Agrilus planipennis Fairmaire
Coleoptera: Buprestidae
Emerald ash borer

Host(s)	CAPS-Approved Survey Method
Major/Primary hosts *Fraxinus* spp. (Ash), *Fraxinus americana* (White ash), *Fraxinus chinensis*, *Fraxinus chinensis* var. *rhynchophylla*, *Fraxinus japonica*, *Fraxinus lanuginosa*, *Fraxinus mandshurica*, *Fraxinus mandshurica* var. *japonica*, *Fraxinus nigra* (Black ash), *Fraxinus pennsylvanica* (Red ash), *Fraxinus pennsylvanica* var. *subintegerrima* (Green ash), *Fraxinus rhynchophylla*, *Fraxinus quadrangulata* (Blue ash). (Haack et al., 2002; EPPO, 2005; Anulewicz et al., 2008, McCullough et al., 2008)	The purple prism trap with two lure pouches: 1) Manuka oil and 2) Z-3-hexanol.

Reason for Inclusion in Manual
Agrilus planipennis is a PPQ Plant Program pest and is therefore a CAPS target.

Consult the Emerald Ash Borer Plant Pest Program website for detailed information regarding biology, survey protocols, and identification for EAB: http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml.

Pest Description
Egg:
"Eggs are white in color, turning to orange-brown before hatching. They are oval shaped, 1 x 0.6 mm [$<^1/_{16}$ in] in size. The center of each egg is slightly convex" (Ciesla, 2003).

Larva:
"Mature larvae are 26 to 32 mm [approx. 1 to 1 ¼ in] long and creamy white in color. The body is flat and broad. The head is small and brown and it is retracted into the prothorax, exposing only the mouthparts. The prothorax is enlarged, and the meso- and meta-thorax are slightly narrower. The mesothorax bears spiracles. The abdomen is 10-segmented. Segments 1 to 8 have one pair of spiracles each and the last segment bears one pair of brownish, pincer-like appendages (urogomphi)" (Ciesla, 2003).

A. planipennis adult (Image courtesy of David Cappaert, Michigan State University, Bugwood.org).

Pupa:
"Pupae are 10 to 14 mm [approx. $^{3}/_{8}$ to $^{9}/_{16}$ in] long and are creamy white in color. The antennae stretch back to the base of the elytra and the last few segments of the abdomen bend slightly ventrad (Canadian Food Inspection Agency 2002, Haack et at. 2002)" (Ciesla, 2003).

A. planipennis adult (Image courtesy of David Cappaert, Michigan State University, Bugwood.org).

Adult:
"Adults are 8.5 to 14.0 mm [approx. $^{5}/_{16}$ to $^{9}/_{16}$ in] long and 3.1 to 3.4 mm [approx. $^{1}/_{8}$ in] wide. The body is narrow and elongate, cuneiform, and is a beautiful metallic blue-green color. This species is glabrous (hairless), and is characterized by dense but fine sculpture. The head is flat and the vertex is shield-shaped. The compound eyes are kidney shaped and somewhat bronze colored. The prothorax is transversely rectangular and it is slightly wider than the head, but is the same width as the anterior margin of the elytra. The anterior margin of the elytra is raised forming a transverse ridge, the surface of which is covered with punctures. The posterior margins of the elytra are round and obtuse with small tooth-like knobby projections on the edge" (Ciesla, 2003).

Biology and Ecology

In North America, the life cycle usually takes one year to complete, although some individuals may take two years (Anulewicz et al., 2008). Adults feed on plant foliage throughout their life. Adults are active in warm, sunny weather (Haack et al., 2002).

Adults usually mate within the first 7 to 10 days after emergence; females will mate multiple times (Scarr et al., 2002). Females lay approximately 68 to 90 eggs throughout their life. Eggs are laid individually along the trunk and lower portions of major branches of host trees (Haack et al., 2002). The upper trunk is usually colonized first (Scianna and Logar, 2004). Eggs hatch in about one week (Haack et al., 2002).

