Title
Evaluating Potential Shifts in Pierce's Disease epidemiology

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Reporting Period
The results reported here are from work conducted November 2018 to February 2019.

Abstract
In this report we summarize some of the epidemiological data gathered during this study. Other aspects of this project have been summarized in previous reports.

Layperson Summary

A PD epidemic emerged in Napa and Sonoma counties. Very high PD prevalence was reported throughout the region, with a large number of stakeholders reaching out to UCCE Farm Advisors. In summer 2015, the project team held a series of joint meetings/field visits with the Farm Advisors. Two observations have been made that raised our concern about the problem. First, high prevalence of PD in the North Coast is usually below 1-2% per vineyard; several vineyards visited had over 25% of vines symptomatic. Second, historically PD is closely associated with riparian zones in the North Coast; we have visited several vineyards where PD does not appear to be associated with riparian zones. We have observed these greater rates of disease incidence and dissociation with riparian areas throughout Napa and Sonoma counties—they are not district specific. The goal of this proposal is to determine what factors are driving this epidemic, so that ecology-based disease management strategies can be devised and immediately implemented, as was successfully done in the past when disease drivers appear to have been different.

Introduction

Pierce's disease of grapevine (PD) has reemerged in Napa and Sonoma counties, where disease incidence has been much higher than usual and the distribution of sick vines within vineyards often does not fall within expectations. These field observations taken together with the very high number of vineyards affected in the region indicate that a PD epidemic is emerging. The goal of this proposal is to determine what factors are driving this epidemic, so that ecology-based disease management strategies can be devised and immediately implemented, as was successfully done in the past when disease drivers appear to have been different. In this report we summarize progress made trying to understand the biology of spittlebug vectors and seasonality of blue-green sharpshooter natural infectivity.

Objectives

Objective 1. Vector, pathogen, and host community surveys to inform the development of a quantitative model to assess future Pierce's disease risk and develop integrated management strategies.

Objective 2. *Xylella fastidiosa* colonization of grapevines and the role of overwinter recovery in Pierce's disease epidemiology.

Objective 3. Determine the role of spittlebug insects as vectors of *Xylella fastidiosa*.

Objective 4. Data mine and disseminate existing information on vector ecology, vegetation management, and efficacy of pruning.

Objective 5. Develop a larger extension and outreach footprint with additional seminars, extended interviews made available on the web, and an update to the *Xylella fastidiosa* website, the main online resource for PD information.

Description of Activities

One of the main objectives of the project is to understand better the role of various vectors, including blue-green sharpshooter (BGSS; *Graphocephala atropunctata*) and other sharpshooters and spittlebugs, on Pierce's disease incidence. To address this objective we conducted a set of surveys at each site, including 1) sweep-net surveys for insects on the vineyard floor, 2) visual surveys of spittlebug abundance and host-plant use, and 3) plant community composition in surrounding habitat as it relates to BGSS pressure in vineyards.

1. Sweep net surveys of vineyard insects.

Starting in late February or March, we conducted replicate sweep-net sampling in each of 32 vineyard sites in Napa and Sonoma Counties. This included sampling on the vineyard floor between vine rows, along the edge of vineyards, and in a limited number of cases from underneath vines. Sampling occurred twice a month at Sonoma sites and monthly at Napa sites through at least August, at which point sampling was halted because a substantial portion of plants on the vineyard floor had reached senescence. For each set of sweeps all insects were collected, identified, and counted. We then compared seasonal differences in the abundance of all known vector taxa over the season, among site types (i.e. those near riparian areas versus those not), and among sampling locations (i.e. vineyard edge, between rows, and under vine rows). In addition, we compared the abundance of the most common vector taxa over the season. Thus far these comparisons have been completed for Sonoma sites.

