Biology and management of the goldspotted oak borer and polyphagous shot hole borer

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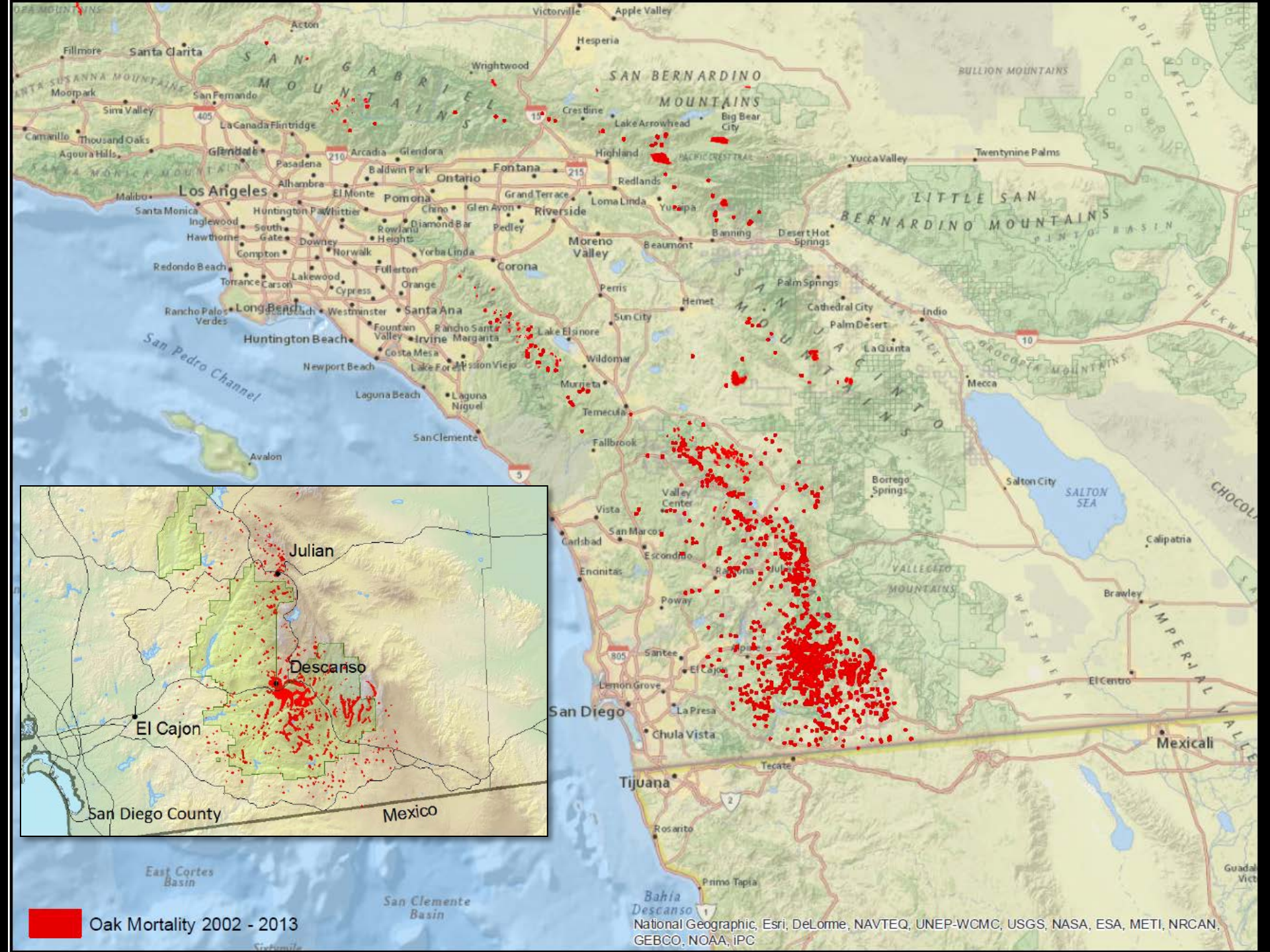
Goldspotted oak borer (GSOB) (*Agrilus auroguttatus*)

Background

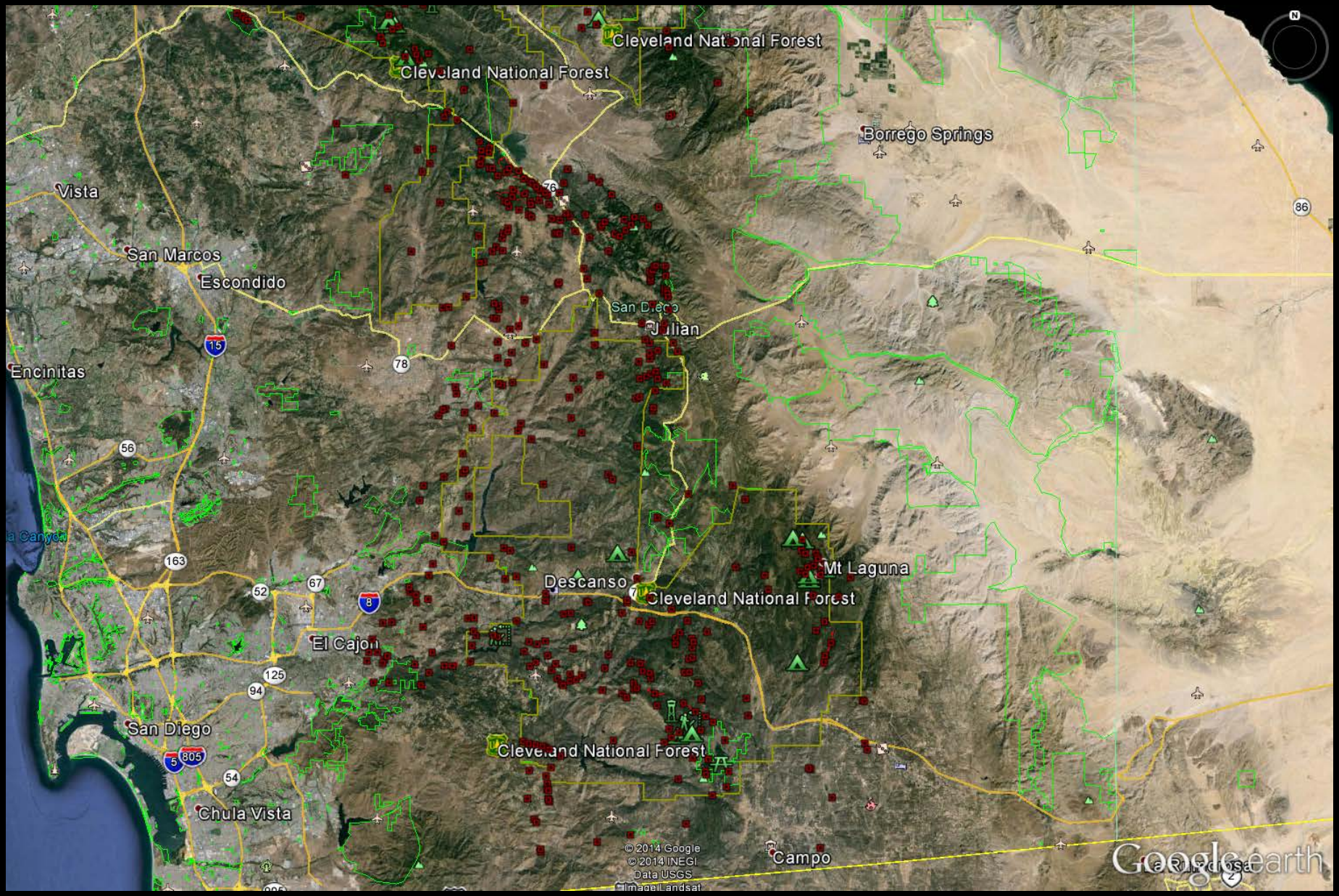
- GSOB was likely introduced to California from Arizona
- GSOB favors large diameter red oaks
  - Coast live oak
  - California black oak
- GSOB completes one generation a year, adults fly from May to September and larvae feed from July to November

