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# Invasive Tree Boring Beetles



**University of California**  
Agriculture and Natural Resources

# Protecting Hawai'i



Pre-entry  
(laws & agreements)

Port-of-entry  
(inspection)

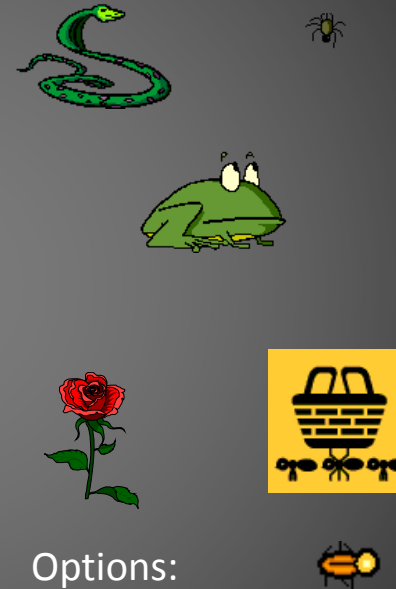
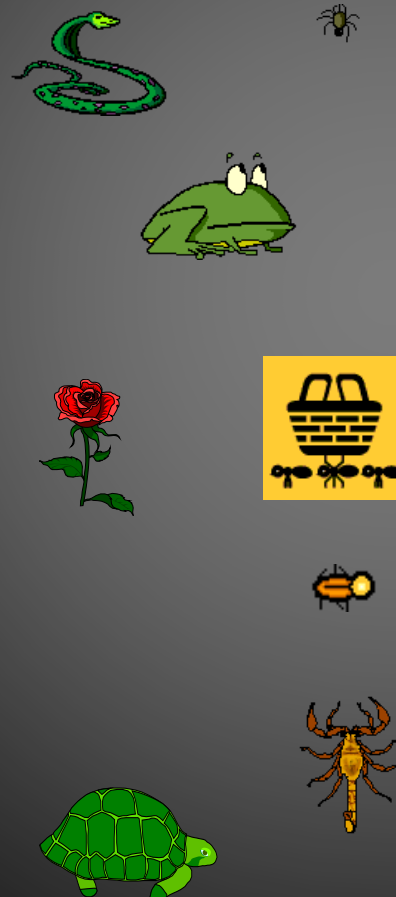
Rapid-response  
(response crews/regional containment)

World's Biota

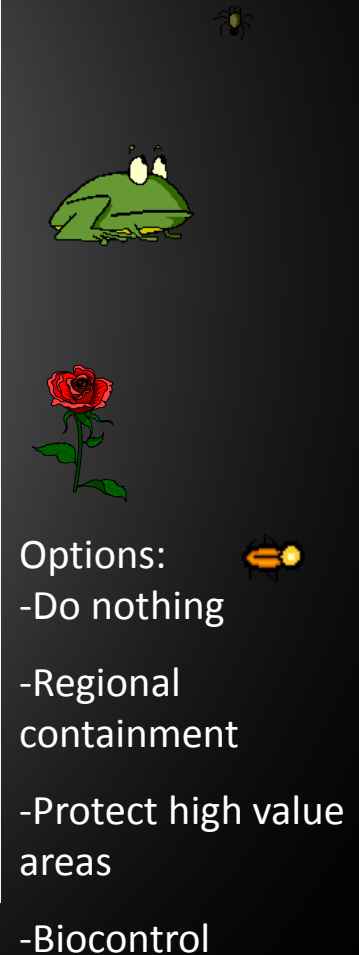
Arrivals

Escapes

Widespread



Options:  
-Do nothing  
-Eradication  
-Regional  
containment



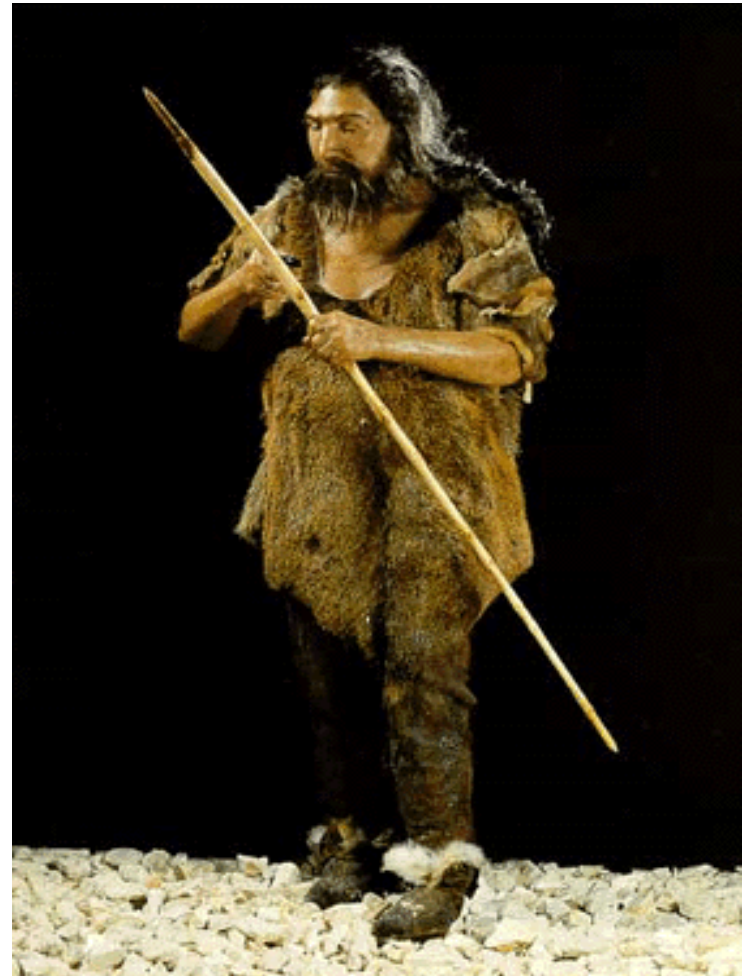
Options:  
-Do nothing  
-Regional  
containment  
-Protect high value  
areas  
-Biocontrol

Slide courtesy of Christy Martin - CGAPS

# *Homo ignoramus*

## – Responsible for:

- Overwatering
- Underwatering
- Over fertilizing
- Soil compaction
- Tree mutilation
- Poor plant selection and placement
- Growing poor quality specimens
- **Transporting pests across international, state and county lines**
- Producing plant damaging pollution





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*Solve your pest  
problems with  
UC's best science*

**Announcements**

- Highlights: [2012 Annual Report](#)
- Upcoming workshops:  
- [Pesticide safety](#)

**What's New**

- 2013 Grape Powdery Mildew Risk Index
- Agricultural Pest Management: Kiwifruit revised, Floriculture new page added, Strawberry updated
- Pest Notes: [Pantry Pests](#), [Clothes Moths](#) and [Horsehair Worms](#) revised
- [More...](#)

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## Home, garden, turf, and landscape pests

University of California's official guidelines for managing pests with environmentally sound methods. ([More...](#))

Search home & landscape:

Q

### Pests of homes, structures, people, and pets

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- [Flowers](#)
- [Fruit trees, nuts, berries, and grapes](#)
- [Lawns and turf](#) (including comprehensive lawn guide)
- [Trees and shrubs](#) (including roses and other ornamentals)
- [Vegetables and melons](#)

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- [Birds, mammals, and reptiles](#): vertebrate pests
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- [Alternatives to pesticides](#)
- [Biological control](#)

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- [UC IPM Kits](#)
- [UC Statewide Master Gardener Program](#): find your local Master Gardener Program
- [Home and landscape publications](#)
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- [Pest Notes library](#)
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- [Retail nurseries & garden centers](#)
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#### Some common pests

- [Birds, mammals, and reptiles: vertebrate pests](#)
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[Natural environment pests](#)

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[Weed gallery](#)

[Natural enemies gallery](#)

[Weather, models & degree-days](#)

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[Research](#)

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## Insects, mites, mollusks, nematodes

Choose a button or view a list of [ALL INVERTEBRATE PESTS](#).

### Ants

Household & outdoor ants, carpenter ants, fire ants

### Aphids, scales, & thrips

Also whiteflies, mealybugs, psyllids, and hoppers

### Arachnids

Spiders, mites, ticks, & scorpions

### Bees & wasps

Honey bees, carpenter bees, wood wasps, yellowjackets, hornets

### Beetles

Leaf beetles, grubs, woodborers, weevils, pantry pests

### Beneficials

Natural enemies of plant pests such as predators and parasites

### Caterpillars

Larvae of butterflies & moths

### Earwigs & grasshoppers

Also cockroaches, crickets, katydids, and stick insects

### Flies & mosquitoes

Fruit flies, house flies, maggots, leaf miners, gnats

### Household pests

Pests of homes, structures, people, & pets

### Snails & soil-dwellers

Slugs, centipedes, nematodes, pill bugs, springtails

### True bugs

Stink bugs, plant bugs, lace bugs

Detailed information about certain pests can be found in the [Pest Notes Library](#).

If you don't know what your pest is, search by plant type:

[Flowers](#) | 
 [Fruits, nuts, and vines](#) | 
 [Lawns and turf](#) | 
 [Trees and shrubs](#) | 
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[Agricultural pests](#)

[Natural environment pests](#)

[Exotic & invasive pests](#)

[Weed gallery](#)

[Natural enemies gallery](#)

[Weather, models & degree-days](#)

[Pesticide information](#)

[Research](#)

[Publications](#)

[Events & workshops](#)

[Online training](#)

[Links](#)

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## Beetles

Beetles have hardened outer wings, giving adults a sturdy, armored appearance. Beetles feed by chewing, so damage includes holes, notches, tunnels, and chewed plant parts. The group includes leaf beetles, woodboring beetles, grubs, wireworms, and weevils. A few beetles are common pantry pests.



### Fruit, flower, and bud beetles

Many beetles feed on fruit or flowers during their adult or larval stages.



