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Soapberry Borer, *Agrilus prionurus* (Coleoptera: Buprestidae): An Exotic Pest Threatens Western Soapberry in Texas

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Abstract - *Sapindus saponaria* var. *drummondii* (Western Soapberry) is a small- to medium-sized tree native to the western Gulf Region and southwestern US and is valued in urban and rural landscapes. Recently in the United States, it has become host to an invasive insect introduced from Mexico. *Agrilus prionurus* (Coleoptera: Buprestidae) (Soapberry Borer) was first reported in Travis County, TX, in 2003 and has been detected in 51 additional counties as of December 2013. As its populations expand rapidly in Texas, this invasive pest is killing Soapberry trees >6 cm in diameter. Additionally, it may eventually threaten Western Soapberry populations throughout the tree's range. Infestations of Soapberry Borer are similar to those of *A. planipennis* (Emerald Ash Borer), a destructive invasive pest of *Fraxinus* spp. (ash) but not yet found in Texas. Signs of Soapberry Borer infestation include large bark flakes that accumulate at the base of infested trees, galleries between the bark and sapwood, trees that die back from the top, and excessive epicormic sprouts on the lower trunk. Western Soapberry appears to be the Soapberry Borer's sole host in Texas, and trees of this species exhibit little resistance to this introduced pest. Preliminary studies indicate that Soapberry Borer adults emerge and fly from late May to August and that this species has no more than one generation per year in Texas. Preventative and therapeutic treatments with the systemic insecticide emamectin benzoate are showing promise as a means to protect valuable Soapberry trees in rural and urban landscapes.

Introduction

Sapindus saponaria var. *drummondii* (Hook. & Arn.) L. Benson (Western Soapberry) is a small- to medium-sized deciduous tree, 7.7–15.4 m tall (Dirr 1990, Little 1950, Phillips and Gibbs 1953). Previously classified as *Sapindus drummondii* Hook. & Arn., Western Soapberry is known by other common names, including Wild China-tree, Soapberry, Indian Soap-plant, Cherrioni, and Jaboncillo (Little 1950, Tirmenstein 1990). Leaves and fruit (Fig. 1) resemble those of the invasive *Melia azedarach* L. (Chinaberry). Both tree species have compound leaves and round fruits that persist from summer through the winter, but soapberry leaves are not double-compound and the leaflets do not have serrated (toothed) margins, as does Chinaberry.

Western Soapberry grows on clay soils and on dry limestone uplands from southeastern Missouri and Louisiana, westward through Kansas, Oklahoma, and Texas to southern Colorado, New Mexico, southern Arizona, and northern Mexico (Fig. 2; Read and Zasada 2011). The soapberry family comprises nearly 2000 species, which are primarily tropical.

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Figure 1. *Sapindus saponaria* var. *drummondii* (Western Soapberry) trees can be distinguished from *Melia azerdarach* (Chinaberry) trees by the singly pinnate-compound leaves, off-set midveins, and lack of serration on the individual leaflets.

