WE NEED YOUR HELP!

We are glad to provide these materials for free. In order for us to continue receiving funding for new materials, we need to collect information on how they are used.
Thank you for taking the time to answer the following one-minute survey.

There are three ways to complete the survey:

1 Scan this code with your smartphone camera

2 Type the following link into your web browser:
https://plantheroes.org/educator-survey

3 Email your answers to:
plantheroes@publicgardens.org

1) Job title
2) Name of organization you belong to
3) What kind of educator are you?
   - Teacher
   - Summer camp counselor
   - Home schooler
   - Public garden educator
   - Informal educator
   - Other (please describe)
4) What grade level do you teach?
   - Elementary (K–5)
   - Middle School (6–8)
   - High School (9–12)
   - Other (please describe)
5) Specify what subject area you teach:
   - Science
   - Math
   - Language Arts
   - Social Studies
   - Other (please describe)
6) How many students do you teach in a school year?

PLANT HEROES

Field Guide:

Invasive Shot-Hole Borers

Invasive shot-hole borers may be tiny, but they can damage many different types of trees. They carry several types of fungi that grow in the beetles' tunnels and serve as food for the adults and larvae.

Photo: Matt Bertone, Flickr.com

Plant Protection Program

AMERICAN PUBLIC GARDENS ASSOCIATION

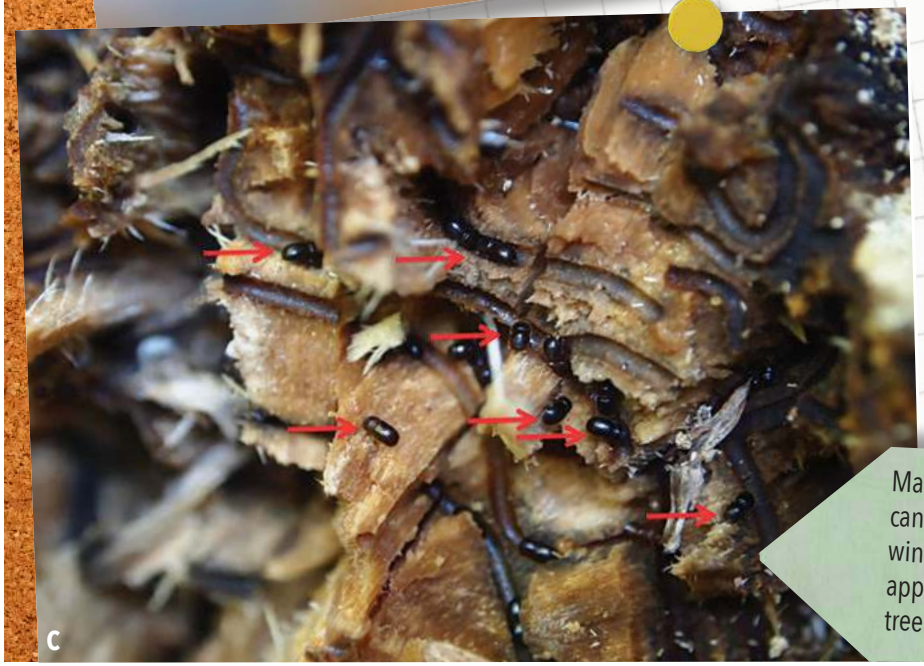
INVASIVE SHOT-HOLE BORERS

Identification

Side view of a female shot-hole borer. These tiny black beetles are smaller than a sesame seed (2–2.5 millimeters or 0.07–0.1 inches long) and covered with spiky golden hairs.

Top view of a female shot hole borer (*Euwallacea* sp.)

The dark stains in this branch were caused by the fungus (*Fusarium euwallaceae*) carried by an invasive shot-hole borer. The fungus not only stains the beetle's tunnels black but also clogs the tree's xylem (water-carrying cells).



Many adult female shot-hole borers, shown by red arrows, can be seen in this cross section of an infested tree. Their winding tunnels (known as "galleries") can measure approximately 3 inches (8 centimeters) deep into the tree's wood.

PHOTO CREDITS: A: 5477252, B: 5477253 Javier Mercado, Bark Beetle Genera of the U.S., USDA APHIS ITP, Bugwood.org; C, D: Akif Eskalen, University of California Riverside

PLANT HEROES

INVASIVE SHOT-HOLE BORERS

Life Cycle

Invasive shot-hole borer eggs are very tiny, oval-shaped, and whitish. These eggs are seen within a cross-sectioned gallery. >>

A

B

C

^^

Life stages of a female invasive shot-hole borer from left to right: young larva, older larva, pupa, immature adult, mature adult. Larvae (immature, grub-like stage) mature in three stages and take about a month to develop into adults. The beetle is probably active year-round and may have between 2 and 4 generations per year in California.

