their leaves are present.
- It is easier to detect canopy thinning, branch dieback, and epicormic sprouting when trees are foliated.
- Adult beetles (the most visible life stage outside the tree) are active from April to August when they may be found mating, laying eggs, or eating ash foliage.

IMAGE 4.5 Inspecting an ash tree for EAB

Image from Linda Burcham, Virginia Cooperative Extension

SECTION 6

Which trees to monitor?

In a community with hundreds of ash trees, it is a challenge deciding which trees to monitor. EAB is more likely to be detected if monitoring focuses on trees that research has shown the beetles to preferentially attack. Key traits of these preferred trees include:

- **Species**
- **Location**
- **Stress**

Species – green ash appears to be most preferred by EAB, followed by black ash, white ash, and blue ash. Green and white ash trees are the species most commonly planted as street and shade trees.

IMAGE 4.6 Infested ash trees growing in an open, sunny location near a parking lot.

Image from David Cappaert, Michigan State University, Bugwood.org

Location – ash trees growing in open, sunny locations are more likely to be attacked by EAB. Lawn and park trees often reside in these conditions.

Stress – ash trees stressed by injury, adverse weather, poor soil, or disease are more attractive to EAB than healthy trees. Street sides, sidewalk pits, and parking lot islands are good places to find stressed ash trees.

SECTION 7

Where in the Tree are Clues for EAB?

It is difficult to detect an infested ash tree during its first year of infestation because EAB density in the tree is usually too low to induce noticeable injury symptoms. Moreover, infestation of large trees often begins in the upper crown and may not reach ground level until the second or third year.

One study found the majority of EAB larvae and emergence holes in recently infested trees were more than 15 ft aboveground and almost none were below 6 ft. Therefore, clues of early infestation may not be apparent to ground-based monitors. If infestation is suspected, an arborist may need to inspect the tree closer by climbing or aerial lift.

IMAGE 4.7 Urban forester using binoculars to look for symptoms of EAB infestation in the upper crown of an ash tree.

Image from Sarah Gugercin, Virginia Tech

Review 4.2

Question 1 of 3

When is monitoring for EAB the MOST EFFICIENT?

- ✓ **A.** during the growing season
- **B.** during dormancy

◀ Check Answer ▶

SECTION 8

Field Tools for Monitoring EAB

When heading to the field to monitor ash trees for EAB, there are several tools that can make the task more accurate and efficient.

- GPS unit – map the monitoring route and the locations of infested trees.
- Mobile device – record inspection data.
- Camera – photograph trees or insects for verification of ash species or EAB infestation.
- ID guides – properly identify ash species, insects, or EAB signs and symptoms.
- Sampling supplies – collect tree parts in plastic bags and insect specimens in vials containing alcohol for submission to a diagnostic lab.
- Binoculars – inspect upper trunk and branches for EAB signs/symptoms.

IMAGE 4.8 Urban forester recording inspection data on his cellphone

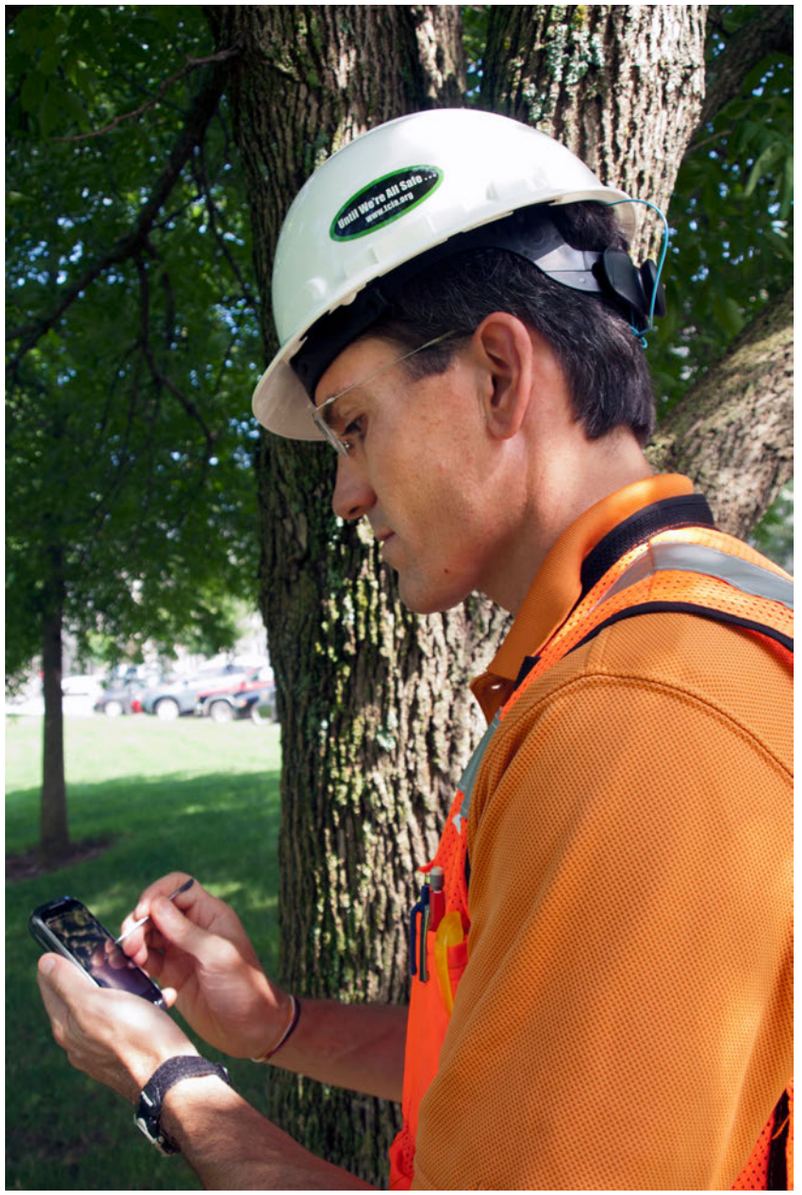


Image from Sarah Gugercin, Virginia Tech

SECTION 9

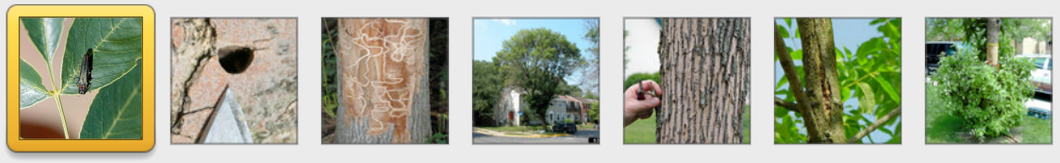
EAB Signs & Symptoms

When inspecting vulnerable ash trees, monitors must look for visual indicators of EAB infestation, including the insect, its signs, and its symptoms. Photos and descriptions of these items are provided in chapter 3 of this iBook.

Besides the insect itself, the only external signs of EAB are its feeding injury on ash foliage and its 1/8” D-shaped emergence hole through the bark surface of trunks and branches. Adult beetles only feed on foliage during the summer months, but emergence holes persist on the bark and can be observed year-round. However, they can be difficult to spot on fissured bark or when infestation of the tree is low.

GALLERY 4.1 EAB signs and symptoms

Adult EAB feeding on ash leaf. Image from Daniel Herms, The Ohio State University, Bugwood.org



EAB infestation is most commonly discovered through detection of its symptoms on host trees, which include:

- canopy thinning
- crown dieback
- epicormic sprouting

Unfortunately, these symptoms are often subtle in the first 1 – 2 years of infestation and may be overlooked due to their similarity with other ash pests and diseases. Symptoms may also be erroneously attributed to tree decline caused by injury, poor soil, extreme weather, or old age. Other externally visible symptoms of EAB infestation include vertical bark splits and woodpecker foraging injury. Again, these symptoms may be subtle in the early stages of infestation.