Larvae tunnel to the cambial region feeding on the phloem (inner bark) and outer sapwood during summer and early fall. Galleries are characterized by being S-shaped, packed with frass, and increasing in width as the larvae grow (Haack et al., 2002). Larvae feed for several weeks and usually finish feeding around autumn. *A. planipennis* can develop in branches and trunks ranging in size from 2.5 cm (approx. 1 in) to 140 cm (approx. 55 in) (McCullough et al., 2008). Galleries can be up to 50 cm long (approx. 19 $^{11}/_{16}$ in) and stretch 16 cm (approx. 6 $^{5}/_{16}$ in) from top to bottom (Scarr et al., 2002).

The prepupal larvae overwinter in 1 cm (approx. $^{3}/_{8}$ in) deep chambers in the outer sapwood or bark (McCullough et al., 2008). Pupal cells can be constructed in the outer sapwood or in the thick outer bark (Haack et al., 2002). Pupation begins around late April and May (McCullough et al., 2008). New adults wait 1 to 2 weeks before they exit the tree through a D-shaped exit hole approximately 3 to 4 mm ($^{1}/_{8}$ to $^{3}/_{16}$ in) in width (Haack et al., 2002).

Initial emergence of *A. planipennis* occurs with the accumulation of 450 base Degree Days (DD); peak emergence occurs at 900 to 1000 DD. By 1500 DD, adult flight is tapering off, but adults have been caught in traps in Michigan into late September.

Adult males live approximately 2 weeks while females live approximately 3 weeks (Haack et al., 2002).

Countries of Origin

This species is native to northeastern China, Japan, Korea, and Mongolia, as well as the Russian Far East and Taiwan (Haack et al., 2002).

Current Distribution

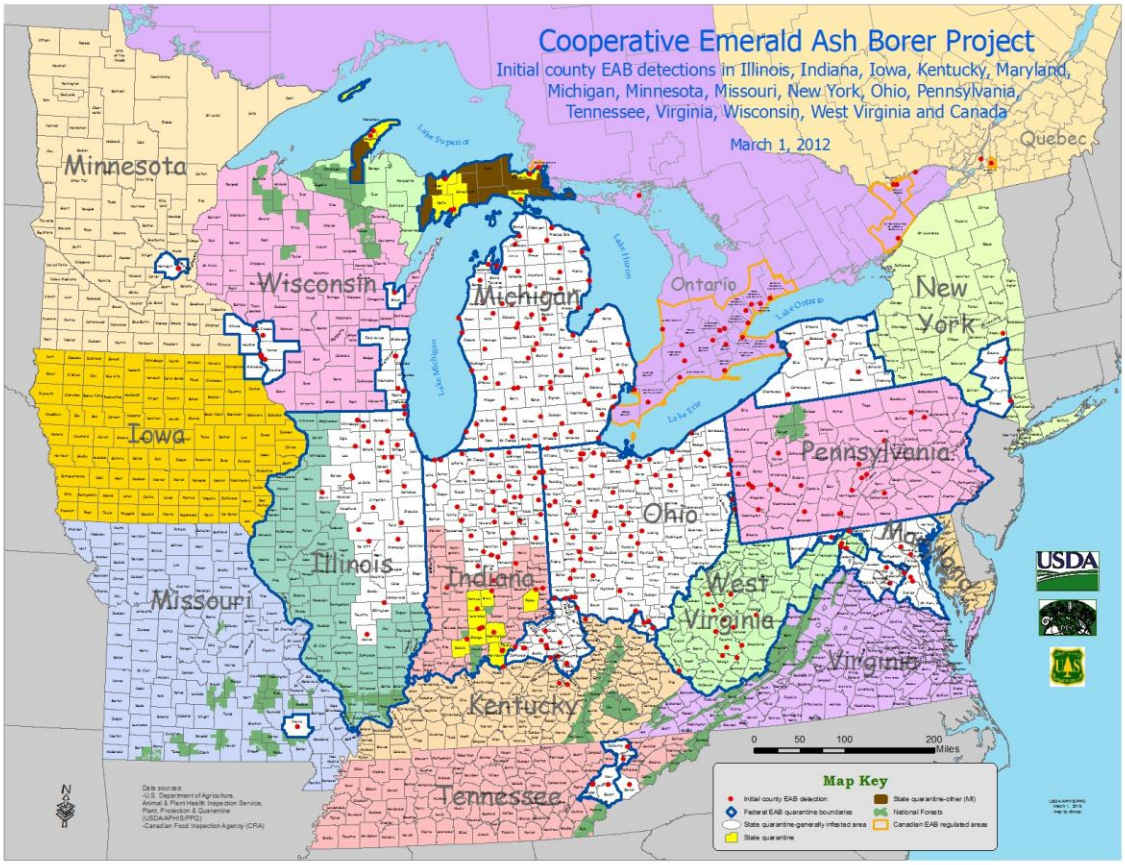
This species is found in Canada, China, Japan, Korea, Mongolia, Russia, Taiwan and the United States (EPPO, 2005; EPPO, 2007).