### Indoor beetle pests

Carpet beetles, wood borers, and pantry pests are among the most common beetles found inside homes.



### Leaf, stem, and seedling beetles

Many beetles chew holes in leaves and stems as adults. For some species, the larvae are also leaf feeders.



### Root beetles

Many beetles, including grubs and most weevils, are root feeders in their larval stages.



### Tree-boring beetles

These beetles bore into tree branches, twigs and trunks. Adults lay eggs on or in the wood, and larvae feed within it, often making distinctive tunnels or galleries.

## RELATED OR SIMILAR SPECIES

For beneficial species such as lady beetles, ground beetles, and soldier beetles, see the [Natural Enemies gallery](#).

[BACK TO INVERTEBRATES](#)



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## Tree-boring beetles

Beetles that bore into tree branches, twigs and trunks include bark beetles, flatheaded borers and longhorned borers. In each case, adults lay eggs on or in wood, and larvae feed within the wood, usually making distinctive tunnel patterns called galleries.

### Tree borers (GENERAL)

#### Bark beetles (GENERAL)

- [Common bark beetles](#)
- [Shothole borer](#)
- [Walnut twig beetle](#)

#### Flatheaded borers

- [Pacific flatheaded borer](#)
- [Goldspotted oak borer](#)

#### Roundheaded (longhorned) borers

- [Eucalyptus longhorned borer](#)
- [Asian longhorned beetle](#)

#### Other borers

- [Branch and twig borers \(grapes\)](#)
- [Branch and twig borers \(trees and shrubs\)](#)
- [Lead cable borer](#)
- [Poplar and willow borer](#)
- [Red palm weevil](#)

#### En español

- [Los Barrenadores \(Woodborers\)](#)
- [Escarabajo descortezador \(Bark beetles\)](#)



Ips bark beetle.



Flatheaded borer larva.



Eucalyptus longhorned borer.

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## How to Manage Pests

## Pests in Gardens and Landscapes

### Bark Beetles

Revised 11/08

[Download PDF](#)[Quick Tip](#)[Nota Breve](#)

In this Guideline:

- [Identification](#)
- [Life cycle](#)
- [Damage and signs](#)
- [Management](#)
- [About Pest Notes](#)
- [Publication](#)
- [Glossary](#)

Bark beetles, family Scolytidae, are common pests of conifers (such as pines) and some attack broadleaf trees. Over 600 species occur in the United States and Canada with approximately 200 in California alone. The most common species infesting pines in urban landscapes and at the wildland-urban interface in California are the engraver beetles, the red turpentine beetle, and the western pine beetle (See [Table 1](#) for scientific names). In high-elevation landscapes, such as the Tahoe Basin area or the San Bernardino Mountains, the Jeffrey pine beetle and mountain pine beetle are also frequent pests of pines. Two recently invasive species, the Mediterranean pine



Engraver beetle holes and sap.



# Ambrosia beetle

- California native
- Farms the *Ambrosiella* fungus
- They kill drought stressed oaks
- No curative treatment









# Ambrosia beetle

- The last part of SOD
- Don't need *Phytophthora* to kill trees
  - See and smell drought stress
    - Outbreaks in low rainfall years
    - Deep, infrequent summer water
    - Preventative pyrethroid insecticides
- Tunnels may flux



# Conifers and beetles

- Monterey pine
  - Five spined Ips  
*Ips paracofusus*
    - Attack higher in the canopy
    - Distinctive Y shaped galleries
  - Red turpentine beetle  
*Dendroctonus valens*
    - Red tunnel entrances at tree base
      - Turn white with age
- Provide summer water







# Longhorned Eucalyptus borer

- Attacks drought stressed soft barked Eucalyptus
  - Blue gum, *E. viminalis*
  - Others
- Egg parasitoid
- Damage not always lethal
  - Branch dieback
  - Kino production
    - Requires water
  - No water, no defense
    - Hydrated logs more resistant than dry logs

# Eucalyptus Longhorned Borer



*Phoracantha semipunctata* (1985)



*P. recurva* (1995)    *P. semipunctata*



# *Phoracantha* Parasitoids



*Anaphes nitens*



*Avetianella longoi*  
Parasitized eggs



*Phoracantha* eggs



*Syngaster lepidus*

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**Bostrichidae**  
**Giant Palm Borer**  
**on *W. filifera***



**Red Palm Weevil**  
*Rhyncophorus vulneratus*  
(not *ferrugineus*)



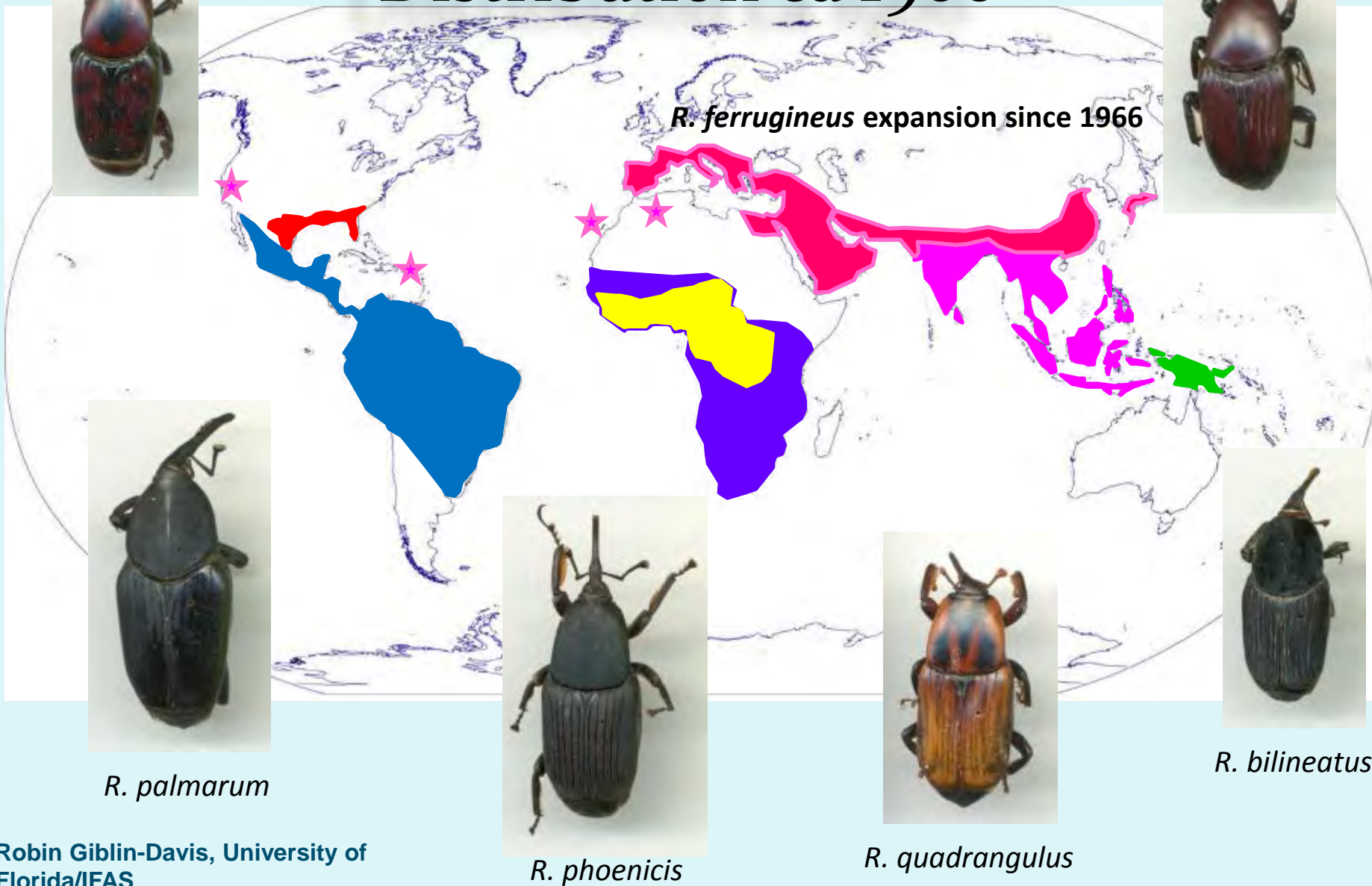


# RED PALM WEEVIL **ADVENTIVE** AND **ENDEMIC** DISTRIBUTION



# *Rhynchophorus*

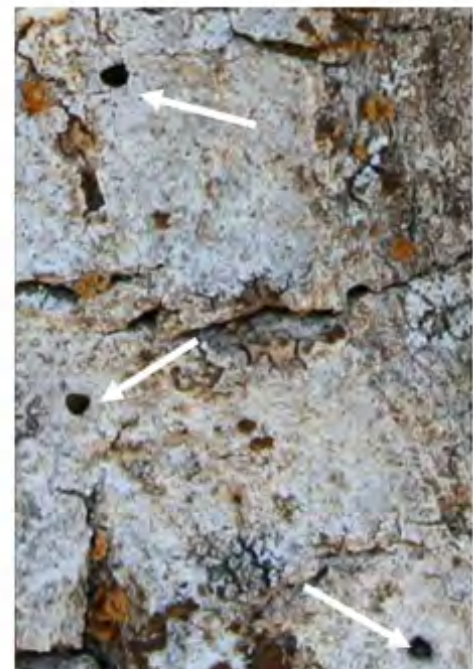
## Distribution ca 1966





# The Goldspotted Oak Borer, *Agrilus coxalis*

## Waterhouse



# GSOB Incident Action Plan

- Survey and Detection
  - Delimitation
  - Outside of known infestations
  - Develop procedures and fund reporting and identifying new infestations
  - Maintenance and location of data base
- Based on Pest Rating and Damage
  - Restrict movement of pest infested material
  - Develop policies and identify agencies and stakeholders
  - Identify how it is moving and how and who will regulate
- Develop and Implement a Management Plan
- Identify Research Needs





GSOB.ORG or ucanr.edu/sites/gsobinfo

Goldspotted

ucanr.edu/sites/gsobinfo/

SHARE EMAIL PRINT SITE MAP Enter Search Terms



University of California Cooperative Extension

## Goldspotted Oak Borer



Home About GSOB Diagnosis & Management Recovery What You Can Do News & Events Resources Contacts

### What is the Goldspotted Oak Borer?



Goldspotted oak borer (GSOB) *Agrilus auraguttatus* is an invasive pest contributing to the on-going oak tree mortality occurring on federal, state, private, and local Native American lands in San Diego, Riverside and Orange Counties in southern California. Widespread oak mortality can have severe implications to the environment and human safety. Due to the current and potential impacts to California oaks and communities, public and private organizations are working together in the research, education and outreach efforts related to GSOB pest management. For more GSOB information [click here](#).

