59th Annual Meeting of the California Forest Pest Council

The Changing Forests of California

Meeting Abstracts

November 16 - 17, 2010
Wildland Fire Training and Conference Center, McClellan, CA

About the California Forest Pest Council (CFPC)

The California Forest Pest Council (CFPC) fosters education concerning forest pests and forest health, and advises the California Board of Forestry and Fire Protection on forest health protection issues. It comprises a diverse group of forestry professionals and others interested in the prevention of damage to forests from insects, pathogens, animals, weeds, and pollution. Meetings are held throughout the State to discuss and evaluate current forest pest conditions. The annual meeting is the most important, providing the membership a chance to review what has happened in the last year, to formulate and vote on resolutions, and to address topics of special concern. Membership in the CFPC is granted to anyone attending. The CFPC is a 501(c)3 non-profit corporation (Tax-ID 94-3248518).

2010 Conference Organizers

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Meeting Sponsors

The USDA Forest Service, Pacific Southwest Region, State and Private Forestry, Forest Health Protection

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The Changing Forests of California

Program of Events Summary

Tuesday, November 16, 2010

11:30 am	Registration
12:30 pm	Welcome and 2010 Forest Conditions
1:00 pm	California Insect and Disease Atlas (CAIDA) WebGIS
1:15 pm	Insect Committee Meeting (all are welcome)
	Forest Insects in California
2:30 pm	Break
2:45 pm	Disease Committee Meeting (all are welcome)
	Forest Diseases in California
4:20 pm	Pesticide Laws and Regulations
5:30 pm	Poster Session and Social
7:00 pm	Adjourn

Wednesday, November 17, 2010

7:30 am	Registration and Continental Breakfast
8:30 am	Welcome
8:35 am	Forest Insect and Disease Challenges
10:00 am	Break
10:30 am	Climate Change – How will Forests Fare?
12:30 pm	Lunch (provided)
1:30 pm	CA Forest Pest Council Business Meeting and Elections
2:00 pm	Special Papers
3:00 pm	Break
3:15 pm	On the Lookout for Tomorrow's Threats to California's Forests
4:30 pm	Adjourn

Oral Presentation Abstracts

(In Agenda Order)

California Insect and Disease Atlas (CAIDA) WebGIS

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The California Insect and Disease Atlas (CAIDA) was initially designed to be a geodatabase for California's insect and disease detections data. Populated with historic federal and state detection reports and pest detection surveys, CAIDA tracks trends, explores spatial patterns, and assists with aerial survey assessments.

Today, the scope of CAIDA's collection has expanded greatly, with data from other sources including the Pest Trend Impact Plots (PTIP) data and the Annotated Bibliography of Climate and Forest Disease of Western North America compiled and maintained by the Forest Service Pacific Southwest Research Station (PSW). In addition, using the latest webGIS technology, a CAIDA-based website is currently being developed in collaboration with the UC Berkeley Geospatial Innovation Facility (GIF). We hope this CAIDA webGIS site will in the future serve as an online portal for efficiently collecting, managing, and sharing forest health data for California.

Effects of Fire Seasonality and Severity on Ponderosa Pine Resistance to Bark Beetles in Northeastern California

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The structure and function of ponderosa pine forests have been highly modified from their pre-settlement condition by past management practices including fire exclusion, logging, and heavy grazing. Thinning and prescribed burn treatments are being implemented to reduce the likelihood of stand replacing wildfires and to reduce the threat of unacceptable levels of bark beetle-caused tree mortality. Little information is available on how bark beetles will respond to the increased use of fire; in particular, how fire seasonality and severity may alter host resistance to bark beetles.

This study examined the effects of fall and spring prescribed fires on ponderosa pine resin yield and subsequent bark beetle activity on trees with varying levels of fire-caused injury on three National Forests in northeastern California for two years. Resin quantity, resin quality, bark beetle activity, tree mortality, and annual growth rates were measured. Resin was collected from 255 study trees at two times each field season. Study trees in fall-burned stands produced significantly higher constitutive resin yields compared to trees in spring-burned or unburned control stands. Induced resin yields were significantly lower in trees with high crown scorch. Monoterpene compositions varied by burn season; α-pinene and limonene were higher in trees in fall-burned stands compared to trees in spring-burned stands. *Dendroctonus brevicomis* attacked less than 2 percent of fire-injured study trees while *Dendroctonus valens,* which is attracted to wounds and host terpenes, attacked approximately 10 percent of study trees. There was no significant difference in annual growth rates between trees in spring- and fall-burned stands, or between trees with high crown scorch compared to those with low crown scorch. These studies further our knowledge regarding bark beetles and prescribed fires and the implications of such treatments in ponderosa pine stands.

Forest Soil Arthropods in the High Canopy of California's Coastal Redwoods: Community Structure and Dynamics

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Soil dwelling arthropods and microarthorpods are ubiquitous residents of forest soils, where they perform numerous important ecosystem services such as providing connectivity in food webs and aiding nutrient regeneration and recycling. Several components of this assemblage, such as the entognathous hexapod Collembola and the acarine Oribatei, are often hyperdiverse, and because they frequently respond to disturbances such as drought and fire in predictable ways, they have the potential to serve as indicators of ecological trajectory. For example, in studies conducted in the Southern Cascade range of California, the authors have observed several characteristic changes in microarthropod assemblage structure in response to forest stand structure manipulations and low intensity prescribed fire applied for silvicultural management purposes.

One of the characteristics of old growth coast redwood (*Sequoia sempervirens*) forest canopies, especially in deep, well-watered alluvial habitats is the retention of persistent, often large mats of decomposing leaf litter and other organic debris at heights ranging from a few meters to nearly 100 m above ground. These mats decompose into rich, humic arboreal histosols that share many features with the upper layers of forest floor soils, and which provide habitat for several arboreal vertebrates and numerous invertebrates. These later include soil dwelling arthropods and microarthropods that are normally associated with the forest floor. Arboreal litter accumulations decompose *in situ* and serve as unique suspended habitat islands for forest soil microarthropods. Although certainly more dynamic than corresponding ground soils, many arboreal soil accumulations appear to persist for decades and perhaps centuries.