GSOB larval feeding

- Larval feeding girdles a tree's cambium
- Several years of repeated larval feeding are required to kill a tree

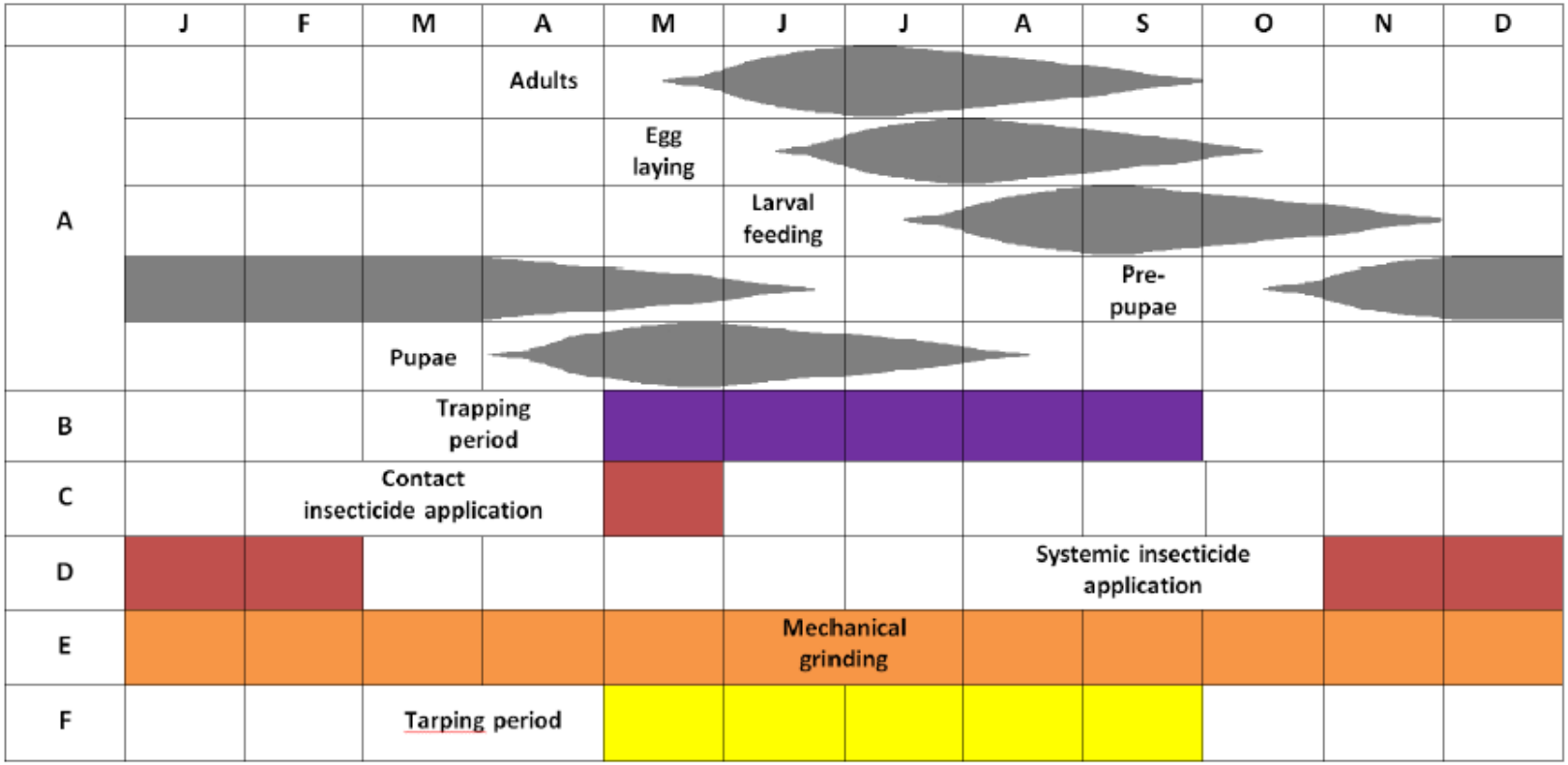

Julian
Descanso
El Cajon
San Diego County
Mexico
Oak Mortality 2002 - 2013
National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC

2014 mapped oak mortality



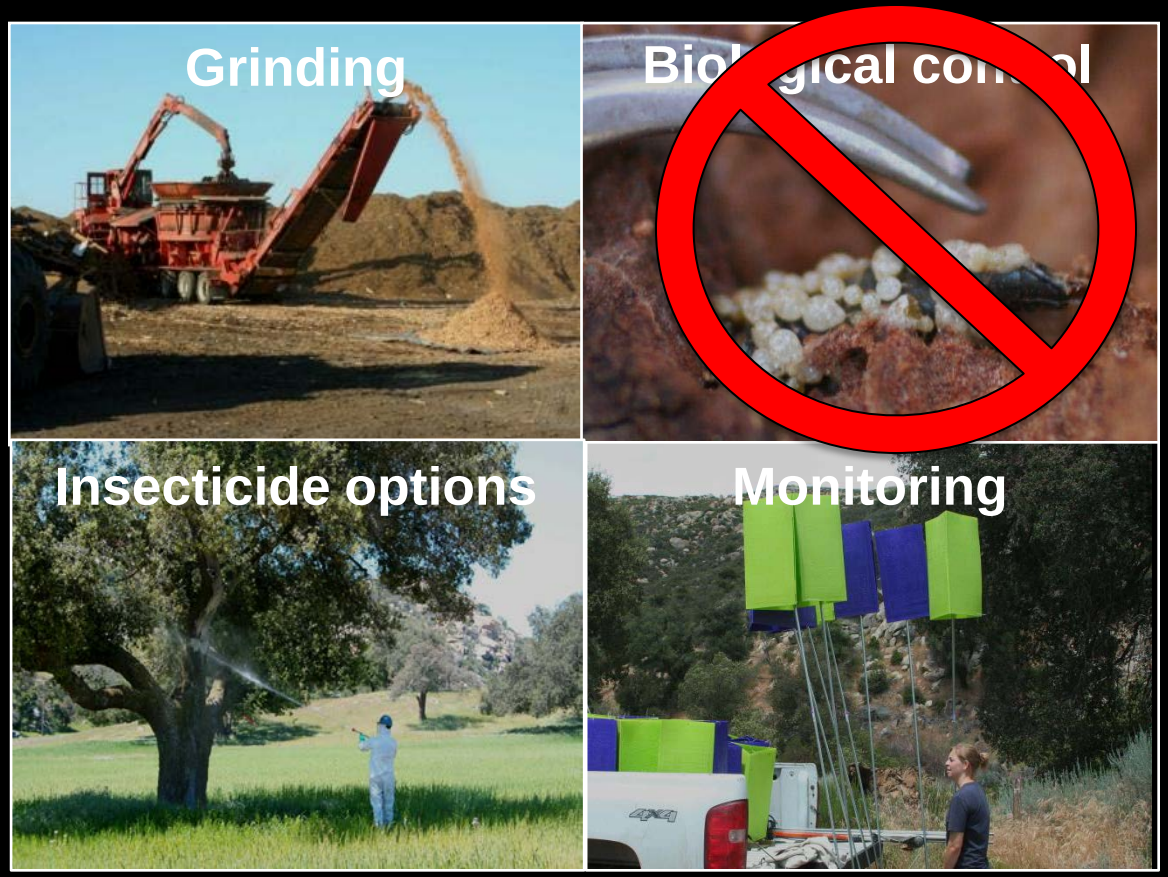
GSOB integrated pest management

Table 1. Approximate timing of the goldspotted oak borer, *Agrilus auroguttatus*, life cycle in southern California (A) and optimal timing of trapping period (B); application of contact (C) and systemic insecticides (D); and timing of mechanical grinding and tarping of infested oak wood for the goldspotted oak borer (E).