**If you suspect goldspotted oak borer**

**infestation in your area, report it [here](#)**

### Quicklinks

#### **Report**

[Report suspected GSOB](#)

#### **Revised! ZOI Expanded**

CA Bd of Forestry and Fire Protection

[GSOB Zone Of Infestation](#)

[Resource Toolkits](#)

[Firewood Management Information](#)

[California Firewood Taskforce](#)

### What's New



#### **Goldspotted Oak Borer**

**Forest Insect & Disease Leaflet 183** (March 2015)

by USDA Forest Service

[\(Download PDF\)](#)

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### Infestation Damage

Drought

GSOB

Oaks



# Emerging Tree Pests

John Kabashima, UCCE







Photo by G. Arakelian





Photos: Richard Stouthamer



# PSHB Life Cycle and Reproduction



- Majority of life cycle spent in gallery
- Brothers and sisters can mate in galleries - females are already mated when they leave
- Beetle colony stays in one host until the tree is killed

# Fungal Pathogens associated with PSHB and KSHB



Los Angeles Co  
Orange Co  
San Bernardino Co  
Riverside Co

Polyphagous  
Shot Hole  
Borer

**PSHB**

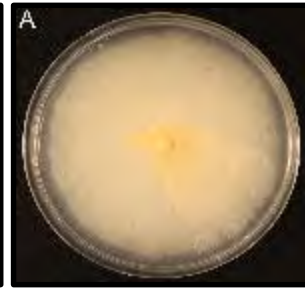
*Euwallacea* sp. #1



*Fusarium*  
*euwallaceae*



*Graphium*  
*euwallaceae*



*Acremonium*  
*pembeum*



San Diego Co

Kuroshio  
Shot Hole  
Borer

**KSHB**

*Euwallacea* sp. #5



*Fusarium* sp.



*Graphium* sp.



# Fusarium dieback caused by fungal pathogens



# *Euwallacea fornicatus*-like sp.

---

- Where does the beetle come from?
  - Probably South East Asia, possibly Africa
  - Also an invasive species in Israel causing extensive damage to Avocado
- Beetle identity: Morphologically *E. fornicatus*
  - Based on DNA evidence there are 2 other species
  - Suggested common names:
    - Polyphagous Shot-Hole Borer
    - Kuroshio Shot-Hole Borer
- California and Israeli form of beetle identical and different from the tea infesting form from Sri Lanka (original collection site of *E. fornicatus*).



# Beetle Life Cycle

---

- Sex ratio offspring very female biased, brothers mate with sisters in galleries and mated females leave the galleries to create their own galleries for offspring production
- Lifestyle leaves very few ways to combat the beetle. Single mated female can initiate new population

# Ambrosia Beetles are difficult to detect

---


- Generally only short time outside the tree
- Attract Sex pheromones- No
- Aggregation pheromone – No
- Lures – Yes
- Deterrents - Yes
- Beetles fly vertically around infested tree, not horizontally and fly to other trees when host is depleted.



Pshb.org



University of California, Agriculture and Natural Resources

# Invasive Shot Hole Borers




Home Pest Overview Distribution Map Diagnosis and Management Resources Monitoring and Research News and Events Contacts

## What are the Polyphagous and Kuroshio Shot Hole Borers?



### Upcoming Events

Event Name	Date
<a href="#">Invasive Tree Pests Issues-San Diego</a>	7/28/2016



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The Polyphagous Shot Hole Borer (PSHB) is an invasive wood-boring beetle that attacks dozens of tree species in Southern California, including commercial avocado groves, common landscape trees, and native species in urban and wildland environments.

PSHB spreads a disease called Fusarium Dieback (FD), which is caused by pathogenic fungi. Trees that are FD-susceptible may experience branch dieback, canopy loss, and, in some cases, tree mortality.

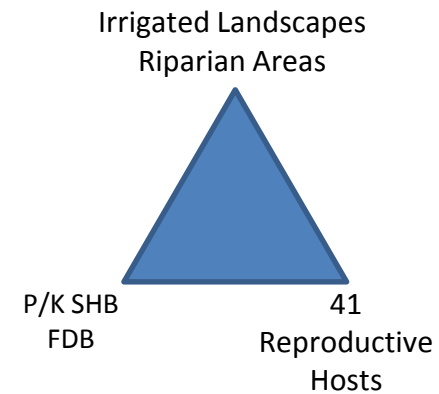
Like PSHB, Kuroshio Shot Hole Borer (KSHB) is an exotic *Bursaphelenchus* species that also vectors Fusarium Dieback. Both beetles are present in Southern California but are concentrated in different regions. [See their known distribution here.](#)

### PSHB News

www.pshb.org was made possible by support from the US Forest Service Forest Health Protection Program, UC Riverside, Orange County Parks, the California Avocado Commission, and the work and in-kind support of federal, state, and local partners.

This site contains research-based information for education purposes. For specific guidance check with your local land management regulatory authorities. Any

Eskalenlab.ucr.edu



## Polyphagous Shot-Hole Borer Host Range (Oct 2016)

- |  |   |
|--|---|
| 1. Box Elder ( <i>Acer negundo</i> )*                | 25. Palo verde ( <i>Parkinsonia aculeata</i> )*             |
| 2. Big leaf maple ( <i>Acer macrophyllum</i> )*      | 26. Moreton bay chestnut ( <i>Castanospermum australe</i> ) |
| 3. Evergreen maple ( <i>Acer paxii</i> )             | 27. Brea ( <i>Cercidium sonora</i> )                        |
| 4. Trident maple ( <i>Acer buergerianum</i> )        | 28. Mesquite ( <i>Prosopis articulata</i> )*                |
| 5. Japanese maple ( <i>Acer palmatum</i> )           | 29. Weeping willow ( <i>Salix babylonica</i> )              |
| 6. Castor bean ( <i>Ricinus communis</i> )           | 30. Chinese holly ( <i>Ilex cornuta</i> )                   |
| 7. California sycamore ( <i>Platanus racemosa</i> )* | 31. Camellia ( <i>Camellia semiserrata</i> )                |
| 8. Mexican sycamore ( <i>Platanus Mexicana</i> )     | 32. Acacia ( <i>Acacia</i> spp.)                            |
| 9. Red willow ( <i>Salix laevigata</i> )*            | 33. Liquidambar ( <i>Liquidambar styraciflua</i> )          |
| 10. Arroyo willow ( <i>Salix lasiolepis</i> )*       | 34. Red flowering gum ( <i>Eucalyptus ficifolia</i> )       |
| 11. Avocado ( <i>Persea Americana</i> )              | 35. Japanese wisteria ( <i>Wisteria floribunda</i> )        |
| 12. Mimosa ( <i>Albizia julibrissin</i> )            | 36. Goodding's black willow ( <i>Salix gooddingii</i> )*    |
| 13. English oak ( <i>Quercus robur</i> )             | 37. Tree of heaven ( <i>Ailanthus altissima</i> )           |
| 14. Coast Live oak ( <i>Quercus agrifolia</i> )*     | 38. Kurrajong ( <i>Brachychiton populneus</i> )             |
| 15. London plane ( <i>Platanus x acerifolia</i> )    | 39. Black mission fig ( <i>Ficus carica</i> )               |
| 16. Cottonwood ( <i>Populus fremontii</i> )*         | 40. Japanese beech ( <i>Fagus crenata</i> )                 |
| 17. Black cottonwood ( <i>Populus trichocarpa</i> )* | 41. Shiny xylosma ( <i>Xylosma congestum</i> )              |
| 18. White alder ( <i>Alnus rhombifolia</i> )*        | 42. Mule fat ( <i>Baccharis salicifolia</i> )*              |
| 19. Titoki ( <i>Alectryon excelsus</i> )             | 43. Black poplar ( <i>Populus nigra</i> )*                  |
| 20. Engelmann oak ( <i>Quercus engelmannii</i> )*    | 44. Carrotwood ( <i>Cupaniopsis anacardioides</i> )         |
| 21. Cork oak ( <i>Quercus suber</i> )                | 45. California buckeye ( <i>Aesculus californica</i> )*     |
| 22. Valley oak ( <i>Quercus lobata</i> )*            | 46. Canyon live oak ( <i>Quercus chrysolepis</i> )*         |
| 23. Coral tree ( <i>Erythrina corallodendron</i> )   | 47. Kentia palm ( <i>Howea forsteriana</i> )                |
| 24. Blue palo verde ( <i>Parkinsonia floridum</i> )* | 48. King Palm ( <i>Ptychosperma elegans</i> )               |