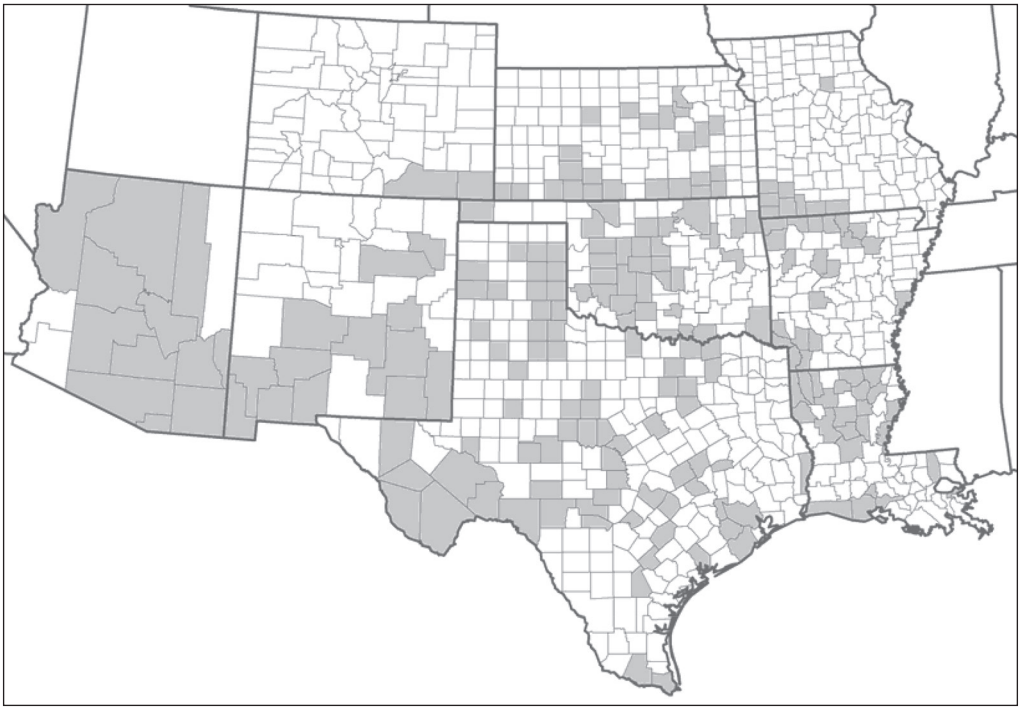

Figure 2. Counties with Western Soapberry in the US (shaded), based on USDA Natural Resource Conservation Service records [REFERENCE?].

Western Soapberry is planted for its environmental and wildlife value and, to a small extent, for shelterbelts in the southern plains (Tirmenstein 1990). It is valued for its fruits, colorful fall foliage, and utility as a landscape tree in Texas and other southwestern states, and is also a useful shade and ornamental tree in dry, windy, landscape sites (Khatamian and Abuelgasim 1986). Western Soapberry is a common native tree found in rural and urban landscapes, particularly in western and central counties in Texas, and it is used as an indicator species for riparian habitats in parts of the southwestern United States (Tirmenstein 1990). The small, white flowers, borne in rather large clusters of terminal or axillary panicles, open from May to July (Read 1974). The glossy, yellow fruits and long, pinnate leaves make it especially attractive (Fig. 1). The fruits ripen September or October and persist on the tree until late winter or spring (Engstrom and Stoeckeler 1941). The fruits contain about 37% saponin and in the past were used locally to make soap (Tirmenstein 1990). The heavy, strong, close-grained wood splits into thin strips that have been used in basketry (Read 1974). Western Soapberry also serves as roosts for *Meleagris gallopavo* L. (Wild Turkey). Trees in the genus *Sapindus* are the larval food-plants of the Soapberry Hairstreak Butterfly, *Phaeostrymon alcestis* (W.H. Edwards) (Lepidoptera: Lycaenidae; Robbins 2004). The limited literature concerning the native pests of Western Soapberry indicates that the species was largely free of disease and insect pests in the United States until the arrival of the invasive wood-boring beetle *Agrilus prionurus* Chevrolat (Soapberry Borer).

This insect, a native of northern Mexico, was first reported in eastern Travis County, TX, in 2003 infesting and killing Western Soapberry (Wellso and Jackman 2006). Reports by landowners and arborists indicate that the insect had probably been infesting Soapberry trees in Texas for several years prior to its identification. Infested trees were observed in Travis and McLennan counties as early as 1998 (J. Pulley, Tree Clinic, Austin, TX, pers. comm.). As of January 2009, when this study began, Soapberry Borer infestations had been reported in 18 counties (Bastrop, Brazoria, Brazos, Collin, Dallas, Denton, Fort Bend, Harris, Hays, Mason, Matagorda, McLennan, Rockwall, San Patricio, Tarrant, Travis, Victoria, and Webb) including sites near or within the cities of Fort Worth, Dallas, Waco, College Station, Austin, Houston, and Corpus Christi (Fig. 2; R. Billings, pers. observ.; Wellso and Jackman 2006) and communications from affected landowners.

Soapberry borer is a non-native wood-boring beetle in the family Buprestidae that aggressively attacks and kills Western Soapberry, its only known host. The adult, 8–12 mm long, has a shiny, black to slightly green body distinctively marked with four white dots on the elytra (Fig. 3a). The adult female lays eggs on the bark of live Western Soapberry trees, and the white larvae develop beneath the bark in winding galleries (Fig. 4). The larva may be 3 cm or more in length at maturity. After feeding beneath the bark, the larvae bore into the wood to complete development and to pupate. New adults emerge through the bark, leaving D-shaped exit holes characteristic of the family Buprestidae.

