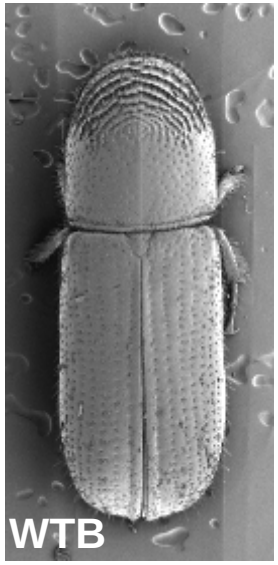
Status and Impact of Walnut Twig Beetle in California



Mass attack by walnut twig beetle on English walnut, *Juglans regia*

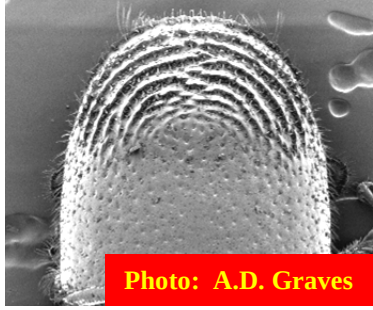
Steven Seybold, USDA Forest Service, PSW Res. Station, Davis, CA

Cooperating Scientists: J.P. Audley, R.M. Bostock, Y. Chen, E.J. Fichtner, J.K. Hasey, A. Hefty, S.M. Hishinuma, B.D. Lampinen, C.A. Leslie

Advances in Walnut Production-Short Course, November 7, 2018, Davis, CA

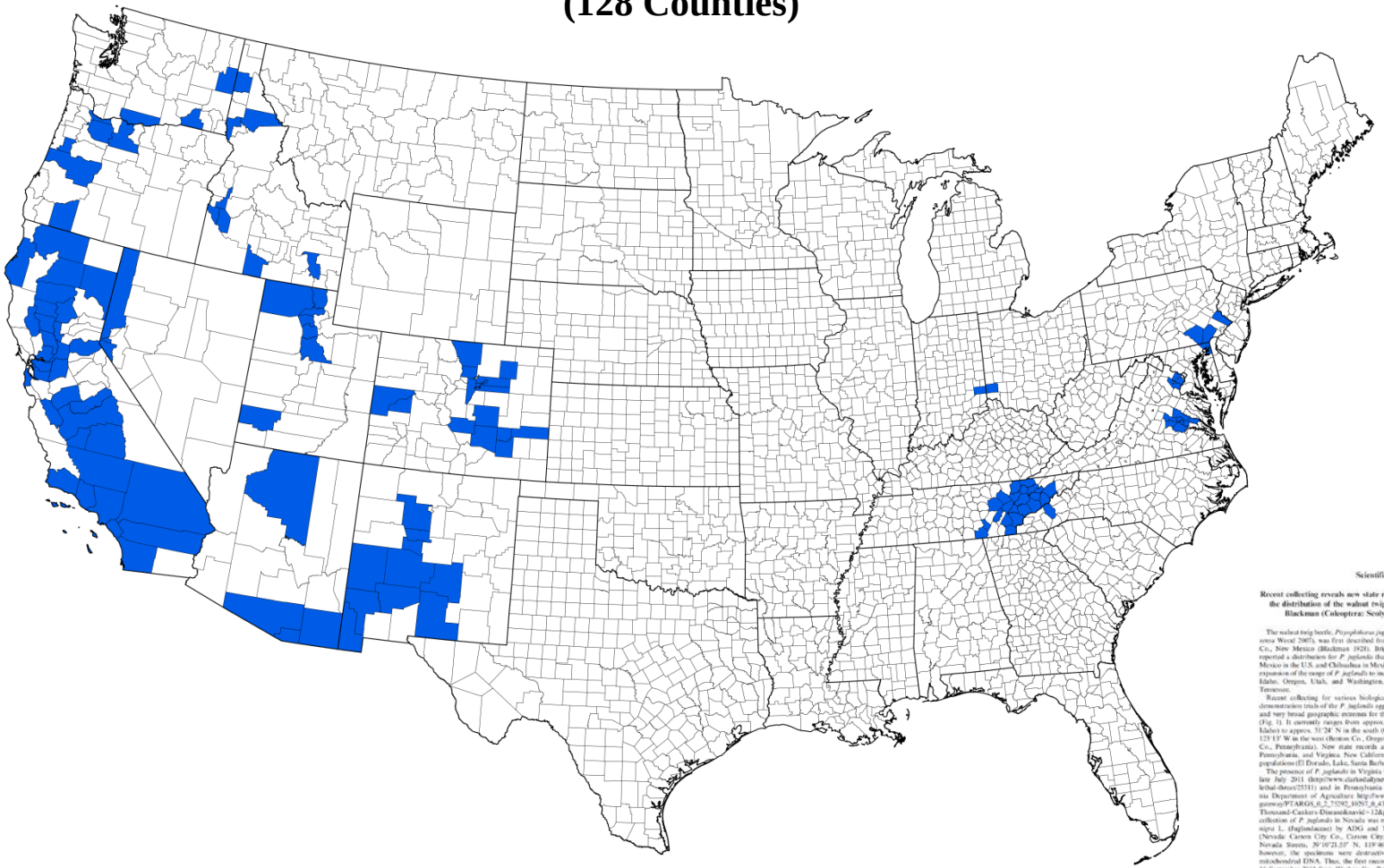
Walnut Twig Beetle: Distribution, Biology, Impact, and Host Range

The Walnut Twig Beetle
Pityophthorus juglandis Blackman



U.S. Distribution: Jan. 23, 2017

(128 Counties)



THE PAN-PACIFIC ENTOMOLOGIST

Scientific Note

Recent collecting reveals new state records and geographic extremes in the distribution of the walnut twig beetle, *Pityophthorus juglandis* Blackman (Coleoptera: Scolytidae), in the United States

The walnut twig beetle, *Pityophthorus juglandis* Blackman (Coleoptera: Scolytidae, sensu Wood 2007), was first described from specimens collected in 1896 in Grant Co., New Mexico (Blackman 1928). Bright (1981) and Wood & Bright (1992) reported a distribution for *P. juglandis* that included Arizona, California, and New Mexico in the U.S. and Chihuahua in Mexico. Cranshaw (2011) described the recent expansion of the range of *P. juglandis* to include the western U.S. states of Colorado, Idaho, Oregon, Utah, and Washington, as well as the eastern U.S. state of Tennessee.

Recent collecting for various biological and genetic studies as well as from demonstration trials of the *P. juglandis* aggregation pheromone has established new and very broad geographic extremes for the distribution of this species in the U.S. (Fig. 1). It currently ranges from approx. 47°43' N in the north (Kootenai Co., Idaho) to approx. 31°24' N in the south (Cochise Co., Arizona) and from approx. 123°13' W in the west (Benton Co., Oregon) to approx. 75°8' W in the east (Bucks Co., Pennsylvania). New state records are recorded formally here for Nevada, Pennsylvania, and Virginia. New California county records for unusually isolated populations (El Dorado, Lake, Santa Barbara, and Siskiyou Cos.) are also recorded.

The presence of *P. juglandis* in Virginia was first reported in the popular press in late July 2011 (http://www.clarkesdailynews.com/virginias-black-walnut-trees-face-lethal-threat/25311) and in Pennsylvania in early August 2011 (The Pennsylvania Department of Agriculture http://www.agriculture.state.pa.us/portal/server.pt/gateway/PTARGS_0_2_75392_10297_0_43/AgWebsite/ProgramsDetail.aspx?name=Thousand-Cankers-Disease&navid=12&parentnavid=0&pageid=137&). The first collection of *P. juglandis* in Nevada was made from the lower branches of *Juglans nigra* L. (Juglandaceae) by ADG and TWC on 8 May 2011 in Carson City (Nevada: Carson City Co., Carson City, near intersection of W. Park and N. Nevada Streets, 39°10'21.25" N, 119°46'7.92" W, approx. 1436 m elevation), however, the specimens were destructively sampled for an analysis of their mitochondrial DNA. Thus, the first record for Nevada with voucher specimens is 16 September 2011 from Washoe Co., Reno (see below).

With a planned national survey for *P. juglandis* anticipated in the coming years, it is likely that an expanded distribution of the beetle will be revealed in the eastern U.S. The northern limits of the distribution may eventually reach into Canada. The distribution of *P. juglandis* is not continuous within the geographic limits described here. It will be governed by the presence of walnut, *Juglans* spp., in the landscape and the degree of human-mediated movement of *Juglans* spp. raw logs or barked wood products.

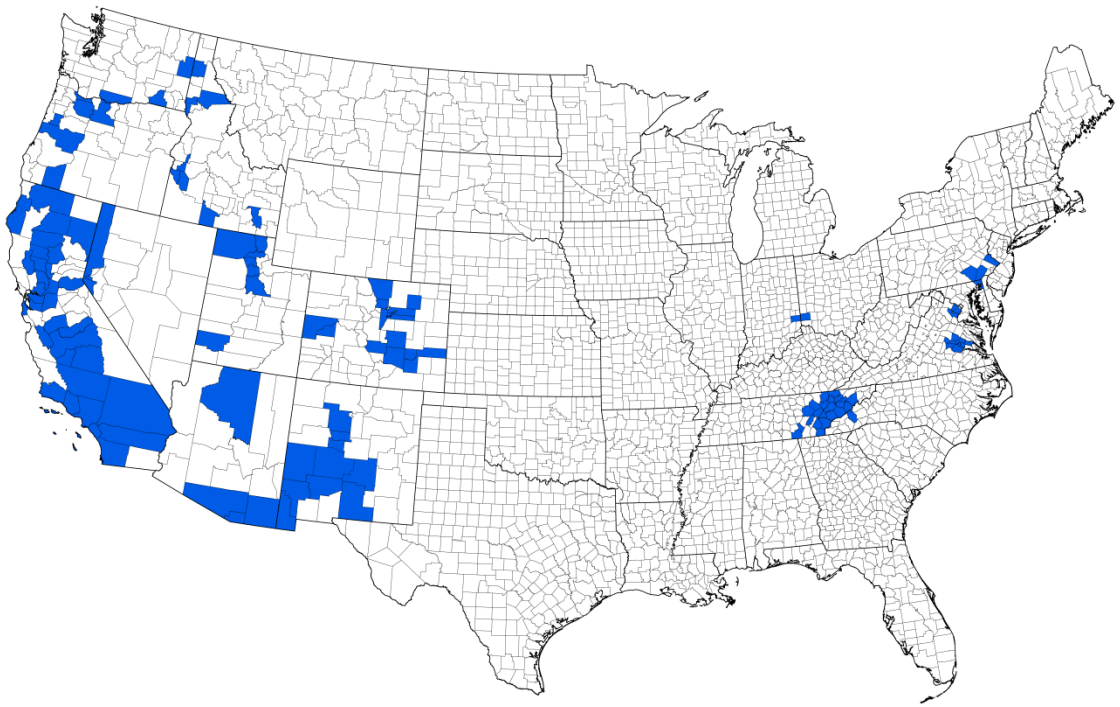
New Records. ARIZONA: Cochise Co., Coronado National Forest, Hunter Canyon, approx. 1600 m elev., 31°24'9.22" N, 110°15'8.71" W, III-5-2011, coll. A.D. Graves, T.W. Coleman, ex. reared from beneath the bark of dead branches from

Graphic by A.D. Graves/D.E. Ryerson
USDA FS FHP, Albuquerque

The Walnut Twig Beetle
Pityophthorus juglandis Blackman

U.S. Distribution: Jan. 23, 2017

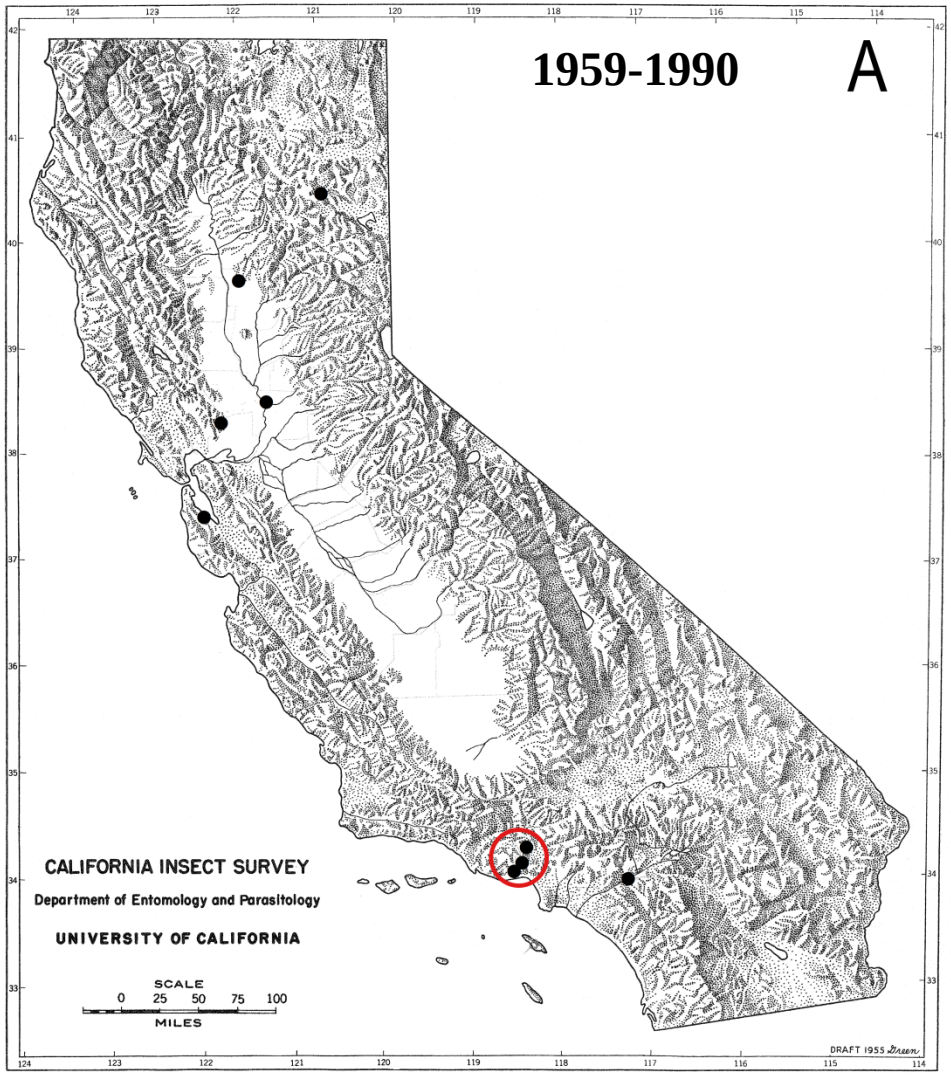
(128 Counties)

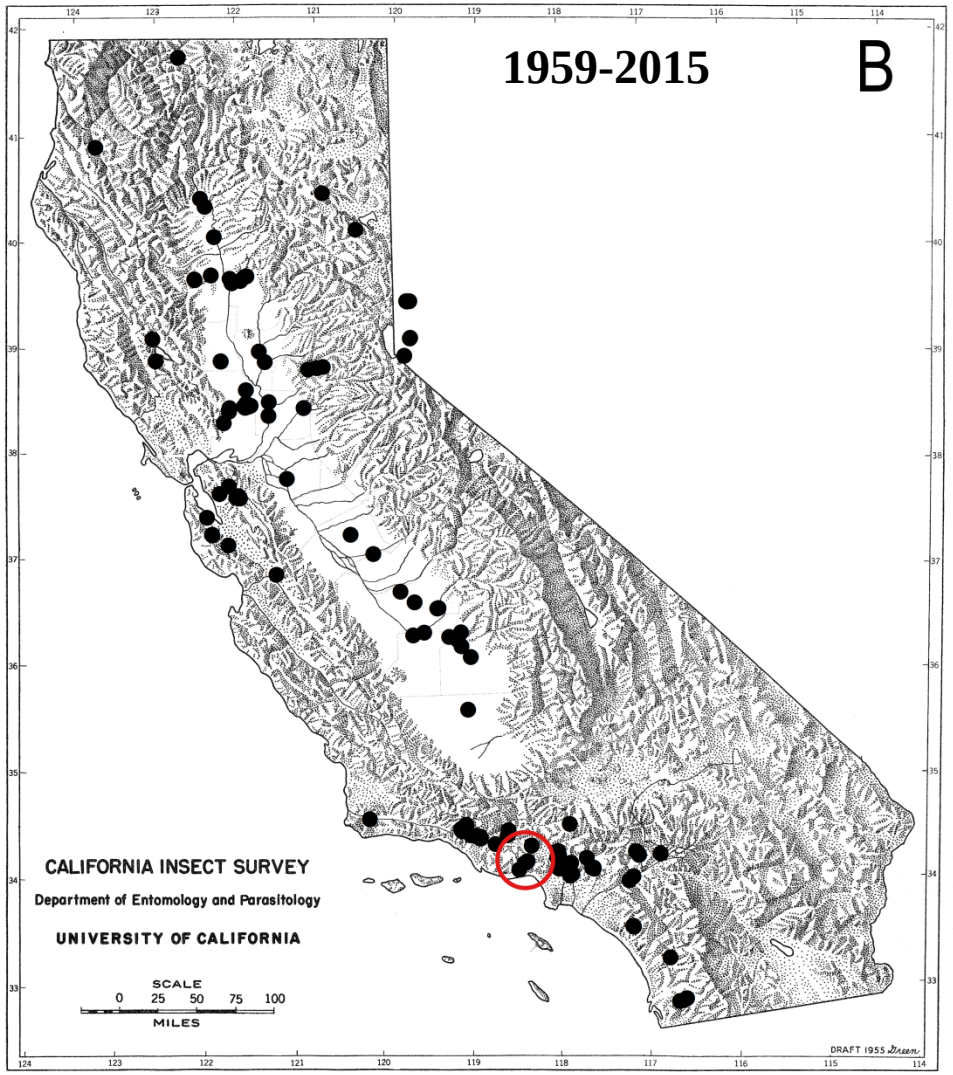


European Distribution: 2015
(4 Regions in Northern Italy)

