Title of report:
Evaluating Potential Shifts in Pierce's Disease epidemiology

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Abstract

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. This report summarizes activities performed, essentially, during the first year of this award (2016). We present Results and Discussion sections together addressing each original objective. Furthermore, we note that limited amount of data analyses has been done, primarily because efforts have focused on collecting data, and not spending time generating/interpreting preliminary results.

Lay Summary

A PD epidemic is emerging in Napa and Sonoma counties. Very high PD prevalence is being 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.

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.

Results and Discussion

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.

Sixteen vineyard blocks in Napa County and 16 vineyard blocks in Sonoma County were selected as study sites (Table 1; total of 138 acres). Beginning in late February 2016, yellow sticky traps were deployed in either a transect or grid pattern in each study block such that between 4 and 12 traps were deployed at each location. In addition between 1 and 3 vegetation traps were deployed at each location adjacent to the putative source of blue-green sharpshooters (BGSS, mostly riparian vegetation). Insect vectors were also monitored with the use of insect sweep nets; sweeping the vine canopies and vegetation between the vine rows (middles) began in August and continued every two weeks. BGSS were collected from the canopy and green and red-headed sharpshooters from grasses in the middles. Traps were checked every 14 days, and presence of vectors (mainly BGSS) was recorded.

Beginning in late August and continuing through mid-September 2016, incidence of PD was recorded for each vine in all study blocks. Disease incidence was based on the occurrence of a combination of the common visual symptoms of PD, including leaf scorching, uneven lignification of shoots, matchstick petioles and stunted growth. Two hundred samples were collected from Napa and Sonoma valleys, respectively (n=400), to correlate visual assignment of vines as PD-positive with *X. fastidiosa* PCR-based detection in the laboratory (ongoing). Researchers walked every row of each block and recorded incidence of PD symptoms for individual vines on vineyard block maps. These maps were generated using Geographic Information Systems (GIS) to digitize a matrix of points in a spatial environment where each point represents a vine in its exact geographic location. A customized geoprocessing tool was created to generate detailed vine-by-vine GIS files with accurate row and vine spacing. Based on the inputs, the tool generates a new GIS point shapefile representing vine locations within a vineyard block. Data on disease incidence was recorded in the vineyard on these maps. Once digitized, the georeferenced data on PD incidence and trap captures of BGSS (similar to sample map on left) will be subjected to spatial statistics.

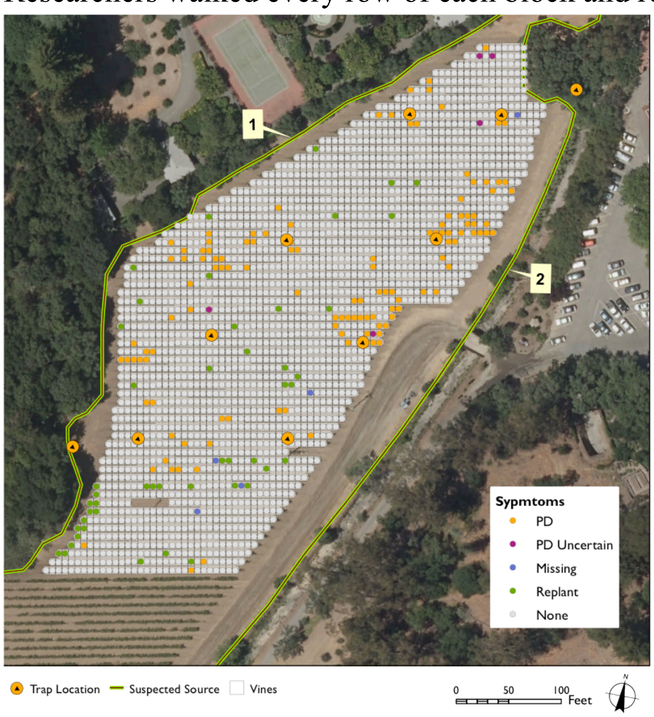
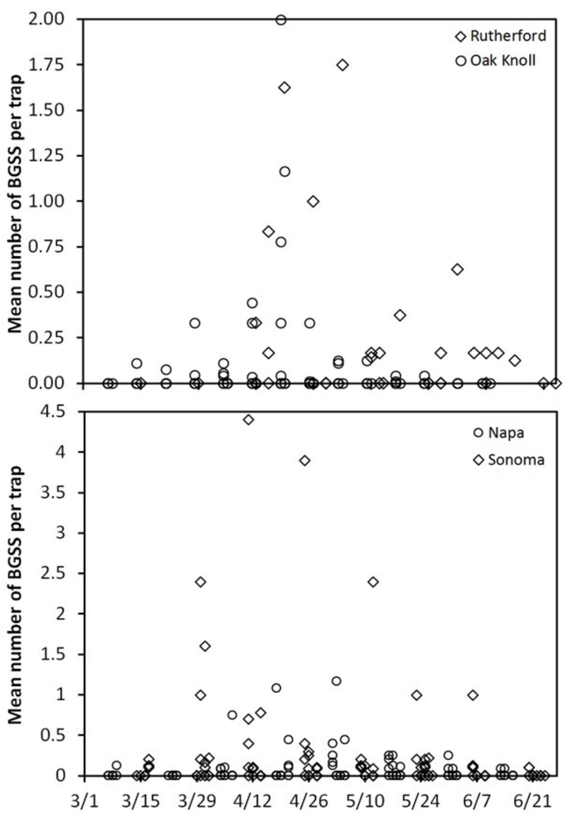