Signs of Soapberry Borer infestations are similar to those of the destructive *A. planipennis* Fairmare (Emerald Ash Borer), a close relative not yet found in

Texas (Wilson and Rebek 2005). The first signs of Soapberry Borer infestation that landowners usually notice are large chips of bark that flake off the bole (Fig. 5a) and accumulate at the base of the infested tree, a result of woodpeckers feeding on the larvae. Infested trees eventually die back from the top, often producing abundant epicormic shoots on the lower trunk (Fig. 5b). Infested trees typically die within two or three years after initial attack.

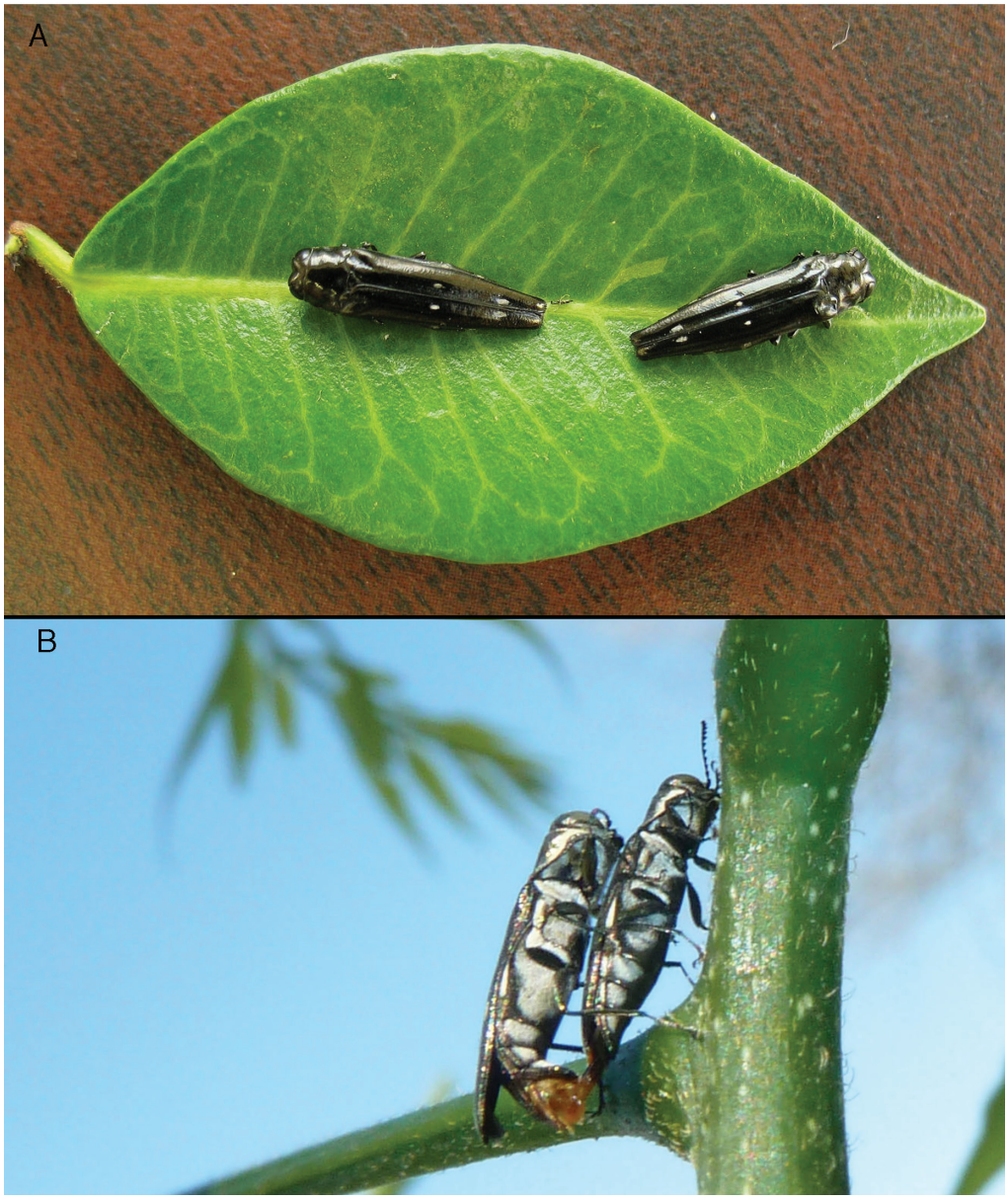

Figure 3. (A) Adults of *Agrilus prionurus* (Soapberry Borer) are ≈10 mm long and have shiny black bodies with four white dots on the elytra. (B) Adults of the native *A. limpiae* are common on Western Soapberry, but are smaller (≈5 mm long) and have white markings on the underside of the abdomen.

