Effect of Heat Stress on Grape Production in the San Joaquin Valley (SJV)

George Zhuang, Viticulture Farm Advisor, UCCE Fresno County

As the year concludes, I often reflect on the challenges of past growing seasons. Weather variability has significantly impacted grape production in the San Joaquin Valley (SJV), from the super cool 2023 season to wildfire smoke in 2020 and severe winter storms in 2021 and 2022. These events have led to suboptimal raisin drying conditions, high mildew and bunch rot incidence, delayed berry ripening, and inadequate raisin drying time. The 2024 growing season brought a prolonged heat wave, prompting concerns about its effects on grape yield and physiology. This discussion aims to summarize the short- and long-term impacts of heat waves on grape physiology and yield performance, alongside vineyard management practices to mitigate these effects.

Physiological Impacts of Heat Stress

Data from the UC IPM weather station at Kearney REC reveals that the daily maximum temperature inside canopy exceeded 100°F from June 21, 2024, through July 27, 2024 (Figure 1). Prolonged heat waves reduce stomatal conductance, which reduces photosynthesis, and thereby limits berry size and sugar accumulation. Detailed physiological effects from heat stress include:

1. **Impaired Photosynthesis**: Leaf photosynthesis operates optimally between 77°F and 86°F. Temperatures exceeding 110°F result in declines in stomatal conductance and photosynthesis. High temperature also increases photorespiration leading to a loss of carbon fixation and photosynthesis.
2. **Elevated Respiration**: Higher night temperatures from heat waves accelerate respiration, consuming stored carbohydrates faster and reducing carbohydrate supply for vine and fruit development.
3. **Oxidative Stress**: Heat stress leads to the accumulation of reactive oxygen species (ROS), which damage organelles such as chloroplasts and mitochondria, impairing essential metabolic processes.
4. **Water Stress and Stomatal Closure**: Heat stress intensifies water loss through transpiration, while stomatal closure to conserve moisture further limits gas exchange, compounding physiological strain.
5. **Accelerated Senescence**: Heat exacerbates physiological strain, hastening leaf senescence and reducing productive photosynthetic areas.

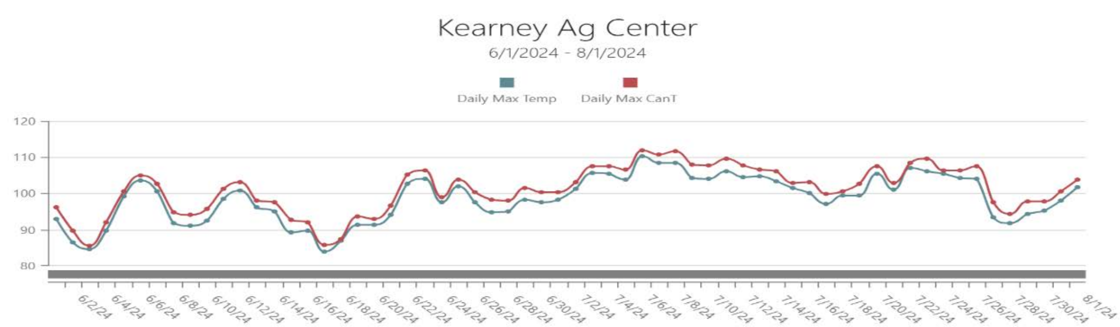

Figure 1. Daily Max ambient temperature (Max Temp) and Max temperature inside canopy (Max CanT) at UC Kearney REC Selma Pete vineyard between 06/01/24 and 08/01/24.

Direct Impacts on Yield Formation

Heat stress affects grape yield indirectly through impaired photosynthesis; however, more importantly, heat stress can affect grape yield directly. Yield components can be affected by heat stress, including:

1. **Bud Fruitfulness:** Cluster primordia forms between bloom and veraison and are highly dependent on temperature and sunlight. For example, sun-exposed "sun canes" of *Thompson Seedless* develop more fruitful buds than shaded canes. Heat stress during this period reduces photosynthetic carbon supply, negatively affecting next year's crop potential.
2. **Fruit Set:** Heat stress interferes with pollen viability and production of auxins, preventing fertilization. Combined with water deficit during bloom, heat exacerbates poor fruit set and even bunch necrosis (Photo 1).
3. **Berry Size**: Berry growth follows a double-sigmoid curve, and heat stress during berry growth impairs cell division and elongation, leading to smaller, less plump berries (Photo 2).

