Proposal: WC-F-08-01

Title: Monitoring invasive bark and woodboring beetles in periurban forests following wildfire

Location: Periurban national forests in southern California

Duration: 2 years **Funding Source:** Fire

Project Leader: Steven J. Seybold, Pacific Southwest Station, USDA FS, 530-297-1072, sseybold@fs.fed.us

Cooperators:
• Michael Bohne, Tom W. Coleman, and Zachary Heath, R5, FHP; Mary Louise Flint, UC Davis; Richard L. Penrose, CDFA

Project Objectives:
• Determine if burned forests support higher population densities of invasive bark and woodboring beetles
• Evaluate the relationship between the response of invasives and the postfire interval
• Evaluate the relationship between the response of invasives and the extent of wildfires

Justification:
Linkage to FHM Detection Monitoring. Bark and woodboring beetles occur in many parts of the West. Forest Health Protection Aerial Detection Surveys have repeatedly document tree mortality caused by these beetles in the four Southern California National Forests. Mortality caused by these beetles have contributed to recent severe wildland forest fires. Exotic invasive beetles have also been detected in the periurban forests by FHP/Research detection trapping (Map 1). The relationship between these invasive beetles and fire is unknown.
Significance in terms of geographic scale. Although this project will be conducted in USFS R5 in and around the LA Basin, similar fire impacts are experienced at periurban sites (e.g., Boise, Denver, Portland, Salt Lake City) throughout the range of western pine forests. The findings will lead to management approaches consistent with ecological processes, and be applicable to other western regions.
Biological and political importance. Fire is a constant threat to forests and homes in the arid West. For example, in 2003 California experienced nearly 6,000 fires, with over 400 thousand acres burned, and a cost of over $970 million (CDF 2007). The number of invasive bark and woodboring beetles is rising rapidly in the U.S. California is a focal point for invasive bark beetles, accounting for a third of the U.S. total (Penrose et al. 2007). However, the relationship between wildfire in and around urban areas where invasives are introduced, and the establishment and spread of these invasives is poorly understood. Policymakers and land managers should know how these invasives can respond to fire extent, frequency, and post-fire interval, and whether fires facilitate invasion and damage by these insects.
Feasibility or probability that the project will be successfully completed. The National Forests around the LA Basin provide a good location to implement this monitoring project because of the frequent occurrence of fires and the high number of invasive species. Since 2005, our group has studied invasive bark beetle species in southern California (Lee et al., 2005, 2006, 2007; Liu et al., 2007); has optimized monitoring baits; and has accumulated other baseline data such as host range and dispersal potential. Therefore, we have highly qualified staff and infrastructure to conduct the project.

Description:
a. Background:

Fire and invasive species are both important disturbance agents that can negatively affect forest health. Fires significantly alter the structure of forest arthropod communities (McCullough et al. 1998). Fires may also weaken the physiological defense mechanism of trees, and make trees more susceptible to bark and woodboring beetles (Boulanger and Sirois 2007). Invasive insect species also have significant ecological impacts on forest ecosystems (Liebhold et al. 1995) by changing the arthropod community or impacting trees. Invasive insect species sometimes capitalize on fire-exposed habitats (Gandhi 2005).

Recently, personnel from PSW, UCD, CDFA, and R5-FHP have cooperated to characterize the invasion biology of the redhaired pine bark beetle, *Hylurgus ligniperda*, in the urban forests of southern California (Map 1). Based on surveys of urban parks and golf courses, a *Pest Alert* was prepared (Liu et al. 2007), and a funnel trap bait was developed with optimized release rate and stereochemistry. Flight periodicity curves were developed by using this bait. During the course of this collaborative work, we also found that α-pinene was attractive to *Arhopalus syriacus* (an invasive cerambycid) and ethanol was attractive to *Xyleborinus saxeseni* (an invasive ambrosia beetle). Two of the three species colonize pines. We know almost nothing about their behavior and distribution in the national forest lands around the LA Basin (Angeles, Cleveland, Los Padres, and San Bernardino NFs), although these lands are heavily forested with pine. We also do not know whether invasion of one insect species facilitates or impairs the invasion of a second species.