Figure 4. Galleries beneath the bark of a Western Soapberry tree created by Soapberry Borer larvae.

Figure 5. (A) The first signs of Soapberry Borer infestation are trees with bark missing from the tree bole and bark chips at the tree base. The winding larval galleries are visible on the bark chips and sapwood. (B) Infested trees characteristically die from the top downward and exhibit numerous epicormic shoots along the lower trunk.

The objectives of this study were to 1) determine the number and distribution of Texas counties currently infested by the Soapberry Borer, 2) describe the attack symptoms and hosts in Texas, 3) expand knowledge of the insect's life history, and 4) test a systemic insecticide as a means to protect trees from mortality due to Soapberry Borer infestation.

Methods

We first observed the signs of Soapberry Borer infestation of Western Soapberry in Brazos and Fort Bend counties, TX, in 2008. To document the current geographical distribution of *A. prionurus* in Texas, we distributed a questionnaire in the spring of 2009 to county extension agents with the Texas AgriLife Extension Service and administrators of State parks and wildlife management areas administered by the Texas Parks and Wildlife Department in counties where Western Soapberry is known to occur. We also posted the questionnaire on the Texas invasive species webpage (http://www.texasinvasives.org), the Texas Forest Service (TFS) web page (http://texasforestservice.tamu.edu), and the International Society of Arborists, Texas Chapter webpage (http://www.isatexas.com).

Recipients of this questionnaire and visitors to these web sites were asked to report dying Western Soapberry trees and infestations of Soapberry Borer, including location, signs of infestation observed, and numbers and size of trees infested. To confirm the host tree and causal agent, we requested that respondents post digital photos of both the foliage of the infested trees (Fig. 1) and damage observed (Figs. 4, 5a). In addition, we prepared a full-page advertisement with color photos of the insect and related signs of attack and published it in the September 2009, July 2010, and July 2011 issues of the Texas Parks and Wildlife magazine. Readers were asked to visit the Texas invasive species webpage to learn more about the insect and to report new infestations.

To expand knowledge about the biology of this pest in Texas, we caged infested Western Soapberry log sections collected from standing trees in Fort Bend, Brazos, and Dallas counties in May 2008, 2009, and 2010, and maintained them under ambient conditions in Lufkin, TX. The cages consisted of 60-cm x 60-cm wood frames covered with fine mesh screening. After the cages were filled with infested logs, we checked them periodically throughout the remainder of the year. We collected adult buprestids and we preserved those identified upon emergence as Soapberry Borer in 70% ethyl alcohol.

We hung purple and green sticky traps (Synergy Semiochemicals Corp., Burnaby, BC, V5J 5G3, Canada), developed for the Emerald Ash Borer, from trees in areas that had Soapberry Borer infestations—six in Fort Bend County in 2009, two in Brazos County in 2009, and six in Dallas County in 2010. The trap consisted of a cardboard sticky panel, 60-cm x 106-cm in size, folded into a triangle. We hung the traps 2–10 m above the ground in infested stands of Western Soapberry. We baited a few of the traps with manuka oil, used to attract a closely related buprestid, Emerald Ash Borer, and monitored the traps throughout the summer and fall of each year.

