TREE NOTES

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

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Goldspotted Oak Borer

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Introduction/Summary

The goldspotted oak borer (GSOB), *Agrilus auroguttatus* Schaeffer, (Coleoptera: Buprestidae) is a flatheaded wood borer that infests and kills red oak species (Fagaceae: *Quercus*) in California. GSOB was first detected in 2004 in San Diego County California by the California Department of Food and Agriculture during an exotic woodborer survey, but was not linked to the oak mortality until 2008 in the San Diego area. GSOB prefer large diameter coast live oak, *Quercus agrifolia* Née and California black oak, *Q. kelloggii* Newberry (greater than 18 and 20 inches DBH respectively). Canyon live oak, *Q. chrysolepis* Liebm. have been attacked and killed by the goldspotted oak borer but at low levels. GSOB were discovered in isolated infestations in Riverside, Orange, Los Angeles and San Bernardino Counties in 2012, 2014, 2015 and 2019 respectively. The movement of infested firewood was most likely responsible for the new infestations in southern California and will continue to be a mechanism for long-range dispersal.

Flatheaded borers are a diverse and important family of beetles that commonly attack trees and woody plants. A few species are known to attack and kill apparently healthy trees, but most attack weakened, dead or recently felled trees (Furniss and Carolin 1977). Larvae commonly bore under the bark into the cambium region of the trunk, branches and roots, often penetrating the wood where they feed and sometimes mine extensively (Borror and White 1970, Furniss and Carolin 1977). Woodborer adults frequently emerge in the spring and summer, then feed and lay eggs in crevices of the bark (Furniss and Carolin 1977). GSOB larvae have been found attacking stems and branches larger than 8 inches in diameter. Larval feeding in the phloem and xylem outer surface are the damaging life stage. Extensive mining by larvae disrupt flow of water and nutrients in the tree. Signs and symptoms of injury include twig dieback, crown thinning, bark staining, and distinctive adult exit holes and eventual tree death. Integrated pest management for prevention and control of GSOB may include topical and systemic insecticides, cultural control methods and not moving infested firewood.

Life Cycle and Identification of the Goldspotted Oak Borer

Goldspotted oak borer adults are about 0.39 inches in length and 0.07 inches wide, Figure 1 (Coleman and Seybold 2008). Adults are dark black to dark green in color, compact and bullet-shaped, with three prominent golden yellow spots located on each forewing. Adults can live for up to several months in the laboratory, but longevity has not been recorded in the field and is likely shorter in duration. Adults emerge from May to September, with June and July being peak emergence, Table 1A. Adults feed on oak foliage for survival and

females require 10 days of feeding to become sexually mature. Mating likely takes place in the crown or on the bark surface and females can lay approximately 200-500 eggs, singly or in small clusters in crack and fissures on the bark surface of the main stem or larger branches (Coleman et al 2015, Furniss and Carolin 1977). Eggs are small, tan in color, approximately 0.01 inches wide and extremely difficult to find, Figure 2. Eggs are laid from June to October and develop in approximately 12 days, Table 1A. First instar larvae bore through the bark into the phloem (Coleman et al, 2015).

Figure 1: Goldspotted oak borer adult

Photo by Tom Coleman, USDA Forest Service

Figure 2: Goldspotted oak borer eggs.

Photo by UCANR, Pub 74163, January 2013

GSOB likely have four complete larval stages or instars. Mature larvae are about approximately 0.8 inches in length and 0.1 inches wide. Larvae are white and legless with an elongated slender shape with two pincher-like spines located at the tip of the abdomen (Coleman and Seybold 2008). Larvae also have C-shaped spiracles, along with the other characteristics that can be used to identify *Agrilus* larvae, Figure 3.

Table 1: Goldspotted oak borer approximate timing of life cycle in southern California (Coleman et al 2017). (A) Goldspotted oak borer life cycle for southern California; (B) Optimal trapping period; (C & D) Timing for insecticide applications; (E) Mechanical grinding effectiveness and (F) tarping of infested oak wood.