In studies conducted at Prairie Creek Redwoods State and National Park (PCRSNP) in Humboldt County, California, and on private and public property in northern Mendocino County, we surveyed several aspects of arthropod and microarthropod assemblage structure in old growth redwood stands on the forest floor and in arboreal histosols in redwood and Sitka spruce (*Picea sichensis*) canopies ranging up to 85 m above ground. We also performed measurements of microarthropod mediated lichen detritus decomposition using harvested epiphytic thalli of the chlorolichen *Hypogymnia apinnata* and the cyanolichen *Lobaria pulmonaria*. We have identified 54 species of Collembola from old growth redwood forest at PCRSNP. This is certainly an underestimate of the total Collembola diversity because it was focused exclusively upon microarthropods associated with decomposing lichen thalli. We have identified approximately 70 species (or morphospecies) of oribatid mites at PCRSNP, including both ground dwelling and canopy dwelling taxa. Again, this is doubtless an underestimate of the total oribatid diversity at PCRSNP. At least 70 percent of the oribatid species found at PCRSNP are distinctly different from similar species assemblages we have found in old growth interior California ponderosa pine forests and Douglas-fir/fir associations at similar latitude. Several of these oribatids appear to be either unique to redwood forests or as yet undescribed species. We have also identified unique assemblages of forest soil microarthropods inhabiting soils at the bases of relict old growth redwoods embedded within a matrix of second growth forest.

Firewood Movement: A Threat to California's Forests

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Interstate transport of firewood has been implicated in the rapid spread of devastating forest pests such as the gypsy moth and the emerald ash borer. The California Department of Food and Agriculture (CDFA) inspects firewood entering the State at sixteen border stations and confiscates wood with pests found on or in it. Currently, there is a lack of factual data and information to fully define the risk of spreading invasive insects and diseases through the movement of firewood to California's forests. The risks associated with firewood movement within California and at bordering states need to be fully understood to effectively develop policies, guidelines, and public messages.

The purpose of this analysis is to evaluate the data and information collected since 2008 at the Border Stations on firewood inspections. The firewood survey data along with 20 years' worth of Pest Detection Reports (PDRs) that were collected on intercepted firewood were used to answer key questions including: How much firewood is entering the State? What is the origin and destination of the firewood? What pests have been identified on firewood entering California?

Over 14 million pounds of firewood were inspected at California border stations between 2008 and 2010. Firewood arrived from 36 different states, Canada, and Mexico; but the majority came from California, Oregon, and Nevada. Almost 400 different destinations in nine different states and Canada were named, most of them within California. Over 13 percent of commercial firewood loads were en route to Nevada. Ninety-six percent of the firewood in private vehicles was expected to travel less than 200 miles from the border station and commercial loads generally traveled greater distances. However, none of the commercial loads recorded on firewood surveys generated a Pest Detection Report.

Between 1990 and 2010, 1212 pests were intercepted on firewood at border stations and identified to at least the family (e.g., Buprestidae). Nineteen percent of these were rated as potentially serious by the CDFA and 23 percent of them belonged to families that include known forest pests. Potential forest pests arrived from 41 different states and Canada, and 46 percent of them entered the state at the Needles (I-40) Border Station. Firewood containing pests was en route to over 100 different destinations in California and nearby states, including most major CA cities and Yosemite National Park. Notable forest pest species intercepted in or on firewood included: gypsy moth (*Lymantria dispar*); Eastern tent caterpillar (*Malacasoma americanum*); tussock moth (*Orgyia* sp.); numerous engraver beetles (*Ips* sp.); and flatheaded borers (*Buprestis aurulenta*).

These results demonstrate that firewood can be an important intra- and inter-state vector of forest pests.

Update on Pitch Canker in California

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From a statewide perspective, the occurrence of pitch canker in California has been relatively stable. No significant changes in geographic or host range have been recorded in the last several years. On a local scale, the picture is more variable. On the Monterey Peninsula, the incidence and severity of pitch canker are little changed over the past ten years. In part this has reflected the operation of systemic induced resistance, which has slowed the progression of disease in many trees. On the other hand, pitch canker infestations in bishop pine at Pt. Reyes National Seashore are expanding rapidly with a high incidence of mortality. This is in dramatic contrast to an otherwise similar population of bishop pine in the Del Monte Forest in Monterey County, where the impact of pitch canker has been much less severe. There are many possible reasons for this difference but it seems likely that differential effects of environmental stress are an important contributor. To better understand these effects, plots are being established to characterize the progression of pitch canker in bishop pine at Pt. Reyes.

White Pine Blister Rust Research at the Institute of Forest Genetics after Major-Gene Resistance

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White pine blister rust (WPBR) is an exotic pathogen introduced to the United States through southeastern Canada into New York on *Pinus strobes* (eastern white pine), and through southwestern British Columbia into Washington and Oregon, on *P. monticola* (western white pine). It was found on *P. lambertiana* (sugar pine) in northwestern California around 1936. The eradication of *Ribes* (currant or gooseberry), the alternate host to WPBR, began in the 1930s and continued until 1967 with a 5 year interruption for World War II. During that time scientists from ID, OR, and CA started looking at resistance as a more effective way to manage this pathogen. In 1970 Dr. Bohun Kinloch of the Pacific Southwest Research Station (PSW) discovered a single dominant gene for resistance to WPBR in sugar pine, termed Major Gene Resistance (MGR). A protocol for screening sugar pine and western white pine was developed at the Institute of Forest Genetics through the next few decades and was successfully transferred to the Pacific Southwest Region, Placerville Nursery in 1986, where it continues operationally today.

The PSW Institute of Forest Genetics (IFG) WPBR research has continued on different white pine species: southwestern white pine, *P. strobiformis*; foxtail pine, *P. balfouriana*; limber pine, *P. flexilis*; and the bristlecone pines, *P. longaeva* and *P. aristata*. Through greenhouse inoculation we have determined that none of these species, with the exception of *P. strobiformis,* carries MGR, or at least they do not express it in the typical hypersensitive needle reaction that is expected. In an effort to find alternative defense mechanisms for WPBR, we have been monitoring infected seedlings from high-elevation white pine species at multiple times over multiple years.

