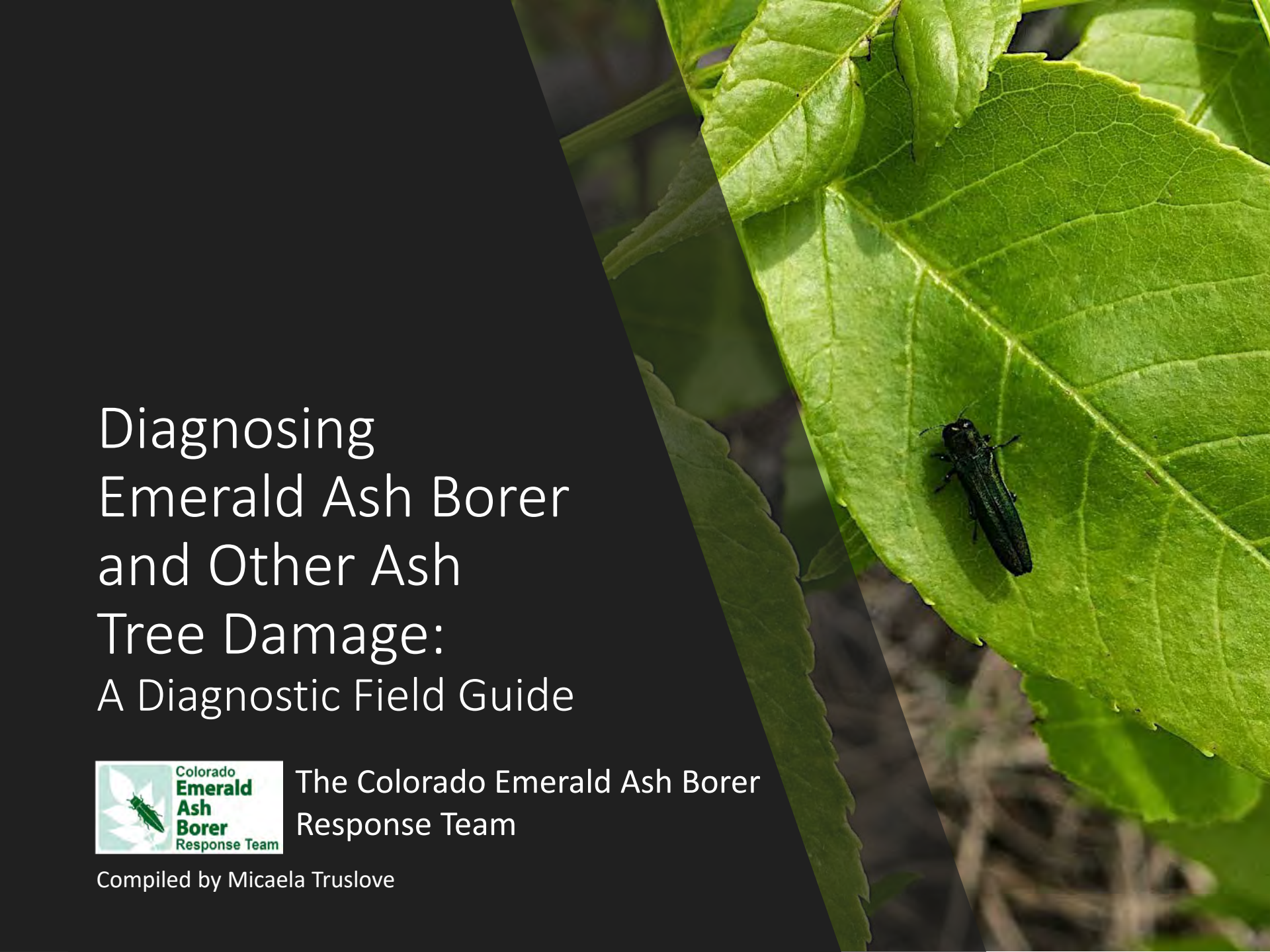
Diagnosing Emerald Ash Borer and Other Ash Tree Damage:

A Diagnostic Field Guide



The Colorado Emerald Ash Borer Response Team

Compiled by Micaela Truslove

The Colorado EAB Response Team includes members from the following agencies/organizations: Colorado Department of Agriculture, Colorado State Forest Service, City of Boulder, Boulder County, Colorado State University Extension, Colorado Tree Coalition, Green Industries of Colorado, University of Colorado, USDA Animal and Plant Health Inspection Service and various Front Range municipalities.