The key to detecting subtle EAB infestation symptoms is first understanding the normal, healthy appearance of ash trees of particular species and age in your community. All vulnerable ash trees harboring insects, signs, or symptoms similar to EAB warrant further inspection. When in doubt, collect a specimen or take a photograph for proper identification by authorities.

To learn more about EAB signs and symptoms tap here.

SECTION 10

Visual Inspection Summary

Monitoring trees during the growing season is more efficient because it is easier to identify potential host trees and see crown dieback. Adult beetles are also more likely to be seen. While EAB can attack any trees in the *Fraxinus* genus, they prefer green ash, open-grown trees and stressed trees. EAB infestation starts at the top of the tree, which makes it very difficult to detect during initial infection stages.

Signs and symptoms of EAB infestation include: D-shaped holes in bark, canopy thinning, crown dieback, epicormic sprouting, vertical splits in the bark, and signs of woodpecker foraging.

IMAGE 4.9 Ash tree crown dieback from EAB infestation

Image from Joseph O'Brien, USDA Forest Service, Bugwood.org

Advanced Monitoring Techniques

Federal and state agencies have developed advanced monitoring techniques to enhance their EAB detection abilities. These techniques are usually employed in coordinated surveys organized by resource professionals. These techniques include:

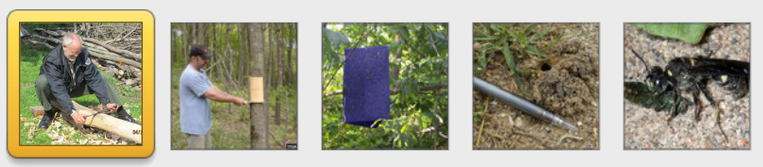
Destructive Sampling – ash trees located in high risk areas and/or suspected to be infested by EAB are inspected by stripping their bark to look for **EAB larvae** and **larval galleries**. Although this method can detect a local infestation in its early stages, it is resource intensive and destroys the sampled tree. Destructive sampling of public trees should only be performed under the supervision of local authorities.

Detection Trees – healthy ash trees are systematically selected across a geographical area and wounded to induce stress, making the tree attractive to nearby beetles. A band of bark and phloem is removed from the tree in fall, winter, or spring, and then destructively inspected for EAB larvae and larval galleries the following fall. In some instances, potted detection trees can be used to augment sampling distribution.

Traps – purple panel traps have been used extensively in the U.S. in recent years for early detection of EAB. The adult beetles are attracted to the traps' color and chemical lure that

GALLERY 4.2 Advanced monitoring techniques

Peeling bark to find EAB galleries. Image from Kenneth R. Law, USDA APHIS PPQ, Bugwood.org



mimics the scent of a stressed ash tree. The traps are coated with adhesive to capture attracted beetles and are hung 12 – 15 ft off the ground in or near vulnerable ash trees. Traps are distributed in early summer and then collected for inspection in fall.

Biosurveillance – recent research suggests that the predator wasp *Cerceris fumipennis* has the potential to detect low levels of EAB. The wasp captures an assortment of beetles, including EAB, and stockpiles them in ground nests. It is believed that cultivated wasp nests could be periodically monitored during the growing season for the presence of EAB brought there by local wasps. There may not be enough well placed natural colonies of *C. fumipennis* to use this as a primary surveillance tool.

Tap here to see the 2013 USDA APHIS EAB Survey Guidelines

INTERACTIVE 4.1 YouTube video Hunting for EAB 4:50

Video by Minnesota Department of Agriculture (2009)

Documenting & Reporting a Suspected EAB infestation

Consequences of an EAB outbreak may be potentially severe for a community. All suspected infestations should be taken seriously and reported promptly to authorities. If you suspect that you have discovered an EAB insect or an infested ash tree:

1. Document your location. If you are in an urban area, note the nearest street address or intersection. If you are in a forest, mark the tree with a ribbon, paint, or hatchet blaze. GPS or map coordinates will help with relocation.

2. Collect a sample or photograph of the insect or symptomatic tree part. Place tree parts in a paper or plastic bag. Place insects in a bottle or vial containing alcohol. Refrigerate samples until submission instructions are obtained.

3. Report your discovery to local, state, or federal authorities. If your community has an urban forester or horticulturist, then contact that individual first. Go to http://emeraldashborer.info/call.cfm. This page has a list of states and the appropriate telephone numbers to call.

IMAGE 4.10 Dead ash tree with exposed larval galleries

Image from David Cappaert, Michigan State University, Bugwood.org

Section 13

Chapter Summary

Monitoring is the inspection of vulnerable trees to detect and document pest activity.

What: all ash tree species, especially stressed and/or trees growing in open sunny locations.

When: during the growing season

Where: infestation starts in the upper crown and moves its way down the tree

Look for signs and symptoms discussed in chapter 3 and reviewed in this chapter.

Advanced monitoring techniques include destructive sampling, detection trees, traps and biosurveillance.

If EAB is found, document your location, collect a sample or photograph, and report your discovery.

IMAGE 4.11 Urban forester examining ash tree foliage
Image from Sarah Gugercin, Virginia Tech

CHAPTER 5

EAB Management

SECTION 1

Chapter Objectives

This chapter provides an overview of the procedures and practices currently used for preventing, responding to, and recovering from an EAB outbreak.

Upon completing this chapter, you should be able to:

- Identify practices that help slow infestation and minimize its impacts on a community
- Identify the options available for managing an EAB outbreak and discuss their applications and limitations
- Explain how communities and their urban forests can recover from an EAB outbreak and minimize threats from future invasive pests

IMAGE 5.1 A field surveyor marking an ash tree

Image from The Ohio State University, ashalert.osu.edu

SECTION 2

Preparing for an EAB Outbreak

Without substantial advancements in EAB detection and control methods, the spread of EAB across the eastern U.S. is inevitable. As such, individuals and communities are advised to begin preparing for EAB outbreaks. The purpose of these preparations is to facilitate response and recovery activities, thereby minimizing the negative impacts of an outbreak. Preparedness plans include details of the administrative, regulatory, and technical actions to be taken once an EAB outbreak occurs.

To see examples of preparedness plans, visit:
http://www.emeraldashborer.info/communityplan.cfm

IMAGE 5.2 Crown dieback in ash tree with ash stump in foreground

David Cappaert, Michigan State University, Bugwood.org

Preventing an EAB Outbreak

Natural spread of migrating EAB adults is very slow compared to the rate of spread by human transport of infested ash trees and wood. Based on current research, the rate of natural spread of EAB on its own does not exceed 2 miles per year. In contrast, people move infested ash materials hundreds and even thousands of miles in only a few days.

Therefore, a fundamental strategy for preventing EAB spread is restricting movement of ash trees, materials, and products. Educating both citizens and businesses can raise awareness of EAB spread and reduce the incidence of high risk behaviors. In areas where EAB has not yet been found, recommended practices to prevent EAB spread include:

IMAGE 5.3 Infested ash firewood

Image from Troy Kimoto, Canadian Food Inspection Agency, Bugwood.org

Firewood – buy only local firewood and encourage local campgrounds to prohibit out-of-state campers from bringing their own firewood.

Nursery stock – discourage sale and planting of native ash trees.

Raw wood products – avoid importing ash timber, waste wood, landscape debris, green lumber, and untreated wood products from other states.

IMAGE 5.4 EAB awareness bumper sticker

Image from USDA-APHIS

REVIEW 5.1

Sources of infested ash materials that risk spreading emerald ash borer include:

- **A.** firewood
- **B.** nursery stock
- **C.** raw wood products
- ✓ **D.** all of the above

Check Answer

SECTION 4

Responding to an EAB Outbreak

Once an EAB outbreak has been verified by federal and state officials, a series of response actions may be taken to limit the spread and impact of the pest. Some state response plans entail four phases: delimitation, quarantine, mitigation, and restoration. Initial response actions are usually directed by USDA- APHIS (Animal and Plant Health Inspection Service) and the State's agriculture department.

