



# Invasive Shothole Borers



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Shothole borers  
website:

ishb.org


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## Invasive Shothole Borers

Pest Overview ▾ Diagnosis ▾ Management ▾ News & Events ▾ Resources ▾ Contacts ▾




### Small Beetle, Big Problem

Invasive shothole borers (ISHB) are two closely related species of small, non-native, beetles that bore into trees. ISHB introduce fungi that cause a tree disease called *Fusarium* dieback (FD). The ISHB-FD pest-disease complex is responsible for the death of thousands of trees in Southern California and poses an imminent threat to the integrity of our urban and natural forests.

Invasive shothole borers attack a wide variety of tree species including avocados, common landscape selections, and California native species in urban and wildland environments.

For more information about invasive shothole borers and *Fusarium* dieback, view the video below and explore this website.



UC-IPM Introduction to Invasive Shothole Borers  
**An Introduction to Invasive Shothole Borers** Share

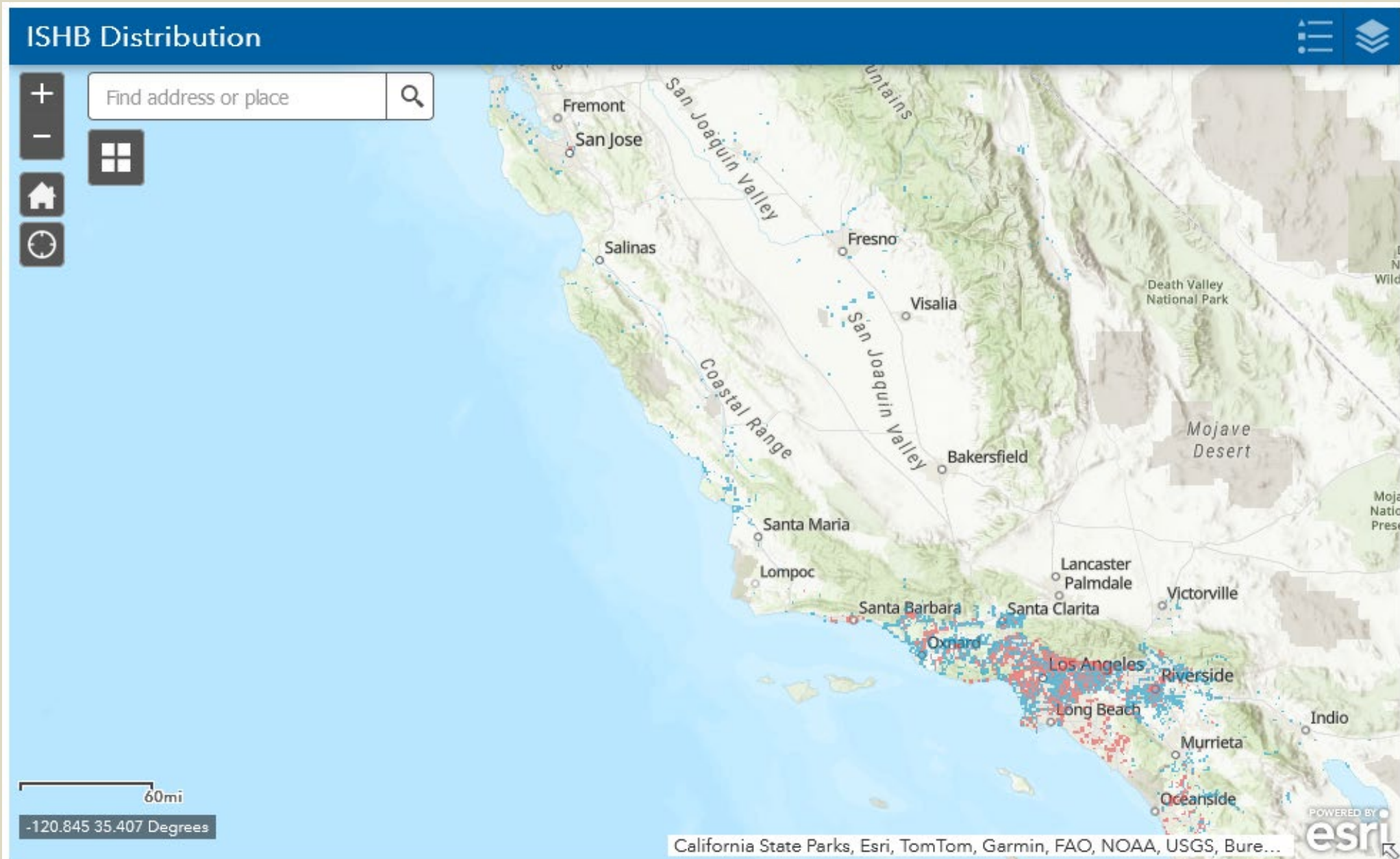
#### Online Training

[ISHB eXtension Training!](#)  
The course is served by the eXtension national online learning platform.

#### ISHB Detection & Management Assessment

Before reporting infestations, take the [ISHB Detection Assessment](#) to see if your tree is suffering from ISHB damage.

# Shothole borers: <https://ucanr.edu/sites/pshb/>



## Shothole borers update from John K. (since 2013)

1. Monitoring is key (visual and trapping)
2. So: have a tree inventory before the borers arrive!
3. Amplifier trees: identify and remove
4. Low-to-medium severity: imidacloprid (soil, injection), bifenthrin (bark); dinotefuran?
5. Also, fungicides: tebuconazole, *Bacillus subtilis*
6. IF monitored, then OK to only treat infested trees
7. Borers LOVE *Botryosphaeria*: so, remove Bot canker-infested branches, and check for Bot!

# Shothole borers Outline of this talk

1. ISHB biology
