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

Emerald Ash Borer Program Manual

Agrilus planipennis (Fairmaire)

Cover image of Emerald Ash Borer courtesy of Joel Floyd

When using pesticides, read and follow all label instructions.

Second Edition Issued 2020

Emerald Ash Borer

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1 Introduction

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Purpose

The Emerald Ash Borer Program Manual contains information to guide a management program for the emerald ash borer (EAB) beetle, *Agrilus planipennis* (Fairmaire), (Coleoptera: Buprestidae) using nonregulatory options.

The guidelines are intended to assist the United States Department of Agriculture, Animal and Plant health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ, hereafter PPQ), Field Operations and state departments of agriculture personnel in implementing specific action plans to manage EAB infestations. This information includes strategies for detection and response to an EAB infestation with available information for implementing surveys, EAB identification, management, and containment procedures. Although domestically, EAB is no longer regulated by PPQ, the EAB program staff will continue to provide non-regulatory assistance and support to state regulatory agencies as they implement their own regulations. The EAB program will continue to provide EAB parasitoid wasps for release in appropriate locations. EAB program staff will also work with state departments of agriculture and forestry to evaluate establishment of the EAB parasitoids at release locations.

PPQ staff will also, if asked, help state personnel with the use of temperature probes, training for kiln certifications, and the use of temperature probe data from other kiln certifications that PPQ conducts.

Specific program activities should be based on the most current information available. This manual provides best management practices for EAB.

PPQ develops guidelines through discussion, consultation, or agreement with other APHIS staff, State Plant Regulatory Officials (SPRO), USDA Forest

Service, tribal governments, and other State and Federal agencies and cooperators directly involved in EAB management. The APHIS Emergency Response Programs Manual and other pest national response guidelines may be found at:

https://www.aphis.usda.gov/aphis/ourfocus/planthealth/complete-list-of-electronic-manuals

Disclaimers

Document Comprehensiveness

This document is not intended to be a complete and exhaustive resource, but does provide a foundation based on literature available to assist current EAB management efforts. As ongoing EAB research and program efforts provide new information, the direction and strategies described in this manual may change to reflect the best management practices for EAB. For the latest updates on this pest, it is recommended to conduct periodic literature searches on the web and in other archives.

Commercial Suppliers or Products

References to commercial suppliers or products should not be construed as an endorsement of the company or product by the U.S. Department of Agriculture, APHIS, or PPQ.

Program Safety

Safety of the public and program personnel has priority in pre-program planning and training, and throughout operations. Safety officers and supervisors must enforce on-the-job safety procedures.

Support for Program Decision-Making

The USDA-APHIS-PPQ Science and Technology (S&T) provides technical support, in consultation with other scientists, to program managers concerning risk assessments, survey methods, management strategies, and other aspects of the pest response program.

2 Pest Information

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Systematic Placement

Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Family	Buprestidae
Genus	*Agrilus*
Species	*planipennis*
Entomological Author	Fairmaire, Léon Marc Herminie
Approved Name	*Agrilus planipennis* (Fairmaire)
Synonyms	*Agrilus marcopoli* (Obenberger 1930) *Agrilus marcopoli ulmi* (Kurosawa 1956) *Agrilus feretrius* (Obenberger 1936)
Common Names	emerald ash borer (English) agrile du frêne (French) изумрудная ясеневая златка (Russian)

Background Information

Emerald ash borer (EAB) is a non-native phloem-feeding pest of ash trees. This devastating pest was first found in 2002 in North America where it was discovered in southeastern Michigan and adjacent areas in Windsor, Ontario, Canada. It is thought to have been introduced in the 1990's on solid wood packing material originating from Asia.

This destructive beetle poses an enormous threat to all of North America's ash resources. Unlike many other wood boring beetles, EAB aggressively kills healthy and stressed trees; many dying within two to three years after becoming infested. Currently, EAB has no natural enemies in North America (although there are some native parasitoids that will attack EAB) and no effective and practical chemical or mechanical control options. If it is not contained or its effects mitigated, this pest will continue to infest and kill all species of trees in the genus *Fraxinus*. The impact on ash in North America has been compared to the effects of chestnut blight and Dutch elm disease, which devastated rural and urban forests in the 20th century.

The lack of effective survey and control methods has reduced the effectiveness of EAB containment efforts. At the current time and with currently available tools, EAB eradication in North America is not possible. Effective and appropriate use of the four currently available biological control parasitoid wasps may be the most effective direction of the program. Please see the Emerald Ash Borer Biological Control Release and Recovery Guidelines for more information.

https://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/EAB-FieldRelease-Guidelines.pdf

Historical Information

EAB Detections

When first detected in the United States in 2002, only two short publications on EAB could be found in the literature: Chinese Academy of Science (1986) and Yu (1992). These papers include brief morphology, biology, host range, and symptoms of infestation. Significant progress has been made in the last 18 years on the biology and host range of EAB, including numerous symposia conducted by USDA and has been documented in other resources. Please see this body of literature for more information (Herms and McCullough, 2014).

In 2002, shortly after EAB was confirmed as the cause of significant ash tree mortality observed in Detroit, Michigan, five counties were found to be

infested and were placed under quarantine. Since then, PPQ, USDA Forest Service, state, and local cooperators have conducted survey and mitigation activities. Efforts have included imposing quarantines, conducting surveys, delimiting areas around confirmed infested sites, removing ash trees, and developing information which will support management efforts as well as research into the development of more effective survey tools and foreign exploration to identify and test EAB biological control parasitoids.

Intensive visual survey efforts in 2003 expanded this area by 10 additional counties in Michigan and five counties in northern Ohio. Additionally, due to a 2002 Michigan quarantine violation involving nursery stock, control actions were implemented in Maryland and Virginia in 2003, resulting in an EAB detection in one Maryland county.

Survey methods were improved in 2004 with the use of trap trees (trees with the outer bark removed to stress the tree). This survey method, in combination with the visual survey methods, resulted in the discovery of 28 additional counties in 2004: 24 in Michigan, two in Ohio, and two in Indiana discovered in April and May.

In 2005, two additional new detections were made in Indiana, eight in Ohio, and 12 in Michigan which accounted for the 22 new county detections that year.

Two counties in Illinois were found to be infested in 2006. This was in addition to nine additional new county finds in Michigan, 11 in Ohio, and eight in Indiana, for a total of 30 new county finds for 2006. In addition, Maryland reported a re-infestation of a site that underwent eradication actions in 2004.

Michigan found EAB in six additional counties in 2007. Indiana discovered five more infested counties and Ohio saw an increase of 8 more counties this same year. EAB was detected in two more counties in Illinois. The state of Pennsylvania reported their initial EAB infestation in two counties with West Virginia reporting EAB in a single county.

In 2008, 25 additional new detections in Ohio, Indiana, Michigan, Illinois, Pennsylvania, Maryland, along with new infestations in singular counties of Missouri, Virginia and Wisconsin occurred.

In 2009, EAB was detected in 47 new counties and in three new states (Kentucky, Minnesota and New York). In 2010, EAB detections occurred in 46 new counties and in 2 new States (Iowa and Tennessee and the District of Columbia. New EAB infestations were detected in 61 new counties in 2011and also in the District of Columbia.

In 2012 EAB was found in 74 additional counties in all the previous states and in three new states (Connecticut, Kansas and Massachusetts). In 2013, 95 additional counties were found to have EAB infestations in 4 new state (Colorado, Georgia, New Hampshire and North Carolina, with the first non-contiguous detection in Colorado. At this time, a total of 23 states had at least one county with an EAB infestation.

In 2014, EAB was detected in a total of 134 new counties and in two new States (Arkansas and New Jersey) and 129 new county detections in 2015 and the first Parish in Louisiana. In 2016, EAB was found in 127 new counties and five new States (Alabama, Delaware, Nebraska, Oklahoma, and Texas).

In 2017, new EAB infestations were detected in the State of South Carolina and in a total of 100 new counties. By then, a total of 32 states had some EAB infested counties. In 2018, 4 new States found EAB infestations and an additional 75 new counties were found positive for EAB.

As of the writing of this document in December 2020, 1,244 counties in 35 states and the District of Columbia had EAB infestations.

Regulations

The first State and federal quarantines were enacted in 2002 with the original six infested Michigan counties. This area was expanded in 2003 to include 13 full counties and portions of two counties in Michigan, portions of four counties in Ohio, and a portion of a Maryland county. At the end of 2004, 20 Michigan counties were considered generally infested and quarantined; portions of 16 additional counties in Michigan, four counties in Ohio, and two counties in Indiana were quarantined due to small spot infestations caused by the movement of firewood, nursery stock, or timber. In 2005, the quarantine expanded to 21 entire counties and 25 partial counties in Michigan, four entire counties in Indiana, and one county and ten partial counties in Ohio.

By December, 2006, the entire Lower Peninsula of Michigan (68 counties) as well as one partial county in the Upper Peninsula, the entire states of Ohio, Indiana, and Illinois and a county in Maryland were federally quarantined to prevent the human-assisted spread of this destructive pest.

On August 8, 2007 the federal quarantine was expanded to include four counties in Pennsylvania after discovery of an initial infestation in that State.

The initial Missouri infestation was detected in Wayne County and was added to the federal quarantine on August 8, 2008. Four additional counties (Ozaukee, Washington, Fond du Lac and Sheboygan) in Wisconsin were federally quarantined on August 12, 2008. On December 4, 2008 the counties

of Delta, Mackinac, and Schoolcraft in the Upper Peninsula of Michigan were added to the Federal Quarantine.

Since 2010, State and Federal quarantines have been implemented in Alabama, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, and Wisconsin following the detection of EAB.

A total of 1,198 counties in 35 states and the District of Columbia were under the federal EAB quarantine when the federal EAB regulation ended.

On September 19, 2018, PPQ published in the Federal Register a proposed rule (83 FR 47310-47312, Docket No. APHIS-2017-0056) to remove domestic quarantine regulations for EAB.

EAB was officially deregulated by PPQ on December 15, 2020, with an effective date of January 14, 2021 (https://www.regulations.gov/docket?D=APHIS-2017-0056).

Economic Impact

The eastern United States produces nearly 114 million board feet of ash saw timber with a value of $25.1 billion annually (McPartlan et al. 2006). White, black, and green ash make up over 7 percent of all hardwood species and 5.5 percent of all tree species in the northeastern United States and eastern Canada. The wood is used for a variety of applications including tool handles, baseball bats, furniture, cabinetry, solid wood packing materials, pulp, and paper. The continued spread of this pest threatens these resources and may permanently alter urban landscape ecosystems of the Midwest, which consists of up to 20 to 40 percent ash in some areas.