Delimitation – Following an initial emergency quarantine of the entire vicinity, a field survey is performed to determine the extent and duration of the EAB infestation. The survey commences at the epicenter of the outbreak and proceeds outward, documenting the location of infested trees.

Quarantine – The purpose of quarantine is to prevent EAB spread by people to uninfested areas. Based on delimiting survey information about the source, extent, duration, and secondary spread of an outbreak, authorities implement a formal

IMAGE 5.5 Quarantine sign at the Michigan-Ohio border.

Image from The Ohio State University, ashalert.osu.edu

quarantine to restrict movement of ash wood. Quarantines can range in geographic scale from the county level to the state level depending on the circumstances of an outbreak.

Who regulates the quarantines?

Interstate – USDA APHIS

Intrastate – State's agriculture department

To view the current quarantine maps, visit: http://www.emeraldashborer.info/firewood.cfm

ILLUSTRATION 5.1 EAB Quarantine map as of October 1, 2013

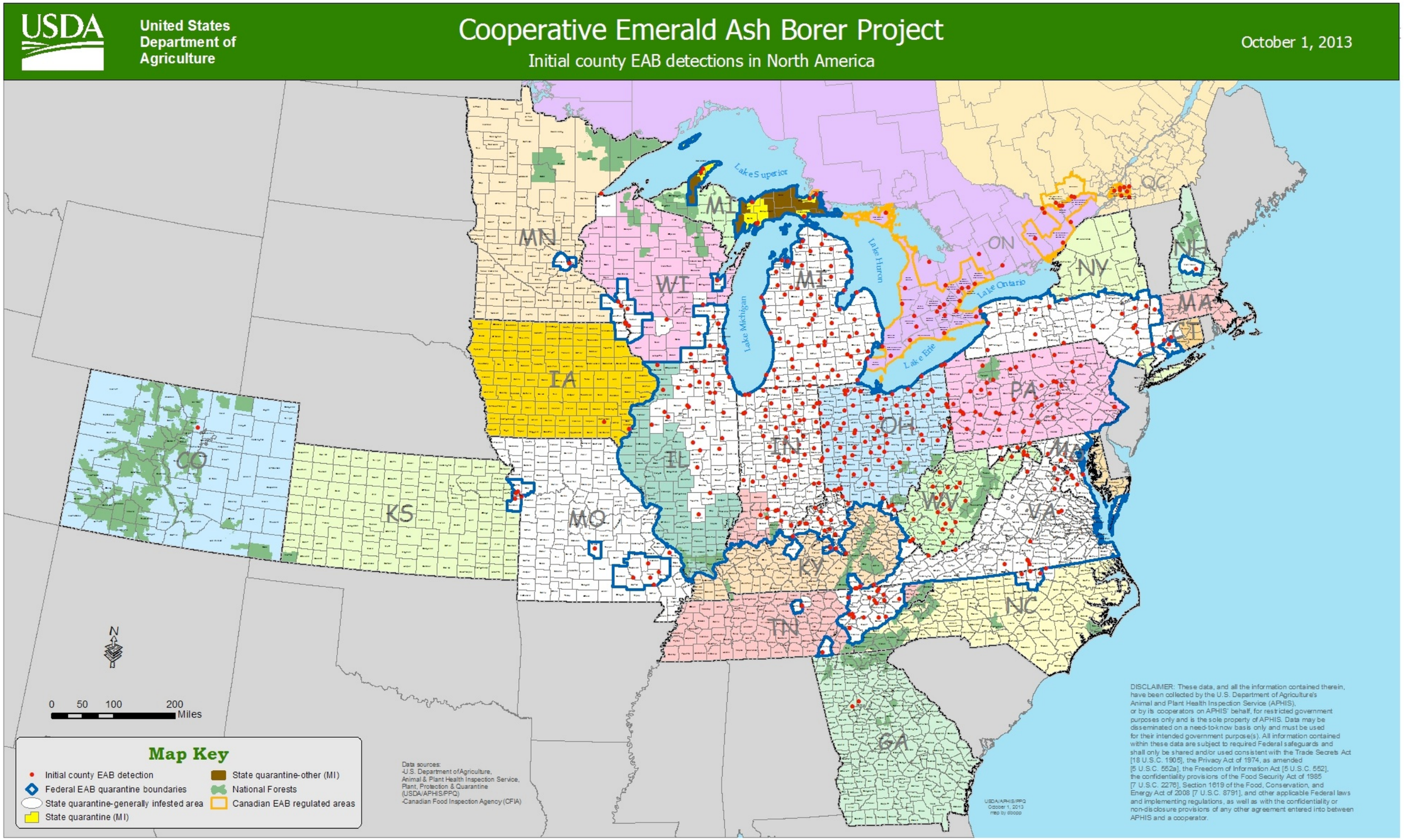


Illustration from the USDA.

Mitigation – Once a quarantine has been established, authorities begin actions to mitigate impacts within the infested area.

Choosing an appropriate **course of action** at the community level is a complex matter that is influenced by numerous factors that include:

- Age and size of infestation
- Ash density and distribution
- Risk of reintroduction
- Risk of spread from the location
- Resources to manage infestation
- Community attitudes and values

Ideally, the course of action should represent community consensus based on input from government officials, resource professionals, and citizens.

REVIEW 5.2

Mitigation of an emerald ash borer outbreak:

- **A.** precedes delimitation and quarantine of the infested area
- **B.** is the sole responsibility of elected officials
- ✓ **C.** is a complex matter influenced by factors such as age and size of infestation, resources available for management, and community attitudes and values
- **D.** all of the above

Check Answer

SECTION 5

Course of Action: Overview

Communities responding to an EAB outbreak typically choose from three courses of action

- Take no action
- Eradication
- Suppression

Taking no action means EAB is permitted to run its course without human intervention. This will result in severe damage to the local ash tree resource. While direct costs could be minimized in the short-term, the long-term costs associated with removal of dead trees, loss of ecosystem services, and loss of forest revenues would be substantial. Moreover, state laws could mandate citizens and communities to take action regardless of local opinion.

The intention of **eradication** is to completely eliminate EAB from an infested area. This entails removing and destroying native ash trees within the delimited outbreak area plus an outside buffer zone that provides a margin of safety.

Eradication of EAB is problematic for several reasons. First, it is difficult to accurately delimit an outbreak area because it is hard to distinguish infested trees from uninfested trees in its early stages. For this same reason, it is risky to cull only infested trees, sometimes necessitating the removal of seem-

IMAGE 5.6 Chipping harvested trees

Image from Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

ingly healthy ash trees too. Finally, the cost of equipment, fuel, labor, and disposal (not to mention the environmental and aesthetic impacts) can be high.

Some individuals and communities have opted for pre-emptive removal of their ash trees so that the cost can be spread over several years and ash wood can be safely utilized.

When not mandated to do otherwise, most communities opt to **suppress** an EAB outbreak, which is a compromise between doing nothing and attempting eradication. In fact, USDA APHIS has transitioned from an eradication program to an integrated pest management (IPM) program, which combines a range of practices including sanitation, trapping, tree removal, biological control, and insecticide application.

The purpose of EAB suppression using IPM is to slow pest spread and minimize its impacts on the economy, the environment, and the citizens. For best effect, an IPM strategy should be implemented at the community level and combine practices most suitable for the circumstances of the outbreak.

IMAGE 5.7 Arborist cutting down an ash tree

Image from The Ohio State University, ashalert.osu.edu

REVIEW 5.3

Which of the following is a course of action for a community in response to EAB?

