# ZONE OF INFESTATION PROPOSAL:

# GOLDSPOTTED OAK BORER

# San Diego County

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# GOLDSPOTTED OAK BORER:
# ZONE OF INFESTATION PROPOSAL

## INTRODUCTION

The invasive gold spotted oak borer has become firmly established in much of San Diego County and is killing tens of thousands of trees already costing millions of dollars in remediation costs and property value loss. Habitat and recreational values are being lost. Over the last two years a coordinated multiagency effort involving all levels of government has made an intensive effort to slow the spread of the beetle. All of this good work has been effective, however the looming threat of GSOB moving beyond San Diego County and into surrounding counties and the rest of the state requires even more proactive steps be taken. Establishing a Zone of Infestation would significantly bolster the effort against GSOB and elevate the level awareness its potential threat to the state.

## DISCUSSION

Southern California forest and oak woodlands are threatened by an introduced oak-killing pest, known as the goldspotted oak borer (GSOB), *Agrilus auroguttatus.* Since its first detection in 2002, GSOB has killed over 80,000 oaks in forest and woodland settings in southeastern San Diego County. Although GSOB is present in southeastern Arizona, forest entomologists suspect the spread of GSOB into California is not through natural vectoring, but rather through the introduction of infested firewood. Once introduced in Southern California oaks, the insect has thrived and is now causing significant mortality in California black oak (*Quercus kelloggii*), *coast live oak (Quercus agrifolia*), and canyon live oak (*Quercus chrysolepis*). All ownerships - federal, state, tribal, county and city lands and as well as private property- have been impacted by GSOB. Recognizing that this pest is new to California and that our oaks seem to have no natural defense mechanisms, there is significant concern that this pest will spread beyond the current known locations in San Diego to other forest and oak woodlands throughout California.

GSOB has already caused significant economic, ecological, cultural, and aesthetic losses to the region. Estimated cost and losses associated with mitigating this pest is currently well over 9 million dollars. As this pest continues to expand within and potentially spread beyond San Diego County, it is likely to create significant fiscal impacts to private property landowners and public agencies. The high potential for further significant economic, ecological, cultural, and aesthetic impacts is of great public concern.

In 2009, federal, state, county and city agencies in San Diego recognized that the impacts from GSOB were significant and likely would continue without intervention. In an effort to provide the public with coordinated services to address GSOB, a steering committee was formed to provide leadership and guidance. Additionally, a research-education-outreach subcommittee was developed to provide the grassroots connection for informing and distributing published materials to the public, including providing information through the website www.GSOB.org. In

partnership with the steering committee, the San Diego Unit is requesting the Director of the California Department of Forestry and Fire Protection (Department) and the California Board of Forestry and Fire Protection (Board) to consider declaring a Zone of Infestation (ZOI) for GSOB. A Zone of Infestation would represent an official and formal action to recognize GSOB as a threat to California's forest and woodland resources and exhibit leadership in the effort to combat GSOB while providing the public with important information.

**VALUE OF CREATING A ZONE OF INFESTATION FOR GSOB**

The value of establishing a Zone of Infestation for the goldspotted oak borer is linked to:

- Fostering collaborative efforts with both current and potential local, state and federal agency partners working on GSOB prevention, containment, control and remediation.
- Communicating the concern of both the Department and the Board for the GSOB issue and its current and potential impact in California to the public.
- Showing support from both the Department and the Board for efforts to seek funding, research, education outreach, best management practices for control, management efforts in managing GSOB-infested wood, and other GSOB related activities.
- Creating a directive that GSOB suppression and control measures be feasibly addressed in Timber Harvesting Plans within the ZOI (applicable only in mixed conifer stands where oaks are being harvested incidentally along with commercial species of conifers and a THP would be required).
- Establishing an official mapped boundary of the known GSOB infestation which can serve to notify communities within the current infested area and also to alert communities in neighboring non-infested areas of proximity, spread and threat of GSOB.
- Expressing the concern to the state legislature and governor's office about the potential impact and harm that GSOB could have statewide.
- Partnering with local governments in efforts to help stop the spread.
- Supporting the use of California Conservation Camp crews in control or management projects for GSOB on private and state lands.

**DESCRIPTION OF PROPOSED ZONE**

Mapping criteria were developed to determine the proposed ZOI boundary. The mapping criteria are defined as: known locations of GSOB, flight range of GSOB (utilized the average emerald ash borer flight per year distance as 4-miles/year, Siegert et al., 2008), location of host species and lines of convenience (road ways, property and/or ownership lines and other geographical features). Additionally, the latest data sets from San Diego Association of Governments (SANDAG), USDA Forest Service and CALFIRE were used to determine the proposed ZOI boundary.

The analysis of the mapping criteria resulted in the identification of two areas (a coastal area and an inland area) within San Diego County (Appendix A). The description of the boundaries for the two areas is described in Table 1. The combined areas total over 1.1 million acres.

Table 1: Boundary Description of the Zone of Infestation for GSOB

| Boundary | Coastal Area | Inland Area |
|---|---|---|
| Western | Lands east of the Pacific Ocean | Lands east of Valley Center Rd., then east of South Centre City parkway, , then east of interstate highway 15, then south of Bernardo Center Dr., then east of Can Crisalida, then south of San Diego Corporate Boundary, then east of Black Mountain Rd, then east of Second San Diego Aqueduct, then east of Interstate Highway 15, then north of Miramar Naval Air Station, then east of Fanita parkway, then north of Carlton Oaks Dr., then east of Carlton Hills Blvd., then north of Mission Gorge Rd., then east of Olive Lane, then southeast of Via Zapador, then east of Prospect Avenue, then east of Forester Creek, then east of North Marshall Avenue, then north of Interstate Highway 8, then east of Ballantyne Street, then east of Avacado Avenue, then east of Campo Rd., then north of Highway 94, then east of Tecate Rd. |
| Southern | Lands north of Interstate Highway 8 | Lands north of the San Diego County line |
| Eastern | Lands west of Interstate Highway 15 | Lands west of the San Diego County line, then south of state land parcels (06-073-5293100100, 06-073-5290801200, 06-073-5292900100, 06-073-5292500300, 06-073-5292400400, 06-073-5292701100 and 06-073-5293703600), then west Anza-Borrego Desert State Park, then west of state land parcels (06-073-4141200100, 06-073-4142000100, 06-073-4141600300, 06-073-4141300300), then west of S2 rd (Imperial highway), then south of San Felipe Rd., then west of Anza Borrego Desert State Park western boundary, then west of federal parcels (06-073-2490500600, 06-073-2490500500, 06-073-1963201400, 06-073-1963501000, 06-073-1962500900, 06-073-1962300300, 06-073-1502400), then west of parcels 06-073-1960703100, west of Los Coyotes Indian Reservation, then west of the Cleveland National Forest boundary, then south of parcel 06-073-1361604100 |
| Northern | Lands south of Fenton Rd., then west of Cam Ruiz, then south of Mira Mesa Blvd, then west of Cam Santa Fe., then south of Los Penasquitos Creek, then south of Interstate Highway 5, then south of Genesee Ave, then south of N. Torrey Pines Rd., then south of Torrey Pines Scenic Dr. | Parcel lands of 06-073-1361604100, then east and south of Cleveland National Forest, then south of Dyche Valley, then south of highway 76 until intersection of Valley Center rd. |

The distribution of ownership within the proposed ZOI reflects a wide variety of land owners (Table 2). Many of the leading public land managers have restricted the movement of infested wood from their lands through internal action or adoption of policy. While many public land managers have taken action to minimize spreading GSOB on their lands, currently there are no policies or regulations at the county, state or federal level that restricts the movement of GSOB infested wood from private property and other non-federal lands.

