

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:
 - Removal and replacement cost: \$36.2 billion approximately
 - 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 Mexicana*)
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 corallodendron*)
24. Blue palo verde (*Parkinsonia floridum*)*
25. Palo verde (*Parkinsonia aculeata*)*
26. Moreton bay chestnut (*Castanospermum australe*)
27. Brea (*Cercidium sonora*)
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 chrysolepsis*)*
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*)

Kuroshio Shot-Hole Borer Host Range

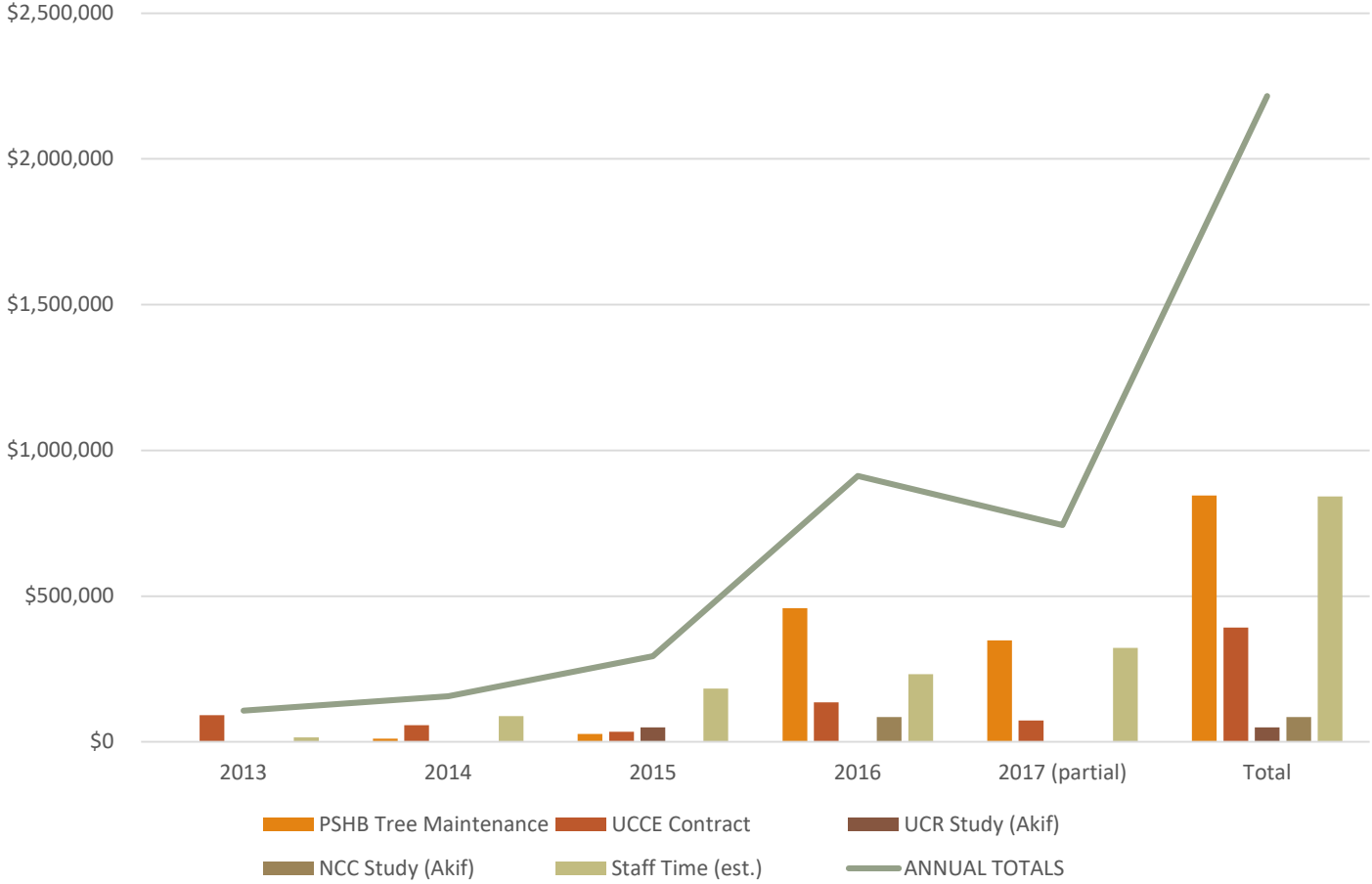
1. Avocado (*Persea Americana*)
2. California sycamore (*Platanus racemosa*)*
3. Coast live oak (*Quercus agrifolia*)
4. Cork oak (*Quercus suber*)
5. Draft coral tree (*Erythrina humeana*)
6. Black poplar (*Populus nigra*)*
7. Black locust (*Robinia pseudoacacia*)
8. Red willow (*Salix laevigata*)*
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 caccuminum*)
15. Mule fat (*Baccharis salicifolia*)*

*7 Native species to California

*19 Native species to California

Source: www.eskalenlab.ucr.edu

OC Parks Annual ISHB Expenditures



PSHB Impacts OC Parks

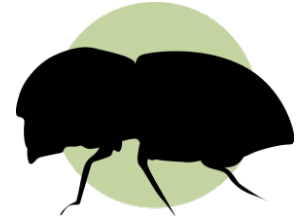


- Cost of:
 - Treatment - \$6/inch dbh
 - Pruning
 - Removal \$650 to \$1000 per tree (\$25-30/inch dbh)
 - Chipping
 - Stump grinding
 - Handling and disposal
 - Transport
 - Compost
 - Alternative Daily Cover
 - Biomass Electrical Generation

WILL HOMEOWNERS DO OR BE ABLE TO AFFORD THIS?