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Introduction

This guide is intended to assist field personnel in identifying life stages of, and damage caused by, emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire). This difficult-to-detect insect causes symptoms in ash trees similar to those caused by many other abiotic and biotic causes. When diagnosing ash tree problems, it is important to step back and look at the whole picture as many diagnostic clues can be obtained by analyzing site conditions.

Symptoms in EAB infested trees initially occur in the top portion of the canopy for the first 1-3 years after infestation. These symptoms gradually progress, and indications of the presence of EAB—such as bark splits, s-shaped galleries, and exit holes—are not often seen on the trunk and lower branches until the tree is in steep decline.

There are many other species of wood-boring insects in Colorado, including other *Agrilus* species, that closely resemble EAB. Proper identification of beetles and their larvae can be difficult, and should be submitted to the Colorado Department of Agriculture, USDA APHIS PPQ, or the Colorado State Forest Service for positive identification.

In Colorado, EAB typically completes its life cycle in one to two years. Adult emerald ash borer beetles emerge from late May to early June, and are present until late August to September. In a one-year life cycle, emerald ash borer larvae are present under the bark from mid- to late summer through the winter. In the case that EAB takes two years to complete its lifecycle, larvae may be present throughout the year.

If you suspect you have detected emerald ash borer in a location OUTSIDE of the current quarantine area, please contact the Colorado Department of Agriculture, local USDA APHIS office, or local municipal forester immediately. DO NOT move any wood suspected of containing EAB. Someone will arrange to meet you at the site. Contact information can be found at the end of this guide under “Emerald Ash Borer Reporting”.

Emerald Ash Borer

Signs and Symptoms

Signs and Symptoms

Gradual canopy thinning and dieback

Winter injury caused by extreme weather events, or other acute wounds, may result in sudden dieback of all or part of the canopy. In the case of an EAB infestation, crown symptoms progress steadily, and worsen from year to year.

Signs and Symptoms

Epicormic growth mid-crown

Signs and Symptoms

Early fall color

In EAB infested trees, early fall color may appear in mid- to late summer while surrounding ash trees remain green. Early fall color is also a common sign of drought and other stressors, so check surrounding conditions to rule out other causes.

Signs and Symptoms

Miniaturized leaves

Leaves on all or part of the tree appear smaller and lighter in color compared to normal leaves. Examine this area closely for bark splits, galleries, and exit holes.

Signs and Symptoms

Bark splits and galleries

Cracking or splitting bark revealing s-shaped galleries below.