Photo 1.) Poor fruit set and early bunch necrosis

Photo 2.) Shot berries on Pinot Noir

4. **Sugar Accumulation**: Heat shifts carbon allocation towards vegetative growth, delaying fruit ripening and leading to uneven berry maturation.
5. **Berry sunburn:** Grape berries are designed to minimize water loss by transpiration, especially after veraison. Berries on the "afternoon sun" side of the canopy experience higher temperatures, risking sunburn due to limited evaporative cooling and insufficient protective phenolic accumulation (Photo 3).

Photo 3.) Sunburn on Thompson Seedless

Mitigation Strategies

Vineyard management should aim to minimize heat load and vine water stress, while enhancing evaporative cooling to protect both the canopy and the berries. Effective management practices that can mitigate the impacts of heat stress include:

1. **Irrigation**: Providing adequate irrigation before and during heat events supports vine transpiration and evaporative cooling. Pre-heatwave drip irrigation is especially critical. Although overhead misting—common in apple orchards, like in Washington—offers effective cooling, it may increase fungal disease risk in grapes
2. **Canopy Management**: Early-season leaf removal can balance sun exposure and airflow. However, late-season removal (post-veraison) can expose previously shaded berries to sunburn, especially if those berries lack phenolic "sunscreen" compounds (Photo 4).
3. **Vine Row Orientation and Trellis Design**: Orienting rows from southwest to northeast and selecting sprawling trellis systems can help reduce canopy temperature. Raising cordon and fruiting zones reduces soil heat radiation on the cluster zone.

Photo 4.) Sunburn on Cabernet Sauvignon

4. **Variety and Rootstock Selection**: Planting heat-tolerant cultivars and drought-resilient rootstocks improves long-term vineyard resilience to climate extremes.
5. **Shade Nets and Overhead Film**: Shade nets and overhead films can reduce direct solar exposure and lower canopy temperatures, though cost and practicality must be considered (Photos 5a and 5b).

Photo 5a.) Shade Cloth

Photo 5b.) Shade Film

6. **Sprayable Sunblock**: Products like kaolin and calcium carbonate create reflective barriers, reducing heat absorption and protecting berries (Photo 6).
7. **Cover crop**: Inter-row cover crops increase soil reflectance and evapotranspiration, reducing soil heat accumulation and enhancing evaporative cooling. However, maintaining cover crops during summer may require additional irrigation.


Photo 6.) CaCO3 spray

Conclusion

The prolonged heat events of 2024 have underscored grower concerns about both immediate yield losses and the long-term impacts on future crops. While a range of mitigation strategies—such as trellis design, shade nets, and sprayable sunblock—can help reduce heat load, irrigation remains the most effective and accessible tool for short-term mitigation. Cover crops also provide cooling benefits but require additional irrigation to remain viable during summer.

Strategic pre-heatwave irrigation, combined with thoughtful canopy and vineyard design, can substantially reduce the physiological and yield-related impacts of extreme temperatures. For long-term climate resilience, the adoption of heat-tolerant cultivars and drought-resistant rootstocks will be essential.

By understanding how grapevines respond to heat stress, growers can implement targeted management practices to maintain vine health and productivity—ensuring sustainable grape production in the face of increasing climate variability.