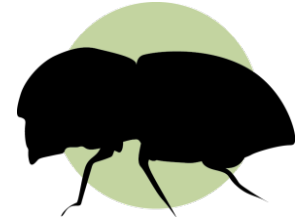
- Potential injury Hazards from falling and weakened limbs

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.

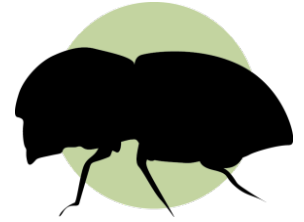
Settling Into Your New Neighborhood



- ❑ 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.



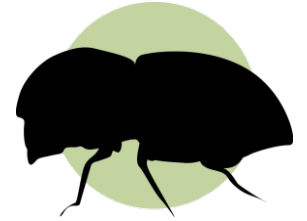
Reveal Your True Intentions



- ❑ 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.



I 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

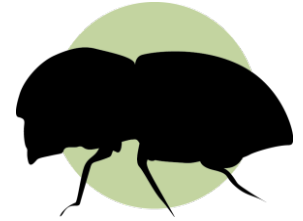
- **2010**

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

- A single beetle found in a trap in Santa Cruz County.
- KSHB confirmed on Avocado and landscape trees in north San Diego County

- **2015**

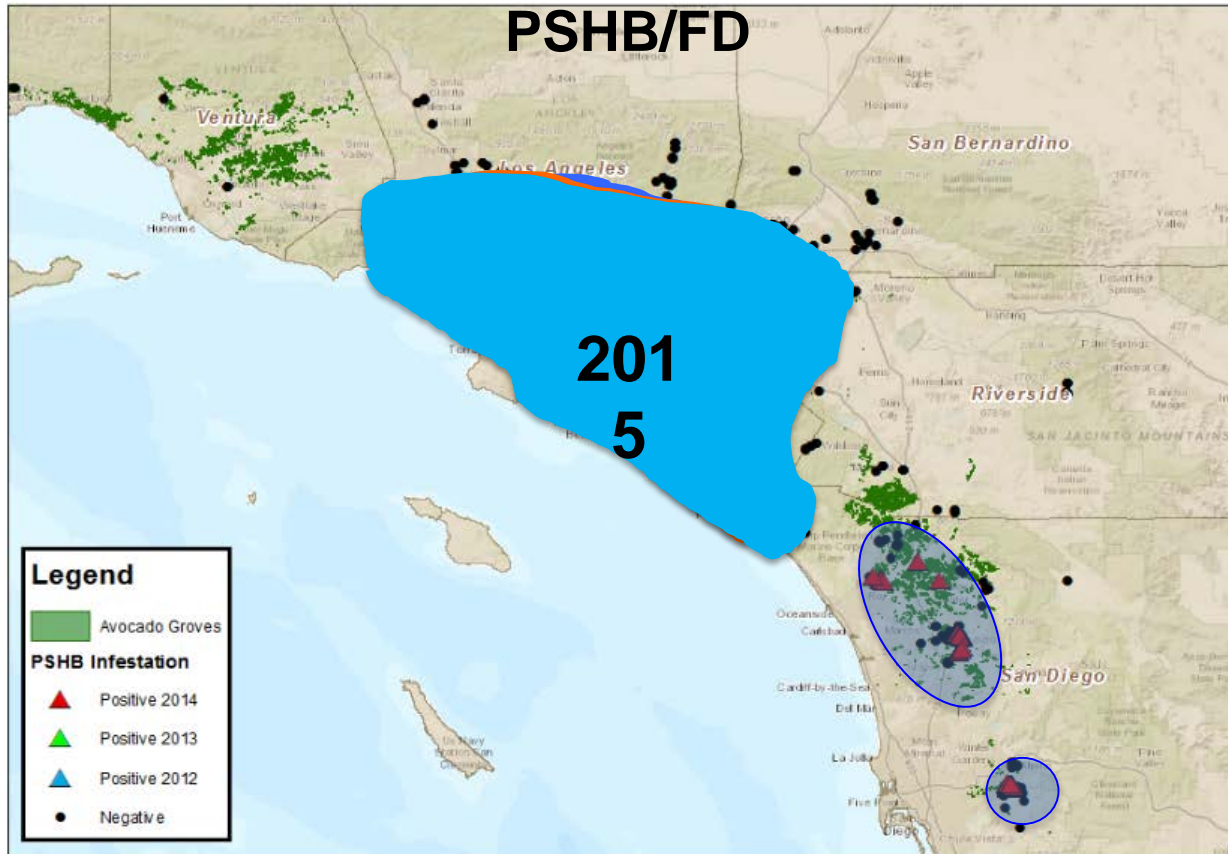
PSHB established in L.A., Orange, Riverside, San Bernardino Counties and KSHB in the north and SW San Diego County

- **2016**

- Tijuana River Valley Willow devastation
- KSBH found in a trap in Santa Barbara and San Luis Obispo County