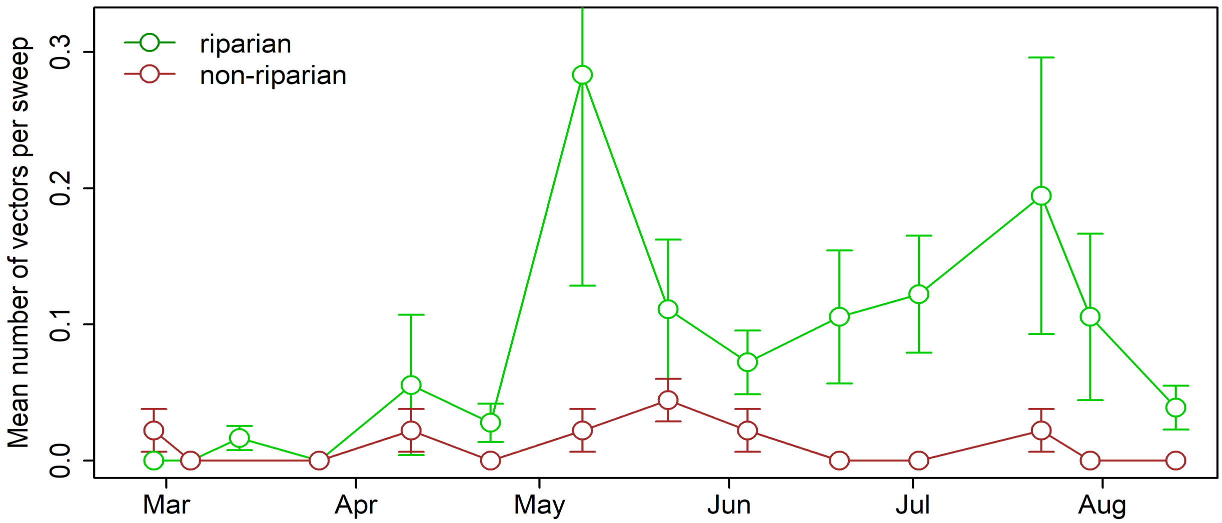

Figure 1. Mean (±SE) total number of all vector taxa collected in sweep-net sampling over the season at riparian versus non-riparian sites in Sonoma County.

A total of more than 400 vectors were collected during sweep-net sampling over the season. Collectively, vector taxa were most common from May through the end of July, and were less common the remainder of the year. On average, vectors were approximately 8-fold more abundant at riparian sites compared to non-riparian sites, particularly during May and July (Fig. 1). Within sites, substantially more vectors were collected on the periphery of vineyards compared to between rows, or especially underneath vine rows – though the relatively small number of sweeps conducted underneath vine rows may have influenced this conclusion (Fig. 2).

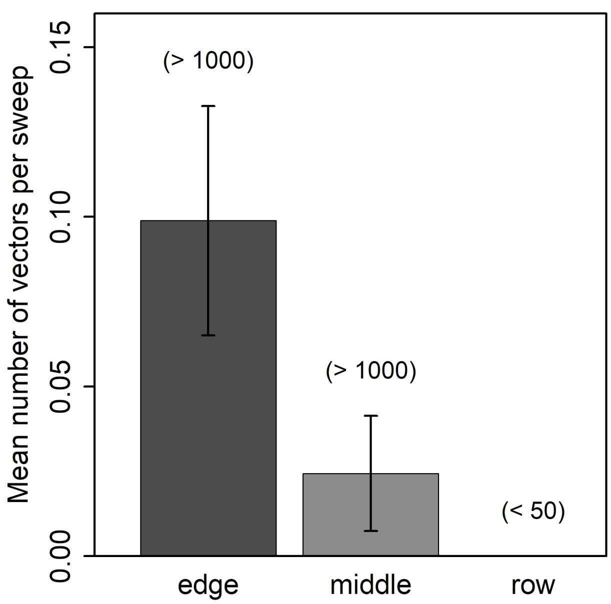

Figure 2. Mean (±SE) total number of vectors over the season in sweep-net sampling at the edge of vineyards, in the middle between rows, and underneath vine rows. Numbers in parentheses reflect the approximate total number of sweeps at each location.

