Renewal Progress Report for CDFA Agreement Number 06-0617-SA

Project title: “Mapping Pierce's Disease and vector populations in the southern San Joaquin Valley and developing a dynamic model to assess management strategies.”

Time period covered: April 1, 2017 – January 31, 2018

Key personnel

Last Name, First Name	Institutional Affiliation	Role on Project
PI:		
Neil McRoberts	Plant Pathology Department, University of California, Davis	Project Leader
Co-PI:		
Other Key Personnel:		
David Bartels	USDA-APHIS PPQ	Cooperator
David Haviland	Kern County UCCE	Cooperator
Mark Sisterson	USDA-ARS	Cooperator

Introduction

Reports of increasing incidence of Pierce’s Disease (PD) in the southern San Joaquin Valley in recent years have prompted concern among growers. Well-established, and previously successful, area-wide management practices of glass-winged sharpshooters (GWSS) do not appear to be controlling the disease. Understanding how and why transmission by GWSS of the causative pathogen, *Xylella fastidiosa* (*Xf*), is changing over time and space is essential in order to efficiently and effectively interrupt transmission.

Controlling PD hinges on controlling GWSS. GWSS and grapes are not, however, a closed system. Citrus and grapes both act as GWSS hosts and as *Xf* reservoirs, although citrus does not manifest disease. Further, windbreaks are believed to provide havens for GWSS. These three groups exist in close proximity in the General Beale area outside of Bakersfield in Kern County. This enclosed, well-described area presents a unique opportunity to elucidate population-level *Xf* transmission dynamics in a multi-use scenario. Findings will benefit not only local growers but may be generalized to make evidence-based recommendations in other California vineyards that are adjacent to citrus, windbreaks, or other potential GWSS and/or *Xf* harbors. Identifying a spatial risk gradient regarding proximity to citrus (even assuming citrus growers were taking GWSS control measures) in particular would be of immediate use to growers.

The observation that PD incidence is increasing despite orchestrated area-wide management of GWSS is worrying but perhaps not surprising. It is not realistic to expect static management tactics to consistently return positive results in a dynamic system. For example, environmental changes in degree days may affect GWSS development and activity in ways that permit the insect to evade set spray schedules. A dynamic response to a dynamic system requires that we: (1) identify and define observable processes, and (2) use those observations as building blocks to predict what might happen in the system under further changes. To that end, the overarching goal of this research project is to identify time-varying spatial patterns of PD incidence and GWSS abundance in the context of General Beale, and to incorporate these findings into a dynamic model that can be used to evaluate prospective disease incidence.

Objectives

Objective 1: Compare spatio-temporal patterns of PD-affected grapevines and GWSS populations in the Southern San Joaquin Valley.

Objective 2: Develop a dynamic simulation model of GWSS and PD levels across the southern San Joaquin Valley to evaluate prospects for disease management under changing conditions.

Objective 1

Key events

May 2017 – Sandra Olkowski hired as Postdoctoral Scholar by UC Davis
February 2017 – Received GWSS trap count data from David Bartels
March 2017 – Received PD incidence data from David Haviland
May 2017 – Sandra Olkowski resigned from UC Davis and left the project
July 2017 – Neil McRoberts presented preliminary results from mapping GWSS populations over time to the Directors of Consolidated Central Valley Table Grape Pest Control District (CCVTG-PCD) to frame discussion of future PD/GWSS research.
Jan 2018 – Megan Dickson hired as intern researcher to continue the project

We are working to establish spatial stability metrics for GWSS population hotspots identified in the historical trap data (see Fig 1). At the same time, analysis of the PD data has continued although the variation in sampling dates and protocols used in the annual PD survey limits the useful information that can be extracted from the data.

Discussion with growers and the coordinator of CCVTG-PCD highlighted the shortcomings of the existing database, resulting in a recommendation that future PD surveys follow a standardized protocol that will allow the data to be used for analysis and support management of PD in the region. Dr McRoberts and Dr Haviland will confer on the details of the survey design to ensure the proposed protocol can be serviced by available UC staff.

Progress on this objective was impacted by Dr Olkowski's resignation and is approximately 6 months behind schedule. Ms Dixon has re-started the work and is making good progress.

Objective 2

As a preliminary modeling activity we examined the thermal time availability for GWSS development in two 3-year periods: Jan 1 2011 – Dec 31 203 and Jan 1 2014 – Dec 31 2016. These two periods bracket the time when the area-wide GWSS program in the southern San Joaquin Valley experienced control failure.

