Has Climate Contributed to a Pierce’s Disease Resurgence in North Coast Vineyards?

M.P. Daugherty, M. Cooper, R. Smith, L. Varela, R. Almeida

**Climatic Conditions Play an Important Role in Agroecosystems**

Differences in temperature, precipitation or humidity may contribute to interannual variability in crop yield, quality, or damage and underlie long-term trends in such effects over longer timescales. For grapevines, vine growth and berry quality are sensitive to climatic conditions, with the expectation that climate change is altering which regions are most suitable for premium wine grape production. Climate change may also impact damage to vines, requiring changes to pest and disease management programs. One disease whose epidemiology is strongly tied to climate is Pierce’s disease (PD).

**Pierce’s Disease and the Role of Climate**

PD is caused by a strain of the bacterium Xylella fastidiosa that causes progressive leaf scorch, desiccation of fruit, defoliation, and vine death (Figure 1). Although there are some differences in symptom expression among cultivars, all conventional cultivars of Vitis vinifera are considered susceptible to the pathogen. X. fastidiosa is transmitted by multiple species of xylem-sap feeding insects, including sharpshooter leafhoppers and spittlebugs.

In coastal areas of California, PD is strongly associated with the activity of the native blue-green sharpshooter (BGSS, Graphocephala atropunctata), which is efficient at transmitting X. fastidiosa to grapevines. Patterns of disease reflect proximity to BGSS reproductive habitats, with clustering of diseased vines typically on the periphery of vineyards near riparian habitats.

PD in the North Coast, including Napa and Sonoma counties, is episodic—modest in most years, but with occasional periods of high incidence. At least three epidemics have occurred in the region since the 1970s, including an ongoing resurgence in which surveys have documented upwards of 30 percent disease in some vineyards (Figure 2). A comprehensive understanding of the episodic nature of PD in this region, or the cause of the current outbreak, is lacking. Ongoing research by the authors, funded by the Pierce’s Disease Control Program (cdfa.ca.gov/pdcp/), is evaluating the potential drivers of this resurgence, including whether recent climatic conditions played a role.

PD epidemiology has been known to depend on climate for several decades, based on observations that disease incidence was higher following warm, wet rainy seasons (Figure 2). Many aspects of the PD pathosystem have been linked around relatively wet, warm rainy seasons and warm growing seasons. Here, we ask whether recent climatic conditions in the North Coast have contributed to the ongoing PD resurgence by using long-term weather station records. Specifically, multiple temperature and associated metrics were analyzed to determine if conditions surrounding the approximate onset of an outbreak were noticeably different than historic observations in a way that is expected to favor PD.
Monitoring is needed to guide when or where vector management should occur. The easiest way to monitor blue-green sharpshooter is with double-sided sticky traps, which are available from several retailers (Figure 3). Very trap number based on block size, from at least a few traps for small blocks (less than two acres), up to one per two to three acres for larger blocks. Spread traps along the periphery of the block, especially nearby vector sources (riparian habitat, ornamental plantings) or other areas with high PD prevalence in the past. Place traps on trellis wires or posts above the trellis, slightly above the canopy, raising them as the canopy develops. Check traps at least monthly from budbreak through leaf fall, particularly during the Spring when weekly to biweekly checks may be justified. Record the number of sharpshooters and replace the trap as needed.

Disease surveys should occur yearly to identify which vineyards to remove due to lack of vigor or limited source of infection for vectors. PD symptoms are most apparent later in the growing season. Visually inspect each vine in the late Summer or early Fall, and flag those vines with symptoms for later removal. PD can be highly variable, and may appear similar to other diseases (Esca, Grapevine Lethal Blight Disease), nutrient deficiencies (magnesium, potassium), and excess soil salinity. Prior to vine removal, if unsure about symptoms, consider sending a sample of one leaf per vine collected from a subset of suspected PD vines to a laboratory for confirmation.

### Best Practices for Sharpshooter and Pierce’s disease Monitoring

#### Key Points
- Pierce’s disease (PD) has affected grape production for as long as commercial vineyards have been present in California.
- Ultimately, a large-scale, long-term monitoring program is needed in the region to understand comprehensively the role of climate in triggering a PD outbreak.
- Several PD epidemics have occurred, but their causes have not always been clear.
- Since approximately 2012, vineyards in the North Coast of California have seen a marked increase in PD prevalence, at least the third such outbreak since the 1970s.
- Local climatic conditions are known to affect many aspects of the PD pathosystem, including performance of the pathogen (Xylella fastidiosa) and vector (Graphophasa phlomoides).
- Analyses were conducted to assess whether the climate in recent years may have contributed to the observed PD resurgence in the region.
- Observed higher temperatures during both the dormant and growing seasons are consistent with elevated PD incidence in some, but not all, recent years.