- **A.** take no action
- **B.** eradication
- **C.** suppression
- ✓ **D.** all of the above

Check Answer

Integrated Management of EAB

Removing stressed ash trees can reduce EAB feeding and brood habitat. **Trap trees** can be created by girdling them to trigger stress, which attracts EAB to the ash tree, where they mate and the females lay eggs. The trees are then destroyed before the larvae complete their life cycle.

IMAGE 5.8 EAB trap tree

Image from Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

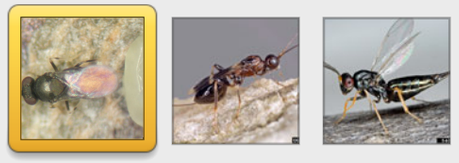
Integrated Management: Biological Control

There are no known natural enemies of EAB in North America that can appreciably suppress its populations. However, there is considerable interest in biological control as an EAB management tactic because most other tactics are not practical in natural ecosystems.

Scientists have discovered three species of small, stingless wasps in China that parasitize EAB eggs and larvae. As of the summer of 2013, seventeen states have released wasps to evaluate their ability to naturalize and suppress EAB. Although initial results are promising, the time required to conduct full research and the challenges of rearing these natural enemies suggest that large-scale use of biological controls is several years away.

GALLERY 5.1 Parasites of EAB

Oobius agrili adult parasitizing EAB egg. Image from Debbie Miller, USDA Forest Service, Bugwood.org



SECTION 8

Integrated Management: Insecticides

Recent advancements in insecticide technology have improved the efficacy and affordability of controlling EAB. Insecticides can be used to protect valuable ash trees as well as suppress the local EAB population.

Careful consideration should be given to both the benefits and limitations of managing EAB with insecticides. First, recognize that a single application of insecticide is effective for only 1–2 years depending on the product. Second, not every tree can be effectively treated. Since most products are systemic, the tree must be reasonably healthy to ensure adequate uptake and distribution of the insecticide. For this reason, infested trees with >50% dieback may not respond to treatment. Third, current evidence suggests that insecticides are less consistent in protecting trees with trunk diameter over 25

IMAGE 5.10 Trunk injection

Image from David Cappaert, Michigan State University, Bugwood.org

IMAGE 5.9 Ash defoliation from left to right: 30%, 50%, and 70%

Image from David Smitley, Michigan State University

inches, and trees over 20 inches are best treated professionally due to limitations on pesticide use by homeowners. Finally, a treated tree in a mandated eradication zone may still be subject to removal by authorities, even on private property.

With these considerations in mind, it is apparent that long-term use of insecticides for controlling EAB is most appropriate for healthy, intermediate-size, high-value ash trees. Because current products provide limited residual protection, it is not cost effective to treat trees preventively if EAB has not been detected within 15 miles.

To see the EAB Management Statement from the Coalition for Urban Ash Tree Conservation, tap here.

To see the EAB Management Decision Guide, tap here.

To see EAB insecticide recommendations, tap here.

INTERACTIVE 5.1 YouTube video Homeowner Treatments for Emerald Ash Borer 3:27

Video by Purdue Extension Entomology (2012)

REVIEW 5.4

Question 1 of 2

An IPM approach to managing emerald ash borer incorporates practices such as:

- **A.** sanitary tree removal and trap trees
- **B.** biological control
- **C.** insecticide application
- ✓ **D.** all of the above

◀ Check Answer ▶

SECTION 9

Recovering from an EAB Outbreak

Recovering from EAB outbreak can be challenging. However, communities should not let the experience foster negative attitudes towards landscape trees and instead should embrace the opportunity to improve its urban forest. EAB recovery has three focus areas:

- Remove low-value ash trees threatened by EAB
- Protect high-value ash trees from EAB
- Replace lost ash trees with diverse species not susceptible to EAB

Ideally, a recovery plan that identifies objectives, priorities, tasks and deadlines for recovery of the community forest should be included in the community's preparedness or response plan.

In communities with many ash trees, the removal and disposal of trees during and following an outbreak can overwhelm local resources. As a result, many dead trees are left standing and large amounts of ash wood debris accumulate awaiting proper disposal. During recovery, the highest priority is to remove infested ash trees and dead trees that have become hazardous. Large, dead trees that are located near high-use areas (e.g. streets, buildings, parks) present the greatest hazard and should be removed right away. Quarantines usually dictate how and where ash tree debris is disposed, but there are utilization options that can help reduce waste and recover value.

IMAGE 5.11 A high-value green ash worth protection from EAB

Image from Dana Malone

To learn more about recovery after an infestation, tap here.

Some communities opt to systematically harvest uninfested ash trees as part of their outbreak recovery efforts. The rationale is that removal costs can be spread over several years and the vacated spaces can be promptly replanted with non-susceptible species to jumpstart reforestation. This strategy should preferentially cull low-value ash trees that are over-mature, in poor-condition, or growing in undesirable locations. In remote areas, it may be desirable to simply kill ash trees by girdling or herbicide application to reduce work, minimize disturbance, and create wildlife habitat.

In many cases, ash tree conservation is economically and environmentally superior to tree removal, especially in residential and municipal settings. Insecticide treatment is most appropriate after EAB infestation has been detected within 15 miles, and is most effective when applied before trees are infested. However, treatment can also save ash trees with a low level of EAB infestation. Along with periodic insecticide treatments, preserved ash trees should be placed on a routine maintenance program that includes pruning, irrigation, fertilization, and mulching as well as annual inspection by an arborist to evaluate health and structure.

Beauty, adaptability, and ease of transplant have made white and green ash popular choices as lawn and street trees, particularly in Midwestern communities where American elms were decimated by Dutch elm disease. Ironically, overuse of

IMAGE 5.12 Planting street trees

Image from Susan Pierce, Trees Atlanta, Bugwood.org

native ashes has led to the same calamity experienced with American elms fifty years ago. Communities over-reliant on ashes are now facing significant losses in canopy cover that must be addressed through tree planting. Keep in mind that a single genera should not account for more than 20% of a community's trees and that some vacated spaces (e.g. under power lines) may not be suitable for large-stature species.

To learn more about recommended replacement species, tap here.

The EAB recovery phase provides a good opportunity to improve local urban forestry policies and practices. Indeed, much of the turmoil caused by EAB could have been avoided with better planning and management of community forests. EAB has taught us that promoting species diversity is a fundamental stewardship practice. Enacting tree ordinances and establishing a tree commission can also help ensure that suitable species are planted by citizens and that trees are afforded reasonable protection to keep them healthy and safe. Finally, developing a long-term management plan helps articulate a vision for the urban forest and identifies tasks needed to avoid future threats to this community resource.