There is potential for extensive negative economic effects if this wood-borer were to become widespread in the United States. If left unchecked, EAB will continue to infest and destroy ash trees, resulting in the losses of millions of dollars to the lumber and nursery industries as well as urban communities. Preliminary findings by U.S. Forest Service estimate that EAB's potential impact to the national urban landscape is a potential loss of between 0.5 to 2 percent of the total leaf area (30-90 million trees) and a value loss of between $20-60 billion (McPartlan et al. 2006).

Infested states may experience significant economic losses in forest products if EAB spreads from the currently quarantined area into the forests of the eastern United States. Quarantines imposed by State and Federal agencies have negative impacts on the nursery, landscaping, forest product, recreation, and tourism.

industries which are economically important to the region.

In addition to its value to the timber industry and the forest ecosystem, ash is one of the most popular landscape trees because of its wide ecological amplitude and resistance to other pests. It has been one of the most commonly planted tree in new residential and commercial developments.

In an initial economic analysis of EAB, the U.S. Forest Service estimated that EAB, if not contained and eradicated, could cause approximately $10.7 billion in additional costs to State and local governments and landowners to remove and replace dead and dying ash trees in urban and suburban areas over the next 10 years (Kovacs et al, 2010). Nationwide, the nursery industry produces an estimated 2 million ash trees each year. With median approximate values ranging from $50 to $70 per tree, the ash nursery stock crop is worth between $100 and $140 million annually (McPartlan et al, 2006).

A cost projection of EAB in just 25 northeastern communities of the United States for only one decade (2009-2019) to treat, remove, and replace landscape ash was $25 billion (Kovacs et al, 2010), making EAB the most destructive and costly wood-boring insect to invade the United States (Aukema et al, 2011) (Duan et al, 2018).

Host Range

In North America, EAB is capable of infesting all 16 species of ash trees in the genus *Fraxinus*, including green ash (*F. pennsylvanica*), white ash (*F. americana)*, black ash (*F. nigra*), pumpkin ash, (*F. profunda*), blue ash (*F. quadrangulata*), and other native species in this same genus (MacFarlane and Meyer, 2005). The white fringetree (*Chionanthus virginicus*) and cultivated olive (*Olea europea*) has also been found to be reproductive hosts of EAB while in the presence of heavily infested ash trees (Cipollini, 2015). An approximate natural range map of all ash species in North America can be found in Appendix D and here.

Chinese reports indicate that the species *F. chinensis* var. *chinensis*, *F. chinensis* var. *rhynchophylla*, and *F. mandshurica*. (Chinese Academy of Science 1986, Yu 1992) are native Asian EAB hosts.

In Japan, the host range has been reported to include Manchurian ash, (*Fraxinus mandshurica* var. *japonica*), Manchurian walnut (*Juglans mandshurica* var. *sieboldiana*, and var. *sachalinensis*), Japanese wingnut (*Pterocarya rhoifolia*) and Japanese elm (*Ulmus davidiana* var. *japonica*), (Akiyama and Ohmomo 1997, Sugiura 1999).

There is an isolated reference to privet (*Ligustrum* spp.) being suitable for 1st stage larval development in a laboratory setting (Cappaert et al. 2005).

Geographic Distribution

Native distribution of EAB in Asia includes several provinces of China (Liaoning, Jilin, Heilingjiang, Inner Mongolia, Hebei, and Shandong), Korea, Japan, Taiwan, and a small area in adjacent Russia and Mongolia (U.S. Forest Service 2008).

EAB is now considered established in 35 States and the District of Columbia in the United States and four Canadian Provinces. As of the writing of this document in June 2020, 1,206 counties in 35 states and the District of Columbia had EAB infestations.The most current map depicting the emerald ash borer infestation can be found here https://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/eab_quarantine_map.pdf.

Biology

Current research suggests that EAB can complete its life cycle in either a one- or two-year cycle. Low density populations on vigorous ash trees tend to support a two-year life cycle while stressed trees with higher larval population densities tend to support a one year life cycle (Cappaert et al. 2005). Effects on life cycle due to latitudinal and altitudinal variation are unknown at this time, but are being actively researched, especially in Southern U.S. States where new EAB establishments have occurred.

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Life Cycle

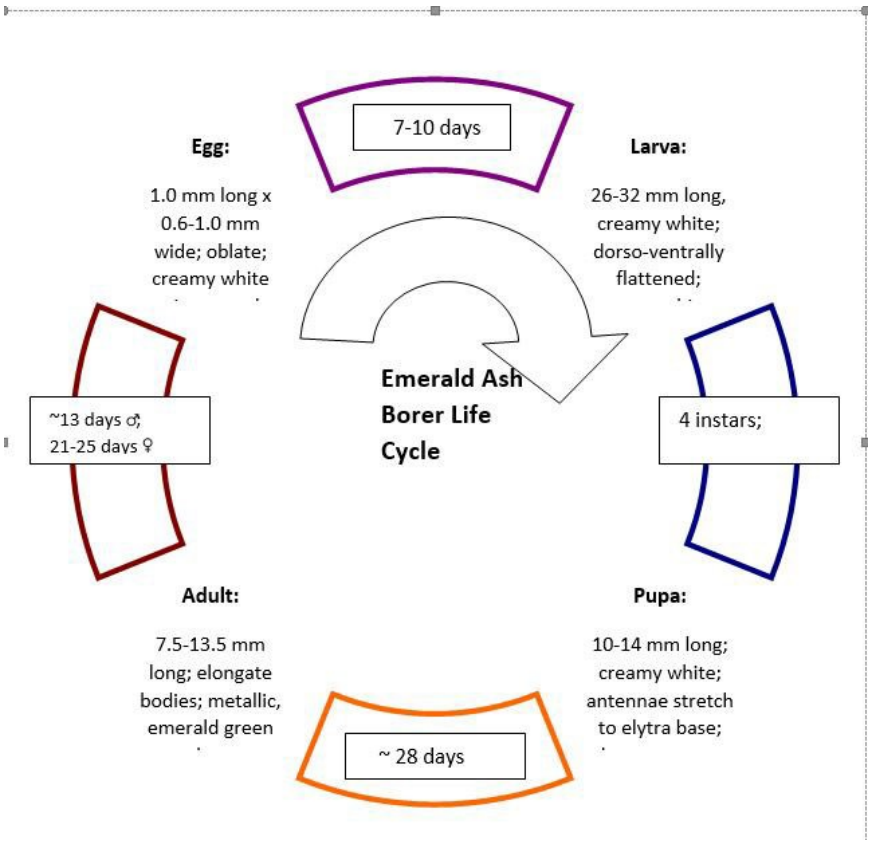

Figure 2-1 Emerald Ash Borer Life Cycle

Eggs

This life stage is extremely difficult to visually detect during survey. Oviposition sites are likely to be correlated with the direction of sunlight, with the most eggs being laid on the southwestern side of the tree (Timms et al. 2006). Recent research indicates that females may prefer to lay eggs in areas where the bark is rough, cracked, or rippled, as may be found near branch crotches. The female may lay 1-23 eggs at a time, with one being the norm. Each female can lay 60-90 eggs in their lifetime, depositing them individually on the bark along the trunk and portions of the major branches. The eggs typically hatch in 7-10 days (Yu 1992).

Larva

Minute larvae bore through the bark and into the cambium where they feed on the phloem from late spring to early autumn. There are four stages to larval development (Cappaert et al. 2005). As they feed, the larvae create long serpentine galleries filled with frass, which enlarge in width as they grow. Larvae continue development into fall. Facultative diapause occurs after fourth instar larvae enter the sapwood or outer bark and excavate a pupal chamber where they overwinter as prepupae.

Larvae too immature to prepupate spend the winter in the larval gallery and complete development the following spring. Larval galleries are typically 20-30 cm long.

Pupa

Pupal development is variable according to humidity and temperature. Pupation may begin upon the accumulation of 100-150 growing degree days and, in ideal laboratory conditions, pupal development typically takes approximately 4 weeks. After pupae transform into adults, the beetle takes 1 to 2 weeks before it emerges through D-shaped exit holes 3-4 mm wide. More research is necessary to fully understand pupal development.

Adult

Newly formed adults typically remain in the pupal chamber for 1-2 weeks after pupation is complete. Initial adult emergence predictively occurs when an accumulation of 400-500 growing degree days is achieved. Evidence of adult emergence appears in the form of a D-shaped exit hole 3-4 mm in diameter. Peak activity for adults is predicted to occur at approximately 1,000 growing degree days (McCullough and Siegert 2006). Adults are capable of immediate flight and, in laboratory conditions, adults mate shortly after emergence. Females may mate as many as 3 times with mating lasting 20-90 minutes (average of 60 min.). An approximate 3 week period of maturation feeding occurs before oviposition. The adults feed on ash foliage, causing minimal damage. Adults may feign death when frightened or disturbed. They are phototactic and thermotactic and most active on warm, cloudless, windless days. Oviposition begins 7-9 days after the initial mating (Yu 1992). Average longevity for adult males is 13 days; average longevity for females is 22 days (Bauer et al. 2004, Lyons et al. 2004, Poland and McCullough 2006). EAB adults are strong fliers, with females flying twice as far as males and mated females flying twice as far as unmated females. Tethered flight under laboratory conditions suggests that a mated female may fly more than 20 km (Taylor et al. 2006).

Development

Many environmental factors can influence the development of insects, the timing of their biological events, and the dynamics of their populations. Among these factors are host availability, population densities, photoperiod, and weather. Temperature and moisture, because they are so critical to biochemical reactions, are universal influences on egg, larval, pupal and adult development in insects. Current research suggests initial adult emergence occurs when cumulative growing degree days reach 400-500 degree days with peak activity occurring at approximately 1000 growing degree days. Temporal variation for these occurrences may exceed one month when considering latitudinal differences in the quarantine area.

Over the last decade much has been learned about the biology of EAB but more research is necessary to fully understand EAB biology, including developmental thresholds on its life cycle and EAB phenology associated with latitudinal changes.

Natural Dispersal

The rate of natural dispersal by adult flight of EAB is estimated to be as little as 800 meters per year (Taylor et al, 2004), but may be more than 10 km per year (6.2 miles). However, unpublished data suggests that this rate may be much higher and variable due to environmental factors and insect population density. The average distance a mated female EAB could fly was 3 km in a day, but 20% flew more than 10 km and 1% of the females flew more than 20 km (Taylor et al, 2010).

3 Identification

Contents

Importance

Accurate identification of the pest is key to assessing its potential risk, developing a survey strategy, and deciding the level and manner of management with biological control.

Authorities

For new detections in a State or county, the USDA APHIS PPQ National Identification Services can identify the suspect pest as *Agrilus planipennis* before consideration of any management activities.

Identification

Some pre-identification and screening can be performed by field personnel assigned to the program if training is provided. A description of EAB, *Agrilus planipennis*, including distinctive features that separate it from native species that resemble it, with pictures, is provided below.