To develop a means to protect valuable Western Soapberry trees in urban and rural landscapes from losses to Soapberry Borer, we investigated chemical methods of prevention and control. We injected emamectin benzoate, a new systemic insecticide (TREE-äge®, Syngenta, Wilmington, DE; Grosman et al. 2006), at the rate of 5 ml per inch of diameter into uninfested Western Soapberry trees or those in early stages of beetle attack. We injected a total of 62 trees—17 trees in Collin, Dallas, and Fort Bend counties in June and July 2009, and 45 trees in Aransas, Bell, Grimes, Kaufman, Rockwall, and Tarrant counties in June–September 2010. Injected trees were 6–90 cm in diameter. Depending on tree diameter, we injected the insecticide into three or more evenly spaced points located about 0.3 m above the ground using an Arborjet Quikjet™ microinfusion system (Arborjet, Inc., Woburn, MA). The largest tree injected (90 cm in diameter at breast height) was the Texas state champion Western Soapberry, located in Rockport, TX. We monitored an additional 52 Soapberry trees (22 in 2009 and 30 in 2010) distributed among the same study sites as untreated checks. An additional 38 Soapberry trees (22 in 2009 and 16 in 2010) distributed among the same study sites were monitored as untreated checks. We evaluated tree health at the time of treatment application and monitored survival periodically through 2011, assigning trees a rank depending specific criteria Table 1).

Results

As a result of 76 responses to the TFS questionnaire, the magazine advertisement, and website information, we added records for 15 new Texas counties to the Soapberry Borer distribution map in 2009 (Fig. 6), as follows: Archer, Burnet, Cottle, Galveston, Grimes, Hill, King, Lavaca, Limestone, Parker, Roberts, Robertson, San Jacinto, Waller, and Wharton counties. It is worthy of note that responders from several Texas State Park and Wildlife Management Areas (WMA) reported that no Soapberry Borer infestations had been observed at the time of the 2009 survey: Elephant Mountain WMA (Brewster County), Kerr WMA (Kerr County), Goliad State Park (Goliad County), Eisenhower State Park (Grayson County), Fairfield State Park (Freestone County), Bonham State Park (Fannin County), and Lake Mineral Wells State Park (Parker County). Soapberry Borer infestations have been reported from Parker County, including the Lake Mineral Wells Trailway, but have not been observed on nearby Lake Mineral Wells State Park.

Table 1. Tree health condition ranking criteria used in our study to evaluate the effectiveness of emamectin benzoate as an insecticide to control and prevent *Agrilus prionurus* (Soapberry Borer, SBB) infestation of Soapberry trees in Texas.

Rank	Condition	Criteria
1	Excellent	Mostly full crown, no epicormic branches, no apparent SBB attacks
2	Good	Mostly full crown, no epicormic branches, a few SBB attacks
3	Fair	Thinning crown, a few epicormic branches, several SBB attacks
4	Poor	Moderately thin crown, several epicormic branches, many SBB attacks
5	Near death	Mostly dead crown, many epicormic branches; bark starting to flake
6	Dead	No leaves, many areas of flaking bark

Based on landowner feedback, we added Soapberry Borer records to the distribution map for an additional nine counties in 2010, bringing the total number of confirmed infested counties to 42 as of January 2011. The counties reporting infestations for the first time in 2010 were Bandera, Bell, Bexar, Burleson, Ellis, Kaufman, Live Oak, Washington, and Wichita. In 2011, reports of Soapberry Borer infestations were confirmed from eight new counties (Kerr, Kleberg, Kimble, Lampasas, Montgomery, Nueces, Taylor, and Williamson), bringing the total number of counties with documented infestations to 50. Since that time, one additional county (Navarro) was added in 2012 and one more county (Grayson) in 2013 (Fig. 6).

We collected about 100 Soapberry Borer adults from rearing cages from late May until early August (Fig. 7). The earliest emergence occurred in late May 2008 from logs collected in Fort Bend County, in southeast Texas. The latest seasonal emergence occurred in August 2010 from logs collected in Dallas County, in north-central Texas. No emergence occurred after August in any of the three years of rearing. More recently, we collected *A. prionurus* adults during 1–20 November 2013 as they emerged from infested log sections caged outdoors in Lufkin. The infested