IMAGE 5.13 Street trees

Image from Eric Wiseman, Virginia Tech

Chapter Summary

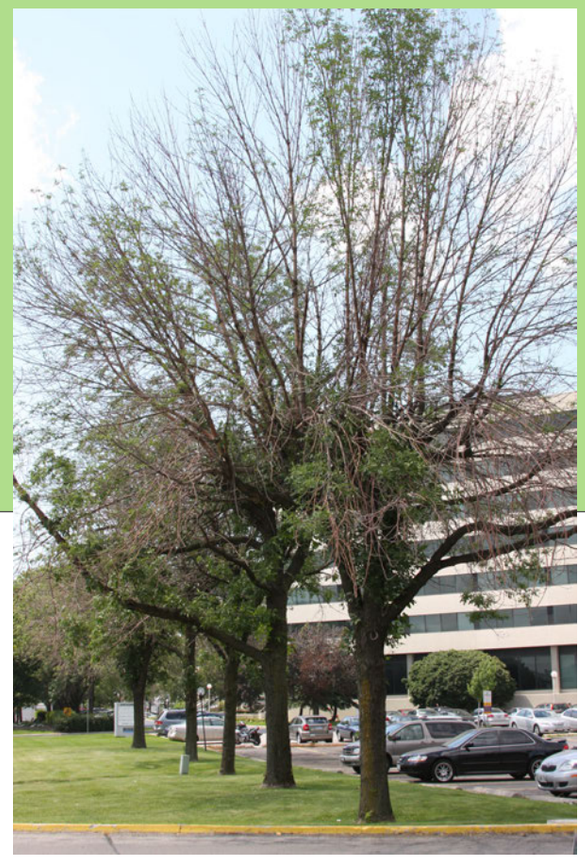


Image 5.14 Dying ash trees

Image from D.B. Lyons, Natural Resources Canada, Canadian Forest Service

Responding to an EAB outbreak

1. Delimitation- field survey to determine the extent and severity of the infestation

2. Quarantine- restricting movement of ash trees, materials and products

3. Mitigation- course of action

   - Take no action- let EAB run its course without human intervention
   - Eradication- completely eliminate EAB from an infested area by removing and destroying all ash trees within the outbreak area
   - Suppression- integrated management which includes sanitation, trapping, tree removal, biological control, and insecticide application

4. Restoration and recovery- different treatment regiments will be optimal under different situations, so communities need to develop a strategy that works for them, using up-to-date information. Replace dead ash trees with a diversity of tree species.

Chapter 6

EAB Resources

SECTION 1

Chapter Objectives

The purpose of this module is to summarize internet resources that are helpful for understanding an exotic, invasive tree pest called emerald ash borer (EAB).

Upon completing this module, you should be able to:

- Identify authoritative online resources for EAB information
- Use online resources to stay informed about events and developments in the ongoing effort to suppress EAB spread
- Refer friends, neighbors, and colleagues to online resources when they have questions about EAB

emeraldashborer.info

The first place that you should go for information about EAB is www.emeraldashborer.info.

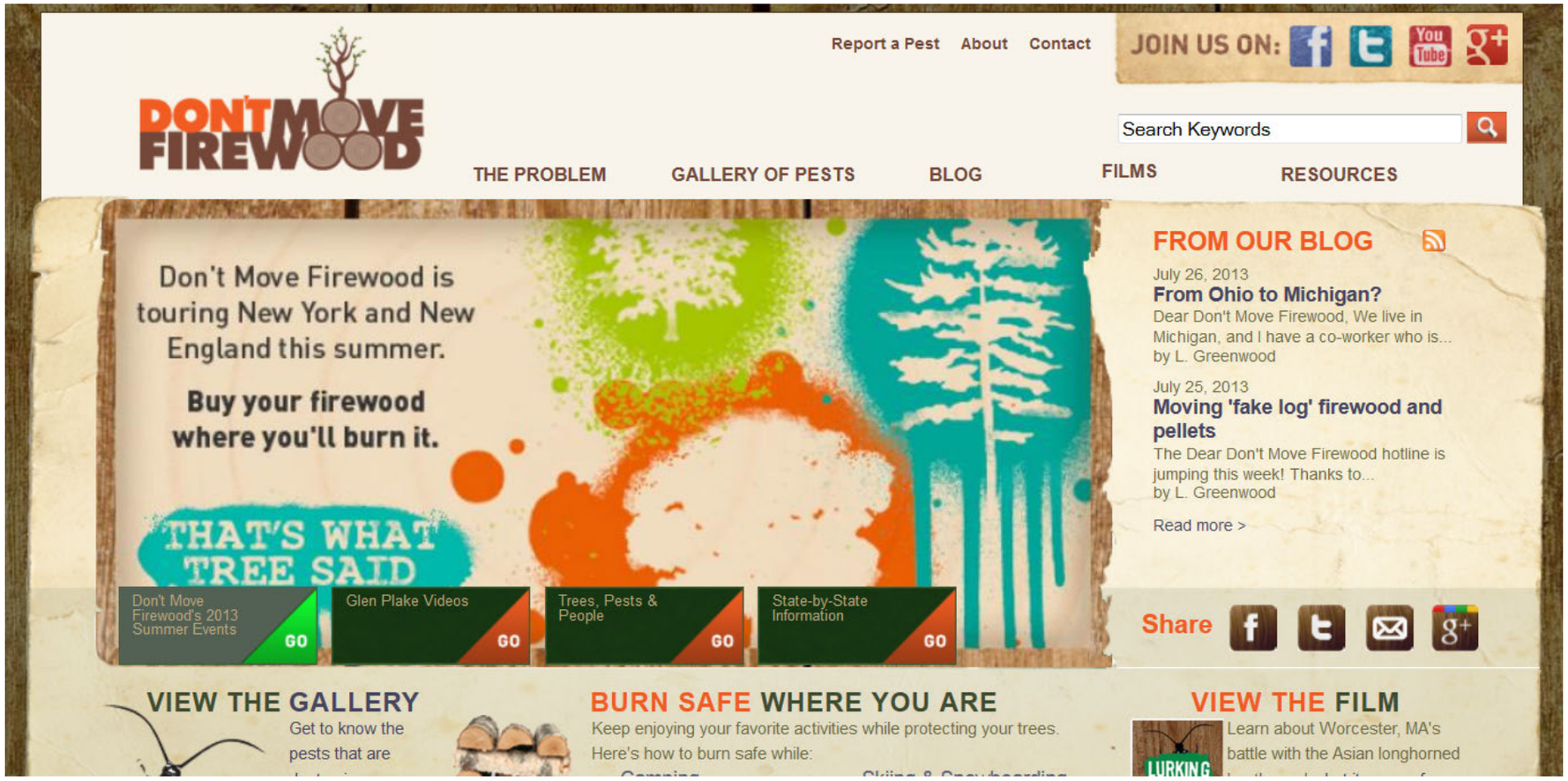
This website is a collaborative effort of the USDA Forest Service, the MI Dept. of Agriculture, the MI Dept. of Natural Resources, and USDA APHIS as well as Michigan State University, Purdue University and Ohio State University. The site provides comprehensive, credible and timely information on the emerald ash borer.

stopthebeetle.info

Transporting EAB in firewood from infested areas is one of the greatest threats for spreading EAB. The USDA website www.stopthebeetle.info spreads the message about the dangers of moving firewood.

dontmovefirewood.org

Another outreach site, www.dontmovefirewood.org is owned by the Nature Conservancy and was developed by the Continental Dialogue on Non-Native Forest Insects and Diseases. It is not specifically focused on EAB, but seeks to protect North American forests from non-native insects and diseases.