Description of the Species, *Agrilus planipennis*

Eggs

Figure 3-1 *Agrilus planipennis* Egg on Bark[1]

Figure 3-2 *Agrilus planipennis* Egg Cluster[2]

Figure 3-3 Unhatched *Agrilus planipennis* Neonate on Bark[3]

1 Photo: Houping Liu, www.forestryimages.org

2 Photo: David Cappaert, Michigan State University

3 Photo: Houping Liu, www.forestryimages.org

Eggs are 1.0 mm long x 0.6 mm wide and oblate. They are creamy white turning to amber before hatching with a reductus extending radially toward the edges. Eggs are extremely difficult to observe with the naked eye.

Larvae

Larvae are creamy white, and dorso-ventrally flattened. They are 26-32 mm long when fully mature in the fourth instar. The small, brown head is mostly retracted into the prothorax with only the mouthparts remaining visibly externally. The prothorax is enlarged with the mesothorax and metathorax more narrow. The mesothorax and each of the first eight abdominal segments have a pair of spiracles.

Figure 3-4 Three Instars of *Agrilus planipennis* Larvae[1]

1 Photo: David Cappaert, Michigan State University

There are ten abdominal segments. The first abdominal segment shape varies considerably but can be distinctly rectangular to trapezoidal shaped. Segments A2 through A6 are somewhat trapezoidal with protruding flattened lobes. A7 is strongly bell shaped and A8 is somewhat trapezoidal in shape. The last abdominal segment (A10) contains a pair of urogomphi. Emerald ash borer prepupae are more difficult to identify, being subtly different than less mature larvae, but A8 is still bell shaped.

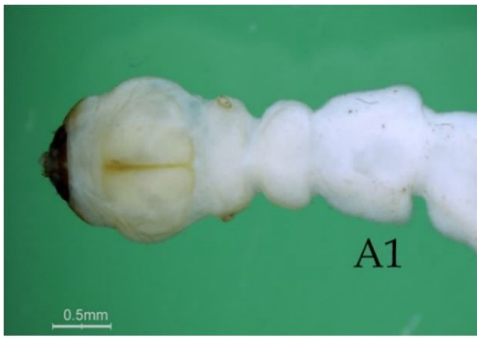

Figure 3-5 Anterior Abdominal Segments[1]

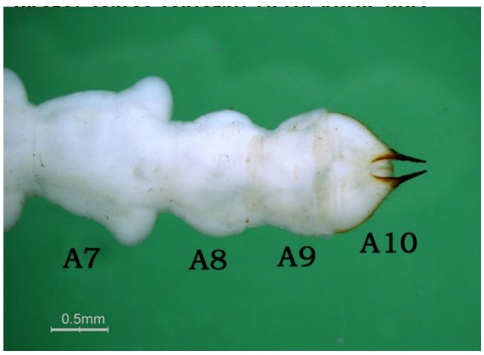

Figure 3-6 Posterior Abdominal Segments[1]

1 Photo: James Zablotny, USDAAPHIS PPQ

A larval screening guide comparing *Agrilus planipennis* to *A. anxius* may be found in Appendix B.

Pupae

Pupae are creamy white and 10-14 mm long. The antennae extend dorsally to the base of the wing buds. The posterior abdominal segments are slightly curved ventrally.

Figure 3-7 *Agrilus planipennis* Prepupal Stage

Figure 3-8 Pupal Ventral and Dorsal Views[1]

1 Photo: Deborah Miller, USFS (NC)

Adults

Adults have metallic (brassy or golden) green pronotum, with darker, metallic emerald green elytra and abdominal sternites. They may reach a length of 8.5-13.5 mm long and 3.1-3.4 mm wide. The cuneiform body is narrow and elongate. The abdominal tergites are metallic coppery red. The head is flat with the vertex shield shaped. The compound eyes are obscure-aeneous and kidney shaped. The rectangular prothorax is slightly wider than the head, but the same width as the elytra. The anterior margin of the elytra is raised, forming a transverse ridge; the surface is covered with punctures. The elytra's posterior margins are round and obtuse with small denticles on the edge. There is an emarginate pygidial spine.

Figure 3-9 *Agrilus planipennis* Adult[1]

1 Photo: David Cappaert, Michigan State University

Similar Species

Agrilus is one of the largest genera in the world with almost 3,000 described species. Species in this genus are difficult to identify because of structural coloration (i.e., *Agrilus bilineatus* in Figure 3-11) and subtle morphological differences.

In North America *Agrilus* also is a very diverse genus with 171 known species on this continent. North American species most similar to *Agrilus planipennis* are *A. anxius* (Weber) (Figure 3-10), *A. bilineatus* (Weber) (Figure 3-11), *Agrilus cyanescens* Ratzeburg (Figure 3-12), *A. masculinus* Horn (Figure 3-13), *A. obsoletoguttatus* Gory, *A. subcinctus* Gory, and *A. vittaticollis* (Randall) (Figure 3-14).

Figure 3-10 *Agrilus anxius* (Weber)

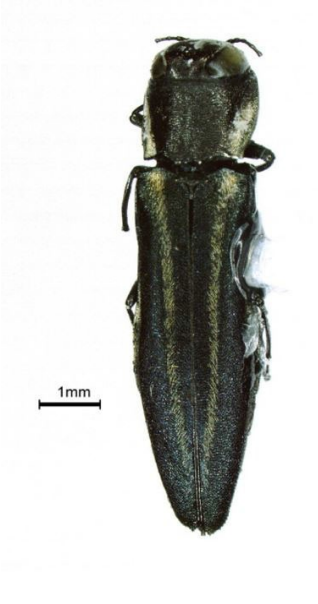

Figure 3-11 *Agrilus bilineatus* (Weber)

Figure 3-12 *Agrilus cyanescens*

Figure 3-13 *Agrilus masculinus*

Figure 3-14 *Agrilus vittaticollis*

The only other *Agrilus* species besides *Agrilus planipennis* known to occur on *Fraxinus* spp. in the Midwest is *Agrilus subcinctus*. *A. subcinctus* is a twig borer and prefers smaller branches for oviposition.

Collection and Preparation of Specimens

Collect as many specimens as possible of the pest for identification. **Do not** mix samples. Be sure to separate larvae into vials by tree or location. Use of entomological forceps is recommended in order to minimize damage to the specimen. Even with deregulation, the location of new EAB-positive counties is important to know and is still needed to support non-regulatory activities, such as biological control. Collect additional information as noted:

- Fill out PPQ Form 391.
- Gather the following information about the tree:
  - State
  - County
  - Date
  - GPS Coordinates
  - Tree Diameter at Breast Height (DBH)

Prepare specimens according to the following protocols.

- Gather larvae/pupae from the same tree into the same vial. **Do not** insert larvae into alcohol at this time.
- Label the vial with the naming protocol: Year-collector initials-Month-Date (for example: 06-PDB-10-29)
- Larvae should be killed in boiling water, allowed to cool, and placed in vials with hand sanitizer gel (70% ethanol).
- If there are too many larvae/pupae, extras may be placed in hand sanitizer gel in larger container (labeled completely)
- Ship vials in a well-padded box (be aware of possible restrictions on shipping alcohol by air carriers).

Large specimens or small specimens that have been crowded into one vial should be transferred to fresh vials with new hand sanitizer gel. If the hand sanitizer becomes too dilute, the specimens may begin to decompose. It is recommended to place vials in a vapor lock bag to prevent leakage.

Screening for Suspect Buprestidae and Specimen Submission

Any suspect Buprestidae adult or suspect EAB specimen from a new State should be placed in a vial with hand sanitizer gel or 90% ethanol and delivered to the State Plant Health Director or PPQ representative to be packaged and shipped to Dr. James Zablotny along with a completed *PPQ Form 391 - Specimens for Determination*. Be sure to include any survey record number and/or GPS coordinates on the PPQ Form 391 so identified specimens can be linked to survey records.

Dr. James Zablotny
USDA, APHIS, PPQ
11200 Metro Airport Center Drive, Suite 140
Romulus, MI 48174

Phone: 734-942-9005
e-mail: james.e.zablotny@usda.gov

Dr. Zablotny will make a determination and send specimens to the Systematic Entomology Laboratory (SEL) if necessary for initial state detection confirmation.

Any suspect Buprestidae adult or suspect EAB specimen collected from a trap in a new county in a quarantined EAB-positive State should be placed in a vial with hand sanitizer gel and delivered to the State Plant Health Director or PPQ representative to be packaged and shipped to Dr. Bobby Brown along with a completed *PPQ Form 391 - Specimens for Determination*. Be sure to include any survey record number and/or GPS coordinates on the PPQ Form 391 so identified specimens can be linked to survey records.

Dr. Bobby Brown
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Phone: 765-496-9673
e-mail: robert.c.brown@usda.gov

4 Response Procedures

Content

Introduction

Emerald ash borer (EAB) is a difficult pest to detect during incipient infestations. Following introduction, visual signs or symptoms of infestation are often not observed for 3-5 years. When obvious visual signs of infestation (e.g., D-shaped holes, bark splits, crown dieback) are observed the possibility of eradication is remote.

Consultation

PPQ will no longer conduct regulatory activities. However, it is advantageous for the State Plant Regulatory Official (SPRO), State Plant Health Director (SPHD), and local officials to understand where in the state's EAB populations are known to occur for the possibility of future EAB parasitoid releases in those infested counties. PPQ encourages continued consultations with the PPQ National Policy Manager and the Operations Manager.

New State Detection

In addition, general outreach efforts have educated the public on the identification of signs and symptoms of EAB infestation. New state detections may be identified in a variety of ways.

Identification by PPQ Identifier

Official confirmation of EAB by PPQ is no longer required. If a collected suspect is submitted to the PPQ Identifier along with PPQ Form, the sample will be identified and forwarded to the appropriate authorities for confirmation and subsequent notifications.

Please submit suspect samples from any new counties as shown in Chapter 3 (Identification Please refer to instructions provided in Identification on page 3-1). New county detections are important to support the release of EAB parasitoids in all counties with EAB infestations.

Radial Delimiting Survey

States may conduct an initial visual delimiting survey of infestations accompanied by close inspection and/or destructive sampling of trees exhibiting obvious signs (e.g., D-shaped exit holes, epicormic sprouting, crown dieback, serpentine galleries, bark splits, woodpecker damage) may be conducted. This initial survey is intended to provide a preliminary sense of the size and scope of the infestation. A more intensive follow-up survey strategy may also be developed in consultation with EAB Program Management to determine the suitability of specific sites for biological control releases.

Survey Data

Compilation of the number of infested trees, larvae, prepupae, and adults and plotting the location where each was found on a map aid in determining the suitability of locations as biological control release sites.

