

Influence of the Invasive Goldspotted Oak Borer on Fuel Loading in Southern California¹

Tom W. Coleman²

Abstract

The exotic goldspotted oak borer (GSOB), *Agrilus auroguttatus* (Coleoptera: Buprestidae), continues to cause elevated oak mortality in southern California. Initial GSOB research was directed at developing an integrated pest management program. However, little research has examined the secondary impacts associated with this invasive pest. My primary objective was to compare the fuel loading in severely GSOB-infested woodlands (>10 years of oak mortality) to uninfested woodlands in southern California. Forest stand characteristics, canopy fuels, understory fuels, and surface fuels were recorded from 0.25 ha plots, belt transects, and Brown's transects, respectively. Following preliminary analyses, 77 percent of oaks were infested with GSOB and 41 percent of the oaks were killed by GSOB in infested plots. Dead oaks were slowly decaying in severely infested woodlands, but greater increases in surface fuels (1-, 10-, 100-, and 1000-hour fuels) were recorded, but these differences were not statistically significant. Oak regeneration was greater in GSOB infested stands than uninfested stands, but highly variable in infested plots. An increase in understory vegetation and a greater abundance of surface fuels can lead to an increase in the rate of fire spread, flame lengths, and fire line intensities.

Key words: Brown's transects, exotic wood borer, fuel structure, oak mortality

Introduction

In 2008, the exotic goldspotted oak borer (GSOB), *Agrilus auroguttatus* (Coleoptera: Buprestidae), was linked to elevated oak mortality in southern California (Coleman and Seybold 2008). The wood-boring beetle prefers to attack and kill large diameter coast live oak (*Quercus agrifolia*), and California black oak (*Q. kelloggii*), in California (Coleman and others 2012b). The movement of infested firewood likely led to the spread of this invasive insect from its native region of southeastern Arizona to southern California and from San Diego County into the mountain community of Idyllwild (Riverside, California) and the city of Orange (Orange County, California) (Coleman and Seybold 2011, Coleman and others 2012a). Tree injury and mortality associated with GSOB has persisted for greater than a decade in eastern San Diego County. Annual aerial surveys estimate GSOB has killed >27,000 oaks in this part of the county (USDA FHM 2014). Tree mortality spans all landownerships, impacting county, federal, private, state, and tribal lands. The GSOB infestation was recently detected killing California black oak on the Palomar Ranger District, Cleveland National Forest (CNF).

Since 2008, GSOB research was directed at determining its biology, developing monitoring techniques, assessing host susceptibility and responses, assessing insecticide and cultural management options, surveying for natural enemies, and disseminating education and awareness (Coleman and others 2011, 2014; Haavik and

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² USDA Forest Service, Forest Health Protection, 602 S. Tippecanoe Ave., San Bernardino, CA 92408. (twcoleman@fs.fed.us).

others 2013, 2014; Jones and others 2013; Lopez and Hoddle 2013, 2014). However, little research has examined the secondary effects associated with this invasive pest, including changes to the fuel structure in impacted stands. The influence of invasive insect species, including the emerald ash borer (*Agilus planipennis*), European woodwasp (*Sirex noctilio*), and Asian longhorned beetle (*Anoplophora glabripennis*), on changes to the fuel structure and influence on wildfire behavior has been largely overlooked in the United States, which might be due to location of infestations in urban areas, limited distributions, and presence of invasive species in ecosystems not frequently disturbed by wildfire. However, the influence of *Phytophthora ramorum*, the causal agent of sudden oak death, on fuel structure was assessed in coastal oak woodlands of northern California (Valachovic and others 2011), offering a valuable comparison of the impact exotic species have on wildfire behavior.

Methods

The main objective of this study was to compare the changes in fuel structure in severely GSOB-infested coast live oak woodlands (>10 years of oak mortality) to uninfested coast live oak stands in southern California. Infested GSOB sites were surveyed on the Descanso Ranger District, CNF in San Diego County. Uninfested stands were surveyed on the Palomar and Trabuco Ranger Districts, CNF in San Diego and Riverside Counties, respectively. From 2013 to 2014, the forest composition and fuel loads were recorded from a total of nine coast live oak stands (four infested and five uninfested).

Forest stand characteristics (for example, tree and oak diameter at breast height (1.4 m, DBH), basal area (m²/ha) and stems/ha for trees (>1.4 m tall), percent GSOB infestation, percent oak mortality with and without GSOB injury, and GSOB crown injury ranking (1-5)) were recorded from 50 x 50 m plots. Canopy fuels (for example, tree height (m), base crown height (m), percent canopy cover, decay class of dead oaks (rank 1-5)) were recorded from three 6 m x 50 m belt transects. A hypsometer was used to determine tree and base crown height and a densitometer was used to determine percent canopy cover. Tree injury associated with GSOB was determined by the presence of D-shaped emergence holes along the main stem and crown injury rankings followed the health system developed by Hishinuma and others (2011) and Coleman and others (2011). Understory fuels (for example, count of tree species regeneration (<1.4 m) and height (m)) and surface fuels (for example, 1-, 10-, 100-, and 1000-hour fuels, slash depth (cm), percent ground cover (leaf litter, grass, exposed soil, wood cover, rock, moss, tall shrub, and low shrub cover), leaf litter depth (cm), and duff fuel depth (cm)) were recorded from 10 Brown's transects. Additional detail about the sampling methods can be found in Brown (1974), Simard and others (2011), and Donato and others (2013).