June, 2025

Spotted Lanternfly, California's Next Problematic Invader

Karl T. Lund, Area Viticulture Advisor, Madera, Merced, and Mariposa Counties

The Spotted Lanternfly (SLF) (*Lycorma delicatula*) is an invasive plant hopper native to Northern China. It was first identified in the United States in Berks County, Pennsylvania, back in 2014. From there, it spread along the eastern seaboard with known infestations from Massachusetts down to North Carolina, and west as far as Chicago, Illinois, and Nashville, Tennessee, with 17 states currently having known infestations (Image 1). Since the publication of image 1, an

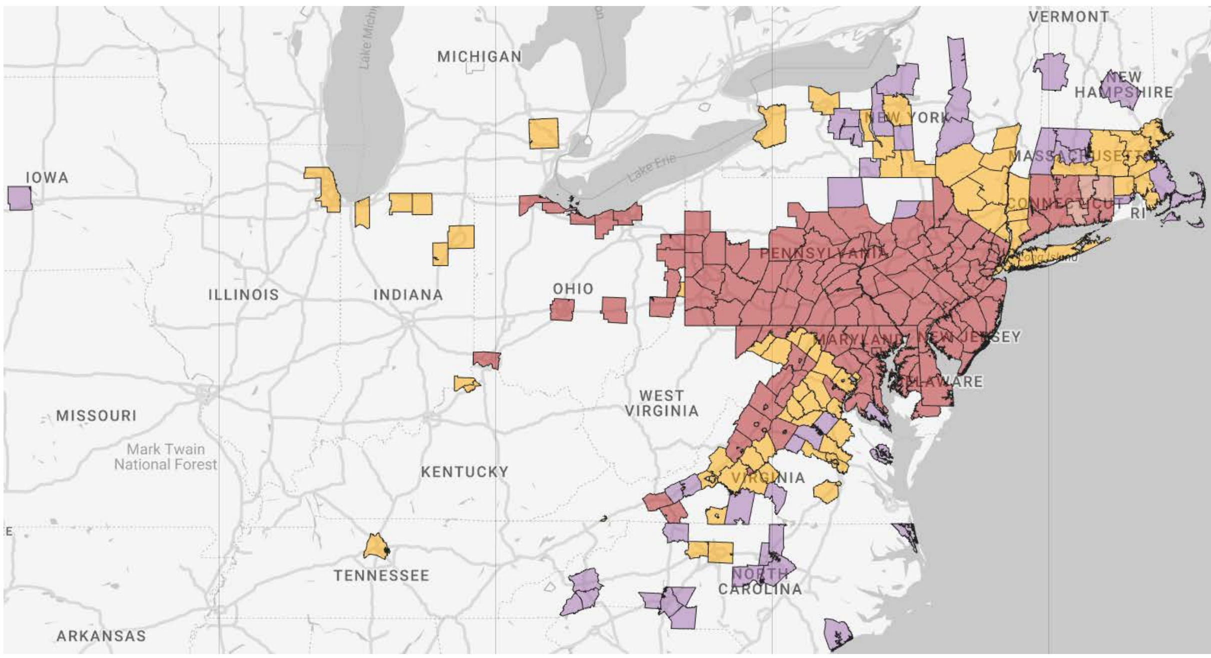

Image 1. September 2024 Spotted Lanternfly Infestation Map. Red is Counties with infestations under quarantine, Yellow is Counties with infestations not under quarantine, and Purple is Counties with at least one sighting but no known Infestation. Map and data from New York State Integrated Pest Management webpage, part of Cornell University College of Agriculture and Life Sciences (https://cals.cornell.edu/new-york-state-integrated-pest-management/outreach-education/whats-bugging-you/spotted-lanternfly/spotted-lanternfly-reported-distribution-map)

up to 18 states. Given SLF's quick spread across the eastern United States, it is crucial to understand where else SLF can spread.

Scientists from the USDA and Xinjiang Institute of Ecology and Geography in China have already conducted work to see what portions of the United States have the right climate for SLF. The analysis shows that the Atlantic coast from the Carolinas up to New Hampshire and Maine is moderately to highly suitable for SLF. On the western side of the Appalachian Mountains, a belt forms starting in Western New York along the Great Lakes, spreading along the lakes into Ohio before it spreads out and covering most of Ohio, Indiana, Illinois, and Missouri, along with portions of Southern Michigan, Iowa, Nebraska, and Kansas with high suitability climate for SLF infestation (Image 2). Comparing the current (Image 1) and climatic (Image 2) ranges of SLF we can see that SLF has already colonized much of its climatic range along the East Coast and is spreading into the belt west of the Appalachian Mountains.