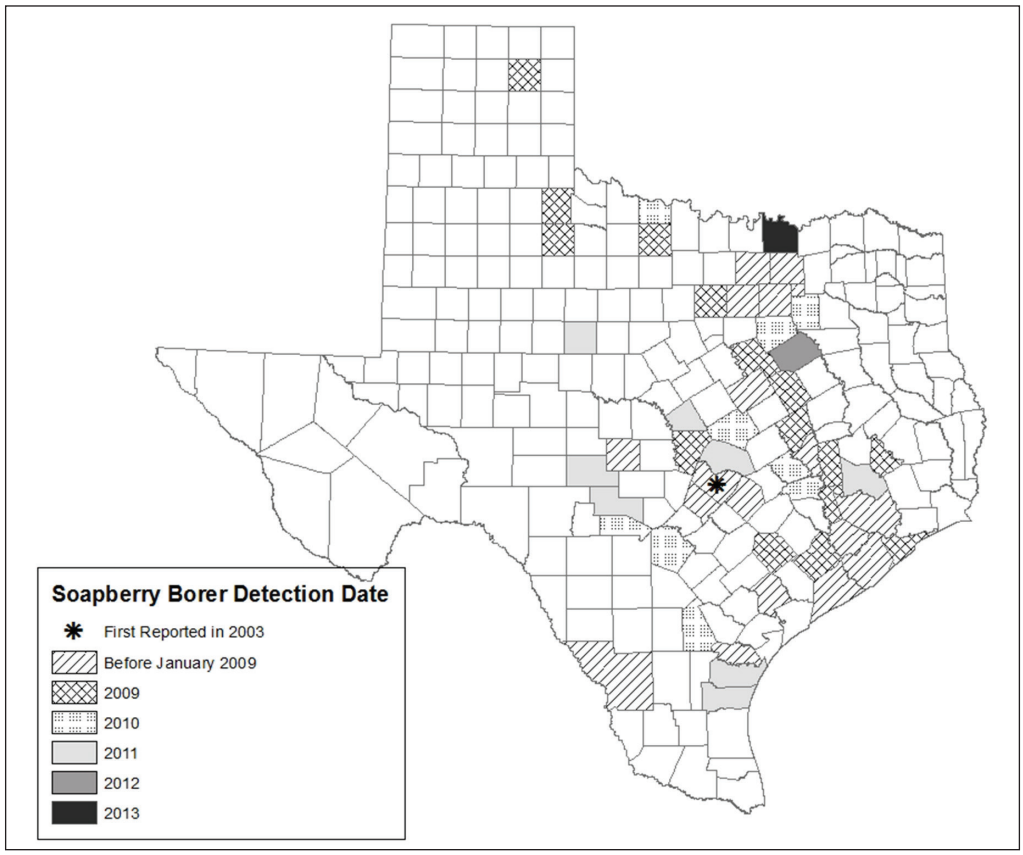

Figure 6. Counties in Texas known to be infested by *Agrilus prionurus* (Soapberry Borer) in Texas by year of detection as of 31 January 2013.

logs from a single Western Soapberry tree (25 cm in diameter) were removed from the Grayson County infestation located near Sherman, TX, on 22 October 2013. In addition, we collected large numbers of a native buprestid species of the same genus from both the survey traps and rearing cages in 2009 and 2010. We also observed adults of this insect in mating pairs on Western Soapberry foliage in Dallas County on 1 April 2011 (Fig. 3b). Stan Wellso, a retired specialist in Buprestidae from Bastrop, TX, identified this insect as *Agrilus limpiae* Knull. This species is one of six or seven native buprestids known to occur on Western Soapberry (S. Wellso, pers. comm.), all of which, except Soapberry Borer, are believed to be secondary woodborers, infesting only dying or dead trees.

We and numerous affected landowners also have noted that Western Soapberry exhibits little or no sign of resistance to the invasive Soapberry Borer. As its populations expand rapidly in Texas, this wood-boring beetle is infesting and killing all sizes of Soapberry trees larger than 6 cm in diameter. Trees larger than 15 cm in diameter are particularly susceptible and seldom escape infestation once the Soapberry Borer colonizes an area. The bark of small-diameter trees presumably is too thin to attract adults for egg laying and/or to permit successful development of the early larval stages.