Table 1. Description of study sites.

County	Vineyard	Variety	Rootstock	Planting date	Size (acres)
Napa	CL	Merlot	101-14	1997	3.03
	CV	Cabernet Franc	3309C	1999	6.37
	C	Cabernet Sauvignon	3309C, St. George	2004, 2005	7.44
	DC	Cabernet Sauvignon	110R	2000	1.92
	E2	Petit Verdot	110R	2004	0.89
	E3	Cabernet Sauvignon	101-14	2004	2.84
	F	Cabernet Sauvignon	O39-16	2014	9.07
	I	Cabernet Franc	O39-16	2002	2.5
	JP	Cabernet Sauvignon	101-14	2004	4.88
	RJ	Chardonnay	101-14	2000	4.6
	R	Malbec	420A	2004	1.69
	SF	Cabernet Sauvignon	Riparia Gloire, 420A, 101-14, 3309C	2000, 1994, 1993, 1990	7.33
	S	Cabernet Sauvignon	3309C, 1103P, 110R	1991, 1993	4.42
	T	Chardonnay	1103P	2008	2.6
	V	Cabernet Sauvignon	101-14	2013	5
	WH	Chardonnay	101-14	2010	5
Sonoma	1	Chardonnay	5C	1998	5.1
	2	Chardonnay	039-16	2011	5.45
	3	Zinfandel	110R	2001	1.1
	4	Zinfandel	039-16,110R	NA	4.3
	5	Chardonnay	1103P	2001	3.8
	6	Gruner Veltliner	101-14	NA	4.93
	7	Merlot, Cabernet Sauvignon	NA	NA	5.8
	8	Pinot Noir	101-14		3.97
	9	Merlot	5C	1996	3.8
	10	Chardonnay	5C	2001	7.5
	11	Malbec	039-16	2008	4.25
	12	Chardonnay	3309C	2008	2.25
	13	Chardonnay	AXR, 5C	1986, 1992, 1993, 1994	5.0
	14	Chardonnay	101-14	2003	4.2
	15	Chardonnay	101-14	2003, 2005	4.1
	16	Chardonnay	S04	2007	2.8