Community Management Plan

Examples of community management and response plans for states may be found at:

http://www.emeraldashborer.info/communityplan.cfm

Biological Control

The APHIS EAB parasitoid rearing facility for biological control agents is located in Brighton, Michigan. Tools and techniques for rearing and releasing biological control parasitoids of EAB are refined at this location with the goal of release of parasitoids in EAB infested counties in the Unites States. For further information on release and recovery of EAB parasitoids, please refer to the Emerald Ash Borer Biological Control Release and Recovery Guidelines.

The APHIS EAB parasitoid rearing facility is currently rearing four parasitoid stingless wasps and releasing theme in EAB infested counties by our PPQ staff and cooperators at appropriate pre-approved release sites. These parasitoids are known to attack EAB in its native range in China and Russia.

PPQ began small-scale trial releases in 2007, 2008, and 2009. In 2010-2012, PPQ made program releases and additional releases for research of larger numbers of parasitoids. Release sites are monitored for establishment of the parasitoids and evaluated for their potential to control and slow the dispersal of EAB. To date, more than 7.5 million EAB parasitoid wasps have been reared in the PPQ Rearing Facility in Brighton, MI and released in 340 counties in 30 States, the District of Columbia and 4 Canadian Provinces over 11 release seasons (B. Slager, USDA, Pers. Comm.).

Eradication

Eradication is **not** a feasible outcome with currently available detection and management tools. The EAB Program transitioned from an eradication program in 2013 to an integrated pest management (IPM) program focusing on the use of biological control parasitoids. Now the program is further directing activities to parasitoids for EAB management. Program partners and PPQ are also conducting research to provide additional IPM tools and methodologies.

5 Survey Procedures

Contents

Introduction

Surveys support EAB management by providing information on the location, distribution, and movement of EAB. Surveys also function as a delimiting tool to estimate the scope and extent of current EAB infestations. Survey information provides the basis for management decisions and provides continuous assessment of the effectiveness of the parasitoid release and recovery activities.

Trace Back and Trace Forward Investigations

States and communities may conduct trace back and trace forward investigations to find new infestations and determine the extent of a known infestation. Because of EAB deregulation, PPQ will no longer be conducting these investigations.

General Detection Surveys

The purpose of a general detection survey is to determine if a pest exists in an area. Positive results indicate that a pest is present. Lack of a positive result is valuable for providing clues to dispersal, temporal, or spatial activity patterns of pests particularly when considered with positive results from similar areas or proximities.

The survey methods for *Agrilus planipennis* are conducted to determine distribution of EAB and for selection of appropriate locations for the release of EAB parasitoids.

Activities for conducting general surveys include:

- Planning, prioritizing, and procuring equipment and supplies for survey activities
- Developing or adapting existing protocols to meet new or unusual site-specific program needs
- Assisting scientists with the development and evaluation of new or improved survey protocols
- Following procedures for reporting new infestations and prompt specimen identification
- Maintaining survey records and maps
- Reporting survey results to management officials in a timely fashion

Many EAB infestations have been found by the public. As such, a strong outreach program is crucial for survey to be utilized efficiently. For current information on survey protocol, please consult the USDA-APHIS-PPQ EAB Survey Guidelines located at the Emerald Ash Borer site.

Visual Survey

Visual survey can be helpful in locating older (3-5 yr.) infestations for use as biological control release sites. Visible symptoms are difficult to identify in early infestation stages with no visible symptoms in the first years of infestation.

Visual survey may only detect trees that have been infested for three or more years. Early stages, which show few signs of EAB infestation, are not easily detected by visual survey alone. Panel traps are most effective in detecting earlier stage infestations (Marshall, 2009). On larger trees, symptoms may be present only in the upper canopy in the early stages of infestation.

Trees in a state of decline or with a combination of other symptoms should be examined more closely by an experienced tree climber or a destructive sampling technique. The trees should be marked and their location recorded with GPS coordinates. If no life stages, exit holes, or serpentine galleries under bark are found, the tree should be considered negative for data recording purposes.

Symptoms of EAB Infestations

Symptoms of *Agrilus planipennis* infestation to be cognizant of when conducting visual surveys include:

Figure 5-1 Canopy Stress/Dieback

Figure 5-2 Epicormic Shoots/Suckering

Figure 5-3 Bark Splits with Larval Galleries Underneath

Figure 5-4 Woodpecker Damage

Figure 5-5 D-Shaped Exit Holes (3-4 mm diameter)

Figure 5-6 Serpentine Larval Galleries

Delimiting Survey

The purpose of a delimiting survey is to gather population density and dispersal information that will assist in planning a strategy for management.

1. After detecting adult EABs in traps or finding an infested tree, conduct a visual survey until symptomatic trees are no longer found. Continue visual

survey for a distance of two miles beyond the initial trap capture or infested tree detection.

2. The season will indicate which of the following methods are used for delimiting new detections.

During the dormant season ("Leaf-off"):

Cooperators may consult with EAB Program management to determine if destructive sampling is warranted and to determine the amount of destructive sampling in order to define the extent of the infestation.

During the growing season ("Leaf-on"):

After completion of the visual survey, measure the distance between the two infested trees with the greatest separation. This distance will serve as the buffer zone measurement to create an exclusionary zone void of traps surrounding the infestation. A systematic grid of traps starting at the outside boundary of the exclusionary zone and extending for one mile in radius for every year that the infestation was determined to have existed and then add one additional mile.

EXAMPLE Aging of the infestation indicates that it is three years old. From the last infested tree determined from visual survey, draw a band four miles wide (3 years + 1 mile) around the infestation and survey the area with program traps.

Aging of the infestation indicates that it is three years old. From the last infested tree determined from visual survey, draw a band four miles wide (3 years + 1 mile) around the infestation and survey the area with program traps.

Recommended trap deployment is eight traps placed per square mile where ash trees are accessible. If a candidate area has no ash, the area should be omitted. Exceptions to setting traps in only ash trees include areas where volumes of potentially infested logs and/or firewood were introduced to the site.

If inexperienced personnel are assisting with the survey, a training session with all participants is recommended. Information covered should include recognition of EAB life stages, damage symptoms, ash tree identification, description of infested sites, survey methods, data collection protocols, and safety considerations.

Destructive Sampling Option

Destructive sampling of standing trees should be limited to specific trees displaying two or more symptoms of EAB in an uninfested county.

Monitoring Survey

The purpose of a monitoring survey is to evaluate the effectiveness of an action to contain or suppress EAB. These surveys may also be used to examine the efficacy of EAB parasitoids release and recovery. Use the same survey tools specified for delimiting surveys. More information is available at the EAB parasitoid release and recovery guidelines for EAB parasitoid surveys here and in the Emerald Ash Borer Biological Control Release and Recovery Guidelines: https://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/EAB-FieldRelease-Guidelines.pdf

Survey Sample Collection

Please refer to instructions provided in Identification on page 3-1.

Quality Control for Survey Activities

Survey activities should include quality control monitoring. Quality control techniques will include resurvey of a percentage of the sites, analysis of survey data, and by direct observation.

6 Regulatory Procedures

Contents

Instructions To Officials

There are no longer domestic quarantine regulations for EAB. However, PPQ officials should continue to coordinate with states and to help with any appropriate nonregulatory activities they need (such as training on the use of kiln certification, use of kiln probes and use of kiln certification data from other appropriate activities).

Authorities

There are no longer any federal domestic quarantine regulations for EAB. Contact your state plant regulatory official (SPRO) for EAB regulations in your state.

APHIS removed the domestic quarantine regulations for EAB (7CFR 301.53) as of January 14, 2021, and no longer provides the authority to establish quarantines and conduct regulatory activities. Individual states may have established state quarantines regulating intrastate movement of regulated material. The EAB program will assist states with nonregulatory activities during the transition from federal EAB regulatory compliance.

PPQ will continue to work in conjunction with states' departments of agriculture as they conduct EAB surveys and implement control actions.

Outreach

Outreach is a vital component of every aspect of the EAB program. Without public support and cooperation, the efficacy of the EAB program is limited. PPQ personnel will take opportunities during operations to inform the public about the EAB program and enlist their cooperation. APHIS will maintain an active outreach program for EAB as described on page 9-1.

7 Management Procedures

Contents

Overview

APHIS removed the domestic quarantine regulations for EAB and is now directing available resources toward management of EAB. The APHIS EAB Program is a pest management program that uses biological control agents to mitigate and control EAB. The program goal is to maintain ash trees in the North American landscape.

In the future additional tools may become available to suppress EAB. Program partners are conducting extensive research to develop additional tools and methodologies. The EAB program will incorporate appropriate methods and tactics as they become available.

This section provides program information on the development and deployment of EAB biological control agents and other integrated pest management approaches. This program emphasis will assist states, local communities, and the public in mitigating the effects of this destructive pest.

Because research is ongoing on EAB by APHIS, other federal agencies, and universities, APHIS will modify management procedures as new information on EAB management is ready for operational use. Please contact EAB Program Management to ensure that procedures are up to date before implementing management measures.

Community Preparedness Planning

Since options to eradicate or prevent dispersal are not effective at this time, it is recommended that communities at risk consider and take appropriate action to prepare for an infestation of emerald ash borer.

Examples of preparedness/response plans for States may be found at: http://www.emeraldashborer.info/communityplan.cfm

Examples of individual city response plans may be found at the following URLs:

https://www.mariettaoh.net/images/Government/Commissions/EAB_man_plan.pdf

https://dnr.wi.gov/topic/UrbanForests/EABToolBox.html

https://www2.illinois.gov/sites/agr/Insects/Pests/EmeraldAshBorer/Pages/default.aspx

Urban forest management experts suggest taking preventive measures such as diversifying landscape plantings using the 30:20:10 rule: The urban forest should be composed of no more than 30% of the same family, 20% of the same genus, and 10% of the same species. Choosing native species over non-native species is recommended in order to reduce costs associated with maintenance (watering and fertilizers). Ash (*Fraxinus* spp.) should be avoided as landscape plantings. Models exist for ash phloem reduction in managed forests/woodlots. One such model can be found at: http://www.ashmodel.org/

Reduction of ash populations should be considered in consultation with forest management experts.