From 2003 to the present, over 100 large (>300 acres) fires occurred in Southern California, ranging in size from 350 to 273,246 acres. However, little is known about the impacts of these fires on the range expansion of the invasive bark and woodborers noted above. Specifically, we do not know if wildfires create a favorable environment for colonization by the invasives, if the response of the invasives would be affected by fire extent and severity, or how the response would change with time since burning. This is a significant knowledge gap that needs to be addressed so that policymakers and land managers can make informed decisions and assessments of threats from invasive bark and woodboring beetles after fires.

b. Methods:

We used historical fire data, including aerial survey data, to guide our selection of 12 burned and 12 unburned sites in southern California for monitoring of invasives. Criteria for selection include (1) date of the fire; (2) size or extent of the fire; (3) location of the fire relative to the current known distribution of *H. ligniperda*; (4) cover type; (5) land ownership; and (6) if small, location of the fire relative to larger "mega-fires". We will allocate six sites to recent fires (2005-2007) and six sites to older fires (2002-2004). Within each group of six, we will select three sites that represent large fires (>1,000 acres) and three sites that represent small fires (300-1,000 acres). Small fire monitoring sites will be located as far as possible from large fire sites to avoid any landscape level influences from the large fires. The burned and unburned plots at each site will be located as close as possible to one another to reflect similar geographic conditions. At all 24 sites, we will place 12-unit Lindgren funnel flight traps and pitfall traps (both baited) to monitor *H. ligniperda*, *A. syriacus*, and *X. saxeseni*. All three of these invasive species respond to funnel traps baited with α-pinene and ethanol. Three funnel traps and three pitfall traps will be placed in two transects each site. Pitfall traps will consist of an outer 1 L and an inner 500 ml plastic cup filled with 2-3 cm of antifreeze as a preserving agent, and each trap will be covered with a 100 cm^2 plywood roof to protect the collecting cup from small mammals and rain. Traps will be emptied bi-weekly for 4 months each year (April-August). The trap catches (surrogate for population density) of the three invasives will be compared between burned and unburned sites, between times since the fire occurred (recent vs. old), and between fire extent levels

(small vs. large). Correlation analyses will be used to determine the potential interactions among the three invasive species (e.g., facilitated or impaired invasion).

c. Products:
The study will determine the impacts of fires on invasive species, and produce a map showing known occurrences of these invasive beetles on federal forest lands, a technical report, and a peer-reviewed manuscript. Findings from this study will be transferred to land managers through local and regional meetings (e.g., FHM annual meeting, WFIWC, CFPC Annual Meeting) and *via* web media. Guidelines will be developed to prevent the facilitated spread of invasives by wildfire. The linkage to Mary Louise Flint's UC Statewide IPM Program insures that the guidelines we develop will have longevity and will be made widely available through their already successful web-based offerings and IPM network.

d. Schedule of Activities:

February to March 2008	Locate monitoring sites
April to August 2008	1st year monitoring trapping
September to December 2008	Sample sorting
April to August 2009	2nd year monitoring trapping
September to December 2009	Sample sorting, data analysis, and report preparation

e. Progress/Accomplishments:
• Determine if forest fires are conducive to the expansion of invasive populations in national forests

Twelve burned and 13 unburned sites were selected in the San Bernardino, Angeles and Cleveland National Forests from March to early May in 2008. All sites have been sampled bi-weekly until late September using both funnel and pitfall traps. We are still sorting the samples. However, according to our preliminary data, burned sites in Southern California national forests tended to accommodate more invasive beetles of *Hylurgus ligniperda*, *Xyleborinus saxeseni* and *Arhopalus syriacus* than unburned sites. The invasive redhaired pine bark beetle (*H. ligniperda*) has climbed up to about 3400 ft in the San Bernardino National Forest, and 3700 ft in the Angeles National Forest. Clear comparisons will be made between burned and unburned sites with the full data set.
• Document the impact of time since fire on invasive species populations
• Document the impact of forest fire extent on invasive species populations

Costs:

FY08	**Requested FHM EM funding**	**Other-Source funding (e.g. contributed salary)**
Salary (UC Davis postdoctoral assoc.) Fringe (4 mo salary + fringe) Salary (student assistant-southern California)	$14,994 $3,749 $5,000	$14,994 (UCD postdoc) $3,749 (UCD postdoc) $6,700 (PSW) $4,899 (R5-FHP)
Travel-Mileage/per diem	$4,000	
Materials (baits/misc. supplies)	$7,974	$2,880 (72 traps @$40/trap)
SUBTOTAL	$35,717	$33,222
Overhead PSW (3%-passthrough rate from PSW to UCD)	$1,072	