Table 2: Distribution of Land Ownership - Private and Public Lands

| Ownership | Number of Parcels | Acres |
|---|---|---|
| Private Properties | 17,209 | 162,376 |
| BLM | 109 | 134,976 |
| City | 553 | 55,583 |
| County | 174 | 21,780 |
| California Fish & Game | 14 | 2,564 |
| Fire Districts | 14 | 19 |
| Indian Reservation | 44 | 85,243 |
| Military Reservation | 32 | 23,469 |
| Other Federal | 17 | 340 |
| Other Special Districts | 43 | 2,848 |
| Sanitation | 3 | 20 |
| School Districts | 198 | 3,461 |
| State | 48 | 16,155 |
| State – Cal Trans | 28 | 8,256 |
| State Parks | 14 | 340,134 |
| US Forest Service | 48 | 229,512 |
| US Fish & Wildlife | 7 | 2,730 |
| Water Districts | 139 | 49,581 |
| **Totals** | **18,694** | **1,139,047** |

**PEST BIOLOGY AND STATUS OF THE OUTBREAK**

The goldspotted oak borer, *Agrilus auroguttatus* Shaeffer (Coleoptera: Buprestidae) (Coleman, 2010), has one generation per year. In the United States, it is native to southeastern Arizona, where oak damage and mortality have not been reported previously from this species. In fact, very little information was known about this insect prior to 2008. Research conducted in southern California has revealed much about this insect's biology.

Adults feed on oak foliage where they also likely mate. The adult flight period is from May to October with peak flight in late June. Adults have a possible maximum flight distance of 20km/day and live for an average of 52 days. Research is underway to determine flight distance for GSOB (Vanessa Lopez, UC Riverside personnel communication). Adult GSOB likely lay eggs singly or in clusters in bark crevices on the main stem and larger branches of oaks similar to other *Agrilus spp.*, though this event has not been observed. In the lab adults produce an

average of 51 eggs in their lifetime of which approximately 90% hatch to produce larvae (Lopez, 2011). Eggs hatch within 10-14 days. The newly hatched larvae bore into the bark where they complete 5 larval stages. Larvae have a bulbous head with hardened mandibles which are used for boring into bark and phloem and they possess two pincher-like spines at the tip of the abdomen, a distinguishing characteristic. Mature GSOB larvae are 18 mm long and 3 mm wide, legless, white, and have a long slender appearance (Coleman, 2008).

Larvae feed near the interface of the phloem and xylem, which damage both of these conductive tissues as well as the cambium, the generative tissue that produces new layers of phloem and xylem. Larval feeding results in strips and patches of killed areas of the cambium, which eventually causes tree death after several years of injury inflicted by multiple generations of the beetle (Hishinuma et al., 2011). The larval feeding zone is concentrated in the lower parts of the main trunk although larger branches are attached when populations are high in the tree. Larval feeding galleries are extensive, meandering and dark in color. Larvae have been observed under the bark from early summer to early fall, and as late as October. Once larvae mature they tunnel to the underside of the bark where can be found in a hairpin configuration. In this configuration they will go through pupation before reaching adulthood. Mature larvae can be found in this configuration in the outer bark from early fall until early summer. Larvae can survive a wide range of temperatures, from approximately 43°C to -10°C. Pupation occurs from May to October. Adults chew through the bark leaving a D-shaped emergence hole upon exiting the tree. Adults are 10 mm long and 2 mm wide and identified by the 6 golden-yellow spots on the dark green forewings (Coleman, 2008).

External Symptoms

There are four morphological attributes that characterize the response of *Quercus agrifolia* to GSOB infestations: crown thinness; bole stain resulting from extensive larval feeding; D-shaped exit holes associated with adult emergence; and distinctive woodpecker foraging holes in the outer bark (Coleman, 2008). Symptoms of GSOB infestation can include premature twig dieback and thinning in the crown that worsens progressively over several years.

Larval feeding occurs primarily on the main stem (or trunk) and larger branches of mature oaks. Elevated levels of larval injury are indicated by black, wet staining or dark red bleeding on the bark resulting from a build-up of tree sap around patches of dead phloem. Bark staining varies greatly in size with dark patches ranging from less than 1 square inch to 0.5 square foot, and there can be multiple stained or bleeding areas on the stem.

When new adults emerge through the outer bark, their exit holes are D-shaped and 0.15 inch wide. Exit holes often are found along the lower 6 feet of the main stem, at the very base of the tree, or adjacent to bark-stained areas. From fall to early summer, woodpeckers forage for larvae and pupae in the outer bark, exposing the brick-red phloem (in coast live oak) and signifying an infested tree. Woodpecker foraging often exposes the black larval galleries or pupal cells. Inner bark that has been exposed from woodpecker foraging darkens to black over time. Woodpecker activity, although high in certain areas, has been insufficient to control GSOB or slow its spread.

Internal Symptoms

Beneath the bark, larval feeding galleries are found primarily in the inner bark and surface of the wood. To expose larval galleries, carefully shave a small area of bark down to the wood surface. Larval feeding occurs in a meandering pattern and has a black appearance when the bark is freshly removed. Larval galleries are tightly packed with dark-colored frass. Extensive larval feeding can kill large areas of the phloem, leaving areas of dead tissue often filled with tree sap. This feeding activity eventually girdles and kills trees (Hishinuma et al., 2011).

Status of Outbreak

Within infested stands, oaks greater than 12 inches diameter at breast height (DBH) are susceptible to GSOB injury and mortality. In some stands, all mature and old grown oaks have succumbed to GSOB (Coleman, 2011). Many of the mature oaks are showcase specimens having diameters that are greater than 40 inches DBH, standing up to 80 feet in height, and providing canopy cover approaching 125 feet in diameter.

Entomologists believe that GSOB was artificially introduced into San Diego County through the importation of infested oak firewood from southeastern Arizona. The initial infestation center was presumed to have been near the towns of Descanso, Guatay and Pine Valley, where oak mortality was first detected via aerial survey in 2002. Subsequent evaluation of sequential aerial photography mapping of GSOB-caused mortality has confirmed that observation. Since that time, oak mortality has expanded to cover more than 4,900 $km^2$, some of which may be attributed to natural spread of GSOB adults, but rapid spread over longer distances likely attributable to the movement of firewood. Mortality resulting from this insect has been continuous for 8 years. Infestation rates on oaks on the Cleveland National Forest average 65%, but are approaching 100% in areas with long-term tree mortality. Based on the above information, GSOB will likely continue to expand within and beyond the borders of the currently infested area. To date approximately 80,000 oak trees have been killed by GSOB since 2002 in San Diego County.

A separate GSOB infestation resulting in tree mortality was detected in 2009 at Marion Bear Memorial Park near La Jolla, north and well west of the larger infested area in east county. This infestation may be the result of GSOB adults emerging from infested firewood brought into the nearby residential or recreational area and attacking nearby oaks. Firewood represents a significant pathway for introducing GSOB into uninfested areas. Observations indicate that GSOB adults can emerge from firewood for at least two seasons if the bark remains intact. It is likely that numerous additional infestations will be detected in the future outside the current infestation area as a consequence of transporting GSOB-infested firewood.

Effects of GSOB on many California red oak species is likely to be severe; however, there appears to be some differences in GSOB host tree preference, tree susceptibility and resulting tree mortality and injury levels among oak species. As GSOB populations expand and the resulting supply of oak wood increases, the risk of accidental transport of infested firewood to other parts of California and beyond will be high. If GSOB escapes San Diego County, its impact will be variable dependent upon the amount of susceptible host trees available for feeding and

reproduction. Remediation costs and property value losses will vary based upon and the location and value of the oaks affected, but, for the most part, it is anticipated that these costs and losses would be very substantial.

