TITLE: Detection and impact of an invasive insect-disease complex, the Polyphagous shot hole borer, *Euwallacea* sp., and Fusarium dieback, *Fusarium euwallaceae*, in southern California

LOCATION: Angeles National Forest, San Bernardino National Forest, Cleveland National Forest, and private land in Los Angeles, Orange, Riverside, San Bernardino, and San Diego Cos.

DATE: September 2013

DURATION: Year 2 of 2-year project **FUNDING SOURCE:** Fire Plan

PROJECT LEADER: Akif Eskalen, University of California, Riverside, Department of Plant Pathology, 951-827-3499, akif.eskalen@ucr.edu

COOPERATORS: Richard Stouthamer, UC Riverside, Department of Entomology; Kim Camilli and Tom Smith, California Department of Forestry and Fire

FHP SPONSOR/CONTACT: Tom W. Coleman, San Bernardino, CA, 909-382-2871, twcoleman@fs.fed.us

PROJECT OBJECTIVES: We have two main objectives for this project: 1) Delimit the distribution of the invasive ambrosia beetle, *Euwallacea* sp., and its symbiotic fungus, *Fusarium euwallaceae*, on public and private land with ground surveys and two trapping methods; and 2) Determine the impact of the invasive insect-disease complex in native hardwood stands and in urban forests.

JUSTIFICATION:

a. **Linkage to FHM program.** This project will determine the host species at risk on public land and in urban forests from an exotic insect-disease complex in CA. Little life history information is known about the *Euwallacea* sp. in CA and other regions of the world. The susceptibility and impact to native hardwood species from the insect-disease complex will be incorporated into future national insect and disease risk mapping layers.
b. **Significance/Impact of forest health issue.** The *Euwallacea* sp. is an exotic ambrosia beetle to CA, which carries *Fusarium euwallaceae*, a new species of fungus (Eskalen et al. 2012, Eskalen and Stouthamer 2012). *Fusarium euwallaceae* causes cankers on the main stem and branches of numerous hardwood species and the insect-disease complex can lead to tree dieback and death. *Fusarium euwallaceae* has been recovered from 107 species representing 55 families (seven species native to CA) including box elder (*Acer negundo*), coast live oak (*Quercus agrifolia*), California sycamore (*Platanus racemosa*), avocado (*Persea americana*), English Oak (*Q. robur*), bigleaf maple (*Acer macrophyllum*), and sweetgum (*Liquidambar styraciflua*). Hardwoods are an integral component of low-elevation riparian forests and losses of these species can have potential impacts to water quality, the fuel structure, wildlife habitat, and recreation. The insect-disease complex has the potential to impact the $450 million avocado industry if the beetle invades groves in southern CA. The cost of preventive treatments and hazard tree removal has already begun to impact arboretums, gardens, and the city of Long Beach, CA.

c. Scientific basis. Methods for trapping the *Euwallacea* sp. will follow published methods for detecting ambrosia beetles (Miller and Rabaglia 2009, and Hanula et al. 2008). Dr. Eskalen has previously collaborated with FHP on other forest health projects in CA and has developed methods for verifying the new *Fusarium euwallaceae*. Drs. Coleman and Stouthamer have collaborated and published previous work on an invasive species in CA (Coleman et al. Biocontrol 2012). Coleman previously received funding for two DM/EM projects and successful completed these projects (Coleman et al. For. Ecol. and Manag. 2011).

d. Cost/Economic efficiency. The University of California and California Department of Forestry (CALFIRE) will contribute salaries as match for funding. Funding for vehicles and travel will also be contributed by CALFIRE. Pathogen testing will be conducted at UCR for all samples collected during ground surveys, whereas trapping contents will be sorted and identified by FHP.

e. Priority issues. The recent discovery of this insect-disease complex in southern CA has received regional and national attention. The threat of the insect-disease complex to the avocado industry is a significant concern, and the threat to native hardwood stands is unknown. The objectives for this project align with detection and monitoring priorities for the *Euwallacea* sp. in southern CA that were formulated during a recent scientific meeting about this insect-disease complex in Riverside, CA (August 2012).