Distribution in United States

This species was first discovered in the United States in May 2002 in southeastern Michigan (Ciesla, 2003).

As of July 12, 2011, this species has been found in 15 states including: Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Missouri, New York, Ohio,

Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin (www.emeraldashborer.info).



Map showing initial county *A. planipennis* detections as of March 1, 2012 (USDA-APHIS-PPQ, 2012).

Pathway

A. planipennis most likely entered the United States through infested ash crating or pallets (Scianna and Logar, 2004). This species may have moved throughout the U.S. in firewood moved from infected to uninfected areas as well as movement of unprocessed logs and other ash commodities (EPPO, 2003; McCullough et al., 2008). *A. planipennis* has also been found in nursery stock in the United States (Ciesla, 2003).

This species can fly over 1 km (0.62 mi) when searching for host material. They may also be dispersed by wind currents (Ciesla, 2003).

A list of regulated articles and quarantine areas can be found in the Code of Federal Regulations (Title 7, part 301.53) which can be found online at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=6a0070c57042eb3433494e5bebe5f0df&tpl=/ecfrbrowse/Title07/7cfr301_main_02.tpl.

Pathogens Vectored

This species is not known to vector any pathogens or other associated organisms.

Damage

A. planipennis was found in 2002 to be the cause of widespread *Fraxinus* (ash) spp. mortality in southeastern Michigan and Essex County, Ontario, Canada (Cappaert et al., 2005).

In North America, this species has killed both healthy and stressed ash, including green ash (*F. pennsylvanica*), white ash (*F. americana*), black ash (*F. nigra*) and blue ash (*F. quadrangulata*) (Anulewicz et al., 2008).

It is difficult to detect newly infested trees as there are few, if any, external symptoms initially. One of the first symptoms may be excavated holes from woodpeckers feeding on *A. plannipennis* larvae and pupae (Wilson and Rebek, 2005; McCullough et al., 2008).

Tree with new shoot growth below attack site (James W. Smith, USDA APHIS PPQ, Bugwood.org).

Symptoms can include: 1) canopy dieback which begins in the top third of the canopy and progresses down until the tree is bare; and 2) epicormic shoots, sprouts that grow from the roots and trunks, often with larger leaves than normal. Bark splitting, vertical fissures that form on the bark (due to callous tissue formation), may also occur (Wilson and Rebek, 2005). These are usually 7 to 10 cm ($2\ ^{13}/_{16}$ to $3\ ^{15}/_{16}$ in) long (Scarr et al., 2002). This symptom may be observed in the bark over larval feeding galleries (McCullough et al., 2008). Suckers (new shoot growth) can grow below *A. planipennis* activity on trunks and branches (Jesse et al., 2011). Feeding by adult beetles can leave small, irregular shaped patches around leaf margins (McCullough et al., 2008).

If bark is removed from infested trees, serpentine galleries can be observed. Galleries run along the

Galleries caused by *A. planipennis* larvae (Toby Petrice, USDA Forest Service, Bugwood.org).

outer sapwood and phloem and are frass-filled (McCullough et al., 2008). D-shaped exit holes approximately 3 to 4 mm ($^{1}/_{8}$ to $^{3}/_{16}$ in) in width can also be observed (Haack et al., 2002). Sawdust may be present around the exit hole or around the surrounding bark (Scarr et al., 2002).