- Forest Insect and Disease Leaflet
  - Coming out late 2014 or early 2015

GSOB integrated pest management



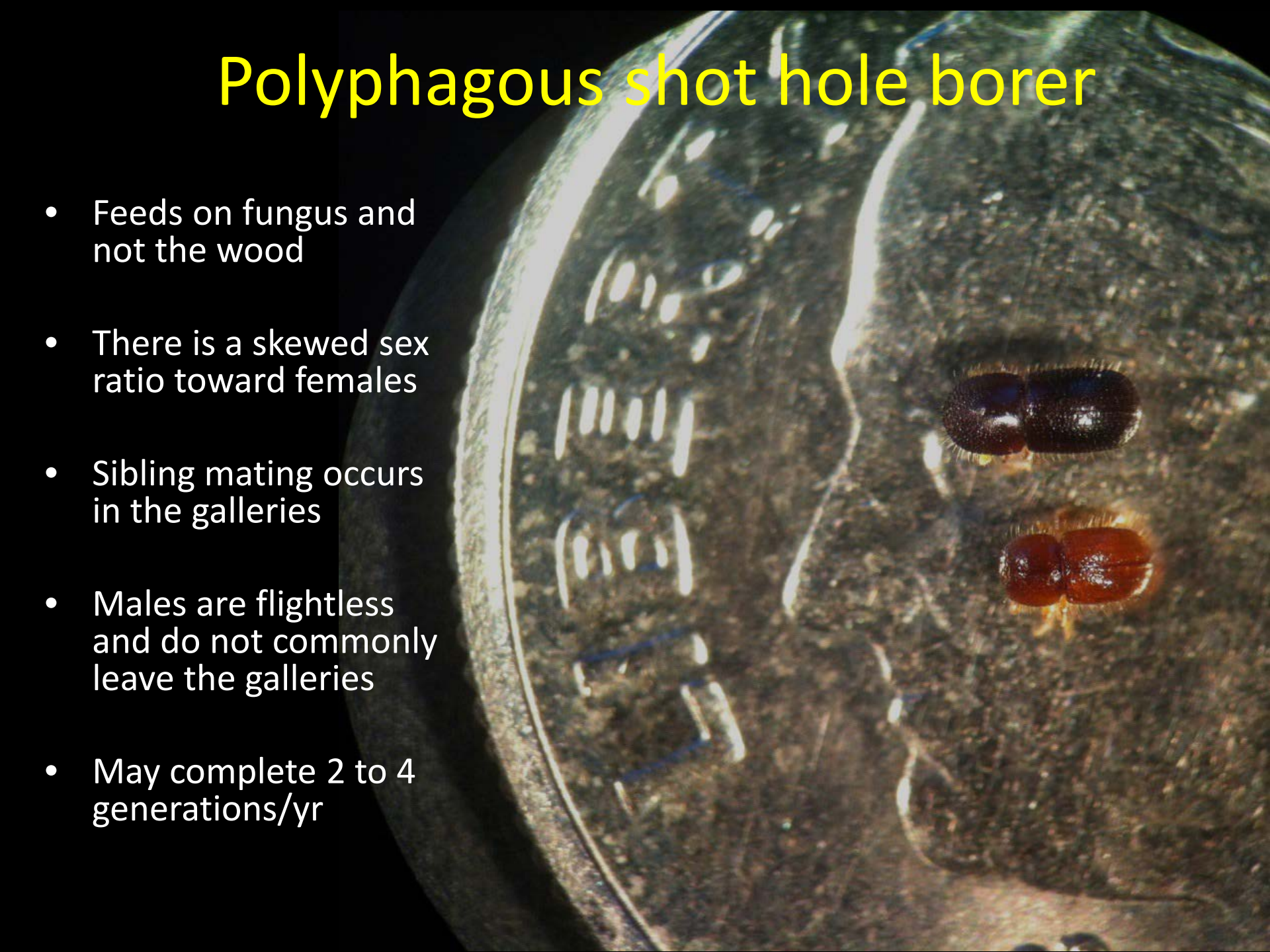
- Developing an IPM program for high-value sites
  - Include monitoring, tree removal, and specific plans for preventative treatments

Polyphagous shot hole borer (PSHB), *Euwallacea* sp.

- First detected in California in 2003
  - Insect/disease complex not linked to tree injury and mortality until 2012 in LA County
- PSHB was initially believed to be the tea shot hole borer, *Euwallacea fornicatus*
  - Recent DNA work suggests PSHB may be a new species and this same species is found in Israel
  - Our PSHB population may be from Vietnam/ S. China

Polyphagous shot hole borer

- Feeds on fungus and not the wood
- There is a skewed sex ratio toward females
- Sibling mating occurs in the galleries
- Males are flightless and do not commonly leave the galleries
- May complete 2 to 4 generations/yr



Insect/Disease complex: PSHB and Fusarium dieback

- PSHB carries several fungi
  - *Fusarium euwallaceae* (new species)
  - *Graphium* sp.
  - *Sarocladium* sp.
  - Eskalen (UCR) is conducting pathogenicity tests with each fungus

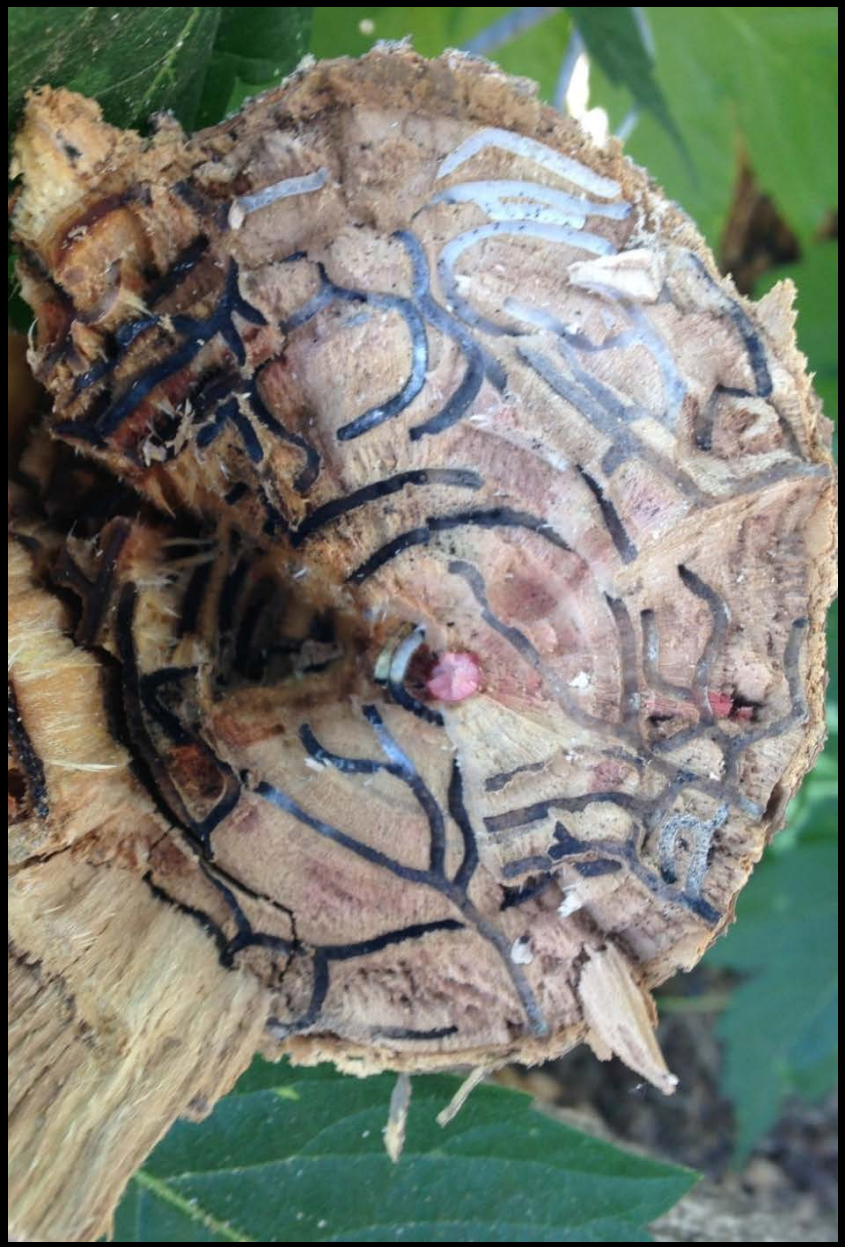
PSHB known host species

Table 1. Known reproductive hosts, agricultural crop hosts and native species hosts of the polyphagous shot hole borer/fusarium dieback disease complex as of February 2014[a].