DESCRIPTION:

a. Background: The *Euwallacea* sp. was first collected in southern CA in 2003 (Rabaglia et al. 2006), but tree injury was not linked to the beetle and fungus until 2012 (Eskalen et al. 2012). The distribution of the beetle is currently limited to the urban areas of Los Angeles, Orange, and San Bernardino Cos. However, the infestation lies adjacent to the boundaries of the Angeles and Cleveland National Forests. The ambrosia beetle can produce brood in >20 hardwood species including box elder, coast live oak, avocado, castorbean plant (*Ricinus communis)*, California sycamore, and big leaf maple. The insect-disease complex has killed box elder and English oak and caused dieback on numerous other hardwood species in the urban forests of Los Angeles Co.

b. Methods: *Objective 1*. We will conduct ground surveys in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Cos. and on the Angeles, San Bernardino, and Cleveland National Forests. Ground surveys will expand along the known zone of infestation and focus on local parks, arboretums, gardens, street trees, and hardwood stands on public land. Species that are susceptible to the beetle and fungus will be examined for injury. The main stem and branches of trees will be examined for either crown thinning and dieback, boring dust, entry holes, or cankering. Any presence of cankering and staining will be collected and verified at UC Riverside using real time qPCR (Schena and Ippolito 2003).

Ethanol-baited Lindgren funnel traps will be used to monitor for the ambrosia beetle. Trapping transects will span the known infested and uninfested areas in the urban forests. On the national forests, trapping transects will run from the urban areas and span the riparian hardwood stands into the mixed-conifer forests. A total of 40 traps will be established in March and monitored bi-weekly until October during each year of the study. The location of trapping transects will be adjusted in year two depending on the first year of data.

Cut bolts of host material will be used as a second type of detection tool for the insect-disease complex. Several native and urban hardwood species will be collected from the national

forest and local arboretums. Three bolts of box elder, coast live oak, white alder (*Alnus rhombifolia*), California sycamore, bigleaf maple, castorbean, and California bay laurel (*Umbellularia californica)* will be hung in infested and uninfestead areas. Bolts will be approximately 12.5 cm in diameter and hung from 1.5 m metal conduit. Bolts will be associated with sticky panel traps for detecting insects. At the end of the study, bolts will be placed in rearing boxes to assess the ambrosia beetle fauna. Cut bolts will be hung at three sites, representing one infested urban site and two uninfested sites on public land (low-elevation woodlands and mixed conifer forest).

*Objective 2.*To determine the impact from the insect-disease complex, long-term plots will be established during the ground surveys. Plots will be used to record the hardwood composition and current tree injury and mortality. Plot size will vary depending on the setting (NF or urban land), but encompass at least 50 hardwood trees at a site. Individual trees will be tagged and the following data recorded: species, diameter at breast height (DBH), other insect and disease injury, and ranked for tree health. The degree of crown dieback and cankering, gumming, and sugaring response from the *Fusarium* sp. will be determined on the stem and branches using a five-point scale. A total of 40 plots will be established in the urban and forest landscape. Plots will be revisited in 2013 to follow the progression of tree injury from the insect-disease complex or to determine if the insect has moved into these sites.

c. Products: This project will delimit the distribution of a new exotic insect-disease complex in southern CA. Ground surveys and plot assessments will determine the most susceptible species at risk and its impact in these sites. Initial data from this project was used to produce a Pest Alert and identification guide on the new insect-disease complex. The PI's have presented data from this project at greater than 20 research and technical talks at local and regional meetings. A scientific publication will be produced from this project that details the injury and risk associated from this insect-disease complex in southern CA.

d. Schedule of Activities:

Year	Objective
2012	Preliminary ground surveys were conducted on the Angeles NF and Los Angeles and Orange Cos. from July to September. Bolts of several hardwood species were collected in August
2013	Trapping transects will be established in March and monitored through October. Ground surveys and plot establishment will occur throughout the year. Preliminary progress reports will be prepared in September
2014	Trapping transects will be re-established in March based on 2012 detection data. Plots will be reassessed during the year and a publication will be prepared the winter.

e. **Progress/Accomplishments:** *Objective 1.* Ground surveys were conducted for the *Euwallacea* sp. and *Fusarium euwallaceae* in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Cos. and on the Angeles, San Bernardino, and Cleveland National Forests. (Appendix 1). Lindgren funnel traps, clear sticky panel traps, and cut bolts of several hardwood species were use to monitor the distribution and activity of ambrosia beetle (Appendix 1). Adults were collected in Lindgren funnel traps and clear sticky panel traps, but cut bolts were not effective at collecting adults. Trapping determined the beetle was active throughout most of the year (February to September) in lower elevation

stands. The zone of infestation was found in Los Angeles, Orange, and San Bernardino Cos. and two canyons on the Angeles National Forest.

Objective 2. Tree injury from the insect-disease complex was observed on red willow, white alder, California sycamore, coast live oak, and castorbean on the Angeles National Forest (Appendix 1). The insect-disease complex has killed red willow, white alder, and castorbean on public land. In September 2013, mean infestation rates from the *Euwallacea* sp. on white alder was 92%, 82% on red willow, 71% on castorbean, 50% on California sycamore, and 13% on coast live oak in Pasadena Glen. Injury has only been observed on castorbean in Santa Anita Canyon.

f. Relevant Citations:

Eskalen, A., Gonzalez, A., Wang, D.H., Twizeyimana, M. Mayorquin, J.S., Lynch, S.C. 2012. First report of a *Fusarium* sp. and its vector tea shot hole borer (Euwallacea fornicatus) causing *Fusarium* dieback on avocado in California. Plant Disease. 96: 1070.