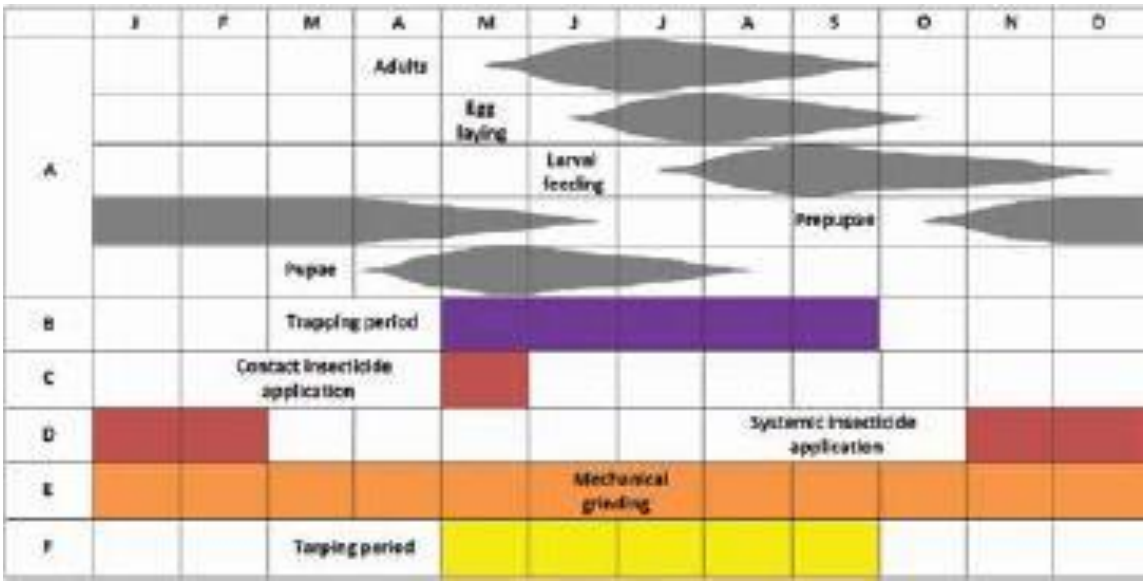


Figure 3: Goldspotted oak borer mature larvae.

Photo by Tom Coleman, USDA Forest Service

Figure 4: Mature larvae in a hairpin formation.

Photo by Mark Hoddle, University of California - Riverside

In southern California, larvae can be found feeding from July to mid-December in the phloem and outer xylem surface, Table 1A. Mature larvae migrate to the outer phloem just beneath the bark surface where they create a pupal cell. Here they turn into a hairpin formation to form a prepupa, Figure 4. Prepupa and pupae can be found beginning late October to mid-August, Table 1A.

Sign of Infestation

Staining **-** GSOB infestation can result in extensive bark staining along the main stem and large branches. It is not associated with staining at cavities along the stem, at branch junctures or mechanically and structurally wounded areas. Staining appears as black regions or red blistering with sap oozing from under the bark (Coleman et al 2017, Coleman and Seybold 2008). When the outer bark is removed from stained regions, large amounts of accumulated water can drain from areas of dead cambium. Stained areas can vary from dime-size 0.23 inches to 8 inches in length, and are common from the root collar of the stem to larger branches, Figure 5.

Larval galleries **–** Galleries are dark in color, packed with frass (black in color) and are about 0.16 inches wide. They have a meandering pattern and are sometimes vertical in orientation, Figure 6. Extensive larval feeding can result in strip or patch killed areas of the cambium. (Coleman, and Seybold 2008).

Feeding by Woodpeckers– Acorn woodpeckers, *Melanerpes formicivorus* Swainson, forage for larvae, prepupae and pupae just beneath the bark in the out phloem. Foraging frequently occurs in the fall to early summer when larval densities are highest in the tree stem. Woodpeckers chip away the outer bark and expose the red phloem in coast live oaks.