**TREE SPECIES DISTRIBUTION**

The goldspotted oak borer attacks three native oak species in California, Coast live oak (*Quercus agrifolia* Nee), California black oak (*Q. kelloggii* Newb.) and canyon live oak (*Q. chrysolepis* Liebm.). These species dominate 15 million ha (37 million acres) of the Californian forest landscape (Gaman et al., 2006) and see Appendix B for map on extent of these species. Coast live oak occurs in California and northern Mexico and is distributed from Mendocino County, California, south to Baja California. Limited inland populations occur along watercourses in the Central Valley (Steinburg 2002). Canyon live oak is native to Oregon, California, Nevada, Arizona, and Mexico. It is distributed0 from southwestern Oregon south through California and into northern Baja California, Mexico. It is the most widely distributed oak in California, occurring in the Klamath Mountains, the Coast Ranges, western slopes and eastern slope canyons (scattered) of the Sierra Nevada, and the Transverse and Peninsular ranges (Tollefson 2008). Black oak is native to Oregon and California. It is the most widely distributed of the western oaks. It grows in the foothills and lower mountains of southern Oregon and California, with a north-south range of about 780 miles (1,260 km). It is contiguously distributed from west-central Oregon, south to just north of the Mexican border in the Agua Tibia Mountains and the Mount Laguna Mountains of San Diego County, California. One California black oak population extends into the Great Basin in Lassen County, California. An isolated population occurs in the Sierra de San Pedro Mártir of northern Baja California (Fryer 2007). It is possible that other oaks overlapping the ranges of these species may also be hosts. On a rare occasion GSOB has been found on Engelmann oak (*Q. engelamannii*) but not to the point of significant mortality.

**DAMAGE TO AFFECTED STANDS AND TREES**

Damage caused by goldspotted oak borer infestation includes decline in growth, decreased tree vigor, and oak tree mortality, resulting in a decline/loss of oaks within a mixed conifer stand or oak woodland stand. In areas where the infestation had been ongoing for several years, GSOB is infesting up to 100% of host oak species. Infestation rates for black oak, coast live oak, and canyon live oak are 74%, 57% and 52% respectively (Coleman, GSOB workshop Alpine, CA).

In terms of distribution, the originating infestation has the highest concentration of mortality, whereas the furthest sites typically involve less than a dozen trees. As the infestation spreads beyond the originating site – which mostly occurred on private property and federal lands – it also impacts state, county and city lands.

All those who value oak trees, whether for cultural, environmental or aesthetic purposes, are impacted by the rise in oak tree mortality. Trees of high ecological, cultural and aesthetic value are commonly located in parks, campgrounds, administrative sites, tribal lands and private

property. Oaks play an important role in the culture of Native American tribes and the loss of oak trees threatens their cultural practices. Native Americans in Southern California have collected acorns for centuries. At one time California black oak acorns were a tribal food staple. Loss of a significant part of the oak resource would greatly impact Southern California tribes both financially and culturally.

Wildlife are dependent on oaks, and the loss of oak trees also reduces their habitat and food supply. Oaks may be the single most important trees used by wildlife for food and cover in California forests and rangelands. California black oak occupies more total area in California than any other oak species, and its acorns are heavily consumed by livestock, mule deer, feral pig, rodents, mountain quail, wild turkeys, jays and woodpeckers. In addition, oak woodlands are also important habitat for several rare and threatened wildlife species.

Native oak species are valuable ornamentals providing deep shade and aesthetic appeal, which makes oaks a highly desirable landscaping tree. Dead and dying oaks create fiscal and physical liability to landowners and persons using and living in the forest and woodland areas. High levels of crown dieback and mortality of oaks in community areas, which are highly visible, likely will increase the public concerns regarding hazard trees. The loss of oaks is correlated to reduction in property values and lessens scenic values. Dead and dying oak trees create a more dangerous wildfire situation by adding combustible fuel, increasing dead fuels within overstocked forested areas and increasing safety hazards along evacuation routes.

**TERRAIN AND COVER IN RESPECT TO CONTROL**

The terrain of the area of infestation varies in slope and elevation. Slopes range from flat to steep and include all aspects. The infested area has been discovered slightly above sea level - 300 feet in elevation - to elevations nearing 6000 feet in elevations in San Diego County. Access and terrain conditions will likely influence the range of the feasible treatment areas. Most homeowner and campground sites that may be subject to treatment are relatively flat terrain. Nonetheless, moderately steeper sites may be treated but may be limited to due to equipment limitations.

**PROPOSED CONTROL METHODS**

The proposed control methods are framed as objectives and serve as a guide to minimize the spread of GSOB. Moreover, the proposed control methods are consistent with the steering committee's charter. The GSOB ZOI objectives are described as follows:

1) Protect forest, woodlands and communities from the oak tree killing pest known as Goldspotted Oak Borer (GSOB), *Agrilus auroguttatus*
2) Contain GSOB pest within the ZOI boundary in San Diego County
    a. Limit the spread and severity of GSOB infestations within the ZOI by implementing Integrated Pest Management (IPM), providing educational outreach and utilizing CAL FIRE resources where appropriate, including resource

management personnel, conservation camp crews, other personnel and/or equipment.

i. Minimize the fiscal hardship caused by GSOB attacks on private and publicly-owned lands.
ii. Protect natural and cultural resources threatened by GSOB attack.

b. Direct Timber Harvesting Plans that harvest GSOB susceptible oak species within the ZOI to comply with the Forest Practice Rules (14 CCR 957.9 Prevention Practices) and utilize feasible measures guided by IPM.
c. Prepare for and coordinate a rapid response should GSOB spread outside the ZOI, including conducting an assessment and implementing mitigation measures with partner agencies, in order to contain the spread and limit the severity of the new GSOB population.

i. Network with the appropriate agencies and groups of counties and communities at risk and encourage them to develop GSOB preparedness plans.
ii. Evaluate the need to change the ZOI boundary for any new infestation occurring outside the current boundary.

3) Improve knowledge and understanding of the GSOB pest by supporting and guiding studies and research efforts in order to develop effective Integrated Pest Management and Best Management Practices for GSOB.
4) Minimize public hazards created by GSOB-killed trees and resulting fuel build-up through coordinated abatement
5) Foster oak wood product utilization that minimizes the chance of spreading GSOB
6) Seek funding, whenever grant or other funds become available, to assist with activities associated with containing the spread of the GSOB pest and mitigating its impact in infested areas
7) Keep local/state/federal elected representatives, other state agencies, local/federal agencies, interest groups and the public apprised of the status and threat posed by GSOB and updated on containment and management efforts.

The objectives are intended to bolster efforts without the burden of quarantine or other regulatory action. Moreover, this type of framework provides a public foundation to link local, state and federal agencies across jurisdictional boundaries in California. More importantly, in the event that GSOB is detected in other parts of the state, this ZOI document may provide the necessary guidance to initiate a rapid response and prevent GSOB from becoming an established pest in other forest or oak woodland areas.

Partnering for Effective Education Awareness

To maximize efforts the key land management agencies formed the San Diego County GSOB Steering Committee to initiate partnership for addressing the multi-jurisdictional pest. Additionally, the GSOB Research-Education-Outreach Committee, Southern California Committee of the California Forest Pest Council (CFPC), GSOB Subcommittee under the Southern California Committee of the CFPC, and Firewood Task Force of the CFPC are outreach efforts to expand the educational awareness network. The GSOB subcommittee of the

Southern California Committee CPFC was specifically created to supplement the San Diego County GSOB steering committee for the area outside of San Diego. Information on the GSOB partnerships and accomplishments is attached (Appendix C).