Eskalen, A. and Stouthamer, R. 2012. Pest Alert: Fusarium dieback on California avocado trees vectored by Teas Shot Hole Borer (*Euwallacea fornicatus*). http://eskalenlab.ucr.edu/handouts/fusarium_dieback_english.pdf

Hanula, J.L., Mayfield, A.E., Fraedrich, S.W., and Rabaglia, R.J. 2008. Biology and host associations of redbay ambrosia beetle (Coleoptera: Curculionidae: Scolytinae), exotic vector of laurel wilt killing redbay trees in the southeastern United States. J. of Econ. Entom.101: 1276-1286.

Miller, D.R. and Rabaglia, R.J. 2009. Ethanol and (−)-*α*-Pinene: Attractant kairomones for bark and ambrosia beetles in the Southeastern US. J. of Chem. Ecol. 35: 435-448.

Rabaglia, R.J., Dole, S.A., and Cognato, A., 2006. Review of American Xyleborina (Coleoptera: Curculioniadae: Scolytinae) occurring north of Mexico, with an illustrated key. Ann. of the Entom. Soc. of Am. 99: 1034-1055.

L. Schena, Ippolito, A. 2003. Rapid and Sensitive Detection of *Rosellinia necatrix* in root and soil by real time scorpion-PCR. J. of Plant Path. 85: 15-25.

COSTS:

	Item	Requested FHM EM Funding	Other-Source Funding	Source
FY 2014				
Administration	Salary (35% Jr. Spec.)	20,489	12,306 (A.E.), 3,768 (R.S.), 6,300 (K.C. & T.S.)	UCR/CALFIRE
	Overhead	0	4,348 (15% waived[2])	UCR
	Travel	4,000	3,000	CALFIRE
Procurements	Equipment	0	0	
	Supplies (baits, lab supplies[1])	4,500	0	
Total		**28,989**	**29,722**	

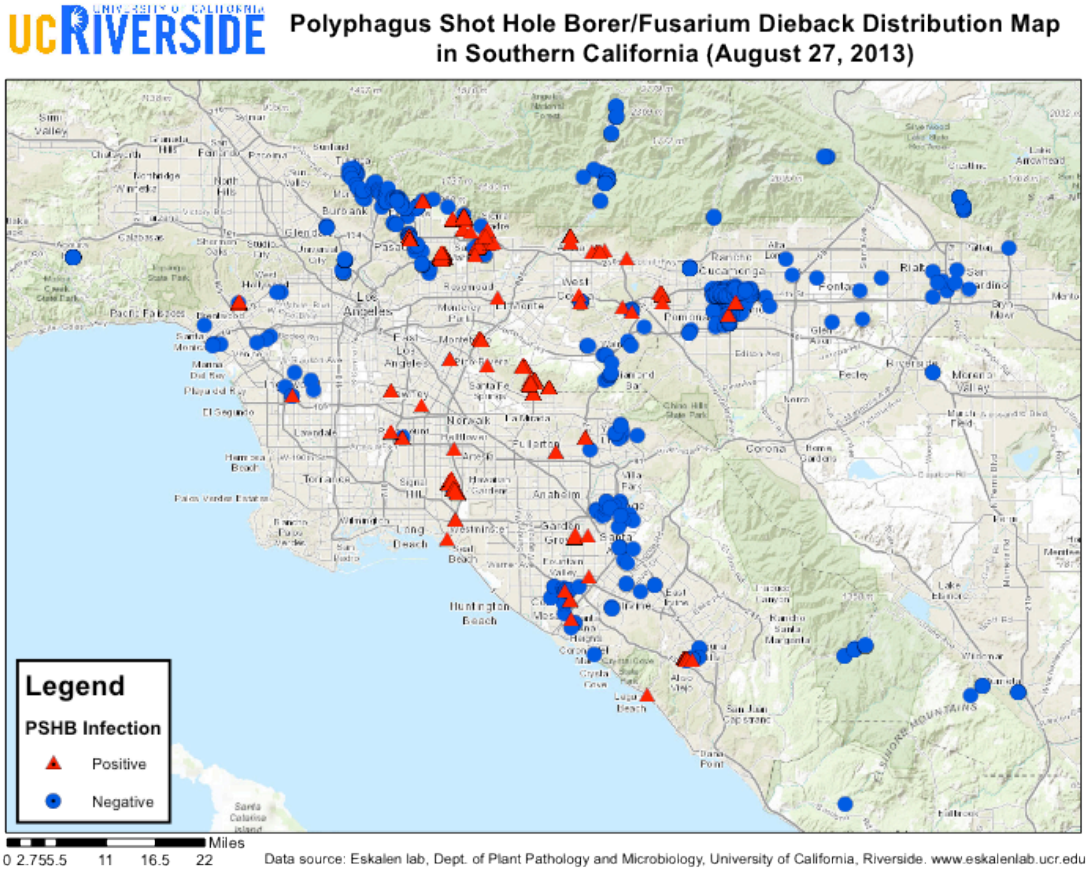
[1]Lab supplies will be used for fungal identification (PCR, PCR purification, and DNA Sequencing).