Exit holes – Goldspotted oak borer is the only subcortical insect that constructs D-shaped exit holes on the main stem and larger branches (greater than 8 inches in diameter) of oaks in California (Coleman et al 2017). Emergence holes are about 0.15 inches in width and can appear before any other injury signs and symptoms are observed, Figure 7 (Coleman and Seybold 2008). These are easily overlooked at low densities, but as GSOB density increases exit holes become very noticeable.

Figure 5: Bark staining and exposed dead cambium (base of tree) on coast live oak.

Photo by Tom Coleman, USDA Forest Service

Figure 6: Goldspotted oak borer larval galleries

Photo by Kim Corella, CAL FIRE

Figure 7: GSOB D-shape exit hole

Photo by Kim Corella, CAL FIRE

Crown thinning **-** GSOB infested trees often progress through several stages of crown thinning, beginning with premature leaf drop, twig and tip dieback and eventual branch dieback. Crown thinning may only be evident after several years of infestation. Crown color of coast live oak trees infested by GSOB ranges from healthy dark green to grayish green (severely injured). Injured trees can flush new foliage in the spring when attacked. California black oak leaves will turn a tan brown and may drop prior to leaf drop in the fall, Figures 8A and 8B.

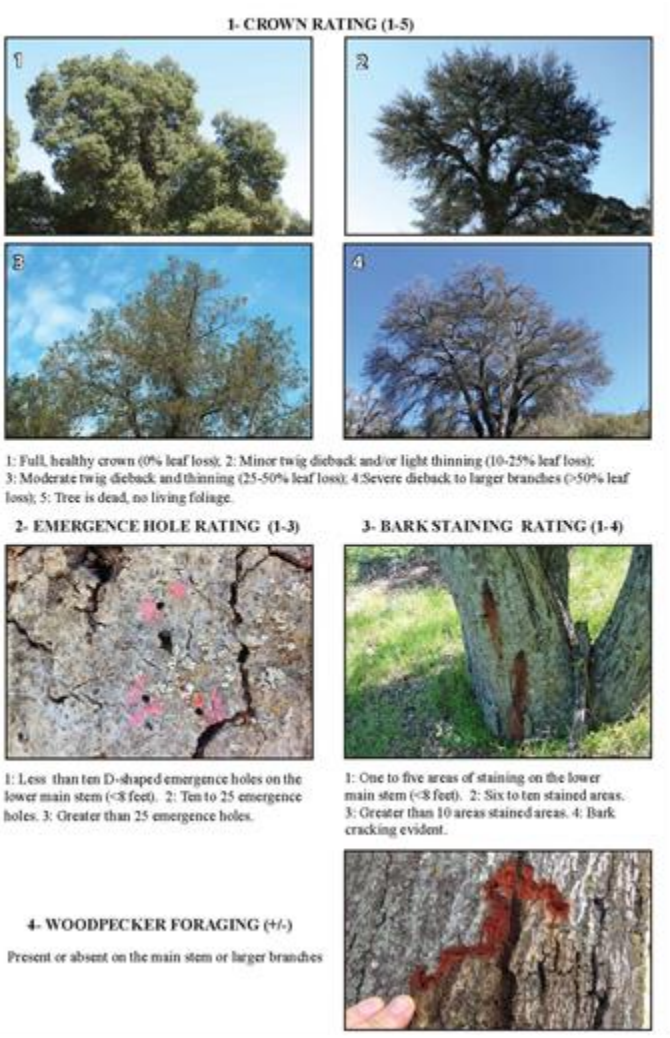
Figures 8: (A) Crown dieback of coast live oak (left) and (B) California black oak (right).