2. ISHB effects (as experienced in Southern California)
3. ISHB management options
4. ISHB planning and management considerations
5. Discussion

My goal is for you to:

1. ~ understand the basic biology of this pest
2. ~ understand effects on tree (including elevated risks!)
3. ~ understand management options, and planning considerations
4. ~ have a good overview of the educational resources

# Shothole borers My goals and your follow-up 😊

I want you to:

1. ~ understand the basic biology of this pest
2. ~ understand effects on tree (including elevated risks!)
3. ~ understand management options, and planning considerations
4. ~ have a good overview of the educational resources

What you will need to do:

- a. Spend some time with the ISHB.ORG website
- b. Set up a monitoring and/or trapping plan
- c. Decide on the management options you can accept
- d. Figure out the funding, including funding for REPLANTING
- e. Monitor → Manage/Remove → Monitor → **Replant!**

# Invasive Shot-Hole Borers / Fusarium Dieback



## Polyphagous Shot Hole Borer (PSHB)



Photos | Akif Eskalen - UCR

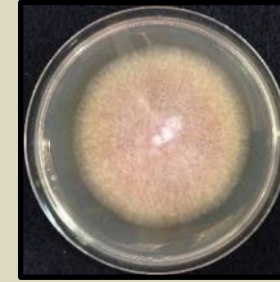


*Fusarium  
euwallaceae*

## Kuroshio Shot Hole Borer (KSHB)



Photos | Akif Eskalen - UCR

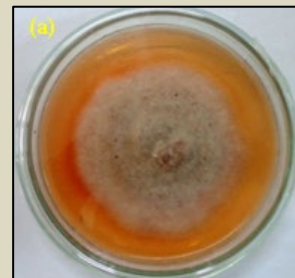


*Fusarium sp.*

## Tea Shot Hole Borer (TSHB)



Hanna Royals, Museum Collections:  
Coleoptera, USDA APHIS ITP, Bugwood.org



Cheka Kehelpannala et al. 2018  
Journal of Chemical Ecology

**Morphologically  
indistinguishable**

- DNA analysis
- ID the associated fungus

# How did they get here?

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Pallets



Packing crates



# Invasive Shot-Hole Borer / Fusarium Dieback



# PSHB effects on tree trunk and branches

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24"  
60cm



Infestation in  
main trunk



7"  
18cm

Infestation in  
branches

# Life cycle of Shot Hole Borers / Fusarium Dieback



Beetles inoculate the fungus onto gallery wall.