Graphic by A.D. Graves/D.E. Ryerson
USDA FS FHP, Albuquerque

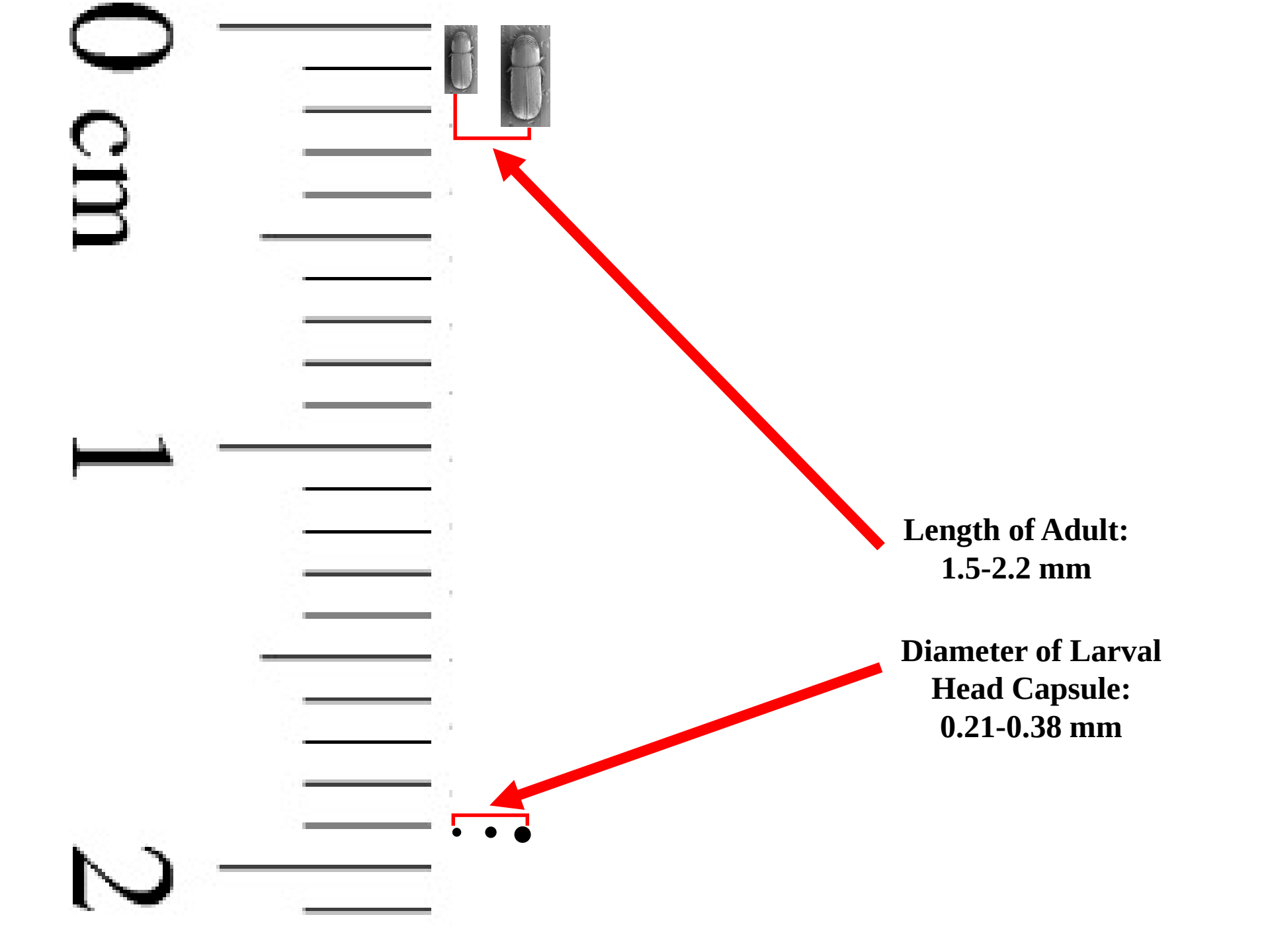
Distribution of Walnut Twig Beetle in California

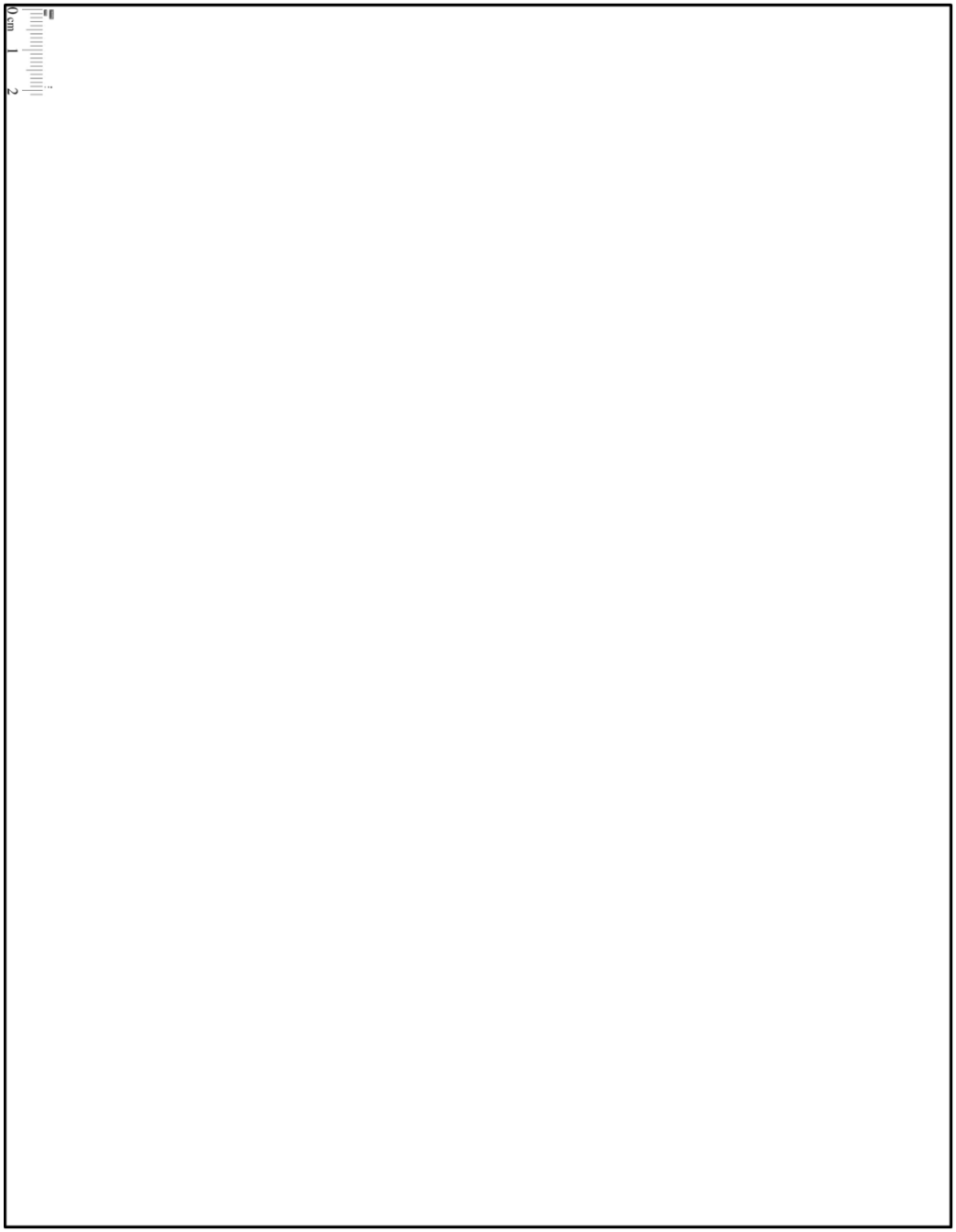




Colonization of Southern California Black Walnut, *Juglans californica*, by WTB USDA ARS NCGR, Winters, Solano Co.

Colonization of Southern California Black Walnut, *Juglans californica*, by WTB USDA ARS NCGR, Winters, Solano Co.


0
cm
1
2
Length of Adult:
1.5-2.2 mm
Diameter of Larval
Head Capsule:
0.21-0.38 mm


0
cm
1
2

WTB Life Cycle: Males Attack First

Recording New Attacks on *Juglans hindsii*

Males colonize first

S. Hishinuma, photo

Joined by 1-2 females, transverse galleries

S. Hishinuma, photo

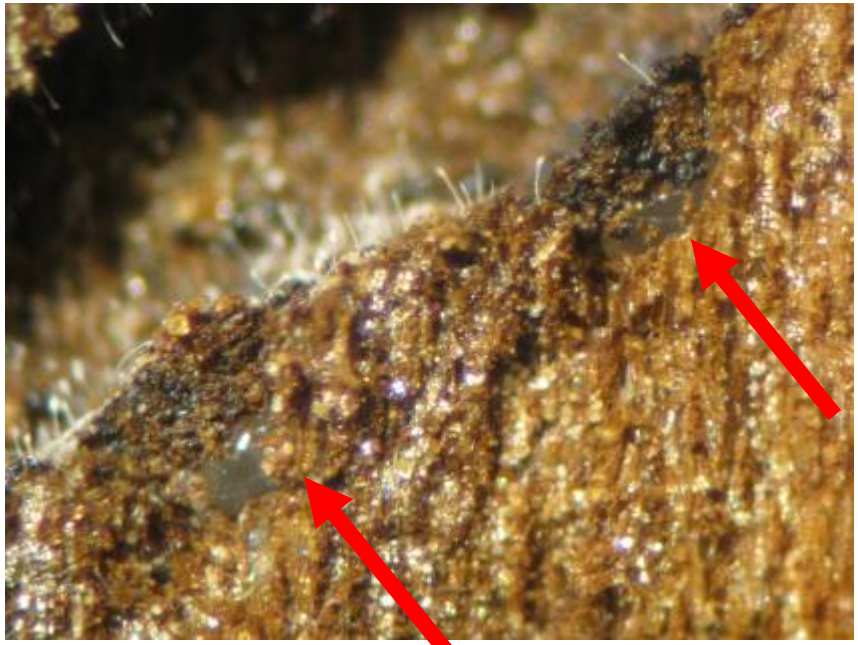
Landing on uninfested branches is a rare event:

15 attacks over two months- most were on the same branches (i.e., pheromone-directed behavior)

Incipient galleries on small green branches of *J. hindsii* Aug.-Sept. 2008, Davis, CA

	1 ♂	1 ♀	1 ♂ + 1 ♀	1 ♂ + 2♀
No. galleries	**7**	**0**	**6**	**2**

Females construct transverse egg galleries



Bark of *J. nigra*, May 2009, Sutter Co., CA
A.D. Graves, photos

Identification of signs of thousand cankers disease

III) Beetle galleries are etched on the wood (xylem) surface

Adult galleries are transverse (against the grain); larval galleries are longitudinal (with the grain)

Longitudinal larval mines and black boring dust

Bark of *J. nigra*,
May 2009,
Sutter Co., CA

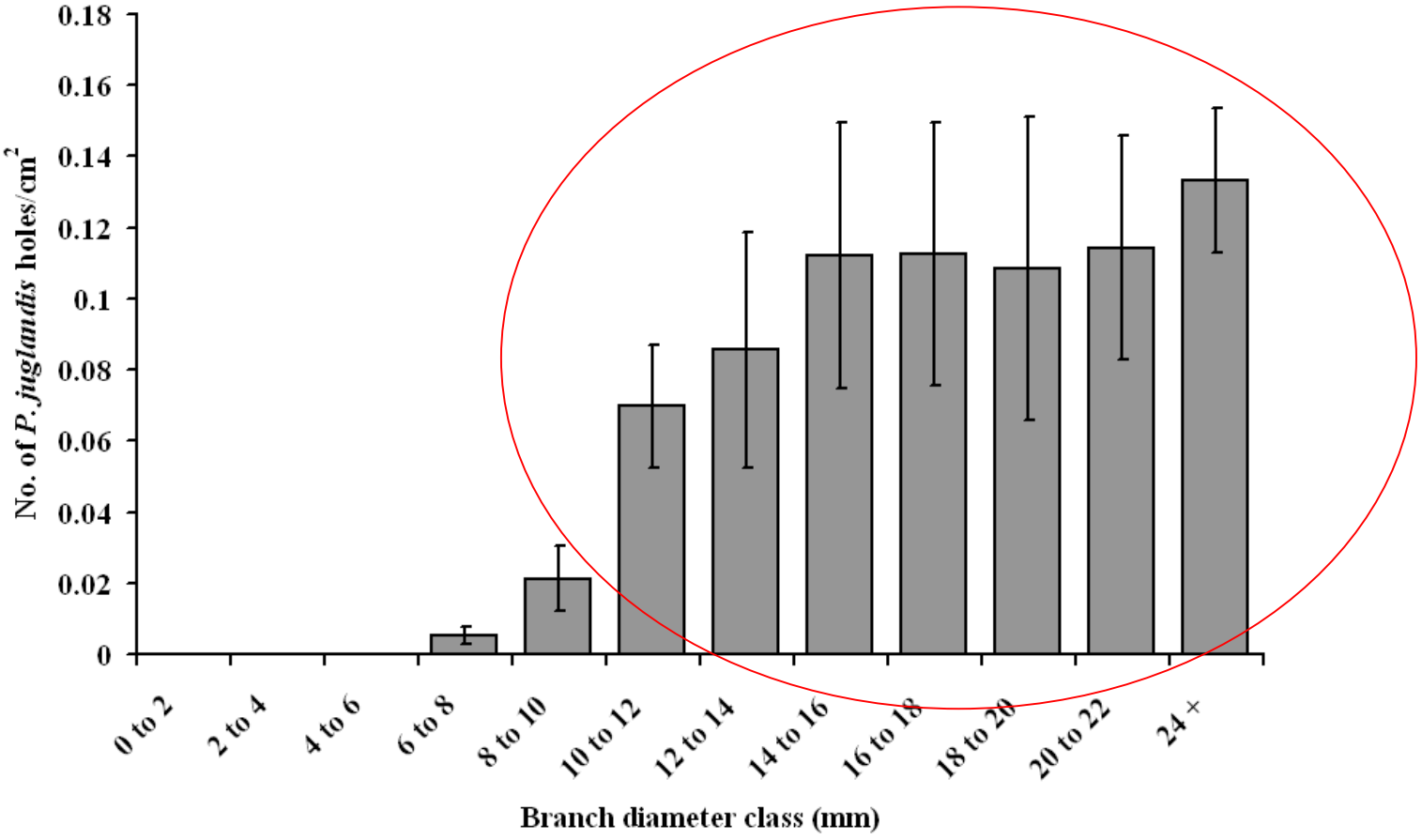
A.D. Graves, Photo

Walnut twig beetles pupate in cells in the phloem

Host Interactions: What Size Branches does WTB Prefer? Is it truly a "twig" beetle?