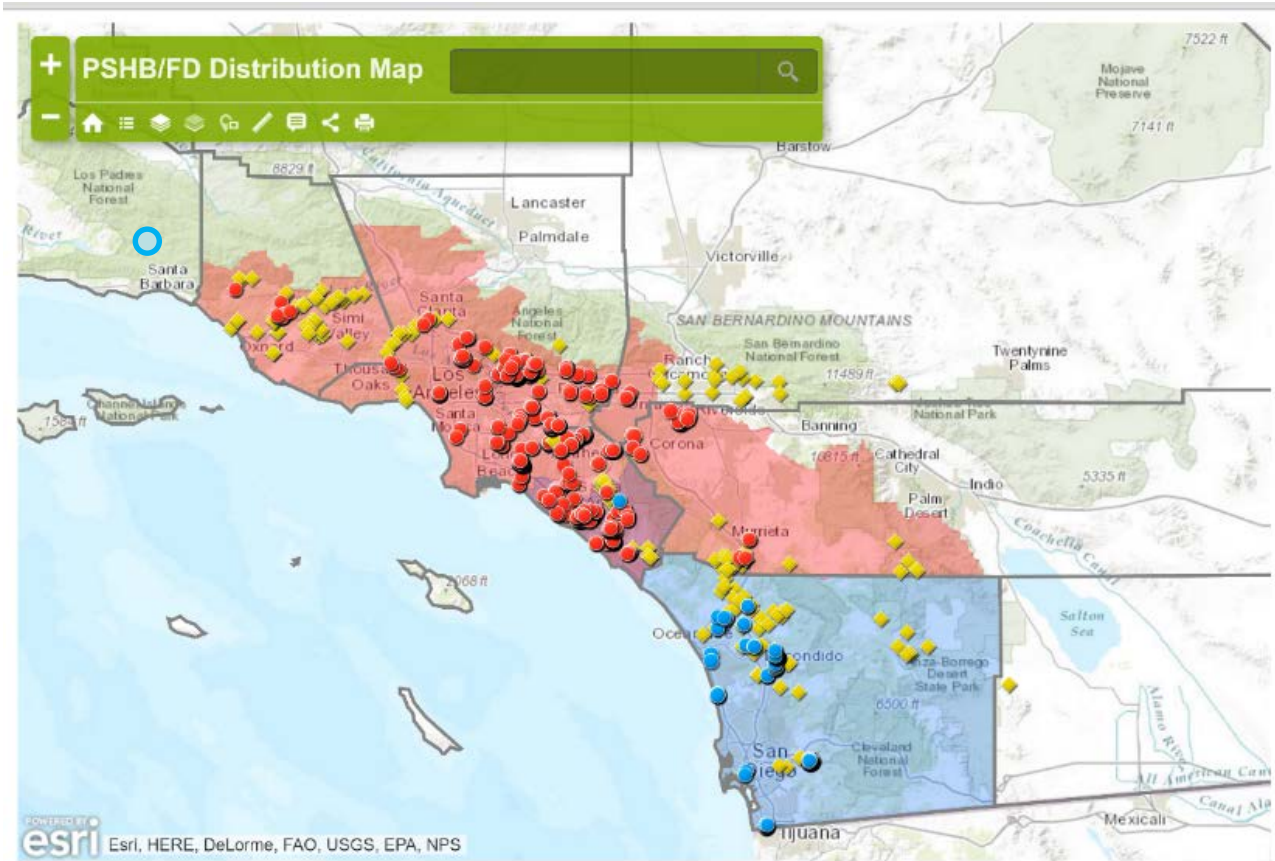
Current distribution of infestation of

PSHB/FD



0 5 10 20 30 40 Miles

Data source: Eskalen lab, Dept. of Plant Pathology and Microbiology, University of California, Riverside. www.eskalenlab.ucr.edu