Plant community adjacent to surveyed vineyard blocks

To test the hypothesis that vegetation composition of the areas surrounding vineyards may be influencing the abundance of *X. fastidiosa* vectors (sharpshooters and spittlebugs) and the prevalence of PD in the vineyards, we designed the following protocol. We surveyed the species richness and relative abundance of all vascular plants found at each vineyard site (N=32 sites) in Napa and Sonoma counties. Each site included 1-3 lines of insect traps extending from the center of the vineyard towards the edges. Our vegetation surveys extended these lines for 50 meters in the same cardinal direction, sampling the vegetation in the bordering areas surrounding the vineyards. In most cases, these areas were riparian communities with mixes of native and non-native vegetation; however, in some cases these areas were cleared or managed lands with plantings. In total, we surveyed 71 geo-referenced 50-m transects at the 32 sites (1-3 transects per site), and sampled a total of 154 different vascular plant species. Our objective was to characterize the vegetation structure as well as sample the plant diversity at each vineyard so we sampled ground cover as well as all woody stems greater than 1 cm in diameter. For ground cover, we calculated the percent cover of different species of herbs, grasses, woody stems, and bare ground for 2 m X 50 m (0.01 ha) in each transect. For woody stems, we counted and identified each stem greater than 1 cm in diameter in the same 2 m X 50 m area as the groundcover transect. For large trees, we counted and identified each stem greater than 10 cm in diameter for 10 m X 50 m (0.1ha) in each transect. In total, we counted and identified 3935 stems > 1cm < 10cm, and 1208 trees greater than 10cm in diameter. We will use this vegetation structure data, percent cover data, and species composition and relative abundance data to correlate with the insect trap vector relative abundance and *X. fastidiosa* prevalence data when it is available.



Blue-green sharpshooter monitoring

So far this season, the BGSS monitoring program indicate vector populations in vineyards are low. For example, although the grower generated monitoring data showed up to an average of 2 BGSS per trap in late April, approximately 70% of vineyard block censuses found no BGSS on that date (Figure A). The researcher generated monitoring data showed similarly low BGSS densities, with the highest densities primarily in some Sonoma County vineyard blocks between the end of March and mid-May, but with most vineyard censuses finding no BGSS on that date (Figure B).

Figure. Number of BGSS caught over Spring 2016 in parallel trapping programs A) conducted by grape growers in two regions of Napa County, and B) by researchers (our team) at sites throughout Napa and Sonoma Counties.

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

As a first step towards understanding whether climatic conditions in recent years have contributed to the ongoing PD resurgence in the North Coast, we have started to compare recent versus historic climate data. Thus far we have collated climate data from more than a dozen weather stations in the region, with some having temperature data going back more than 70 years.

All else being equal, a lack of cold conditions over the winter and early spring should contribute to PD incidence, by reducing the fraction of vines recovering from infection. To address this prediction, we've started to compare two metrics of dormant season climate – the mean daily minimum temperature, and the number of days where minimum temperatures were below 40°F – for recent seasons compared to historic values. Thus far, for two sites in Napa and Sonoma Counties (i.e. Oakville and Healdsburg, respectively) temperature data over the previous 5 seasons do not stand out as being warm by historic standards. Indeed, two to three of the previous 5 seasons have somewhat higher numbers of cold days (i.e. <40°F) and lower mean minimum temperatures compared to historic averages.