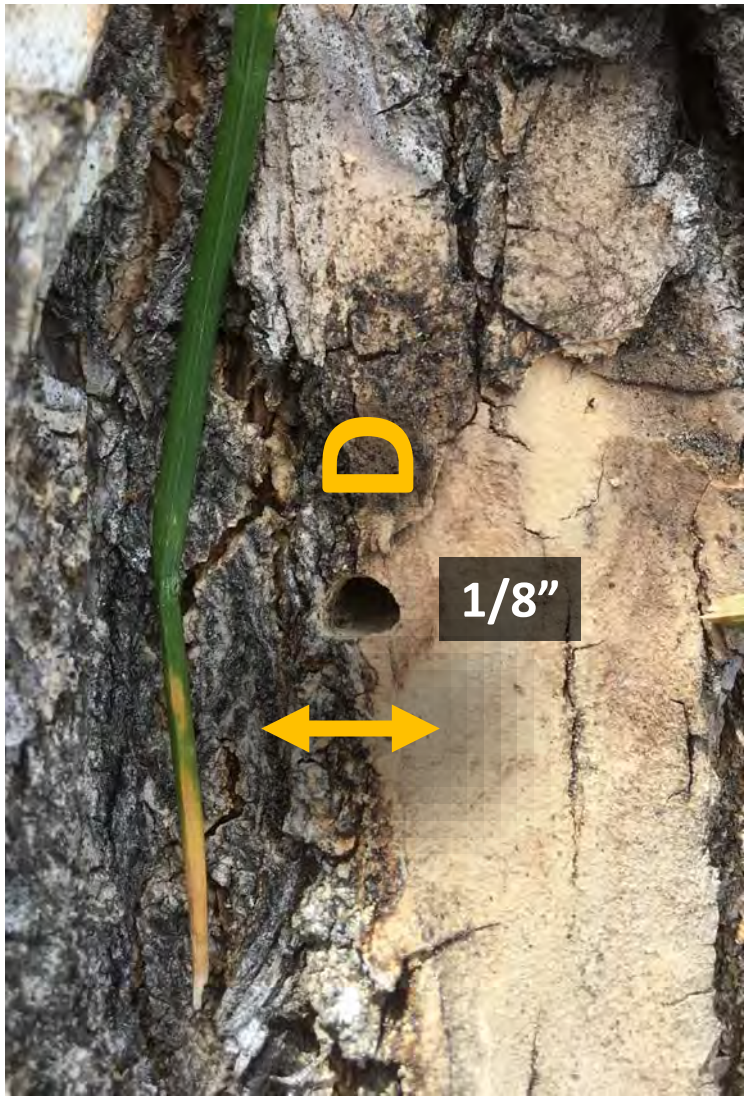
Signs and Symptoms

Woodpecker activity

Woodpeckers remove bark in search of larvae, giving the trunk a mottled appearance. The holes produced by woodpecker feeding are ragged around the edges, unlike the smooth holes other wood boring insects make. In the Midwest, woodpecker activity is reportedly used as a means of early detection.

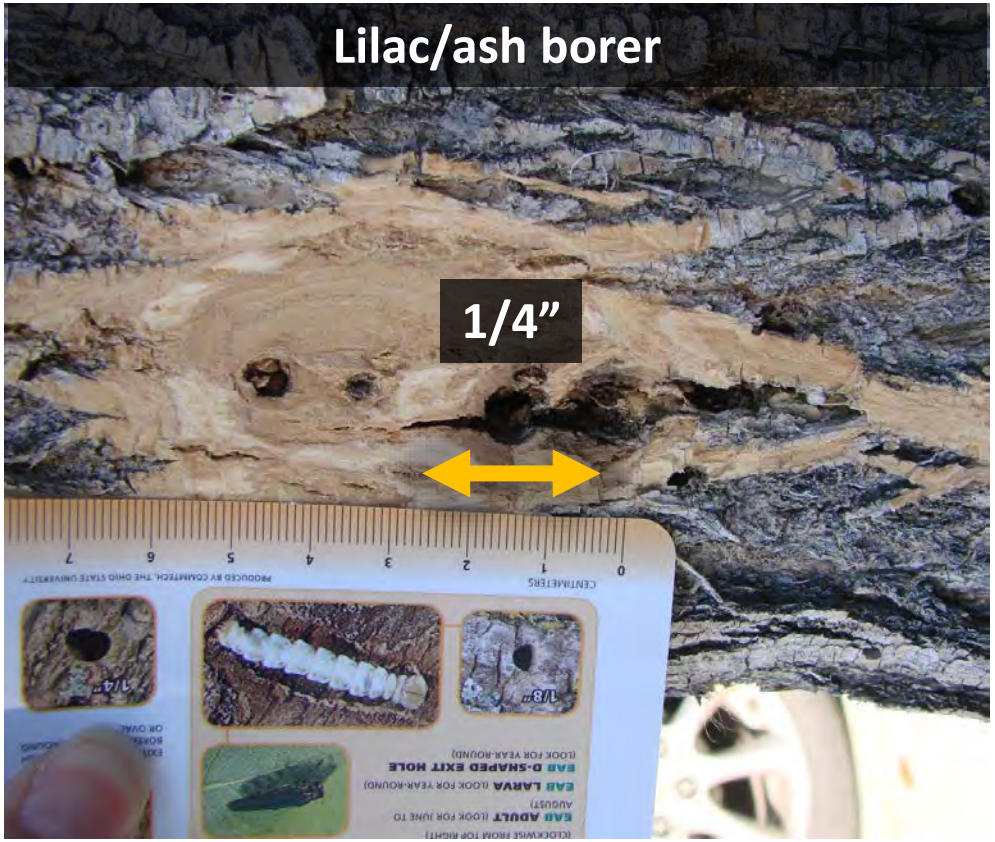
Signs and Symptoms

1/8” D-shaped exit holes



Signs and Symptoms

Exit holes: Lilac/ash borer vs. EAB



Exit holes made by lilac/ash borer are approximately ¼” across (about the size of a pencil eraser). Those produced by EAB are smaller than those made by lilac/ash borer, other roundheaded borers, or flatheaded appletree borer.