Finally, with respect to vector species, six taxa were relatively common in sweep-net sampling among sites but to varying degrees. These vector taxa include the blue-green sharpshooter, red-headed sharpshooter (RHSS; *Xyphon fulgida*), green sharpshooter (GSS; *Draeculacephala minerva*), another sharpshooter (*Pagaronia* sp.), the meadow spittlebug (MSB; *Philaenus spumarius*), and another spittlebug (*Aphrophora* sp.). Of these, GSS was the least common over the season, while *Pagaronia* and *Aphrophora* were most common briefly in the spring (Fig. 3). MSB, RHSS, and BGSS were more common, but showed substantially different seasonal patterns. RHSS was moderately abundant over the Spring and Summer, MSB abundance peaked in May they declined thereafter, and BGSS was common in sweep-net sampling only in July and August – corresponding with the secondary peak of the F1 generation of BGSS that typically is represented in yellow sticky-trap monitoring.

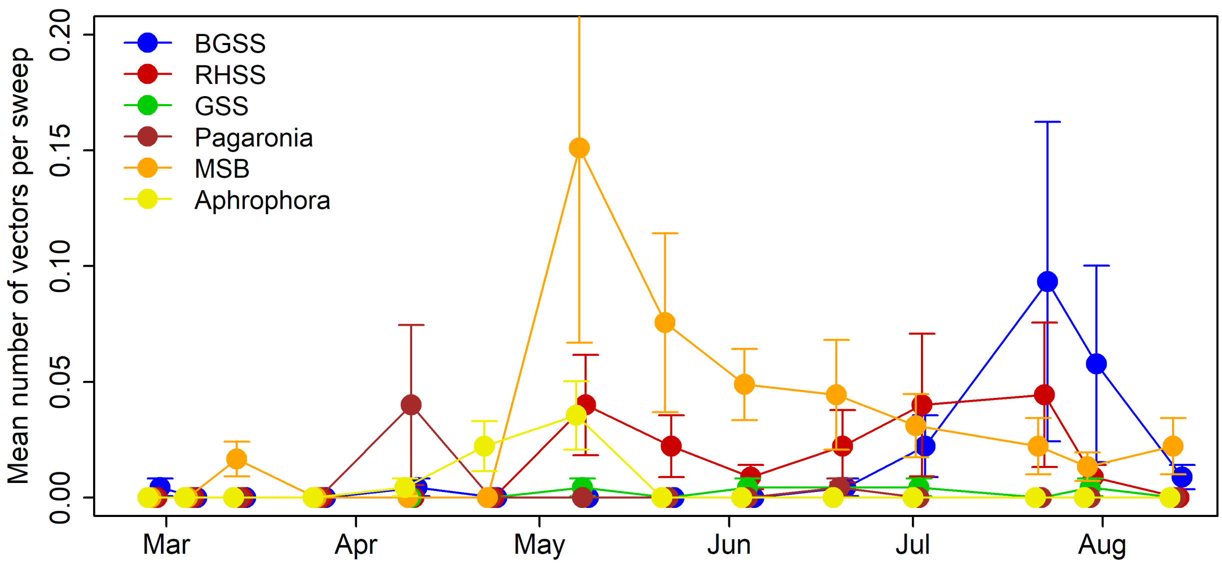

Figure 3. Seasonal abundance of vector taxa in sweep-net sampling at Sonoma County sites.

2. Visual surveys of spittlebug abundance and host-plant use

In addition to sweep-net sampling, we monitored spittlebug abundance each Spring via visual surveys at a subset of sites in Napa and Sonoma. For each census, transects were established that included recording the number of nymphal spittle masses present, the most common plant species on the vineyard floor, and the plant taxa on which nymphs were present. These surveys, in addition to other studies documenting spittlebug development rates, are being used to understand which host plant species are most important for spittlebug populations. Below are the results for *Aphrophora* abundance at the Sonoma County sites.