Branch Dissections of Infested *Juglans californica*

Entrance and emergence hole density of *P. juglandis* suggests that it prefers branches > 1.5 cm in diameter, Aug. 2008, *N*=268



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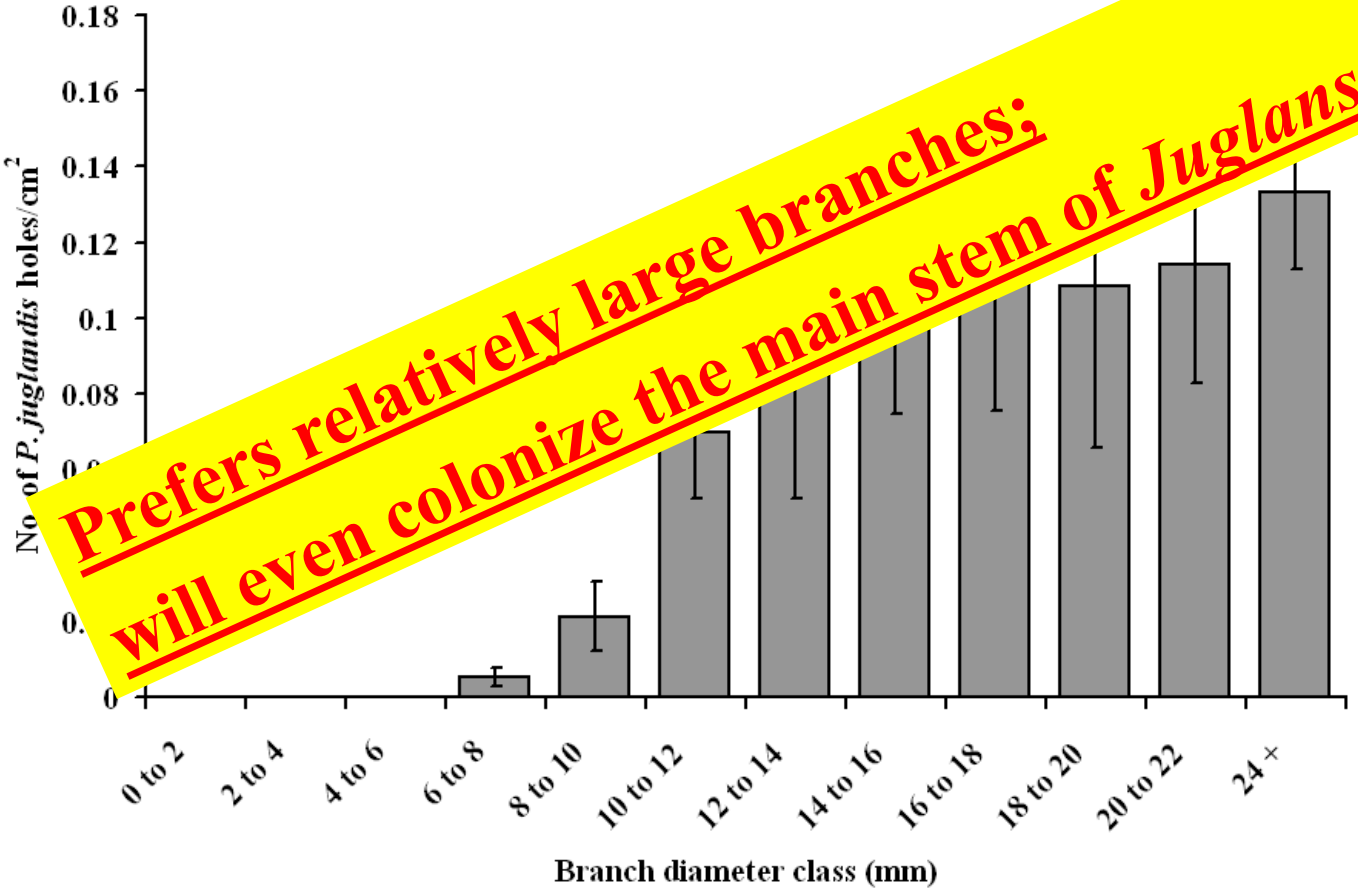


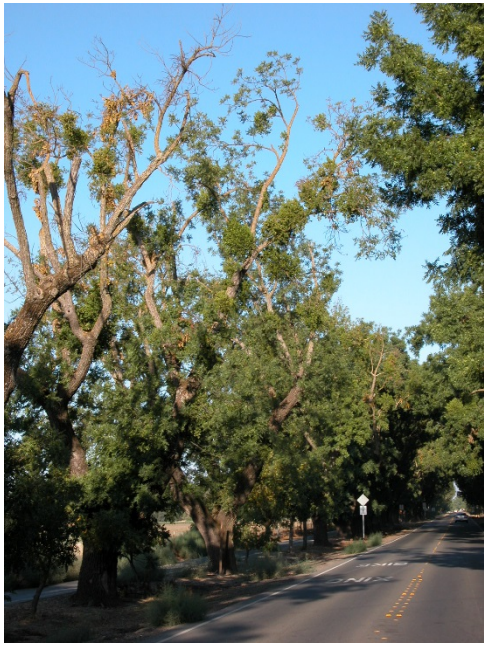
WTB Entrance and Emergence Holes from Mass Attack on Main Stem of English Walnut

Photo: E.J. Fichtner, Tulare Co.

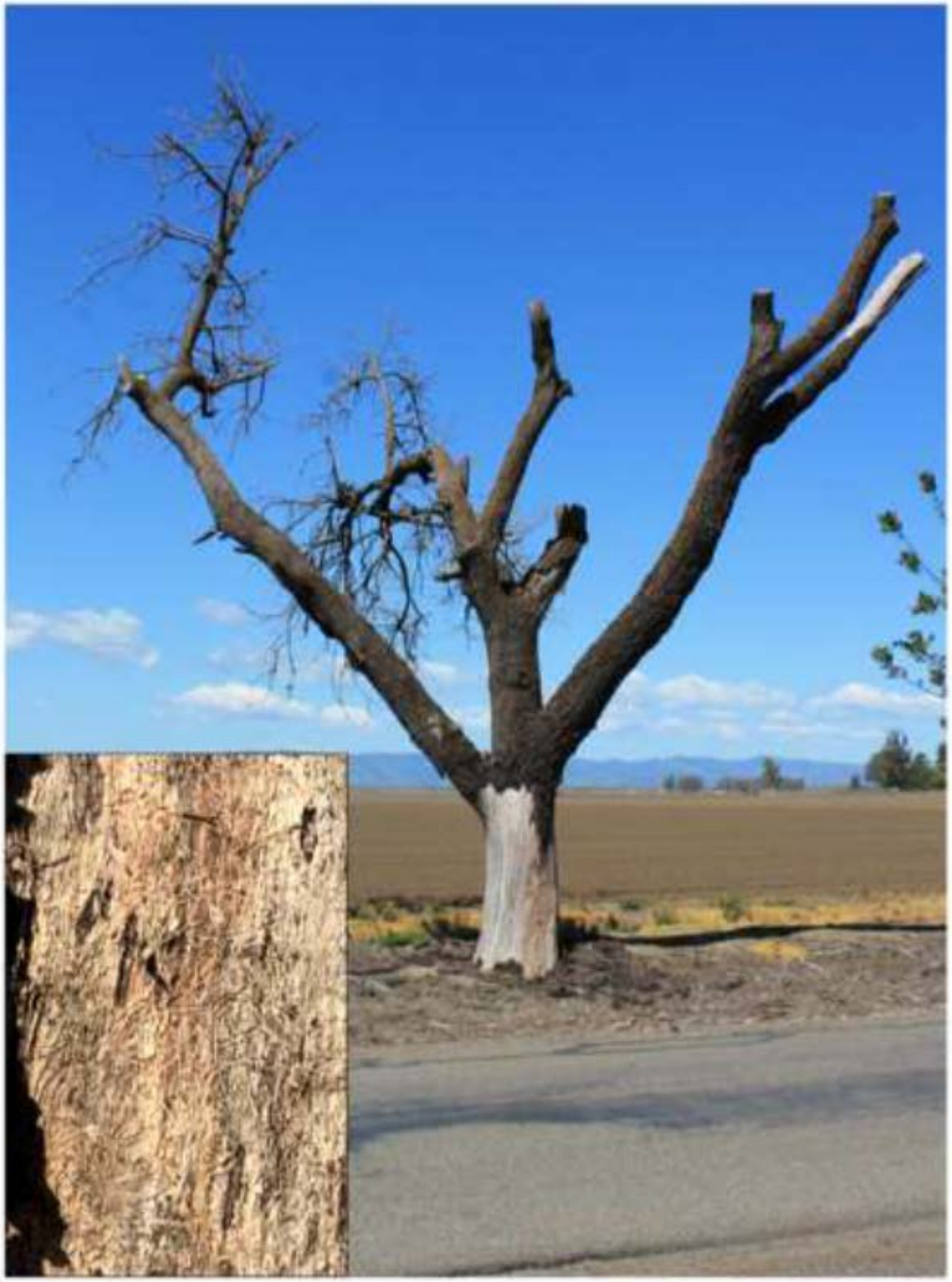
Davis, Yolo Co., California Branch Dieback and Mortality on *Juglans hindsii* on city streets and along rural highways, June-Aug., 2008

Chuck Leslie

Andy Graves



Photos: S.J. Seybold, A.D. Graves, UC-Davis, Department of Plant Pathology



Walnut Twig Beetle Continues to Kill Trees in Northern California

(Dead Northern California black walnut, *Juglans hindsii,* along rural road, Solano Co., California April, 2018)

Photo: Jackson P. Audley, UC-Davis, Department of Entomology and Nematology

Walnut Twig Beetle Continues to Kill Trees in Northern California

(Dead "Royal" hybrid black walnut, *Juglans nigra x hindsii,* in a seed orchard, Sutter Co., California July, 2018)

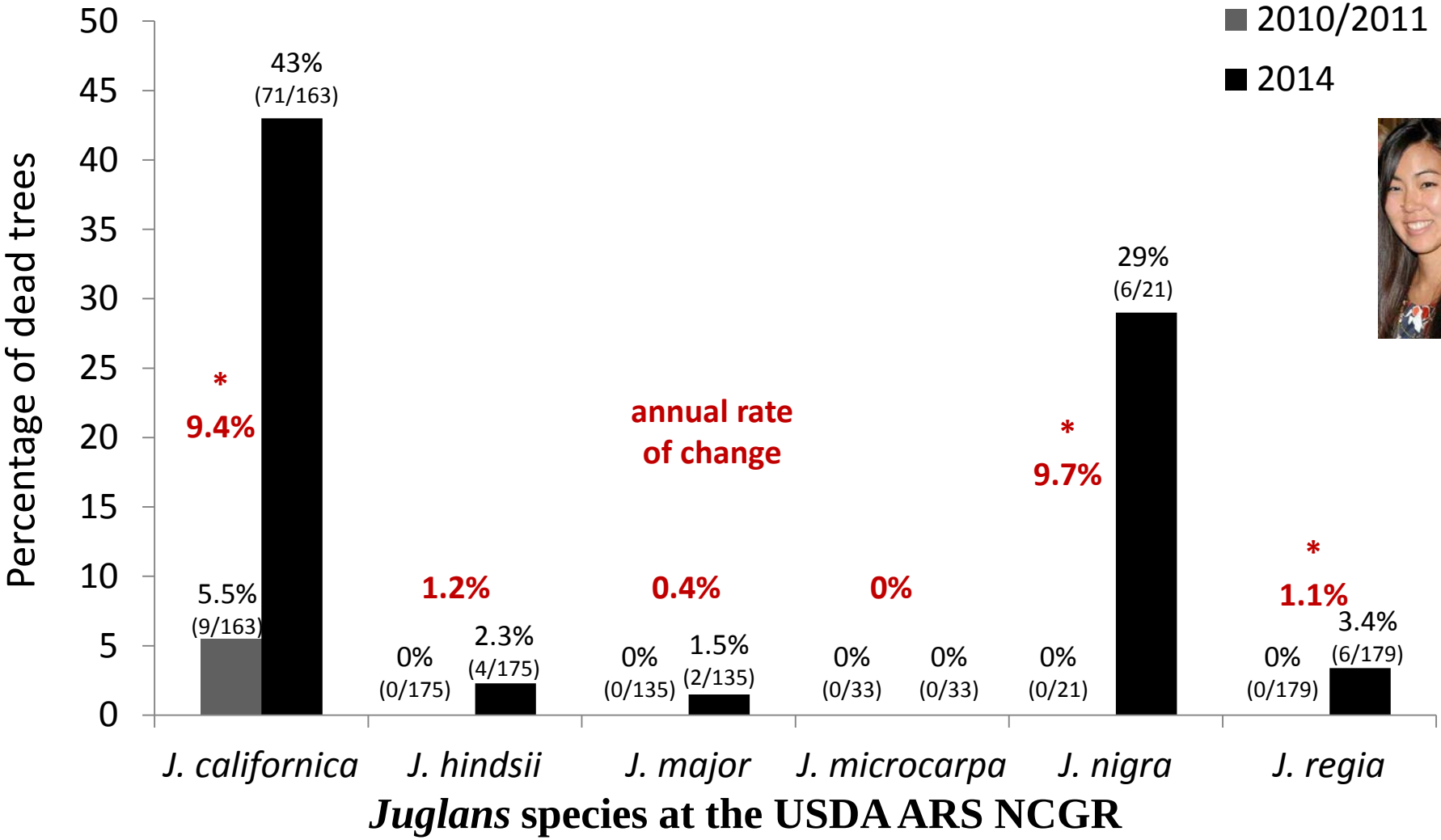
Photos: Megan A. Siefker, UC-Davis, Department of Entomology and Nematology

Walnut Twig Beetle Continues to Kill Trees in Northern California

(Dead Southern California black walnut, *Juglans californica,* in the USDA ARS NCGR Solano Co., California June, 2016)

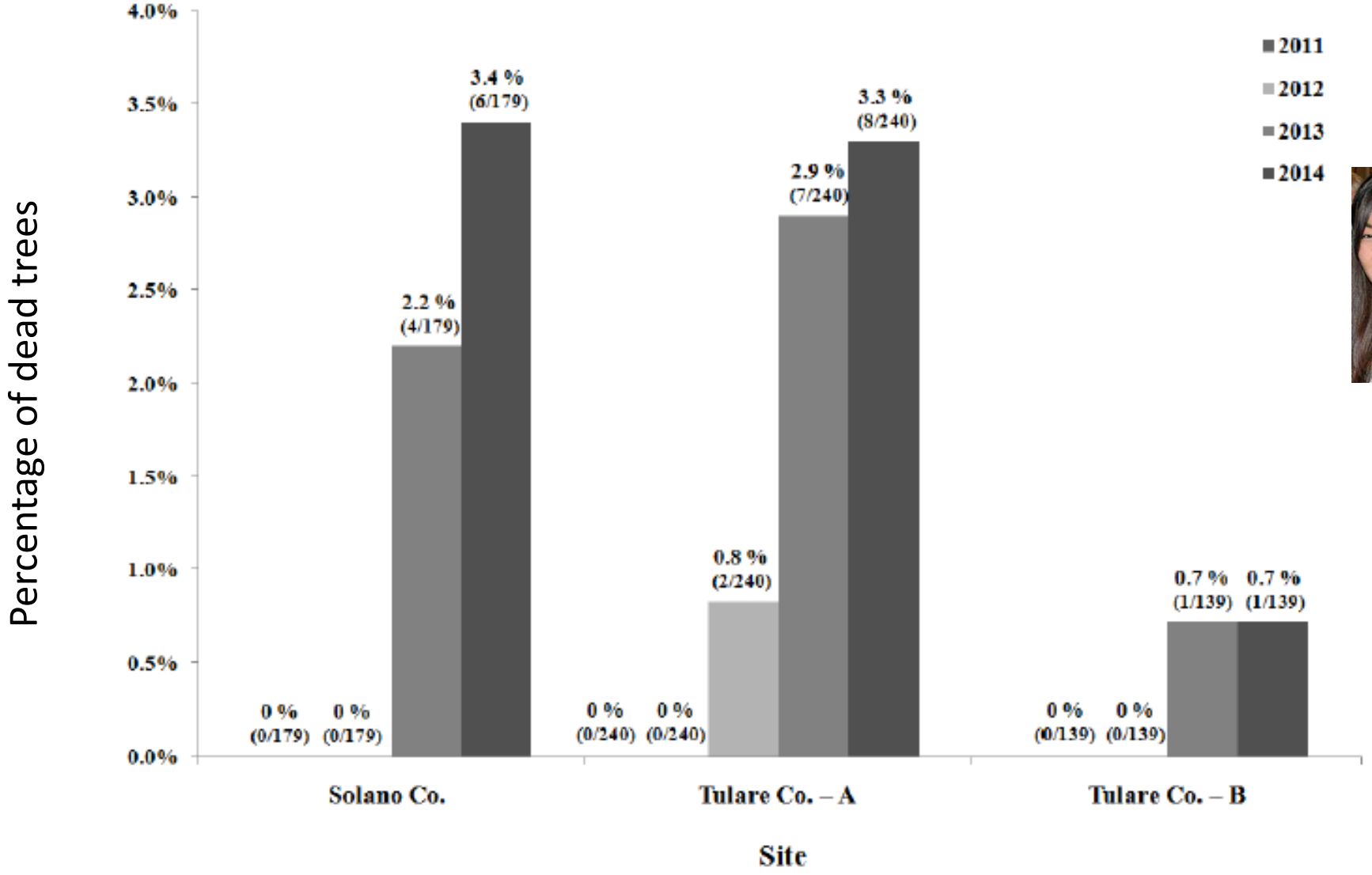
Photos: Stacy Hishinuma, UC-Davis, Department of Entomology and Nematology

Tree mortality of six walnut species at one California survey location (2010/2011 to 2014)



Hishinuma SM (2017) Interactions among the walnut twig beetle, *Pityophthorus juglandis*, the pathogenic fungus, *Geosmithia morbida*, and host species in thousand cankers disease in California. Dissertation, University of California, Davis.