	Reproductive Hosts	Agricultural Crop Hosts	Native Species Hosts
1.	Box elder (*Acer negundo*)	Avocado (*Persea americana*)	California box elder (*Acer negundo* var. *californicum*)
2.	Castor bean (*Ricinus communis*)	Japanese persimmon (*Diospyros kaki*)	Coast live oak (*Quercus agrifolia*)
3.	Avocado (*Persea americana*)	Olive (*Olea europa*)	California sycamore (*Platanus racemosa*)
4.	English oak (*Quercus robur*)	Macadamia (*Macadamia integrifolia*)	Big leaf maple (*Acer macrophyllum*)
5.	Coast live oak (*Q. agrifolia*)	Mulberry (*Morus* spp.)	Red willow (*Salix laevigata*)
6.	California sycamore (*Platanus racemosa*)	Hazelnut (*Corylus colurna*)	Valley oak (*Q. lobata*)
7.	Big leaf maple (*A. macrophyllum*)	Loquat (*Eriobotrya japonica*)	Blue palo verde (*Parkinsonia florida*)
8.	Mimosa (*Albizia julibrissin*)	Peach (*Prunus persica*)	Engelmann oak (*Q. engelmanii*)
9.	Coral tree (*Erythrina corallodendron*)	Grape (*Vitis vinifera*)	White alder (*Alnus rhombifolia*)
10.	Titoki (*Alectryon excelsus*)	Sweet orange (*Citrus sinensis*)	Canyon live oak (*Q. chrysolepis*)
11.	Blue palo verde (*Parkinsonia florida*)	Cassava (*Manihot esculenta*)	California bay laurel (*Umbellularia californica*)
12.	Tortuosa (*Salix matsudana*)		Desert fan palm (*Washingtonia filifera*)
13.	Weeping willow (*S. babylonica*)		California buckeye (*Aesculus californica*)
14.	Red willow (*S. laevigata*)		Velvet ash (*Fraxinus velutina*)
15.	Trident maple (*A. buergerianum*)		Coffee berry (*Rhamnus californica*)
16.	Japanese maple (*A. palmatum*)		
17.	Evergreen maple (*A. paxii*)		
18.	Chinese holly (*Ilex cornuta*)		
19.	Brea (*Cercidium sonorae*)		
20.	Black bean (*Castanospermum australe*)		
21.	Camellia (*Camellia semiserrata*)		
22.	Cork oak (*Q. suber*)		
23.	Red flowering gum (*Eucalyptus ficifolia*)		
24.	Engelmann oak (*Q. engelmanii*)		
25.	Palo verde (*P. aculeata*)		
26.	Sweetgum (*Liquidambar styraciflua*)		

[a]For a complete list of all host species see: Eskalen et al. 2013. Plant Disease 97(7):938-951.