Current distribution of infestation 2016

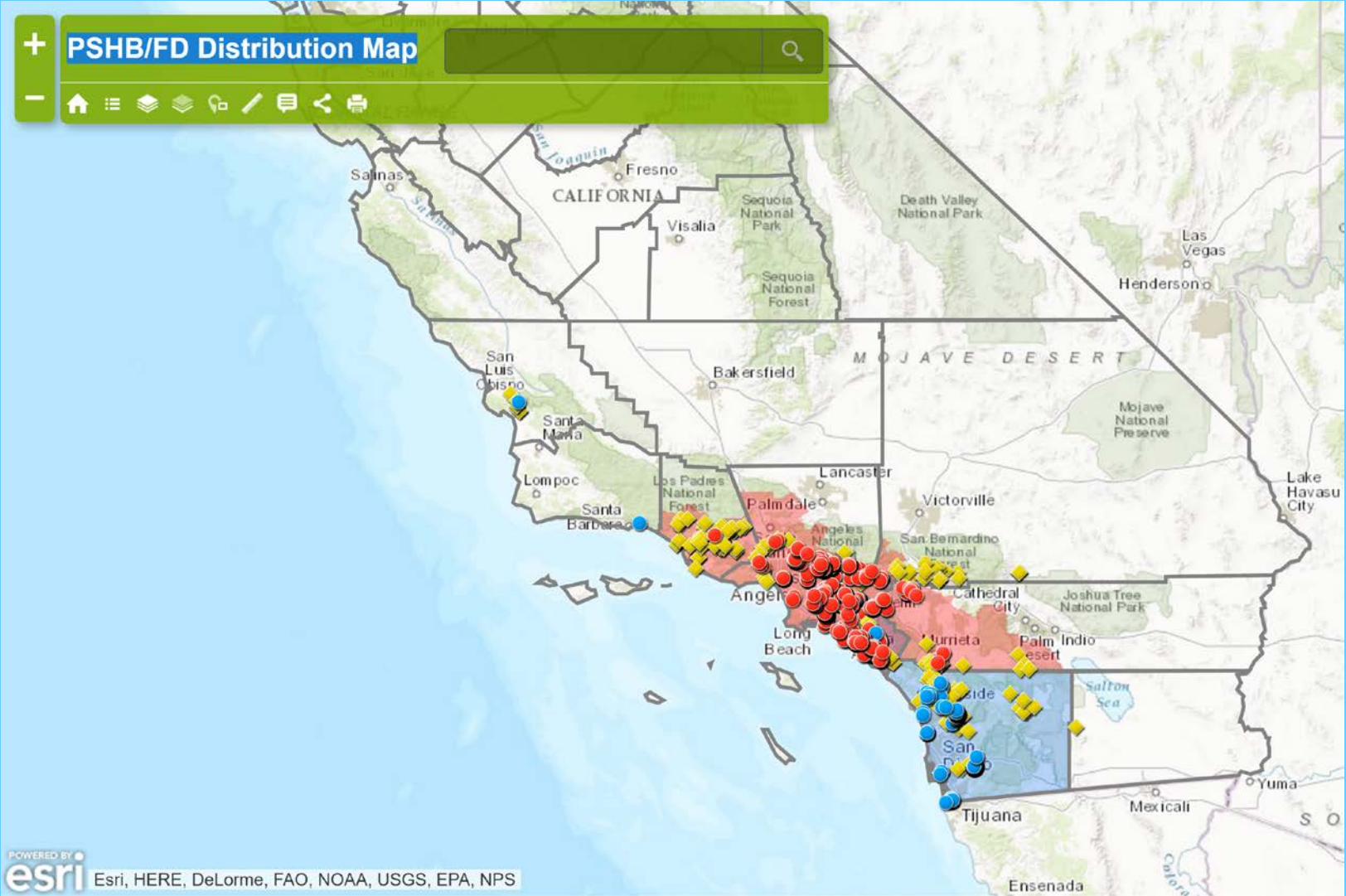
Source Information

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

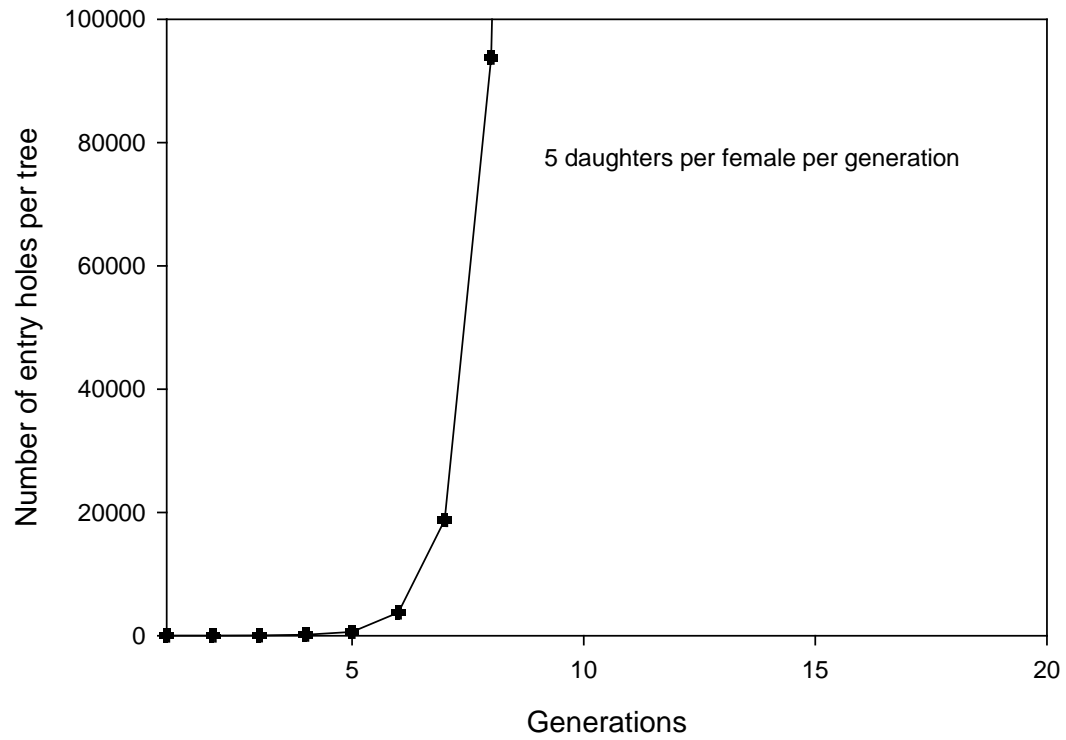
Source: PSHB.ORG

+ PSHB/FD Distribution Map 