English walnut tree mortality at three California survey locations (2010/2011 to 2014)

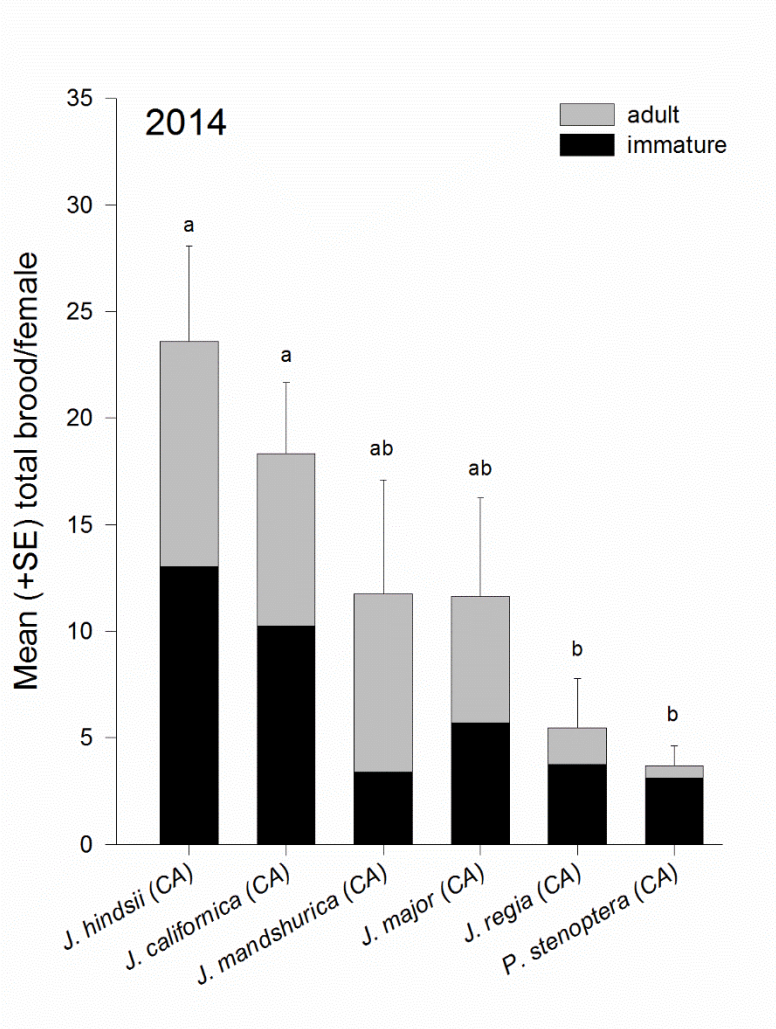


Hishinuma SM (2017) Interactions among the walnut twig beetle, *Pityophthorus juglandis*, the pathogenic fungus, *Geosmithia morbida*, and host species in thousand cankers disease in California. Dissertation, University of California, Davis.

Assessing Reproduction of Walnut Twig Beetle in Walnut and Related Species

Fig. 3. Frass mounds outside of a pre-drilled hole were one sign used to determine that a male was ready for a female.

Fig. 4. Males and females were contained in holes with modeling clay to prevent escape until establishment.



Andrea Hefty
Ph.D. Dissertation
University of Minnesota

Hefty, A.R. *et al.* (2018) Reproduction and potential range expansion of walnut twig beetle across the Juglandaceae.
Biological Invasions (Accepted with revisions)
***Juglans* and *Pterocarya* branch sections from USDA ARS NCGR Winters, CA**

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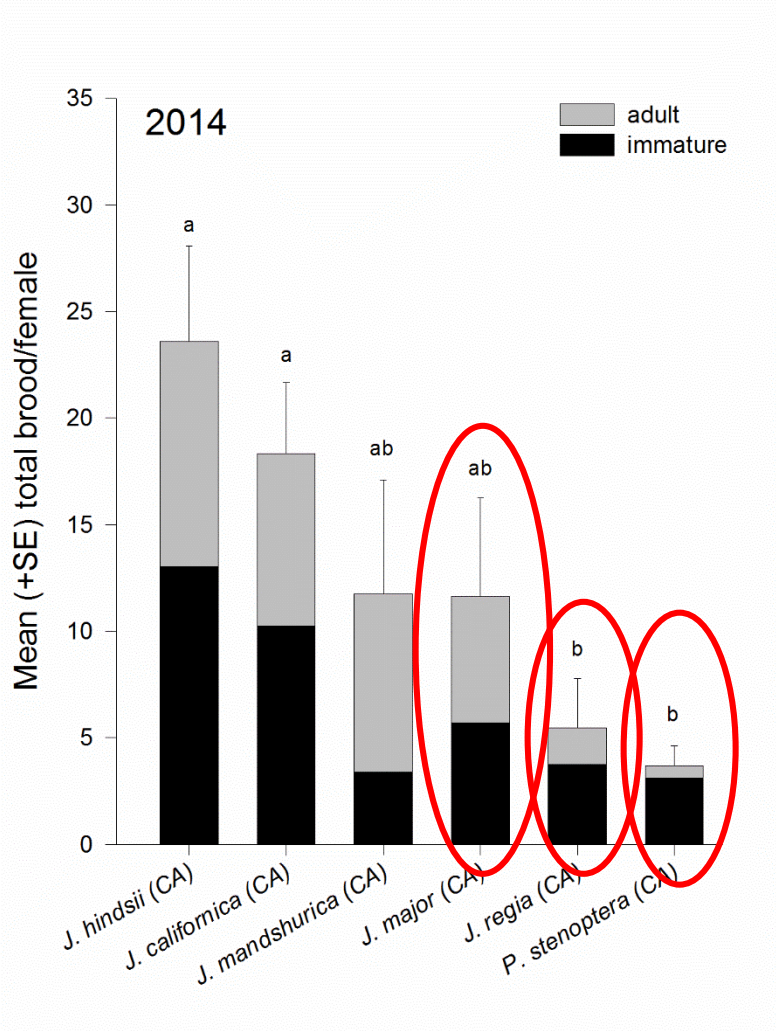

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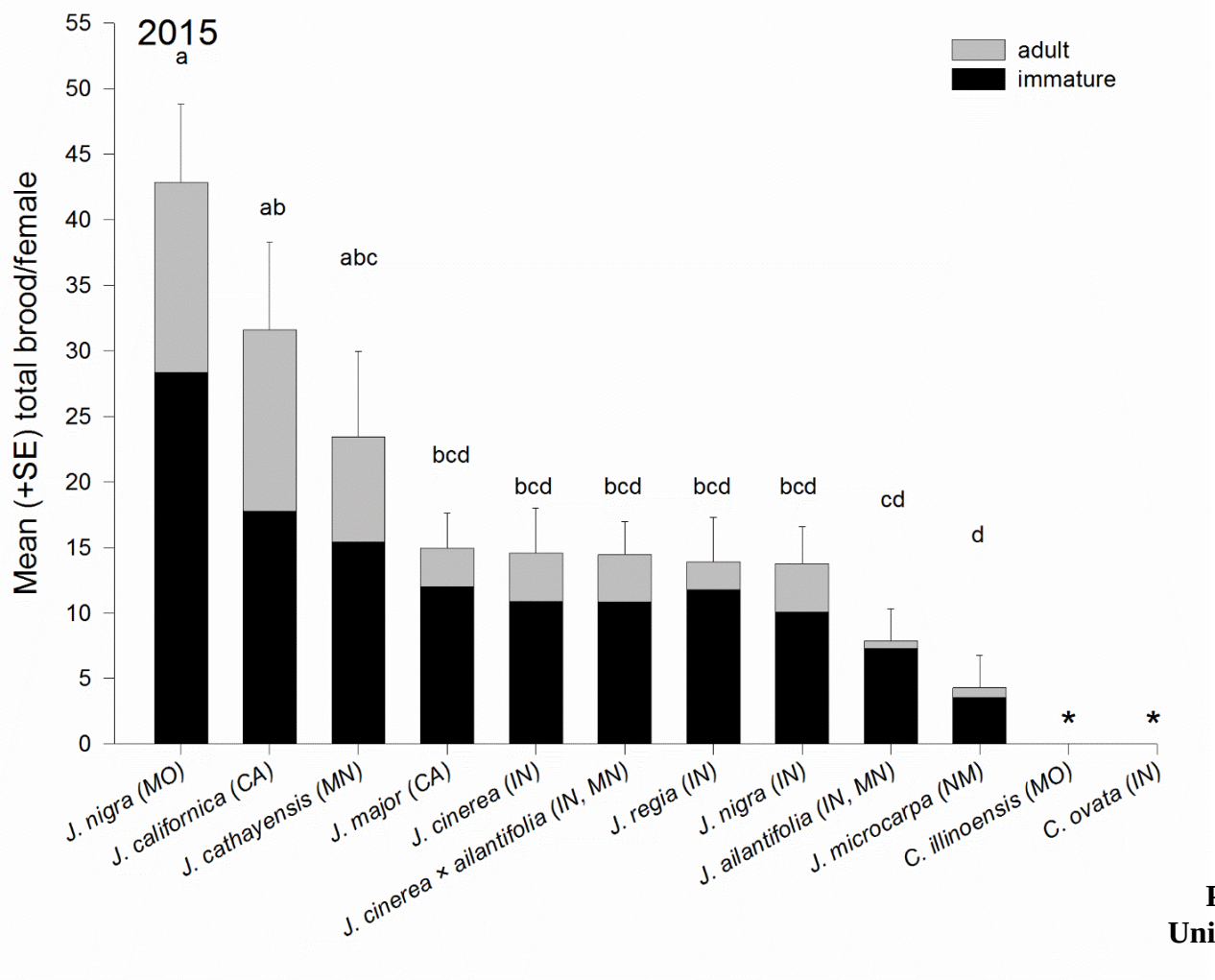

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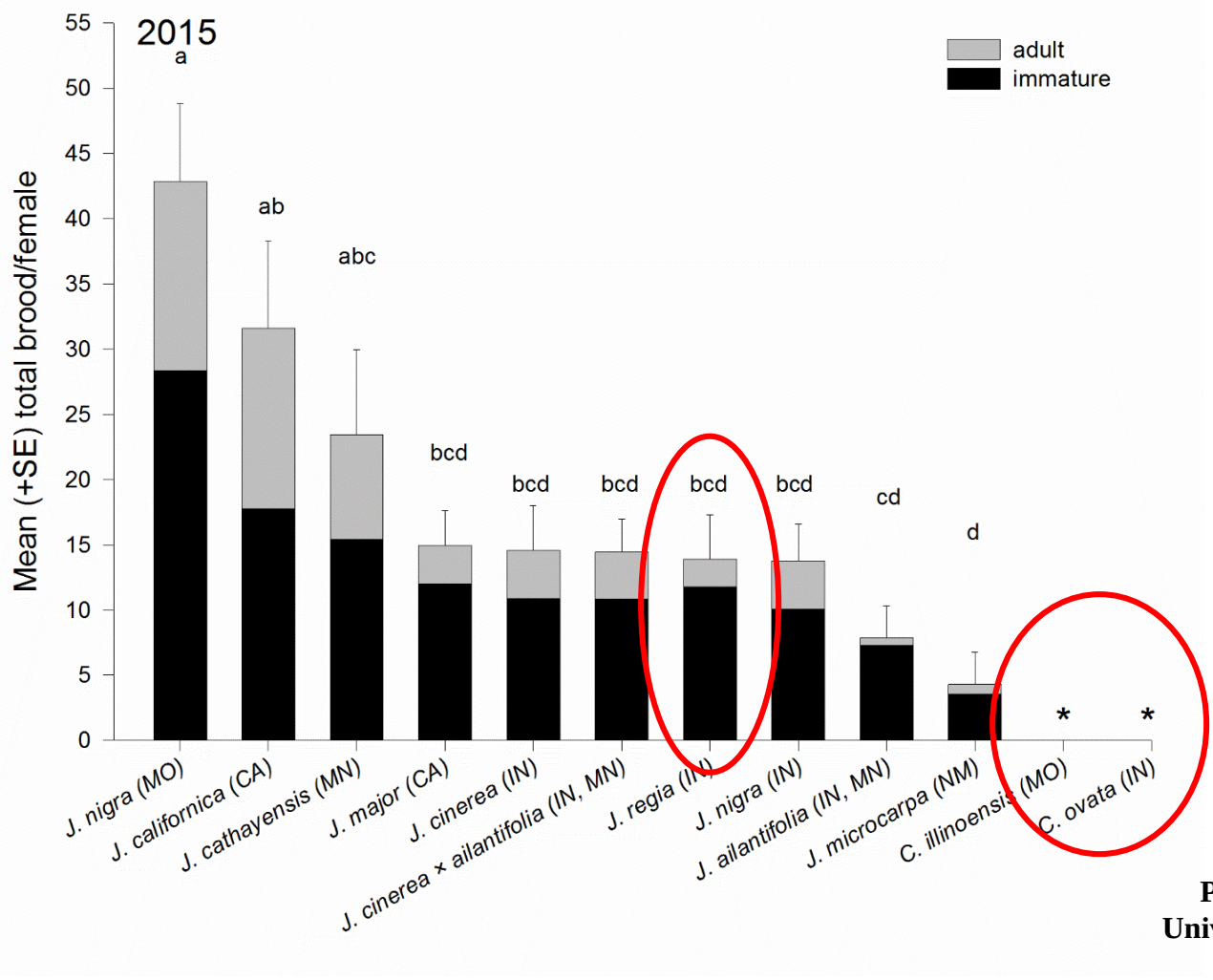

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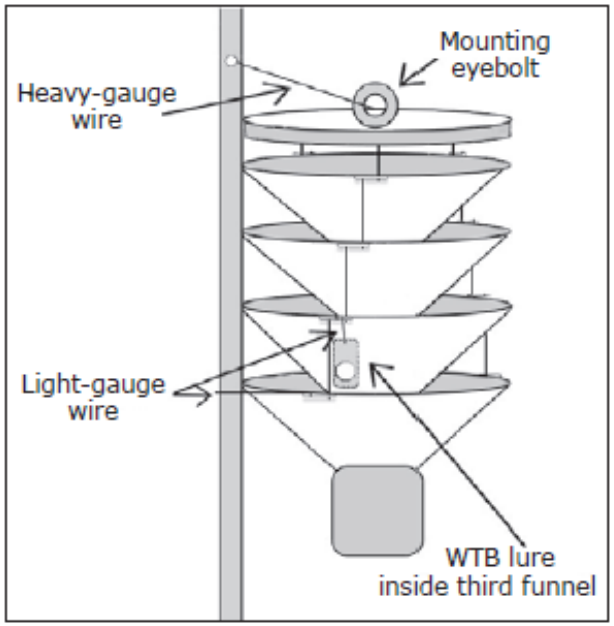
Biological Invasions (Accepted with revisions)
***Juglans* and *Carya* branch sections from USDA FS HTIRC and USDA ARS NCGR Winters, CA**

Walnut Twig Beetle: Flight Period and Management

Baited Funnel Traps for Detecting Walnut Twig Beetle



J. A. King, UC Davis

Figure 9. Schematic of a four-unit funnel trap showing the attachment between the eyebolt and pole with heavy-gauge wire, attachment and placement of the lure, and attachment of the lowest funnel strut to the pole with light-gauge wire.

S. J. Seybold, USDA Forest Service

Figure 10. A four-unit funnel trap in place at the top of a pole.