Right photo by: Tom Coleman, USDA Forest Service
Left photo by: Kim Corella, CAL FIRE

Management

Monitoring by ground surveys are the most effective method for detecting GSOB infestation and severity. Large-diameter red oaks are the preferred host and oaks located along forest edges (less than 150 feet from forest stand edge). A system to rank tree health and guide management decisions has been developed. This guide includes the following tree signs and symptoms caused by GSOB; degree of crown thinning; density of D-shaped emergence holes and bark staining and presence/absence of foraging by woodpeckers, Figure 9 (Coleman et al 2017).

Figure 9: Health rating system to determine the degree of goldspotted oak borer injury and assist with management decisions (Coleman et al 2017).



Insecticide Treatments – A topical insecticide applied by a certified pesticide applicator to the main stem and to the larger branches (greater than 8 inches in diameter) is the best option for preventing GSOB injury to high-value oaks. Treating the entire crown is not necessary and reduces impacts to non-target arthropods. Topical spray applications should occur in May but can occur earlier, Table 1C, prior to adult flight period in southern California and should be re-applied annually.

Topical and systemic insecticides should only be applied after evidence of GSOB has been found in the immediate area (less than 1/2 mile). These insecticides should not be applied to GSOB-infested oaks with a crown injury rating of "3" or greater and an emergence hole rating of "3" or greater because of the high level of injury already impacting the tree. Insecticide treatments to benefit trees with these high ratings will have very limited benefit in preventing tree death. Trees with greater than 120 GSOB emergence holes on the lower trunk (less than 8 feet) will likely die within the next few years (Coleman et al, 2017). Preventive contact sprays with carbamate (Carbaryl) or pyrethroid (bifenthrin and permethrin) insecticides have killed GSOB adults in laboratory assays of treated foliage one month and one year post -application. Preventive contact sprays on tree boles reduced mean days lived of GSOB adults compared to untreated trees (Coleman et al 2016).

Systemic insecticides applied as a trunk injection or basal spray may kill larvae feeding in the cambium area and adults feeding on foliage. In the laboratory setting, the systemic insecticides of neonicotinoids (imidacloprid

or emamectin benzoate) were effective at killing GSOB adults when fed leaves from injected coast live oak and California black oak leaves 3-5 months later. In the field, treated trees had reductions in annual increases in emergence holes 1.5 - 2.5 years later compared to untreated trees. Studies to evaluate the protection of systemically treated trees from GSOB will continue (Chen et al 2015). Systemic treatments applied as trunk injections to oaks should be applied from November to February when the trees are actively taking up water and nutrients to allow for the translocation of the active ingredient into the vascular system. Systemic injections need to be repeated every two years in California.

Basal sprays of the systemic insecticide dinotefuran to uninfested coast live oak and California black oak resulted in a high level of active ingredient in the foliage when applied in May just prior to adult flight. Residues of dinotefuran decline drastically 5 months post-application, so this systemic insecticide should be re-applied to trees every year to coincide with peak flight period (Coleman et al 2017).

For high value sites and individual trees, a combination of contact and systemic insecticides may provide the most effective protection. However, this combined approach has not been researched sufficiently to support this management system.

Mechanical treatments options

Grinding – Grinding infested logs and large branches in an industrial tub grinder to a 3-inch- "minus" (or smaller) industry standard is effective for killing GSOB populations from infested wood. Treatments can be applied year-round to kill any of the life stages, Table 1E.

Aluminum Screening – Chipping infested wood with a standard chipper is difficult due to the size and density of oak stems. The more economical and practical method is to screen the infested wood. Stacks of infested firewood can be enclosed in aluminum metal screening and placed in a sunny location from the first of May to September, Table 1F. The edges of the screen must be buried in the soil or secured tightly and checked routinely for integrity. The enclosed sheeting will prevent the GSOB adults from escaping and they will eventually die. It is essential to check the integrity of the metal screening periodically for any holes that may have formed to prevent any adults from escaping, Figures 10A and 10B. Plastic tarp is not recommended for containment as it can tear, degrade in the sun, cause the wood to become moldy and can be chewed through by GSOB adults. Aluminum window screen is very durable, prevents mold while allowing the wood to dry and is reusable. The key to successful containment is to ensure there are no beetle-sized gaps or openings.