Among sites, *Aphrophora* nymphs were found on more than 20 plant taxa. Among the most common hosts at these sites were weedy or naturalized exotic species (Fig. 4, white bars) such as: shortpod mustard (*Hirschfeldia incana*; Hiin), curly dock (*Rumex crispus*; Rucr), bristly oxtongue (*Picris echioides*; Piec), poison hemlock (*Conum maculatum*; Coma), prickly lettuce (*Lactuca serriola*; Lase), filaree (*Erodium cicutarium*; Erci), burclover (*Medicago polymorpha*; Mepo), sowthistle (*Sonchus* sp.; Soas), catsear (*Hypochaeris radicata*; Hyra), buckhorn plantain (*Plantago lanceolata;* Plla), and dandelion (*Taraxacum officinale*; Taof). In general, *Aphrophora* spittle mass abundance was strongly correlated with the relative abundance of these hosts, but with shortpod mustard and curly dock showing a greater spittle abundance than expected based on plant abundance (Fig. 4, dark bars).

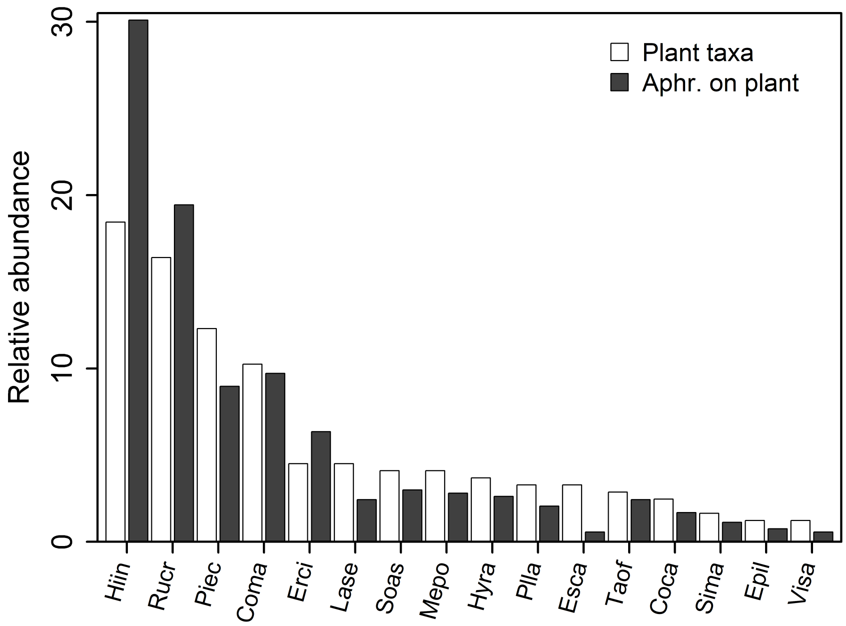

Figure 4. Relative abundance of the most common 16 plant taxa (white bars; % of all plants) and corresponding fraction of *Aphrophora* nymphs on those plants (dark bars). Most plant names listed in the text above.

3. Plant community composition as it relates to BGSS pressure in adjacent vineyards

Our final set of activities focused on characterizing the plant community composition in the area surrounding each vineyard site to understand its contribution to BGSS pressure in