\*19 Native species to California

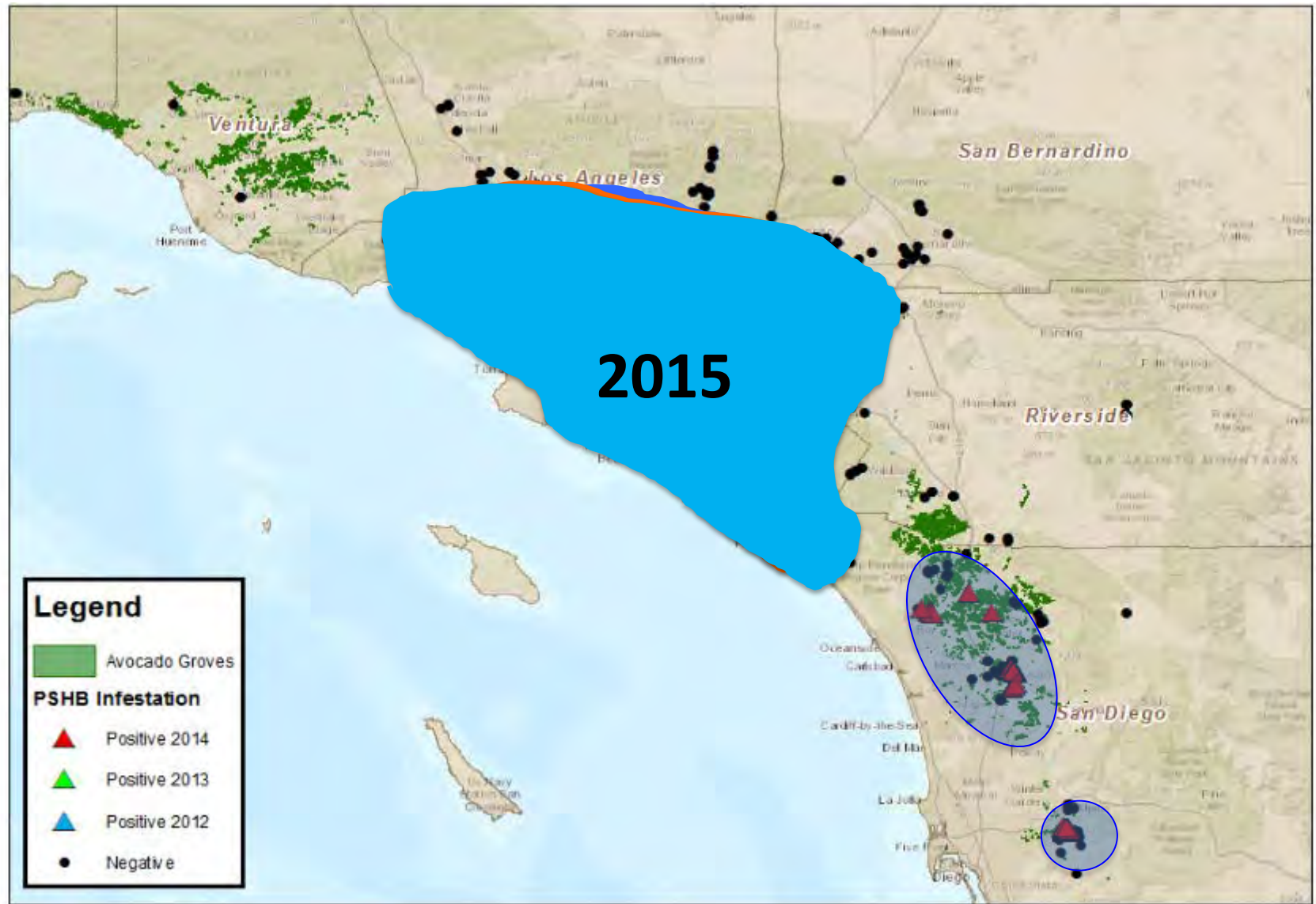
## Kuroshio Shot-Hole Borer Host Range

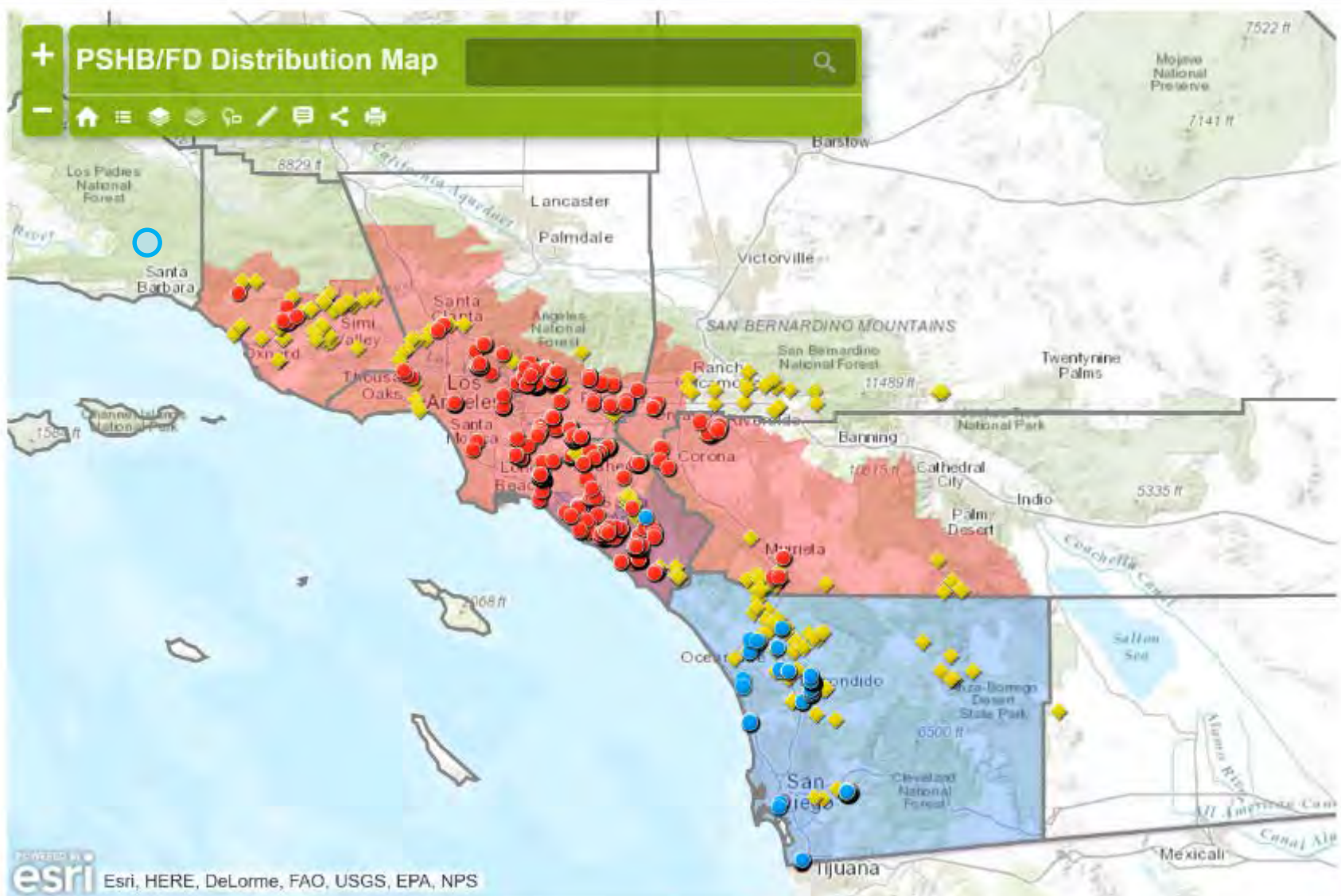
1. Avocado (*Persea Americana*)
2. California sycamore (*Platanus racemosa*)\*
3. Coast live oak (*Quercus agrifolia*)
4. Cork oak (*Quercus suber*)
5. Draft coral tree (*Erythrina humeana*)
6. Black poplar (*Populus nigra*)\*
7. Black locust (*Robinia pseudoacacia*)
8. Red willow (*Salix laevigata*)\*
9. Arroyo willow (*Salix lasiolepis*)\*
10. Cottonwood (*Populus fremontii*)\*
11. Mimosa (*Albizia julibrissin*)
12. Castor bean (*Ricinus communis*)
13. Black willow (*Salix nigra*)\*
14. Strawberry snowball tree (*Dombeya cecuminum*)
15. Mule fat (*Baccharis salicifolia*)\*