It is prudent to have a response plan prior to an EAB infestation. An example of a response planning exercise may be found at:

http://www.mda.state.mn.us/news/publications/pestsplants/insects&pests/eab/eabxrciserpt.pdf

Biological Control

In order to be a successful biological control agent, the following traits are desired:

1. Parasitoid (organism that lives on or in another organism)
2. Multivoltine (producing more than one generation per year)

APHIS PPQ is releasing four parasitoids that meet the above criteria. USDA ARS is continuing to evaluate a fifth egg parasitoid in the ARS research containment facility in Delaware (Duan, pers. Comm.). Research on EAB biological control began in 2002 when this destructive beetle was first found in Michigan. Because EAB is native to southeastern Asia, researchers conducted much of the early biological control research in China. The four non-native biological control agents include two larval ectoparasitoids, *Spathius agrili*

(Hymenoptera: Braconidae) (Yang et al. 2005) *Spathius galinae* Belokobylskij & Strazanac (Hymenoptera: Braconidae); one species of egg parasitoid, *Oobius agrili* (Hymenoptera: Encyrtidae) (Zhang et al. 2005); and one species of larval endoparasitoid, *Tetrastichus planipennisi* (Hymenoptera: Eulophidae) (Liu et al. 2003; Yang et al. 2006). These parasitoids are known to attack EAB consistently in its native range in China and Russia. APHIS PPQ is seeking additional parasitoids that meet these criteria in Asia.

These natural enemies are tiny stingless wasps that seek and kill EAB eggs and larvae. Five years of research in China and quarantine laboratories led to an environmental assessment of field release of these natural enemies. After a 60-day public comment period and a "Finding of No Significant Impact", PPQ and the State of Michigan approved release of these wasps for control of EAB. Small-scale inoculative releases were performed in Michigan in 2007 and 2008. Releases have occurred in 31 states since 2008. PPQ and our cooperative partners will continue to monitor sites for establishment of the parasitoids and evaluate their potential to control and slow the dispersal of EAB in the United States.

Early results indicate that three species are capable of overwintering and reproducing in North America. The fourth species, *Spathius agrili*, is expected to perform well at locations south of the 40 degrees North Latitude. Additional research is being conducted in areas south of this region on the phenology of EAB and timing of parasitoid releases in the southern part of the U.S.

APHIS PPQ established an EAB parasitoid rearing facility in Brighton, Michigan. PPQ continues method development work on tools and techniques for rearing EAB parasitoids at the PPQ Science and Technology Laboratory in Otis, Massachusetts and the facility at Brighton, Michigan. Beginning in 2010, APHIS PPQ selected specific release sites for EAB parasitoid research and tracked the releases at these sites to collect data to determine:

- Successful establishment of released EAB parasitoids
- Numbers of parasitoids needed for establishment
- Site conditions required for establishing parasitoid populations
- Interactions among the four exotic parasitoids and native natural enemies
- EAB parasitoid dispersal rates
- Impacts on EAB populations and ash survival or recovery
- Effects on non-target species

While the focus in the first several years of the biological control program was centered on how to maintain and mass-produce the parasitoids, release them into the field, and monitor for their ability to overwinter across the EAB-

infested areas of the United States, the program is now focusing on the release of the parasitoids in EAB infested counties and the impact of the parasitoids. Specifically, the program is now maximizing efforts to understand the dynamic relationship of the host EAB population to the parasitoids, and the impacts of releasing parasitoids on ash stand health and longevity.

Advances in rearing technology in the early stages of the biological control program have allowed average annual production of female parasitoids to increase rapidly from a few tens of thousands annually in 2009 to more than 250,000 per year in 2012. Increases in annual parasitoid production occurred in 2013 and 2014 with continued improvements. These improvements, in turn, have facilitated additional investments into the parasitoid-impact questions that are now our focus.

The program has increased the suggested base numbers of insects released at a site as production increases have been made. We have also made parasitoids available to research cooperators to examine key questions that support program initiatives. These questions include: how far and how quickly the parasitoids are able to spread naturally (dispersal ability); how well-suited individual parasitoid species may be for specific ecological and climatological regions of the United States as EAB spreads; and how the parasitoids are influencing ash stand health as we evaluate recovery and establishment at parasitoid release sites over several years following the initial release.

The EAB rearing facility is responsible for rearing these four parasitoids for scheduled releases. Release sites will be determined by PPQ in consultation with program partners. The releases will depend upon program needs, regulatory approval, and production capabilities. Availability of parasitoids is limited, but is increasing and every effort has been made to fill requests when appropriate, i.e., correct time of year and stage of EAB needed by the parasitoids.

For more information on release considerations for EAB parasitoids, please refer to the Emerald Ash Borer Biological Control Release and Recovery Guidelines:

http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/EAB-FieldRelease-Guidelines.pdf

Initial releases and post-release monitoring, including impacts on EAB and non-target wood-boring beetles, and dispersal and establishment of each parasitoid species, will be conducted. The environmental assessment for this release can be found at the following web site:

https://www.aphis.usda.gov/plant_health/ea/downloads/2015/spathius-galinae-eab-biocontrol.pdf

Chemical Control

At this time available chemical treatments are not cost effective for large scale implementation. Therefore, the EAB program can not recommend chemical control on a large scale. However, depending on EAB population densities, research suggests individual trees may be effectively treated (Herms et al., 2009). Consult your county or university extension agent for information on approved ash tree treatments recommended for your specific location.

8 Environmental Compliance

Contents

Overview

Environmental and Risk Analysis Services (ERAS) is a unit of APHIS' Policy and Program Development Staff (PPD). This unit manages the preparation of environmental documentation, such as environmental impact statements and environmental assessments, to aid in program operational decisions. ERAS also coordinates pesticide registration and approvals for APHIS pest control and eradication programs, ensuring that registrations and approvals meet program use needs and conform to pesticide use requirements.

Disclaimer

All uses of pesticides must be registered or approved by appropriate Federal, State, and/or Tribal agencies before they can be applied. The information provided on pesticide labels may not reflect all of the actual information, including precautions and instructions for use, which you are required to follow in your specific State or locality. It is the responsibility of persons intending to use a pesticide to read and abide by the label, including labeling that has been approved for the particular State or locality in which the chemical is to be used, and to comply with all Federal, State, Tribal, and local laws and regulations relating to the use of the pesticide. APHIS program staffs are responsible for their compliance with applicable environmental regulations.

Protected Species

To ensure that protected species are not impacted negatively during survey and control activities, contact the Emerald Ash Borer (EAB) National Operations Manager (NOM) with USDA APHIS PPQ Field Operations.

To date, program activities have significantly interfaced with several protected species. Specific protocols have been implemented to mitigate negative impacts on the Indiana gray bat, the bald eagle, the copperbelly water snake, and other species in consultation with Fish and Wildlife Services.

For further details, see the biological assessment and contact the EAB Field Operations NOM.

Environmental Assessment

All program control activities require review by Headquarters Environmental Services staff before any work may begin. Control activities include eradication and containment actions that require cutting and/or destruction of trees. An environmental assessment is mandatory before APHIS supported control or containment activities may begin.

9 Public Outreach

Contents

Introduction

EAB outreach and education has been a sustained and dynamic program objective since the pest was first detected in 2002. Collectively, Federal and State program partners work to increase awareness, facilitate understanding and garner program support. Education and outreach efforts include the use of various vehicles and initiatives (outdoor advertising, radio and television, web, written materials, public presentations, etc.) to accomplish its goals and reach its audiences. EAB Outreach and Education has a variety of material available free of charge. An electronic ordering system is available at: https://www.aphis.usda.gov/aphis/newsroom/publications or contact the EAB program's Legislative and Public Affairs (LPA) specialist.

Regarding the development of new communication tools (publications, videos, posters, news releases, etc.) Federal/State cooperators are encouraged to work with LPA to prevent duplication of efforts and to ensure consistency. When USDA is mentioned/identified, and/or federal dollars are used, communication tools must be reviewed by the LPA program specialists prior to publication/release.

It is never too early to begin the education and outreach process, especially firewood messaging. "Don't move firewood" and "Buy it (firewood) where you burn it" speaks to firewood as a vector and supports proactive environmental stewardship.

Outreach Objectives for State Partners

Coordinate outreach efforts among your cooperators to ensure the program has a consistent message.

1. Establish a small, core committee, to manage and direct program communication; membership should include local, State, and Federal partners, cooperative extension, and other partners deemed relevant. This group will develop standard program messages in accordance with Federal and State regulations.
   - ❖ Identify roles and responsibility for individuals and as a whole
   - ❖ Identify policies and procedures for releasing information to the public and stakeholders
   - ❖ Address financial responsibilities
   - ❖ Develop a two-way reporting mechanism with Cooperative Management Staff
   - ❖ Establish a Communications Advisory Committee and identify roles and responsibilities.
2. Membership could include industry groups such as professional landscapers and arborists, lumber and wood industry, nursery owners, environmental organizers, and other economically impacted groups. This group will be an invaluable network for the dissemination of standard program messages and information Develop outreach materials to meet State program needs and reach multiple audiences. Outreach personnel will work with EAB program managers to identify areas or activities where outreach materials are needed and do not currently exist. Priorities may include the following:
   - ❖ Identify target audiences and leadership
   - ❖ Identify key messages for all program initiatives; survey, public meetings, control activities, etc.
   - ❖ Identify key messages to support activities “Don’t move firewood,” “Buy it where you burn it” examine your trees, know state regulations, etc.
3. Deliver outreach materials through a variety of outlets to ensure widest exposure.
   - ❖ Create a marketing mix using mainstream/alternative/grassroots media to reach targeted audience. (Television, radio, outdoor, newspaper, internet, industry publications, civic groups, newsletters, etc.)

- ❖ Reach out to specialized target audiences through their industry newsletters, web site links, and association meetings. Develop "champions" for the program.
- ❖ Seek out opportunities for communication: County fairs, home and garden shows, regional association meetings, Chamber of Commerce events, etc.
- ❖ Establish a speakers' bureau and create canned PowerPoint presentations

General Outreach Activities and Initiatives

Listed below are some common outreach and education initiatives to support an agency's EAB program:

1. Develop/maintain an EAB website to provide access to current information on EAB, state quarantines, survey areas, etc.
2. Develop and staff a toll-free EAB hotline to address State-specific regulations and messages.
3. Catalogue and review existing informational materials to prevent duplication of effort and ensure consistency.
4. Develop your own public service announcements (PSA's) or use USDA-provided PSA's and arrange for broadcast.
5. Keep the media informed regarding program activities.
6. Keep local officials, local government, community leaders, tribal leaders, etc. informed about the program.
7. When necessary, craft easy to read letters regarding time, date, location, and purpose of public meetings and execute mailing.
   A. Use tax rolls for names and addresses

NOTICE

Tax rolls apply to owners, not necessarily residents.

   B. Allow substantial lead time.
   C. In resort areas, allow for absentee homeowner issues.
8. Arrange, moderate, and provide presentations and support at public meetings. Periodically meet with program staff for program feedback, problems, concerns, etc. Engage and encourage open dialogue. Create specialized communication vehicles when needed to support EAB awareness. Continually refine and develop communication vehicles (brochures, posters, newsletters, etc.) to ensure accuracy and current program information. Develop and arrange for publication of news releases for mainstream, electronic, and alternative media.

