How To Be Invasive

A Three-Step Process
by Euwallacea sp.
ISHB (Polyphagous & Kuroshiro SHB)

Have reached epidemic levels in southern California

• 53-137 tree species such as sycamores, oaks, box elder, and willow are at risk of attack

• Affects Urban, riparian, and natural forests

• May eventually affect agriculture

• US Forest Service researchers estimate that 27M trees out of 71M urban trees in southern California are especially at risk. If 27M trees are lost, this will result in:
  o Removal and replacement cost: $36.2 billion approximately
  o Lost ecosystem services valued at: $1.4 billion annually or $28 billion over a 20-year life span.

• 100M trees at risk if moves into northern California

• Lack of Funding for a Coordinated Response because it is a “B” rated pest
Polyphagous Shot-Hole Borer Host Range (Oct 2016) – NOT A “DO NOT PLANT” LIST!!!

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

*19 Native species to California

Source: www.eskalenlab.ucr.edu

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 lasolepsis)*
10. Cottonwood (Populus fremontii)*
11. Mimosa (Albizia julibrissin)
12. Castor bean (Ricinus communis)
13. Black willow (Salix nigra)*
14. Strawberry snowball tree (Dombeya cacuminum)
15. Mule fat (Baccharis salicifolia)*

*7 Native species to California
PSHB Impacts
OC Parks

• Cost of:
  – Treatment - $6/inch dbh
  – Pruning
  – Removal $650 to $1000 per tree ($25-30/inch dbh)
    • Chipping
    • Stump grinding
    • Handling and disposal
      – Transport
      – Compost
      – Alternative Daily Cover
      – Biomass Electrical Generation

WILL HOMEOWNERS DO OR BE ABLE TO AFFORD THIS?
– Potential injury Hazards from falling and weakened limbs
Making Your Entrance

- Blend in with a crowd, preferably a really big crowd, like wood boring pests from Asia that travel in solid wood packing material.
- Be inconspicuous and hard to find – being really small helps.
- Anonymity is good – if your reputation precedes you, you’ll attract more unwanted attention.
- Have an Identical Twin that nobody is worried about.
- Leave your Enemies behind.
- Form a partnership. Feed the one that provides transportation, care & a home.
Settling Into Your New Neighborhood

- Stay indoors, party at home and mate with your siblings so you don’t need a pheromone that can be used to lure you into a trap.
- Don’t get caught outside and don’t fly far from home where you can be lured into a trap.
- Don’t disturb your new neighbors – initial impacts should be minimized. Attack a plant like Castor bean that nobody likes anyway. Limit the variety of victims to avoid alarming authorities.
- Don’t occupy the whole neighborhood at first. Quietly build up your population in a few trees before invading the rest of the neighborhood.
Settling Into Your New Neighborhood

- Don’t occupy the whole neighborhood at first. Quietly build up your population in a few trees before invading the rest of the neighborhood.

- Use the Stages of Grief to buy time, especially DENIAL

- Be an adventurous eater, just be selective. Try some new plants, but none that can afford to fight back hard enough to thwart your plan.

- Once you are noticed try to confuse and confound those sent to evict you - be an enigma to the usual IPM options.
Reveal Your True Intentions

- Timing is everything – attack when your opponent least expects it and in overwhelming numbers.

- Synergize – a vector and a pathogen working together can amplify their damage and are harder to control.

- Divide and conquer – focus your attacks on separate opponents so they won’t join forces against you.
Origin and History

Believed to be introduced via wood products and/or shipping material from southeast Asia.

- 2003
  First found at Whittier Narrows, Los Angeles County

- 2003 – 2010
  Found on a few trees

- 2010
  Presumed cause of death of large number of Box Elder street trees in Long Beach

- 2012
  PSHB collected by Dr. Eskalen from an Avocado tree in South Gate
Origin and History

• 2012
  SHB infestations at the Los Angeles Arboretum and Huntington Library

• 2014
  Established in Los Angeles, Orange, and Riverside County
  o A single beetle found in a trap in Santa Cruz County.
  o KSHB confirmed on Avocado and landscape trees in north San Diego County

• 2015
  PSHB established in L.A., Orange, Riverside, San Bernardino Counties and KSHB in the north and SW San Diego County

• 2016
  o Tijuana River Valley Willow devastation
  o KSBH found in a trap in Santa Barbara and San Luis Obispo County
Current distribution of infestation of PSHB/FD

Legend
- Green: Avocado Groves
- PSHB Infestation:
  - Red: Positive 2014
  - Green: Positive 2013
  - Blue: Positive 2012
- Black: Negative

Data source: Esichten lab, Dept. of Plant Pathology and Microbiology, University of California, Riverside, www.esichtenlab.ucr.edu
Current distribution of infestation 2016

Data Sources: University of California; Riverside, US Forest Service and Forest Health Protection; California Avocado Commission; UC Cooperative Extension in Orange, Los Angeles, Ventura, San Luis Obispo and San Diego Counties; Ag Commissioner’s Office in San Diego, Los Angeles and Ventura Counties; CalFire; Orange County Parks, The Huntington Library, Art Collections and Botanical Gardens; Los Angeles County Arboretum and Botanic Gardens