Local, state and federal agencies have collaborated on producing brochures, handouts, and flyers on the goldspotted oak borer to provide the public with a consistent and uniform message about GSOB and effective management practices. Town hall meetings, workshops and other public meeting engagements have been developed and delivered with the same consistent and uniform message. The University of California, Agricultural & Natural Resources - Statewide Integrated Pest Management Program produced GSOB field identification guide on integrated management options (Appendix D).

Best Management Practices

Transporting GSOB-infested logs or firewood can and has introduced GSOB into uninfested areas. GSOB adults may emerge from the bark any time during their flight season (May through October) after the tree has been dead for a year. Therefore best management practices (BMPs) have been developed to help landowners and the firewood industries safely utilize wood from known infestation areas (Appendix E).

Hazard tree removal

Dead oaks on lands of all ownerships are being removed to abate life and property hazards. Management, storage and disposal of infested wood and associated costs continue to present challenges. Determinations are underway to address the immediate and future needs for hazard tree abatement including funding requirements, potential funding sources and mechanisms for addressing infested wood storage, grinding and disposal.

At this time the efficacy of direct control, meaning the removal of actively infested trees, is unknown. Studies are needed to better understand the value of removing the actively infested trees to minimize GSOB spreading into new areas.

Individual tree protection - Systemic and Contact Insecticides

Based upon insecticide trials conducted by U.S. Forest Service Forest Health Protection the topical application of insecticide on the boles and large branches of high value trees is the only effective prevention option currently available to protect oak trees from being attacked by GSOB. This treatment is aimed at killing newly hatched larvae before they chew through the bark. Treating a tree after the tree has been attacked may have no effect - as the larvae area already present in the tree. Stem injection of systemic insecticides may be effective at killing larvae under the bark but the efficacy of this type treatment is still being evaluated. Insecticide treatment may need to be periodically repeated to optimize long-term protection.

**ESTIMATED CONTROL COSTS/BENEFITS**

Economic/ecological costs of GSOB parallel those caused by emerald ash borer in the Midwestern US, including tree removal costs and the loss of house/land values. Unlike the Midwest, oaks susceptible to GSOB are often the only tree species growing in California

woodlands; the death of these trees represents a large loss of forest and woodland acreage, cascading into losses of recreation, watershed, wildlife, and cultural resources. Oak trees in San Diego occupy less than 10% of the area, yet a single tree or group of trees killed can results in ecological loss in terms of shading, acorn production, shelter, roosting, and other habitat values. Additionally, many large oaks that have died from GSOB are well over 200 years old and represent significant cultural, aesthetic, and property value losses. High GSOB tree mortality areas have occurred in campgrounds, administrative sites and homeowner and tribal lands and these trees are being removed at high costs. The existing and future oak mortality will impact ecosystems for years to come in addition to the large increase in hazardous trees that threaten life and property. If GSOB continues to spread as expected, great economic losses are anticipated across all land ownerships.

Value of Potential Tree Loss

Assuming 10 to 20 dead trees/acre, the cost of removing 40 to 80,000+ dead oaks (averaged at $500/tree), could range from $20 to 40 million or more. This result would create a catastrophic cost for local governments, similar to the situation ongoing in the Midwest with ash tree removal for the invasive emerald ash borer (Smith et al., 2010). The San Diego Resource Conservation District has spent $2 million to remove dead oaks from about 300 private properties near the epicenter of the problem - this expenditure only scratched the surface of the problem.

Between 2008 and 2010, Cuyamaca Rancho State Park spent $52,600, in addition to 1,300 person hours, removing hazardous oaks throughout the park. Several campsites were also closed due to hazard tree concerns attributed to GSOB resulting in over $400,000 loss of camping revenue and day use fees. In addition, San Diego Resource Conservation District has evaluated over 1,000 acres of private property in Descanso and surrounding areas in need of hazard tree removal. The Cleveland National Forest has spent over $60,000 on tree removal at campgrounds, picnic areas, fire stations, and along the Sunrise Highway (Smith et al., 2010).

In terms of property value losses, a GSOB infestation in Ramona could affect at least 1,800 properties with an assessed land value of $225 million, and secondarily affect 16,000 other properties with an assessed land value of $2.8 billion over the next 5 years. Previous studies suggest that oaks contribute from 5 to 30% of the appraised values of real estate; partitioning this value across parcels of different sizes, cost of GSOB-caused tree mortality could be calculated as a direct loss of $25 to 40 million of property value if oaks die at the currently observed rate. Loss of property values to adjoining parcels is more ambiguous, but could range from $50 to 150 million (Smith et al., 2010).

Ramona is just one of 250 southern California communities with substantial numbers of oaks and oak woodlands. About half of these cities and communities use oaks as a defining element, and many have oak protection ordnances. The economic impact of GSOB statewide ultimately could be measured in billions of dollars (Smith et al., 2010).

The cost of dead and hazardous tree removals is only one aspect of GSOB's potential economic impact. Large majestic oaks (particularly susceptible) greatly add to property values in urban settings. As an example, correlating parcel data with oak tree data in Los Angeles County (where an oak tree protection ordinance is in place and oaks are the signature tree for many communities) to assess the potential magnitude of costs should GSOB spread, suggests that tree removal costs could range from $27.1 million to $135.5 million and that property values could decline from $150 million up to nearly $1 billion (Scott and Turner). Nearly all California counties have oak resources.

Cost of Tree Removals by Property Owners and Agencies

The current cost of tree removal is estimated at over $8 million dollars plus other associated costs are reaching nearly $3 million in San Diego County alone, for a total of over $11 million (Table 4).

Table 4: Current incurred cost associated with Tree Removal Cost in San Diego County

| Funding Source and/or landowner | Tree Removal Direct and Indirect Costs | Opportunity Costs (Lost Revenue) | Other Associated Costs |
|---|---|---|---|
| Private Property: owner-funded residential, commercial, campgrounds, organizational camps and ranches * | $4,320,000 | (unknown) | |
| Cuyamaca Rancho State Park + (Opportunity Cost ++) | $341,145 | $458,500 | |
| San Diego County Parks and Recreation + | $1,000,000 | (unknown) | |
| Greater San Diego Resource Conservation District + | $1,900,000 | na | |
| USFS Cleveland National Forest Descanso District # | $500,000 | (unknown) | |
| USFS Forest Health Protection + | na | na | $2,345,000 |
| CALTRANS++ | $100,000 | na | |
| San Diego County Department of Public Works (county roads) | unknown | na | |
| Tribal Lands | unknown | unknown | |
| San Diego Gas and Electric | unknown | na | |
| Sempra Energy | unknown | na | |
| California Department of Forestry and Fire Protection++ | $100,000 | na | |
| Total estimated cost to date | $8,361,145 | $458,500 | $2,345,000 |

| | |
|---|---|
| * | *Estimate based upon preliminary information from private tree services and extrapolation to entire infestation area.* |
| + | *Actual cost as provided by the agency* |
| ++ | *Estimated costs provided by the agency* |
| # | *USFS dollar estimate made by Kevin Turner using USFS provided figure of approximately 500 large trees removed from USFS improved sites (campground, administrative facilities) and an average $1,000/tree direct and indirect removal cost (based upon actual expenditures borne by other agencies for their campgrounds with similar sized trees).* |

Estimated Costs of BMP Treatment Types

Typically, the cost of treatment types are to related felling/removing, grinding, hauling, covering (tarping) and using insecticides. These estimated costs may be of assistance to various agencies and organization seeking funding to minimize the spread of GSOB (Table 5). Field conditions likely will influence the actual cost.