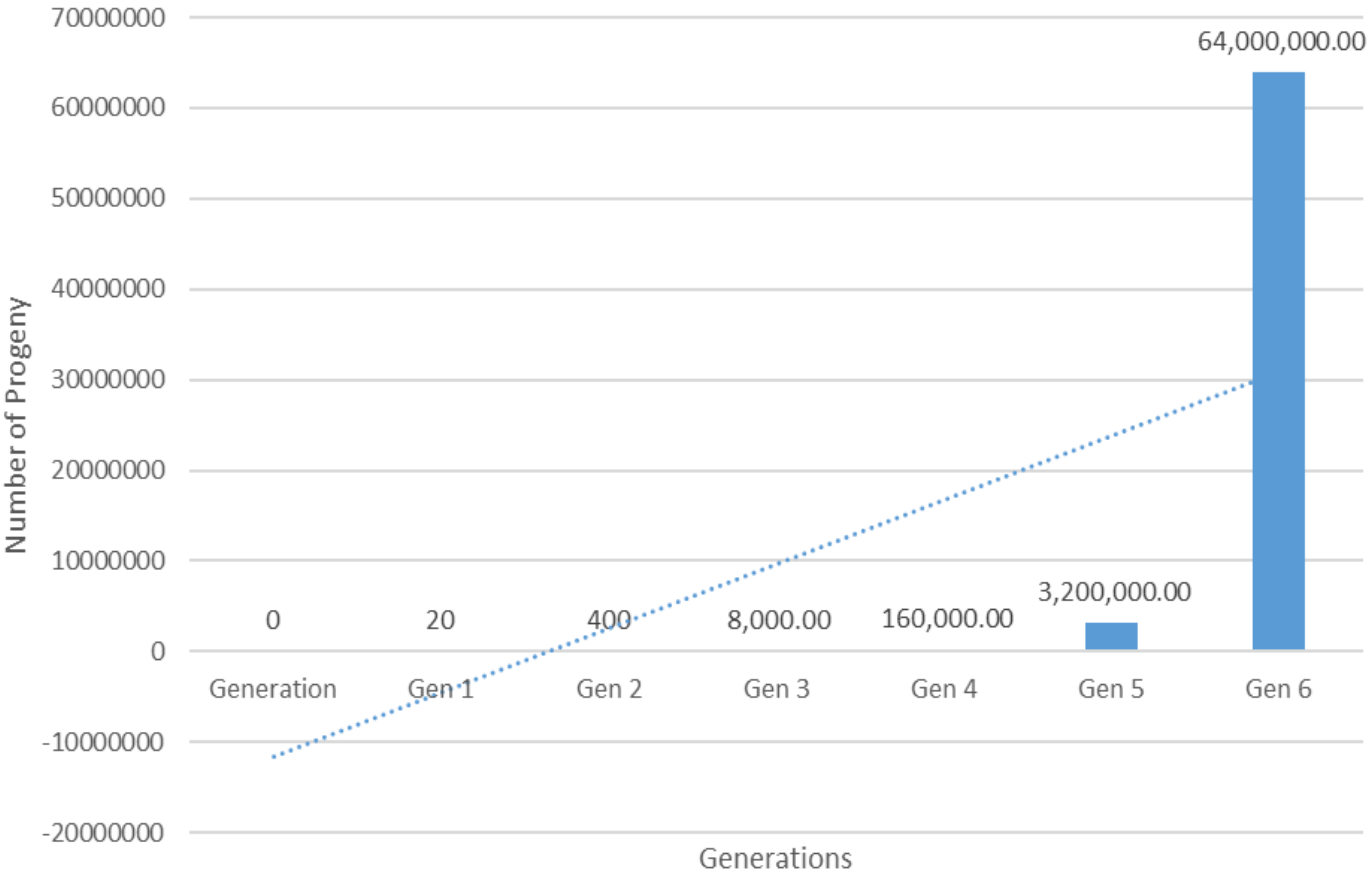
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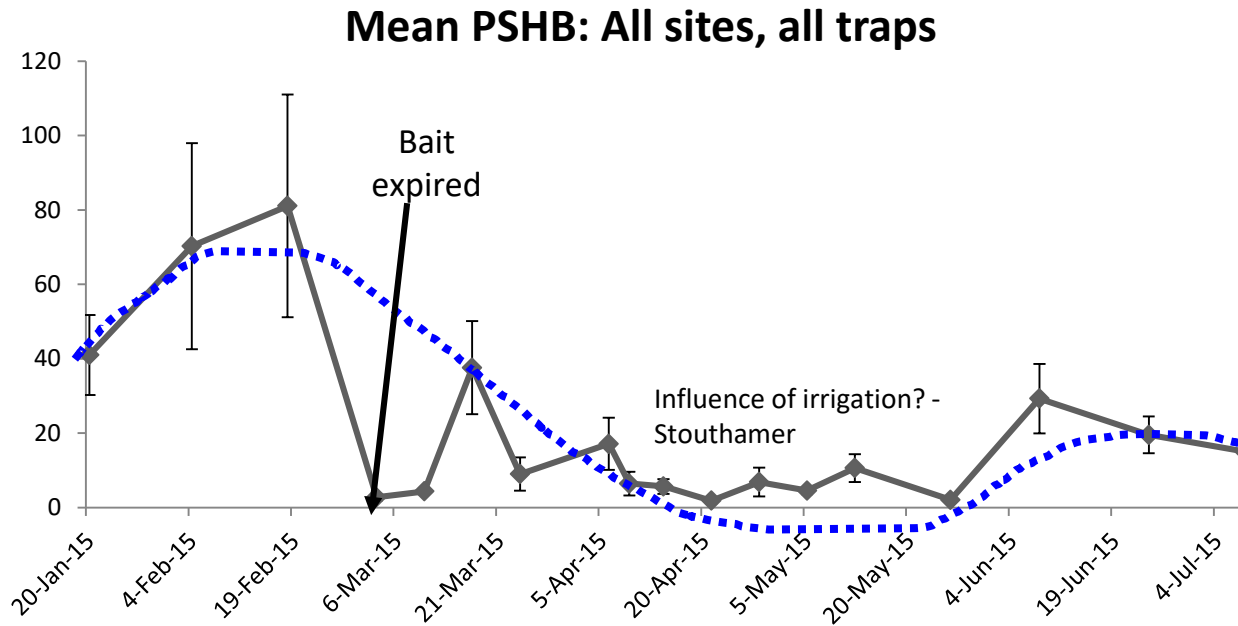
Growth of entry hole number per tree when a single female initiates the population at generation 1 and 5 daughters/ generation/mother remain on tree