Outreach Material

Program materials are available free of charge to support public education.

To prevent duplication of effort and to ensure consistency, before implementing outreach activities contact the EAB LPA specialist to review existing outreach materials.

Telephone Hotline

The toll-free telephone National EAB hotline is 866-322-4512. The hotline is staffed by trained and knowledgeable personnel who can answer questions about the EAB program and direct callers to appropriate program personnel.

Report EAB Email

The email address to report new detections of EAB is Report.EAB@usda.gov. The email box goes directly to the EAB NOM and the email will be forwarded to the State Plant Health Director to determine the appropriate response.

Websites

The PPQ EAB website is located at: www.aphis.usda.gov/plant-health/eab.

The website contains current program information including: EAB signs and symptoms, ash tree identification, treatment options, tree replacement options, community preparedness plans, maps, and on-going research.

The Emerald Ash Borer Information Network is a multinational website developed by the Cooperative EAB Program and funded by the U.S. Forest Service as a resource and link to Federal and State information. The website is located at: www.emeraldashborer.info.

National Plant Board Firewood Working Group Guidelines located at https://firewood.nationalplantboard.org/

Public Meetings or Informational Open Houses

Public meetings or informational open houses take place when deemed necessary and/or appropriate. These meetings address public concerns, communicate the program strategy and actions, and help to garner community support and compliance.

Outreach personnel work collectively to: Coordinate scheduling, secure suitable facilities, ensure the delivery of adequate notification, and provide

collateral materials (handouts, fact sheets, informational posters, etc.) for the meeting.

Public venues may include additional participation from:

1. Political representatives and community leaders who are familiar with local concerns and recognized by the local community.
2. State and Federal program representatives who can respond to questions about EAB, state quarantine restrictions, control measures, and its impact.
3. Representatives from cooperating State universities who can answer questions about biology of EAB, its host range, and potential impact in the United States.
4. County, city, and local cooperators who can respond to questions about their roles.

Media Relations

The APHIS PPQ and LPA staff should be notified when a new EAB detection is confirmed. In addition, PPQ staff should also be notified of media requests. National media calls (from high profile media outlets) must be coordinated with APHIS LPA. To avoid conflicting and confusing statements, all outgoing information should be processed through the designated spokesperson. It is recommended that one primary media spokesperson be designated by the State cooperator to work with the EAB LPA spokesperson. Spokespersons should thoroughly understand particular aspects of the program, such as survey and management activities. EAB program spokespersons will develop and maintain close contacts with each other and reporters and community group leaders to provide accurate and consistent information. If no personnel at the local level exist or he/she does not have adequate media experience, the EAB LPA specialist should be notified so he/she can provide experienced media representation to the program.

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Appendix A

Agrilus planipennis Fairmaire Screening Aid

Figure A-1 *Agrilus planipennis* Fairmaire

Members of the genus *Agrilus* are challenging to identify due to structural coloration and subtle morphological differences between species.

Furthermore, the presence of newly discovered exotic *Agrilus* species in New York, the Midwest, and Ontario complicates identification issues and demands a renewed interest in applied taxonomy of *Agrilus* beetles.

The emerald ash borer (EAB) is an invasive buprestid beetle native to Northeast China, Korea, Japan, and Russia. In the United States, EAB is established in 35 states and the District of Columbia. In Canada, EAB is established in Manitoba, New Brunswick, Nova Scotia, Ontario, and Quebec. In Michigan and Ontario, this pest has devastated stands of native ash trees. The following characteristics can be used for discriminating EAB from other native *Agrilus* species:

- No patches of pubescence
- Pronotum copper/green
- Elytra and abdominal sternites emerald green
- Abdominal tergites purplish copper in color
- Length 13 mm
- Emarginate pygidial spine (Figure A-2)
- EXOTIC

Figure A-2 Pygidium of *A. planipennis*

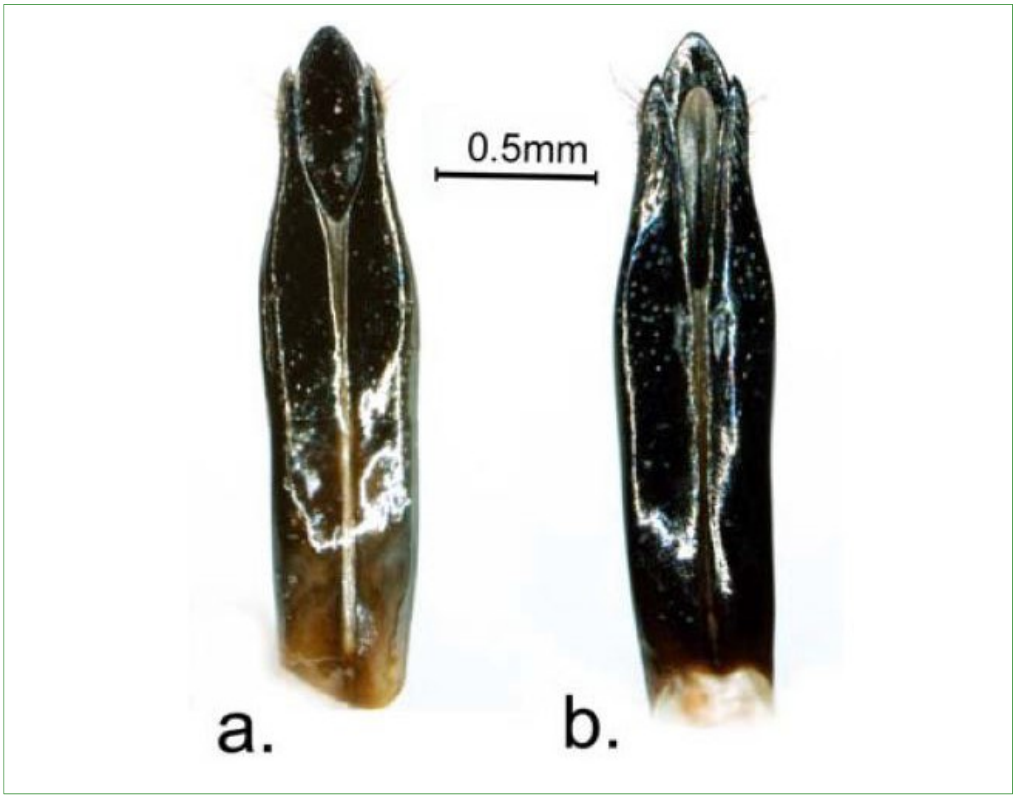


Figure A-3 Aedeagus of *A. planipennis* (a. tergal, b. sternal views)

Some commonly intercepted native and exotic species are illustrated and briefly described on the following pages.

Figure A-4 *Agrilus bilineatus* (Weber)

- Pubescent line on pronotum extending down each elytron
- Bronze-black to dark blue
- Length 11 mm
- Host *Quercus* spp.

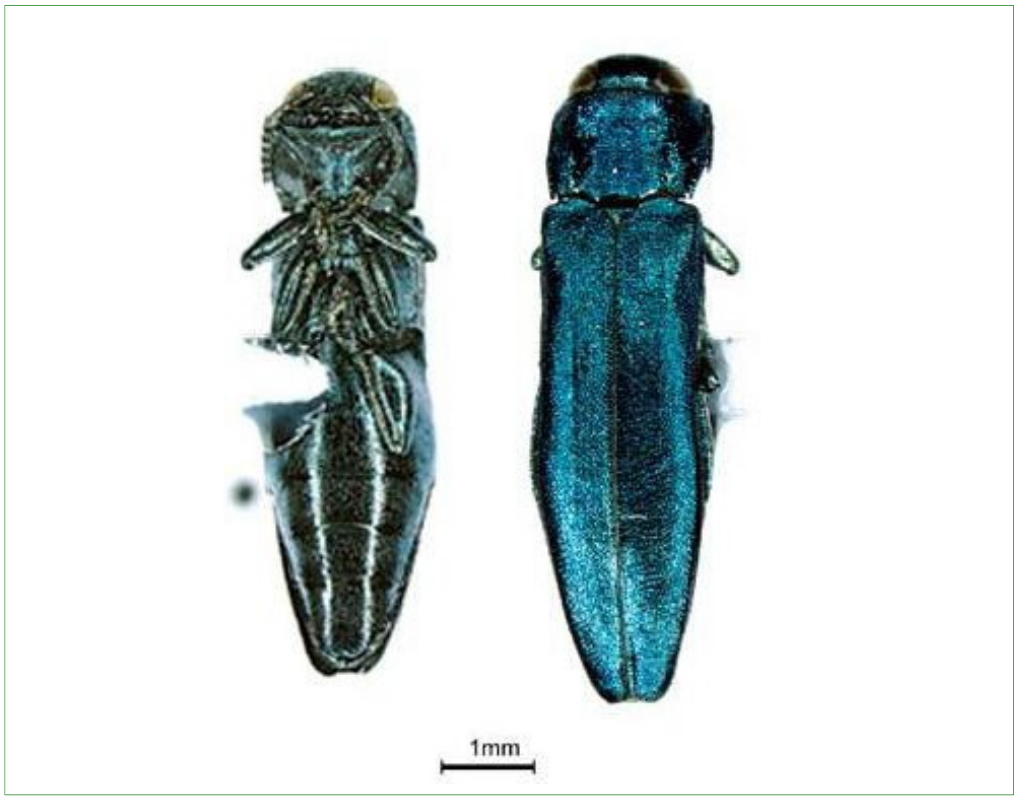


Figure A-5 *Agrilus cyanescens* Ratzeburg

- No patches of pubescence
- Metallic blue in color, darker below
- Length 8 mm
- Host: *Lonicera* spp.
- EXOTIC

Figure A-6 *Agrilus anxius* (Weber)

- No patches of pubescence
- Bronze-black
- Length 12-13 mm
- Host: *Betula* spp.

Figure A-7 *Agrilus vittaticollis* (Randall)

- Pubescent line on pronotum
- Pronotum copper colored with dark elytra, darker below with violet highlights
- Length 10-12mm
- Hosts: *Crataegus*, *Malus*, *Amelanchier* spp.

Figure A-8 *Agrilus obsoletoguttatus* Gory

- Pubescent spots on elytra
- Copper color with violet elytral apices, darker below
- Length 9-10 mm
- Hosts: Hardwood spp.

Figure A-9 *Agrilus masculinus* Horn

- No distinct patches of pubescence
- Bronze-black, green face on males
- Length 6-7 mm
- Hindleg tarsi longer than tibia
- Host: *Acer negundo*

In addition to *Agrilus planipennis*, *A. subcinctus* Gory is the only other *Agrilus* species known to occur on *Fraxinus* in the Midwest. *A. subcinctus* differs behaviorally from *A. planipennis* in that it is a twig borer and prefers smaller branches for oviposition. In the field, *A. subcinctus* can be sweep-netted from ash leaves. *A. subcinctus* is small in size (>4.0 mm) and features a distinct subbassal and subapical spots of scale-like pubescence on the elytra (Figure A-10).