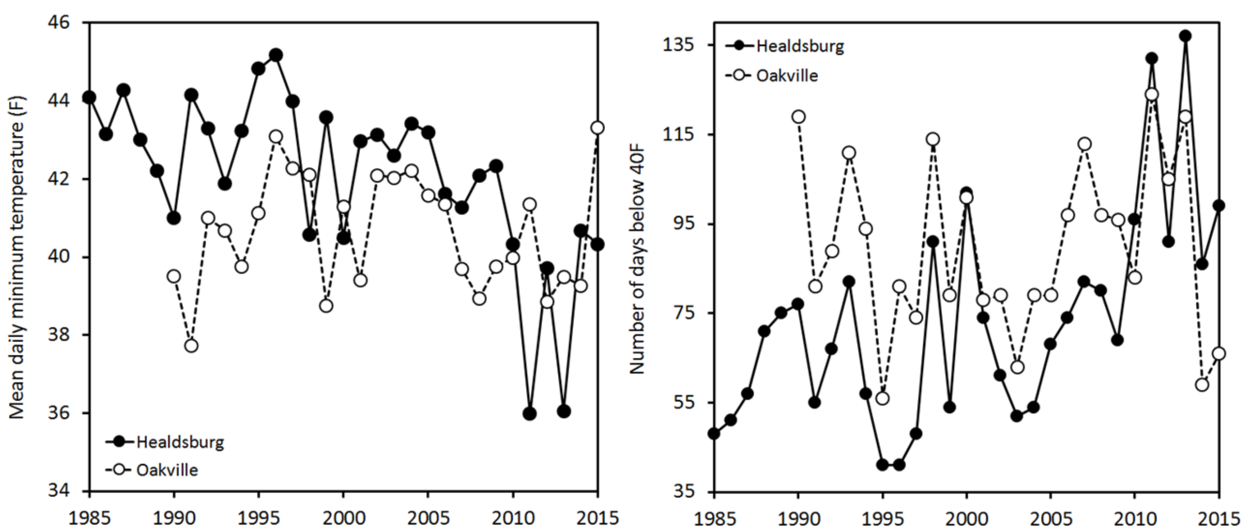


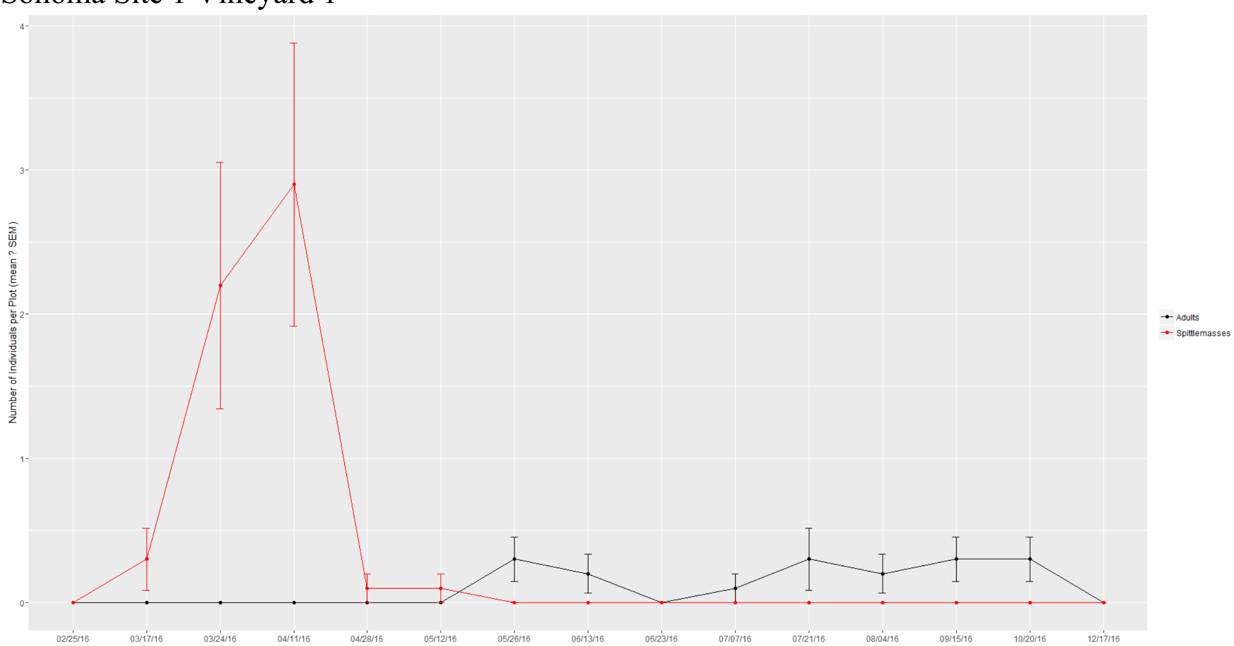
Figure. Comparison of A) daily minimum temperature and B) number days with minimum temperatures below 40°F over the dormant season (October – April) for the last 30 years at two sites in Napa and Sonoma Counties.

