

Introduction

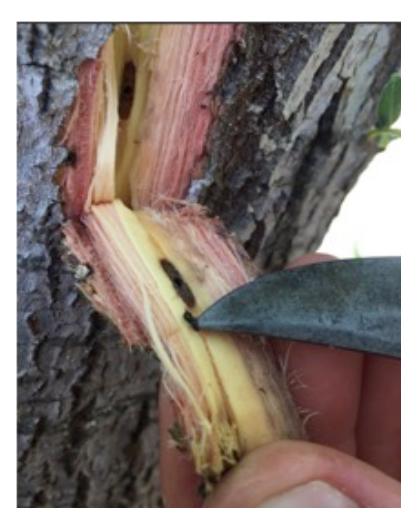


Figure 1. Top: Female Polyphagous shot hole borer (Source: Gevorik Arakelian, L.A. Co. Dept. of Ag.). Bottom: PSHB in an arroyo willow (*Salix lasiolepis*).

The Polyphagous and Kuroshio shot hole borers (*Euwallacea* spp. nr. *fornicatus* [Curculionidae]) are recent invaders of southern Californian riparian habitats (Figure 1). These beetles have a broad host range including many invasive woody plant species, like castor bean (*Ricinus communis* [Euphorbiaceae]), as well as native, dominant riparian species, such as sycamores (*Platanus* spp. [Platanaceae]), oaks (*Quercus* spp. [Fagaceae]), willows (*Salix* spp. [Salicaceae]), cottonwoods (*Populus* spp. [Salicaceae]) and maples (*Acer* spp. [Sapindaceae]). The shot hole borers (SHB) carry obligate fungal symbionts that are inoculated into host trees and often grow into the host's xylem, leading to branch dieback and often mortality. Due to a wide host range and fast growing populations, these beetles have the potential to wipe out large areas of riparian woodland in just one year's time, as was seen at the Tijuana River Valley from 2015-2016, which was subsequently colonized by invasive species, including *Arundo donax* and *R. communis* (Boland 2016) (Figure 2).

The distribution of shot hole borers (SHB) in riparian habitats is not well known in the northern extent of their expanding range. Aside from two singletons detected in Santa Cruz and San Luis Obispo Counties in 2014 and 2016, respectively, the most northern known infestation was detected in Santa Barbara County in September 2016. Here we deployed detection traps in Ventura and Santa Barbara Counties to (1) characterize the current distribution of invasive SHBs in central California, (2) track their northward dispersal, and (3) monitor seasonal changes in their activity.



Figure 2. Willow dieback at the Tijuana River Valley due to SHB infestation. Left: Photo taken in May 2015. Right: Photo taken in February 2016.

Methods

- We used an inverted 2-Liter bottle trap baited with quercivorol, a chemical attractant specific to this species complex, and filled with a propylene-glycol/water solution to preserve specimens. (Figure 3). All traps were monitored biweekly. Due to a complete decline in beetle activity, trap monitoring ceased in early December 2016 and resumed in mid-March 2017.
- Ventura County**
 - Santa Clara River (Estuary to Piru, CA): 42 traps deployed in August – October 2016
 - Ventura River (Ojai, CA): 17 traps deployed in May 2017
- Santa Barbara County**
 - Montecito, CA: 4 traps deployed in November 2016
 - Santa Barbara, CA: 6 traps deployed in April 2017
 - Carpinteria, CA: 16 traps deployed in April 2017
- Due to high population numbers, the Montecito site was monitored for seasonal changes in beetle abundances. Trap catches from this location were counted weekly from November 2016 – April 2017 and biweekly thereafter.



Figure 3. Shot hole borer trap, baited with quercivorol.

Results

- The Polyphagous SHB (PSHB) was detected at 16 out of the 42 traps in the Santa Clara River watershed in 2016, mostly concentrated in Santa Paula, CA. In 2017, PSHB was detected at 4 additional trap locations, in Santa Paula and Fillmore, CA (Figure 4).