\*7 Native species to California



# Current distribution of infestation of PSHB/FD





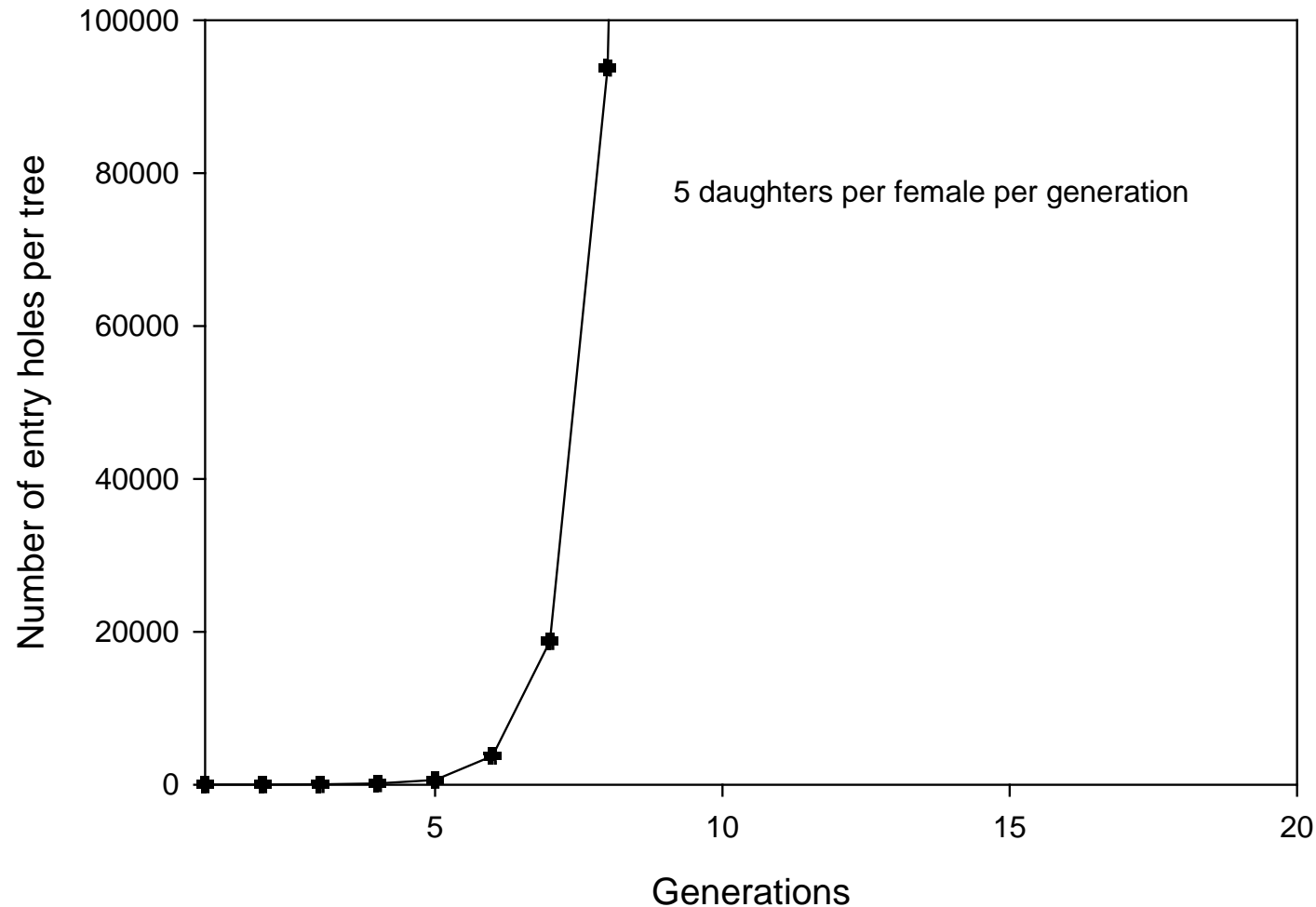
## Current distribution of infestation 2016



# PSHB/FD Distribution Map

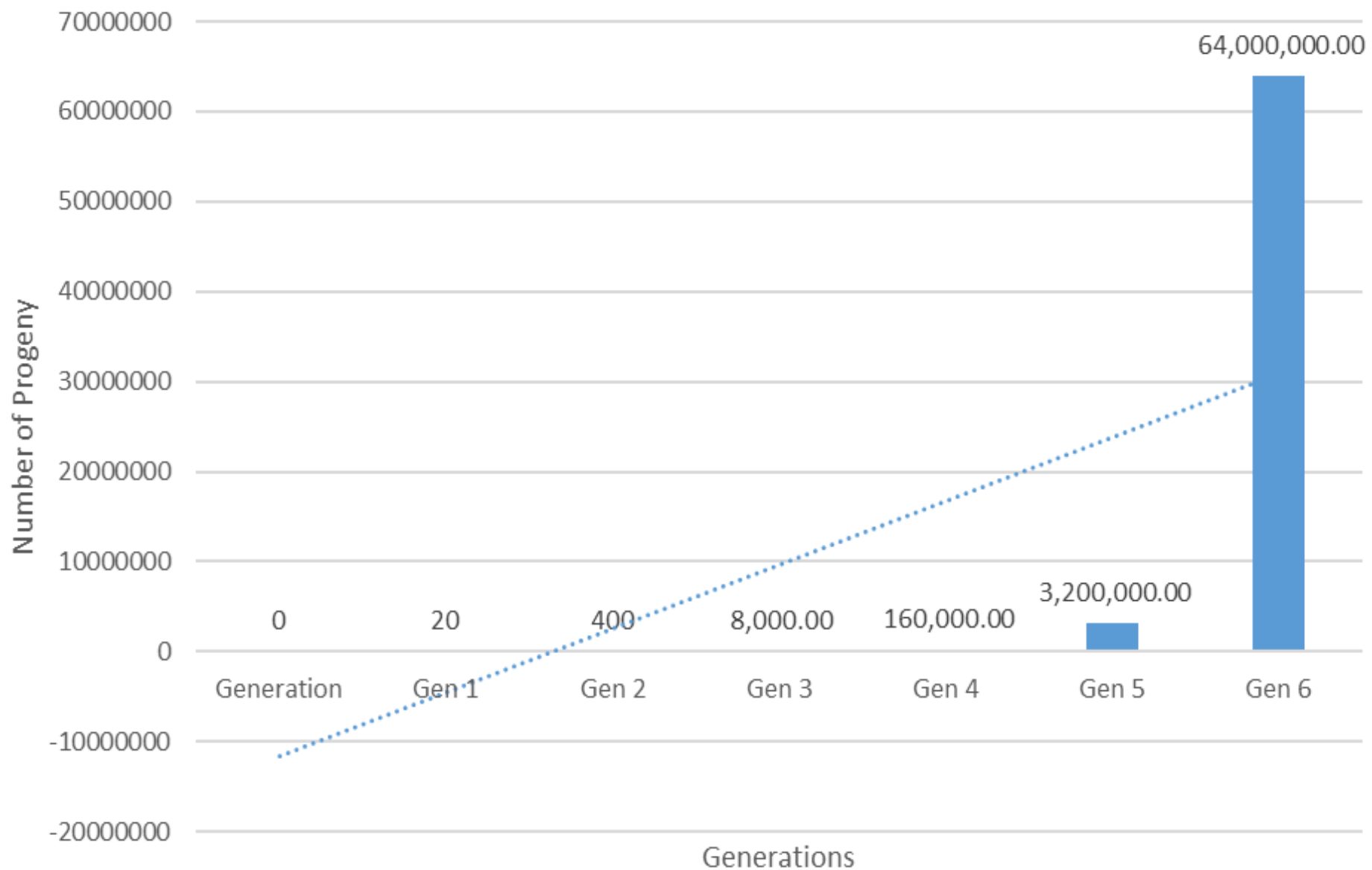


Growth of entry hole number per tree when a single female initiates the population at generation 1 and 5 daughters/ generation/mother remain on tree





# Population growth when a female has 20 progeny per generation



# PSHB 2012

## Urban Landscape

- Incubator
- Threat to Urban Forest

## Nursery

- Potential to transport
- Economic Impact
- Shipment Protocols

## Avocado

- PSHB/KSHB and Fusarium
- A major threat

## Natural/Riparian

- Major threat to native trees
- Important Alternate Host
- Ecological Impact

## Regulatory

- Pathways
- Survey/Detection
- Rapid Response
- Pesticide Use
- Water Runoff



# Weak Branch Connection - Fusarium Dieback



Photos | John Kabashima, UC Cooperative Extension



# Compromised wood tissue on a PSHB/FD infested Sycamore in UCI





# Infested Sycamore tree in UCI

24"  
60cm



Infestation in main trunk

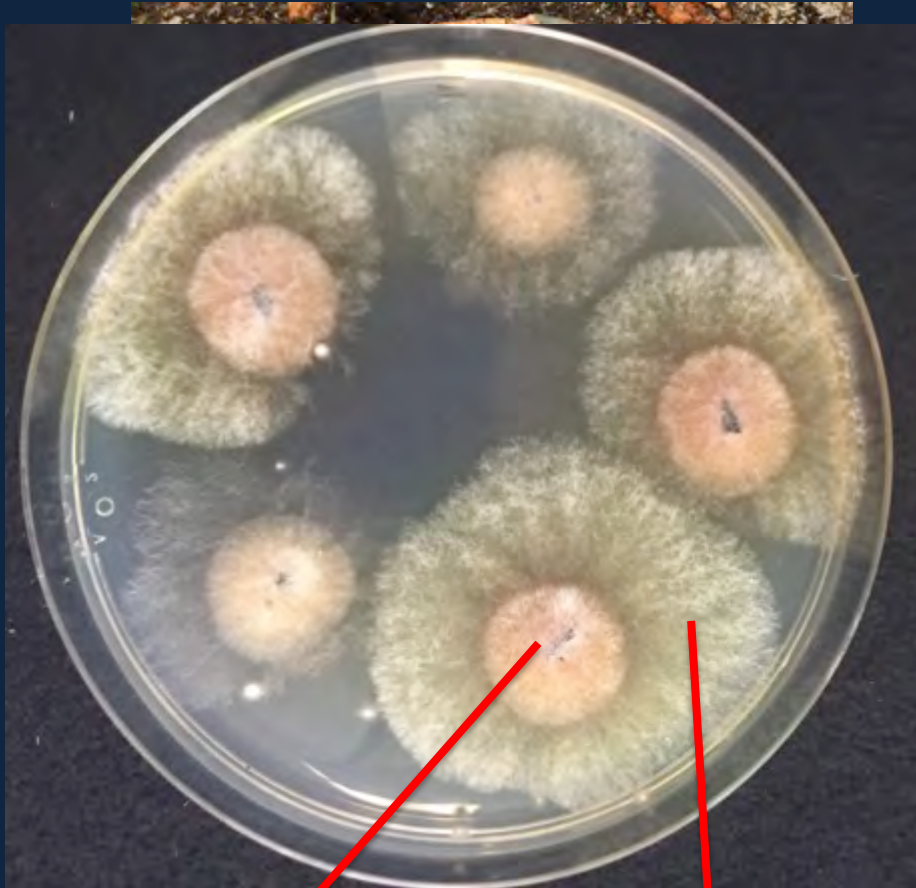
7"  
18cm



Infestation in branches



# Botryosphaeria infestation on PSHB infested Sycamore tree in UCI



Infestation in main trunk  
*Fusarium euwallaceae* *Neofusicoccum parvum*

Infestation in branches

Akif Eskalen, UCR

# PSHB Impacts

- Cost of:
  - Treatment
  - Pruning
  - Removal \$(650 to \$1000 per tree)
    - Chipping
    - Stump grinding
    - Handling and disposal
      - Transport
      - Compost
      - Alternative Daily Cover
      - Biomass Electrical Generation



WILL HOMEOWNERS DO OR BE ABLE TO AFFORD THIS?