A general linear model was used to detect significant differences in forest stand characteristics, canopy fuels, surface fuels, and understory fuels between the GSOB-infested and uninfested stands (PROC GLM). Statistical significance was defined as $P \leq 0.05$ using SAS 9.2 (SAS Institute, Cary, NC 2008). Assumptions of normality were checked for all data using the Shapiro-Wilk test (PROC UNIVARIATE) and heterogeneity of variances was checked by comparing residuals (PROC UNIVARIATE).

Results

Following preliminary analyses, 77 percent of oaks were infested with GSOB and 41 percent of the oaks were killed by GSOB in infested plots. Crown injury rankings from GSOB was significantly greater in infested stands than uninfested stands ($F_{1,8} = 11.81$, $P = 0.01$). Mean crown injury ranking was $2.33 (\pm 0.86)$ (mean \pm s.e.) in infested stands and (1.21 ± 0.19) in uninfested stands. No statistically significant differences were detected for mean stand diameter at breast height (DBH), mean coast live oak DBH, stand basal area (m^2/ha), and stem density (ha) between infested and uninfested coast live oak stands. Canopy fuels, including tree height (m), base crown height (m), and percent canopy cover, were not statistically different between the two stand types.

The decay of dead coast live oaks was greater in infested stands than uninfested stands following the initial assessments ($F_{1,8} = 50.33$, $P = 0.0002$). The mean decay rate of the dead oaks was $1.97 (\pm 0.36)$ and $1 (\pm 0)$ for uninfested stands, suggesting many dead oaks show minimal decay (only loss of smaller twigs) in infested stands. Coast live oak regeneration was greater ($100 (\pm 122)$) in GSOB infested stands than uninfested stands ($17 (\pm 8.10)$), but highly variable in the infested sites.

Surface fuels (1-, 10-, 100-, and 1000-hour fuels) were greater in infested stands than in uninfested stands, but these differences were not statistically significant. Mean slash depth (m), leaf litter depth (cm), and duff litter depth (cm) did not differ between the two stand types. Leaf litter depth was greater in the uninfested stands than the infested stands, but this difference was also not statistically significant. Percent leaf litter was the highest ground cover surveyed across the two stand types. The second and third highest ground cover type measured were grass and soil cover, respectively. These three cover types did not differ between the two stand types. Grass was the tallest (cm) understory ground cover in both infested ($21.7 (\pm 10.1)$) and uninfested ($20.8 (\pm 8.15)$) stands, but these differences were not statistically significant.

Discussion

Preliminary data show high levels of injury and mortality from GSOB in infested stands. Coleman and others (2012) reported similar rates of tree injury and mortality associated with GSOB at the center of the outbreak. Several fuel measurements from the canopy, understory, and surface were highly variable between the two stand types, reducing statistical significance. As additional stands are surveyed for this study, the high levels of variability among these fuel measurements will likely be reduced between the two stand types and also provide greater statistical power for the analyses.

The decay of dead oaks in GSOB-infested stands was greater than uninfested stands. However, these trees showed low rates of decay with most dead oaks still standing in the canopy and possessing many large branches. The slow rates of decay may be attributed to recent tree mortality from GSOB (<10 years) and the dry Mediterranean climate of southern California. Similar rates of decay for dead oaks were recorded in stands impacted by *P. ramorum* along the central coast of California (Valachovic and others 2011) despite the formation of large cankers on the main stem of oaks and secondary attack from ambrosia beetles. Extensive attack from ambrosia beetles (Coleoptera: Scolytidae) along the main stem, which can lead to stem failure, is not commonly observed in the GSOB system. Oak mortality will continue in these woodlands from this invasive wood borer, leading to continuous changes in the fuel

loading. This is in contrast to the cyclical outbreaks of bark beetles and other native insects that typically have short bouts (2 to 3 years) of tree mortality. Recent studies assessing changes in fuel loading in the western United States have focused on bark beetle-caused tree mortality (see Donato and others 2013, Simard and others 2011), but the influence of exotic insects on fuel loading is still largely underrepresented. Multiple fuel reduction treatments will likely be necessary to reduce the increase in surface fuels associated with GSOB in southern California. A greater abundance of surface fuels can lead to an increase in the rate of fire spread, flame lengths, and fire line intensities. However, fuel managers in the region were more concerned with an increase and the release of understory vegetation that may carry wildfire from the forest floor into the canopy. Currently, these data do not show an increase in abundance of woody plant species in the understory that may increase the threat of a wildfire crowning. These data provide an initial assessment of the changes in fuel loading in this area and long-term changes to plant community may be evident as plots are resampled in the future.

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