In 2006 we had a *P. strobiformis* MGR experiment going in the IFG greenhouse. The standard process of the MGR screening is to discard susceptible infected seedlings after the infection has reached the stem. Breaking away from that standard, the susceptible seedlings were held for a year after infection. It was observed at year's end that stem infection did not progress to pycnia in all of the seedlings; the pathogen was apparently inactive. After sorting the active and inactive seedlings per family we observed that some families were segregating for this reaction. From this, we began looking at all of the other high-elevation white pines that we had at various stages of infection and indeed observed the same reaction. We are in the process of refining the protocols to identify this trait. Unlike MGR we believe this mechanism to be complexly inherited and have termed it Complex Gene Resistance (CGR).

True Fir Dwarf Mistletoe in the Sierras: Long-Term Growth and Mortality Trends

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Red fir (*Abies magnificae*) and white fir (*Abies concoloris*) are commonly infected by two distinct form species of dwarf mistletoe, *Arceuthobium abietinum*, f.sp. *magnificae* and *A. abietinum* f.sp. *concoloris.* This study tracked the impacts of mistletoes on mortality and radial growth of regenerating firs (5.1 to 30.5 cm dbh) in thinned and unthinned mixed-conifer stands over time. Thirty-two plots on the Klamath, Lassen, Tahoe, Stanislaus, and Sequoia National Forests, as well as the LaTour Demonstration State Forest, were established in the late 1970s and were sampled multiple times from 1981 to 2006. Mistletoe infection significantly increased mortality risk in regenerating fir, and also reduced radial growth. Overall, trees in thinned stands had higher survival rates and greater radial growth than trees in unthinned stands. However, the effect of thinning treatments on mortality and growth was not significant in all forests, likely due to the disproportional number of thinned plots (23) in comparison to unthinned plots (9).

An Overview of Mistletoes on Hardwoods in California

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Mistletoes are parasitic, perennial plants. Four species of leafy mistletoes are found on hardwoods in California. The three species in the genus *Phoradendron* are native. Another species, *Viscum album*, was introduced from Europe. Leafy mistletoes can be identified by their foliage, which emerges from the host branch or stem, usually forming oblong or spherical clumps. The leaves vary in color, size, shape, and texture according to species. A swelling often develops where the root-like structure of the mistletoe plant is embedded in the host. On old trees these swellings can become very large and break open, exposing decayed wood. Leafy mistletoe most commonly occurs in the upper crowns of open-grown trees.

Leafy mistletoes reproduce by seeds that are spread by birds. Germinating seeds produce a specialized structure that physically penetrates the bark of suitable hosts. A root-like system grows within the host and connects to the host xylem, allowing the parasite to absorb water and minerals. Once established within the host, aerial shoots, leaves, and flowers are produced. Leafy mistletoes are able to photosynthesize and produce much of the carbohydrates they need. They may also take up some carbohydrates from their hosts.

Native leafy mistletoes are an important component of California's woodland and desert shrub ecosystems. Leafy mistletoes provide food and habitat for birds and other animals. A long list of bird species feed on the berries, especially during the winter. Mistletoe foliage provides food for deer and elk during the winter. Decayed wood in swellings due to mistletoe infection on boles and large branches creates habitat for cavity-nesting birds and small mammals.

Significant negative impacts due to mistletoe usually occur in older, heavily infected trees. Dieback of branches beyond the mistletoe plants is common. Trees with sufficient water supply can remain vigorous for many years even with large numbers of mistletoe plants. However, heavily infected trees can be weakened and suffer significant decline and mortality during dry years. Branch and bole swellings that are colonized by decay fungi may eventually become hazardous due to their potential for failure.

In developed settings treatment of individual trees may be needed to maintain vigor and prevent or reduce hazard. Removing mistletoe foliage by cutting or with chemicals reduces the loss of water and nutrients from infected trees, but does not kill the mistletoe plant, which will eventually grow new shoots, requiring retreatment. The entire mistletoe plant can only be removed by pruning infected branches. However, excessive pruning of heavily infected trees can damage trees as much or more than the mistletoe does. In addition, previously infected trees are likely to be re-infected if they are attractive to birds. The best option for heavily infected, declining trees in developed settings may be to replace them with resistant species. In woodland settings the best option may be to promote regeneration of oaks and other native species. Because it generally takes many years for most trees to become heavily infected, increasing the population of young trees may be the best way to lessen the impact of mistletoe at the stand level.

Selected references

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Swiecki, T.J. and E.A. Bernhardt. 2006. Afield guide to insects and diseases of California oaks. USDA Forest Service General Technical Report PSW-GTR-197. 151 p.

Potential Impacts of Court-Ordered Injunctions on Pesticide Use and the Protection of Endangered Species

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Over the last six years, three separate pesticide use injunctions have resulted from litigation between U.S. EPA and environmental advocacy groups such as Californians Against Toxic Substances (CATS), Washington Toxics Coalition, and the Center for Biological Diversity.

The first injunction was put into place in February of 2004, and is known as the "Salmonid Injunction." It resulted from a lawsuit by environmental and fishery groups charging U.S. EPA with failure to solicit National Marine Fisheries Service (NMFS) formal consultation on the risks from 38 pesticides to 26 distinct populations of Chinook salmon, Coho Salmon, and Steelhead. This injunction imposes prohibitions for use of 38 active ingredients 100 yards by air and 20 yards by ground from "Salmon Supporting Waters." It also requires EPA to consult with NMFS on the potential hazards posed by the 38 active ingredients to Salmon populations.

The first round of consultations in 2008 resulted in a Biological Opinion for Chlorpyrifos, Diazinon, and Malathion. DPR expressed disagreement with the Biological Opinion and posted comments to the Public Docket. The Biological Opinion proposed buffers of 500 feet for ground applications and 1,000 feet for aerial applications. Additionally, it imposed requirements for fish kill reporting, runoff prevention measures, and environmental monitoring.

In response, U.S. EPA decided to impose variable buffers depending on application rate + droplet size + size of adjacent body of water. Nevertheless, for aerial applications the resulting buffers are still almost 1,000 feet. For ground applications, the resulting buffers can be a minimum of 100 feet.