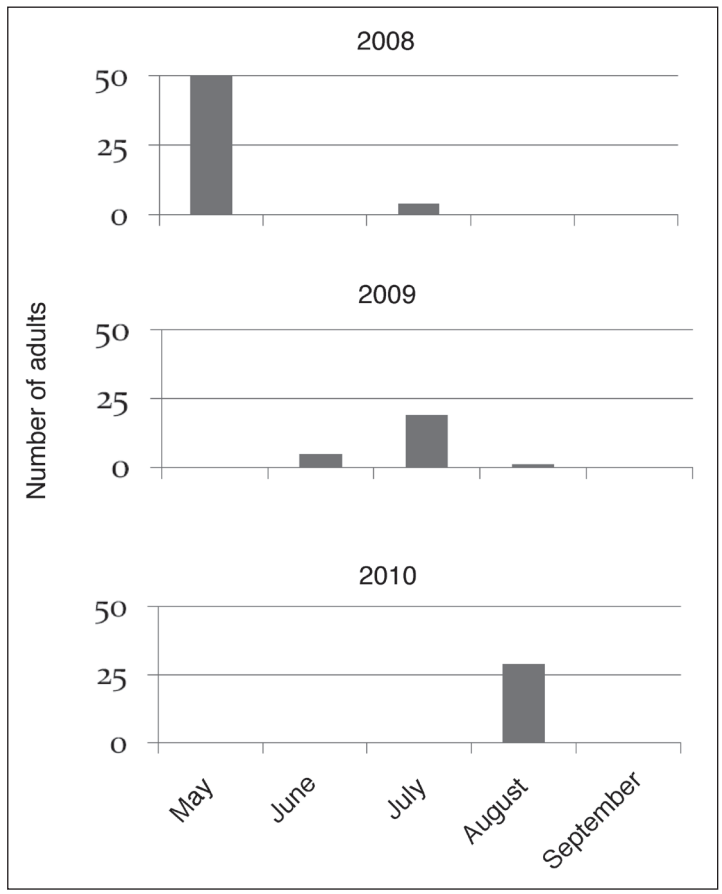

Figure 7. Emergence of adult *Agrilus prionurus* (Soapberry Borer) from caged Western Soapberry log sections in 2008 (Fort Bend [May] and Brazos [July] counties), 2009 (Fort Bend County), and 2010 (Dallas County).

Sticky traps developed for the Emerald Ash Borer were largely ineffective in catching Soapberry Borer adults. We caught no adults in traps in Fort Bend or Dallas counties. Only two adults were caught in the Brazos County traps, both during the last two weeks of June 2009; the presence of manuca oil did not increase trap catches.

The Western Soapberry trees used in the systemic insecticide injection study were monitored until April 2012, and results were favorable. Of the 22 control trees monitored since 2009, 6 (27%) died from Soapberry Borer infestations and others continued to decline (Fig. 8). None of the 17 trees injected with emamectin benzoate had died as of September 2011. Similarly, trees treated in 2010 showed improvements, while the untreated control trees from 2009 and 2010 continued to decline, though none had died as of September 2011.

Discussion

Western Soapberry appears to be the primary, if not sole, host of the invasive Soapberry Borer, *A. prionurus*, in Texas. Whether the more eastern variety *S. saponaria* L. var. *saponaria* (Wingleaf Soapberry), which occurs from Mississippi to Florida, would be a suitable host remains to be determined. Results from rearing