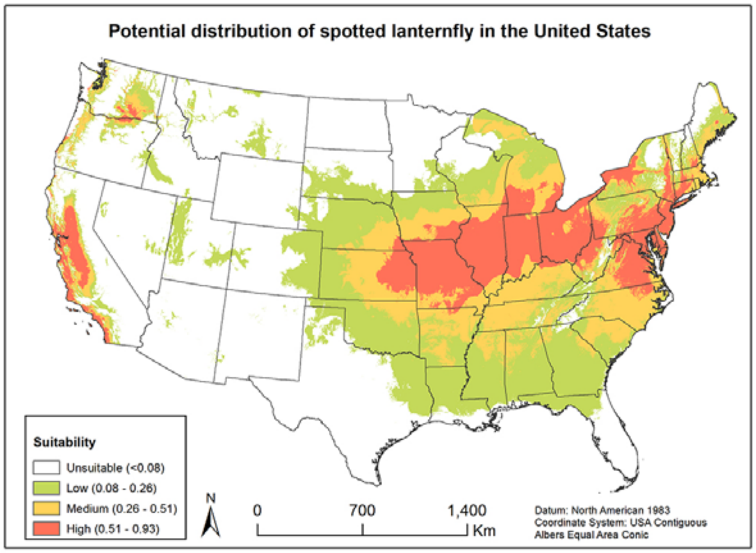

Image 2. Potential distribution of Spotted Lanternfly across the United States using climatic data. Image from https://entomologytoday.org/2019/10/03/invasive-spotted-lanternfly-large-potential-range-united-states-beyond/

The climatic range also shows that the mountain ranges in the Western United States will provide West Coast agriculture with a barrier to SLF. The grape-growing regions in eastern Washington state have a large section of highly suitable climate regions for SLF. Meanwhile, the grape-growing regions in western Oregon have a moderately suitable climate. However, if SLF can make it to California, most of our agriculturally important regions will be highly suitable for SLF. Despite the long distance from Chicago and Nashville to California, human intervention has already brought SLF to California's doorstep (at least twice).

These two incidents occurred in July of 2022 and March of 2024. The July 2022 incident occurred when CDFA Border Inspection Agents identified Spotted Lanternfly egg masses on firewood at the Truckee Border Protection Station. The firewood, originally from New Jersey, was confiscated and destroyed before entering California. The March 2024 incident again occurred when CDFA Border Inspection Agents identified Spotted Lanternfly egg masses at the Truckee Border Protection Station. In this case, 11 viable egg masses were identified on a 30-foot-tall metal artwork being transported to California. The infested artwork was refused entry until it was decontaminated. In Nevada, 30 additional egg masses were found during decontamination. Once the artwork reached its final destination in Sonoma County, the local AG Commissioner's staff reinspected the load and found an additional three egg masses, which were promptly destroyed.

These two incidents are a great example of the value that the CDFA Border Inspection Agents and local AG Commissioner's staff can have in preventing invasive species from getting into California. They are also two critical examples of how quickly and far humans can move an invasive species. Lastly, it shows us in California that we need to understand the threat that Spotted Lanternfly poses to California's viticulture and agriculture in general. To do this, we will go through SLF reproduction, identification, host range, feeding damage, and control methods being used in Pennsylvania.

In Pennsylvania, SLF has an annual lifecycle (Image 3). Eggs are the overwintering portion of the lifecycle, hatching in spring (May to June). The first instar that hatches from the eggs has a black body with white spots and can be up to 1/8 inch long (Image 4B). The second and third instars also have black bodies with white spots only differing from the first instars by their larger size. The fourth instars appear in Summer (July to September). They have red bodies with black lines and white spots measuring up to ½ inch in length (Image 4C). Adult SLFs appear in summer and live until the