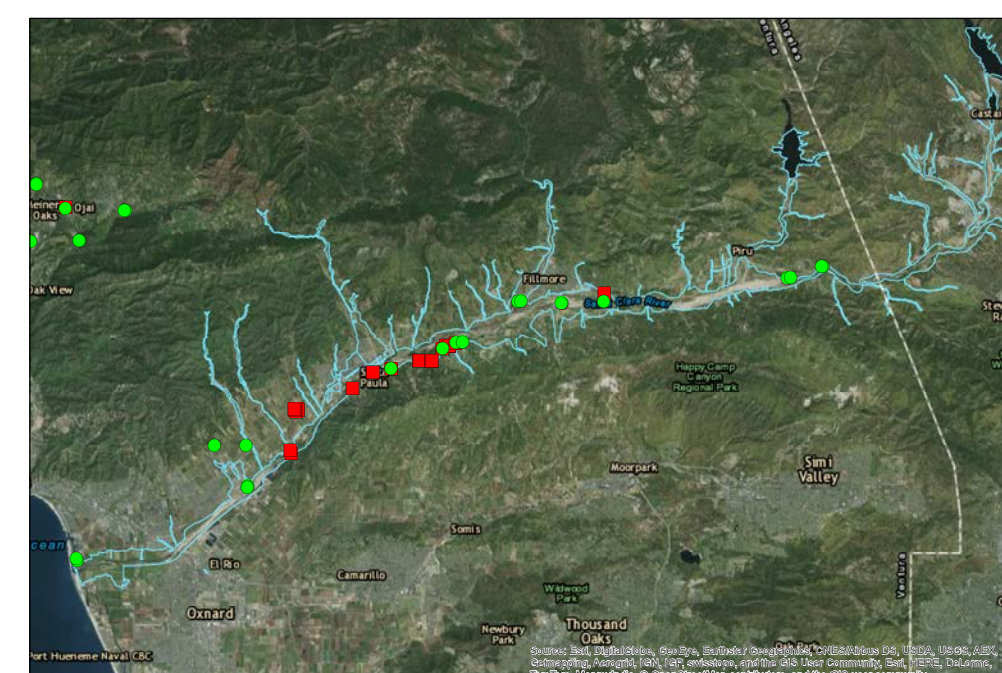


Figure 4. Polyphagous shot hole borer (PSHB) trap locations in the Santa Clara River watershed. Red dots indicate traps where PSHB has been detected while green dots indicate where PSHB has not been detected.

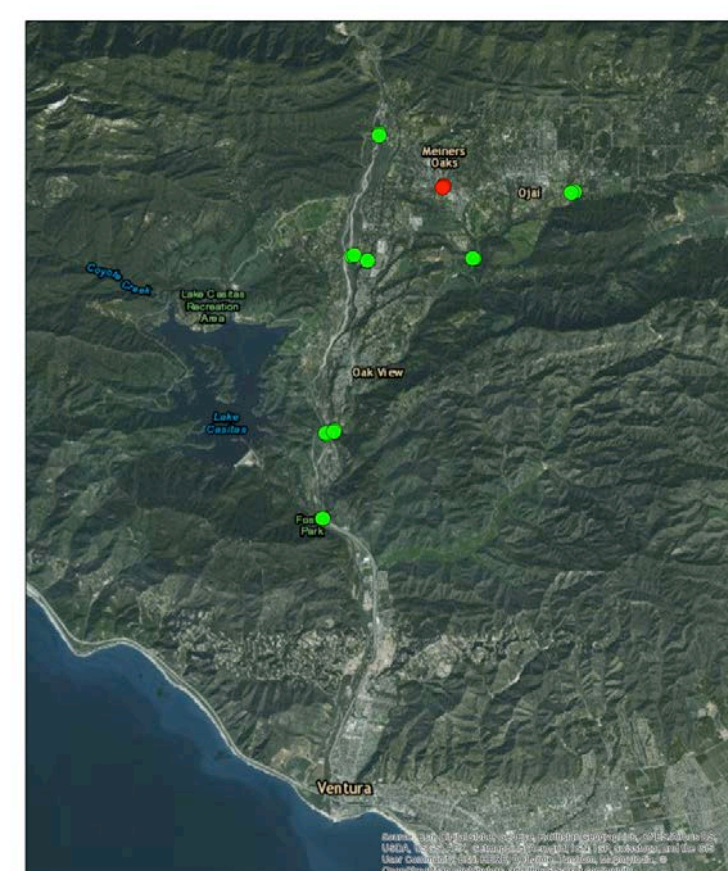


Figure 5. Polyphagous shot hole borer (PSHB) trap locations in the Ventura River watershed. Red dots indicate traps where PSHB has been detected while green dots indicate where PSHB has not been detected.

- PSHB was detected at 2 out of 17 traps in the Ventura River watershed, both at the Ojai Meadow Preserve (Figure 5).