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

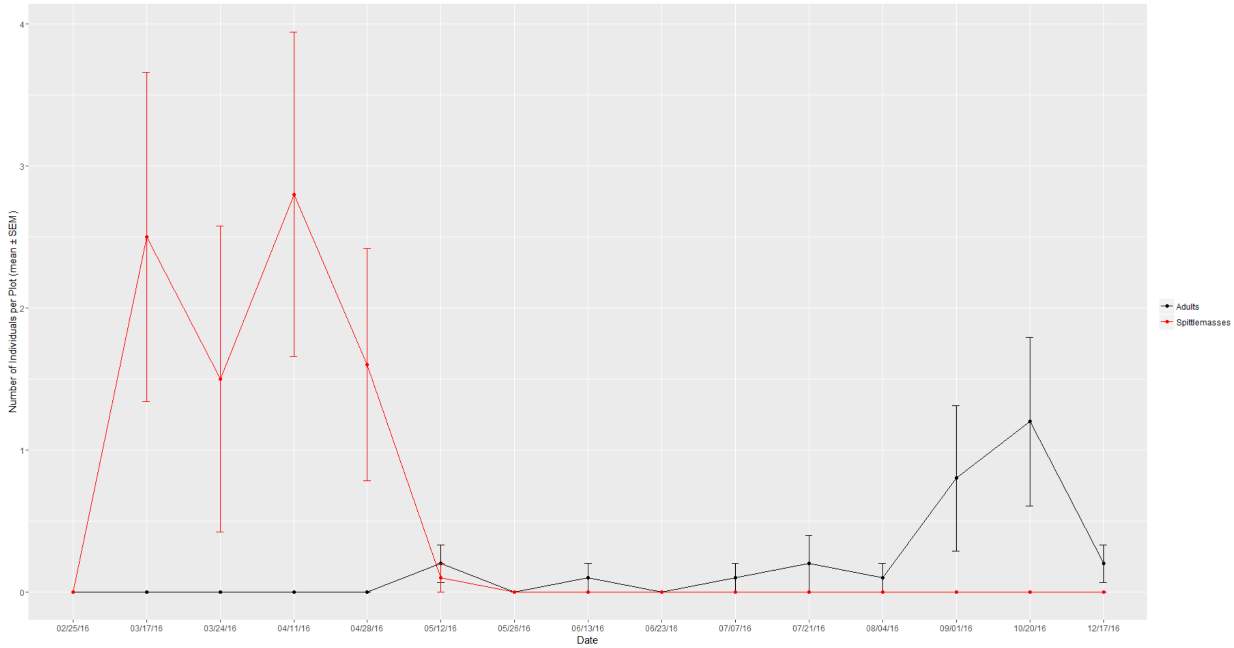
Work on the characterization *X. fastidiosa* transmission by the main spittlebug found in vineyards to date, *Philaenus spumarius*, was finished. A manuscript has been published (Cornara et al. 2016. Phytopathology) and is available online or upon request if reader is not able to download the PDF. As that work is now published, we will refrain from including the details here. Among our findings, we determined that *P. spumarius* transmits *X. fastidiosa* to grapevines with an efficiency of 20%/individual/day.

To study spittlebug phenology in the North Coast, a field project was initiated. Starting in February 2016, we surveyed partner sites in Napa and Sonoma County for nymphs of the meadow spittlebug, *P. spumarius*. At the site in Sonoma, two vineyards were surveyed while at the Napa site, only one vineyard was surveyed. Except in cases of extreme weather, the vineyard sites were surveyed biweekly. These surveys consisted of randomly selecting 10 plots in each vineyard during each sampling period. Each plot consisted of two vine-rows and one inter-row and had an approximate area of 7x15 ft^2. Nymph sampling consisted of randomly tossing six 2x2 ft^2 quadrats in each plot and collecting all nymphal spittlemasses within each quadrat. Nymphs were removed from spittlemasses and individually counted back in UC Berkeley. Associated host plants of the nymphs were identified in the field and any unknown host plants were collected and preserved for identification back at UC Berkeley. In late March to early April, biweekly surveys for the adult *P. spumarius* began at our two sites in conjunction with observations of this species' phenological development. In each of the 10 plots, the two vine-rows and the inter-row were each subjected to 25 sweeps with a sweep net. Additionally, a yellow sticky trap (*Seabright Labs*) was hung on the middle trellis wire of each plot's two vine-rows and checked biweekly for captured adults of *P. spumarius*. Every four weeks the yellow sticky traps were collected and replaced. Starting in September 2016, the sweep net and trap surveys were conducted every four weeks when weather conditions allowed. Results from 2016 are presented here.