We used the data presented in Gutierrez et al. (2011) to generate an approximate generation-time model for GWSS using a lower base temperature for development of 11.9C and an upper temperature limit on development of 37.5C. The data presented by Gutierrez et al. (2011) indicate a minimum thermal time per generation of 1155 degree days above 11.9C and an adult reproductive period of 1660 degree days above 11.9C.

We extracted historical temperature data from the Arvin CIMIS weather station for the two time periods indicated and used the UC IPM online degree day calculator to calculate the daily and accumulated degree day availability using the single sine calculation method.

Inspection of the data suggested that Jan 1 could be used as an approximation for the development start date, in lieu of a detailed analysis of the appropriate biofix for GWSS development. We scaled the accumulated degree day data by dividing by 1155 so that the resulting data series represent an approximate accumulation of GWSS generations over time.

The analysis (Fig.2) indicated that the three year period 2014-16 had higher thermal time availability for GWSS development with the potential for GWSS to have produced 5 generations between Jan 2014 and December 2015. In contrast, the thermal time availability for the period 2011-13 was such that the normal pattern of two generations per year was indicated, and generation 5 over that 3-year period would not have occurred until the Spring of the 3rd year (2013).

We are currently working to compare the degree day approximation with the observed trap count data for the corresponding periods to verify that the projected temperature effect on GWSS development is present in the field data.

Work is progressing on the development of the dynamic simulation for GWSS/PD (Fig 3.). Initial development of the model is based on one previously developed by the Perring research group at UC Riverside, but not published in a widely available format.

Prof Perring shared a description of the model structure and we are in the process of translating this (with modifications) into both Simile and R versions. Figure 3 shows a screen shot from the Simile version of the model.

There are submodels for GWSS and grapevine development with relevant life stages for each organism identified as separate “compartments” within each submodel. The submodels are linked by the processes giving rise to infection of healthy grapevines by adult GWSS carrying bacteria, and by healthy adult GWSS visiting infected grapes and acquiring the bacterium.

Work is in progress to assign numerical values to the various rates in each submodel. The rates are represented by flows between the compartments. Once we have a working version of the model, the spatial structure of the southern San Joaquin production area will be represented by implementing multiple copies of the model, representing different local GWSS populations, and linking them by immigration and emigration relationships that capture the regional movement of GWSS. This is the point where the two objectives of the project come together, because the analysis of the GWSS trap data will inform us as to how the GWSS population is subdivided within the region and allow us to make reasonable estimates of the exchange in adult GWSS between the different local areas.

Research Relevance

Results of this research project will demonstrate what factors, over time and space, are associated with increases in GWSS populations, in the presence of area-wide management practices. Understanding when, where, and under what conditions GWSS populations may be escaping area-wide management will be a significant contribution to adaptive management of PD. We will combine these findings with PD incidence in a dynamic disease transmission model. The ultimate result will be a public-facing tool for growers to assess their PD risk based on easily identifiable factors such as weather conditions, vineyard management practices, and proximity to citrus.