Population growth when a female has 20 progeny per generation



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 The Tijuana River Valley



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

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

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



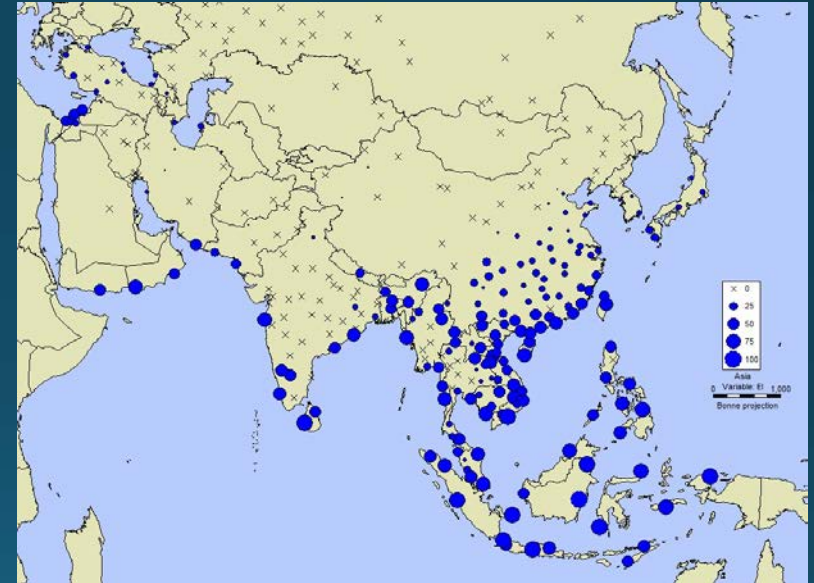
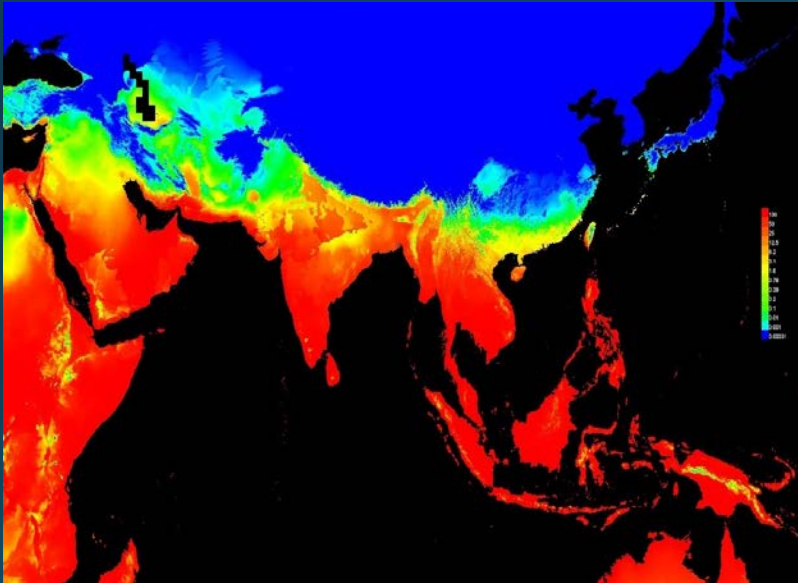
The forest at Dairy Mart Bridge after the beetle attack (February 2016).