<< Close-up of a cross section of an invasive shot-hole borer tunnel (known as a "gallery") made by a female beetle. As she digs the gallery, she plants spores of a fungus, which then grow on the gallery walls, giving them a black color. The beetle will then lay her eggs in the gallery, and the fungus provides a tasty snack for the hatching larvae.

PHOTO CREDITS: A, B: Akif Eskalen, University of California Riverside; C: Michael Lewis, University of California Riverside

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INVASIVE SHOT-HOLE BORERS

Symptoms

Symptoms are visible clues that a tree is suffering from a pest or disease.

This avocado tree is showing wilting and dead branches due to an invasive shot-hole borer attack.

Oozing sap (a sticky liquid substance produced in the tree) and dark patches around borer holes are seen on the bark of some trees.

When invasive shot-hole borer females enter or leave their host trees, they leave tiny holes smaller than the tip of a ballpoint pen on the tree's bark.

Some trees really freak out when they are attacked by invasive shot-hole borers! Avocado trees (*Persea americana*) produce "sugar volcanoes," which are piles of white powder around the beetle holes. >>

"Gumming" is dried sap on the bark of a tree, a common tree response to attack by insects or pathogens.

PHOTO CREDITS: A, C, E: Akif Eskalen; B: Trish Gussler, Flickr.com; D: Erich G. Vallery, Bugwood.org

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INVASIVE SHOT-HOLE BORERS

Host Trees

Host trees are trees that the invasive shot-hole borer lives and feeds on.

A

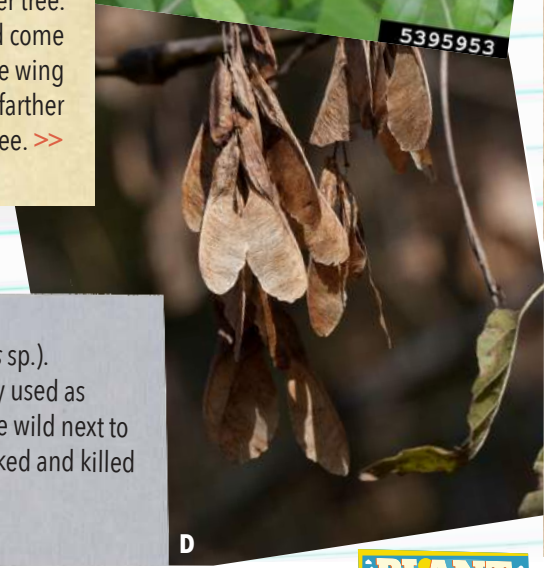
Branch of a coast live oak, a native California species threatened by the invasive shot-hole borer.

B

A coast live oak (*Quercus agrifolia*). This and other oak trees (*Q. lobata, Q. engelmannii*) are threatened by invasive shot-hole borers.

Leaves of a boxelder tree (*Acer negundo*). Unlike most other maples, boxelder trees have leaves made up of 3 to 7 leaflets. Invasive shot-hole borers attack this and other maples, which are often planted as landscape trees.

C



D

Seed clusters of the boxelder tree. The seeds are in long strings and come in pairs. Each seed has a little wing attached to it to help it travel farther from the parent tree. >>

E

<< Leaves and fruit of a sycamore (*Platanus* sp.). Also called "plane trees," they are frequently used as landscaping trees and are often found in the wild next to streams. Several sycamore species are attacked and killed by the invasive-shot hole borer.

F

Sycamores (*Platanus* spp.) have very cool multicolored bark!

PHOTO CREDITS: A: Tracie Hall, Flickr.com; B: Mark Gunn, Flickr.com; C:. Robert Videki, Doronicum Kft., Bugwood.org; D: Kent McFarland, Flickr.com; E: Allen Bridgman, South Carolina Department of Natural Resources, Bugood.org; F: RubyT., Flickr.com

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INVASIVE SHOT-HOLE BORERS

Damage

Cross section of a tree infested with invasive shot-hole. The branching tunnels made by the beetle weaken the tree's structure, causing branches to break off. >>

^^ Invasive shot-hole borer galleries (black holes) and black staining from its *Fusarium* friend on a willow tree. Willows (*Salix* spp.) are another host for the beetles and fungi they carry.