Table 5: Estimated Cost of BMP Treatment Types

| Treatment Type | Estimated Cost | |
|---|---|---|
| Tub Grinding Costs | $250-$350 | Per hour. Does not include haul costs to/from site. |
| Haul Cost | $36 | Per Ton |
| Hazard Tree Removal (Average Tree 15" DBH, 40 height) | $9,000 | Per Parcel |
| | $1,200 | Per Acre |
| | $500 -$1,500 | Per tree oak |
| Clear Plastic Tarp Costs (6 millimeter, ultraviolet resistant) | $39 - $880 | Per roll depending on length and width |
| Contact Insecticide Costs | $6 - $20 | Per 20" DBH oak tree - chemicals only |
| Systemic Insecticide Costs | $50 - $70 | Per 20" DBH oak tree - chemicals only |

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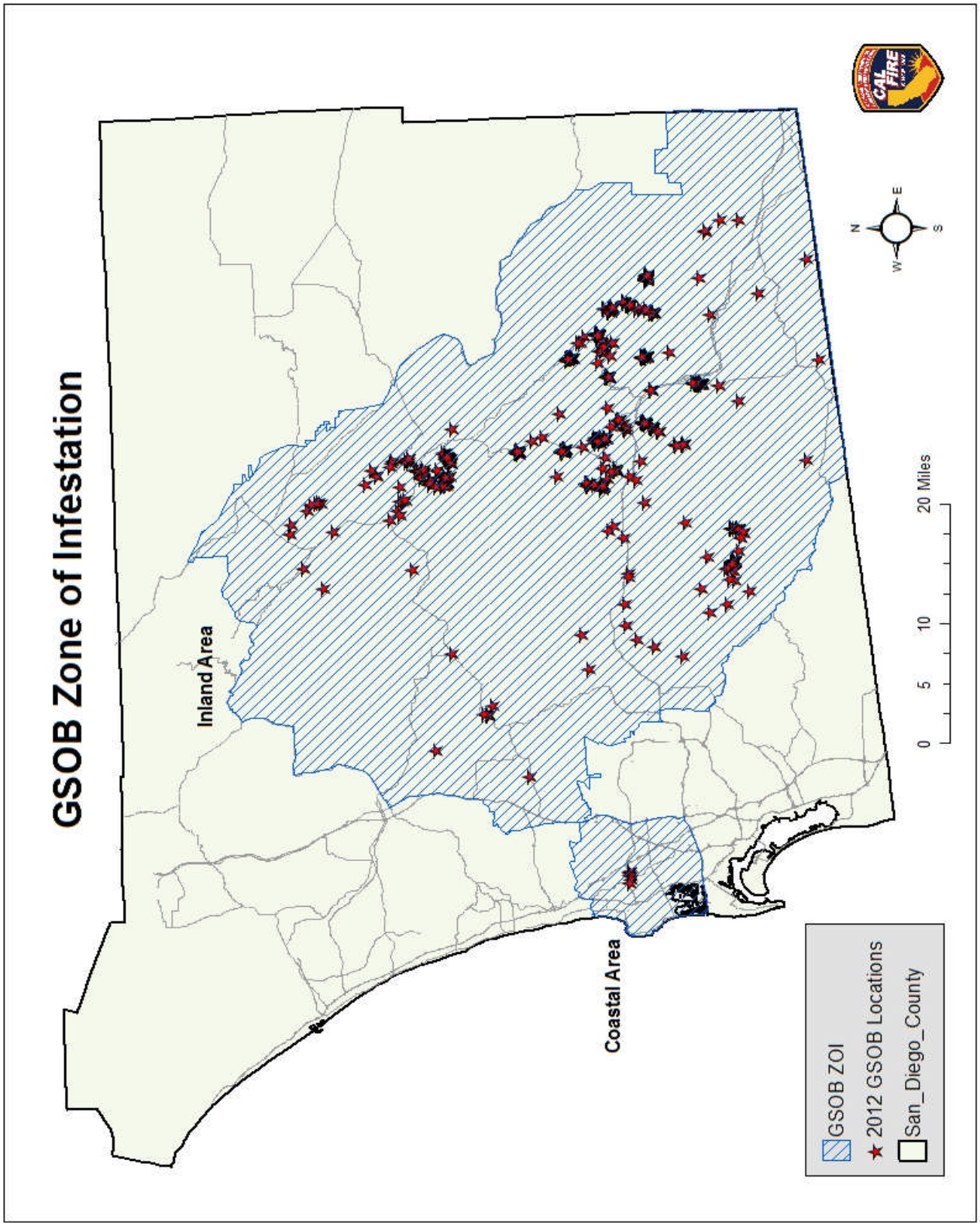
**APPENDIX A: PROPOSED MAP FOR THE GSOB ZONE OF INFESTATION**