Figure A-10 *Agrilus subcinctus* Gory

All of these *Agrilus* are often found on sticky and in funnel trap samples. With close to 50 *Agrilus* species known from the Midwest, other species may be added to this preliminary guide in the near future.

Appendix B

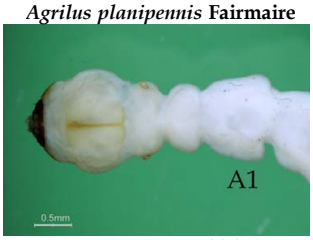
Emerald Ash Borer Larval Screening Guide

Figure B-1 Emerald Ash Borer Larval Screening Guide

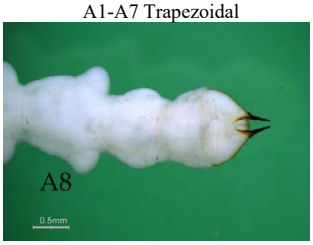
Emerald Ash Borer Larval Screening Guide

J. E. Zablotny

***Agrilus planipennis* Fairmaire**

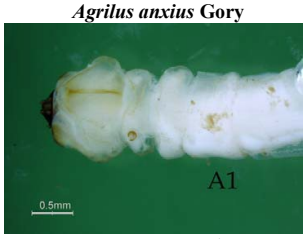


A1-A7 Trapezoidal

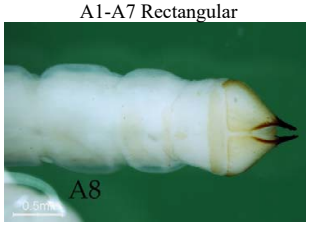


A8 Bell-shaped

***Agrilus anxius* Gory**



A1-A7 Rectangular



A8 Rectangular

The shape of the abdominal segments as well as host is useful for discriminating EAB (*Agrilus planipennis* Fairmaire) larvae from other native *Agrilus* species such as the bronze birch borer (*Agrilus anxius* Gory). I chose *A. anxius* to serve as a reference for comparison with EAB as its larval morphology is more typical for the genus.

The first abdominal segment shape varies considerably but can be distinctly rectangular to trapezoidal in *A. planipennis* while more rectangular and cylindrical in *A. anxius.* In EAB, A2 through A7 are somewhat trapezoidal with protruding flattened lobes. In A. anxius, the abdominal segments do not have protruding flattened lobes and are rectangular in profile. A8 is obviously bell-shaped in EAB and rectangular in the bronze birch borer.

These apparent differences in segment shapes are obvious in all instars of EAB examined so far. However, segment shape differences between species can be more subtle in prepupae and in poorly preserved larvae. In EAB prepupae, abdominal segment eight is still bell-shaped and rectangular in *A. anxius*.

In Michigan, EAB is the most common *Agrilus* species associated with F*raxinus*. North American populations of EAB are known only to oviposit in Fraxinus, or white fringe tree.

USDA APHIS

Appendix C

Contacts

USDA-APHIS-PPQ-EAB Program Contacts

EAB Hotline: 866-322-4512 (toll free)

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Appendix D

Ash Identification Guide

MSU Extension Bulletin E-2892, New May 2003

Distinguishing Ash from other Common Trees

Diane Brown-Rytlewski and Rebecca Thompson
Michigan State University IPM Program

Identifying ash trees

Due to the recent discovery of the emerald ash borer (EAB) in Michigan, it is important to be able to recognize and identify ash trees. To date, emerald ash borer has only been found on ash trees (see page 4). Not sure if your tree is an ash? This simple key is intended to help you distinguish between some common deciduous landscape trees frequently confused with ash, including: elm, boxelder, mountainash, walnut and hickory.

Using the identification key

Begin at number 1 on the key and choose (a) or (b). Then proceed to the number listed in italics at the end of your choice. This number will give you a new set of choices. Continue this way through the key. We have listed enough characteristics to help you determine whether or not your tree is an ash. If it doesn't match the characteristics in the key, relax; it most likely isn't an ash. If you don't want to use the key, tree ID photos are on pages 2-4.

If you are still curious about what kind of trees you have, consult Extension Bulletin E-2332, "Identifying Trees of Michigan," or a good field guide such as: "The Tree Identification Book," by George W.D. Symonds; "Tree Finder: A Manual for the Identification of Trees by Their Leaves," by May T. Watts; or "A Field Guide to Trees and Shrubs" by George A. Petrides. There are many other good guides available; these are mentioned only as examples.

Identification key

1. a) Branches alternate (Fig. 1) – *go to 2*
b) Branches opposite (Fig. 2) – *go to 4*

2. a) Simple leaves, with irregular leaf base and toothed edge (Fig. 3). See **elm**, page 2.
b) Compound leaves (Fig. 4), with 9 to 15 leaflets, finely toothed around edge of leaf – *go to 3*
c) Compound leaves, 5 to 7 leaflets – *go to 3c*

3. a) Cut open twig lengthwise.
Chambered pith (Fig. 6). See **black walnut**, page 3.
b) If pith is not chambered, but has white flowers in May, orange or red berries in fall. See **mountainash**, page 3.
c) If pith is not chambered, but has three leaflets at end of leaf larger than the rest. See **hickory**, page 2.

4. a) Compound leaves, 5 to 9 leaflets, smooth or finely toothed around outer edge. See **ash**, page 4.
b) Compound leaves, 3 to 5 leaflets, few coarse teeth or none, end leaflet pointed (Fig. 5). See **boxelder**, page 4.

Fig. 1- Alternate branching

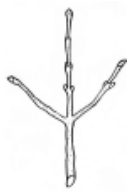

Fig. 2- Opposite branching

Fig. 3- Simple leaf (American elm)

Fig. 4- Compound leaf, 7 leaflets (White ash)

Fig. 5- Compound leaf, 3 leaflets (Boxelder)

Fig. 6- Chambered pith (Black walnut)

Line drawings: Steven Brown

Definitions

- Alternate – leaves/branches that are staggered or not directly across from each other, Fig 1.
- Opposite – leaves/branches that are directly across from each other, Fig. 2.
- Simple – a single leaf blade joined by its stalk to a woody stem, Fig 3.
- Compound – a leaf with more than one leaflet. All leaflets attached to a single leafstem, Fig. 4-5.

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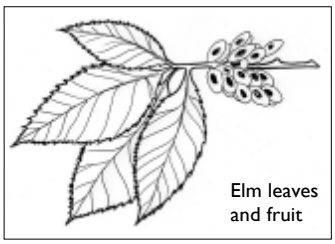
Elm, Ulmus spp.

Branches and buds are alternate and leaf bases are unequal. The leaves are simple, serrate (toothed) and 3 to 6 inches long and 1 to 3 inches wide (American elm) or 3/4 to 3 inches long and 1/3 to 1 inch wide (Siberian elm). The fruit is a winged seed.


Elm leaves and fruit

Sandy Perry

Sandy Perry

Left: American elm has a vase-shaped growth habit. Right: Siberian elms are fast-growing, brittle trees that break easily. Other elms will have similar leaves and seeds, although leaf size and growth habit will vary.

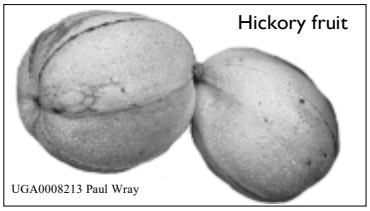

Unequal leaf base

Mary Wilson


Alternate branching

Hickory, Carya spp.

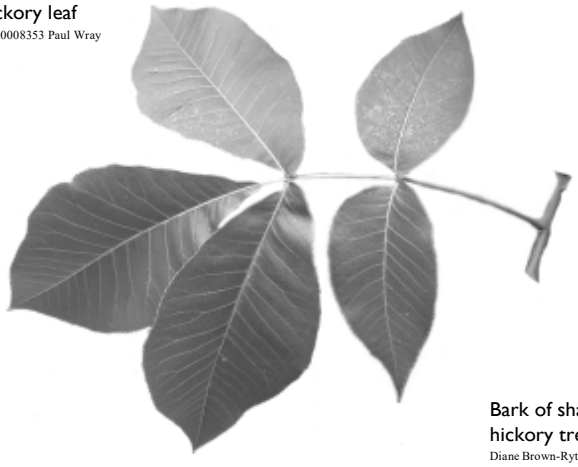
Shagbark hickory has distinctive bark – long, loose, shaggy strips. Leaves are compound, 8 to 14 inches long with 5 to 7 leaflets. The three terminal leaflets are larger than the other leaflets. Other similar species (not shown) include bitternut, pignut and mockernut, which have similar leaves and fruits although leaf size will vary. They do not have distinctive shaggy bark. These trees are seldom planted in landscapes, but are native, and may be found growing in woods. Fruits are hard-shelled light brown nuts, in a green husk that splits into four parts.


Hickory fruit

UGA0008213 Paul Wray

Hickory leaf

UGA0008353 Paul Wray




Bark of shagbark hickory tree

Diane Brown-Rytlewski

2

Black walnut, Juglans nigra

Branches and buds are alternate. Leaves are compound, 15 to 24 inches long, with 9 to 15 leaflets/leaf. Crushed leaflets and stems have a distinct odor – similar to turpentine. Twigs, split lengthwise, have chambered pith. Fruit is a large dark brown nut inside a greenhusk.

Black walnut fruit
UGA0008279 Paul Wray

Black walnut leaf
UGA0008448 Paul Wray

Black walnut chambered pith

Alternate branching

Mountainash — alternate branching
Diane Brown-Rytlewski

European mountainash, Sorbus aucuparia

Leaves are compound, 5 to 9 inches long with 9 to 15 leaflets per leaf. Leaflets are a toothed, rounded oval shape. Flowers are five-petaled, white and similar to cherry or apple blossoms but in clusters. Fruits are fleshy, red-orange berries in clusters – they are found in the fall.

Mountainash leaf
Diane Brown-Rytlewski

Mountainash flowers
Diane Brown-Rytlewski

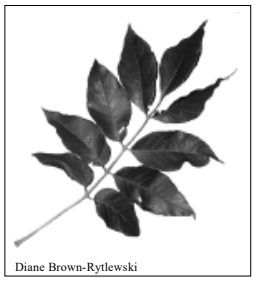
3

Ash, Fraxinus spp.