Seybold *et al.* (2013) WTB Trapping and I.d. Guidelines, UC-IPM
http://www.ipm.ucdavis.edu/PMG/menu.thousandcankers.html

Male-Produced WTB Aggregation Pheromone as a Tool for Detection and Research

2011-2012 Formulation

2013 Formulation

Release Devices used in the National Detection Program

Final Patent

Seybold, S. J., Dallara, P. L., Nelson, L. J., Graves, A. D., Hishinuma, S. M., and Gries, R. 2015. Methods of monitoring and controlling the walnut twig beetle, *Pityophthorus juglandis*. United States Patent No. US 9,137,990 B2, 12 pp. + 7 Figs., September 22, 2015.

Flight activity of WTB at the USDA ARS NCGR Wolfskill, Winters, Solano Co. (May 2013 to Dec. 2017)

|------2013------|----------2014--------|----------2015-------|--------2016--------|--------2017-------|

Orange = Female

Blue = Male

No. WTB/trap/day

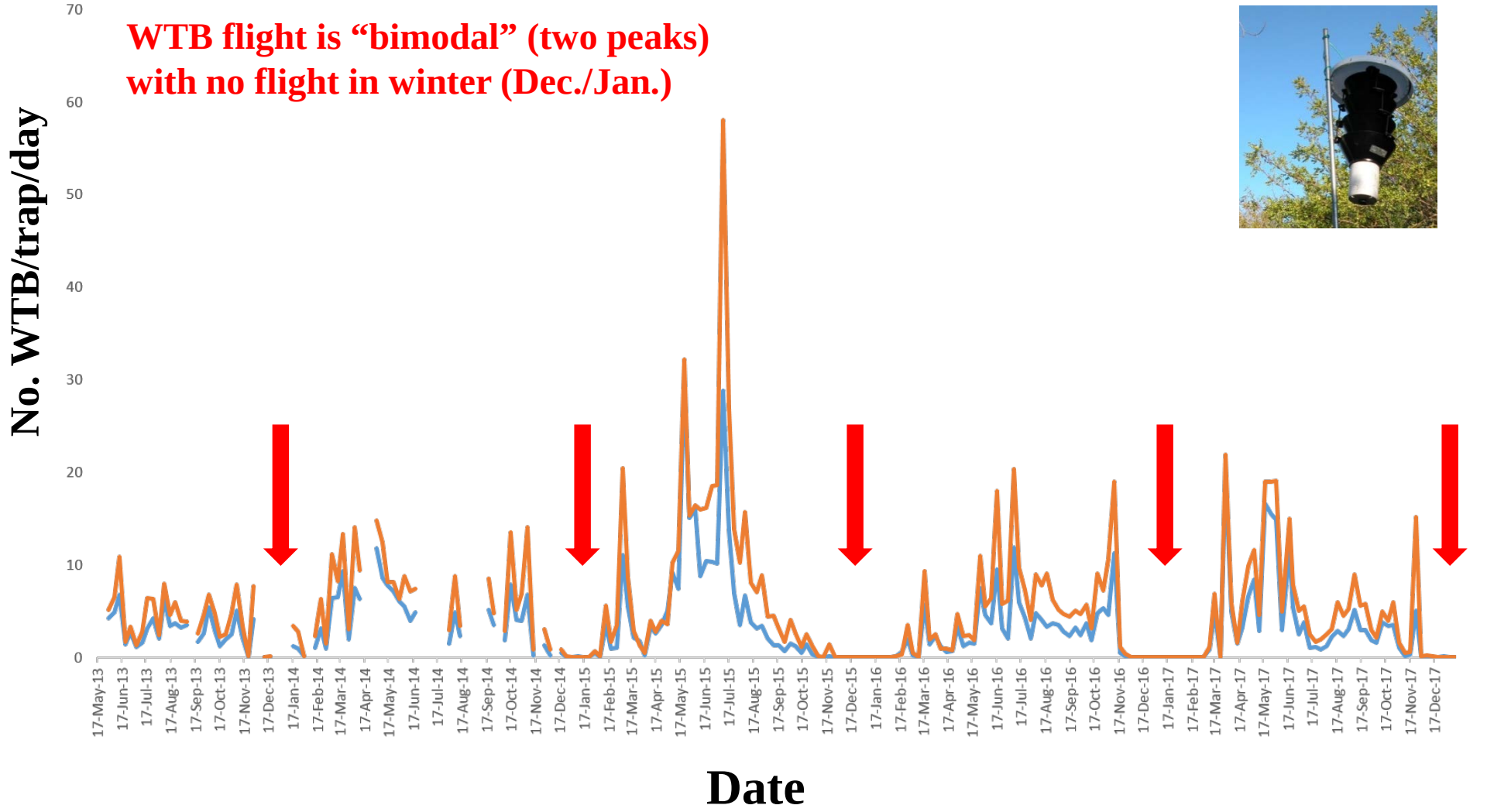
70
60
50
40
30
20
10
0

17-May-13 17-Jun-13 17-Jul-13 17-Aug-13 17-Sep-13 17-Oct-13 17-Nov-13 17-Dec-13 17-Jan-14 17-Feb-14 17-Mar-14 17-Apr-14 17-May-14 17-Jun-14 17-Jul-14 17-Aug-14 17-Sep-14 17-Oct-14 17-Nov-14 17-Dec-14 17-Jan-15 17-Feb-15 17-Mar-15 17-Apr-15 17-May-15 17-Jun-15 17-Jul-15 17-Aug-15 17-Sep-15 17-Oct-15 17-Nov-15 17-Dec-15 17-Jan-16 17-Feb-16 17-Mar-16 17-Apr-16 17-May-16 17-Jun-16 17-Jul-16 17-Aug-16 17-Sep-16 17-Oct-16 17-Nov-16 17-Dec-16 17-Jan-17 17-Feb-17 17-Mar-17 17-Apr-17 17-May-17 17-Jun-17 17-Jul-17 17-Aug-17 17-Sep-17 17-Oct-17 17-Nov-17 17-Dec-17

Date

Flight activity of WTB at the USDA ARS NCGR Wolfskill, Winters, Solano Co. (May 2013 to Dec. 2017)

|------2013------|----------2014--------|----------2015-------|--------2016--------|--------2017-------|



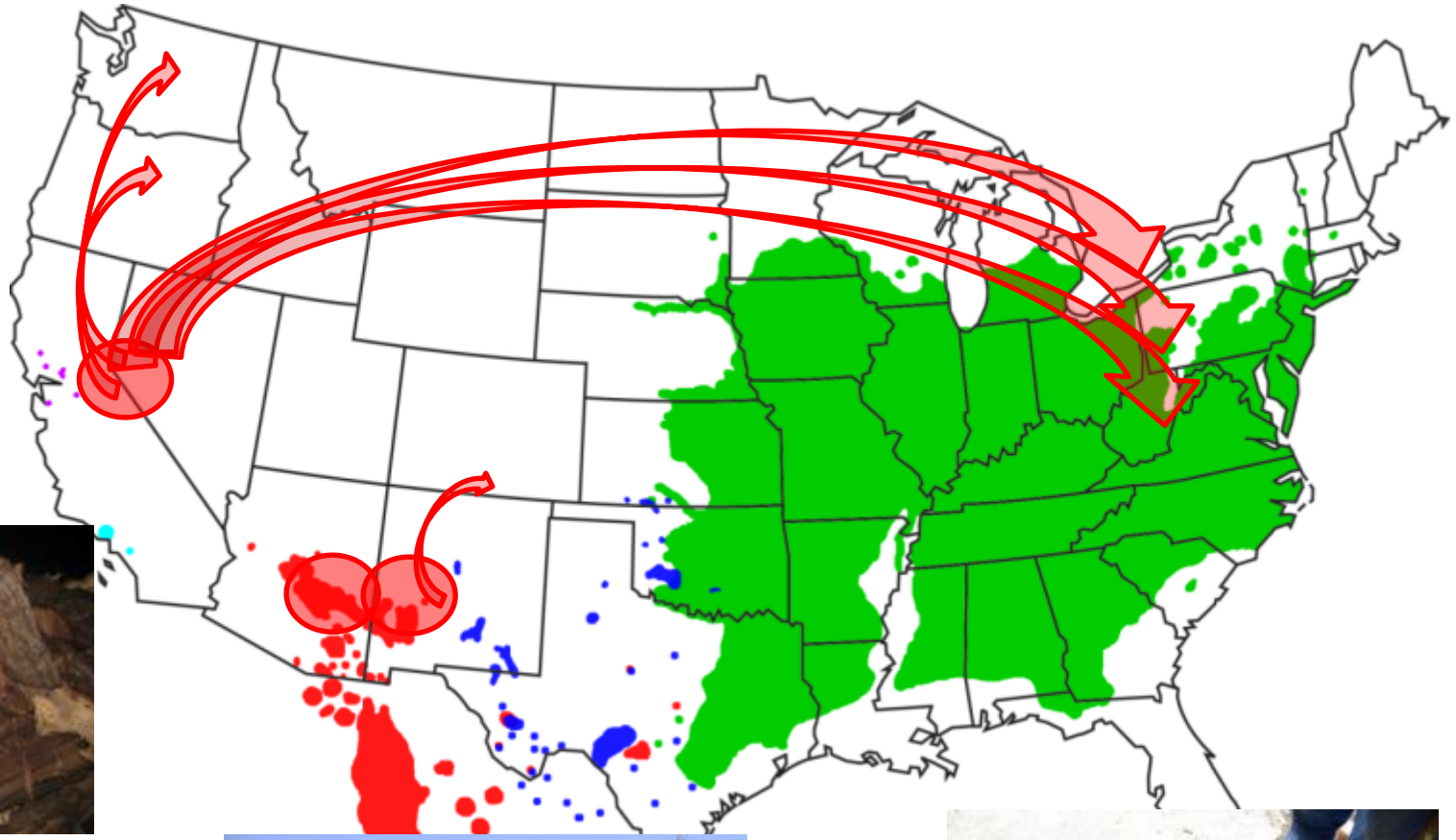
Management: Wood Handling and Sanitation

Orchard Turnover and Wood Products

(Solano Co., CA, Oct. 2015)

Photo by Stacy Hishinuma, UCD

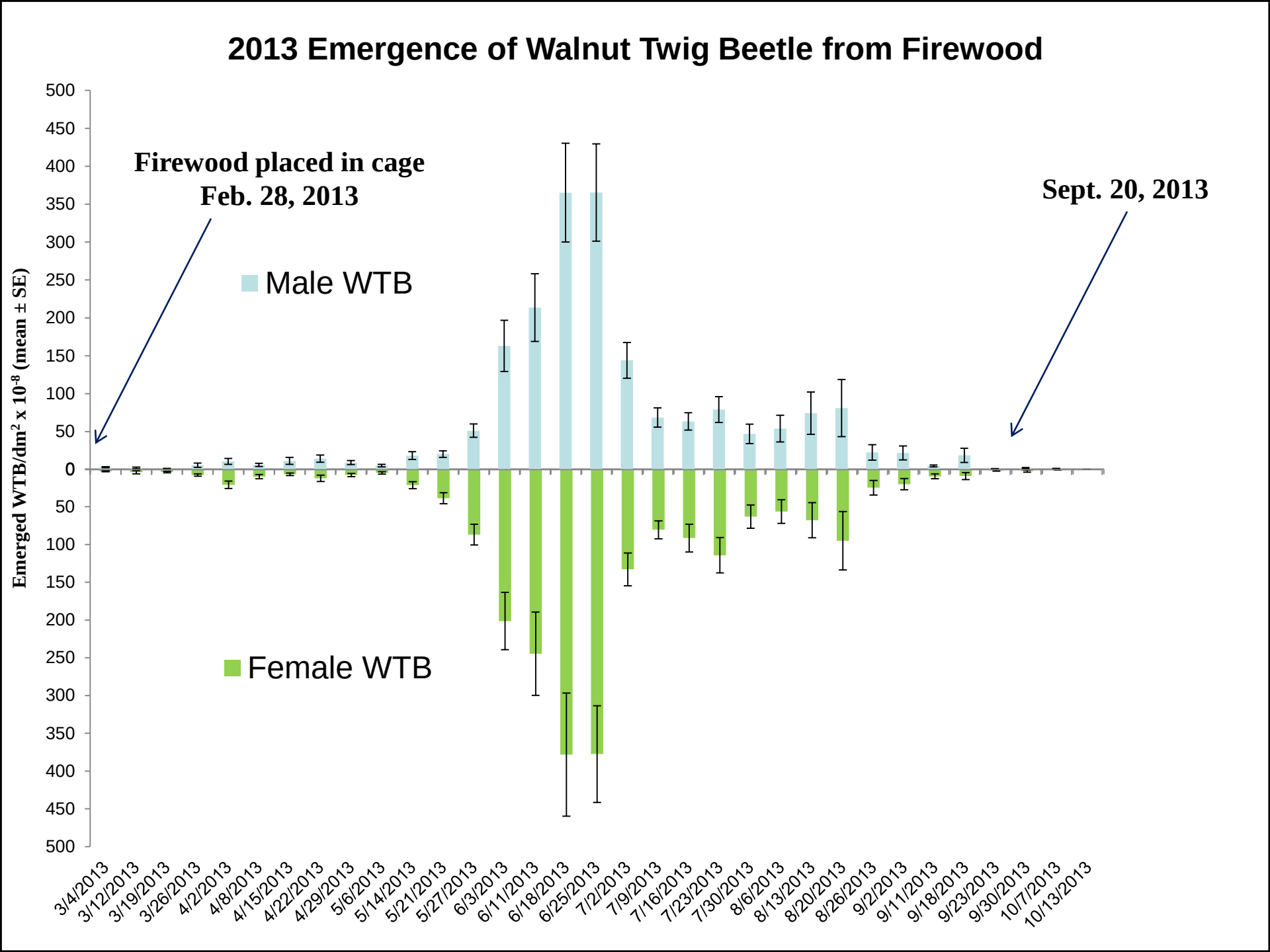
WTB Pathways for transport: Increase awareness of the risks associated with the movement of walnut wood



Andrew Graves USDA FS

How long does it take to clear English walnut firewood of walnut twig beetle and other woodborers?

In collaboration with E. Fichtner and K. Wilson, UCCE, Tulare Co.


2013 Emergence of Walnut Twig Beetle from Firewood
Firewood placed in cage
Feb. 28, 2013
Sept. 20, 2013
Male WTB
Female WTB
Emerged WTB/dm² x 10⁻⁸ (mean ± SE)
500
450
400
350
300
250
200
150
100
50
0
50
100
150
200
250
300
350
400
450
500
3/4/2013
3/12/2013
3/19/2013
3/26/2013
4/2/2013
4/8/2013
4/15/2013
4/22/2013
4/29/2013
5/6/2013
5/14/2013
5/21/2013
5/27/2013
6/3/2013
6/11/2013
6/18/2013
6/25/2013
7/2/2013
7/9/2013
7/16/2013
7/23/2013
7/30/2013
8/6/2013
8/13/2013
8/20/2013
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9/23/2013
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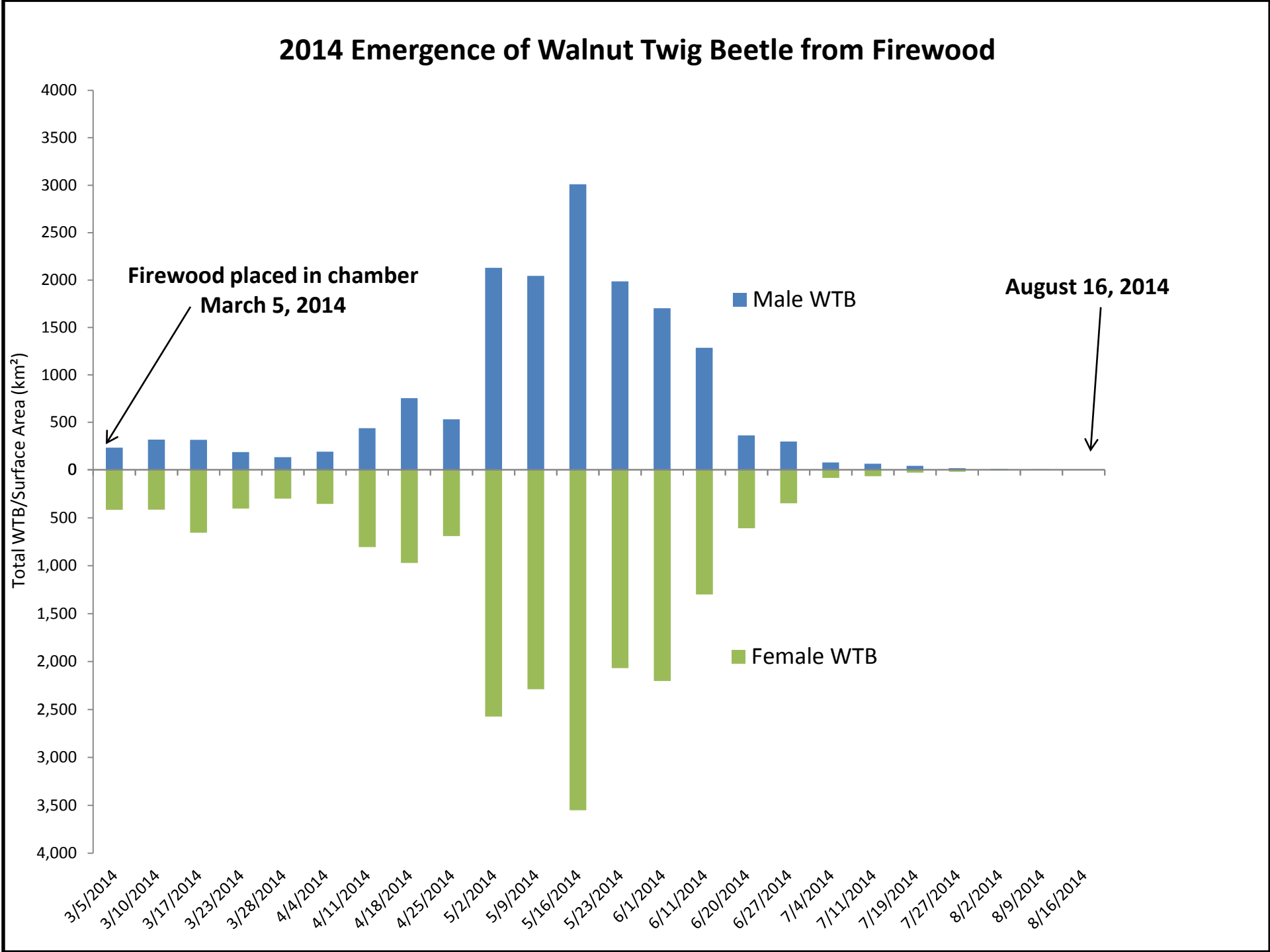
10/7/2013
10/13/2013