Signs and Symptoms

S-shaped galleries under the bark

Signs and Symptoms

EAB larvae

Photo credit: David Cappaert, Michigan State University, Bugwood.org


EAB prepupa in overwintering chamber in the wood

Larvae are flat with distinct, bell-shaped segments. Full-grown (4th instar) larvae are approximately 1” long.

Signs and Symptoms

EAB pupae

EAB overwinters as a prepupa in a shallow chamber in the wood, often forming a ”J” shape (left). Normally feeding occurs more shallowly in the cambium layer, so it may be necessary to remove more wood later in the year to detect larvae if using branch peeling as a means of detection. Pupae (right) are present under the bark from April until emergence.

Signs and Symptoms

EAB adults

Adults are metallic green, approximately ½” long and $^{1}/_{8}$” wide, with a bullet-shaped body. Adults emerge at 450-500 degree days (base 50; usually late May to early June in Colorado), and peak emergence occurs between 900-1100 degree days. EAB emergence roughly coincides with the bloom time of black locust trees.

Signs and Symptoms

Other *Agrilus* species found in Colorado

Gambel oak borer, *A. quercicola*

Photo: Whitney Cranshaw, Bugwood.org

Bronze birch borer, *A. anxius*

Photo: Whitney Cranshaw, Bugwood.org

Honeylocust borer, *A. difficilis*

Photo: Kansas Department of Agriculture, Bugwood.org

Rose stem girdler, *A. cuprescens*

Photo: Whitney Cranshaw, Bugwood.org

Signs and Symptoms

Other EAB look-alikes found in Colorado

Japanese beetle

Photo: David Cappaert, Bugwood.org

Dogbane beetle

Photo: David Cappaert, Bugwood.org

Buprestis confluenta

Photo: Whitney Cranshaw, Bugwood.org

Flatheaded appletree borer

Photo: Joseph Berger, Bugwood.org

Apple flea beetle

Photo: Joseph Berger, Bugwood.org

Six-spotted tiger beetle

Photo: David Cappaert, Bugwood.org

Halictid bee

Photo: David Cappaert, Bugwood.org

Cypriacus intricata

Photo: Steven Valley, OR Dept. of Agriculture, Bugwood.org

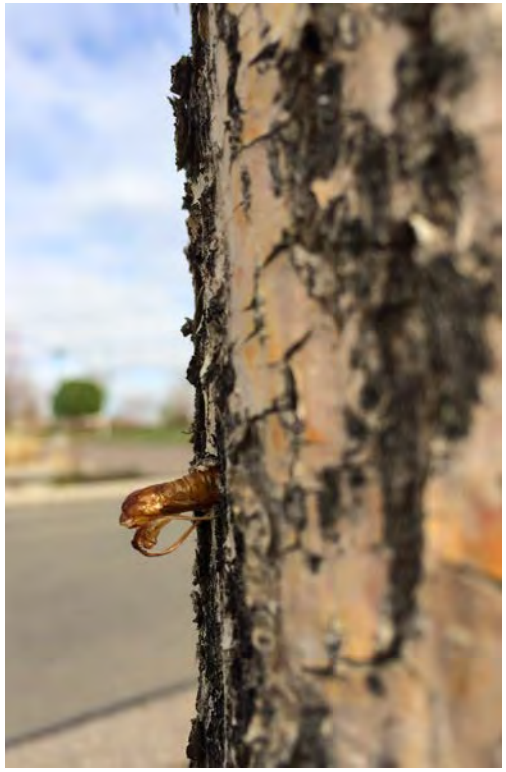
Signs and Symptoms

EAB Detection

In general, emerald ash borer-infested trees have been difficult to detect in Colorado. This is true even in heavily infested areas due to the fact that there are many other stressors that lead to ash decline and symptoms resembling those produced by EAB. Many uninfested trees (left and center), exhibit many of the “classic” symptoms associated with emerald ash borer and look similar to those that are actually infested (right).