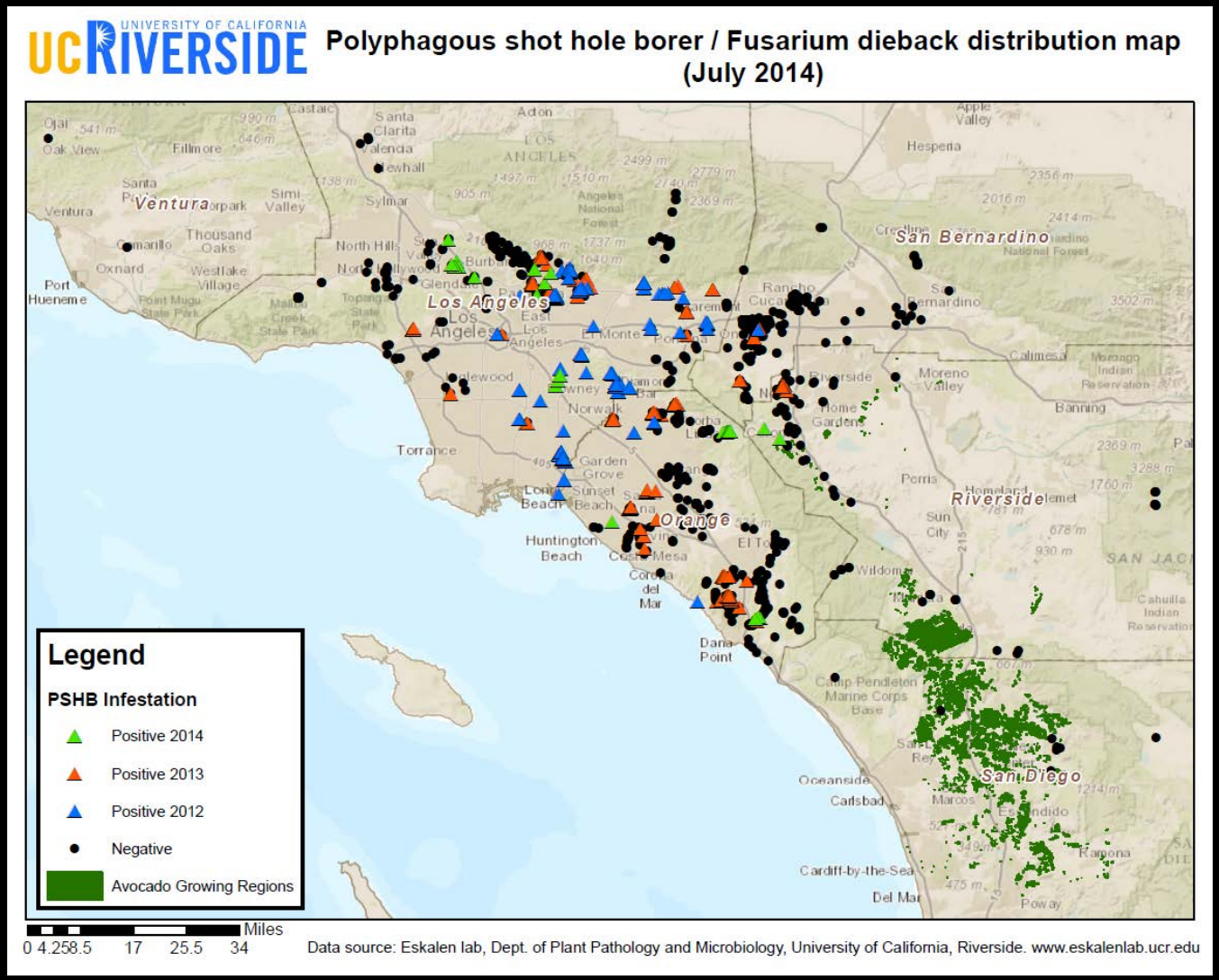
PSHB injury symptoms



- PSHB larval galleries

- Box elder killed by PSHB

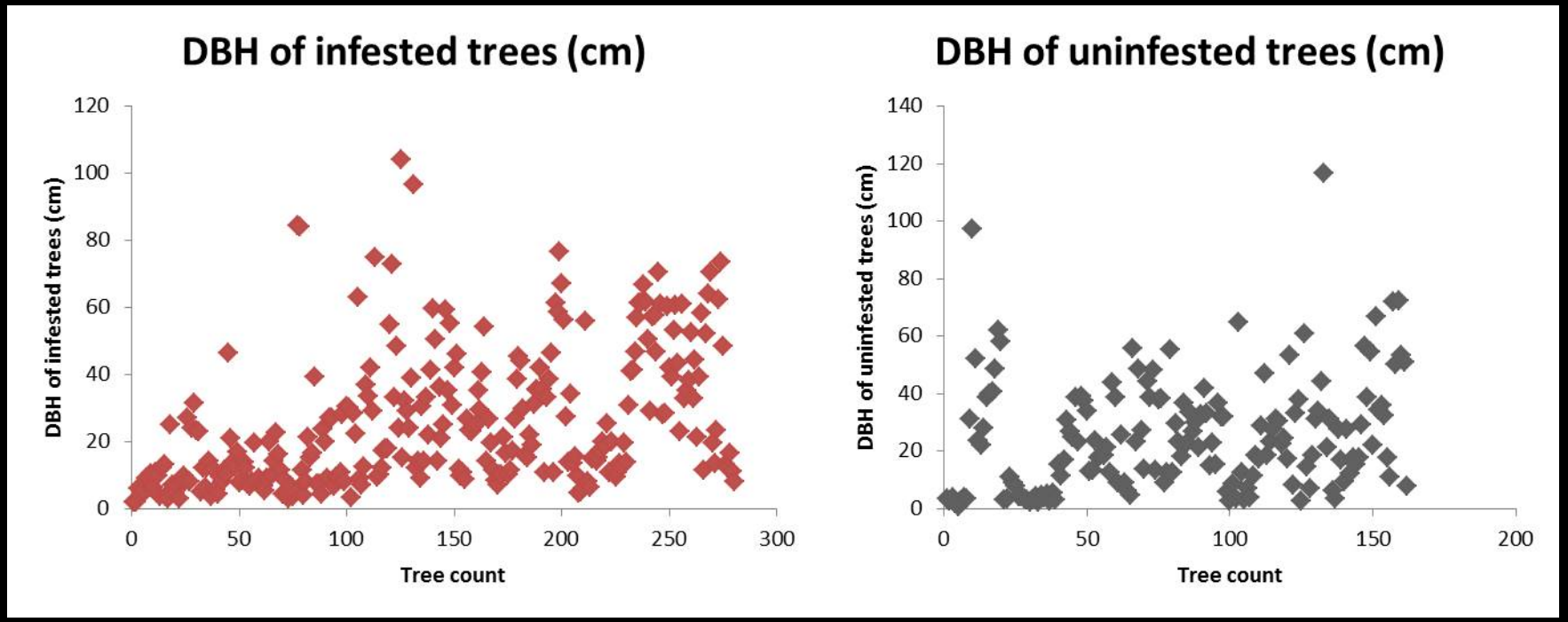
Current distribution of PSHB in CA



- Infested counties:
  - Los Angeles
  - Orange
  - Riverside
  - San Bernardino
  - San Diego

- El Cajon (San Diego Co.): Recent detection of PSHB
  - Population may be from Taiwan

Preliminary survey data:



- PSHB attacks all size classes
  - DBH range of infested trees: <1 to 40.9 inches
- Attacks are more common along the main stem

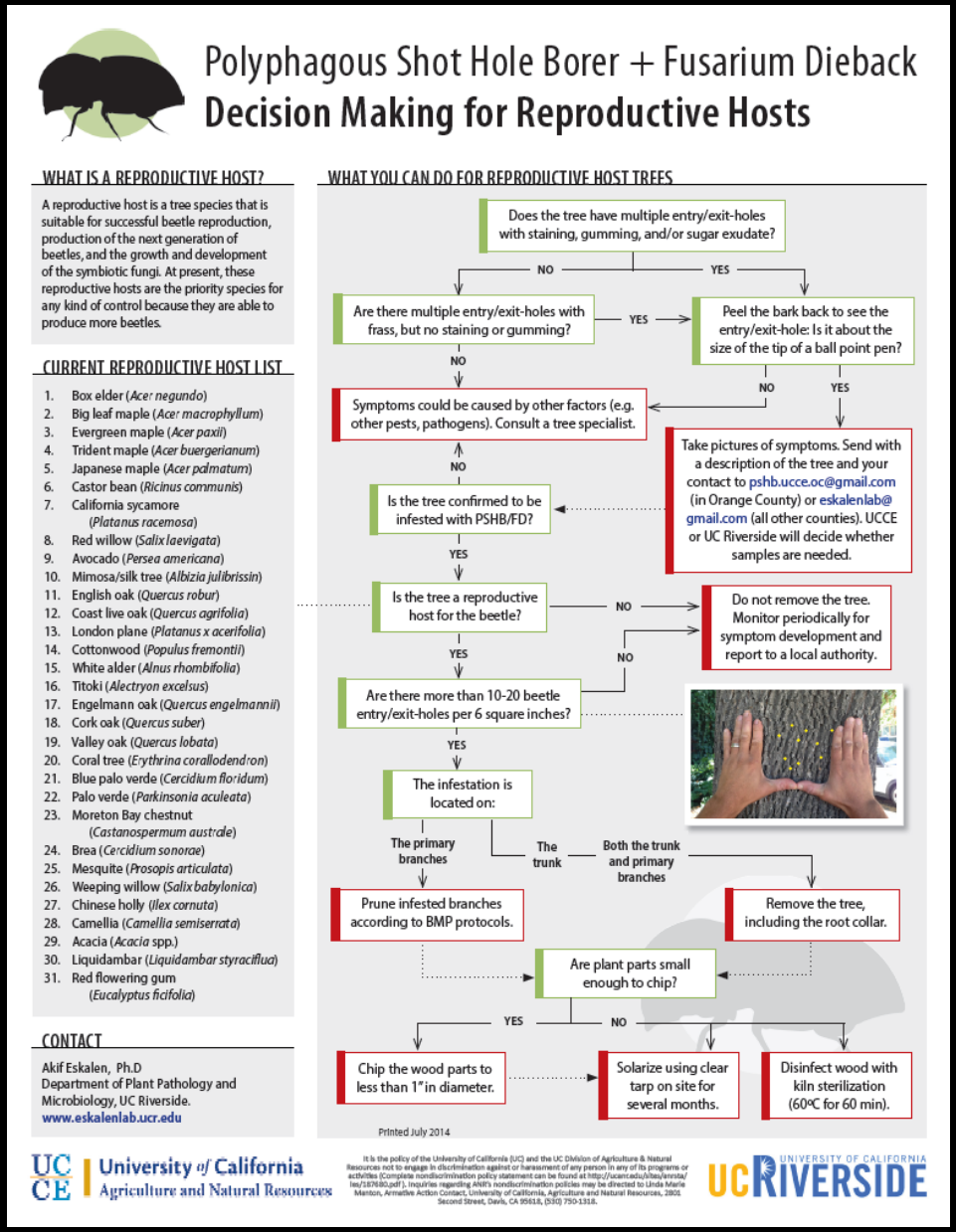
Preliminary survey data:

- ~800 trees surveyed across four sites

Species	% infested (% severely injured) (% dead with PSHB)
Box elder	89% (83%) (30%)
Red willow	83% (49%) (17%)
Castor bean	68% (71%) (16%)
Willow sp.	88% (0%) (7%)
California sycamore	77% (25%) (5%)
Fremont cottonwood	60% (61%) (4%)
White alder	74% (18%) (2%)
Ash spp.	32% (8%) (0%)
Coast live oak	23% (0%) (0%)
California walnut	23% (0%) (0%)

PSHB management

- Management options for PSHB are similar to GSOB:
  - Tree removal
  - Tarping/solarization
  - Chipping
  - Insecticide options
    - Systemic and contact
  - Fungicide options
  - Biological control
    - For fungi and insects



Polyphagous Shot Hole Borer + Fusarium Dieback
Decision Making for Reproductive Hosts

WHAT IS A REPRODUCTIVE HOST?