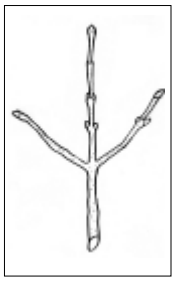
Branches and buds are opposite with a single bud at the end of the branch (terminal bud). Twigs are gray to brown and do not have a waxy coating. Leaves are compound, 8 to 12 inches long, 5 to 9 leaflets/leaf. Leaves may be finely toothed or have smooth edges. The most common ash trees planted in the landscape are **white ash** (*Fraxinus americana*) and **green ash** (*Fraxinus pennsylvanica*). Other native ash trees less commonly found include **black ash** (*Fraxinus nigra*) and **blue ash** (*Fraxinus quadangulata*) (not shown). **Black ash** has 7 to 11 leaflets and is found in wet woods; **blue ash** has 7 to 11 leaflets and distinctive 4-angled corky wings on the stem. **White ash** buds are paired with a leaf scar beneath the bud that looks like the letter "C" turned on its side. **Green ash** buds are paired with a leaf scar beneath the bud that looks like the letter "D" turned on its side (like a smile). Individual fruits are shaped like single wings and occur in clusters; many ash cultivars are seedless.


UGA0008289 Paul Wray

Green ash leaf


Diane Brown-Rytlewski

White ash leaf

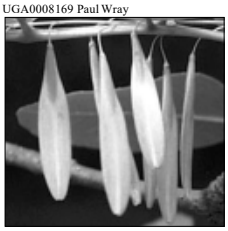


Opposite branching

Dave Cappaert

Left: green ash leaf scar. Right: white ash leaf scar.

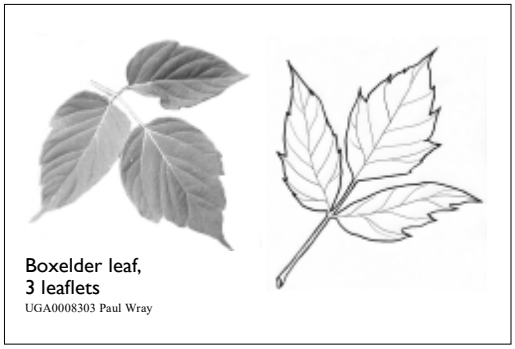
UGA0008169 Paul Wray



Ash seeds

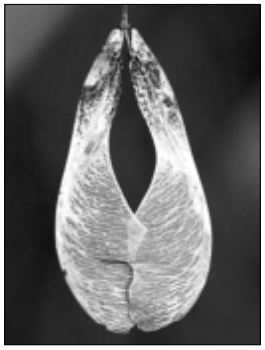
Boxelder, Acer negundo

Boxelder is sometimes called ash-leafed maple. The twigs and buds are opposite; with a single bud on the end of the twig (terminal bud). Twigs are green to purplish brown, and often have a waxy white coating that can be rubbed off the stem. Leaf scars beneath the buds are narrow, and join in a point. Leaves are compound, 4 to 10 inches long, with 3 to 5 leaflets/leaf. Leaves may have a few coarse teeth, or none. The end leaflet is sharply pointed. Fruit is a paired winged seed, occurring in clusters.



Boxelder leaf, 3 leaflets
UGA0008303 Paul Wray

Boxelder branches
UGA1219006 Bill Cook



Boxelder fruit
UGA1219003 Bill Cook

Photo credits:
Bill Cook, Michigan State University, www.forestryimages.org/
Paul Wray, Iowa State University, www.forestryimages.org/

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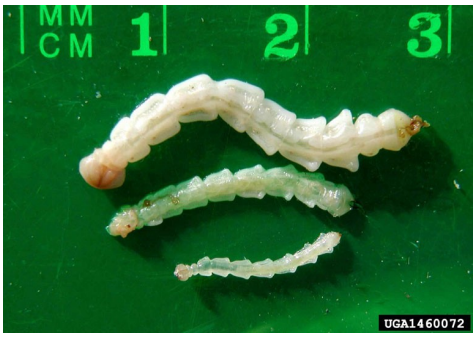
Emerald Ash Borer Symptoms



Images courtesy of bugwood.org

EAB detection Information

The following are links to currently available maps:

- Ash Range Map with Federal EAB detection information
- Federal EAB detection map
- Initial County EAB Detection Map

Appendix E

Passive Dispersal Pathways

The following passive dispersal pathways of emerald ash borer, *Agrilus planipennis* (Fairmaire), (Coleoptera: Buprestidae) are identified by the USDA APHIS PPQ EAB Program.

Firewood

Type	Packaged/bundled or bulk (split, unsplit, or slab)
Pathway	◆ "Big box" store ◆ Firewood producer/distributor ◆ Firewood broker ◆ Sawmill slab wood ◆ Campground ◆ Online sale and auction ◆ Local auction ◆ Roadside sale ◆ Small business sale ◆ Homeowner collection
Method of Transport	◆ Long-distance hauling company ◆ Domestic parcel delivery service ◆ Private vehicle

Solid Wood Packing Material

Type	◆ Dunnage ◆ New and recycled pallets ◆ Pallet stock/cant ◆ Crating ◆ Case ◆ Skid ◆ Block
Pathway	◆ Pallet manufacturer ◆ Sawmill ◆ Distribution center
Method of Transport	◆ Railway ◆ Freighter ◆ Long-distance hauling company ◆ Domestic parcel delivery service ◆ Air cargo service

Lumber

Type	◆ Sawn timber ◆ Green lumber ◆ Air-dried rough lumber ◆ Air-dried dimensioned lumber ◆ Miscellaneous products ❖ Railroad ties ❖ Crane mats ❖ Stakes ❖ Trailer beds and sides
Pathway	◆ Sawmill ◆ Portable sawmill operator
Method of Transport	◆ Railway ◆ Long-distance hauling company ◆ Domestic parcel delivery service ◆ Local delivery service

Logs

Type	◆ Saw log ◆ Pulp log ◆ Veneer log
Pathway	◆ Logger ◆ Log hauling company ◆ Sawmill ◆ Portable sawmill operator ◆ Tree service company ◆ Veneer mill ◆ Paper mill ◆ Pulp mill
Method of Transport	◆ Freighter/barge ◆ Railway ◆ Long-distance hauling company ◆ Local hauling service

Chips

Type	◆ Biofuel ◆ Animal bedding ◆ Engineered wood panel material
Pathway	◆ Wood-fired utility company ◆ Panel manufacturer ◆ Zoo ◆ Tree service company ◆ Sawmill
Method of Transport	◆ Long-distance hauling company ◆ Railway ◆ Local delivery service ◆ Private vehicle

Mulch

Type	◆ Composted and uncomposted
Pathway	◆ Landscape company
Method of Transport	◆ Long-distance hauling company ◆ Local delivery service ◆ Private vehicle

Nursery Stock

Type	◆ *Fraxinus* spp.
Pathway	◆ Nursery ◆ Online sales and auction
Method of Transport	◆ Long-distance hauling company ◆ Local delivery service ◆ Private vehicle

Appendix F

Interstate and Intrastate Movement of EAB Host Materials

Movement regulations of EAB host material may vary from state to state. Please contact the state's department of agriculture where movement in or through will take place for a list of movement conditions or regulations.

Emerald Ash Borer

Glossary

Introduction

Use this *Glossary* to find the meaning of specialized words, abbreviations, acronyms, and terms used in regulating the fresh, cut articles imported for decoration or ornamentation. To locate where in the manual a given definition, term, or abbreviation is mentioned, use the Index.

Definitions, Terms, and Abbreviations

anthropogenic. Human-caused

APHIS. Animal and Plant Health Inspection Service

cambium. The meristematic tissue in woody plants that exists between the wood (xylem) and the inner most bark (phloem)

°C. Degrees Celsius

CFR. Code of Federal Regulations

cuneiform. Triangular or wedge-shaped

DBH. Diameter at breast height, equivalent to 1.37 meters from the ground

delimiting survey. A sampling method to determine extent of an infestation of an exotic species in an area

destructive sampling. Method of observing signs and symptoms of the presence or absence of a pest by destruction of the living sample unit; i.e., removal of bark to look for larvae

detection survey. A sampling technique to determine the presence or absence of a nonnative species in an area

developmental thresholds. The minimum and/or maximum temperatures that support physiological development of a species

diapause, facultative. The cessation of growth and reduction of metabolic activity in a species which occurs seasonally or when environmental conditions are unfavorable

dispersal, active. The spread of an organism by its own method of locomotion (e.g., walking, flight, etc.)

dispersal, passive. The spread of an organism aided by other than it own method of locomotion (e.g., wind, water, man, etc.)

EAB. emerald ash borer

EAN. Emergency Action Notification

ectoparasitoid. A parasitoid that develops outside the host and is attached or embedded in host tissue

endoparasitoid. A parasitoid that develops inside the host

epicormic shoots. Fast growing, relatively soft stems arising from the main trunk below the crown or root collar of a dying or stressed tree. Sometimes referred to as “water sprouts” or “suckering”

ES. Environmental Services

exotic species. An organism or pest species not native to nor historically resident in North America, also referred to as alien, non-native, or invasive species

°F. Degrees Fahrenheit

FIFRA. Federal Insecticide, Fungicide and Rodenticide Act

FY. Fiscal year

generally infested area. All areas within a line extending from the peripheral positive EAB finds

generation. One complete life cycle

GPS. Global positioning system

growing degree day. Or Degree days (GDD, DD). A measure of the number of thermal units (degrees) that accumulate above a specified base temperature over a 24 hour period

host. A species that provides food, shelter, or reproductive requirements for another organism

IES. Investigative and Enforcement Services

IPHIS. Integrated Plant Health Information System

ISPM. International Standard for Phytosaniatry Measures

km. kilometer

leading edge. The boundary defined by the line delineating the generally infested area

LPA. Legislative and Public Affairs

mg. milligram

mm. millimeter

monophagous. Feeding on only one type of food

MOU. Memorandum of understanding

multivoltine. Producing more than one generation per year

obscure-aeneous. Dark coppery color

parasitoid. An organism that lives on or in another organism, usually referred to as its host, and from which it obtains nourishment

phloem. Nutrient conducting tissue of the inner bark

phototactic. Movement of an organism toward or away from a light source

PPD. Policy and Program Development

PPQ. Plant Protection and Quarantine

regulated articles. All known or suspected hosts of a confirmed infestation of a non-native species, including soil and any other suspected product or article

SEL. Systematics Entomology Laboratory

SPHD. State Plant Health Director

SPRO. State Plant Regulatory Official

S&T. USDA-APHIS-PPQ Science and Technology

thermotactic. Movement of an organism toward or away from a heat source

USDA. United States Department of Agriculture

visual survey. Simple examination of areas for eggs, larvae, pupae, or other evidence to determine if a particular insect species is present

xylem. Water conducting tissue that comprises the bulk of most woody plants; wood

Emerald Ash Borer

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