In November of 2009, U.S EPA submitted 40 draft California Bulletins for Chlorpyrifos, Diazinon, and Malathion. They were reviewed by DPR's Endangered Species Program staff and comments were sent to U.S. EPA. In January of 2010, U.S. EPA submitted the revised bulletins, including a test version of an application intended to help pesticide applicators calculate the corresponding buffer for their intended application rate, droplet size, and body of water adjacent to the application site. U.S. EPA is asking registrants of Chlorpyrifos, Diazinon, and Malathion to voluntarily modify labels for pesticides containing these active ingredients and refer users to the bulletins live website at http://137.227.242.131/espp_front/view.jsp in order to find out which buffer size applies to the product they intend to apply. Registrants will be granted 18 months to generate new labels or update existing product. If the registrants don't agree to modify product labels, they face cancellation proceedings. The use limitations imposed by the bulletins will be voluntary until product labels are modified.

The second injunction in place is known as the "Stipulated Injunction and Order for Protection of California red-legged frog." It became effective on 10/20/2006. The lawsuit by the Center for Biological Diversity alleged that U.S. EPA failed to solicit U.S. Fish & Wildlife Service (FWS) formal consultation on the risks from 66 pesticides to California red-legged frog (CRLF). It imposes prohibitions for use of 66 active ingredients 200 feet by air, and 60 feet by ground from California red-legged frog's aquatic and upland habitats occurring in 33 counties.

As with the Salmonid injunction, the Ninth District Court in Seattle ordered U.S. EPA to initiate Formal Consultations with the FWS, and schedule it in such a way it can be completed in approximately 5 years. Since 2007, U.S. EPA has been working on effects determinations for all 66 active ingredients included in this injunction. They are submitting them to the U.S. Fish & Wildlife Service for their analysis and expected Biological Opinions.

The third and latest injunction is referred to as the "Bay Area Stipulated Injunction and Order." This lawsuit by the Center for Biological Diversity charges U.S. EPA with failure to consult U.S. Fish & Wildlife Service (FWS) on the risks from 75 active ingredients to 11 listed species in the San Francisco Bay Area. Eight counties are affected: Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, and Sonoma. The injunction imposes different "no-use" buffers for some of the 75 active ingredients, depending on the type of species. The species included are: Alameda whipsnake, Bay checkerspot butterfly, California clapper rail, California freshwater shrimp, California tiger salamander, Delta smelt, salt marsh harvest mouse, San Francisco garter snake, San Joaquin kit fox, tidewater goby, and Valley elderberry longhorn beetle. The buffers imposed by this injunction range from 100 to 700 feet for ground applications, and from 200 to 700 feet for aerial applications.

During the public comment period, DPR recommended U.S. EPA replace the proposed interim buffer zones with use limitations specified in our web-based database PRESCRIBE.

U.S. EPA completed their review of public comments and posted the final injunction on May 17, 2010 in their website at: http://www.epa.gov/espp/litstatus/stipulated-injuc.html.

All these injunctions share some common denominators:
1) They have resulted from the lack of consultation by U.S. EPA on the effects of "pesticide x" on "species y" with the U.S. Fish & Wildlife Service (FWS) or National Marine Fisheries Service (NMFS).
2) They impose a consultation schedule between EPA and The Services (FWS or NMFS) typically 4 to 6 years minimum.
3) Public vector control and invasive weed control programs are exempt. However, in the case of the Salmonid Injunction, the use limitations resulting from consultation on Chlorpyrifos, Diazinon, and Malathion do not provide exemptions for vector control or invasive weed control programs.
4) They can only be enforced through citizen lawsuits. Federal, state, county, and other local authorities are "vacated' from enforcing them.
5) As products go through consultation, if deemed "not likely to adversely affect" a species they will be taken off the injunction list.
6) If deemed "likely to adversely affect" a species, EPA may impose restrictions to be enforced through labeling, as is the case of Chlorpyrifos, Diazinon, and Malathion.

This process is very contentious, generating a great deal of mistrust between the regulated community and regulatory agencies – in this case U.S. EPA. It also affects DPR, since each injunction comes with its own set of buffers and species; DPR's comprehensive, programmatic approach to protection of endangered species is being impacted by the multitude of injunctions and their litigation-derived buffers. The imposition of court-ordered absolute buffers further discourages good land stewardship efforts, since growers who in previous years might have managed their fields to include field-edge vegetation cover, hedgerows, etc., see their habitat enhancement efforts as a potential liability if listed species move in. Under these injunctions - even with exemptions- some invasive weed programs are still facing no-use zones that become refuges for noxious weeds.

Forest Stand Impacts Associated with the Goldspotted Oak Borer, *Agrilus auroguttatus*, in Native and Introduced Oak Woodlands

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The goldspotted oak borer (GSOB), *Agrilus auroguttatus*, continues to kill three species of oaks in San Diego County, California (CA). Since 2002, tree mortality is estimated at >21,500 via aerial surveys in the zone of infestation. Coast live oak (*Quercus agrifolia*), California black oak (*Q. kelloggii*), and canyon live oak are the primary hosts of this exotic species to CA. Engelmann oak (*Q. engelmannii*) is also a known host of GSOB, but mortality of this white oak species has been rarely associated with this wood borer. Tree mortality has been occurring at elevated levels in San Diego County for eight continuous years. To better understand the threat of this invasive pest to CA's oak woodlands, long-term plots were established in the infested areas in San Diego County and uninfested areas in San Diego, Riverside, and San Bernardino Counties. Additional plots were established in GSOB's native areas of southeastern Arizona (AZ) and southern Mexico (MX) (Oaxaca and Chiapas) to contrast its behavior in CA as an "indigenous exotic."

Forest stand surveys were concentrated in areas with a dominant oak component and followed the protocols of the Forest Service's Common Stand Exam. Tree basal area, tree densities, GSOB infestation rates, tree mortality, oak health, and ground surface cover were recorded during these surveys. Plots were established during 2009-2010 and will be re-assessed in approximately 5 years to follow the impact of GSOB in these stands.