A reproductive host is a tree species that is suitable for successful beetle reproduction, production of the next generation of beetles, and the growth and development of the symbiotic fungi. At present, these reproductive hosts are the priority species for any kind of control because they are able to produce more beetles.

CURRENT REPRODUCTIVE HOST 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. Red willow (*Salix laevigata*)
9. Avocado (*Persea americana*)
10. Mimosa/silk tree (*Albizia julibrissin*)
11. English oak (*Quercus robur*)
12. Coast live oak (*Quercus agrifolia*)
13. London plane (*Platanus x acerifolia*)
14. Cottonwood (*Populus fremontii*)
15. White alder (*Alnus rhombifolia*)
16. Titoki (*Alectryon excelsus*)
17. Engelmann oak (*Quercus engelmannii*)
18. Cork oak (*Quercus suber*)
19. Valley oak (*Quercus lobata*)
20. Coral tree (*Erythrina corallodendron*)
21. Blue palo verde (*Cercidium floridum*)
22. Palo verde (*Parkinsonia aculeata*)
23. Moreton Bay chestnut (*Castanospermum australe*)
24. Brea (*Cercidium sonorae*)
25. Mesquite (*Prosopis articulata*)
26. Weeping willow (*Salix babylonica*)
27. Chinese holly (*Ilex cornuta*)
28. Camellia (*Camellia semiserrata*)
29. Acacia (*Acacia* spp.)
30. Liquidambar (*Liquidambar styraciflua*)
31. Red flowering gum (*Eucalyptus ficifolia*)

CONTACT

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WHAT YOU CAN DO FOR REPRODUCTIVE HOST TREES

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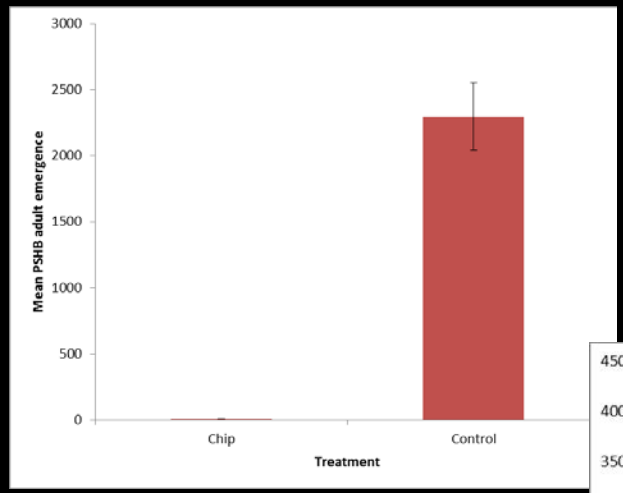
Management options in development for an IPM program

- Monitoring/Surveys
  - Need an effective lure
  - Ground surveys are currently the best survey tool
- Management
  - Prophylactic treatments – protect trees before they are infested
  - Remedial treatments – interfere with beetle and fungi after infestation
  - Long term solutions – biological control
- Work being conducted by FHP, UCR, private companies, APHIS, ARS, counties, etc.

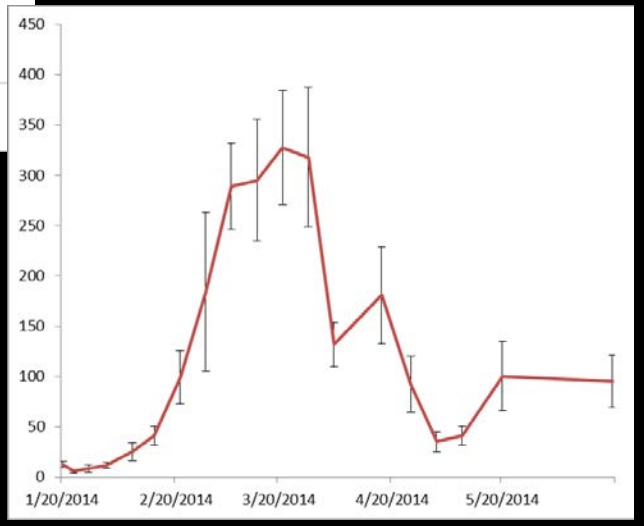
Management options

- Sycamore, red willow, and coast live oak
  - Chipped into ~1 inch pieces
- Total adult PSHB emergence:
  - Chips: 56
  - Control logs: 16,085



- Chipping wood was >99% effective at killing PSHB

- Beetles emerged from wood ~4 mo after tree was cut



Management options

- Insecticide work is being conducted primarily by Tim Paine's lab (UCR)

- Insecticide options
  - Imidacloprid
  - Dinotefuran
  - Bifenthrin
  - Clothianidin- not effective in initial trails

Reduced PSHB attacks in initial trials

- Unknowns:
  - If these treatments can save infested trees
  - Retreatment times
  - Insecticide and fungicide applications

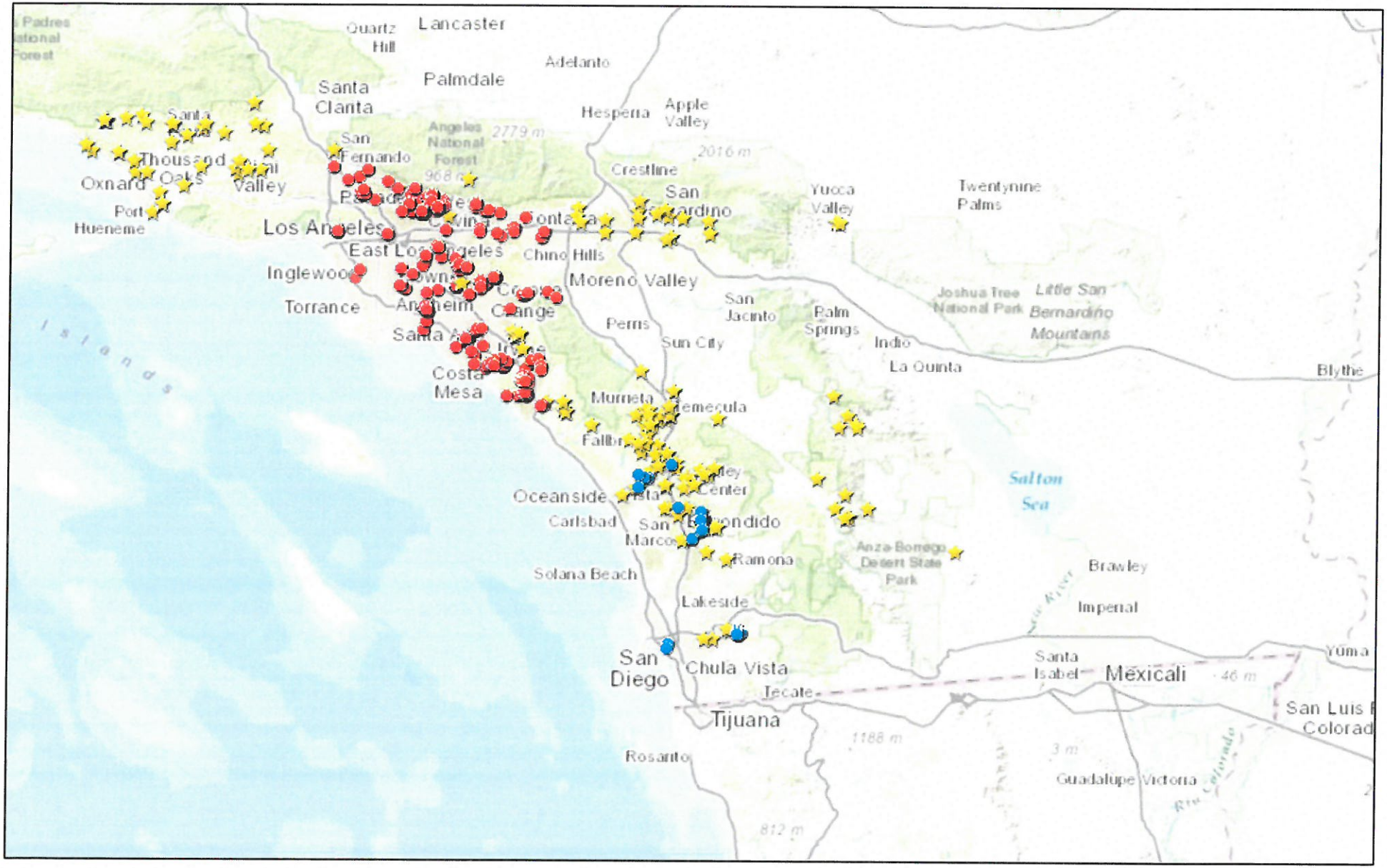
PSHB integrated pest management

- Developing an IPM program for high-value sites
  - Include monitoring, tree removal, chipping, specific plans for preventative treatments (tree species to treat), education/outreach