Females make galleries in the wood and lay eggs.



Female beetle attacks healthy host tree

# Life cycle of Shot Hole Borers / Fusarium Dieback



Developing larvae feed on the fungus in the gallery; mate with siblings.



Females leave the gallery, staying on the same host tree to make their own gallery.



Fungus continues to colonize the wood beyond the gallery wall.



# Life cycle of Shot Hole Borers / Fusarium Dieback



Fungus causes branch dieback and tree mortality.



Female beetle attacks healthy host tree



When the host tree dies, adults leave the host to find a new host.

# Amplifier tree concept



When some preferred host trees are infested, beetles will **STAY** on their “birth tree” until it declines



- Some trees get badly infested and “produce” a lot of beetles
- Amplifiers will not recover; but “their” beetles will pressure neighboring trees
- Remove amplifier trees!**
- Use traps to assess effect
- Then **replant!**



# Reproductive Host Species (March 2018) 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. Castorbean (*Ricinus communis*)
7. **California Sycamore (*Platanus racemosa*)\***
8. Mexican sycamore (*Platanus mexicana*)
9. **Red Willow (*Salix laevigata*)\***
10. **Arroyo willow (*Salix lasolepis*)\***
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 (*Cercidium 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. Camelia (*Camellia semiserrata*)
32. Acacia (*Acacia* spp.)
33. Japanese wisteria (*Wisteria floribunda*)
34. **Black willow (*Salix gooddingii*)\***
35. Tree of heaven (*Ailanthus altissima*)
36. Kurrajong (*Brachychiton populneus*)
37. Black mission fig (*Ficus carica*)\*\*
38. Japanese beech (*Fagus crenata*)
39. Dense logwood (*Xylosma avilae*)
40. Mule Fat (*Baccharis salicina*)\*
41. Black Poplar (*Populus nigra*)\*
42. Carrotwood (*Cupaniopsis anacardioides*)
43. California buckeye (*Aesculus californica*)\*
44. Canyon Live oak (*Quercus chrysolepis*)\*
45. Kentia Palm (*Howea forsteriana*)
46. King Palm (*Archontophoenix cunninghamiana*)
47. Tamarix (*Tamarix ramosissima*)
48. Red Flowering Gum (*Eucalyptus ficifolia*)\*
49. American Sweetgum (*Liquidambar styraciflua*)
50. Honey Locust (*Gleditsia triacanthos*)
51. Brazilian Coral Tree (*Erythrina falcata*)
52. Purple Orchid Tree (*Bauhinia variegata*)\*
53. Council Tree (*Ficus altissima*)\*
54. Tulip Wood (*Harpulia pendula*)
55. Chinese Flame Tree (*Koelreuteria bipinnata*)\*
56. Laurel-leaf Snailseed tree (*Cocculus laurifolius*)
57. Southern Magnolia (*Magnolia grandiflora*)
58. Jacaranda (*Jacaranca mimosifolia*)\*\*
59. Coast coral tree (*Erythrina caffra*)\*\*
60. Australian blackwood (*Acacia melanoxylon*)\*\*
61. Sweet Bay (*Magnolia virginiana*)\*\*
62. African Tulip Tree (*Spathodea campanulata*)\*\*
63. Strawberry snowball tree (*Dombeya cacuminum*)\*\*
64. Chinese Wingnut (*Pterocarya stenoptera*)\*\*

\*18 species native to California

\*\* Canker associated

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

## Which tree species are susceptible?



247 species of trees attacked,

BUT:

“only” 78 species of trees  
can support ISHB reproduction

AND

“only” about 17 tree  
species are killed

See: UC IPM Pest Note

[https://ipm.ucanr.edu/legacy\\_assets/pdf/pestnotes/pninvasiveshotholeborer.pdf](https://ipm.ucanr.edu/legacy_assets/pdf/pestnotes/pninvasiveshotholeborer.pdf)

Table 1. Current list of confirmed ISHB-FD reproductive hosts.