**APPENDIX B: DISTRIBUTION OF OAKS SUSCEPTIBLE TO GSOB**

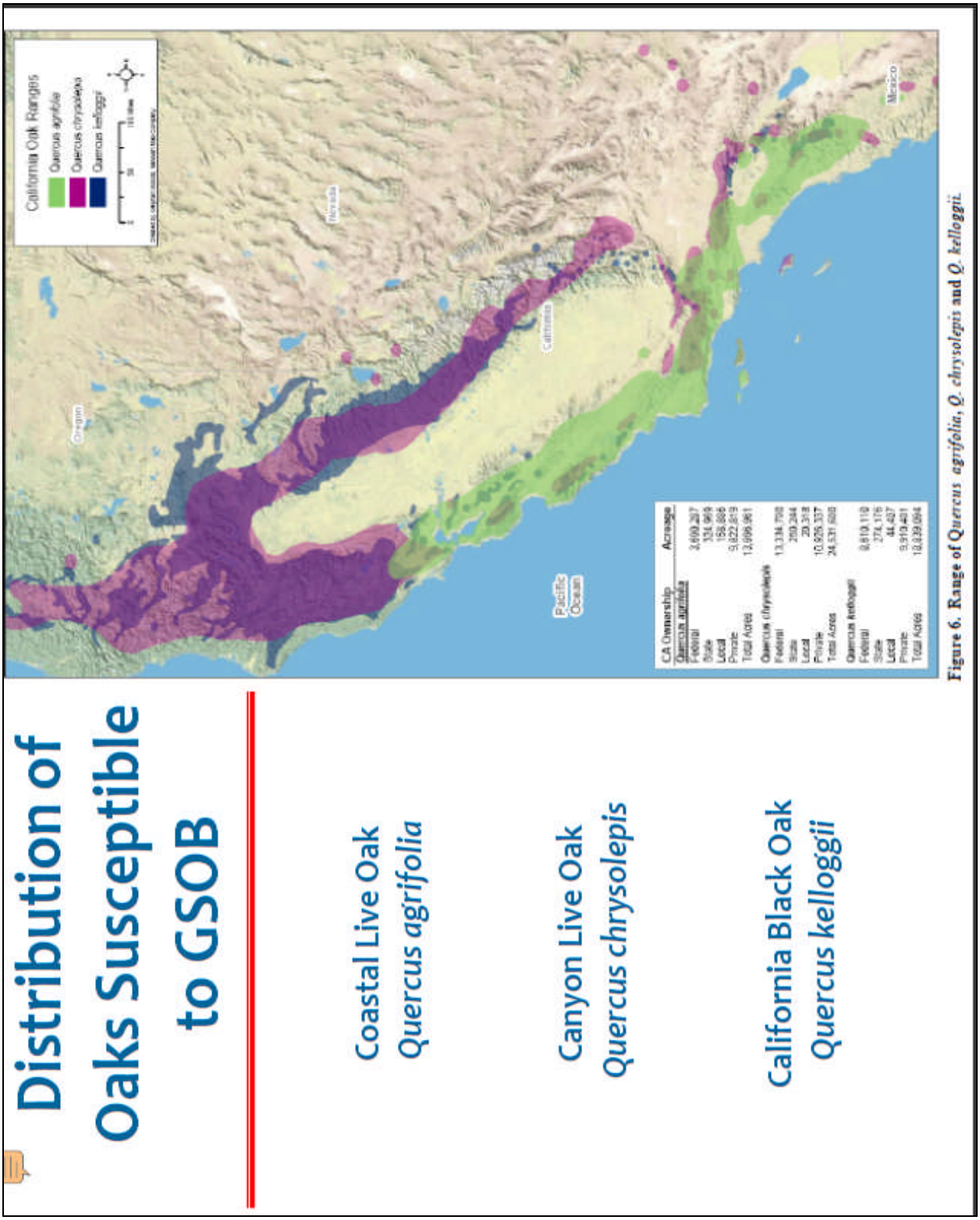



**Figure 6. Range of *Quercus agrifolia*, *Q. chrysolepis* and *Q. kelloggii*.**

## APPENDIX C: GOLD SPOTTED OAK BORER PARTNERSHIPS AND ACCOMPLISHMENTS

### Goldspotted Oak Borer (GSOB) Partnerships and Accomplishments

March 2012

**San Diego County GSOB Steering Committee:**

Cleveland National Forest

CAL FIRE San Diego Unit and Southern Region

California Dept. of Parks and Recreation

San Diego County Agricultural Commissioner

City of San Diego Parks and Recreation

**San Diego County Supporting Partners:**

U.S. Forest Service – Forest Health Protection

San Diego County Parks and Recreation

UC Riverside/UCCE San Diego

Greater San Diego RCD

San Diego Forest Area Safety Taskforce

**Partners Outside of San Diego County:**

Riverside County Agricultural Commissioner

CAL FIRE Riverside/Riverside County Fire Dept.

Riverside Mountain Area Safety Taskforce

San Bernardino Mountain Area Safety Taskforce

Orange County Dept. of Parks and Recreation

Los Angeles County Department of Fire/Forestry

Ventura County Fire

Ventura County Agricultural Commissioner

The Nature Conservancy

UC Riverside, Berkeley, Davis

UC Coop Ext. (Los Angeles, Ventura)

**County of San Diego GSOB Steering Committee (SC)**

- Meets quarterly or as needed for time-critical decisions
- Produces annual GSOB Incident Action Plans to respond to changing knowledge and conditions
- Works with local, state, and federal elected officials representing San Diego County

**GSOB Research, Education, and Outreach Committee**

- Multi-agency coordination and information sharing
- Website (www.GSOB.org)
- Media coverage
- GSOB Community Preparedness/Response Plan template
- Produce and distribute GSOB outreach materials (pamphlets, brochures, posters, ID cards, etc.)
- Given over 130 GSOB presentations to groups and communities at risk, including seven "Workshops for Professionals" using a multi-agency cadre and one webinar.
- Interagency coordination and collaboration on GSOB research and Integrated Pest Management
- Provided GSOB identification and pests in firewood training to CA Agricultural Inspection Station and US Border Protection/Customs personnel

**Firewood Management and Wood Utilization**

- Outreach to most Southern California wood cutters, brokers, and non-box store firewood dealers by phone, letter, email, and/or in-person site visits
- Continually educating agencies, legislators, and the public about the danger posed by moving infested firewood
- Developed Best Management Practices for GSOB-infested firewood
- Participants in CA Firewood Taskforce – Joint development of GSOB-specific "Don't Move Firewood" posters that were distributed to campgrounds and other venues in Southern California Counties
- Multi-agency particle size study to determine maximum effective particle size that will kill GSOB in a tub-grinding process

**Tracking the Rate and Pattern of Spread of GSOB and Its Impact on Red Oak Woodlands in Southern California**

- Sequential Aerial-Photoimagery is used to map progression, severity, and extent of GSOB spread
- Dating outbreaks by Dendrochronology - 2,461 wood samples have been collected from stem cross-sections of oak trees among 38 GSOB infestation localities in San Diego County are being used to determine the timing of GSOB attack and other contributing pests

**GSOB Early Warning System (EWS) Using Citizen Scientist Volunteers and Agency Personnel**

- Recruited and trained approximately 230 EWS volunteers to conduct oak tree health surveys and provide initial inspections of oak trees potentially infested with GSOB
- Established an EWS database to track actual and reported observations of GSOB
- EWS Smart Phone application developed to allow inspections to be conducted and reported directly to the server; Option is to record on paper form and enter data into the database online via the Internet
- Established a network of agency professionals in San Diego, Riverside, San Bernardino, Orange, Los Angeles, and Ventura Counties to conduct inspections of possible GSOB attack

**Grant Funding to Support GSOB Activities**

- Awarded a 2012 Western States Competitive Grant, extending GSOB outreach and EWS programs through 2014
- Awarded 2012 RREA Grant for oak restoration planning
- Submitted a pre-application for 2012 ANR Competitive Grant to develop Oak Mortality Management Plan
- Submitted a CA LCC pre-application for a 2012 grant to develop oak woodland management decision tools, including GSOB resistance, to aid in the development and demonstration of Oak Mortality Management Plan
- Sought and secured Forest Health funding from USDA FS State and Private Forestry through CAL FIRE to continue GSOB Coordinator position for an additional year

**Other Activities**

- Close coordination with the California Forest Pest Council

## APPENDIX D: FIELD INDENTIFICATION GUIDE FOR GSOB

# Goldspotted Oak Borer

## Field Identification Guide

**Figure 1. Adult goldspotted borer.** Photo by Stacy Blomquist, USDA Forest Service, Southern Research Station.

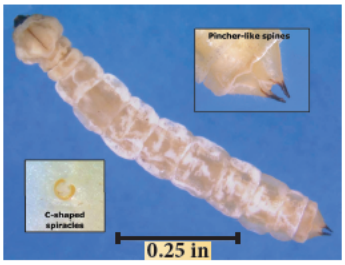



**Figure 2. GSOB larva with close up of spiracles and spines.** Photo by Stacy Blomquist, USDA Forest Service, Southern Research Station.

**Figure 3. Mature larva in hairpin configuration.** Photo by Tom W. Coleman.

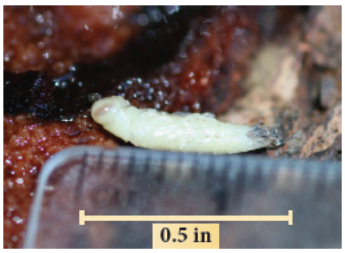



**Figure 4. Pupa in outer bark.** Photo by Tom W. Coleman.

The goldspotted oak borer (GSOB), *Agrilus auroguttatus* (Coleoptera: Buprestidae), is a flatheaded borer new to California that poses a significant threat to oak trees. The pest is native to southeastern Arizona, although a related species occurs in southern Mexico and northern Guatemala. GSOB was first collected and identified in California in 2004 in San Diego County but was not linked to extensive oak mortality until 2008. As of 2010, GSOB has killed an estimated 21,500 trees covering 1,893 square miles in San Diego County in forests, parks, and residential landscapes.

GSOB larvae feed beneath the bark of certain oaks near the interface of the phloem and xylem, the nutrient and water conducting tissues of plants. The larvae damage both of these tissues as well as the cambium, a unicellular layer between the phloem and xylem that is responsible for the radial growth of the tree. Trees die after several years of injury inflicted by multiple generations of the beetle. Currently there are no effective tools for protecting trees once infestation occurs.

### IDENTIFICATION

Capture of adult GSOB on sticky traps in infested areas of San Diego County and observations of immature life stages suggest that this pest completes one generation each year. Adults are about 0.4 inch long and 0.08 inch wide with a slender, bullet-shaped body (Figure 1) and are agile flyers. They are primarily black with an iridescent green sheen and have six gold-colored spots on their forewings, hence the common name.

Eggs are extremely small (0.01 inch), dull colored, and rarely observed on trees. They likely are laid singly or in clusters in bark cracks on the main stem and larger branches of oaks.