In the infested area of CA, GSOB infestation rates are significantly greater when compared to plots in AZ and MX. Infestation rates from GSOB averaged approximately 47 percent in CA, 4 percent in AZ, and 2 percent in MX. Infestations rates of 100 percent were recorded for large diameter oaks (>12.5 cm) in areas that have experienced long-term tree mortality in CA infested sites. Because of the expanding nature of the infestation, infestations rates of 9 percent were also recorded at other sites in CA. Oak mortality associated with GSOB was recorded at approximately 3 trees/ha in CA infested sites, representing an average of 15 percent of the stand. Oak mortality was also recorded at 50 percent of the stand in areas that have experienced eight years of tree mortality. Infestation rates and tree mortality was highest in California black oak than the other CA native oak species. California black oak is rarely mapped during aerial survey detections (10 trees in 2010). It is believed that aerial survey of tree mortality associated with GSOB is significantly underestimated for this species.

Fungal Species Associated with Coast Live Oak (*Quercus agrifolia*) Mortality in Southern California

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Sharp decline and mortality of coast live oak (*Quercus agrifolia*) has been observed in San Diego County, California, since 2002. Much of this decline has been attributed to a new pest in California, the goldspotted oak borer (GSOB, *Agrilus coxalis*). Associated symptoms of crown thinning, bark cracking and/or separation, patches of stain and bleeding on the bole, and tree death have mostly been observed on individuals over 30 cm diameter at breast height (DBH). Oak stands with tree mortality were surveyed for pathogens at nine GSOB-infested and –uninfested sites throughout San Diego and Riverside Counties in 2009-2010 and 408 trees were sampled. *Botryosphaeria spp.* were consistently recovered from bleeding trunk and branch cankers at all locations. Other fungi included *Biscogniauxia mediterranea* and species of *Togninia*, *Ophiostoma*, *Geosmithia*, *Fusarium*, *Bionectria*, *Diatrypella*, and *Pezicula.* Species were identified by ITS4/5 rDNA sequences and morphology. Pathogenicity tests are underway.

Phytophthora ramorum and Sudden Oak Death in Forestlands

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Several significant developments related to *Phytophthora ramorum,* the cause of sudden oak death, took place in 2010 throughout the range of the pathogen in wildland environments. This update discusses (1) the newest find of an isolated *P. ramorum* outbreak in California, in Redwood Creek in northern Humboldt County, along with a presentation of management options and actions taken to-date and (2) a swift and destructive outbreak of the pathogen in England, Wales, and Ireland on Japanese larch (*Larix kaempferi*), which has been observed to be a strong sporulating host of *P. ramorum* as well as being highly susceptible. Each of these situations challenges assumptions and management strategies for the pathogen.

Forest Responses to Increasing Aridity and Warmth in the Southwestern United States

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In recent decades, intense droughts, insect outbreaks, and wildfires have led to decreasing tree growth and increasing mortality in many temperate forests. We compared annual tree-ring width data from 1,097 populations in the coterminous United States to climate data and evaluated site-specific tree responses to climate variations throughout the 20th century. For each population, we developed a climate-driven growth equation using climate records to predict annual ring widths. Forests within the southwestern United States appear particularly sensitive to drought and warmth. We input 21st century climate projections to the equations to predict growth responses. Our results suggest that as projected temperatures rise and precipitation declines southwestern trees will experience substantially reduced growth during this century. As tree growth declines, mortality rates may also increase at many sites. Increases in wildfires and bark-beetle outbreaks in the most recent decade are likely related to an extreme drought and high temperatures during this period. Using satellite imagery and aerial survey data, we conservatively calculate that ~2.7 percent of southwestern forest and woodland area experienced substantial mortality due to wildfires from 1984-2006, and ~7.6 percent experienced mortality associated with bark beetles from 1997-2008. We estimate that up to ~18 percent of southwestern forest area (excluding woodlands) experienced mortality due to both bark beetles and wildfire during this period. Expected climatic changes will alter future forest productivity, disturbance regimes, and species ranges throughout the Southwest. Emerging knowledge of these impending transitions informs efforts to adaptively manage southwestern forests.

Using Provenance Tests to Understand Forest Responses to Climate Change

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Provenance tests are common garden studies that include a number of different tree seed sources (or provenances). While many provenance tests were originally planted for silvicultural reasons (which provenance produces the most/best timber at this location?), these studies are also excellent sources of data for tree responses to climate change. In each trial, seeds were moved from one climate, planted in a new one, and monitored for growth and survival. By incorporating climate data into the analysis of provenance trial data, knowledge can be gained about the response of trees to novel climates and what aspects of climate (temperature vs precipitation, etc) are most important for tree survival and growth. In the 1980s and 1990s, five sugar pine provenance trials were planted by the Institute of Forest Genetics, Pacific Southwest Research Station, USDA Forest Service. These provenance trials are now providing data on tree growth and survival across the range of the species.

Pinyon-Juniper/Shrublands Long-Term Successional Trends: Implications for Woodland Health and Management

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There are currently about 20 million acres of Great Basin woodlands occupying some of what were the region's most productive and diverse sagebrush ecosystems. These major changes have occurred since the mid 1800s as a result of increases in both area occupied and tree density. Major changes in community composition and in standing biomass will continue within these woodlands over the next 40 to 50 years. This includes a doubling of tree dominance, the continued increase in fuel loads with tree growth, and continued loss of the understory. As a result fire size will continue to increase, putting most woodland areas at risk. The ability of Great Basin woodlands to resist dominance by invasive species, particularly after disturbance, is dependent on the robustness of their perennial herbaceous component. Where that herbaceous component is weak or largely absent the risk of such of a conversion is high. The current trend is toward an increasing loss of this vital herbaceous component as tree dominance increases. Restoration can more easily stop and reverse this trend before significant losses in the herbaceous components has occurred. Once it is largely lost it becomes much more difficult to avoid dominance by invasive species. The area within the Great Basin involved in woodland expansion that is becoming at increased risk to crown fire, and to conversion to exotic annual dominance, is currently at about 200,000 acres per year.