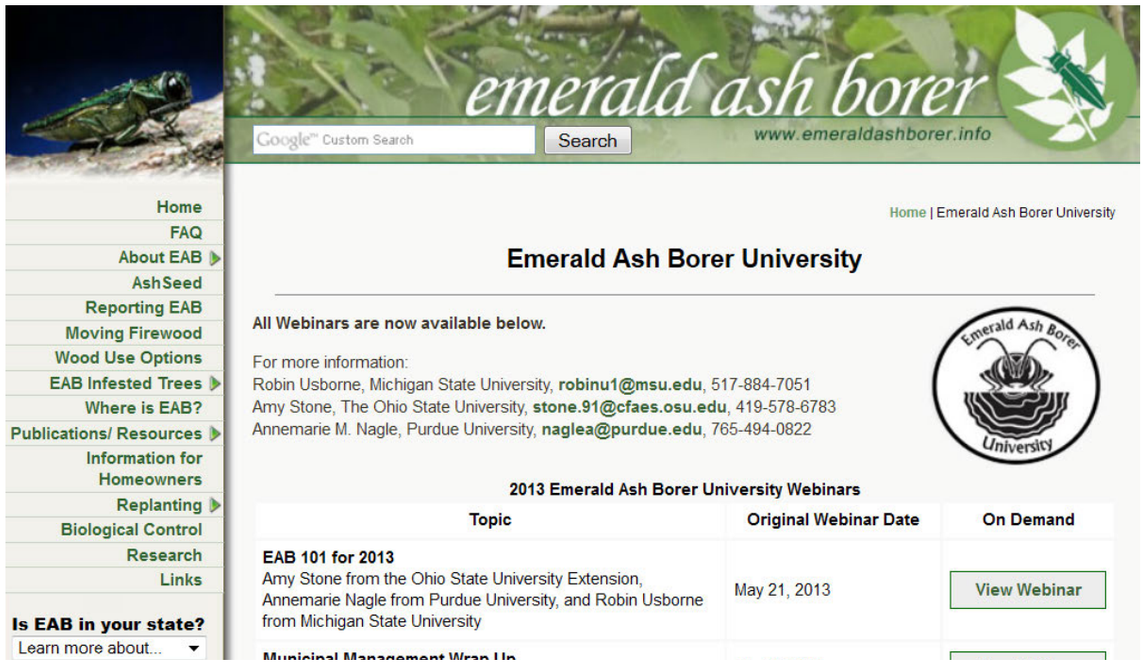


SECTION 5

Emerald Ash Borer University

If you are interested in learning more about EAB, Emerald Ash Borer University offers webinars free of charge.

To view archived webinars, visit www.emeraldashborer.info/eab_university.cfm.



Others training opportunities:

- Forest Connect (Cornell University) webinars cornellforestconnect.ning.com/profiles/blogs/emerald-ash-borer-webinar-april-18-2012?xg_source=activity
- Purdue University Training modules extension.entm.purdue.edu/eab/index.php?page=industries/selfstudy
- University of Minnesota Eyes in the Woods Online Training: www.mlep.org/onlineeabintro.htm

EAB in Your State

Check www.emeraldashborer.info and click “Is EAB in your state?” in the left sidebar to find websites from your state about EAB. Most states that are impacted or threatened by EAB maintain a website about the pest through an agricultural agency or land-grant university.

Ohio Department of Agriculture Emerald Ash Borer Program

Programs and Information

- EAB Home
- Plant Health Home
- Newsroom
- Public Meeting Notices
- Meetings and Events
- Forms
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Cooperative Efforts

Ohio Department of Natural

Plant Health Division - Emerald Ash Borer

Emerald Ash Borer (Agrilus Planipennis), an ash tree-killing insect from Asia, was identified in Ohio in 2003. The department has been battling the pest through detection, regulation, and public outreach in an attempt to protect the state's more than 3.8 billion ash trees over the past decade. The pest has since spread from the initial detection in near Toledo to nearly all other parts of the state. Because the pest is established throughout most of Ohio, including Cincinnati, Cleveland, Columbus, Dayton and the Wayne National Forest, there are no longer quarantine regulations in place for emerald ash borer within the state. Despite the fact that the Ohio quarantine has

Adult Emerald Ash Borer

Collect Ash Seed

If native ash tree populations are completely decimated by the ash borer, stored ash seeds can be used to re-establish ash trees for future generations. There are currently 2 efforts to collect ash seed:

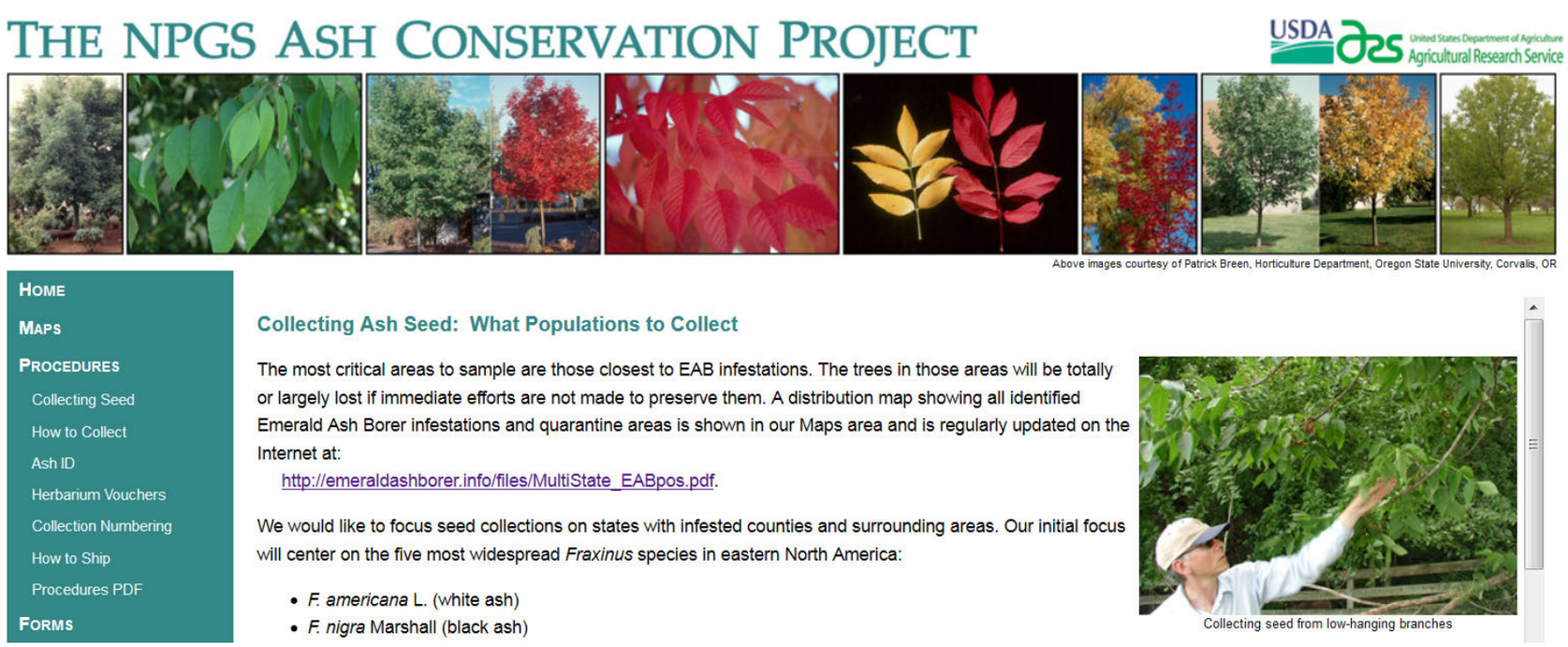
- The NPGS Ash Conservation project is a cooperative network coordinated by the USDA Agriculture Research Service.

If you are interested in collecting seeds visit:

www.ars.usda.gov/sp2UserFiles/Place/36251200/Ash_Project/ProceduresPage.html#howToCollect2

- National Seed Laboratory (USDA Forest Service) Ash Seed Collection collecting seeds predominately in MI and along Great Lakes.