#### Analysis of Recent Climatic Conditions in the North Coast

Records were collected from 11 weather stations located throughout Napa and Sonoma counties (Figure 2) that are part of the California Irrigation Management Information System (CIMIS) or National Climate Data Center networks (ipm.ucanr.edu/weather/index.html#weatherdata). Each included up to 90 years of daily measures of minimum and maximum air temperature, which were used to analyze multiple temperature and associated metrics during two seasons: “dormant” (November to March) and “growing” (March to November). Patterns in precipitation were not explored given the historic drought in the region at the time, which if warmer, more frequent, or slower than observed historically, whereas values less than 1.0 equate to observations that were colder, less frequent, or more rapid than was historically the case.

Three temperature metrics were considered for the dormant season: mean daily minimum temperature (\( T_c \)), number of days with a minimum temperature less than 4°C (i.e. frequency of “cold days” \( T_c \)) and maximum temperature. For the growing season, three similar metrics were considered: mean daily maximum temperature, number of days with maximum temperatures above 18°C (i.e. frequency of “warm days”), and the time to reach the degree-day requirement (i.e. less than 3.0) (Table 1). We then evaluated the following predictions for each year: warmer temperatures than was historically the case (i.e. more than 1.0), fewer cold days during the dormant season (i.e. less than 1.0), more warm days during the growing season (i.e. more than 1.0), and shorter times to reach the degree-day requirement (i.e. less than 3.0)

A set of statistical analyses were conducted to test, overall, whether the standardized temperatures and associated metrics in recent years differed from the historic average (i.e. 1.0). We then evaluated the following predictions for each year: warmer temperatures than was historically the case (i.e. more than 1.0), fewer cold days during the dormant season (i.e. less than 1.0), more warm days during the growing season (i.e. more than 1.0), and shorter times to reach the degree-day requirement (i.e. less than 3.0).

For the dormant season, historic means of the three climate metrics varied up to two-fold among the coldest and warmest sites, with minimum temperature showing the widest range (Table 1). The intercepts for all three metrics differed significantly from 1.0 (Table 1), and some years had significant deviations from historic means in a direction that may have contributed to PD incidence. The 2014-15 dormant season had higher minimum temperatures and lower frequency of cold days than historic averages, and both the 2013-14 and 2014-15 seasons had higher maximum temperatures (Figure 4).

For the growing season, mean values of the three climate metrics varied up to 35 percent among the coldest and warmest sites (Table 1). The frequency of warm days had an intercept that was marginally different from 1.0, whereas the other two were non-significant (Table 1). There were significant deviations from historic means for both of the metrics (in a direction that is consistent with greater PD pressure—daily maximum temperature was higher in 2015 (Figure 5A) and the frequency of warm days was greater in three of the years (Figure 5B).
Conclusions and Next Steps

For vector-borne diseases, epizootics may be attributable to a wide range of factors associated with the pathogen, vector, host or environmental conditions. X. fastidiosa usually needs periods of unusually high incidence that have been ascribed to pathogen introduction, prevalence of nearby reservoir hosts, invasion by a new vector, and with climate likely playing an important role.  

Multiple lines of evidence indicate that warmer conditions are generally associated with increased abundance of X. fastidiosa as well as increases in vector activity levels. Thus, it is plausible that these significantly warmer conditions in recent years elevated PD incidence in the North Coast of California. Ultimately, a comprehensive understanding of whether recent conditions contributed to the ongoing North Coast PD resurgence will require long-term, large-scale observations of sharpshooter abundance and X. fastidiosa infection dynamics in vines beyond what are currently available. This information is needed to gain insight into the epizootic nature of PD in the region, and to eventually be able to predict when an outbreak is likely to occur. In the absence of such predictive tools, it remains especially important for grape growers to monitor regularly for sharpshooters and PD (see sidebar), to identify those areas most at risk and to guide management decisions.

In the analyses presented, one metric each in the dormant and growing seasons had an overall intercept that differed significantly from historic averages. Thus, it is plausible that these significantly different from historic averages in all years. Indeed, by some interpretations, the first couple of years (2011 and 2012) during this window of time appeared colder than historic averages. Nor is it known definitely how many consecutive years of warmer than typical conditions are required to elevate PD incidence in the North Coast. Moreover, for warmer conditions in recent years elevated PD incidence in the North Coast of California. Ultimately, a comprehensive understanding of whether recent conditions contributed to the ongoing North Coast PD resurgence will require long-term, large-scale observations of sharpshooter abundance and X. fastidiosa infection dynamics in vines beyond what are currently available. This information is needed to gain insight into the epizootic nature of PD in the region, and to eventually be able to predict when an outbreak is likely to occur. In the absence of such predictive tools, it remains especially important for grape growers to monitor regularly for sharpshooters and PD (see sidebar), to identify those areas most at risk and to guide management decisions.

References