### Hosts killed by ISHB-FD

Latin Name	Common Name
<i>Acer buergerianum</i>	Trident maple
<i>Acer macrophyllum</i>	Big leaf maple*
<i>Acer negundo</i>	Box elder*
<i>Acer palmatum</i>	Japanese maple
<i>Liquidambar styraciflua</i>	American sweet gum
<i>Parkinsonia aculeata</i>	Palo verde
<i>Platanus racemosa</i>	California sycamore*
<i>Platanus x acerifolia</i>	London plane
<i>Populus fremontii</i>	Fremont cottonwood*
<i>Populus nigra</i>	Black poplar*
<i>Populus trichocarpa</i>	Black cottonwood*
<i>Quercus lobata</i>	Valley oak*
<i>Quercus robur</i>	English oak
<i>Ricinus communis</i>	Castorbean
<i>Salix gooddingii</i>	Black willow*
<i>Salix laevigata</i>	Red willow*
<i>Salix lasiolepis</i>	Arroyo willow*

### Hosts NOT killed by ISHB-FD

Latin Name	Common Name
<i>Acacia melanoxydon</i>	Australian blackwood
<i>Acacia mearnsii</i>	Black wattle†
<i>Acacia spp.</i>	Acacia
<i>Acer paxii</i>	Evergreen maple
<i>Acer saccharinum</i>	Silver leaf maple
<i>Aesculus californica</i>	California buckeye*
<i>Ailanthus altissima</i>	Tree of heaven
<i>Albizia julibrissin</i>	Mimosa
<i>Alectryon excelsus</i>	Titoki
<i>Alnus rhombifolia</i>	White alder*
<i>Archontophoenix cunninghamiana</i>	King palm

### Hosts NOT killed by ISHB-FD

Latin Name	Common Name
<i>Cocculus laurifolius</i>	Laurel leaf snailseed tree
<i>Combretum kraussii</i>	Forest bushwillow†
<i>Corymbia ficifolia</i>	Red flowering gum
<i>Cupaniopsis anacardioides</i>	Carrotwood
<i>Dombeya cacuminum</i>	Strawberry tree
<i>Erythrina caffra</i>	Coast coral tree
<i>Erythrina coralloides</i>	Coral tree
<i>Erythrina falcata</i>	Brazilian coral tree
<i>Fagus crenata</i>	Japanese beech
<i>Ficus altissima</i>	Council tree
<i>Ficus carica</i>	Black mission fig
<i>Gleditsia triacanthos</i>	Honey locust
<i>Harpullia pendula</i>	Tulip wood
<i>Howea forsteriana</i>	Kentia palm
<i>Ilex cornuta</i>	Chinese holly
<i>Jacaranda mimosifolia</i>	Jacaranda
<i>Koelreuteria bipinnata</i>	Chinese flame tree
<i>Magnolia grandiflora</i>	Southern magnolia
<i>Magnolia virginiana</i>	Sweet bay
<i>Persea americana</i>	Avocado
<i>Platanus mexicana</i>	Mexican sycamore
<i>Podalyria calyptrata</i>	Keurtijet
<i>Populus tremuloides</i>	Quaking aspen
<i>Prosopis articulata</i>	Mesquite*
<i>Psoralea pinnata</i>	Fountain bush†
<i>Pterocarya stenoptera</i>	Chinese wingnut
<i>Ptychosperma elegans</i>	Solitaire palm
<i>Quercus agrifolia</i>	Coast live oak*
<i>Quercus chrysolepis</i>	Canyon live oak*
<i>Quercus engelmannii</i>	Engelmann oak*
<i>Quercus macrocarpa</i>	Bur oak



## Which tree species should you focus on?

~ the 17 species that get killed

~ especially:

**Box Elder**

Sycamore

Willows

Castorbean

In city parks and street trees,  
also keep an eye on:

London Plane Tree

English oak

~ these species will be hit FIRST,  
and they will be hit HARDEST

~ once these preferred hosts are  
near death, the beetles will move  
on to less desirable hosts

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## Trapping and surveying



Lindgren  
Funnel Trap



Elm leaf beetle sticky trap

~ traps are only effective at short distances

~ traps can best be used to assess intensity of infestation, and effectiveness of control

However...