Changes and Challenges to High Elevation Conifers of the White Mountains, California

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The White Mountains of eastern California stand as the westernmost range in the Great Basin. They show great topographic diversity ranging from Owens Valley floor at 4,000 feet (1,220 m) to the 14,246 foot peak of White Mountain (4,490 m), and they contain the highest point in Nevada - Boundary Peak. Often referred to as an island in the sky, the White Mountains are the home to two high-elevation conifers, the limber pine (*Pinus flexilis*) and the Great Basin bristlecone pine (*Pinus longaeva*). The White Mountains are both climatically and physically in the shadow of the Sierra Range, a mere 20 miles to the west.

The range is typical in its vegetation diversity and ranges from salt bush/desert scrub in its lower reaches to the iconic ancient bristlecone pine. Pinyon pine (*Pinus monophylia*) and Utah juniper (*Juniperus osteosperma*) comprise extensive stands of forest cover at the mid-elevation ranges. Several species of sage, bitterbrush, ephedra, wax current, and rabbit brush are found in non-forested areas of the mountains. While invasive species are certainly present, whole-scale invaders such as cheat grass are at a minimum.

The climate of the White Mountains is characterized by cold, moderately dry winters and warm, dry summers. Precipitation typically comes in the form of snow and summer thunderstorms and ranges from a desert floor low of 4 inches to nearly 20 inches along the crest.

While geologic diversity is moderate, interest is very high with many geologic field camps making the White Mountains one of their field camp stops. With sparse ground cover in many locations, deep canyons, and road cuts, the geologic history of this area is an open book. A drive from the Owens Valley to the subalpine zone at 10,000 feet travels through areas of Campito sandstone, Poleta limestone, and Reed dolomite, the highly alkaline limestone on which many of the bristlecone pines make their home.

The extensive stands of mixed bristlecone and limber pine are found at elevations of 9,500 feet to their upper limit of 11,350 feet. The two species are often found growing in mixed stands and occasionally in groves in which one tree dominates. The bristlecone pines of the White Mountains are the oldest (non-clonal) trees in the world, with living specimens dating back to nearly 4,800 years. The Inyo National Forest manages this congressionally designated area for “preservation of the ancient trees for scientific research and public enjoyment.”

While past research has concentrated on the dendrochronology of the ancient trees, the emerging threats to the integrity of the bristlecone pine come indirectly from a warming climate.

Upslope movement of both the bristlecone and the limber pine is clearly seen at and above the current treeline. While this may present an obstacle in some cases, there appears to be ample room for this migration. While studies are lacking, it is apparent that the lower range of the bristlecone pine may face a black stain threat from the advancing pinyon pine. There are documented cases east of Schulman Grove where pinyon pine have been found growing at an elevation *above* the bristlecone pine.

Widespread pinyon pine mortality has been well documented in locations within a mile of the bristlecone groves and the leading suspect of this mortality is the *Leptographium*-related black stain. The apparent upward migration of the pinyon pine into traditional bristlecone/limber pine areas may allow for a more rapid and easy transmission of this root fungus.

Additional threats come from white pine blister rust, which has been documented in bristlecone groves of Colorado (*Pinus aristata*), and the pine bark beetle. While neither of these unwelcome threats has had an impact in the White Mountains of California, it may be only a matter of time and more welcoming winter temperatures before we are faced with the triple threat of an advancing root fungus, white pine blister rust, and the opportunistic pine bark beetle.

Renewable Landscapes: Climate and Health as Drivers of Change in High Sierran Ecosystems

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Widespread forest mortality in high-elevation forests has been increasing across western North American mountains in recent years, with climate, insects, and disease the primary causes. Subalpine forests in the eastern Sierra Nevada, by contrast, have experienced far less mortality than other ranges, and mortality events have been patchy and episodic. This situation, and lack of significant effect of non-native white-pine blister rust, enable investigation of fine-scale response of two subalpine Sierran species, whitebark pine (*Pinus albicaulis*, PiAl) and limber pine (*P. flexilis*, PiFl), to climate variability. We report similarities and differences between the two major mortality events in these pines in the last 150 years: 1988-1992 for PiFl and 2006-ongoing for PiAl. In both species, the events occurred within monotypic, closed-canopy, relatively young stands (< 200 yrs PiAl, < 300 yrs in PiFl); were localized to central-eastern Sierra Nevada; and occurred at 2740-2840 m along the eastern edge of the escarpment on north/northeast aspects with slopes > 40 percent. Mortality patches averaged 40-80 ha in both species, with mean stand mortality of trees > 10 cm diameter 91 percent in PiAl and 60 percent in PiFl. The ultimate cause of tree death was mountain pine beetle (*Dendroctonus ponderosae*) in both species, with increasing $20^{th}/21^{st}$ C minimum temperatures combined with drought the pre-conditioning factors. Overall growth in the past 150 years suggests that PiFl is more drought-hardy than PiAl but responds sensitively to the combined effects of drought and increasing warmth. After the 1988-1992 drought, surviving PiFl recovered growth. PiAl trees grew very poorly during that drought, and continued poor growth in the years until 2006 when the mortality event occurred in PiAl. A significant species effect is the apparent difference in levels of within-stand genetic diversity for climate factors. Differential growth between 19th C (cool, wet) and 20th/21st C (warming, drying) of PiFl trees that died versus survivors indicates that considerable within-stand genetic diversity for climate existed in PiFl. For PiFl, the late 20th C mortality event acted as strong natural selection to improve within-stand fitness for warmer and drier conditions. PiFl trees that survived the 1988-1992 drought remained healthy through subsequent droughts, including the drought that is currently causing PiAl mortality. By contrast, the PiAl stands do not appear to have contained adaptive genetic diversity for drought and warmth, and PiAl trees growth behavior over the past 150 years was similar in pattern to the PiFl trees that died. As a result, the mortality event in PiAl is creating forest openings, with unknown future stand conditions, rather than rapid within-species adaptation that occurred in PiFl.

In addition to the situation with PiAl and PiFl, we report observations on near-treeline abiotic conifer mortality in the Great Basin ranges, as well as increasing evidence of aspen (*Populus tremuloides*) mortality in the eastern Sierra.