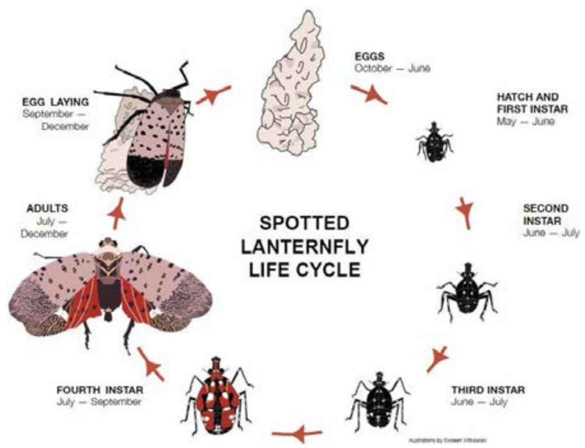

Image 3. Spotted Lanternfly life cycle. Image from: https://extension.psu.edu/spotted-lanternfly-what-to-look-for

end of the growing season. The adults have an upper and lower set of wings. The upper wings, which are visible when they are resting are light grey with black stripes at the wing tips and black spots closer to the shoulders (Image 4D). The lower set of wings are exposed when the adults fly/glide and are red wings with black spots that are easily identified (Image 4E). Adults lay eggs in the fall to early winter (September – December). Egg masses are covered in a white to light-grey putty-like substance. This substance hardens, cracks, and resembles mud or tree bark once dry (Image 4A). Each adult female can lay at least two egg masses, and each egg mass will include 30 – 50 eggs.

All SLF instars are great jumpers, and jumping is their primary mode of movement and defense. They are adapted to jump from plant to plant and away from potential enemies. All instar stages continually migrate while feeding, rarely staying on a single plant for more than 2-3 days. Instar stages 1 - 3 prefer to feed on young (still green) shoots. The fourth instar stage has grown large enough to feed on mature (lignified) plant materials. Adult SLFs are also good jumpers and still use this to get around. The wings of adult insects are strong enough to fly, although not very well. Their dominant mode of movement is to jump and then use their wings to glide from location to location. This jump and glide technique allows SLF adults to have a feeding range of 2-3 miles. The adult SLF is strong enough to feed through the bark of many different tree species.

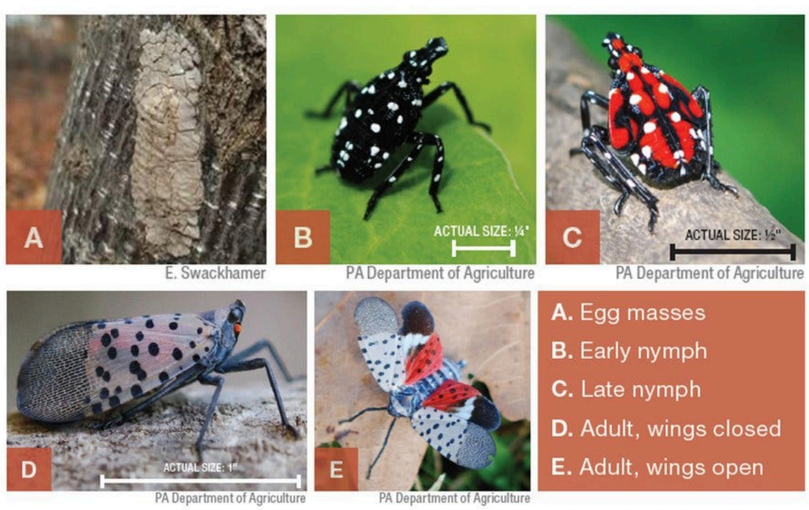

Image 4. Spotted Lanternfly Identification Images. A. Egg mass, B. Instar 1- 3, C. Instar 4, D. Adult with closed wings, E. Adult with exposed underwings. Image from Penn State Extension: https://extension.psu.edu/spotted-lanternfly-what-to-look-for

The host range of SLF is extensive. SLF has been found feeding on soy, corn, basil, cucumber, roses, *Limonium* flowers, and even grass for basic survival. None of these are preferred hosts, but they allow the SLF to feed and survive while looking for its preferred hosts. The most preferred host is the invasive Tree of Heaven (*Ailanthus altissima*). This is a Chinese weedy tree species that attracts SLF. Spotted lanternfly feeding on Tree of Heaven reproduce readily. Grapes, black walnuts, hops, and maple trees also see high levels of feeding and reproduction, although not as high as the Tree of Heaven. Less preferred hosts include willow, apple, blueberry, mulberry, fig, stone fruits, birch, sycamore, lilac, poplar, staghorn sumac, and Virginia creeper. Spotted lanternfly will feed on these hosts but move on more quickly to find better hosts.