Exit hole caused by *A. planipennis* adult (David Cappaert, Michigan State University, Bugwood.org)

Death of the tree usually occurs in 3 years, although outbreak levels can lead to tree mortality in 1 to 2 years (Haack et al., 2002). After tree death, bark will begin to fall off, revealing larval galleries underneath (Scarr et al., 2002).

Survey

Every effort is made to align CAPS survey protocols with PPQ Program survey protocols. However, please refer to the **USDA APHIS PPQ *2012 Emerald Ash Borer Survey Guidelines*** for the most current information: http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml.

1.1 Survey site and selection

"In 2012, trap placement will be based on a survey sampling design developed in collaboration between the APHIS EAB Program and the U.S. Forest Service's Forest Health Technology Enterprise Team (FHTET)" (USDA-APHIS-PPQ, 2012). See the **USDA APHIS PPQ *2012 Emerald Ash Borer Survey Guidelines*** for additional information.

1.2 Trap and Lure

The CAPS-approved method is a trap and lure combination. For the 2012 survey season, the EAB Program's preferred survey method is the purple prism trap with two lure pouches: 1) Manuka oil and 2) Z-3-hexanol. Both lures are effective for 56 days (8 weeks).

IPHIS Survey Supply Ordering System Product Names:
1. Purple Prism Trap
2. Manuka Oil Lure
3. Z-3-Hexanol Lure

If you have leftover lures from previous seasons (manuka and phoebe oil), please contact one of the following EAB representatives (listed in the Contact Information section below) for further instructions. For small amounts of lures you may be able to use the lures during this survey season; however, for large amounts of lures, the lures may need to be redirected to researchers.

Paul Chaloux - National Program Manager for EAB
(301) 734-0917
paul.chaloux@aphis.usda.gov

Philip Bell - Regional Program Manager (Eastern Region) for EAB
(919) 855-7312
philip.d.bell@aphis.usda.gov

Rob Meinders - Regional Program Manager (Western Region) for EAB
(515) 251-4083
robert.d.meinders@aphis.usda.gov

For negative data reporting, any of the following four lure combinations in a purple prism trap will be accepted; however, please strive to follow the 2012 EAB program recommendations and consult with an EAB representative if you have leftover lures from previous years.

Option	Product Name	Length of Effectiveness
1	1) Manuka Oil Lure 2) Z-3-hexanol Lure	56 days
2	1) Manuka Oil and Phoebe Oil Lure 2) Z-3-hexanol Lure	56 days
3	Manuka Oil Lure	56 days
4	Manuka Oil and Phoebe Oil Lure	56 days

Note: *Cerceris* wasps may NOT be used to report negative data for EAB.

1.3 Trap Placement

See the Trap Placement Protocols section of the **USDA APHIS PPQ *2012 Emerald Ash Borer Survey Guidelines*.**

1.4 Time of year to survey

Use Appendix C. Predicted Growing Degree Day Zones for Initial EAB Emergence of the **USDA APHIS PPQ *2012 Emerald Ash Borer Survey Guidelines*** to determine when EAB adult emergence will begin in your state. Traps should stay up until 1500 Degree Days (DD) have accumulated; however, traps should not be taken down before August 1, regardless of how many DD have accumulated.

Identification

CAPS-Approved Method*:

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

Samples should be submitted following the guidance in the ***Screening for Suspect Buprestidae and Specimen Submission*** section of the **USDA APHIS PPQ *2012 Emerald Ash Borer Survey Guidelines*.**

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Mistaken Identities
Agrilus planipennis can be confused with other *Agrilus* species including: *Agrilus anxius*, *Agrilus bilineatus*, *Agrilus cyanescens*, *Agrilus masculinus*, *Agrilus obsoletoguttatus*, *Agrilus subcinctus*, and *Agrilus vittaticollis* (there are 171 *Agrilus* species documented in America north of Mexico). There are at least six other exotic species of *Agrilus* in the United States including: *A. cuprescens* (= *aurichalceus*), *A. cyanescens*, *A. derasofasciatus*, *A. hyperici*, *A. pilosovittatus*, and *A. sinuatus*; none of which use *Fraxinus* spp. as hosts (Haack et al., 2002).