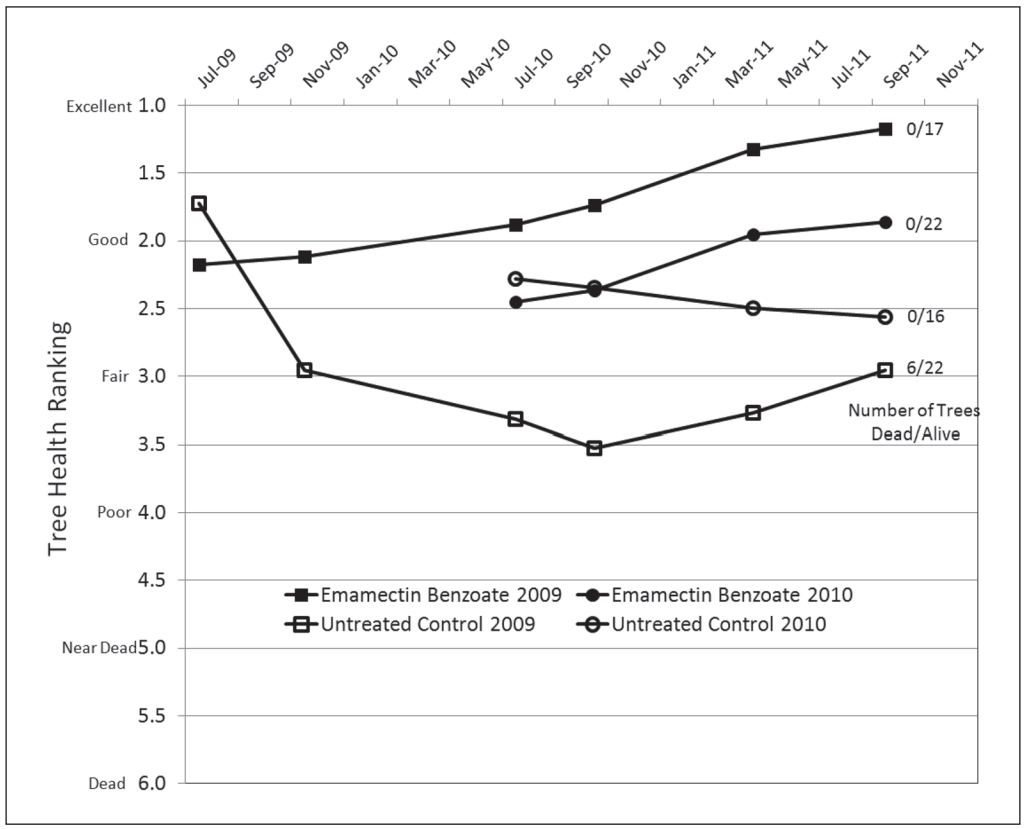

Figure 8. Tree health rankings for Western Soapberry trees with and without injections of emamectin benzoate in central Texas, July 2009 to September 2011. Numbers at end of data curves represent number of dead trees/total number of trees as of 21 September 2011.

and trapping studies suggest that the Soapberry Borer has no more than one generation per year in Texas. The insects overwinter as larvae and emerge to seek new hosts in late spring and summer. Because we do not know when the trees we used for rearing adults were initially infested, it is possible that the insect may require more than one year to complete its development. We have planned further research to establish the length of the Soapberry Borer life cycle.

To date, no infestations have been observed in states other than Texas, although infestations in Wichita, Roberts, and Grayson counties, in northern Texas, suggest that the insect is approaching the Oklahoma border. Until recently, no ecological barriers were known to exist that would prevent Soapberry Borer from eventually infesting Western Soapberry populations throughout its range, which extends north to Kansas and west to southeastern Colorado. However, it is suspected that low winter temperatures may adversely impact Soapberry Borer infestations. Indeed, reports from landowners about dying Soapberry trees in Texas have declined drastically; few have been received since July 2011. At our insecticide study sites, we have observed no new infestations since the latter part of 2010, and many of the 2009 control trees that had initial symptoms of Soapberry Borer attack appear to be slowly recovering (Fig. 8). We speculate that the severe freeze from 2–5 February 2011, when ambient temperatures dropped below 0 °C for 4 consecutive days, adversely affected Soapberry Borer populations throughout Texas. Whether populations of Soapberry Borer will return to previous levels and continue expanding their range in Texas or to other states remains to be determined.

The systemic insecticide emamectin benzoate has proven successful for preventing attacks of Emerald Ash Borer in the states bordering the Great Lakes (Smitley et al. 2010). Our favorable results suggest that this insecticide might be an effective means to prevent initial attack by Soapberry Borer and to protect high value landscape trees from being killed. Emamectin benzoate has recently been registered by the US Environmental Protection Agency for use against several pests of hardwoods and conifers (D. Grosman, unpubl. data). This systemic insecticide is a restricted-use pesticide; it can only be applied by a certified pesticide applicator.

Clearly, the Soapberry Borer is having a major impact on native populations of Western Soapberry in Texas. This invasive pest has the potential to eliminate Western Soapberry from its native range, which includes Texas and 8 other states (OK, LA, AR, MO, KS, NM, AZ, and CO). Why the same insect is not known to have such a devastating effect on Western Soapberry in Mexico, is unknown. Further study is warranted on the insect's biology, natural enemies, geographic spread, potential for host resistance, tolerance of cold temperatures, and host range if a long-range pest management program is to be developed to protect native populations of *Sapindus* spp. (soapberry) in the US.

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distribution of Soapberry Borer in Texas. Funding for this study was provided by a grant from the US Forest Service, Forest Health Protection, Region 8, Atlanta, GA. Photos were taken by R.F. Billings.

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