Source: PSHB.ORG
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

<table>
<thead>
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<th>Generation</th>
<th>Number of Progeny</th>
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<tr>
<td>Gen 0</td>
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<td>Gen 1</td>
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<td>Gen 2</td>
<td>400</td>
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<td>Gen 3</td>
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<td>Gen 5</td>
<td>3,200,000.00</td>
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<td>Gen 6</td>
<td>64,000,000.00</td>
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Flight period

- 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

Tom Coleman, USDA Forest Service
Kuroshio Shot-Hole Borer/Fusarium Dieback Impact on Riparian Habitat in the Tijuana River Valley

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

Photos: John Boland, PhD/Southwest Wetlands Interpretive Association
Kuroshio Shot-Hole Borer/Fusarium Dieback Impact on Riparian Habitat in the Tijuana River Valley

140,000 willow trees severely damaged; loss of ecological services such as endangered species habitat; fire and flood Hazard

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

Photos: John Boland, PhD/Southwest Wetlands Interpretive Association
# Briere model parameters

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>$t_{\text{opt}}$</td>
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Native Distribution
California Distribution - PSHB
California Distribution

Number of Reproductive Hosts

Join_Count
1
2
3
4-5
6-9
California Distribution

![California Distribution Map](image)
Integrated Pest Management Program

1. Pest Identification
2. Monitoring and assessing pest numbers and damage
3. Guidelines for when management action is needed
4. Preventing pest problems
5. Using a combination of biological, cultural, physical/mechanical and chemical management tools
6. After action is taken, assessing the effect of pest management
Integrated Pest Management Program

Pest Identification

Polyphagous Shot Hole Borer
*Euwallacea* sp. #1

Fusarium euwallacea

Graphium euwallacea

Acremonium pembeum

Kuroshio Shot Hole Borer
*Euwallacea* sp. #5

Fusarium sp.

Graphium sp.

San Diego Co
San Luis Obispo
Santa Barbara

Los Angeles Co
Orange Co
San Bernardino Co
Riverside Co
Ventura Co

Akif Eskalen - UCR
Identification of External Signs & Symptoms

- Conducted during every day activities

  • [www.eskalenlab.ucr.edu](http://www.eskalenlab.ucr.edu) and [pshb.org](http://pshb.org)

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**a. Staining**

**b. Frass**

**c. Gumming**

**d. Sugary exudate**

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Photos | a, c: Monica Dimson/UCCE Orange County; b, d: Akif Eskalen/UCR
Field Monitoring: entry/exit holes

Number of entry/exit holes 1) trunk and 2) branches recorded separately
Field Monitoring – Visual Survey
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

Photos | Monica Dimson, UC Cooperative Extension
California Sycamore, *Platanus racemosa*
Box Elder, *Acer negundo*

Photos | John Kabashima/UCCE Orange County
Red Willow, *Salix laevigata*
Kentia Palm, *Howea forsteriana*

Photo | John Kabashima/UCCE Orange County
Kentia Palm, *Howea fosteriana*

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Integrated Pest Management

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Integrated Pest Management Program
Trapping, Repellents & Deterrents

• Traps w/ Querciverol lure
  o Cost range $26 (Vane/Short Funnel)
    • Lindgren Funnel Trap $65 per trap
  o Querciverol lure is $6-10 & lasts 90-120 days
  o Bottle traps may be a cheaper option
    • 40% as effective as the Lindgren Funnel Trap
  o Elm leaf beetle panel trap (18” X 25”) is $3.43 each

• Repellents - Verbenone

• Deterrents – in the testing phase
What are the Polyphagous and Kuroshio Shot Hole Borers?

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 fungal pathogens. Trees that are FD susceptible may experience branch decline, canopy loss, and, in some cases, tree mortality.

Like PShB, Kuroshio Shot Hole Borer (KSHB) is an exotic invasive species that also spreads Fusarium Dieback. Both borers 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 Kearneys, Orange County Parks, The California Avocado Commission, and the work and its latest support of federal, state, and local partners.
QUESTIONS?
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<th>Host Species</th>
<th>Hazard Level</th>
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<th>Low</th>
<th>Moderate</th>
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<td>Remove tree or infested branches</td>
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**LOW VALUE HOSTS**

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Integrated Pest Management Control Options

- Cultural, physical/mechanical
  - Tree and stump removal
  - Pruning infested branches
  - Pruning wound protection (Bifenthrin + Bacillus subtilis)
  - Chipping, Composting, Solarization, Burning/Biogeneration
  - Restrict firewood and green waste movement

- Chemical
  - Trunk sprays
    - Bifenthrin + Bacillus subtilis
  - Systemic soil injection/drench
    - Imidacloprid
  - Trunk injection
    - Emamectin Benzoate + Tebuconazole or Propiconazole
  - Repellents (Verbenone) and Deterrents

- Biological
  - Natural enemies
  - Entomopathogenic fungi
  - Endophytic bacteria or fungi
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Cal Fire
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West Coast Arborists

Photo | Monica Dimson, UC Cooperative Extension