Photos: John Boland, PhD/Southwest Wetlands Interpretive Association

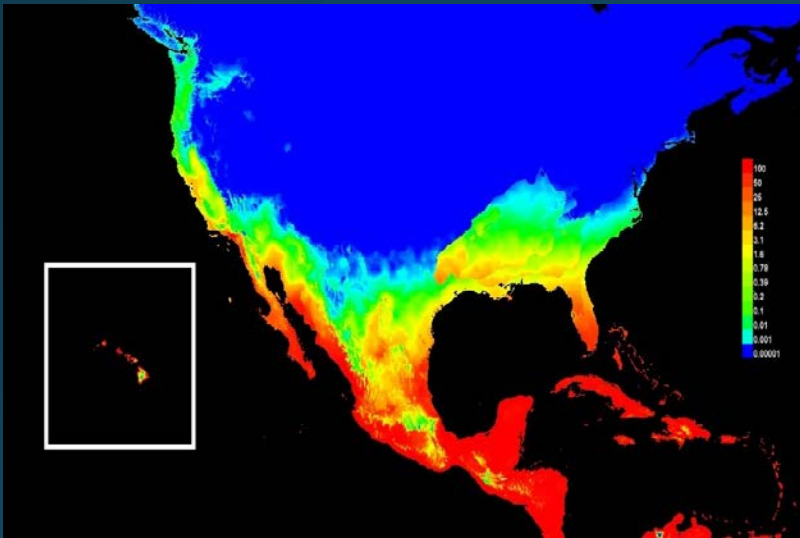
Briere model parameters

Parameter	Value
t_{\min}	14.999
t_{\max}	33.078
t_{opt}	27.581

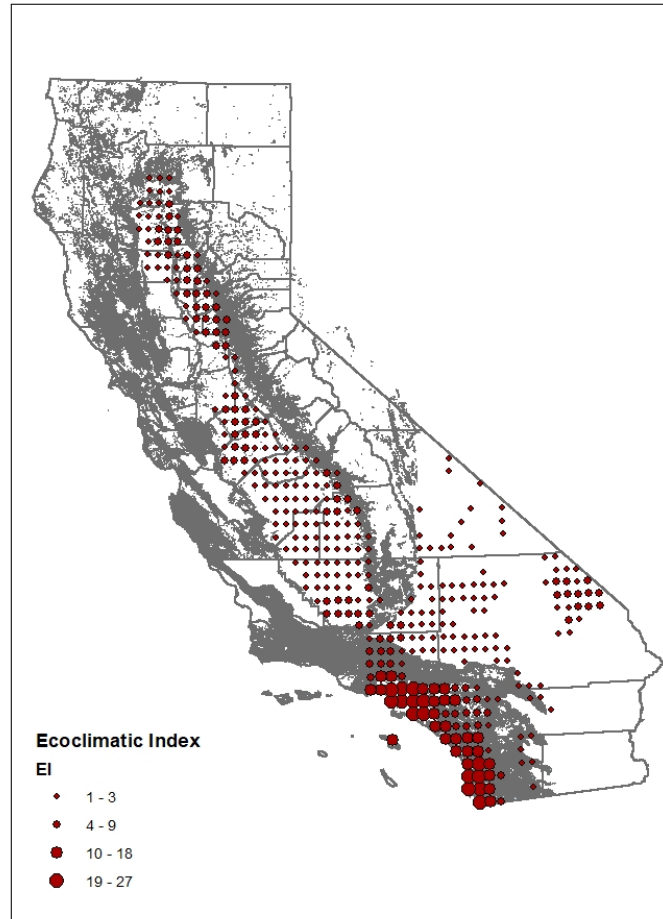
Native Distribution



US Distribution

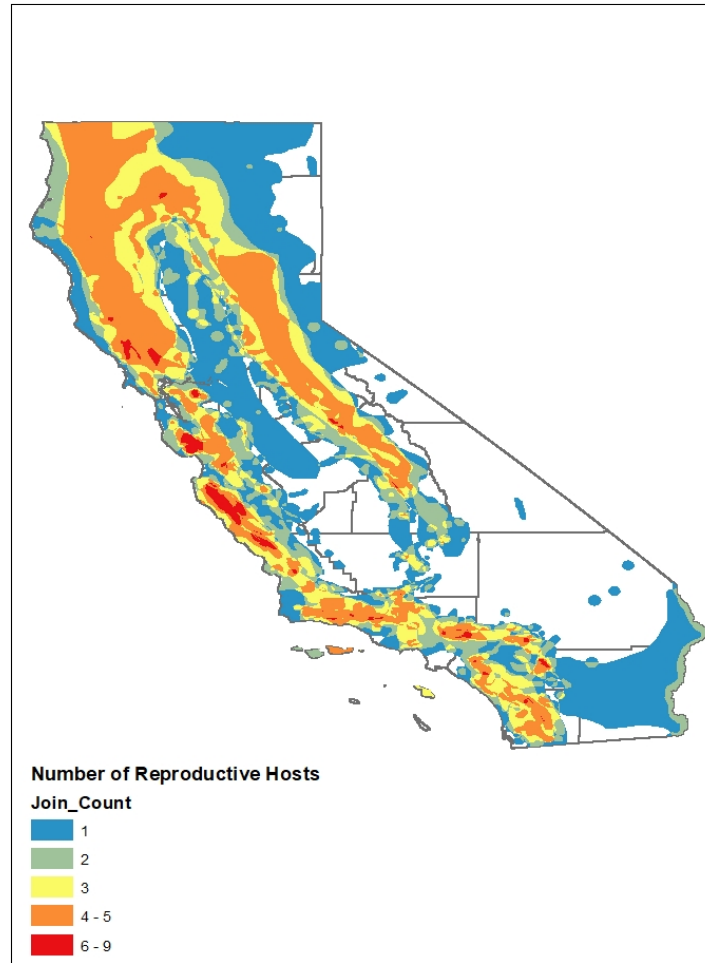


California Distribution - PSHB

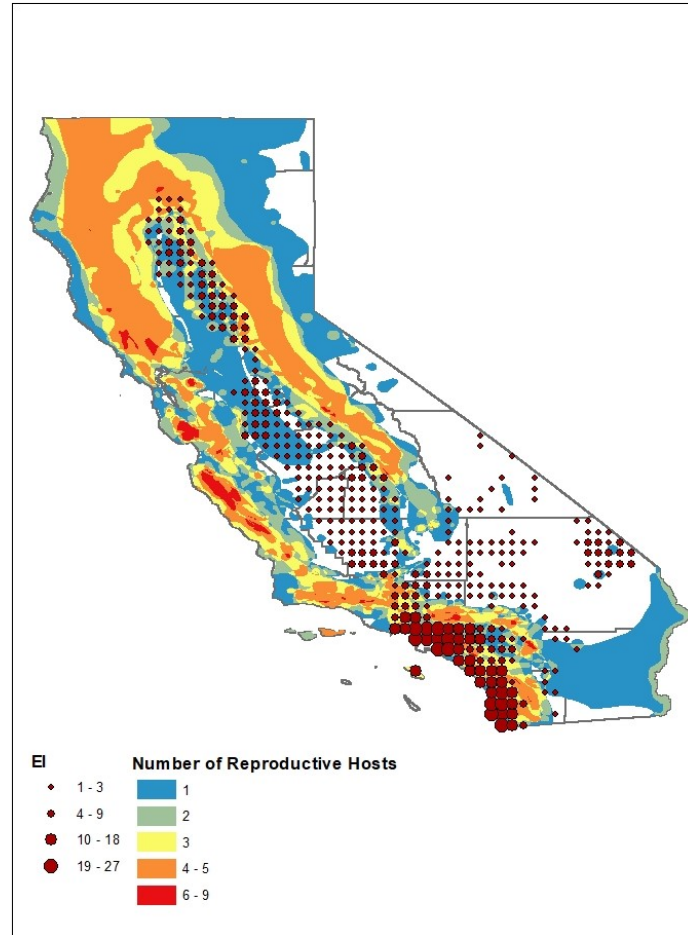


Colin Umeda, UCR

California Distribution



California Distribution





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

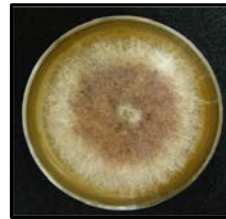
Pest Identification



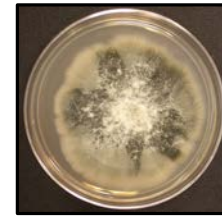
Los Angeles Co
Orange Co
San Bernardino Co
Riverside Co
Ventura Co

Polyphagous
Shot Hole Borer
PSHB

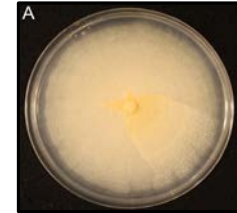
Euwallacea sp. #1



Fusarium
euwallaceae



Graphium
euwallaceae



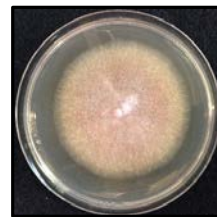
Acremonium
pembeum



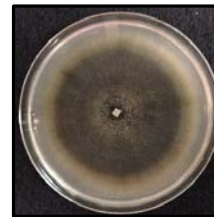
San Diego Co
San Luis
Obispo
Santa Barbara

Kuroshio Shot Hole
Borer
KSHB

Euwallacea sp. #5



Fusarium sp.



Graphium sp.

Akif Eskalen - UCR

Identification of External Signs & Symptoms

– Conducted during every day activities

- www.eskalenlab.ucr.edu and pshb.org

a. Staining



b. Frass



c. Gumming



d. Sugary exudate



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*



Photos | Monica Dimson/UCCE Orange County

Box Elder, *Acer negundo*



Photos | John Kabashima/UCCE Orange County

Red Willow, *Salix laevigata*



Photo | left: Akif Eskalen/UC Riverside; right: Monica Dimson/UCCE Orange County

Kentia Palm, *Howea forsteriana*



Photo | John Kabashima/UCCE Orange County

Kentia Palm, *Howea fosteriana*