- The Kuroshio SHB (KSHB) was detected in all 4 traps in Montecito in 2016. In 2017, KSHB was detected in 6 out of 26 traps in Santa Barbara County (Figure 6). KSHB was detected at Lotusland in May 2017 and later detected in another trap at this location in August, potentially indicating the dispersal of SHB within this site.

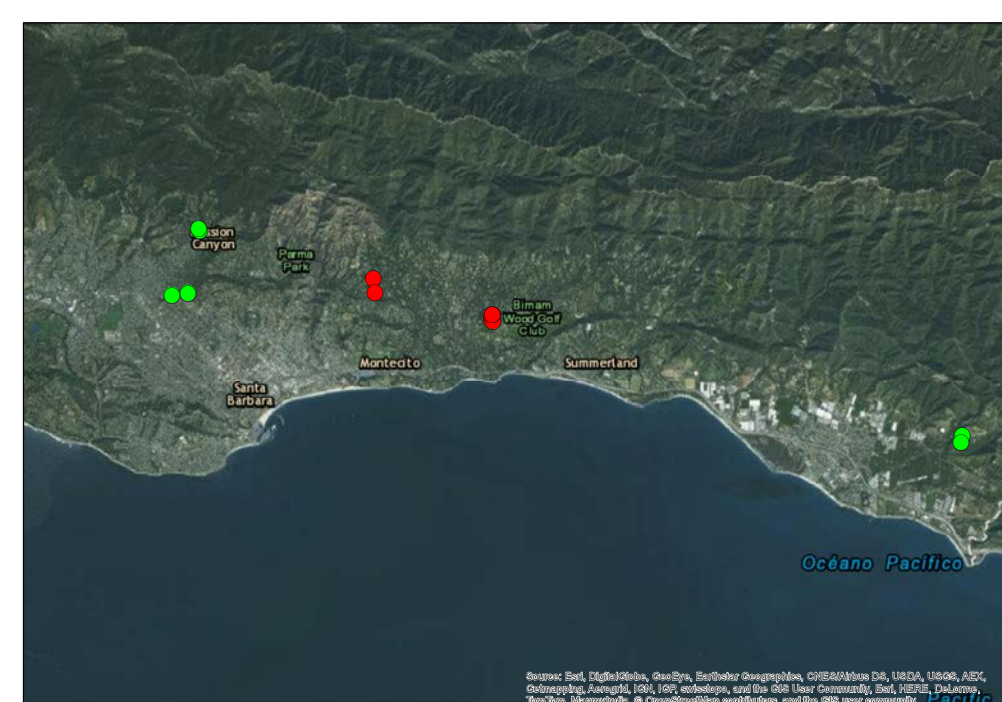


Figure 6. Kuroshio shot hole borer (KSHB) trap locations in Santa Barbara County. Red dots indicate traps where KSHB has been detected while green dots indicate where KSHB has not been detected.

- In both counties, detections were made at sites directly adjacent to water or in regularly irrigated areas.
- KSHB abundances varied substantially throughout the year, showing a complete decline in activity between early December and mid-March (Figure 7). In addition, KSHB showed sharp spikes and declines in abundance over time.

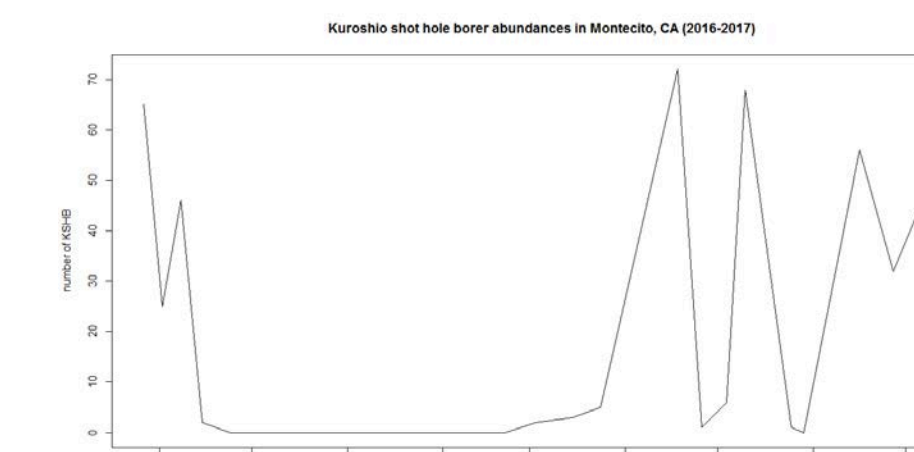


Figure 7. Kuroshio shot hole borer (KSHB) trap catch abundances in Montecito, CA from November 2016 to August 2017. KSHB show a complete decline in activity from early December to mid-March as well as sharp spikes and declines in abundances over time.