Larvae are white, legless, and about 0.8 inch long when mature (Figure 2). GSOB larvae can be distinguished from those of other wood boring beetles by C-shaped spiracles and two pincherlike spines on the end of their abdomen. Mature larvae can be found in a hairpin configuration in the outer bark (Figure 3) from early fall until early summer.

Pupae also are found in the outer bark from late spring to early summer; they resemble the adults in size and shape but are primarily white and soft bodied (Figure 4). When adult beetles emerge from the pupal cell in the bark, they make a diagnostic D-shaped emergence hole; see External Symptoms below. Adult GSOB feed on oak foliage and make notches along leaf margins (Figure 5), but tree mortality results from larval feeding. This pest is known to kill three species of native oaks in California; for more information, see the sidebar Which Oak Species Are Attacked? on Page 3.

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**Figure 5. Adult GSOB and chewing damage on leaf.** Photo by Tom W. Coleman.

**Figure 6. Thinning of coast live oak crown.** Photo by Tom W. Coleman.

**Figure 7. Thinning of California black oak crown.** Photo by Tom W. Coleman.

## TREE SURVEYS: WHAT TO LOOK FOR

When surveying forest, park, or landscape areas for GSOB, begin by examining older, mature trees and/or those trees exhibiting thinning and dieback of foliage in the crown. If GSOB injury is found on older trees, surveys should continue on smaller diameter trees in the same area. When searching for signs of GSOB, focus on the lower 8 feet of the main stem and directly around the root collar.

### External Symptoms

Symptoms of GSOB infestation can include premature twig dieback and thinning in the crown (Figures 6 and 7) that worsens progressively over several years. Other factors can cause similar tree decline, so it is important to confirm the presence of GSOB larvae in trees.

Larval feeding occurs primarily on the main stem (or trunk) and larger branches of mature oaks. Elevated levels of larval injury are indicated by black, wet staining or dark red bleeding on the bark (Figures 8, 9, and 10), resulting from a build-up of tree sap around patches of dead phloem. Bark staining varies greatly in size with dark patches ranging from less than 1 square inch to 0.5 square foot, and there can be multiple stained or bleeding areas on the stem.

When new adults emerge through the outer bark, their exit holes (Figure 11) are D-shaped and 0.15 inch wide. Exit holes often are found along the lower 6 feet of the main stem, at the very base of the tree, or adjacent to bark-stained areas. From fall to early summer, woodpeckers forage for larvae and pupae in the outer bark, exposing the brick-red phloem (in coast live oak) and signifying an infested tree (Figure 12). Woodpecker foraging often exposes the black larval galleries or pupal cells. Inner bark that has been exposed from woodpecker foraging darkens to black over time. Woodpecker activity, although high in certain areas, has been insufficient to control GSOB or slow its spread.

### Internal Symptoms

Beneath the bark, larval feeding galleries are found primarily in the inner bark and surface of the wood. To expose larval galleries, carefully shave

**Figures 8, 9, and 10. Bark staining and bleeding resulting from GSOB larval feeding.** Photos by Tom W. Coleman.

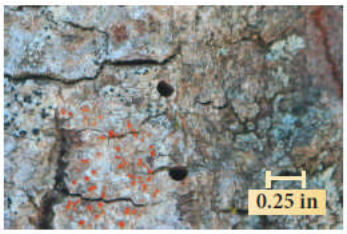


**Figure 11. D-shaped holes indicate locations where adult beetles have emerged.** Photo by Tom W. Coleman.

**Figure 12. Inner bark exposed to woodpecker foraging is first red but later darkens.** Photo by Tom W. Coleman.

**Figure 13. Removal of bark exposes the meandering larval galleries filled with dark frass.** Photo by Tom W. Coleman.

**Figure 14. Extensive feeding kills large areas of phloem leaving areas of dead tissue.** Photo by Tom W. Coleman.

a small area of bark down to the wood surface. Larval feeding occurs in a meandering pattern and has a black appearance when the bark is freshly removed (Figure 13). Larval galleries are tightly packed with dark-colored frass. Extensive larval feeding can kill large areas of the phloem, leaving areas of dead tissue often filled with tree sap (Figure 14). This feeding activity eventually girdles and kills trees.

## WHICH OAK SPECIES ARE ATTACKED?

Extensive research on the host range of GSOB has not been completed. However, in Southern California, GSOB is known to injure and kill three native species of oak: coast live oak, *Quercus agrifolia*; California black oak, *Q. kelloggii*; and canyon live oak, *Q. chrysolepis*. In extremely rare cases, GSOB also can injure Engelmann oak, *Q. engelmannii*, but injury has not been linked with significant tree mortality on this species.

**Coast live oak, *Q. agrifolia***

**California black oak, *Q. kelloggii***

**Canyon live oak, *Q. chrysolepis***

**Engelmann oak, *Q. engelmannii*, can be attacked but is not known to be killed.**

## MANAGEMENT

Preventing movement of infested wood (primarily firewood) to new areas is essential for slowing the spread of this exotic borer to other regions of the state. Wood from infested trees should be kept within several miles from its origin and *never* moved outside of the current area of GSOB establishment in San Diego County. Grinding wood to less than 1 inch particle size can eliminate wood borers in infested wood and is recommended where trees are being removed. Leaving wood on site for more than two years after the tree has died will reduce the risk of moving GSOB in cut wood. Double tarping freshly cut wood with clear plastic or bagging wood from May to October can trap emerging GSOB and reduce localized GSOB populations for homeowners. These trapped GSOB adults cannot disperse and feed, and ultimately they will die. Solarizing infested logs can reduce emergence rates and trap emerged beetles but cannot be relied on to kill all larvae in logs.

Information on using insecticides to manage GSOB is limited. Insecticide treatments for controlling wood borers are more effective for preventing infestation of healthy trees and are unlikely to control larvae in infested trees. Trees with moderate or severe injury from aggressive wood borers are difficult if not impossible to save with current management tools.

Preliminary lab experiments have shown that treatments with the contact insecticides carbaryl and bifenthrin can kill GSOB adults in lab feeding and walking assays. Foliage from trees treated with systemic insecticides have been less effective in controlling GSOB in these assays. Duration of efficacy for contact treatments, efficacy in the field, and the likelihood that these treatments can save trees is currently unknown. If used, insecticide treatments should be limited to protecting high-value trees that have not been significantly infested with GSOB. Timing is critical. Contact insecticides should be applied prior to GSOB adult activity, which begins in early to mid-May. Contact treatments should be applied to the main stem, large diameter branches, and as much of the foliage as possible to reduce numbers of GSOB adults and their egg laying. Trees should be re-treated every year until additional data is collected regarding the duration of efficacy. Carbaryl and bifenthrin can have significant negative impacts on natural enemies, bees, wildlife, and water quality. Research is continuing on effective insecticide treatments for GSOB.

Although woodpeckers are known to forage on goldspotted oak borer larvae, their feeding is not sufficient to significantly suppress populations. No other significant natural enemies of the pest are currently known in California, but research on biological control is continuing.

If you suspect goldspotted oak borer infestation in your oak trees, contact your county department of agriculture or UC Cooperative Extension office.

## TREE HEALTH RATING

A tree health rating for GSOB-infested trees has been developed for land managers and others wishing to evaluate trees; for more information, see the sidebar Health Rating for GSOB-Infested Trees. The rating is based on assessing four factors:

- The severity of crown thinning and dieback;
- The density of exit holes;
- The degree of bark staining; and
- The presence or absence of woodpecker foraging.

Trees with a crown rating greater than 3, an exit hole rating of 3, and a bark staining rating of 4 from GSOB injury likely will die in the next few years.