Figures 10: (A) Infested GSOB firewood or rounds covered by aluminum metal screening for containment (B) GSOB adult escaping through poorly sealed seam in screen enclosure.

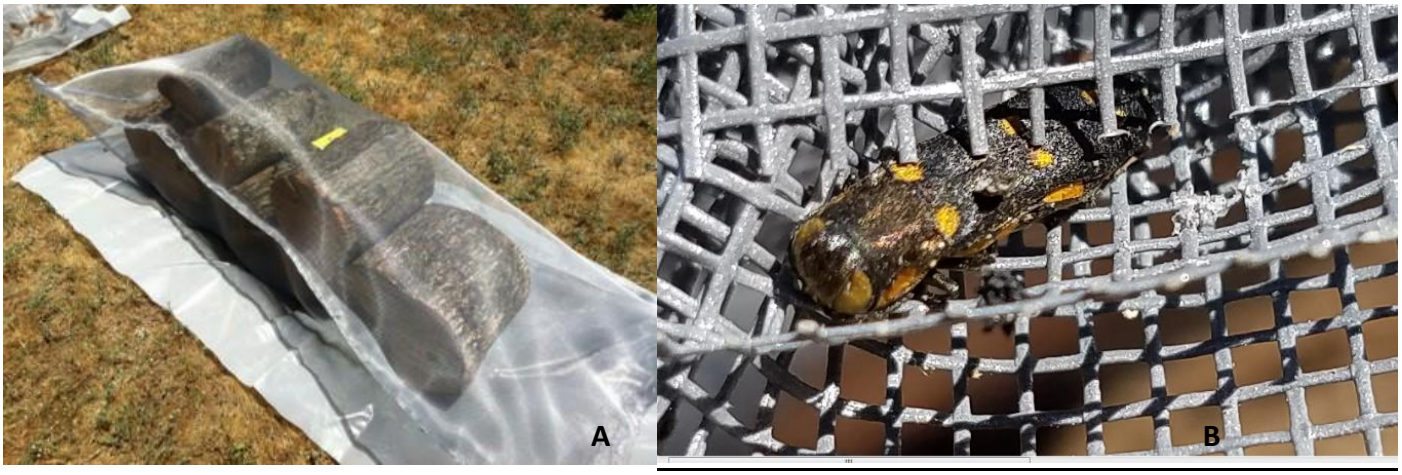


Photo by Kevin Turner, CAL FIRE

Debarking – This option can be very difficult to accomplish but debarking will eliminate any stage of the GSOB lifecycle from the wood and the wood is safe to use as firewood. All bark must be stripped all the way to the sapwood, Figures 11A and 11b. The removed bark must be disposed of carefully as it could contain various GSOB larval life stages. Removed bark must be screened, chipped or burned to kill all life stages.

Figure 11: (A) Debarked piece of GSOB-infested oak wood (B) Removing cambium and bark with chainsaw.

Photo by Kevin Turner, CAL FIRE

Cultural Control

Not moving GSOB infested wood into an uninfested or out of an infested area is the most effective method for reducing long distance spread of this insect. Firewood is easily moved and is one of the primary ways insects and diseases are transported. Limiting firewood movement to only be transported locally and within the same ecosystem is the best management approach for limiting the spread of GSOB and other invasive pests. For more information on the impact of firewood movement and to reduce the spread of invasive insects and diseases visit, www.firewood.ca.gov.

Assistance

If you are unsure if you have found signs or symptoms of GSOB, please visit the website www.gsob.org where you can report a suspected GSOB tree. Please contact a pest control advisor, your local university cooperative extension office, local agricultural commissioner's office or local CAL FIRE or USFS forest entomologist, pathologist or forester for more information.

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This Tree Note is a revision of the original:
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