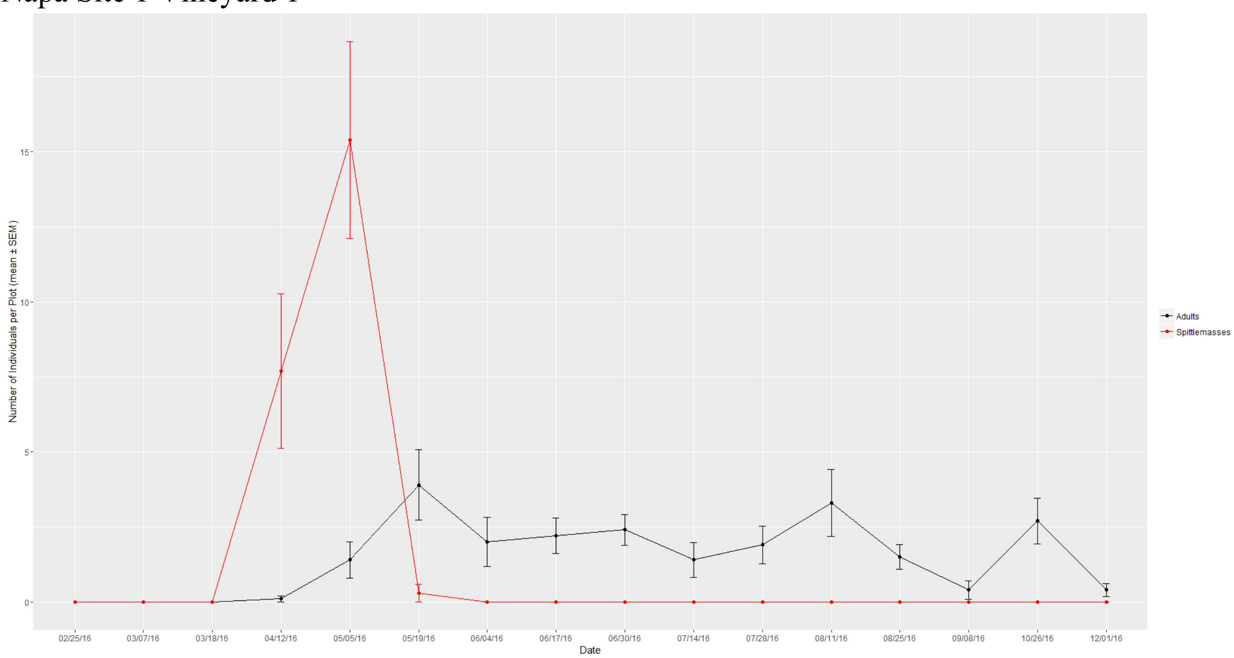
Sonoma Site 1 Vineyard 1-



Sonoma Site 1 Vineyard 2-



Napa Site 1 Vineyard 1-

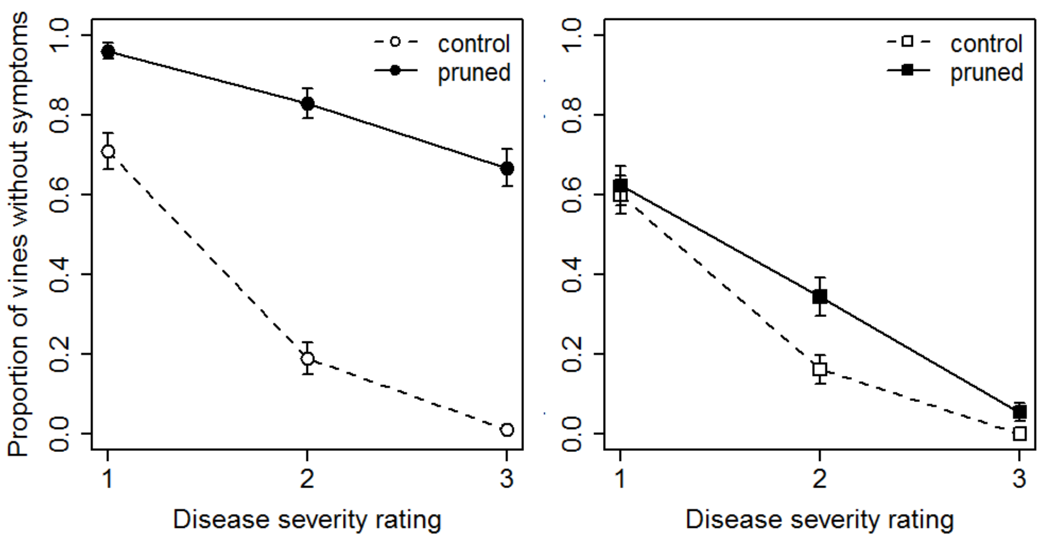


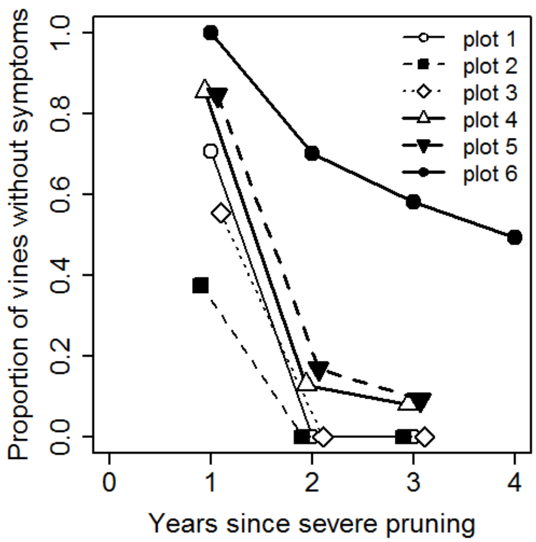
Other components of this project not reported here but that are ongoing include determination of the reproductive cycle of *P. spumarius* (e.g. when are females gravid), host plant preference for nymphal development, usage of tillage for spittlebug population control (results included in previous report), and identification of spittlebug fauna in Napa and Sonoma.

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

Data on the efficacy of pruning generated by Ed Weber and Sandy Purcell about 15 years ago was obtained, organized, analyzed, and a manuscript draft prepared. We are currently editing this manuscript for submission to a peer-reviewed journal. Here we include a summary of that work. Briefly, the work demonstrates that severe pruning (just above rootstock graft) is not effective if vines have strong PD symptoms – i.e. pruning does not eliminate disease. It is also not effective if only early symptoms are identified, as most of those vines will recover from infection anyway – i.e. eliminating vines with early symptoms leads to roguing of vines that would become uninfected anyway. There is, however, a situation with intermediate symptom severity where pruning could provide some help in eliminating infections from plants, which would not occur naturally anyway. It is our opinion that identification of this specific intermediate stage of disease symptoms may be very challenging and be location, variety, and crop management practices specific. Therefore, it is difficult to provide a specific guideline on this topic, other than pruning does not work well for plants with early or severe symptoms, and may provide some (but not necessarily much) assistance in cases where intermediate levels of symptoms are present.