~ visual surveys can be **HIGHLY EFFECTIVE**, esp. for new infestations

~ Focus your effort on the 17 doomed species; especially on **BOX ELDERS**

~ Also: check riparian trees!

~ And keep records!

What are we looking for? Holes! < 1 mm, perfectly round



Number of holes indicate SEVERITY

- **Low Infestation Level:  $< 50$**
- **Moderate Infestation Level:  $\geq 50$  and  $< 150$**
- **Heavy Infestation Level:  $\geq 150$**
- **Severe Infestation Level:  $\geq 150$  + ISHB-related dieback**

→ Severe infestation = no recovery

→ Are the holes still “active?” Paint over, and see if the beetle re-opens the hole

1: Low (<50)



2: Moderate (50-150)



3: Heavy (>150) Without Dieback



4: Severe (>150) With Dieback



Branch Collar



## Management philosophy

### 1. Eradication is unlikely

→ So focus on reducing ISHB pressure

### 2. Severely infested and/or amplifier trees will not recover

→ So remove them early to reduce pest pressure

### 3. Need continuous monitoring

→ Visual surveys AND trapping

### 4. Consider WHICH OPTIONS you can actually use!

→ Everyone should plan on **re-planting quickly**

# Control Options

## Cultural / Sanitation

- Tree removal
- Pruning infested branches
- Pruning wound protection
- Chipping, Solarization/ fumigation
- Restrict firewood movement

## Chemical

- Beetle and/or Fungal Symbionts
- Trunk sprays
- Systemic-Soil injection/drench, trunk injection

## Attract & Kill Traps and deterrents

- Lure-Pesticides and deterrents

## Biocontrol

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

## Management flow

1. Consider your site, situation, and management goals  
~ e.g.: urban trees vs. regional park
2. Consider the value of a tree, and its risk  
~ e.g.: heritage tree; tree in school yard
3. Determine if the tree is a reproductive host
4. Consult the matrix for management options
5. Perform the work; continue monitoring; replant!



## Management matrix: High Value tree

### ISHB Infestation Level & Management Options for High Value Trees

Host Type	Hazard Level	No Infestation	Low Infestation	Moderate Infestation	Heavy Infestation	Severe Infestation
Reproductive Host	Low	Monitor	Treat and/or remove infested branches*	Treat and/or remove infested branches*	Treat and/or remove infested branches*	Remove tree & stump
Reproductive Host	High	Monitor	Treat and/or remove infested/hazard branches*	Treat and/or remove infested branches*	Remove infested branches*, or remove tree & stump	Remove tree & stump
Non-Reproductive Host	Low	Monitor	Monitor	Notify your local UCCE office; consult with ISHB-FD experts to determine if species is a new reproductive host		
Non-Reproductive Host	High	Monitor	Monitor	Notify your local UCCE office; consult with ISHB-FD experts to determine if species is a new reproductive host		

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# Management matrix

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Non-Reproductive Host	High	Monitor	Monitor	Notify your local UCCE office; consult with ISHB-FD experts to determine if species is a new reproductive host		

## Wood management

1. Grind out the stump, if at all possible
  - ~ beetles will continue to emerge from stump!
2. Chipping: to 1" (>99% kill), or to 3" (98% kill)
  - ~ for total kill, either compost or solarize chips
3. Wood: solarize on-site, or kiln-dry
  - ~ solarization may take excessively long;
  - ~ DO NOT MOVE un-covered wood!

## Resources

### 1. ISHB website

~ handouts, webinars, videos

~ you should spend 1-2 hours here! 😊

### 2. eXtension on-line course (that's "E-extension" 😊)

~ requires registration (but is free!)

### 3. County Ag. Commissioner's Office

### 4. California Dept. of Food and Agriculture

### 5. UC Cooperative Extension, and UC Davis

Thank you!

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