Discussion

Shot hole borers (SHB) were detected at previously undetected areas in both Ventura and Santa Barbara Counties, indicating range expansion from initial detection locations, either due to natural or human facilitated dispersal. All detection locations are in close proximity to water or in regularly irrigated areas. Although preference for wetter sites has not yet been confirmed experimentally, these areas should be focused on for SHB surveys. Both detection traps and visual surveys for entry holes and fungal symptoms should be conducted in riparian areas within the SHB's distribution to better characterize their current range. SHB showed a complete decline in activity during winter months, meaning monitoring with traps is not effective during these months. Surveys in winter months should rely on visual surveys of host trees.

While SHB are undoubtedly becoming more widespread, not all detection locations are showing significant damage to host trees. By far, the most damage in central CA is at the Santa Clara River, centered around the Hedrick Ranch Nature Area in Santa Paula (Figure 8). This location, and other locations nearby, are exhibiting substantial dieback, likely due to a combination of PSHB infestation and the 5-year long drought in CA (Figure 9). In addition, there are many other factors, such as host condition (e.g. healthy vs. stressed), the presence of other boring insects in host trees (*Xyleborinus saxeseni*, etc.) and corridors of invasive hosts between riparian patches, that may be affecting host tree infestation and subsequent dieback. It is currently unclear how these factors affect the distribution and intensity of SHB infestations in southern and central CA. More research is needed to better understand the conditions that facilitate SHB infestations and how multiple stressors will affect riparian landscapes.

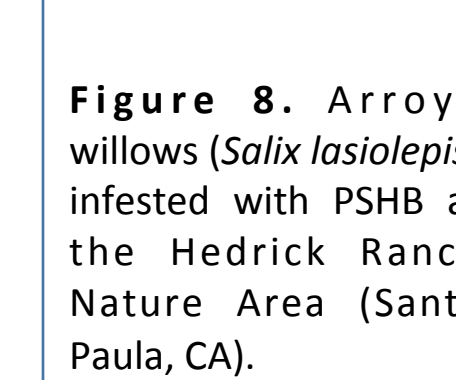


Figure 8. Arroyo willows (*Salix lasiolepis*) infested with PSHB at the Hedrick Ranch Nature Area (Santa Paula, CA).

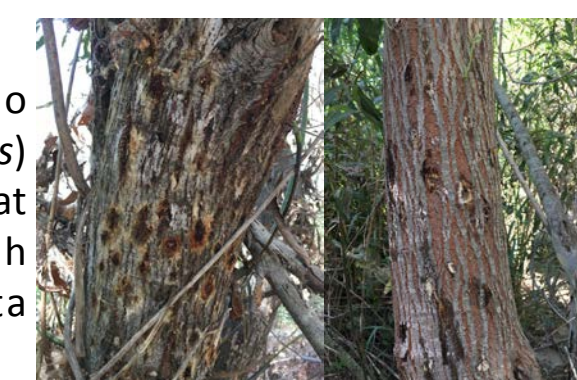


Figure 9. Willow (*Salix* spp.) dieback at the Fillmore Hatchery (Fillmore, CA), which is likely due to SHB infestation and drought.

Next Steps

- Future surveys (2017-2018) will be expanded both northward and into desert regions to better understand the rate of population expansion and potential limits to SHB establishment, as well as to evaluate host plant use in more mesic and xeric ecosystems than those currently infested in southern California.
- Infestation surveys are currently being conducted at the Santa Clara River to track infestation rates and host disease progression over time.
- Experiments are being conducted to test host preference and susceptibility as well as how environmental factors affect host preference.

Contact

Shelley Bennett
Ecology, Evolution and Marine Biology
University of California, Santa Barbara
Email: michelle.bennett@lifesci.ucsb.edu
Website: rivrlab.msi.ucsb.edu

References

- Boland, John. 2016. The impact of an invasive ambrosia beetle on the riparian habitats of the Tijuana River Valley, California. *PeerJ*. DOI:10.7717/peerj.2141