Photo | John Kabashima/UCCE Orange County

Integrated Pest Management

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6. After action is taken, assessing the effect of pest management

Integrated Pest Management Program

Trapping, Repellents & Deterrents

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




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?



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 *Euscelinus* species that also vectors Fusarium Dieback. Both beetles are present in Southern California but are concentrated in different regions. **See their known distribution [here](#).**



Upcoming Events

Event Name	Date
Invasive Tree Posts Issues-San Diego	7/28/2016




Get PSHB Updates

[Join the PSHB Email List](#)

For Email News you can trust.

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

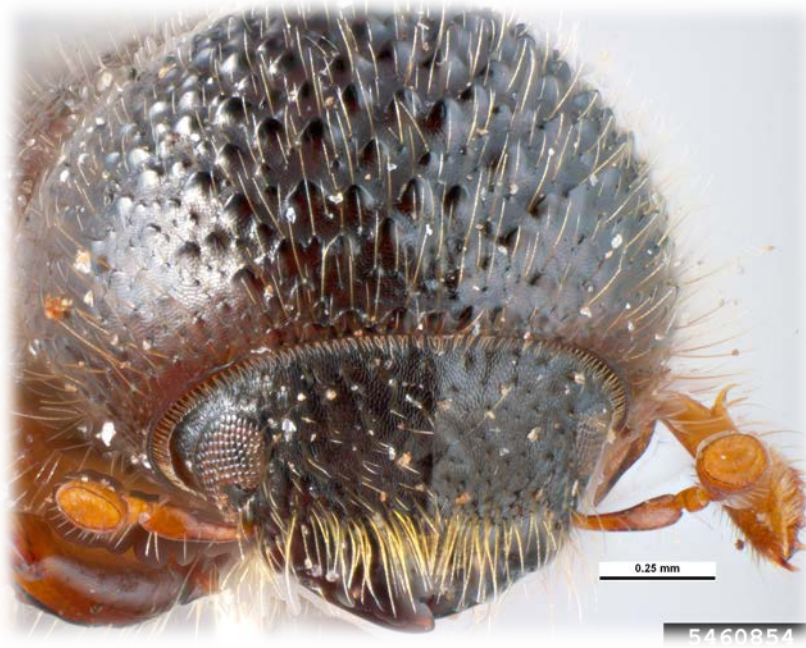
Escalenlab.ucr.edu

Irrigated Landscapes
Riparian Areas



P/K SHB
FD

52
Reproductive
Hosts



QUESTIONS?

			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				

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/Biogenesis
- 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

Long Term Strategy



- Natural enemies
- Entomopathogenic fungi
- Endophytic bacteria or fungi

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Hannah Visilis – OC UCCE

Matt Dimson – OC UCCE

Richard Demerjian, UC Irvine

Matt Deines, UC Irvine

OC Parks

California Avocado Commission

California Association of Nurseries and Garden Centers

Cal Fire

Great Scott Tree Services

RPW Services Inc.

US Forest Service

USDA Farm Bill and Specialty Crop Grants

West Coast Arborists

Photo | Monica Dimson, UC Cooperative Extension