Symptom return in pruned or control vines from 3 different disease severity categories A) 1 year after pruning, or B) 2 years later.





Rate of symptom return after severe pruning for the six research plots. Some plot symbols offset slightly for clarity.

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.

Extension events:

Sonoma Grape Day
One seminar on PD focusing on management strategies. February 10 - ~200 attendees.
Sonoma Vineyard Technical Group
One seminar on PD focusing on management strategies. February 11 - ~75 attendees.
Oak Knoll PD Task Force formed (35 members); have held 3 meetings since early December. We are working closely with this group on insect detection and disease management.
Presentation by M. Cooper, on Pierce's Disease epidemiology (in Spanish) to 220 attendees, at ROOTSTOCK (11/12/2015), organized by Napa Valley Grapegrowers, and held in Napa, CA.
Napa Valley Vineyard Technical Group; Jan 13, 2016; 234 attendees. Two lectures on PD and PD management followed by Q&A.
"Factors affecting Pierce's Disease outbreaks", presented by M. Cooper to Rutherford Dust Society (45 attendees), Feb. 4, 2016, Rutherford, CA.
Pierce's Disease Vector ID workshop, Feb 18, 2016 (English (37 attendees) and Spanish(18 attendees)), Napa, CA.

Outreach
Rhonda Smith, Monica Cooper, and Matt Daugherty have given interviews to several trade publications (e.g. Practical Winery and Vineyard, Wines and Vines). Rhonda Smith was featured in a The Press Democrat article about PD as well.

Conclusions
There are no conclusions at this stage.

References Cited

None.

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