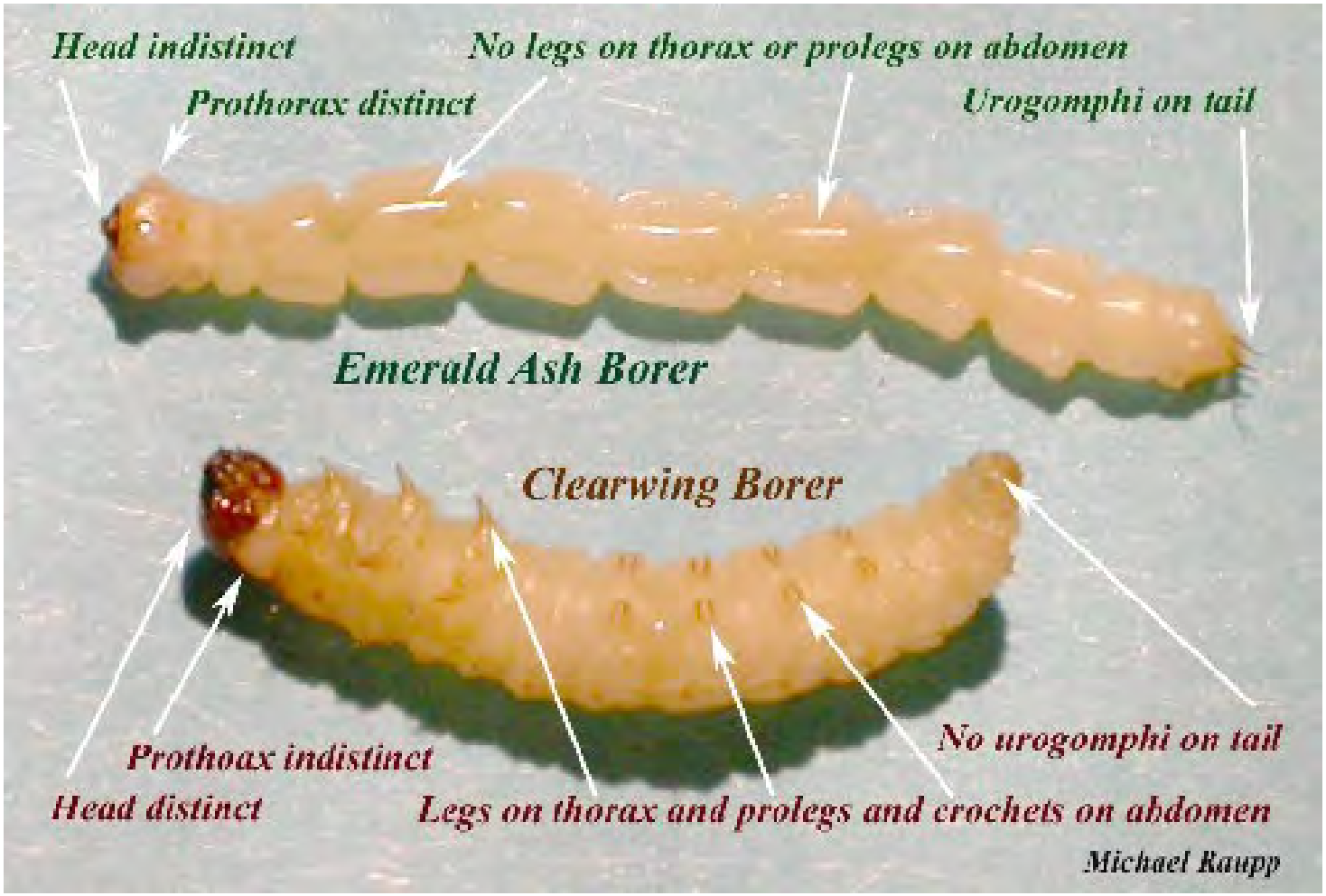
Other Insects and Diseases that Affect Ash Trees

Lilac/ash borer signs


Lilac/ash borer create deep, gouging galleries that may reach the heartwood, exit holes that are about ¼" across, and are round to oval (left). Pupal casings (center) are often left protruding from the trunk, and it is common to find sawdust-like frass in branch crotches or at the base of the tree (right).