Questions

- More information
  - –GSOB: www.gsob.org
  - –PSHB: www.ucr.cisr.edu

PSHB/FD Distribution Map



March 27, 2015

1:2,311,162

0 20 40 80 mi

0 30 60 120 km

Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Polyphagous Shot Hole Borer + Fusarium Dieback
A New Pest Complex in Southern California

BACKGROUND

The Polyphagous Shot Hole Borer (PSHB), *Euwallacea* sp., is an invasive beetle that carries two fungi: *Fusarium euwallaceae* and *Graphium* sp. The adult female (A) tunnels galleries into a wide variety of host trees, where it lays its eggs and grows the fungi. The fungi cause a disease called Fusarium Dieback (FD), which interrupts the transport of water and nutrients in over 110 tree species. Once the beetle/fungal complex has killed the host tree, pregnant females fly in search of a new host.

Photo credit: (A) Gevork Arakelian/LA County Dept of Agriculture

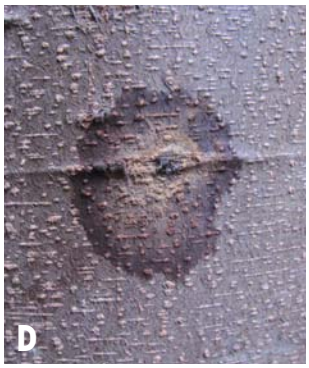
HOSTS

PSHB attacks hundreds of tree species, but it can only successfully lay its eggs and/or grow the fungi in certain hosts. These include: Box elder, California sycamore, London plane, Coast live oak, Avocado, White alder, Japanese maple, Liquidambar, and Red willow. Visit eskalenlab.ucr.edu for the full list.

EXTERNAL SIGNS + SYMPTOMS

Attack symptoms, a host tree's visible response to stress, vary among host species. Staining (C, D), sugary exudate (E), gumming (F, G), and/or frass (H) may be noticeable before the tiny beetles (females are typically 1.8-2.5 mm long). Beneath or near these symptoms, you may also see the beetle's entry/exit holes (B), which are ~0.85 mm in diameter. The abdomen of the female beetle can sometimes be seen sticking out of the hole.

Species pictured: C. California sycamore, D. White alder, E. Avocado, F. Titoki, G. Chinese flame tree, H. Red willow



INTERNAL SYMPTOMS

Fusarium euwallaceae causes brown to black discoloration in infected wood. Scraping away bark over the entry/exit hole reveals dark staining around the gallery (I), and cross sections of cut branches (J) show the extent of infection. Advanced infections eventually lead to branch dieback (K).

Authors: Monica Dimson (UCCE Orange); John Kabashima, Ph.D (UCCE Orange); and Akif Eskalen, Ph.D (UC Riverside).
Images provided by authors unless cited otherwise. Printed 08/2014.

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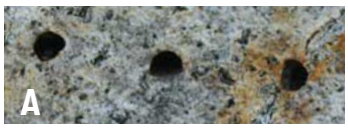
PSHB/FD LOOK-ALIKES

Look out for staining or bark damage caused by other wood-boring beetles and/or fungi, which can be mistaken for similar signs and symptoms of PSHB/FD.



Goldspotted oak borer, *Agrilus auroguttatus*
Hosts: Coast live oak, canyon live oak, CA black oak
Look for: D-shaped exit-holes (A) <4 mm wide but larger than those of PSHB, beetles ~10 mm long (B), bark staining (C), crown thinning, associated woodpecker damage



Western sycamore borer, *Synanthedon resplendens*
Hosts: Species of sycamore, oak, and ceanothus
Look for: whitish/pink larvae 25-38 mm long (D), roughened bark (E), reddish sawdust-like frass and/or pupal cases (F) in bark crevices or on ground, bleeding


Oak ambrosia beetles, *Monarthrum dentiger, M. scutellare* (G)
Hosts: Oak species, tanoak, CA buckeye
Look for: slightly larger beetles (*M. scutellare:* 3.5-4.1 mm long, *M. dentiger:* 1.9-2.4 mm) and entry-holes (1-1.5 mm diameter) with bleeding, frothing, bubbling or white boring dust (H) that is tan when oxidized; often attack stressed trees




Foamy bark canker, *Geosmithia pallida* +
Western oak bark beetle, *Pseudopityophthorus pubipennis*
Hosts: Coast live oak
Look for: beetles 1.7-2.3 mm long (I); smaller entry-holes than those of PSHB; reddish frass (J), reddish sap, wet discoloration, and/or foamy liquid from entry-hole (K); dead tissue around entry hole, beneath bark (L)

Photo credit: (A), (C) Tom Coleman/USDA. (B) Center for Invasive Species Research <cisr.ucr.edu>. (D), (G), (H), (I), (J) UC IPM <ipm.ucanr.edu>.

Stay up-to-date on the latest PSHB research at Eskalen Lab (http://eskalenlab.ucr.edu) or the UC Riverside Center for Invasive Species Research (http://cisr.ucr.edu)

HOW TO REPORT A SUSPECT TREE

Please report suspected tree infestations in Orange County to **pshb.ucce.oc@gmail.com**. Report trees outside of Orange County to UC Riverside at **eskalenlab@gmail.com**. Submit the following information:

- Your contact information (name, city, phone number, email)
- Suspect tree species
- Description of suspect tree's location (and/or GPS coordinates)
- Description of suspect tree's symptoms
- Photos of suspect tree and close-up photos of symptoms (**see examples**)

Based on the symptom description and photos, UC Riverside or UCCE Orange will decide whether a field assessment is warranted.

Take photos of suspect trees from several distances. Include photos of:

1. the trunk or symptomatic branches
2. the symptoms (close-up)
3. the entry/exit hole, if visible, with a ballpoint pen for scale (remove gumming or exudate if necessary)

If dieback is observed, include a picture of the entire tree.

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Polyphagous Shot Hole Borer + Fusarium Dieback
Decision Making for Reproductive Hosts

WHAT IS A REPRODUCTIVE HOST?

A reproductive host is a tree species that is suitable for reproduction of the next generation of beetles and the growth and development of the symbiotic fungi. Reproductive hosts are currently the priority species for control activities as they are able to produce beetles capable of spreading the infestation.