FY08 Total	**$36,789**	**$33,222**
FY09	**Requested FHM EM funding**	**Other-Source funding (e.g. contributed salary)**
Salary (UC Davis postdoctoral assoc.) Fringe (4 mo salary + fringe) Salary (student assistant-southern California)	$15,744 $3,936 $5,000	$6,700 (PSW) $4,899 (R5-FHP)
Travel-Mileage/per diem	$4,000	
Materials (baits/misc. supplies)	$7,974	$2,880 (72 traps @$40/trap)
SUBTOTAL	$36,654	$14,479
Overhead PSW (3%-passthrough rate from PSW to UCD)	$1,100	
FY09 Total	**$37,754**	$14,479
PROJECT TOTAL	**$74,543**	**$47,701**

Salary: Funding is requested for a postdoctoral associate (Dr. Deguang Liu) co-supervised by Dr. M.L. Flint (UCD) for 4 mo each yr to install, and to collect and analyze data from the monitoring study ($3,570/mo) with a 5% increase in yr 2. Fringe for the postdoctoral associate is 25% of salary ($892/mo with a 5% increase in yr 2). A local student assistant will also be hired to empty the monitoring traps ($5,000/yr). Matching salary and fringe will be contributed for Liu for 4 mo in yr 1 and for Seybold (PSW) for 1 mo in yr 1 and 2 for Bohne and Heath (FHP) for 0.5 mo in yr 1 and 2.

Travel: Travel ($4,000/yr) is requested for lodging, meals, and vehicle for the postdoctoral associate and assistant to install and service the traps, and for attending critical annual meetings (e.g., FHM or CFPC) to present the results.

Supplies: The primary materials required for the field study are the trap baits ($25.95 per trap x 144 traps x 1 bait change/yr = 384 baits/yr for $7,474/yr). We are also requesting support for miscellaneous disposable items [antifreeze for pitfall traps, insecticides, sample vials, and bags ($500/yr)]. Sufficient funnel traps and pitfall taps, rebar, and conduit poles for the study are already available at the PSW Chemical Ecology of Forest Insects Laboratory. This equipment will be contributed as a match for the project.

Indirect costs: Indirect costs are charged at 3% of total direct costs for funds that will be passed through from PSW to UCD.

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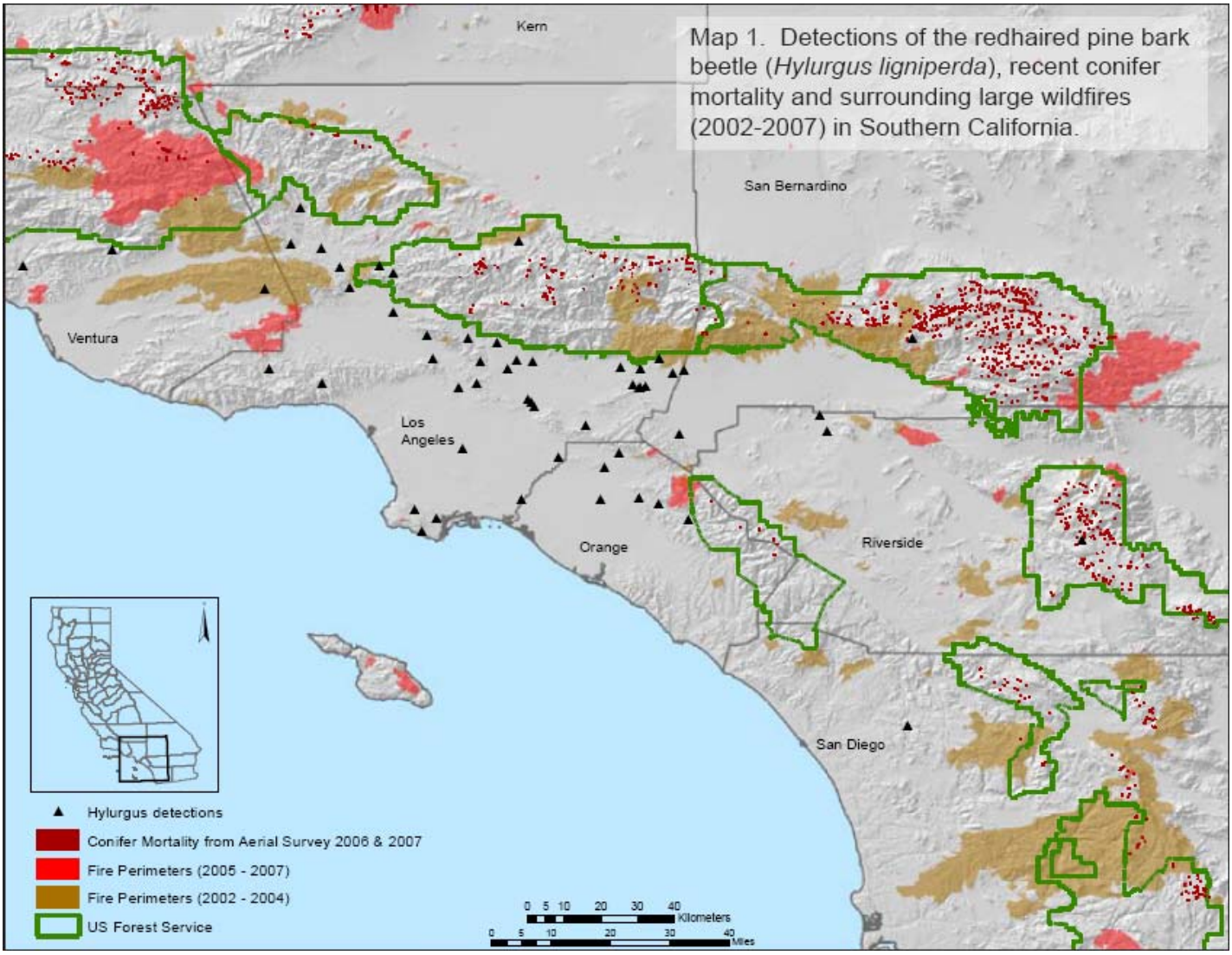