Distinguishing EAB from Lilac/ash borer larvae



Because EAB adults are beetles, larvae are legless. Lilac/ash borer adults are clearwing moths, and larvae are caterpillars with legs and prolegs.

Flatheaded appletree borer


Flatheaded appletree borer larva


Emerald ash borer gallery


Flatheaded appletree borer galleries

Flatheaded appletree borer larvae and galleries are wide and shallow, and are more “meandering” than the serpentine galleries created by EAB. Exit holes are flattened oval, or lemon-shaped, and are smaller than lilac/ash borer exit holes.

Ash bark beetle

Ash bark beetle holes are approximately 1/16” wide

Holes from ash bark beetle are very small (approximately the size of a pin head). Females lay eggs in a gallery under the bark. Larvae tunnel outward perpendicular to the egg-laying gallery, creating very distinctive patterns.

Leaf-feeding damage



Feeding damage from adult emerald ash borer beetles (left) is unremarkable, and not easily distinguished from other insect feeding. Leaf feeding from weevils (center), caterpillars, and circular incisions from leafcutter bees (right) are commonly seen on the leaves of ash trees.

Leafcurl ash aphid

Leafcurl ash aphid is common on urban trees. These insects cause curling and distortion of the leaves. Unfurling the leaves reveals the presence of aphid colonies.

Stem and twig cankers

Canker lesions on the bark appear as sunken, discolored areas. Cracks often form at the center or margins of the canker (left). Pathogenic fungi, such as *Cytospora* sp., are often the causal agents of canker diseases. Fruiting bodies of these fungi may be visible on the outside of stems and twigs, and just beneath the bark (right). The tissue below is often stained a darker brown. As cankers grow, they can girdle stems and twigs, leading to dieback.

Abiotic and Environmental Issues

Poor Site Conditions

Crown thinning, dieback, suckers and other symptoms attributed to emerald ash borer can be caused by a host of other site-related problems, so it is a good idea to step back and look at the whole picture when you're assessing the tree, including the health of nearby trees and shrubs. Look for anything that may lead to plant stress, including:

- limited rooting space
- mechanical injury to the trunk or roots
- drought stress
- too little or no irrigation, or irrigation that has not been adjusted since planting
- severe pruning
- improper planting depth/planted too deep
- soil compaction, saturation, or anything that limits oxygen in the soil
- girdling roots or the wire basket or twine left on the root ball at planting
- changes in grade around a tree because of construction, etc.

Abiotic Issues

Root injury

Limited rooting space, changes in soil grade, and root injury from construction, paving, or trenching operations can lead to crown dieback, yellowing and thinning. Symptoms may appear on the side of the crown where the root damage has occurred.

Abiotic Issues

Trunk injury

Mechanical injury to tree trunks from lawnmowers, string trimmers, and cars is common in urban landscapes, and often exacerbates already stressful conditions. If dieback has occurred in the canopy, check for corresponding trunk injuries.