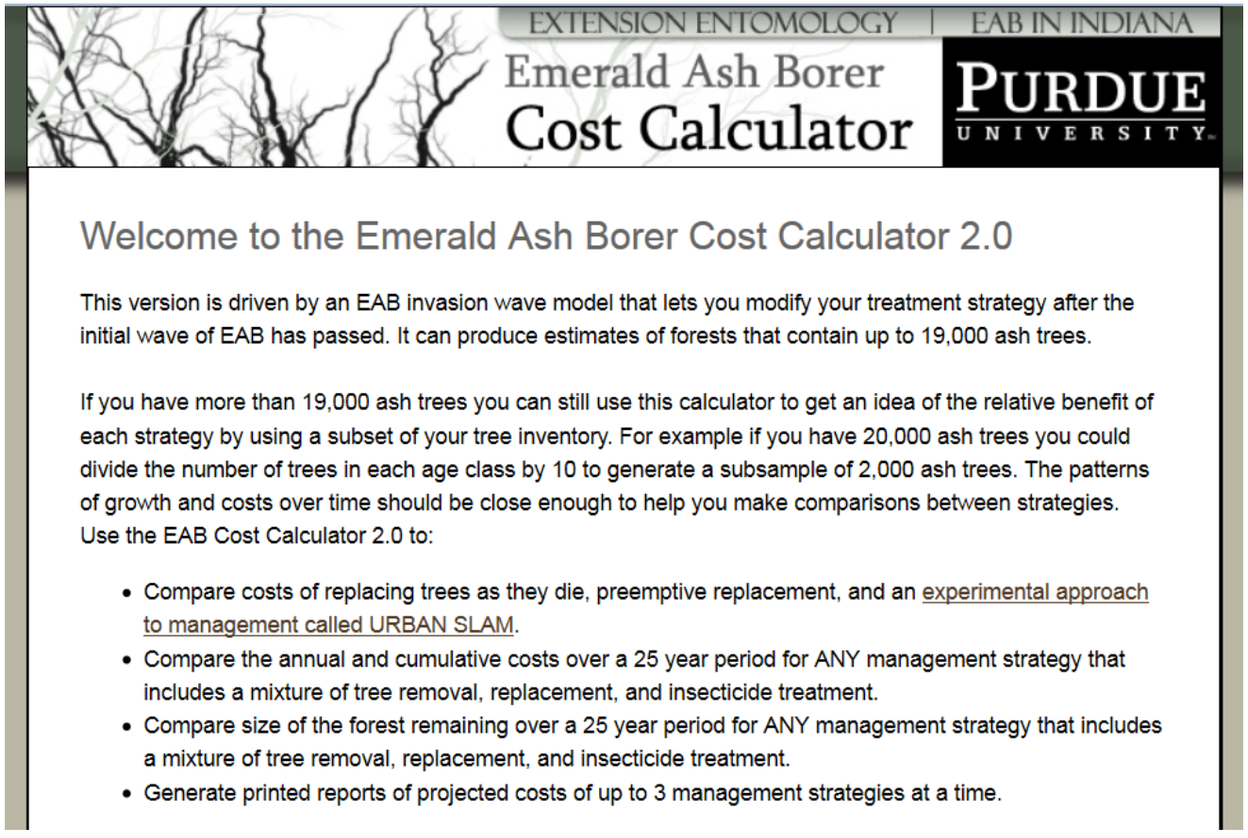
www.nsl.fs.fed.us/GeneticConservation_Ash.html



EAB Cost Calculator

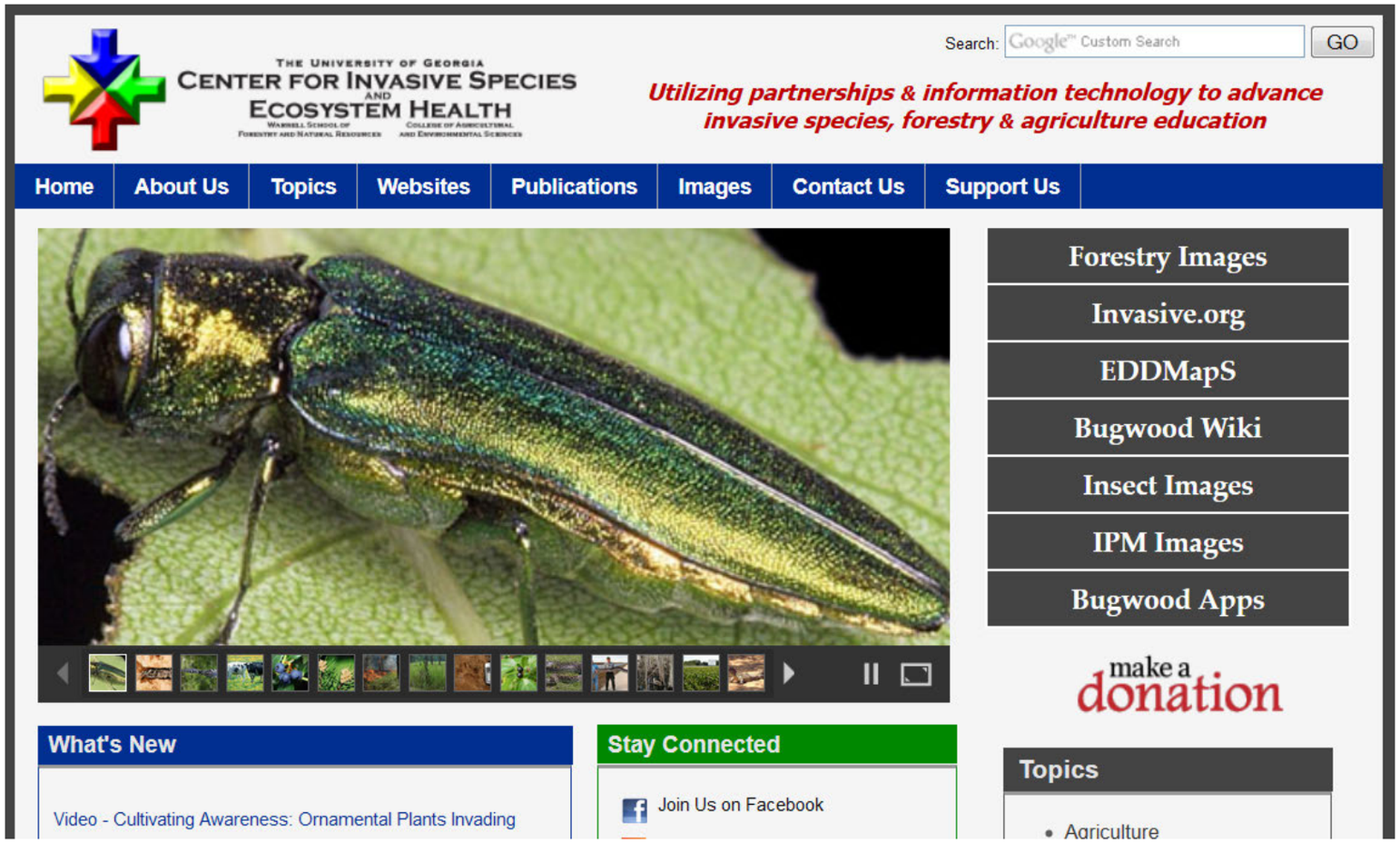
Another resource is
http://extension.entm.purdue.edu/treecomputer/v2beta

This cost calculator can produce estimates of forests that contain up to 19,000 ash trees. Future versions will handle larger forests.



Center for Invasive Species and Ecosystem Health

Center for Invasive Species & Ecosystem Health (formerly known as the Bugwood Network) serves a lead role in development, consolidation and dissemination of information and programs focused on invasive species, forest health, natural resource and agricultural management through technology development, program implementation, training, applied research and public awareness at the state, regional, national and international levels. Visit http://www.bugwood.org/ to learn more.



SECTION 10

The Green Menace- an EAB documentary

This video is a detailed news documentary that was funded by the USDA Forest Service and the USDA Animal Plant Health Inspection Service (APHIS) and produced by Detroit Public Television.

INTERACTIVE 6.1 YouTube video The Green Menace 26:49

Video by Detroit Public Television (2010)

SECTION 11

Closing

The Emerald Ash Borer will continue to threaten native ash trees in our forests and landscapes into the foreseeable future. We hope that this iBook provides the background and resources you need to monitor for EAB and make informed decisions on response to and recover from this pest. This information will inevitably change as EAB moves into new areas and new methods for detecting and managing EAB become available. The website http://www.emeraldashborer.info is the best source for up-to-date information on EAB and we hope that you will use it to stay updated on the latest developments with EAB.