Western Wildland Environmental Threat Assessment Center

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The Western Wildland Environmental Threat Assessment Center (WWETAC) is one of two centers nationally to focus on environmental and biotic stressor effects on forests and rangelands. The second center is located in Asheville, NC (Eastern Forest Environmental Threat Assessment Center, EFETAC). This is an overview of a number of the research projects and application tools that have been developed through FS Research, National Forest, and State and Private Forestry funds. This center has funded the development of ArcFuels, the WWETAC Threat Mapper (risk for fire, bark beetle, and invasives at the national to forest level), two web crawlers (one for gathering GIS based data and one for information on the web pertaining to risks, both using cloud computing), as well as large scale modeling and validation of Mountain Pine Beetle attack on Lodgepole in the northern Rockies. Some of the capabilities of these applications will be described; key findings of funded research projects on the interaction between climate change and forest disease, beetles, and invasives will be presented; and potential future research directions will be solicited.

Observations and Projections of Sudden Oak Death-Induced Tanoak Mortality at Point Reyes National Seashore: A Tale of Two Forest Types

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Sudden oak death, an emerging disease caused by the exotic pathogen *Phytophthora ramorum*, is impacting forests and woodlands throughout coastal California. Tanoak (*Notholithocarpus densiflorus*), the most abundant broadleaf tree in the conifer-dominated forests of the infested area, is the most severely affected species; several lines of inquiry have concluded that sudden oak death could eventually drive tanoak to extinction, at least in certain parts of its current range. In this study, we used data collected in 2007 and 2009 to document and examine disease-induced tanoak mortality rates within the redwood (*Sequoia sempervirens)* and Douglas-fir (*Pseudotsuga menziesii*) forests of Point Reyes National Seashore (Marin County, CA).

We found that rates of mortality were substantially higher in Douglas-fir forests than in redwood forests. Despite the earlier date of disease establishment in the redwood forests of our study area, cumulative tanoak mortality (in terms of both stem counts and basal area) in the Douglas-fir forest type surpassed that of the redwood forest type by 2009; for instance, over 95 percent of tanoak basal area was dead in the most severely diseased Douglas-fir plots, as compared to approximately 75 percent in the most severely diseased redwood plots. We also recorded symptom status for trees that were still alive in 2009, and these data suggest that Douglas-fir forests will continue to experience much higher mortality rates. In addition, we investigated several factors that might have affected disease spread and/or local intensification, and then used these results to simulate mortality through 2025. If mortality rates from 2007 to 2009 were fairly representative of longer-term trends, we predict that even those patches of redwood and Douglas-fir forest that were relatively unaffected in 2007 will have lost approximately 70 percent and 100 percent of tanoak basal area, respectively, by 2025.

Redbay Ambrosia Beetle and Laurel Wilt: A Destructive Duo in the Southeast and a Potential Threat to California

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Laurel wilt is a destructive vascular disease of trees in the laurel family (Lauraceae). It is caused by the fungus *Raffaelea lauricola*, a symbiont of the non-native redbay ambrosia beetle (RAB), *Xyleborus glabratus*. Since 2003, laurel wilt has caused substantial, widespread mortality of redbay (*Persea borbonia*) trees in South Carolina, Georgia, and Florida and has recently been detected in Mississippi. Other species such as sassafras (*Sassafras albidum*), camphor (*Cinnamomum camphora*), avocado (*Persea americana*), and the endangered pondspice (*Litsea aestivalis*) and pondberry (*Lindera melissifolia*) (on state and federal endangered species lists, respectively) are also susceptible hosts of the disease, but the impact (both realized and potential) on these species is less certain. The RAB is the only known vector of the pathogen and carries spores of *R. lauricola* in special fungus-growing structures near its mouthparts. Trees become infected when female RABs initiate attacks on healthy host trees and introduce the pathogen into the xylem. The infection restricts the flow of water in the tree, induces a black discoloration in the outer sapwood and causes the leaves to wilt.

Laurel wilt is now well established in the southeastern Atlantic Coastal Plain region of the U.S. and eradication of the vector and pathogen in this region is not feasible. Continued dramatic reductions in redbay populations are anticipated, although survival of redbay regeneration in the aftermath of laurel wilt epidemics suggests that redbay will not go extinct. Although redbay and most of the other native host species are not highly important commercially from the standpoint of wood utilization, fruit production, or ornamental trade, laurel wilt does cause economic, ecological, and aesthetic impacts that have not been well quantified. In many forests and other natural areas with a redbay component, the most reasonable management response where laurel wilt is established may be to simply let the disease run its course. “Recovery” from laurel wilt in redbay and other forest species could be considered in terms of the following general courses of action:

- Slow the long distance, human-assisted spread of the disease.
- Improve our understanding of the biology, host associations, and impacts of the disease and its vector.
- Protect individual, high-value landscape trees with pesticides when feasible.
- Develop other tools for management of the disease and its vector, possibly to include sanitation, other silvicultural methods, trap-out or attract-and-kill techniques, use of resistant genotypes, and biological control.
- Assess the need for, and possibly pursue, a germplasm conservation program for threatened hosts.
- Continue to monitor the geographic spread of the disease, assess its impacts on host species as its spreads to new ecosystems, and educate the public about the issue.

Redbay ambrosia beetle and laurel wilt fungus pose a dire threat to California, and also to Mexico and countries in Central and South America. The two big problems accidental introduction of these pests into California may cause are the death of avocado trees (*Persea americana*) and native California bay laurels (*Umbellularia californica*). Research in Florida has clearly demonstrated that avocados and California bay laurel are quite susceptible to attack by redbay ambrosia beetles and subsequent infection by the laurel wilt fungus.

Individuals from a variety of government agencies, colleges and universities, non-profit organizations, private companies, and other entities are working collaboratively to understand and address the presence of laurel wilt in the U.S.