Dark staining from the *Fusarium* fungus can be seen around the beetle holes and in the trunk of this sycamore tree. >>

PHOTO CREDITS: A,B,C: Akif Eskalen, University of California Riverside

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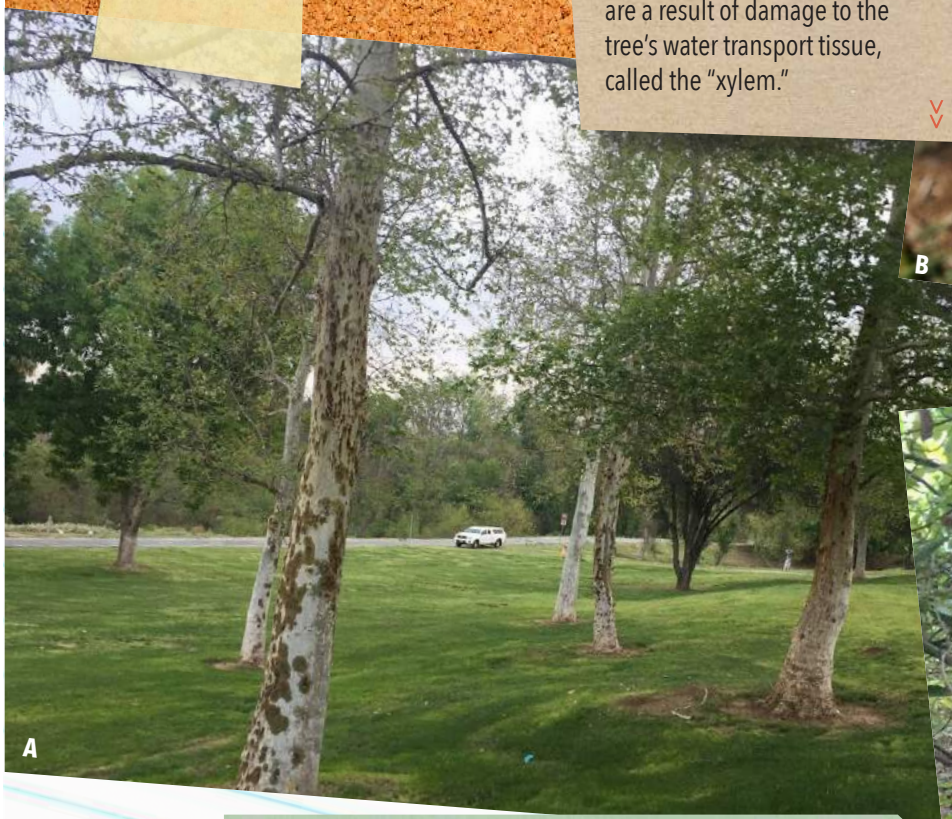
INVASIVE SHOT-HOLE BORERS

Damage

This sycamore tree (*Platanus* spp.) is in bad shape because of the invasive shot-hole borer. The brown leaves and dead branches are a result of damage to the tree's water transport tissue, called the "xylem."


A


B

The branch of this castor bean plant is showing discoloration because its water-conducting tissue, or xylem, is clogged by the *Fusarium* fungus.


C

Avocados provide shade and fruit. Avocado is a very important crop in California, where it is grown on nearly 60,000 acres and the fruit is worth around $435 million every year! Unfortunately, the invasive shot-hole borer is a serious threat to this crop.

PHOTO CREDITS: A,B,C: Akif Eskalen, University of California Riverside

PLANT HEROES

PLANT HEROES

Join our team of Plant Heroes and learn about trees, forests, and the natural world around you!

PLANTHEROES.ORG

You can be a Plant Hero!
Are you curious about plants and animals? Do you like asking questions about nature? Do you enjoy being outdoors and having fun, climbing trees, balancing on logs, or finding a new butterfly or beetle? If so, you are already on your way to becoming a Plant Hero! We invite you to join forces with Nate, Laura, Aponi, and Frankie to protect the plants and ecosystems we all love.

How can you become a Plant Hero?
Join our team and go on a journey with Nate, Aponi, Laura, and Frankie. As a Plant Hero, you will learn to notice when plants are in trouble. You will also find out ways you can act quickly to help find solutions in your own neighborhood. Follow their adventures and learn how they help plants and ecosystems stay healthy.

On the Plant Heroes website, you will find materials to help you learn about plants, forest health, and ecosystem balance. The more you know, the more you can help protect plants and ecosystems in your own yard, neighborhood, and community!

Plant Heroes strives to spark curiosity about nature and science in all children.
Our program provides hands-on, nature-based learning materials for educators to engage children in topics of plant health, ecosystem balance, and forest health. We also spotlight the amazing work our public gardens do in protecting the plants and ecosystems we all depend on through our website and printed materials. Visit **plantheroes.org** today to learn more!

Plant Heroes is brought to you by the American Public Gardens Association, founded in 1940. Over the last eight decades, the Association has supported the work of public gardens in North America and beyond. Our mission is to champion and advance public gardens as leaders, advocates, and innovators in the conservation and appreciation of plants. Our vision is "A world where public gardens are indispensable" as they provide botanic, conservation, community, education, and economic resources to their community.

The Association is committed to increasing the knowledge of public garden professionals throughout North America through information sharing, professional development, networking, public awareness, and research, so that they have the tools to effectively serve visitors and members.

American Public Gardens Association

PublicGardens.org

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USDA