## HEALTH RATING FOR GSOB-INFESTED TREES

### CROWN RATING

1. Full, healthy crown (0% leaf loss). 2. Minor twig dieback and/or light thinning (10-25% leaf loss). 3. Moderate thinning and twig dieback (25-50% leaf loss). 4. Severe dieback to larger branches (>50% leaf loss). 5. Tree is dead.

### BARK STAIN RATING

1. One to five areas of staining present on lower stem (<8 feet). 2. Six to 10 stained areas. 3. Greater than 10 areas of staining on the lower stem. 4. Bark cracking evident on main stem.

### EXIT HOLE RATING

1. Can find at least one D-shaped exit hole on the main stem. 2. Can find a few exit holes (10-25) in clumps on the main stem. 3. Exit holes are scattered and abundant on the main stem (>25).

### WOODPECKER FORAGING (+/-) Present or absent

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This field guide is available online at http://www.ipm.ucdavis.edu/PDF/MISC/GSOB_field-identification-guide.pdf. Published Jan. 13, 2011.

For more information about pests and pest management, visit the University of California Statewide IPM Program Web site at www.ipm.ucdavis.edu.

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## APPENDIX E: BEST MANAGEMENT PRACTICES FOR PREVENTING THE SPREAD OF GSOB

# Best Management Practices (BMPs)

June 2012

for Preventing the Spread of Goldspotted Oak Borer (GSOB)
Through the Movement of Logs & Firewood

### OVERVIEW

Transporting GSOB-infested logs or firewood can introduce GSOB into un-infested areas. These BMPs were developed to help landowners and the firewood industry safely utilize wood from within a known infestation area. Documenting compliance with these BMPs may reduce liability against claims of knowingly spreading GSOB by moving or selling infested wood. Be aware that firewood consumers are being educated about the dangers of GSOB-infested wood and may inquire about the wood's origin and if BMPs were followed to ensure that it doesn't contain GSOB. Documentation that you followed these BMPs could be included along with the bill of sale/permit information required by California law (see California Penal Code Section 384.5) when transporting wood from its harvesting site and presented to retailers and/or the ultimate consumers.

### Why are BMPs Needed?

Wood from GSOB-killed trees can harbor living GSOB larvae under its bark. Pupation (transformation) of GSOB larvae into adult beetles can occur for well over a year after a tree dies. These adults may emerge from the bark any time during their flight season (May through October) after the tree has been dead for a year. Therefore, at a minimum, logs or firewood from GSOB-killed oak trees should not be moved out of an infested area until the wood has seasoned (dried out) for at least one full year plus a subsequent GSOB adult flight season.

*Left: GSOB larva preparing a pupation chamber near the outer bark.*
*Right: GSOB adult beetle that has nearly completed the pupation phase near outer bark.*

## WOOD SEASONING METHOD BMP

The table below will help determine the absolute minimum amount time required for wood from GSOB-killed oak trees to be seasoned sufficiently to be safely moved for processing or taken to market. A "two year" seasoning rule is the easier to apply, but for trees that must be moved before a full two years:

- GSOB-infested trees died or were cut down in the spring – don't move until November 1st of the next calendar year.
- GSOB-infested trees died or were cut down in the summer – don't move until November 1st of the next calendar year.
- GSOB-infested trees died or were cut down in the fall – don't move until November 1st of the next calendar year.
- GSOB-infested trees died or were cut down in the winter – don't move until November 1st of the next calendar year.

**When in doubt, season the wood for a full two years.**

Basing a determination of when a tree died solely upon when its crown (branches and leaves) turned brown is not always reliable. The cambium (living tissue between the bark and sapwood) may live a period of time after the leaves brown, especially in the main trunk near the base of the tree. Starting the "one year" clock after a tree is cut down is more certain than using a dead crown as the indicator. Trees obviously long dead (they have fallen over, or they are standing but totally devoid of leaves and/or their bark is falling off) don't need to be held to such a strict standard. However, you are encouraged to err on the side of caution in determining when the tree died.

Other considerations for seasoning firewood:

- It is important to keep a record of when trees die by keeping notes or tracking it on a calendar. Marking trees that died at the same time using different colors of flagging or paint can help prevent confusion with trees that died in different years.
- Don't mix wood from trees that died in different seasons or different years, otherwise you'll need to hold all the wood in the entire pile until the most recently killed trees have completed their seasoning period.
- Splitting the wood at the time the tree is cut down may aid the drying process.

## CONTAINMENT STRATEGY METHOD

If wood can't be moved away from uninfested trees, consider covering the wood piles with thick mil, clear, plastic tarp or metal window screen (with a mesh small enough to stop mosquitoes) to trap emerging GSOB until they die from starvation. Note that covering cut oak wood with clear plastic does not kill developing GSOB beetles in the bark. Covering very large piles of wood with plastic or screen may be impractical. Either method will be completely ineffective if holes or cracks open up in the covering or the covering is pulled off to access the wood during the May-October flight season.

**Containment strategy considerations:**

- Tarped or screened piles should be located in full sun to speed up the drying process.
- Adult emergence can be contained if you maintain a tight seal and the wood is left covered from May through October. Use UV resistant plastic, or double layer plastic to prevent tearing and avoid pulling it tight over sharp edges. Seal the edge of the plastic with dirt for an air tight seal and for resistance to flapping in winds.
- Metal window screen can be more durable than plastic and potentially re-used if handled carefully. However, it is more difficult to work with than plastic and more expensive. The air flow allowed by screening helps the wood to dry out faster without mold forming. Screen is normally sold in narrow widths and may require creating the enclosure using multiple seams; make sure that all seams are well secured.

*Containment Strategy Photos (starting upper left moving clockwise) 1. Split oak wood in an aluminum window screen envelope. 2. Oak rounds in window screen envelope. 3. Oak wood pile under heavy mil clear plastic and dirt around the edge for an airtight, escape-proof seal. 4. Tarp has been blown off or removed during the flight season making it totally ineffective.*

## BMP Options to the Seasoning Method for Making GSOB-Infested Oak Wood Safe to Move

### Debarking Firewood Option:

Oak firewood that is free of bark will not transport GSOB. However, debarking can be very difficult to accomplish on "green" wood from recently killed trees; bark tends to come off the wood more easily over time as it dries out. If you choose the debarking option, make sure that the bark is stripped off all the way to the sapwood and not just the outer layer of bark is removed. Season, destroy or carefully dispose of the removed bark because it can still harbor borer larvae. Bark can be enclosed within plastic tarp, plastic bags or fine mesh window screen to allow it to season for two years. Make sure there are no seams or holes that would allow the beetles to escape.

*Debarked coast live oak firewood*

### Heat Treatment:

Heat treatment of infested wood material at 160°F for a minimum of 75 minutes in an automated wood-drying kiln has been shown to eliminate many insects and diseases from firewood. These kilns have the capability of measuring and recording temperature time and duration well inside a pile of wood. However, no scientific study has been conducted to confirm that this temperature and time standard will kill GSOB.

*Commercial-sized tub grinders may be required to handle large pieces of oak.*

### Grinding Option:

Grinding to a 3" minus standard in a tub grinder will kill GSOB in infested wood. Many standard chippers used by the landscaping or arborist industry may be of insufficient size and capacity to safely handle large diameter rounds of oak wood; a tub grinder or whole-tree chipper is likely required. In sufficient quantity, the chips resulting from the grinding may have market value as cogeneration fuel or other commercial products such as soil amendments. Ground wood chips can be spread back over the property as mulch or ground cover, but please check with Cal Fire or your local fire agency to ensure you are not adding to the fire hazard by choosing inappropriate locations or depths.

**Visit www.GSOB.org for more information.**

University of California

The GSOB Steering Committee member agencies are equal opportunity employers.