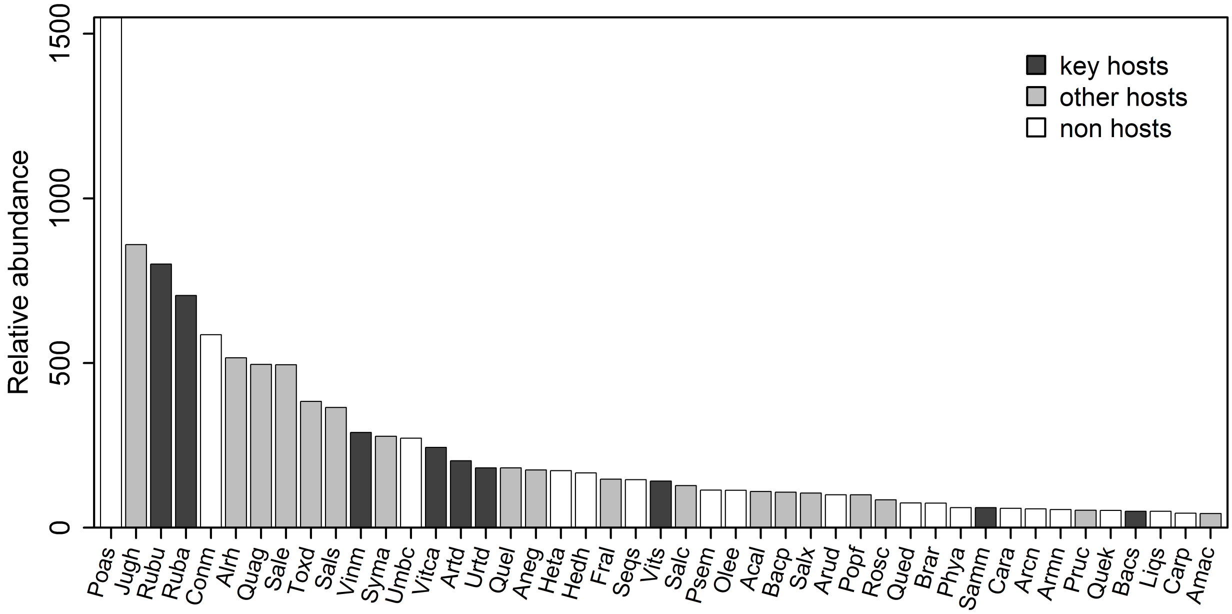

Figure 5. Relative abundance of key BGSS hosts, other BGSS hosts, and non-hosts in transects conducted in the dominant habitat type adjacent to each vineyard site.

The vineyards. The goal of this exercise is two-fold: to explain at least some of the site-to-site variation in BGSS abundance, and to reevaluate those plant species most strongly tied to BGSS abundance. To do this, we established 2 to 3 transects at each site (71 total), 50 m in length from the edge of vineyards into the dominant vegetation type immediately surrounding the vineyard. Surrounding vegetation included riparian habitat, oak woodland, chaparral, ornamental plantings, or primarily other vineyards. At each site the relative abundance of plant taxa were estimated via a combination of tallies of plant number within 2 m of the transect tape and the percentage cover of each species on a 10 x 50 m area of the ground around the transect tape. We then compared the contribution of functional groups of plants (e.g., known BGSS reproductive hosts, other known BGSS hosts, non-host taxa) on the cumulative number of BGSS caught on sticky traps on the vineyard side of each transect. Finally, we analyzed those individual plant taxa that are most strongly related to BGSS catch, in either a positive or negative way.

Among all sites, more than 150 unique plant taxa were identified from a range of plant families. This included grasses, forbs, and woody shrubs and trees. Most of the known key BGSS hosts were relatively common at multiple sites, including: Himalayan blackberry (*Rubus ursinus;* Rubu), California blackberry (*Rubus americanus*; Ruba), periwinkle (*Vinca major*; Vinm), California wild grape (*Vitis californica*; Vitc), hybrid or escaped grapevines (*Vitis* spp.; Vits), mugwort (*Artemisia douglasii*; Artd), stinging nettle (*Urtica dioca*; Urtd), and elderberry (*Sambucus Mexicana*; Samm). Other purported BGSS hosts that were relatively common include: Northern black walnut (Jugh), white alder (Alnr), coast live oak and valley oak (Quag, Quel), willow spp. (Sale, Sals, Salx), poison oak (Toxd), snowberry (Symma), big-leaf maple (Aneg). At some sites several non-hosts were also common, including: grass spp. (Poas), poison hemlock (Conm), California bay (Umbc), toyon (Heta), ivy (Hedl), redwood (Seqs), Douglas fir (Psem), and olive (Olee).