Alternate branching

Arranged singly at each node, as leaves or buds on different sides of a stem.

Related Glossary Terms

Drag related terms here

Index Find Term

Biological control

The use of insect parasitoids, predators or pathogens to control a pest.

Related Glossary Terms

Drag related terms here

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Cambium

The layer of a tree where growth occurs, just beneath the bark.

Related Glossary Terms

Drag related terms here

Index Find Term

Canopy

The cover formed by the leafy upper branches of a tree.

Related Glossary Terms

Drag related terms here

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Co-evolved

Closely associated species that have acted as agents of natural selection on one another.

Related Glossary Terms

Drag related terms here

Index Find Term

Compound leaf

A leaf composed of a number of leaflets on a common stalk.

Related Glossary Terms

Drag related terms here

Index Find Term

Crown

The upper part of a tree, which includes the branches and leaves.

Related Glossary Terms

Drag related terms here

Index Find Term

Cull

Separation and removal of inferior plants.

Related Glossary Terms

Drag related terms here

Index Find Term

Delimitation

A survey to detect the extent and duration of an infestation.

Related Glossary Terms

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Detection tree

A tree that is used to attract pests with chemical signals that are released after the tree has been stressed by natural or intentional means. Synonymous with the term trap tree.

Related Glossary Terms

Trap tree

Index Find Term

Dispersal

The act of spreading or dispersing something.

Related Glossary Terms

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Dormant

Period of minimal metabolic activity, for plants this is usually in the winter.

Related Glossary Terms

Drag related terms here

Index Find Term

Dutch Elm Disease

A fungal disease that destroyed the native elm populations in the 1950's.

Related Glossary Terms

Drag related terms here

Index Find Term

Ecosystem service

The benefits and/or goods that society obtains from ecosystems.

Related Glossary Terms

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Chapter 5 - Course of Action: Overview

Epicormic shoots

Shoots that develop directly from the trunk of a tree or shrub after the tree has suffered injury to its roots or vascular system.

Related Glossary Terms

Drag related terms here

Index Find Term

Eradication

To completely eliminate the pest from an infested area.

Related Glossary Terms

Drag related terms here

Index Find Term

Frass

Insect excrement.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 3 - Adult and Larval EAB Identification

Fraxinus spp.

Fraxinus is the genus name for all true ash tree species.

Related Glossary Terms

Drag related terms here

Index Find Term

Gallery

A small tunnel or passageway made by an insect or animal.

Related Glossary Terms

Drag related terms here

Index Find Term

Genus

The usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

Related Glossary Terms

Drag related terms here

Index Find Term

Girdle

To cut away a tree’s bark and cambium in a ring around the trunk or a branch.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 5 - Recovering from an EAB Outbreak

Growing season

Period of active plant growth, usually spanning from spring to fall.

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Host species

A living animal or plant from which a parasite obtains nutrition.

Related Glossary Terms

Drag related terms here

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Integrated pest management

IPM is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health, and environmental risks.

Related Glossary Terms

IPM

Index Find Term

Chapter 5 - Course of Action: Overview

Invasive species

Any species, including its seeds, eggs, spores, or other biological material, that is not native to that ecosystem and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Related Glossary Terms

Drag related terms here

Index Find Term

IPM

see integrated pest management

Related Glossary Terms

Integrated pest management

Index Find Term

Larva

Immature life stage of emerald ash borer and also the destructive stage. Larvae (pl.) are cream-colored, slightly flattened (dorso-ventrally) and have pincher-like appendages (urogomphi) at the end of their abdomen. Larvae eat on the tissues of an ash tree, underneath the bark, disrupting the tree's ability to move water and nutrients.

Related Glossary Terms

Larvae

Index Find Term

Larvae

plural for larva

Related Glossary Terms

Larva

Index Find Term

Leaflet

One of the separate blades or divisions of a compound leaf.

Related Glossary Terms

Drag related terms here

Index Find Term

Life cycle

The series of changes in the growth and development of an organism from its beginning as an independent life form to its mature state in which offspring are produced.

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Drag related terms here

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Management plan

Plan for long term management of a city's urban forest.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 5 - Recovering from an EAB Outbreak

Mandated eradication zone

Zone designated by the federal government for all ash removal.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 5 - Integrated Management: Insecticides

Mitigation

Make less severe

Related Glossary Terms

Drag related terms here

Index Find Term

Monitor

Periodic, systematic inspection of vulnerable trees to detect and document pest activity.

Related Glossary Terms

Drag related terms here

Index Find Term

Native

Originating naturally in a particular country or region, as animals or plants.

Related Glossary Terms

Drag related terms here

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Natural enemy

A living organism that kills a pest. Examples are a fungus that kills wood boring insects, a predatory beetle that feeds on wood borers below the surface of the bark of the tree, or a wasp that lays its eggs inside the body of a wood boring larva.

Related Glossary Terms

Drag related terms here

Index Find Term

Opposite branching

Branches growing in pairs on either side of the stem.

Related Glossary Terms

Drag related terms here

Index Find Term

Pallet

A portable platform used for storing or moving cargo or freight, usually made of wood.

Related Glossary Terms

Drag related terms here

Index Find Term

Parasite

An organism that lives on or in an organism of another species, known as the host, from which it feeds.

Related Glossary Terms

Drag related terms here

Index Find Term

Phloem

The system of vessels in a plant that carries food from the leaves to the rest of the plant.

Related Glossary Terms

Drag related terms here

Index Find Term

Pinnately compound

Compound leaf with leaflets along each side of a common axis; feather-like.

Related Glossary Terms

Drag related terms here

Index Find Term

Predator

An animal that lives mainly by killing and eating other animals.

Related Glossary Terms

Drag related terms here

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Chapter 4 - Advanced Monitoring Techniques

Pupa

The intermediate stage between larva and adult stages. Pupae (pl.)

Related Glossary Terms

Pupae

Index Find Term

Pupae

plural for pupa

Related Glossary Terms

Pupa

Index Find Term

Pupation

To develop into a pupa from a larva.

Related Glossary Terms

Drag related terms here

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Chapter 2 - Life Cycle

Purple panel traps

Used as a survey tool to help detect the presence of emerald ash borer.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 4 - Advanced Monitoring Techniques

Quarantine

Enforced isolation or restriction of free movement imposed to prevent spread.

Related Glossary Terms

Drag related terms here

Index Find Term

Replacement species

A tree species that will replace dead or removed ash trees.

Related Glossary Terms

Drag related terms here

Index Find Term

Resistance

The act or power of resisting, opposing or withstanding.

Related Glossary Terms

Drag related terms here

Index Find Term

Samaras

A dry, winged, often one-seeded fruit, found on ash, elm, or maple trees.

Related Glossary Terms

Drag related terms here

Index Find Term

Species

A fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.

Related Glossary Terms

Drag related terms here

Index Find Term

Suppression

To reduce in severity.

Related Glossary Terms

Drag related terms here

Index Find Term

Survey

To systematically search for, and record, the presence of an organism in an area. In this book, it refers to the USDA APHIS survey methods (see p. 56)

Systemic

(pesticide) Absorbed and circulated by plant so as to be lethal to pests that feed on it.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 5 - Integrated Management: Insecticides

Trap tree

A tree that is used to attract pests with chemical signals that are released after the tree has been stressed by natural or intentional means. Synonymous with the term trap tree.

Related Glossary Terms

Detection tree

Index Find Term

Chapter 5 - Integrated Management of EAB

Tree inventory

A database containing information about the location and characteristics of individual public trees

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Related Glossary Terms

Drag related terms here

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Tree ordinance

A set of rules or laws pertaining to trees

Related Glossary Terms

Drag related terms here

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Chapter 5 - Recovering from an EAB Outbreak