- Injury Hazards from falling and weakened limbs



# Benefit Cost Ratio of Urban Forests

- Urban Forest
  - Private
  - Street and Park Trees
- Ecological Services
  - BMP to control stormwater
  - Energy savings
    - Mitigate heat-island and clean air in cities
  - Atmospheric CO<sub>2</sub> reduction
  - Air quality benefits
  - Aesthetics and other benefits
  - Ecosystem benefits
    - Habitat for animals and plants
    - Food for animals
    - Cycle water and nutrients through ecosystems



Dan Berry, Huntington Gardens



# PSHB Impacts

- Estimates for **urban areas in three climate zones** where PSHB is found: Inland Empire, Coastal Southern California and Southwest Desert, comprising **4,244 sq. miles and 20.5 million residents**



Preliminary data from Dr. Greg McPherson, US Forest Service

# PSHB Impacts

- • Approximately **26.8 million trees**, **37.8%** of the region's 70.8 million trees, are at risk (1.3 trees per capita).
- The **cost for removing and replacing** the 26.8 million trees should they die is approximately **\$36.2 billion**.
- The value of **ecosystem services forgone** each year due to the loss of these trees is **\$1.4 billion**.

These estimates are conservative because they:

- do not include costs associated with damage to people and property from tree failures, as well as
- increased risk of fire and other hazards or may undervalue benefits of trees to human health and well-being

# Kuroshio Shot-Hole Borer/Fusarium Dieback Impact on Riparian Habitat in the The Tijuana River Valley

140,000 willow trees severely damaged



The forest at Dairy Mart Bridge before the beetle attack (May 2015).



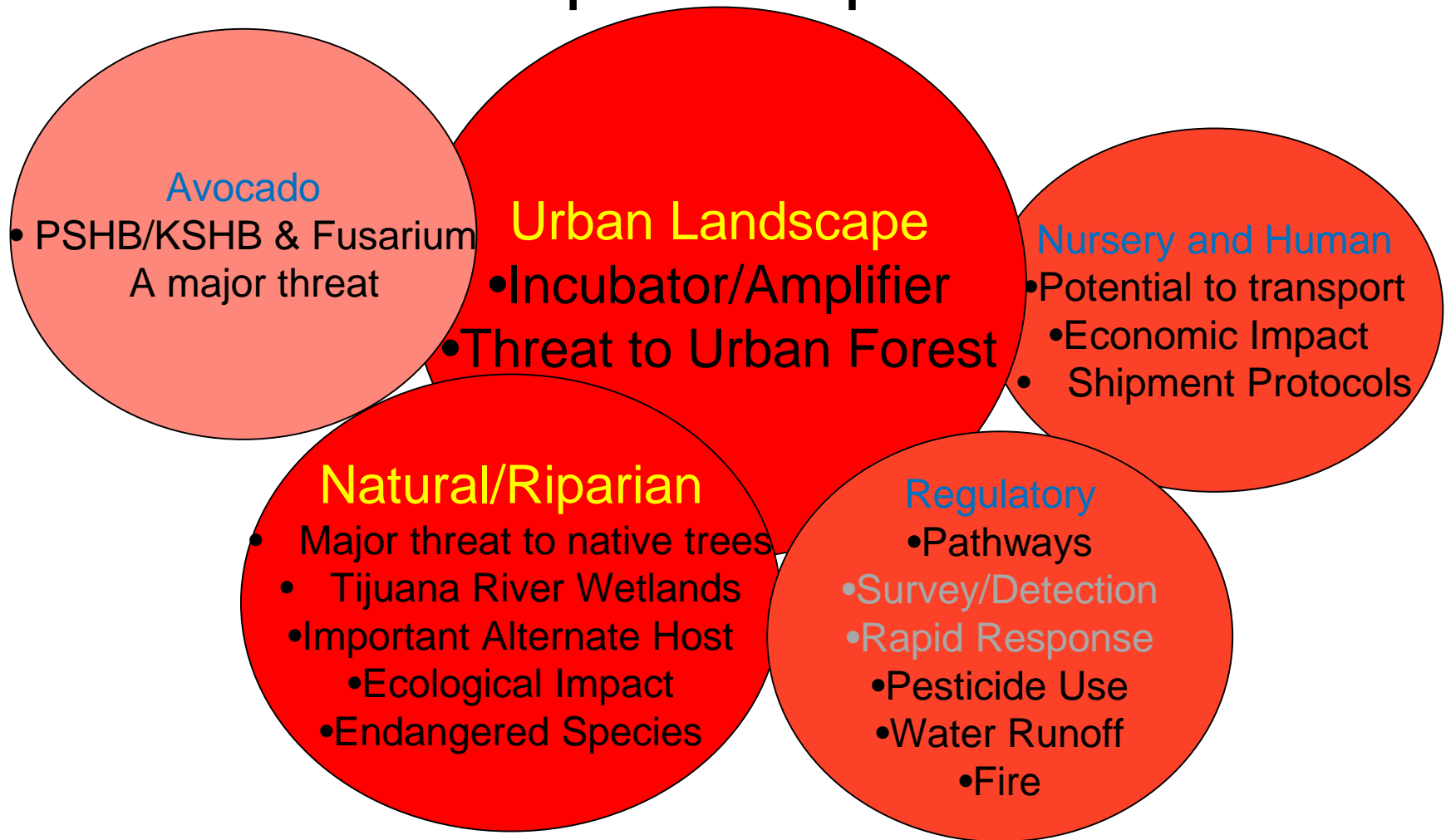
The forest at Dairy Mart Bridge after the beetle attack (February 2016).

Photos by John Boland



# PSHB/KSHB/FDB/ 2016

## Widespread Epidemic



Cal Fire, Fish and Wildlife, Board of Forestry, USDA Forest Service, Ca State Parks  
Public Agencies, NGOs, Land Managers, CDPR, Assembly Ag/Natural Resources,  
Audubon, University of California ANR, NRCS, RCDs, and...

# PSHB/KSHB/FD Needs

- Identify Short, Medium and Long Term Needs
  - **Positively identify pest**
    - Use of DNA testing to determine if it is a known or undescribed species
    - Determine country of origin(s) pathways of entry
    - Southern California has PSHB and KSHB – WHAT HAPPENS WHEN XSHB ARRIVES?
  - **Conduct studies on it's biology**
    - Life cycle
    - Hosts - Agriculture, urban forests, natural ecosystems
    - Flight – when and how far
    - Statewide risk assessment tools for Ag, Urban and Riparian
  - **Develop better traps, lures and detection methods**
    - The why of tree species preference and different patterns of attack
  - **Best Management Practices**
    - Cultural, mechanical, physical, chemical, biological
    - Determine why pesticides efficacy changes with tree species
    - BMPs for homeowners, commercial landscapes and municipalities
    - How to dispose of massive numbers of dead trees
  - **Form Rapid Response Teams**
    - For XSHB
    - Early detections in uninfested areas like Northern California
- **Reforestation**
  - Design and strategies
  - Impact on Nursery Production
- Regulatory Implications for the Ag, Urban and Riparian
- **Education and Outreach**
- Private, Industry, Local, State and Federal **Funding**

# Identification of Symptomatic Trees



[www.eskalenlab.ucr.edu](http://www.eskalenlab.ucr.edu)

[www.pshb.org](http://www.pshb.org)





# Common symptoms of fusarium dieback on avocado





# Coast Live Oak (*Quercus agrifolia*)





# Coast Live Oak (*Quercus agrifolia*)







# Top 3 Infested Species at OC Parks

## California sycamore

53.52% of OCP infestation



## London plane

12.73% of OCP infestation

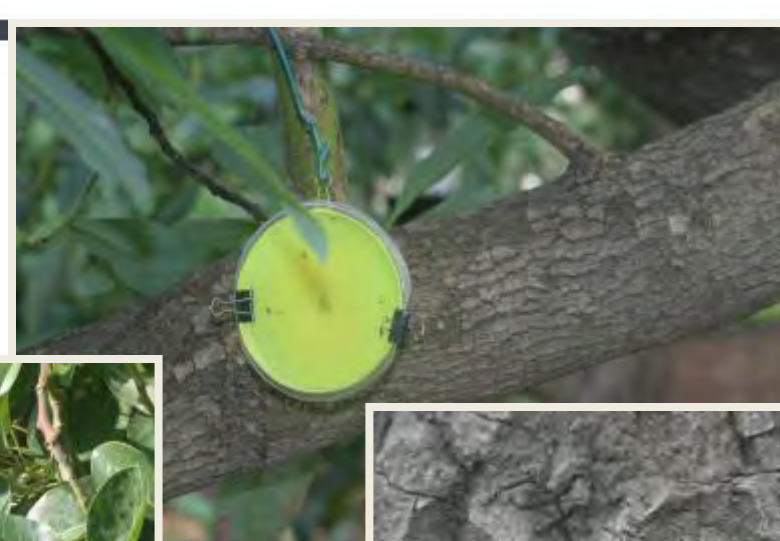
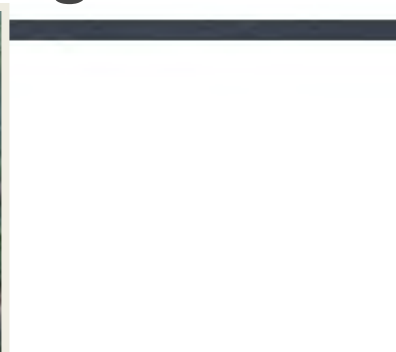


## White alder

9.66% of OCP infestation



# Field Monitoring







# Types of Monitoring

- Identification of External Signs & Symptoms
  - Conducted during every day activities
    - [www.eskalenlab.ucr.edu](http://www.eskalenlab.ucr.edu) and pshb.org
- Traps w/ Querciverol lure
  - Cost range \$28-36 per trap
  - Querciverol lure is \$8-10 & lasts 90 days
  - Bottle traps may be a cheaper option
    - Trial run done by Palm Springs ES Office

# Trapping

- Timing of trapping
  - Growing Season?
- Spacing of traps
  - Lure is weak!
  - Traps should be 10-50 yards apart
  - # of traps may be dependent on \$\$ and manpower
- Potential Trapping Locations
  - Riparian areas containing host species
  - Riparian areas with critical habitat for T & E species



# BMPs for Response to PSHB/FD Infestation

(modified from UC Davis recommendations)

- If tree is confirmed to be infested w/ PSHB/FD & if tree is a reproductive host, then determine if there are 10-20 beetle entry/exit hole per 6 square inches.
  - If No, then monitor tree(s) periodically
  - If Yes, assess if infestation is on primary branches and/or trunk
    - If primary branches only.
      - » Prune infested branches
      - » Chip wood in to 1" diameter
      - » Solarize, on site, using clear tarp for several months
    - If trunk
      - » Remove the tree, including root collar
      - » Chip wood in to 1" diameter
      - » Solarize, on site, using clear tarp for several months

# Best Mgt. Practices continued

- If infestation outside the current known range is confirmed, consider solarization regardless of entry/exit holes or if the tree is a reproductive host.
- Do not move infested wood w/out sterilization!