Luckily, SLF feeding is not extremely detrimental to most plants. SLF are phloem feeders that emit large amounts of honeydew while feeding. That honeydew can act as a substrate to initiate the growth of sooty molds or as an attractant to other insects. Due to the SLF's large size and mobile, the cooperation between ants and other honeydew-producing insects is not likely to be established. The production of honeydew is indicative of a large amount of carbohydrates (energy) being removed from the plant, and the effects this loss has on the plants can be seen in several studies. Studies done on Black Walnut, Red Maple, Silver Maple, and Tree of Heaven found that SLF feeding lowered carbon assimilation, stomatal conductance, and transpiration (Lavely et al. 2022). Long-term, this feeding does lead to lower starch levels, total nonstructural carbohydrates, and overall tree size (diameter) (Hoover et al. 2023), but it does not kill mature trees. The only tree deaths attributed to SLF are young saplings of Black Walnut and Tree of Heaven after heavy infestation.

Studies done on grapevines show a similar lowering of carbon assimilation, stomatal conductance, and transpiration, which leads to lower starch levels in the root system at the end of the growing season. It also leads to lower nitrogen levels in both leaf and root tissues. The carbon deficit is enough that grape samples taken from moderately to heavily infested vines showed lower Brix levels at harvest (Harner et al., 2022). Additional work that has yet to be published shows that SLF infestation leads to lower berry and cluster weight, lower numbers of clusters per vine, and an overall lower yield. Vineyards with high SLF concentrations also see higher levels of overwinter vine mortality.

As a phloem-feeding insect that moves regularly between vines, SLF is also a possible vector of viruses and microbial diseases. Thus far, testing has shown that SLF is not able to vector any grape (or other host plant) viral diseases. However, recently, SLF has been implicated in the vectoring of Pierce’s Disease (PD). Despite being a phloem-feeding insect and PD being a xylem-limited bacteria, recent work has shown that SLF can vector PD (Islam et al. 2024). The findings do indicate that SLF is a poor vector of PD. However, given that SLF feeds in large numbers, regularly moves between plants while feeding, and has an extensive feeding range, even if SLF is a poor vector, it could still be a devastating PD vector.

Given the damage that SLF can cause to grapevines, what control options are available? Extensive testing has been done in the Eastern US, primarily in Pennsylvania, to control SLF in vineyards. As these tests have been conducted in different states, the results may vary due to differences in climatic and cultural practices. More importantly, due to regulatory differences, availability and application concentrations may differ in California (or other western states). For systemic control, dinotefuran has shown excellent control, while imidacloprid has shown variable control. Beta-cyfluthrin, bifenthrin, carbaryl, zeta-cypermethrin, malathion, and natural pyrethrins have demonstrated excellent contact control. At the same time, neem oil, insecticidal soaps, horticultural oil, paraffinic oil, and botanical oil have all shown good control. Overall, this gives growers many different options to choose from.

Despite many promising chemical controls, there are a few general problems with them. The first is the timing of applications near harvest. SLF doesn't start laying eggs until September and continues through December. They are still actively feeding and moving into new locations during harvest. An uninfested vineyard could become infested the week or even the day before harvest and in large numbers. This means you will be limited by the pre-harvest interval as to what controls are available.

Another problem is the reinfestation of your vineyard after a successful spray. Given the mobile nature of SLF, reinfestation of a vineyard after a successful spray is high. Of all previously mentioned chemical controls, only dinotefuran, beta-cyfluthrin, and bifenthrin had good residual activity. The remaining chemicals had limited or no residual control effects on SLF. This means growers must regularly spray their vineyards to combat the reinfestation cycle. Even regularly spraying the vineyard will not prevent the negative impact on the grapevine. The previously mentioned work showing lower carbon assimilation, stomatal conductance, transpiration, and Brix due to SLF feeding (Harner et al. 2022) was conducted by only allowing the SLF to feed in 4–10-day feeding cycles.