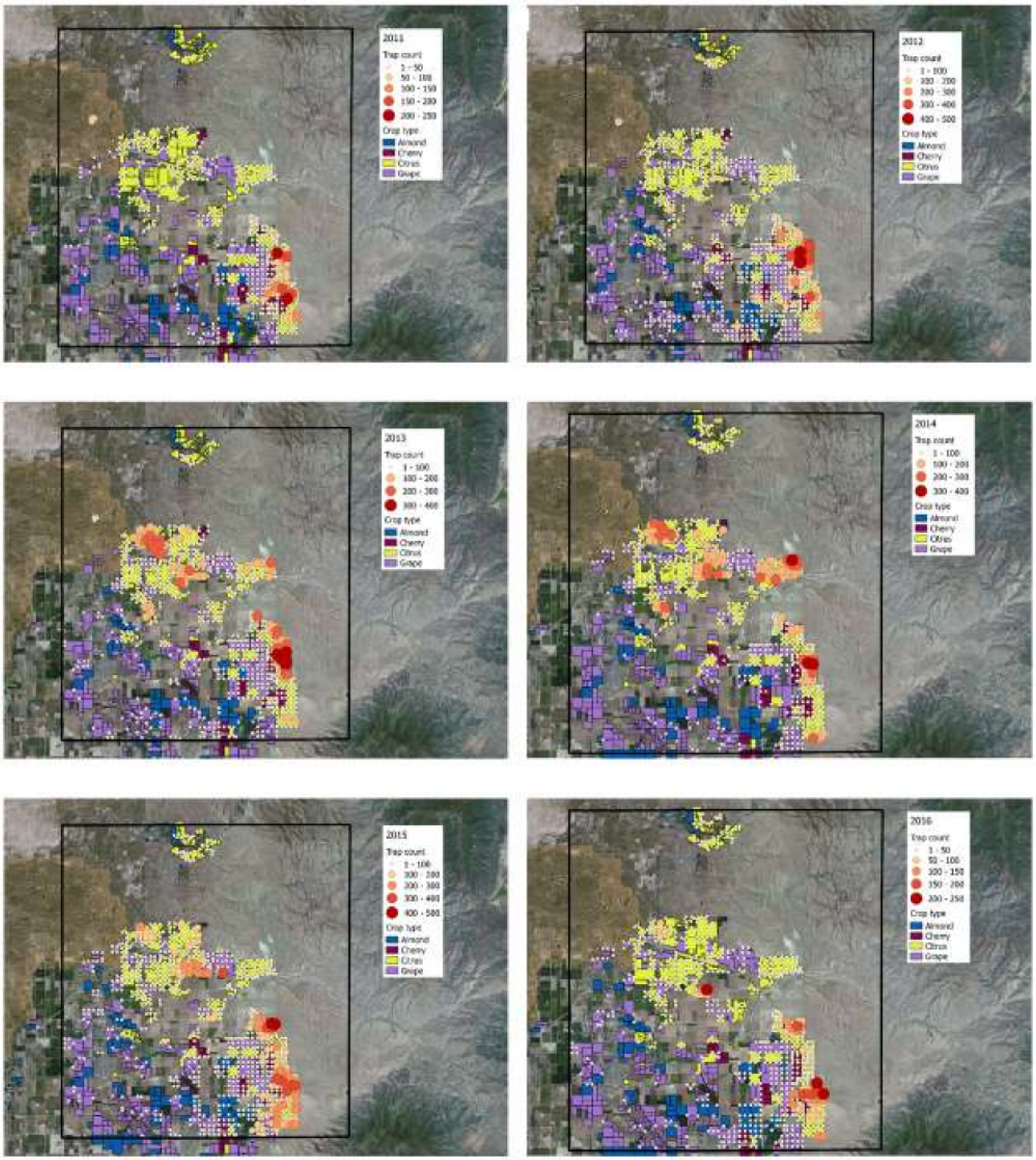
Layperson summary of project accomplishments

We are developing statistical descriptions and mathematical models of the long term Glassy Winged Sharp Shooter and Pierce's Disease situation in the southern San Jaoquin Valley, using the annual data collected by the GWSS area-wide control program and the annual UCCE survey of PD in grapes. The statistical analysis to date has indicated that the GWSS population in the region has localized hotspots that are relatively stable over time, and a more diffuse population which spreads out from and recedes into those hotspots on an annual basis. The analyses completed to date have been mostly descriptive, but we are now moving on to a more quantitative phase.

To complement the statistical analysis we are building a set of mathematical models of GWSS/PD dynamics for the area that will allow PD risk to be assessed more completely that has been possible up till now. An initial, simple phenology model based on degree day accumulation has been implemented, while construction of the more complex numerical simulation model is completed.

Loss of staff from project in the first half of 2017 delayed progress, but a new intern researcher has been appointed and is making good progress toward the project goals.

Figure 1: GWSS trap counts between 2011 and 2016.