# Cultural Control and Sanitation

- Tree removal
- Treatment of slash and debris
- Chipping or grinding
- Solarization and composting
- Firewood movement



# Firewood movement



UGA5039049

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



# Control Options

## Cultural / Sanitation

- Tree and stump removal
- Pruning infested branches
- Pruning wound protection (bifenthrin + *Bacillus subtilis*)
- Chipping, Composting, Solarization
- Restrict firewood movement

## Chemical

- Trunk sprays – bifenthrin + *Bacillus subtilis*
- Systemic-Soil injection/drench, trunk injection
  - Imidacloprid
- Trunk injection – Arborjet, Mauguet

## Biocontrol? (Long Term Strategy)

- Natural Enemies
- Use of Entomopathogenic Fungi
- Use of Endophytic bacteria and/or fungi

## Monitor Attract Traps Deterrents

- Use of flight data in management decisions
- Querciverol - lure
- Verbenone - repellent
- Deterrent



# Management Strategy

## Decision Matrix for Management Actions

- Science-based decision model
- Collaboratively developed
- Objective & consistent method of assessing trees

### Parameters

- Safety
- Type of Host
- Value
- Level of PSHB Infestation
- Duration of PSHB Infestation



### Management Actions

- Monitor
- Corrective Pruning
- Remedial Treatment
- Removal
- Preventative Treatment
- Responsible Green Waste Mgmt.

The image shows a complex decision matrix for PSHB (Pine Shoot Borer) management. It includes multiple tables with columns for 'Host Species', 'Infestation Level', 'Safety', 'Value', 'Duration', and 'Management Action'. The matrix is color-coded (red, orange, green) to indicate different levels of risk and recommended actions. Below the tables, there are several text boxes providing additional context and guidance for decision-making.

			PSHB Infestation Level				
	Host Species	Hazard Level	No infestation	Low	Moderate	Heavy	Severe
HIGH VALUE HOSTS	Reproductive	Low	Preventative treatment	Treat/prune infested branches	Treat/prune infested branches	Treat/prune infested branches	Remove tree or infested branches
		High	Preventative treatment	Treat/prune infested branches	Treat/prune infested branches	Remove tree or infested branches	Remove tree or infested branches
	Non-Reproductive	Low	Monitor	Monitor	Notify UC ANR; reclassify species as reproductive host in consultation with PSHB/FD experts		
		High	Monitor	Monitor			

			PSHB Infestation Level				
	Host Species	Hazard Level	No infestation	Low	Moderate	Heavy	Severe
LOW VALUE HOSTS	Reproductive	Low	Monitor	Monitor	Remove tree or infested branches	Remove tree or infested branches	Remove tree or infested branches
		High	Monitor	Treat/prune infested branches	Remove tree or infested branches	Remove tree or infested branches	Remove tree or infested branches
	Non-Reproductive	Low	Monitor	Monitor	Notify UC ANR; reclassify species as reproductive host in consultation with PSHB/FD experts		
		High	Monitor	Monitor			



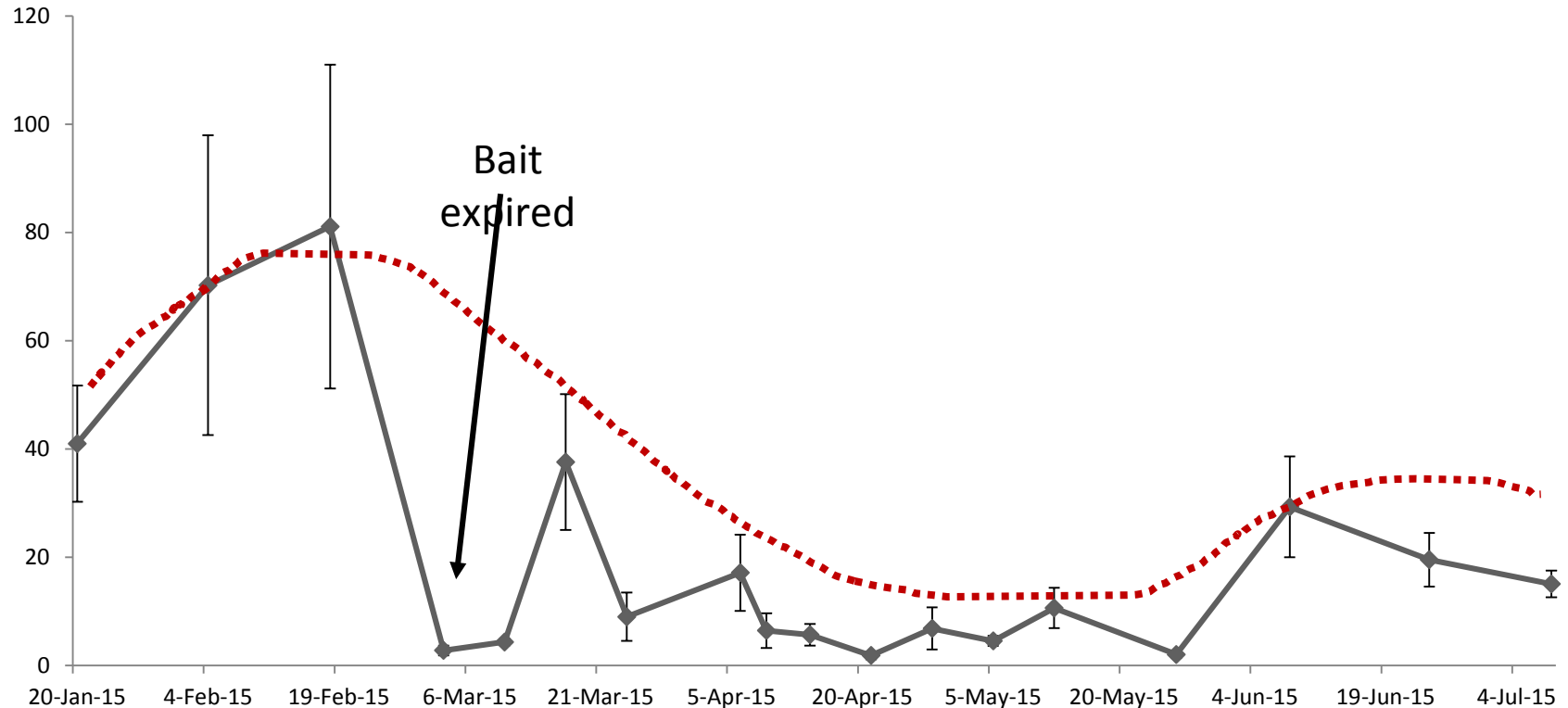






# Flight period

Mean PSHB: All sites, all traps



- Strong flight period early season (early Feb. to mid-April)
  - In 2013, mid-April had the largest peak of activity early in the season
- A second smaller peak of activity in June to ...
  - In 2014, peaks of activity occurred in mid-July and early/mid-Sept

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Statewide Integrated Pest Management Program

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## How to Manage Pests



## Pesticide Information

[About Pesticide Information](#)

## Active ingredient: Imidacloprid

Pesticide type: insecticide (neonicotinoid)

See [example products](#) below.

Potential Hazard <sup>1</sup> to				
Water quality <sup>2</sup> (aquatic wildlife)	Natural enemies (beneficials)	Honey bees <sup>3</sup>	People and Other Mammals	
			Acute <sup>4</sup>	Long Term <sup>5</sup>
 L	 MH	 VH	 M	Not listed

Acute Toxicity to People and Other Mammals<sup>4</sup>

- Toxicity rating: **Moderately Toxic**

Long-Term Toxicity to People and Other Mammals<sup>5</sup>

- On US EPA list: Not listed;
- On CA Proposition 65 list: Not listed

Water Quality Rating<sup>2</sup>

- Overall runoff risk rating: **Low**
- Source: *Pesticide Choice: Best Management Practice for Protecting Surface Water Quality in Agriculture*. UC ANR Publication 8151.

## Impact on Natural Enemies

- Overall toxicity ratings: **Moderate To High**
- Specific Impacts: predatory mites (**Moderate**), parasitoids (**High**), general predators (**Moderate**)

Impact on Honey Bees<sup>3</sup>

- Toxicity category: **I - Do not apply to blooming plants**
- Notes: Soil-applied imidacloprid can move into nectar, so don't apply prior to bloom.

## Pests for which it is mentioned in Pest Notes



I'm Cortana. Ask me anything.

10:42 AM  
2/18/2016

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# Invasive Shot Hole Borers

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## What are the Polyphagous and Kuroshio Shot Hole Borers?