Map 1. Detections of the redhaired pine bark beetle (*Hylurgus ligniperda*), recent conifer mortality and surrounding large wildfires (2002-2007) in Southern California.

Attachments:

Progress Report (2008)

Project Title: Monitoring invasive bark and woodboring beetles in periurban forests following wildfire

Date: September 19, 2008

Award Number: WC-F-08-01

Project Period: May 1, 2008 – April 30, 2010

Reporting Period: May 1, 2008 – September 19, 2008

Recipient Contact Person: Steven J. Seybold

Project Leader: Steven J. Seybold

Cooperators: Michael Bohne, Tom Coleman, and Zachary Heath, R5, FHP; Mary Louise Flint, UC Davis; Richard L. Penrose, CDFA

Progress Achieved in Accomplishing Project Objectives:

Introduction

Fire and invasive species are both important disturbance agents that can negatively affect forest health, but the interactions between them are poorly understood. Hundreds of fires have occurred in Southern California since 2003, ranging in size from dozens of acres to tens and thousands of acres. The number of invasive species has increased rapidly in the last decade in Southern California. Therefore, the peri-urban national forests in Southern California provide a perfect place to evaluate the interactions between fires and invasive species.

Methods

In March and April 2008, we used historical fire data, including aerial survey data, to guide our selection of 12 burned and 13 unburned sites in southern California for monitoring of invasive insect species. Criteria for selection include (1) date of the fire; (2) size or extent of the fire; (3) location of the fire relative to the current known distribution of *H. ligniperda*; (4) cover type; (5) land ownership; and (6) if small, location of the fire relative to larger "mega-fires." The task of locating sites proved to be more difficult than we expected. Many of the burned areas were not accessible due to steep terrain or absence of roads, or they did not meet our selection criteria. Ultimately, six burned and seven unburned sites were selected in the San Bernardino NF, and three burned and three unburned sites were selected in both the Angeles and Cleveland NF (Table 1). One unburned area in the San Bernardino NF (knobcone pine) was selected because it occurred at an intermediate elevation between the basin and the higher elevation coniferous forest sites, and as such could be a "bridge" area for invasive insect dispersal from urban to wildland forest.

Table 1. Burned and unburned sites selected in the San Bernardino, Angeles, and Cleveland National Forests