Emerald Ash Borer: Biology, Impacts, and Management

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Emerald ash borer (*Agrilus planipennis*, Coleoptera: Buprestidae) is a destructive pest of North American ash species (*Fraxinus* spp.). Originally from Asia, it was discovered in southeast Michigan in 2002. It has since been found in approximately 15 states and in Canada, mostly in the Great Lakes Region and the Northeast. The insect had probably been established for over a decade prior to its identification in 2002, and at the time of discovery, approximately 3,000 square miles were infested. New discoveries of populations do not necessarily reflect recent spread of the insect as most infestations that are found had become established a number of years prior to detection. Long-distance movement of the insect has occurred through the movement of infested nursery stock, ash firewood, and other ash products, and the continued threat of movement of infested firewood and other ash resources remains a concern for future spread.

Emerald ash borer takes one or two years to complete development depending on host vigor and climate. Recently infested areas and areas with colder climates are more likely to have a two-year life cycle due to higher host vigor and less conducive weather conditions. Adults become active in the warmer parts of its range in May, and flight may continue in northern areas into September. Females lay eggs in bark crevices and larvae tunnel into the tree and feed on the living portion of the bark. Larvae produce tight serpentine galleries as they feed, and these galleries increase in size as the larvae develop. Heavy infestation of trees results in the destruction of most of the phloem and cambium. Larvae pupate and, in the case of a one-year life cycle, emerge the following summer. For insects that take two years to complete development, the larvae overwinter as early instar larvae in their first winter and as late instar or pupae in their second winter. Symptoms and signs of infestation include the presence of D-shaped exit holes, vertical splits in the bark over larval galleries, woodpecker feeding damage, decline of the canopy, and sprouting from the base of the tree. Ash mortality normally starts to occur in an area that has been infested for five or six years.

On a local scale, emerald ash borer kills the vast majority of ash trees in a stand. While some differences in susceptibility exist between green, white, and black ash in lab tests, all species in all size classes become impacted in the field. There has been concern expressed that this insect threatens the future of the genus *Fraxinus* in North America. When looking at a landscape scale, it is clear that some trees do escape infestation and persist, even in areas where emerald ash borer has probably been present for over twenty years. At a regional scale in the southern half of Lower Michigan and northern Indiana and Ohio, emerald ash borer infested approximately 17 percent of ash trees as of 2007. This percent has undoubtedly increased since that time, but is still likely not as high as the perceived damage caused by this insect has been. The estimate of numbers of infested trees in 2007 in Michigan, northern Indiana, and Ohio was over 50 million trees.

Detection of emerald ash borer population has been problematic, with most infestations discovered only after they have been present in an area for a number of years. For example, an apparently isolated infestation was discovered north of Houghton, Michigan in 2008, but dendrochronological analysis have shown that it was present in the area for at least six years prior to discovery. Early responses to apparently isolated infestations have included attempts to eradicate the insect by removing ash trees around known infested trees. Some of these eradication efforts showed short-term success. However, in most cases where eradication efforts were attempted, including on populations that had only been established for a few years, the effort ultimately failed with emerald ash borer having persisted below detectable levels for a number of years prior to being detected again at the location. It is therefore unlikely that any newly discovered emerald ash borer population could be eradicated. Efforts should focus on using available management tools to live with emerald ash borer in the ecosystem.

Most management techniques for emerald ash borer are still in the development phase. A pilot project to Slow Ash Mortality (SLAM) has been initiated it three sites in the Upper Peninsula of Michigan and integrates the various available management tools in a demonstration project. The overall goal of the SLAM approach is to reduce the rate at which ash trees die. Since tree mortality is related to emerald ash borer density, the project aims to reduce the numbers of emerald ash borer and to reduce the growth of emerald ash borer populations. The tools used include systemic insecticides to kill emerald ash borer larvae and adults, removal of infested trees to reduce emergence of adult beetles, reducing the amount of food resource available in the area by using phloem reduction strategies, and population manipulation to attract adults to groups of girdled trees that will be destroyed prior to emergence of the next generation. In addition, a number of biological control agents have become available over the last few years, and in the SLAM project to date, two species of parasitic wasp from Asia have been deployed at two of the sites. To evaluate the success of these strategies, the SLAM pilot project also includes intensive grids of traps and trap trees to try to accurately delimit the population, a detailed inventory of ash resources in the project area, and a network of long-term monitoring plots to evaluate the rate at which trees become infested and die. The progress of this multi-agency project is reported and updated online at www.slameab.info.

As communities prepare for the arrival of emerald ash borer, developing inventories of ash resources will enable rapid responses to the discovery of infestations using an integrated pest management approach. Ahead of the discovery of an infestation, communities can plan for tree injections, ash phloem reduction, and transitioning the canopy to species other than ash. In addition, preparations can be made for authorization of releases of appropriate biological control agents.

Further information about emerald ash borer, including updated distribution maps, can be found at www.emeraldashborer.info.

Acknowledgements: Collaborating agencies on the SLAM project include USDA Forest Service, Michigan State University, Michigan Department of Natural Resources and Environment, Michigan Department of Agriculture, and USDA Animal and Plant Health Inspection Service.

Asian Longhorned Beetle Infestation in Massachusetts

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An infestation of Asian Longhorned Beetle (ALB) *Anoplophora glabripennis* (Motschulsky) was detected in Worcester, MA in August, 2008 and is currently the largest known infestation outside of its native range. ALB infests a number of trees, but is mainly a pest of maple. The Massachusetts infestation includes large tracts of forested land which marks the first time ALB has been detected infesting the maple and birch trees in the Northern Hardwood Forests of North America.

As of November 2010, the Cooperative Asian longhorned beetle program had removed over 28,000 trees in an effort to eradicate the invasive pest from Massachusetts. In addition, over 60,000 non-infested trees were prophylactically treated with a systemic insecticide to protect trees from attack. Various restoration efforts have so far resulted in the replanting of over 3,000 trees.

There is continued concern of possible satellite infestations in the region. Substantial outreach and early detection efforts continue throughout the Northeast and focus on the potential movement of infested wood out of the infested area before the initial detection in 2008.

Asian longhorned beetle has pest potential wherever suitable host trees exist including urban areas of California. A recent warehouse detection in McClellan, CA prompted researchers to test whether ALB could survive on some common street trees of Sacramento. ALB successfully hatched in a number of common California urban trees, however adult survivorship remains unknown.