Resources and High Resolution Images

Public outreach material can be found on several sites including:
http://www.emeraldashborer.info
http://www.aphis.usda.gov/hungrypests/.

Host tree identification aids
Brown-Rytlewski, D. and R. Thompson. 2003. Distinguishing Ash from other Common Trees. MSU Extension Bulletin E-2892. 4 pp.
http://www.ipm.msu.edu/pdf/E2892Ash.pdf.

Jesse, L., M. Shour, M. Gleason, J. Randall, J. Iles, and D. Lewis. 2011. Common Problems of Ash Trees. Iowa State University, University Extension. 8 pp.
http://www.extension.iastate.edu/pme/EAB%20other%20forms/SUL21AshTreesFINAL2.pdf.

Rebek and Wilson 2005. Ash Tree Identification. Michigan State University Extension. Extension Bulletin E-2942. 2 pp.

Images
http://www.invasive.org/browse/subthumb.cfm?sub=7171.

Screening Aids
Zablotny, J. E. No date. Emerald Ash Borer- *Agrilus planipennis* Screening Aid.
http://caps.ceris.purdue.edu/dmm/535.

Zablotny, J. E. No date. Emerald Ash Borer Larval Screening Guide. USDA-APHIS.
http://www.emeraldashborer.info/files/EABLarvalScreeningGuide.pdf

Parsons, G. L. 2008. Emerald Ash Borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae). A guide to identification and comparison to similar species. Michigan State University, Department of Entomology.

http://www.emeraldashborer.info/files/eab_id_guide.pdf.

References

Anulewicz, A. C., D. G. McCullough, D. L. Cappaert, and T. M. Poland. 2008. Host range of the emerald ash borer (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) in North America: results of multiple-choice field experiments. Environmental Entomology, 37(1): 230-241.

Cappaert, D., D. G. McCullough, T. M. Poland, and N. W. Siegert. 2005. Emerald ash borer in North America: a research and regulatory challenge. American Entomologist 51: 152-165.

Ciesla, W. M. 2003. EXFOR Database Pest Report: *Agrilus planipennis*. USDA Forest Service. Accessed October 17, 2007, from: http://spfnic.fs.fed.us/exfor/data/pestreports.cfm?pestidval=155&langdisplay=english.

EPPO. 2003. Report of a Pest Risk Management: *Agrilus planipennis.* European and Mediterranean Plant Protection Organization. 04/10812. 4 pp.

EPPO. 2005. Data sheets on quarantine pests, *Agrilus planipennis*. European and Mediterranean Plant Protection Organization. 9 pp.

EPPO. 2007. EPPO Plant Quarantine Information Retrieval System (PQR), version 4.6. European and Mediterranean Plant Protection Organization.

Haack, R. A., E. Jendek, H. Liu, K. R. Marchant, T. R. Petrice, T. M. Poland, and H. Ye. 2002. The emerald ash borer: a new exotic pest in North America. Newsletter of the Michigan Entomological Society 47(3&4): 1-5.

Jesse, L., M. Shour, M. Gleason, J. Randall, J. Iles, and D. Lewis. 2011. Common Problems of Ash Trees. Iowa State University Extension. SUL21.

McCullough, D. G., N. R. Schneeberger, and S. A. Katovich. 2008. Pest Alert: Emerald Ash Borer. United States Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. Newton Square, PA. NA-PR-02-04. 2 pp.

Scarr, T. A., D. G. McCullough, and G. M. Howse. 2002. Forest Health Alert-3. *Agrilus planipennis*, Emerald Ash Borer. Canadian Food Inspection Agency, Natural Resources Canada, Ontario.

Scianna, J. D. and R. Logar. 2004. Emerald Ash Borer (EAB) *Agrilus planipennis*. Plant Materials Technical Note No. MT-48. United States Department of Agriculture. Natural Resources Conservation Service.

USDA-APHIS-PPQ. 2012. 2012 Emerald Ash Borer Survey Guidelines. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Accessed February 29, 2012, from: http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/survey_guidelines.pdf.

Wilson, M. and E. Rebek. 2005. Signs and Symptoms of the Emerald Ash Borer. Extension Bulletin E-2938. Michigan State University Extension.