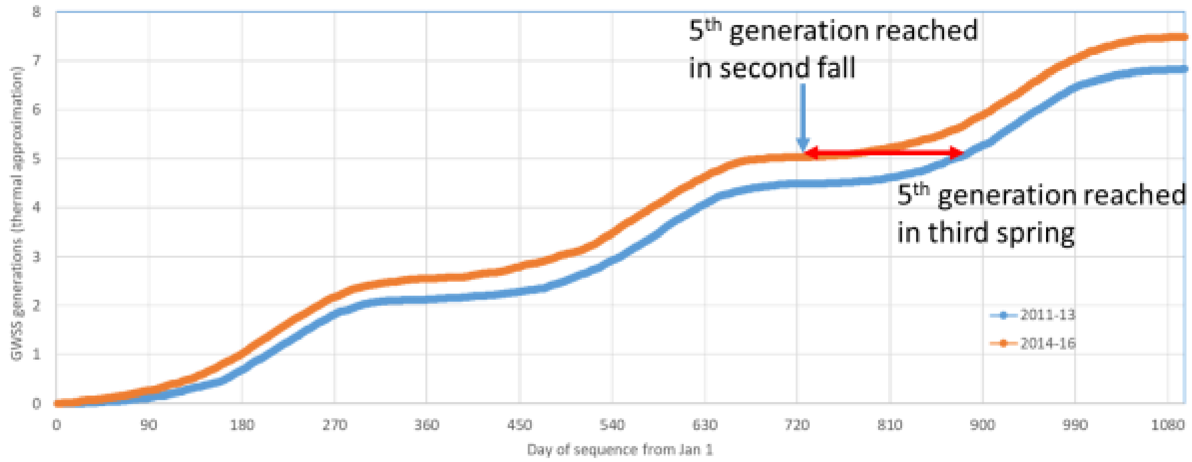


Figure 2. Approximate GWSS development degree day availability in two different 3 year periods in Kern Co, CA, based on temperature data collected at Arvin. The analysis indicates that development over the period 2014-2015 was sufficient to generate an extra adult population late in 2015 and an approximately 6-month advance in generation time compared with the previous three-year period.

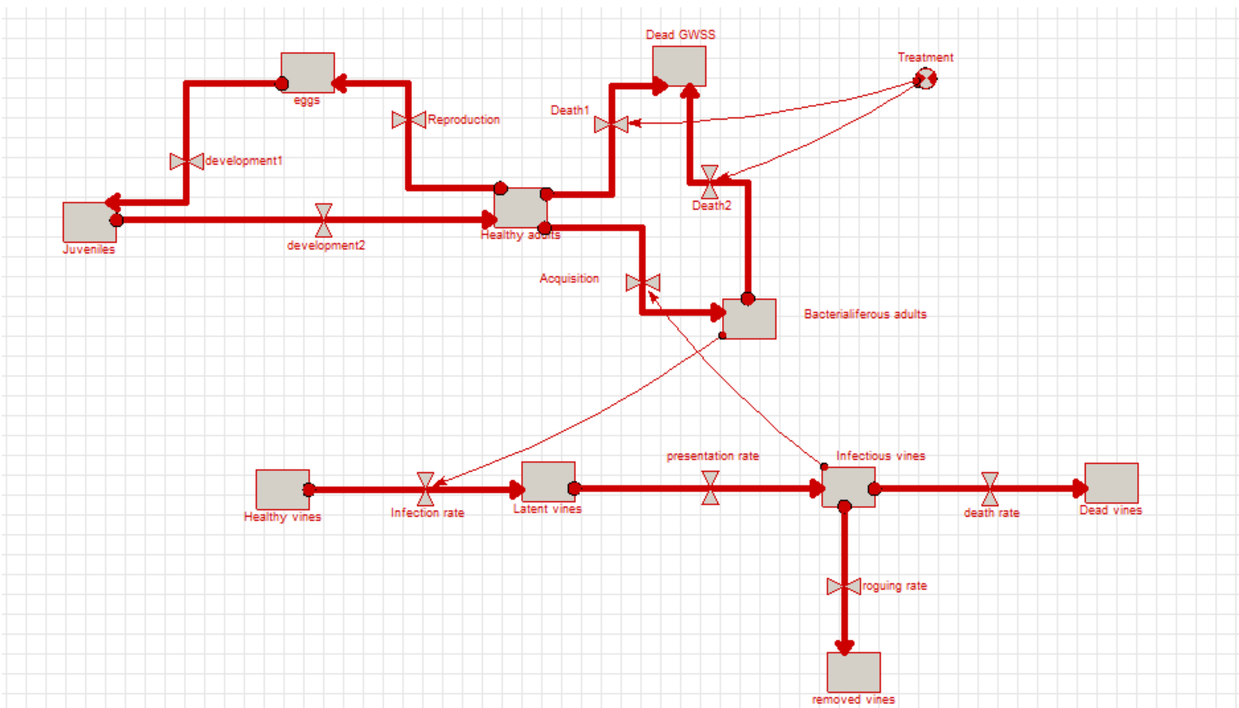


Figure 3. Simile implementation of a GWSS/PD model with submodels for GWSS and grapevine development. The GWSS model is toward the top of the figure and comprises an augmented lifecycle containing both healthy and bacterialiferous adults. The grape submodel contains healthy, latent-infected, infectious, and dead vines, and is augmented by a state for removed vines. The submodels are linked by the infection/acquisition process that transfers Xylella between the host and vector.