Treatments	Size (ac)	Date	Elevation (ft)	GPS coordinates	Cover type
San Bernardino National Forest					
Barton Fire	70	Jul-05	6200	N34°10.163' W116°52.522'	Ponderosa and Jeffrey pine
Barton unburned			6300	N34°10.191' W116°50.977'	Ponderosa and Jeffrey pine
Butler II Fire	14039	Sep-07	7100	N34°17.100' W116°58.202'	Jeffrey and Coulter pine
Butler unburned			7100	N34°17.067' W116°57.817'	Jeffrey and Coulter pine
Slide Fire	12000	2007	6400	N34°13.852' W117°05.800	Jeffrey and Coulter pine
Slide unburned			6498	N34°13.352' W117°05.169	Jeffrey and Coulter pine
Old Fire	91281	2003	5600	N34°13.954' W117°11.290'	Jeffrey, Coulter, and ponderosa pine
Old unburned			5700	N34°14.513' W117°11.358'	Jeffrey, Coulter, and ponderosa pine
Grass Valley Fire	1247	Oct-07	5260	N34°16.672' W117°13.793'	Coulter pine
Grass Valley unburned			5028	N34°17.257' W117°12.908'	Coulter pine
Lytle Fire	554	Sep-02	5816	N 34°17.654' W 117°35.586'	Ponderosa pine
Lytle unburned			5990	N 34°17.871' W 117°36.037'	Ponderosa pine, incense cedar
Knobcone unburned			3375	N 34°10.544' W 117°09.193'	Knobcone pine
Angeles National Forest					
Williams Fire	>1000	2002	1664	N 34°14.398' W 117°51.920'	Aleppo, Canary Island, Coulter, and Turkish red (brutia) pine
Williams unburned			1506	N 34°13.477' W 117°50.989'	Aleppo, Canary Island, Italian stone, Monterey and Turkish red (brutia) pine
Pines Fire	100	2006	3678	N 34°16.284' W 118°9.174'	Coulter and knobcone pine
Pines unburned			3393	N 34°16.426' W 118°9.864'	Aleppo, Coulter, and knobcone pine
Crown Fire	>1000	2004	4120	N 34°28.604' W 118°4.397'	Pinyon pine
Crown unburned			3920	N 34°29.253' W 118°3.791'	Pinyon pine
Cleveland National Forest					
Garnet Fire		Pre-2005	5537	N 32°54.199' W116°27.423'	Coulter and Jeffrey pine
Garnet unburned			5524	N 32°53.425' W116°27.247'	Jeffrey pine

Poomacha Fire	>1000	2007	5254	N 33°18.220' W116°51.032'	Coulter pine
Poomacha unburned			5045	N 33°20.646' W116°53.382'	Coulter and Jeffrey pine
Paradise or Cedar Fire	>1000	Pre-2005	4778	N 32°59.813' W116°34.341'	Coulter and Jeffrey pine
Paradise/Cedar unburned			5978	N 32°50.779' W116°26.306'	Jeffrey pine

At all sites, three 12-unit Lindgren funnel flight traps and three pitfall traps (both baited with α-pinene and ethanol) were placed by Liu, Coleman, and Seybold from late March to early May of 2008. Traps were emptied bi-weekly until late September of 2008. Support personnel were hired to monitor the traps in the Angeles and Cleveland NFs; Coleman monitored the sites on the San Bernardino NF. Trap baits were replaced once in July.

Preliminary results

A preliminary analysis of the a subset of the data across all sites shows that traps in burned sites have tended to catch more *Xyleborinus saxeseni* (an invasive ambrosia beetle) than unburned sites (Table 2). More specimens of *Hylurgus ligniperda* (an invasive bark beetle) and *Arhopalus syriacus* (an invasive longhorn beetle) were also caught in burned sites than in unburned sites. The total number of bark beetles (Scolytidae) in burned sites tended to be higher than that in unburned sites, but we only caught slightly more longhorn beetles (Cerambycidae) in burned sites. Preliminary observation showed that a higher proportion of invasive beetles were caught in most cases relative to native beetles. We have only processed a small portion of our samples so far. After we sort all the samples, we will explore the effects of post-fire intervals and the extent of wildfires on the responses of invasive and native beetles.

Table 2. Comparisons on average catches of bark and wood-boring beetles between burn and unburned sites in national forests in Southern California

	Burned (mean /trap/ sampling period ± SE)	Unburned (mean /trap /sampling period ± SE)
Hylurgus ligniperda (invasive)	0.7 ± 0.5	0.3 ±0.1
Xyleborinus saxeseni (invasive)	4.1 ± 2.4	1.1 ± 0.6
Arhopalus syriacus (invasive)	0.3 ± 0.2	0.1 ± 0.1
Total number of cerambycid beetles	0.5 ± 0.1	0.4 ± 0.2
Total number of scolytid beetles	6.4 ± 2.9	3.2 ± 0.7

Previously, the invasive redhaired pine bark beetle (*H. ligniperda*) was usually found in urban areas of Southern California, because exotic pine species (e.g., Aleppo and Italian stone pine) are planted as landscape trees in those areas. According to our preliminary examination of the trap catches, this invasive beetle is in the native knobcone pine stand in the San Bernardino NF (3400 ft), and in plantations of exotic pines and Coulter pine in the Angeles National Forest (3600 ft).