[2] Overhead costs from UCR will be waived through a cooperative agreement.

Appendix 1. Progress and accomplishments from FY 2013 for *Objectives 1* and *2*.

Objective 1. Ground surveys were conducted on public land and in the urban areas to delimit the distribution of the insect-disease complex. Ground surveys were conducted on the Angeles, Cleveland, and San Bernardino National Forests and in the urban areas of Los Angeles, San Bernardino, Orange, Riverside, San Diego, and Venutra Counties (Fig. 1). Castorbean was commonly observed for *Euwallacea* sp. infestation in the urban areas and on public land. These shrubs will continue to be monitored for use as sentinel trees. Since October 2012, the insect-disease infestation extended from Pasadena north into Altadena and south to Highway 22 in Mission Viejo, Orange, Santa Ana, Costa Mesa, and Laguna Beach. We confirmed the presence of the infestation west of Los Angeles in Santa Monica, Paramount, and Long Beach. We also discovered the infestation in Ontario, which confirms the eastern extent of the infestation in San Bernardino County (Fig 1). The zone of infestation now includes the Angeles National Forest, Los Angeles Ranger District and Los Angeles, Orange, and San Bernardino Cos.

Figure1. Distribution of the polyphagous shot hole borer, *Euwallacea* sp., and Fusarium Dieback, *Fusarium euwallaceae*, determined by ground surveys and trapping in southern California.



Forty-one ethanol-baited Lindgren eight-cup funnel traps were established throughout southern California to monitor the distribution and activity of the *Euwallacea* sp. in native and urban forest stands. In June 2013, traps were established on the Angeles, Cleveland, and San

Bernardino National Forests and in the urban areas of San Bernardino. Traps were sampled monthly from June to September, and will continue to be sampled through the fall and winter of 2013. *Euwallacea* sp. adults were collected in traps located in two canyons (Santa Anita Canyon and Pasadena Glen) on the Angeles National Forest.

In January 2013, 12 clear sticky-panel traps were placed on six *Euwallacea* sp.-infested trees to monitor beetle activity. Panel traps were placed on three red willow and three castorbean in Pasadena Glen on the Angeles National Forest. Panel traps were monitored biweekly from January to September. Beetle activity was recorded in January, peaked in late March, and then activity declined as the trees were killed by the insect-disease complex. Clear sticky-panel traps were established on three additional infested trees to continue monitoring beetle activity through 2014.

Cut bolts of box elder, coast live oak, white alder, California sycamore, bigleaf maple, castorbean, and California bay laurel were associated with yellow-sticky cards to determine if host volatiles were attractive to *Euwallacea* sp. adults. Bolts were hung on 9 September 2012 in one infested stand and two uninfested stands in Los Angeles County. Bolts were checked biweekly, but no adults were collected on the sticky card traps and no attacks were found on the bolts. The thin layer of tanglefoot on the yellow sticky cards was likely not effective for trapping the beetles and the bolts may have dried out too quickly.

Objective 2. From December 2012 to September 2013, long-term plots were established in 40 hardwood stands on the Angeles, Cleveland, and San Bernardino National Forests. Plots were established along an elevational gradient to encompass all hardwood species. A total of 739 trees were surveyed on public land. Canyon live oak, red willow, interior live oak, white alder, California sycamore, California black oak, coast live oak, castorbean, elm species, and Fremont cottonwood were the most abundant species surveyed on public land. The *Euwallacea* sp. can reproduce in red willow, white alder, California sycamore, coast live oak, and castorbean. The insect-disease complex has killed red willow, white alder, California sycamore, and castorbean in survey plots. Tree injury was found on all size classes (5.3-80.2 cm DBH). Mean infestation rates from the *Euwallacea* sp. on white alder was 92%, 82% on red willow, 71% on castorbean, 50% on California sycamore, and 13% on coast live oak. Density of attacks was highest in two 15.2 cm^2 areas along the main stem of castorbean followed by red willow, white alder, and California sycamore. The insect-disease complex has only injured castorbean in Santa Anita Canyon.