### Upcoming Events

Event Name	Date
<a href="#">Invasive Tree Pests Issues-San Diego</a>	7/28/2016

### Get PSHB Updates

Join the PSHB Email List

[Go to the News and Events Page](#)

### PSHB News

www.pshb.org was made possible by support from the US Forest Service Forest Health Protection Program, UC Riverside, Orange County Parks, the California Avocado Commission, and the work and in-kind support of federal, state, and local partners.

This site contains research-based information for education purposes. For specific guidance check with your local land management regulatory authorities. Any

Pshb.org

Eskalenlab.ucr.edu





# Acknowledgements



**Akif Eskalen, Ph.D., UC Riverside**

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**Matt Deines, UC Irvine**

**OC Parks**

**California Avocado Commission**

**West Coast Arborists**

**RPW Services Inc.**

**Great Scott Tree Services**

# Emerald Ash Borer

Eggs



Larva



Adult



Pupa



# Emerald Ash Borer

- Controlling insects that feed under the bark is challenging, especially if it is a novel beetle and host.
- Begin using insecticides when trees are relatively healthy.
- Insecticide Options:
  - Systemic applied as soil injections or drenches
  - Systemics applied as trunk injections
  - Systemics applied as lower trunk sprays
  - Protective cover sprays applied to trunk, main branches, and foliage.



# The Asian Longhorned Beetle

- The ALB is a voracious pest of hardwood tree species such as maple, elm, ash, birch, poplar, horse chestnut, London planetree.
- ALB is potentially one of the most destructive and costly invasive species to enter the US.

Suzanne Bond, USDA Aphis

# North American Asian Longhorned Beetle Infestations

- New York - August 1996
  - **Eradicated 2011**
- Illinois - July 1998
  - **Eradicated 2008**
- Hudson County, NJ - October 2002
  - **Eradicated 2013**
- (Toronto, Canada - September 2003)
- Middlesex/Union Counties, New Jersey – August 2004
- Massachusetts – 2008
- Ohio - 2011



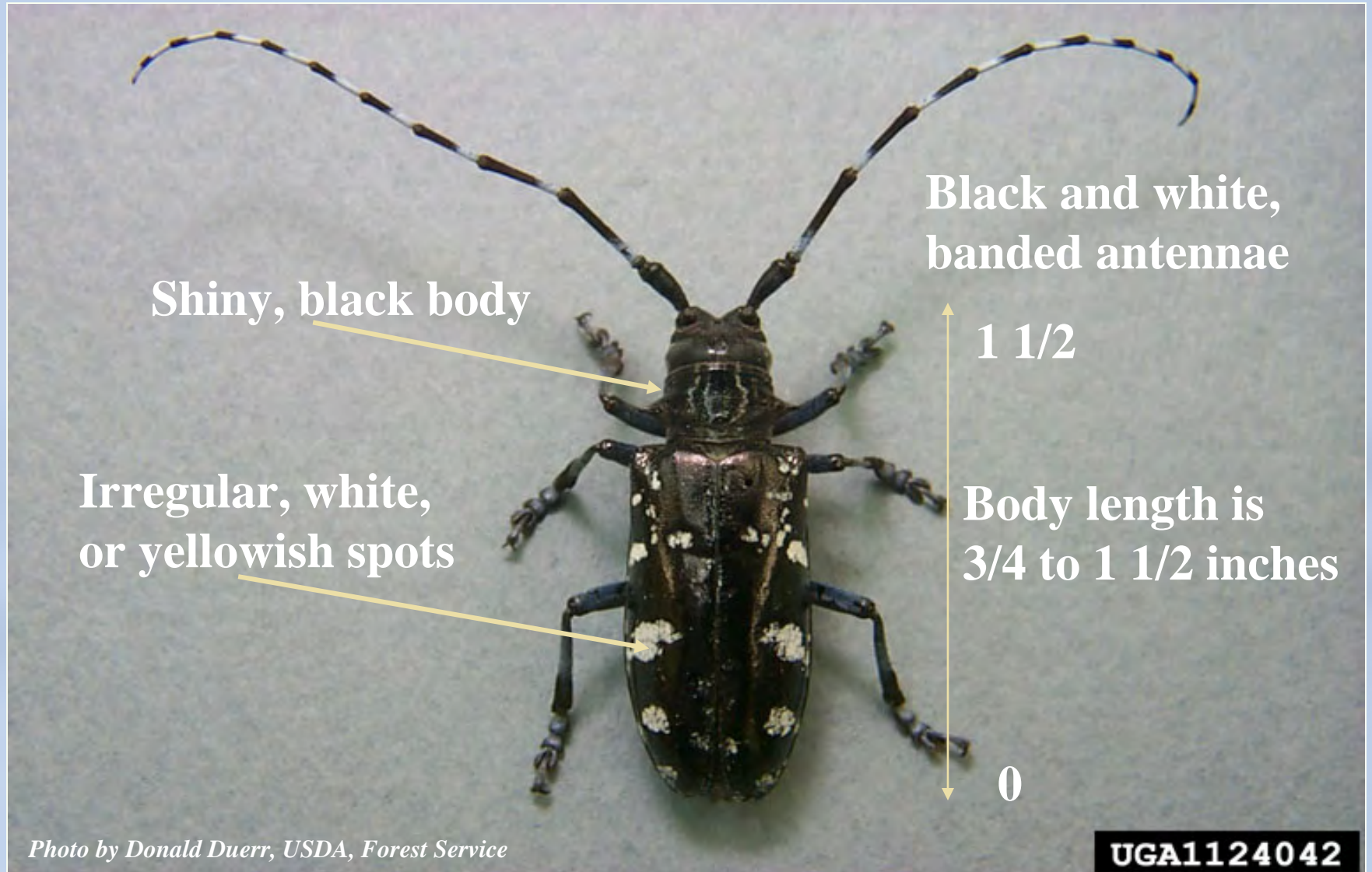


## Citrus Long Horned Borer - CANADA





# What to look for from early spring through late fall




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## Announcements

- Highlights: [2012 Annual Report](#)
- Upcoming workshops:  
- [Pesticide safety](#)

## What's New

- 2013 Grape Powdery Mildew Risk Index
- Agricultural Pest Management: Kiwifruit revised, Floriculture new page added, Strawberry updated
- Pest Notes: Pantry Pests, Clothes Moths and Horsehair Worms revised
- [More...](#)

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## CISR: Leading the Fight Against Invasive Species in California

**Every 60 days, California gains a new and potentially damaging invasive species.** This rate of invasion results, on average, in six new species establishing in California each year. Economic losses to California from invasive species are estimated at \$3 billion per year. The unique climate and geography of California provides diverse ecosystems which are perfect for the establishment of a diverse variety of new pests. CISR's researchers lead the way to determine how pests enter California, where invading populations came from and why these pests are successful in establishing California as their home. [Learn more about the CISR program](#)

**Red Alert!****Laurel Wilt and Redbay Ambrosia Beetle**

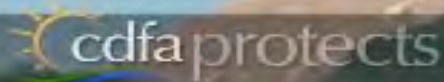
First found in Georgia, these non-native pest threaten to spread throughout the US to all members of the Lauraceae family. The Redbay Ambrosia Beetle is not the true problem, but the fungus it carries: Laurel Wilt. As the fungus grows, it destroys the food and water conduction system, eventually killing the tree. Damage to infested trees are identifiable by the emergence of saw dust tooth picks that radiate from the trunks and branches caused by the [Redbay Ambrosia Beetle and Laurel Wilt.](#)

**New Invasive Species on CISR****Red Bugs**

Red Bugs feed on urban vacant lots and weedy fields. Most commonly, they feed upon developing or mature seeds and seed pods....







#### CDFA NEWS

##### CDFA Announces Vacancy on the Beet Curly Top Virus Control Program Advisory Board

SACRAMENTO, September 3, 2014 — The California Department of Food and Agriculture's (CDFA) Integrated Pest Control Branch is announcing one vacancy on the Beet Curly Top Virus Control Board. This Advisory Board makes recommendations to the California Department of Food and Agriculture on the management of the Beet Curly Top Virus.

[Continue reading](#)

CDFA Announces Vacancy on the Beet Curly Top Virus Control Program Advisory Board

European Grapevine Moth Quarantine Lifted in Solano County and Portions of Napa and Sonoma Counties



Plant Health



Animal Health



Inspection Services



Marketing Services



Dairy Programs

Ext

##### PEIR: DRAFT Statewide Pest Prevention Environmental Impact Report

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Blake Harlan, a sixth generation California farmer in Yolo County, uses a highly efficient drip irrigation system as part of his resource management approach to the California drought.



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2014 Farm Bill, Section 10007



Leave Hungry Pests Behind



The Coconut Rhinoceros Beetle (CRB). A New Invasive Pest in Hawaii. Learn the damage it causes and how to identify the CRB.

Plant Health (PPQ)

APHIS' Plant Protection and Quarantine program vigilantly protects agriculture and the environment against pest and disease threats to ensure a diverse natural ecosystem and an abundant and healthy food supply for all Americans.

Program Priorities



Plant Health Import Information

**Establishing Effective Regulations and Policies:** By determining which plants and plant products can be imported—and which pose a high risk and should be excluded—the regulations and policies established by APHIS protect the environment and U.S. agriculture.



Pests and Diseases

**Protecting Agriculture and the Environment from Invasive Plant Pests and Diseases:** An invasive pest is a non-native species whose introduction into the country can cause damage to the economy, natural resources, or human health.



Center for Plant Health Science and Technology

**Safeguarding Through Science:** APHIS scientists monitor data from around the world and throughout the country to uncover pathways and develop strategies to both exclude pests before they arrive at our shores and to stop or limit their movement if they enter the country.



Phytosanitary Certificate Issuance and Tracking System

**Assisting U.S. Farmers and Exporters:** APHIS assists American farmers and exporters by providing plant health inspection and certification for plants and plant products being shipped to foreign countries. Required by importing countries, these plant health certificates ensure that products are pest and disease free.

<http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth>



# Questions?

Elephant Weevil  
*Orthorhinus cylindrirostris*