2014 Emergence of Walnut Twig Beetle from Firewood
Total WTB/Surface Area (km²)
4000
3500
3000
2500
2000
1500
1000
500
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
Firewood placed in chamber
March 5, 2014
August 16, 2014
Male WTB
Female WTB
3/5/2014
3/10/2014
3/17/2014
3/23/2014
3/28/2014
4/4/2014
4/11/2014
4/18/2014
4/25/2014
5/2/2014
5/9/2014
5/16/2014
5/23/2014
6/1/2014
6/11/2014
6/20/2014
6/27/2014
7/4/2014
7/11/2014
7/19/2014
7/27/2014
8/2/2014
8/9/2014
8/16/2014

Wood Management and WTB

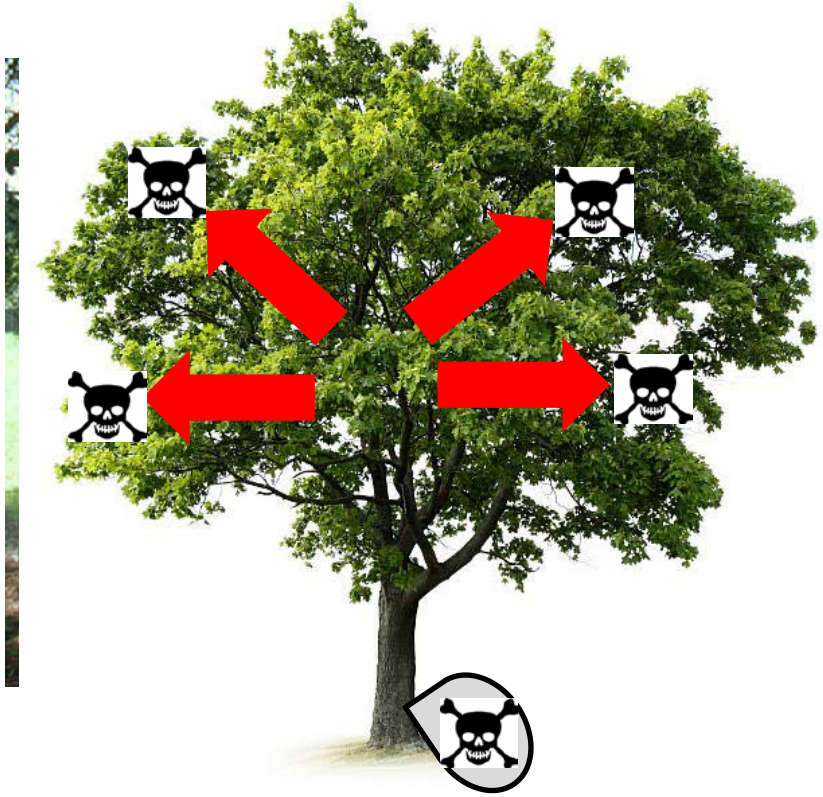
—Firewood can be “cleared” of WTB in 4 to 7 months in the Central Valley.

—Burls, galls, and graft junctions may take longer.

—Develop guidelines for best management practices for handling of WTB-infested walnut wood.

Tree Protection and WTB Management

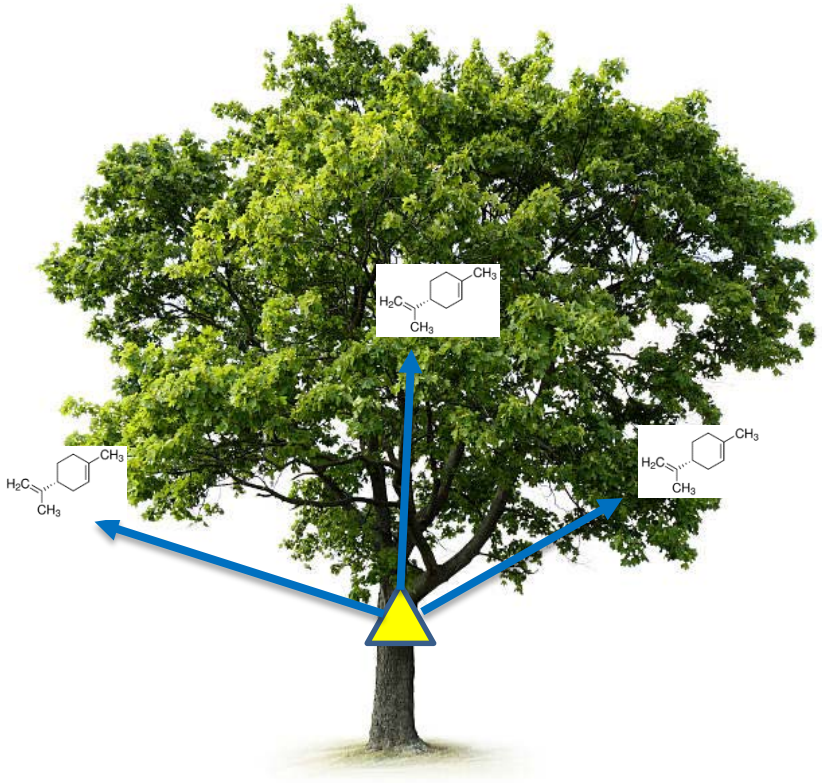
("Selection of Susceptible Walnut Hosts by the Walnut Twig Beetle: New Avenues for Managing Thousand Cankers Disease."
California Department of Food and Agriculture 2016 Specialty Crop Block Grant Program, Project No. SCB16050, R.M. Bostock/S.J. Seybold, co-PI's)



- **Insecticides: Limited efficacy…**
- **Semiochemical (=behavioral chemical) repellents: The new frontier?**

Jackson Audley, UCD Dept. Entomology and Nematology, Ph.D. Thesis Project

Semiochemicals and Protection of English Walnut from WTB

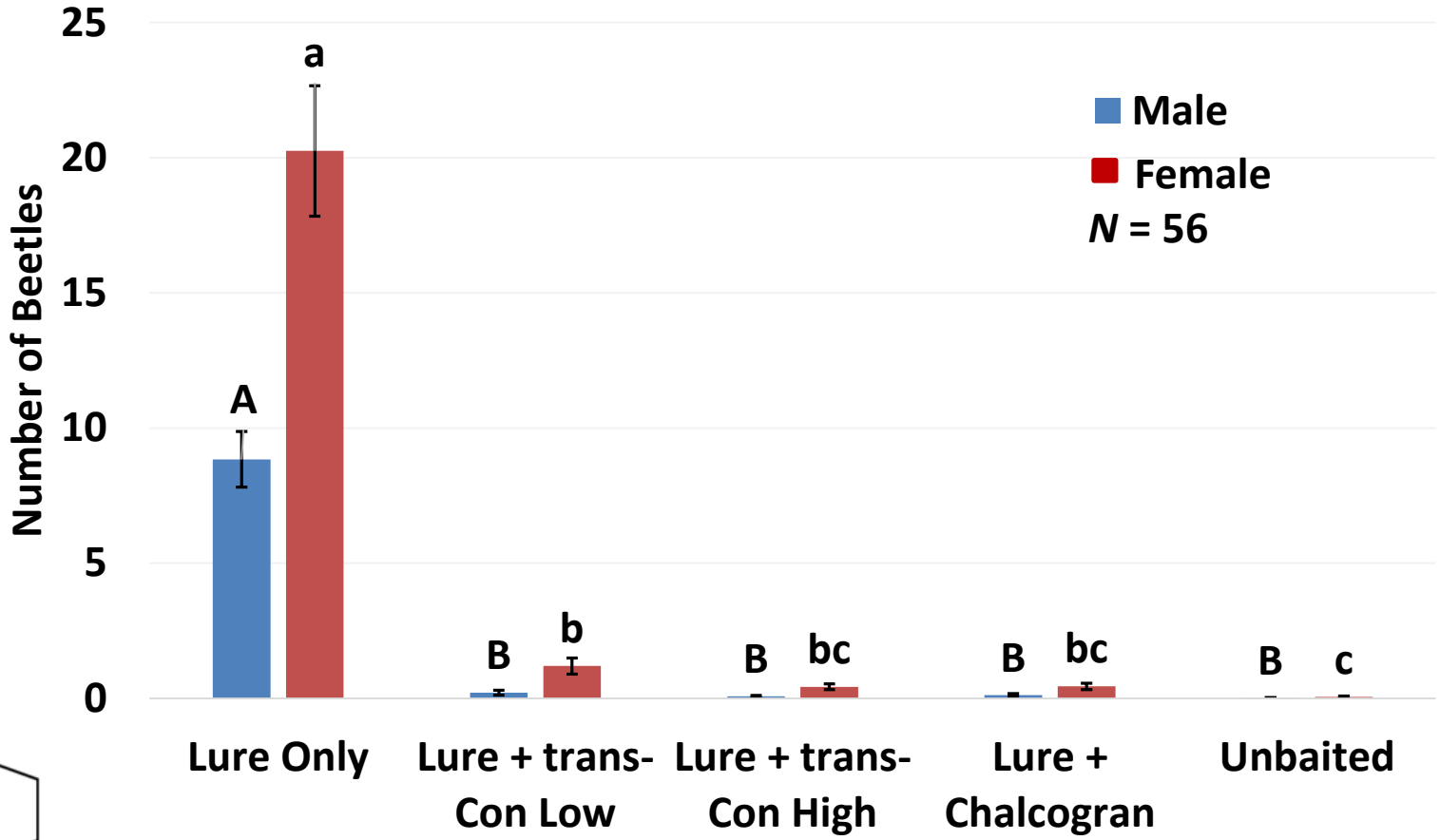


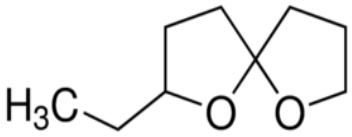
- **Semiochemicals – used to interrupt host finding or host acceptance**

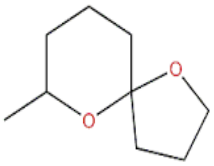
Jackson Audley, UCD Dept. Entomology and Nematology, Ph.D. Thesis Project

Reduction in Funnel Trap Catch with Two WTB Semiochemical Repellents

Mean (±SE) WTB trap catch per day in response to WTB pheromone and *trans*-conophthorin and chalcogran (Sept. - Oct. 2017, USDA ARS NCGR, Winters, Solano Co., CA)







Jackson Audley, UCD Dept. Entomology and Nematology, Ph.D. Thesis Project

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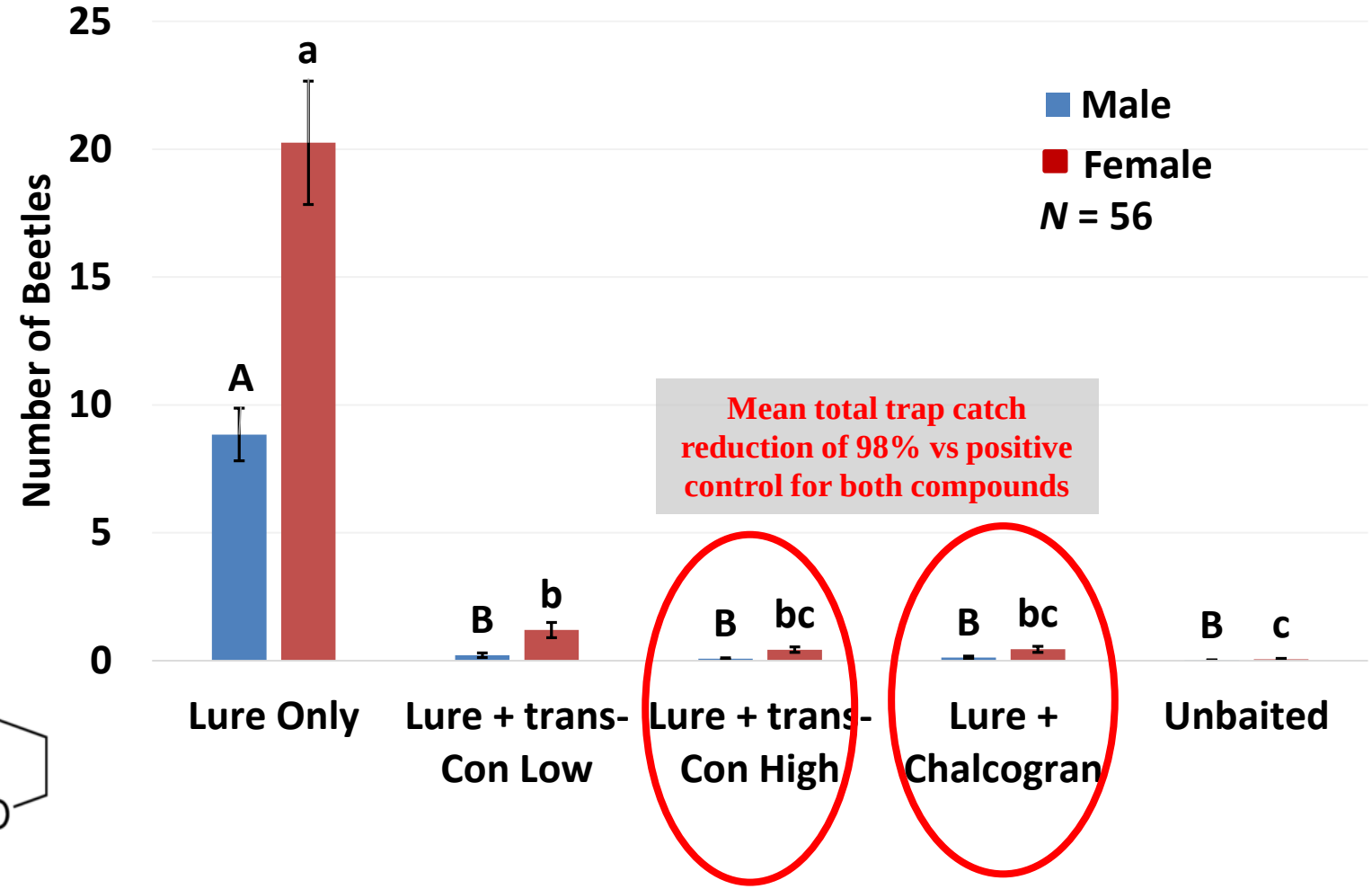

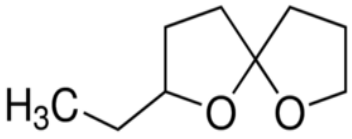

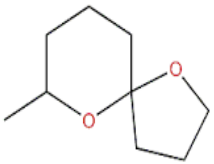

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Walnut Twig Beetle: Host Predisposition through Interactions with Crown Gall and other Root/Stem Diseases

CWB-Funded Project (2015-2017)

Determining the Impact of Walnut Twig Beetle on the Health, Productivity, and Management of English Walnut

Nickels Soil Laboratory, Leslie J. Nickels Trust, Arbuckle, Colusa Co., CA

Steven Seybold, USDA Forest Service, PSW Res. Station, Davis, CA

Cooperating Scientists: J. P. Audley, R.M. Bostock, Y. Chen, E.J. Fichtner, J.K, Hasey, B.D. Lampinen, C.A. Leslie

Nickels Estate: 48 Trees Baited to Elicit Aggregation by WTB

3 Pheromone Lures, west side of stem, 15 mg/d a.i. per tree, 720 mg/d for orchard

Baiting Schedule

Aug. 15, 2014 (3.6 mg/d a.i. per tree, 173 mg/d for orchard)
Jan. 26, 2015 (15 mg/d a.i. per tree, 720 mg/d for orchard)
Feb. 20, 2016 (15 mg/d a.i. per tree, 720 mg/d for orchard)
Feb. 24, 2017 (15 mg/d a.i. per tree, 720 mg/d for orchard)

3rd lure
@ 2 m

2nd lure
@ 1 m

1st lure
@ rootstock

CWB-Funded Project: Determine the Impact of Walnut Twig Beetle on the Health, Productivity and Management of English Walnut

OBJECTIVES

1) Determine whether or not walnut twig beetle (=WTB) has an effect on stem water potential, light interception, and stem/crown health of English walnut;

CWB-Funded Project: Determine the Impact of Walnut Twig Beetle on the Health, Productivity and Management of English Walnut

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2) Determine whether or not WTB (and TCD) has an effect on the quantity and quality of English walnut nuts produced;

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1) Determine whether or not walnut twig beetle (=WTB) has an effect on stem water potential, light interception, and stem/crown health of English walnut;

2) Determine whether or not WTB (and TCD) has an effect on the quantity and quality of English walnut nuts produced;

3) Quantify the rate and understand the kinetics of decline and mortality of healthy English walnut trees under conditions of controlled infestation by WTB.