REPRODUCTIVE HOST 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. Red willow (*Salix laevigata*)
9. Avocado (*Persea americana*)
10. Mimosa/silk tree (*Albizia julibrissin*)
11. English oak (*Quercus robur*)
12. Coast live oak (*Quercus agrifolia*)
13. London plane (*Platanus x acerifolia*)
14. Fremont cottonwood (*Populus fremontii*)
15. Black cottonwood (*Populus trichocarpa*)
16. White alder (*Alnus rhombifolia*)
17. Titoki (*Alectryon excelsus*)
18. Engelmann oak (*Quercus engelmannii*)
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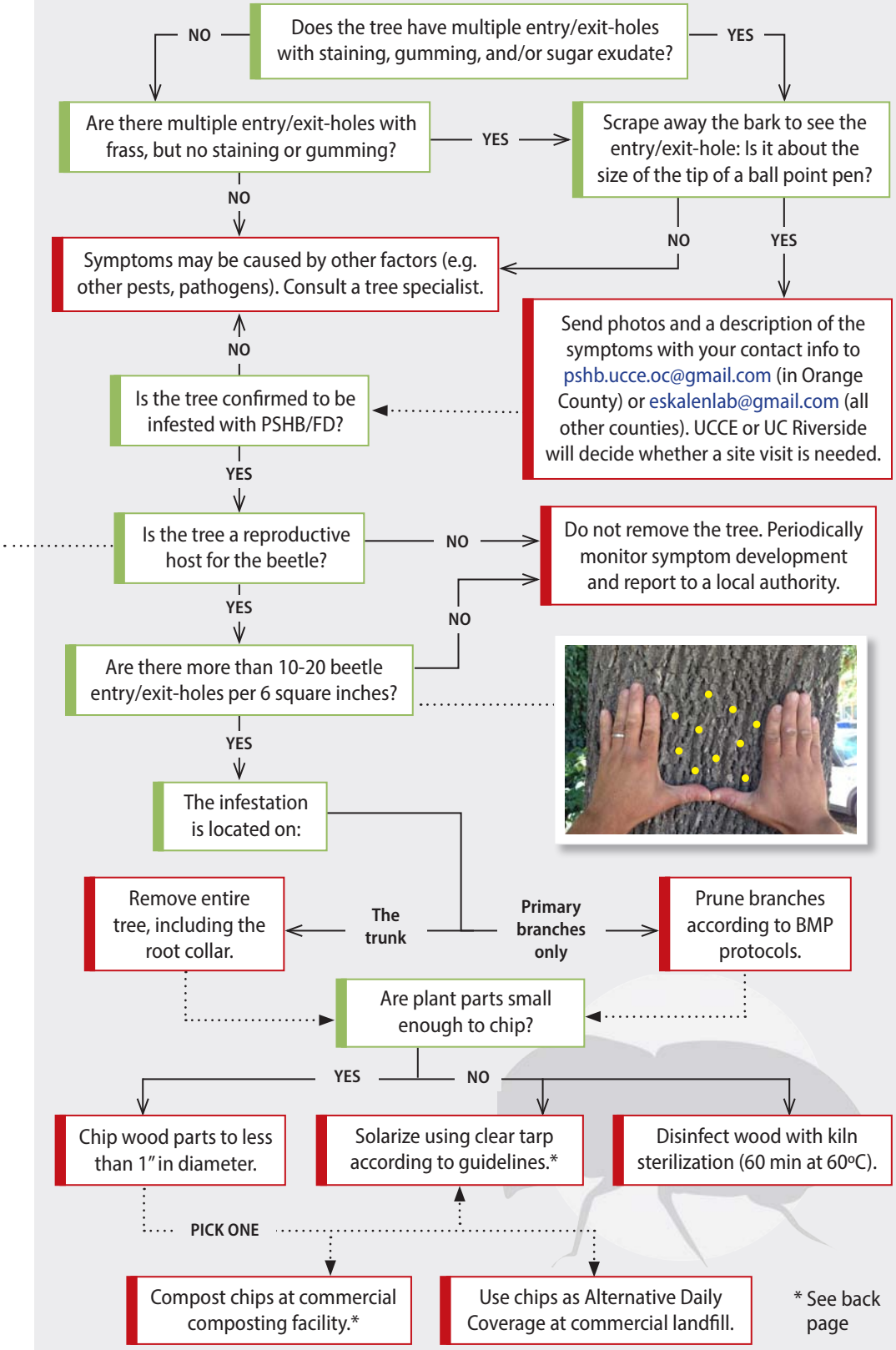
26. Mesquite (*Prosopis articulata*)
27. Weeping willow (*Salix babylonica*)
28. Chinese holly (*Ilex cornuta*)
29. Camellia (*Camellia semiserrata*)
30. Acacia (*Acacia* spp.)
31. Liquidambar (*Liquidambar styraciflua*)
32. Red flowering gum (*Eucalyptus ficifolia*)
33. Japanese wisteria (*Wisteria floribunda*)

Ranked by observed capacity to produce beetles. Updated list at eskalenlab.ucr.edu.

AUTHORS

Akif Eskalen, Ph.D (UC Riverside); Monica Dimson (UCCE Orange). Printed 10/2014.

WHAT YOU CAN DO FOR REPRODUCTIVE HOST TREES



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Polyphagous Shot Hole Borer + Fusarium Dieback
How to Handle Infested Plant Material

CURRENT OPTIONS

Options for handling infested plant material include the following:

- Chip (less than 1") + compost
- Chip (less than 1") + solarize
- Cut logs + solarize
- Chip (less than 1") + deliver to landfill for use as Alternative Daily Coverage
- Cut logs + kiln-dry

Guidelines for effective solarization and composting are included below.

****If relocating infested material, cover it in-transit to prevent beetles from escaping****

SOLARIZATION GUIDELINES

Solarization is a suitable method for handling either infested chips or logs. When done properly, solar energy will heat plant material until both the beetle and fungi are killed. It is most effective during the peak of summer, when temperatures are higher and days are longer, but may be used during the rest of the year as long as time and space can be committed.

Follow these tips for proper solarization:

- Use sturdy plastic sheeting/tarp (clear is recommended) that can withstand rain/wind
- Fully contain chips/logs by wrapping plastic both underneath and over the material
- During July - August: cover chips/logs with sturdy plastic for **at least 6 weeks**
- During September - June: cover chips/logs with sturdy plastic for **at least 6 months**
- **Keep log/chip layers as thin as possible** (2 logs deep maximum) to ensure even heating throughout the pile

WHY COMPOST?

When done correctly, composting can effectively control the plant pathogens that cause Fusarium Dieback. Composted, chipped plant material may then be repurposed as mulch or added back into soil to improve texture and water retention.

TRUSTED COMPOST FACILITIES

It is **recommended** that chipped, infested plant material be taken to a composting facility that has earned the US Composting Council's Seal of Testing Assurance (STA). Compost facilities in the STA program are tested to ensure proper decomposition and pathogen control is achieved.

Find your local STA Compost Facility at:
compostingcouncil.org/participants

PSHB ONLINE

Stay current on the latest PSHB research:
http://eskalenlab.ucr.edu
http://cisr.ucr.edu

AUTHORS

Akif Eskalen, Ph.D (UC Riverside); John Kabashima, Ph.D (UCCE Orange); Monica Dimson (UCCE Orange). Printed 10/2014.

COMPOST DIY

If transporting chipped material is not an option, you can compost chips yourself. These general composting guidelines will help assure the destruction of pathogenic fungi.

Requirements for adequate decomposition

- Woody material should be chipped to less than 1 inch.
- A mixture of equal volumes of green plant and dry plant material will normally achieve a proper carbon-to-nitrogen ratio of 30 to 1.
- Do not add soil, ashes from a stove or fireplace, milk or meat products, or manure from meat-eating animals.
- A pile should be in bins at least 36 x 36 x 36 inches to assure adequate heating. Maintain a temperature of 160ºF, turn the pile every 1-2 days, and add nothing to it once the composting process has begun. If temperatures do not get up to 160ºF within 1-2 days, the pile is too wet or dry. If too dry, add water. If not enough nitrogen, add green material.
- A healthy compost will have a pleasant odor, give off heat as vapor when turned, have a white fungal growth on the decomposing material, will get smaller each day, and change color to dark brown. Compost is ready when no further heat is produced.

Source: UC IPM (ipm.ucanr.edu/PMG/GARDEN/FRUIT/ENVIRON/composting.html)
Read more about composting at uccemg.com/files/78738.pdf and calrecycle.ca.gov/Organics/Products/Quality/Needs.htm

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