Abiotic Issues

Girdling

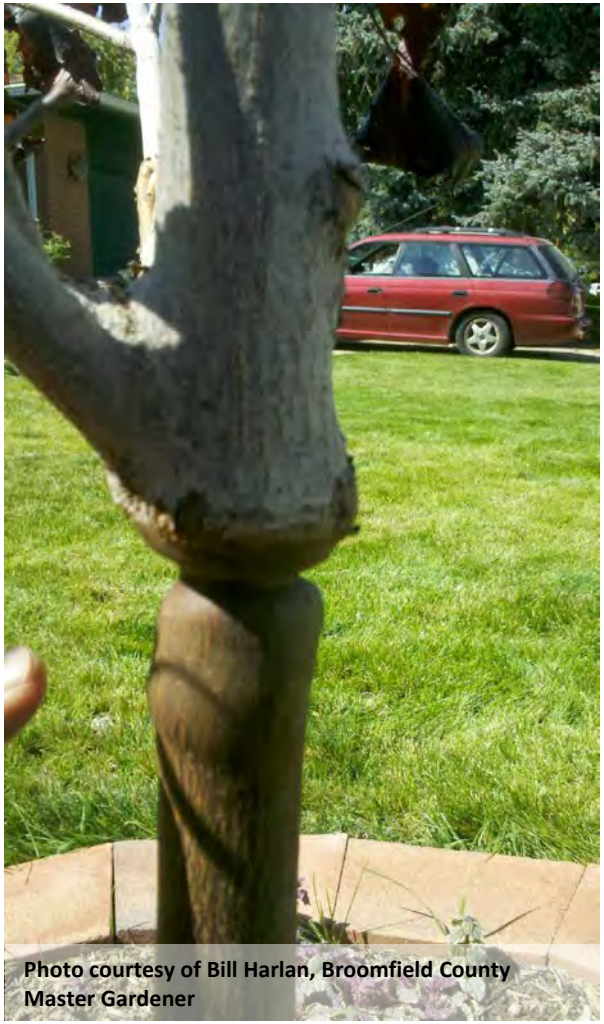


Photo courtesy of Bill Harlan, Broomfield County Master Gardener

Failure to remove staking materials, plant tags, or landscape fabric may lead to girdled stems. Resulting symptoms may include basal sprouts and canopy dieback.

Abiotic Issues

Circling/girdling roots

Circling roots not corrected at planting can turn into trunk-girdling roots. Crown symptoms may include crown thinning, branch dieback and yellowing leaves.

Abiotic Issues

Abnormal leaf growth

Herbicide damage (left) and poor growing conditions (right) can also lead to misshapen, discolored, or abnormally small leaves.

Environmental Issues

Sun scald and frost cracking

Frost cracking and sun scald are common in Colorado landscapes due to winter temperature fluctuations. Damage is often seen on the southwest side of the trunk. Resulting trunk injuries interfere with the movement of nutrients and water, and make the tree more susceptible to attack by insects and pathogens.

Environmental Issues

Winter injury (dieback) and hail damage

Winter injury may result in dieback of entire sections of the canopy (left). These changes are generally more abrupt than the gradual canopy thinning over several seasons that occurs due to EAB infestation. Hail damage (right) may also cause twig dieback, and may provide an entryway into the tree for other disease-causing organisms.

EAB Reporting

If you think you have found EAB

If you think you have found EAB outside of the current quarantine area:

- Contact the Colorado Department of Agriculture, the local USDA APHIS PPQ office, or local municipal forester immediately.

  Colorado Department of Agriculture:

  1-888-248-5535

  USDA APHIS PPQ:

  1-866-322-4512

- If applicable, obtain a sample of a life stage of the insect. This can be either an adult beetle or larvae. Do not move insect samples out of the area until contacting one of the agencies listed above.
- If suspected signs of EAB are present, such as s-shaped galleries under the bark, or D-shaped exit holes in the branches or trunk, DO NOT MOVE THE WOOD. Instead, contact the Colorado Department of Agriculture, APHIS, and/or the local municipal forester. Someone will meet you at the site to determine if the damage is consistent with that caused by EAB.

Additional Resources

Helpful web resources

Colorado Emerald Ash Borer Information: www.eabcolorado.com

Colorado State Forest Service EAB Information: http://csfs.colostate.edu/forest-management/emerald-ash-borer/

National Emerald Ash Borer Information Network: http://www.emeraldashborer.info/

Colorado EAB Reporting: https://www.colorado.gov/pacific/agplants/eab-identification-and-reporting

Wood Boring Insects of Ash Trees by Dr. Whitney Cranshaw, CSU: http://webdoc.agsci.colostate.edu/bspm/WoodBoring2017.pdf

Emerald Ash Borer Quick Guide, Colorado State Forest Service: http://csfs.colostate.edu/media/sites/22/2016/04/FINAL_EAB_QuickGuide_Revision_25APRIL2016.pdf

Options for Safe Handling of Ash Tree Wood, Colorado Department of Agriculture: https://www.colorado.gov/pacific/sites/default/files/atoms/files/QuarantineMap_OneMile_Web_Version.pdf

Colorado Emerald Ash Borer Quarantine Rule: https://www.colorado.gov/pacific/sites/default/files/atoms/files/Emerald%20Ash%20Borer%20Quarantine%20Rules.pdf

Colorado Emerald Ash Borer First Responder Manual: http://extension.colostate.edu/docs/pubs/insect/eab-manual.pdf