Stem Health: Counts of Total Number of WTB Entrance/Emergence Holes Feb. 29, 2016 and March 13/14, 2017

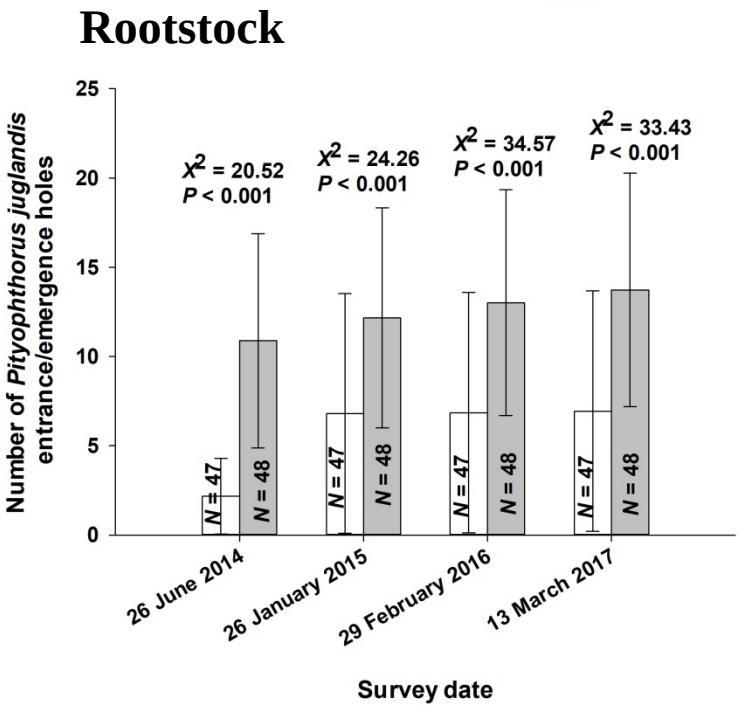
Rootstock

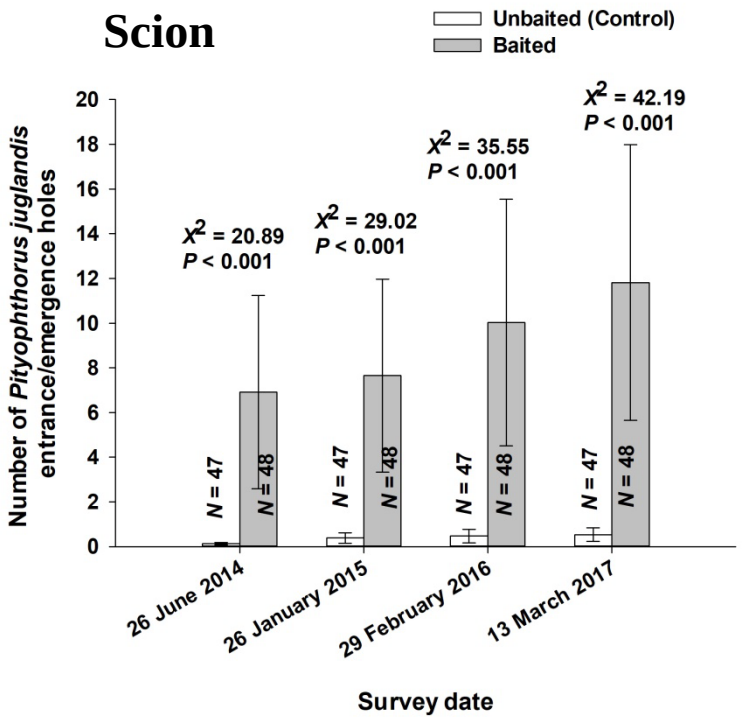
Scion

Stem Health: Counts of Total Number of WTB Entrance/Emergence Holes Feb. 29, 2016 and March 13/14, 2017

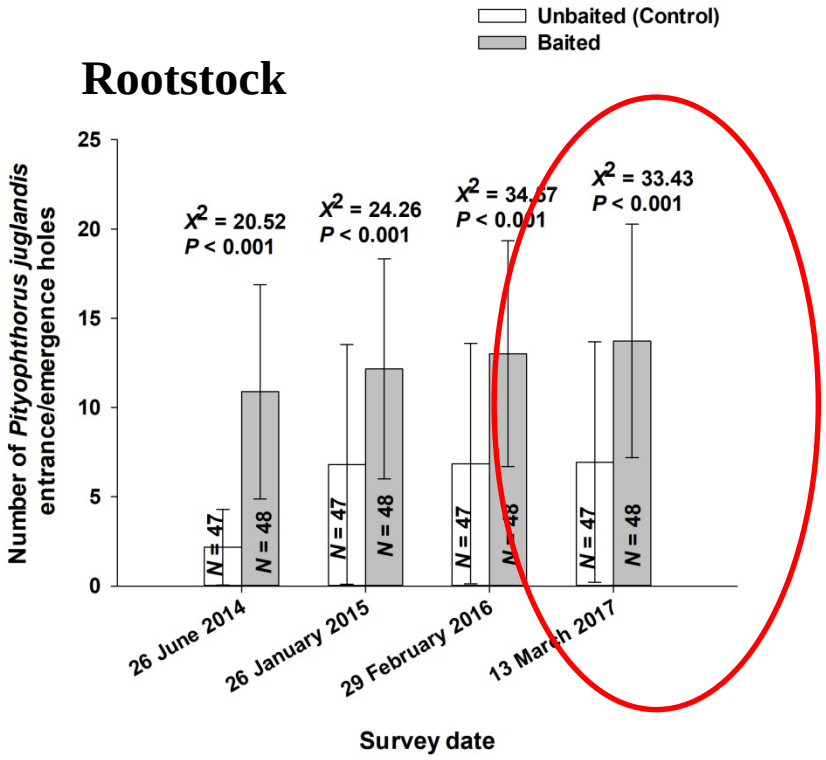
Scion

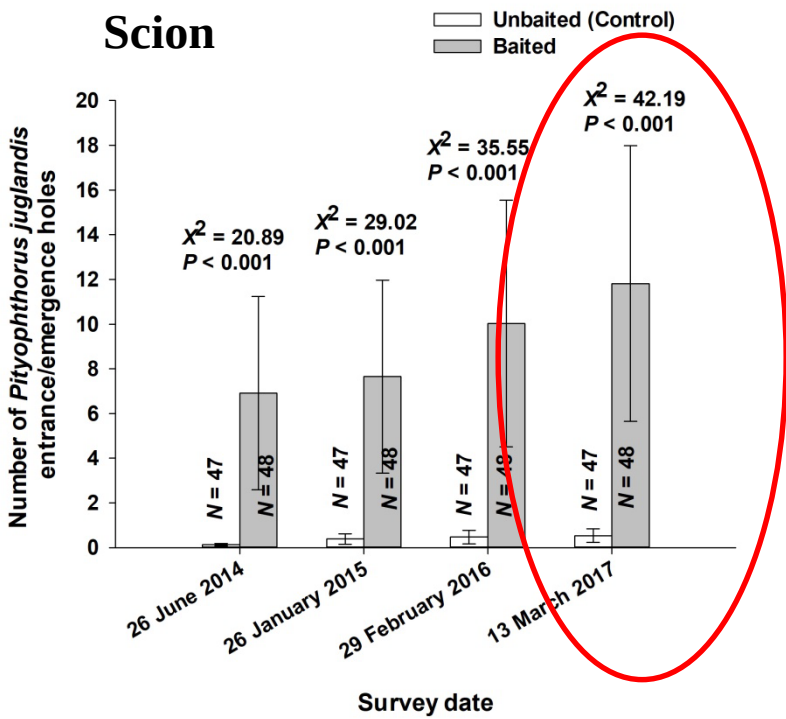
Stem Health: Counts of Total Number of WTB Entrance/Emergence Holes over Three Growing Seasons Show Significant Differences Among Control and Treated Trees



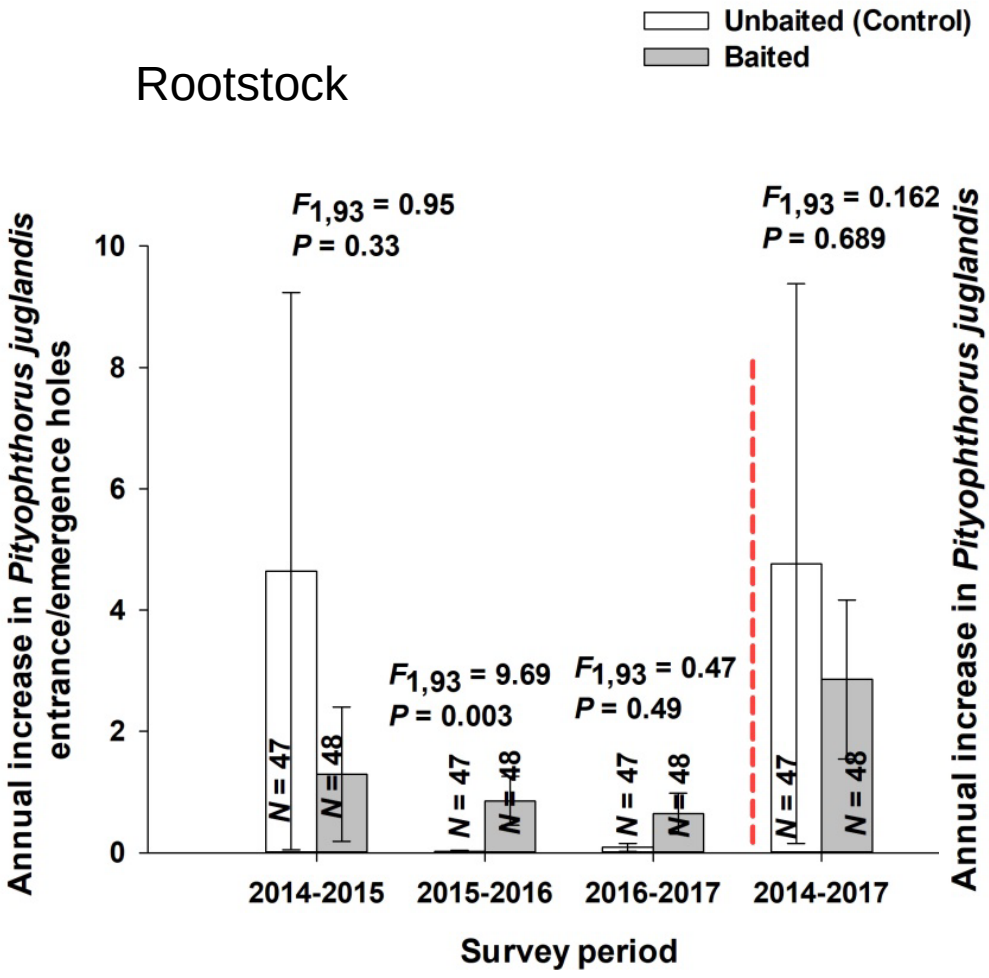


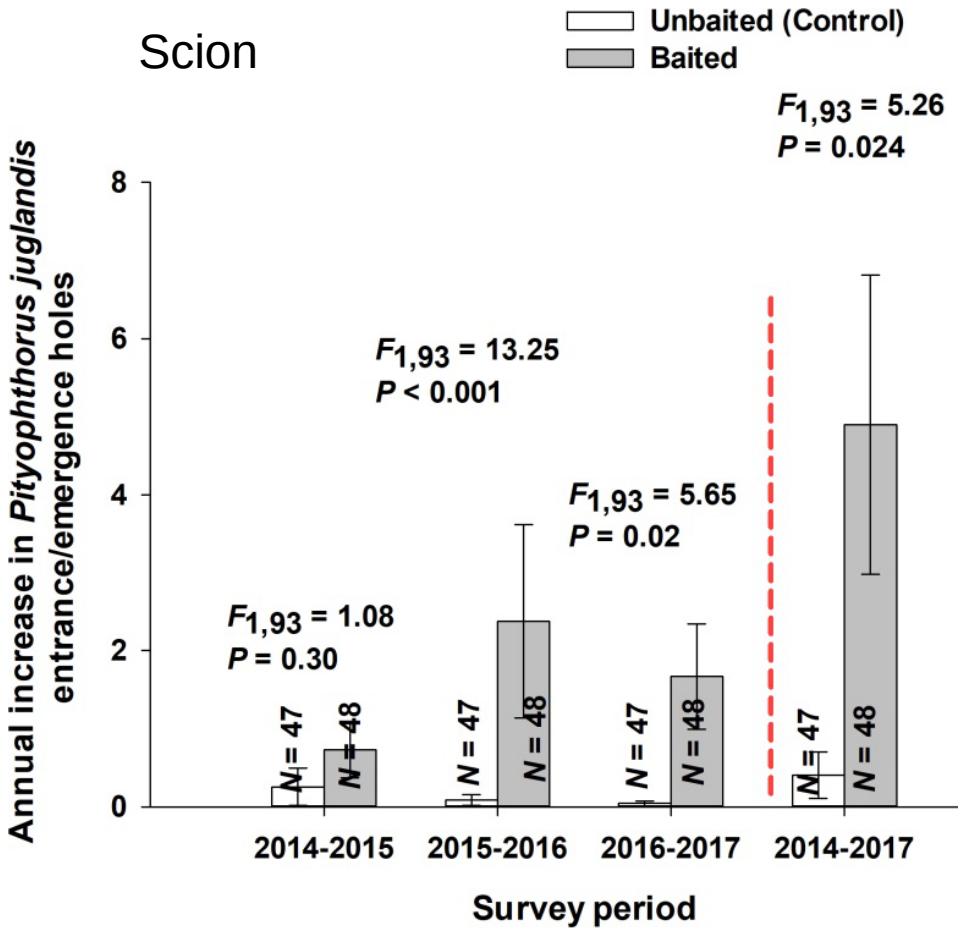
Stem Health: Counts of Total Number of WTB Entrance/Emergence Holes over Three Growing Seasons Show Significant Differences Among Control and Treated Trees





Stem Health: Increases in Number of WTB Entrance/Emergence Holes on the Scion over Four Growing Seasons Show Significant Differences Among Control and Treated Trees