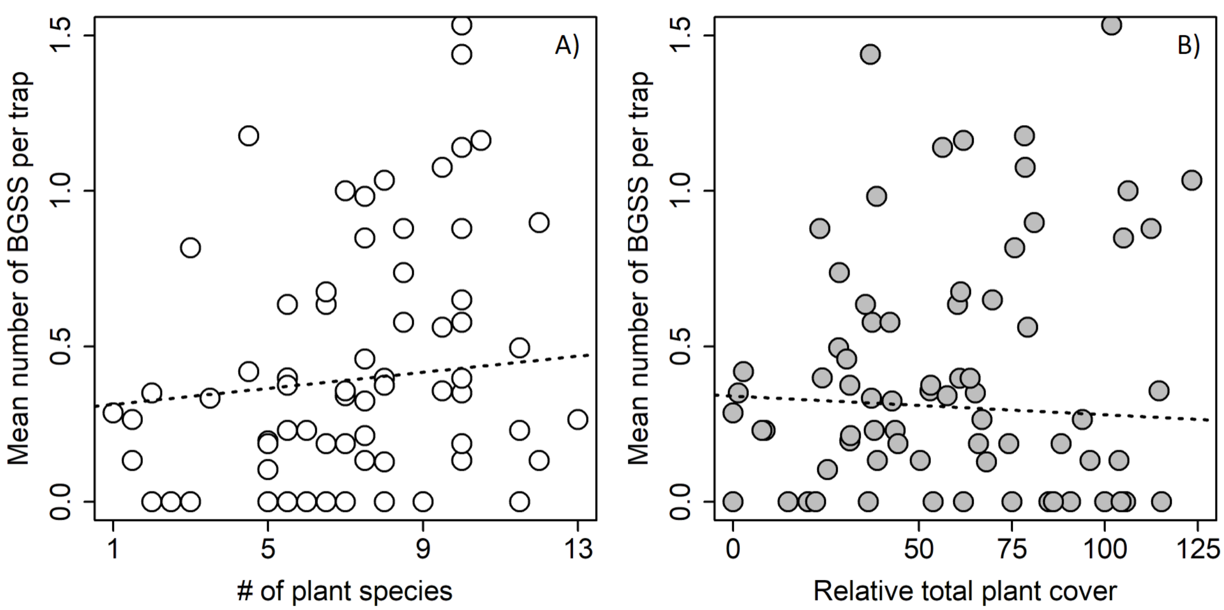

Figure 6. BGSS catch as a function of A) total plant species richness and B) total relative plant cover in adjacent habitat at each vineyard site.

With respect to effects on total BGSS catch, neither overall plant species richness in the surrounding habitat nor overall plant cover showed significant effects (Figure 6). Instead, plant functional type was more important. BGSS abundance was best explained by a positive effect of total cover of all BGSS hosts (key reproductive hosts + other hosts), and slight negative effect of non-host cover (Figure 7). Yet substantial unexplained variation exists, suggesting that site specific effects or species identity effects may be particularly important for explaining BGSS pressure. With respect to the latter, we conducted preliminary analyses of the relationship between abundance of the most common key hosts, other hosts, and non-host taxa, individually, and BGSS cumulative abundance. Of the key host taxa most strongly related to BGSS catch, elderberry showed a significant positive effect, while California grape and blackberry showed non-significant positive effects (Table 1). Among the other purported BGSS hosts, there was a range of effects from strongly significant effects of big-leaf maple, spicebush, and walnut to mildly negative effects of arroyo willow (Table 2). Finally, among the non-hosts there was a range effects from moderate positive effects of ivy and poison hemlock, to significantly negative effects of toyon and grasses (Table 3).