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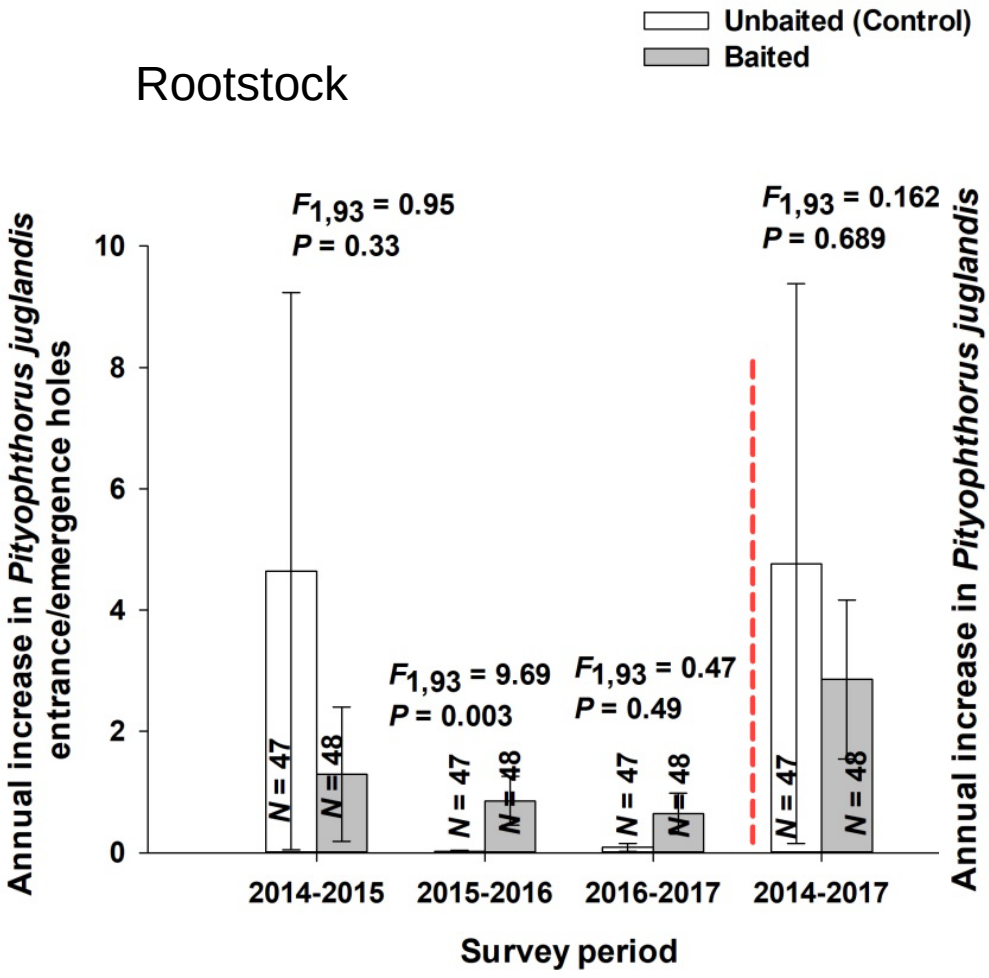
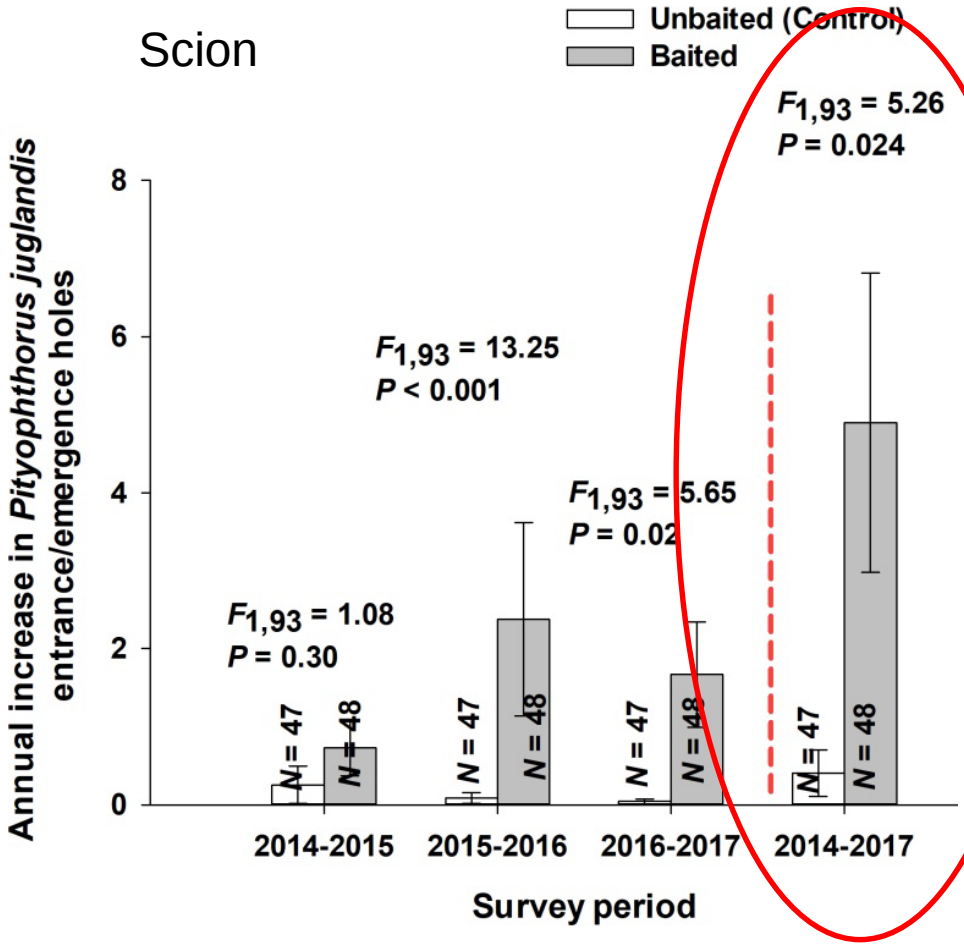
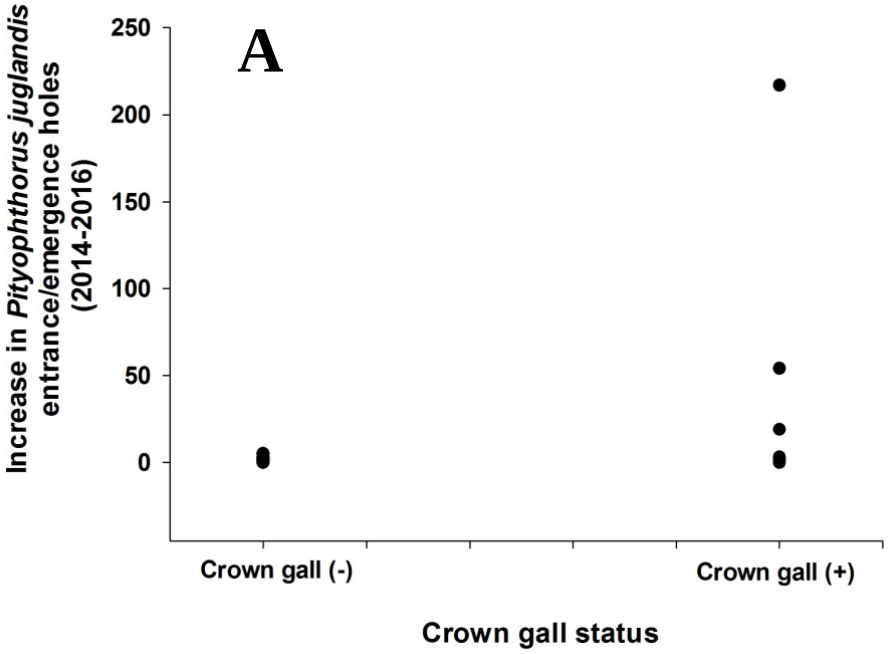


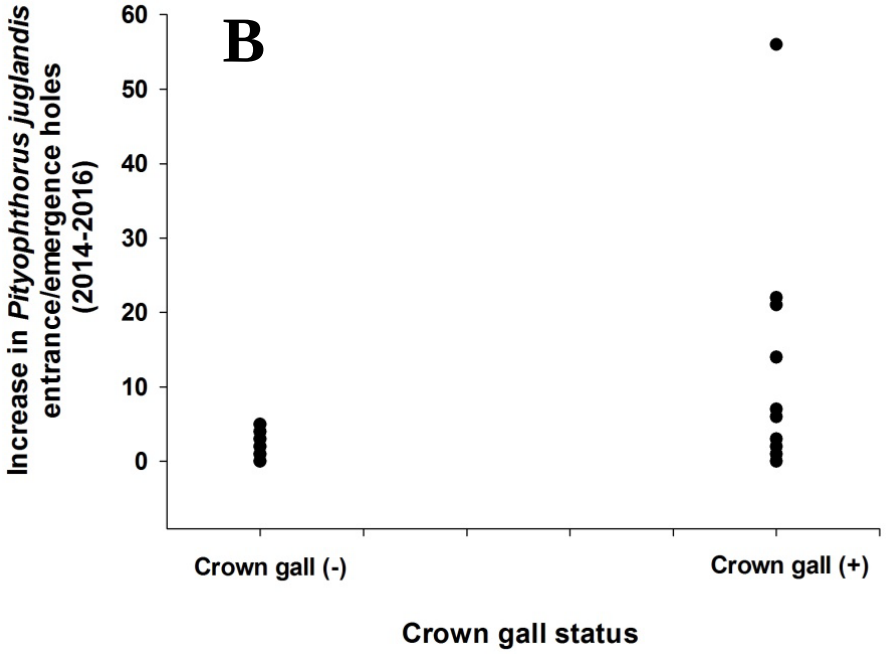


Is there an interaction between crown gall infection and success of WTB at the Nickels site?

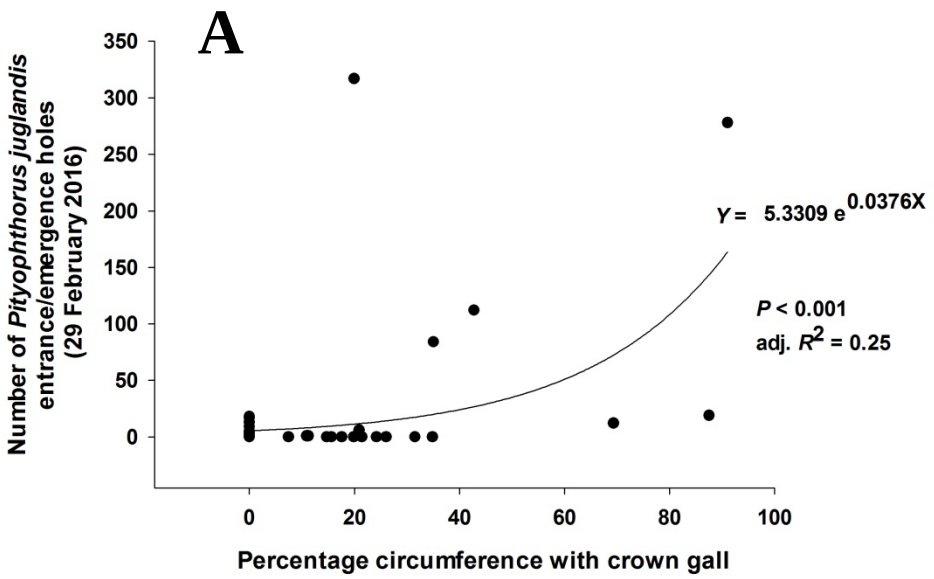
(Preliminary Data and Rationale for Further Study)

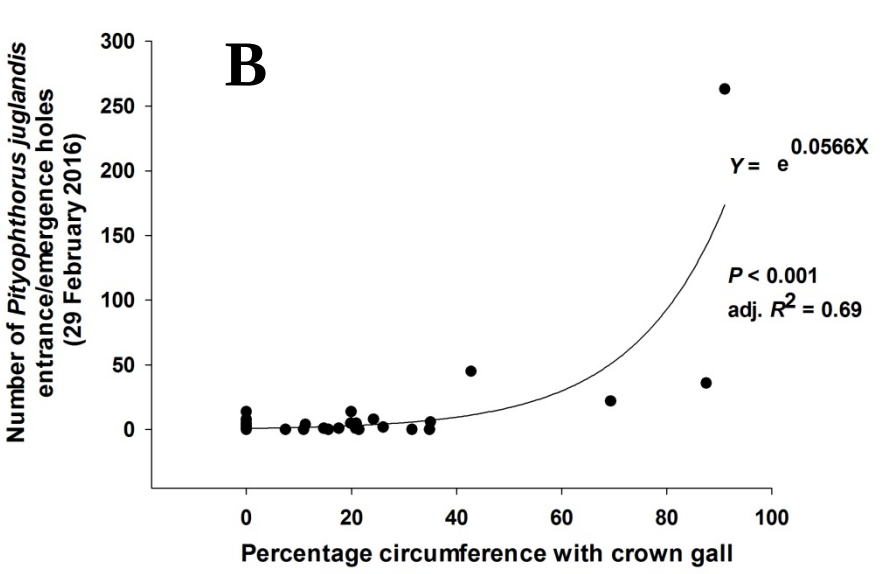
Further Analysis: There was a relationship between the incidence (presence/absence) of crown gall infection and the increase in the number of WTB entrance/emergence holes between 2014 and 2016 in the rootstock (A) and the scion (B)





Further Analysis: There was also a relationship between the severity of crown gall infection and the number of WTB entrance/emergence holes present in 2016 in the rootstock (A) and the scion (B)



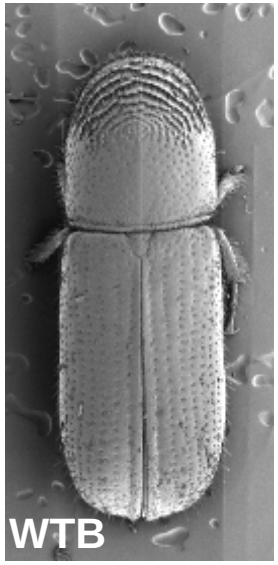


Walnut Twig Beetle Entrance/Emergence Holes around Shallow Bark Canker Stain Spots (53 of 410 trees, Kings Co., March 2-3, 2017)

WTB holes marked with pink paint

Interactions of Walnut Twig Beetle with Multiple Stem Diseases of English Walnut (Crown Gall, Shallow and Deep Bark Cankers, Lethal Paradox Canker)

(2019 New Project Proposal)



Mass attack by walnut twig beetle
on Paradox rootstock with crown gall

Steven Seybold, USDA Forest Service, PSW Res. Station, Davis, CA

Cooperating Scientists: J.P. Audley, R.M. Bostock, E.J. Fichtner, J.K. Hasey, D.A. Kluepfel, B.D. Lampinen, J. Simmons

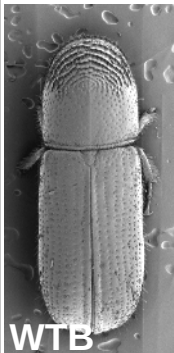
California Walnut Board, 50th Walnut Research Conference
January 26, 2018, Bodega Bay, CA

2019-2021: Proposed Future Work on WTB









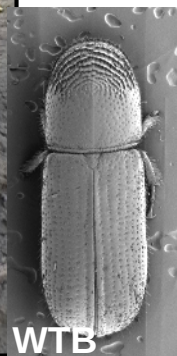
2019-2021: Proposed Future Work on WTB

Project title: Interactions of WTB with Multiple Stem Diseases of English Walnut (Crown Gall, Shallow and Deep Bark Cankers, Lethal Paradox Canker)









2018-2020: Proposed Future Work on WTB

Project title: Interactions of WTB with Multiple Stem Diseases of English Walnut (Crown Gall, Shallow and Deep Bark Cankers, Lethal Paradox Canker)

1) Conduct 100% annual field assessments of Kings Co. Orchard; Nickels study block; and USDA ARS Wolfskill NCGR English walnut collection for WTB activity with incidence and severity of crown gall, shallow and deep bark canker, and lethal paradox canker.

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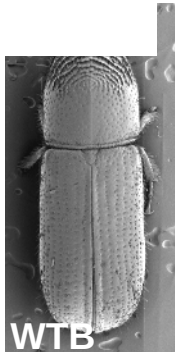
3) Collect rearing data at Lindcove REC for WTB and associated insects from Kings Co. gall tissue.



Acknowledgements

People:

Crystal Homicz, Irene Lona, Megan Siefker, Dept. Entomology and Nematology, UCD
Loreto Contador, Sam Metcalf, Bill Stewart, Dept. Plant Sciences, UCD
Franz Niederholzer, UCCE, Sutter-Yuba Cos.
Eric Heidman, Diamond Foods, Inc.
Dan Kluepfel, USDA ARS/Dept. Plant Pathology, UCD
David Lance, USDA APHIS CPHST, Otis Lab
Bruce Moltzan, USDA FHP, WO

Funding:

California Department of Food and Agriculture
California Walnut Board
USDA NIFA Specialty Crops Research Initiative
USDA FS Forest Health Protection; STDP Program
USDA APHIS CPHST, Otis Lab
University of California ANR Grants Program