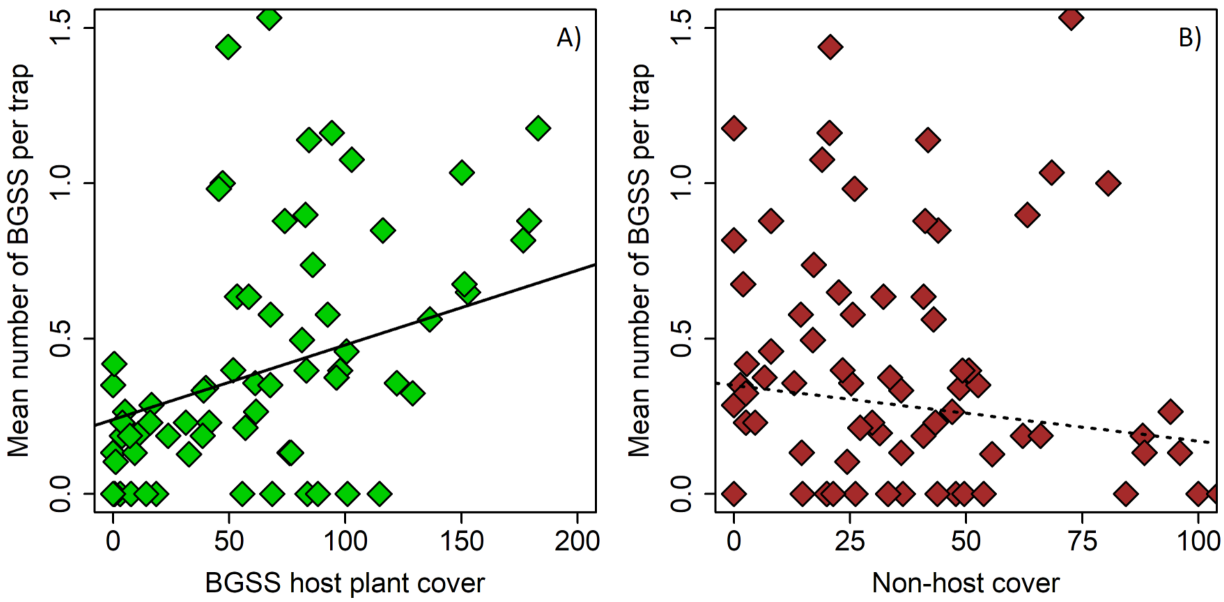

Figure 7. BGSS catch as a function of A) total BGSS host-plant cover and B) total non-host cover in adjacent habitat at each vineyard site.

Table 1. Effect size (slope, standard error) of key reproductive host taxa on cumulative BGSS number. Significant effects are in bold.

Taxon	Slope	SE
Sambucus Mexicana, blue elderberry	**0.029**	**0.017**
Vitis californica, California wild grape	0.0069	0.004
Rubus armeniacus, Himalayan blackberry	0.0023	0.0016

Table 2. Effect size of purported other host taxa on cumulative BGSS number.

Taxon	Slope	SE
Acer macrophylum, big-leaf maple	**0.014**	**0.005**
Calycanthus occidentalis, spicebush	**0.277**	**0.111**
Juglan hindsii, northern black walnut	**0.0036**	**0.0016**
Populus fremontii, Fremont cottonwood	0.0078	0.0052
Symphoricarpos albus, snowberry	0.0031	0.0023
Toxicodendron diversilobum, poison oak	0.0024	0.002
Salix lasiopepsis, arroyo willow	-0.0042	0.0025

Table 3. Effect size of purported non-host taxa on cumulative BGSS number.

Taxon	Slope	SE
Hedera helix, English ivy	0.005	0.003
Conium maculatum, poison hemlock	0.0029	0.002
Olea europaea, olive	-0.0039	0.0029
Arctostaphylos canescens, hoary manzanita	-0.021	0.017
Brasica rapa, yellow mustard	-0.022	0.012
Heteromeles arbutifolia, toyon	**-0.011**	**0.005**
Poaceae spp., multiple species	**-0.0037**	**0.0012**

Status of Funds

We are working with UC Berkeley and a subaward on closing the award. Work is not finished but being finalized and relevant research being continued with other funding.

Funding Agencies

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