This all leads to the ultimate limitation of chemical control of SLF: growers cannot spray the source of the SLFs. Given SLF's extensive host range and large feeding range, they are just as likely to find a home in agricultural, urban, abandoned, or riparian/wild settings and move back and forth between them. To prevent the infestation cycle, we need to control SLF in all these settings, which is outside of growers' control. Even with urban spraying from the local agricultural commissioner's office or other government agencies, we won't be able to curb their numbers everywhere once a population is established in enough locations.

The best option to stop SLF is to either prevent it from entering California or eliminate it before it can establish and start spreading. CDFA Border Inspection Stations have blocked SLF from entering CA twice (with an assist from the Sonoma County Agricultural Commissioner's office). Continued and increased support for the border inspection stations will hopefully prevent California agriculture from ever dealing with SLF. However, given the size of California, the number of ways into California, and the amount of people and products that come into California, there is a strong likelihood that, eventually, SLF will find itself in California.

If (when) SLF does find its way to California, the only chance to stop it is before it can establish and spread. That can only happen if we catch SLF before they can do that. When going back to the initial infestation site in Pennsylvania and the most recent site in Georgia, SLF had been in those sites for an extended time before official discovery. In the case of the initial infestation site in Pennsylvania, local workers commented on trying to catch the 1st, 2nd, and 3rd instars as they jumped away from them. Those workers didn't know what they were playing around with would become such a problem. Nor did those workers know how and where to report SLF. California cannot have the same thing happen. The first Californian who sees a SLF needs to know what they are looking at and how to report that SLF has made it to California.

Thankfully, CDFA and the Pierces Disease/Glassy Winged Sharpshooter (PD GWSS) Board have seen SLF's threat to California. CDFA has produced a series of handouts and fliers in English and Spanish in their snag it, snap it, report it response plan. These handouts and fliers are free to download from the CDFA website: https://www.cdfa.ca.gov/pdcp/board/spottedlanternfly.html. The handouts and fliers have images to help identify SLF, a phone number, a website, and even a QR code to report any SLF sightings. This is a fantastic start for California's response to SLF. The problem with the response is its lack of extension to the agricultural community and the general public.

I want your help in spreading the word about this pest. The handouts and fliers linked above are set to print on a standard 8.5 x 11 sheet of paper. Printing out some of the flies to hang your operations' common areas is a good start. Sharing this information and the link with neighboring operations, labor contractors, and pest management partners will also help spread the information further. A step further would be to hand out these handouts and fliers to anyone spending significant time in your fields. Everyone involved in agriculture, from owners and managers to harvest crews and day laborers, should know how to identify and report SLF. Of course, even if everyone involved in agriculture nationwide knew how to identify and report SLF in 2014, that would not have prevented much of the current situation. From the initial outbreak in Pennsylvania to the furthest western extent of SLF's current expanse in Chicago, Nashville, and Atlanta, have not been agricultural areas. We in the agricultural community need to spread the information internally and get information about SLF to the general public.

Additional Resources:

As they have been on the front lines of this fight for 10 years, Penn State Extension has a vast amount of knowledge available on their webpage:

https://extension.psu.edu/spotted-lanternfly

Their neighbors to the north New York State Integrated Pest Management also have a great webpage to find additional information:

https://cals.cornell.edu/new-york-state-integrated-pest-management/outreach-education/whats-bugging-you/spotted-lanternfly

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UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UC Cooperative Extension, Fresno County

2025 San Joaquin Valley Grapevine Rootstock Field Day
Wednesday, July 23rd, 2025
17353 W Oakland Ave, Five Points, CA 93624

6:30 AM Refreshments and take the tram to the field

7:00 AM **Grape Varieties and Rootstocks Evaluation under Drought and Saline Conditions**
George Zhuang, UCCE Fresno, and Karl Lund, UCCE Madera, Merced, and Mariposa

7:30 AM **Vineyard Soil Health and Cover Crop**
Lauren Hale, USDA ARS

8:00 AM **Vineyard Weed Management**
Jorge Angeles, UCCE Fresno, Tulare, and Kings

8:30 AM Take the tram back to the conference room

9:30 AM **Sunpreme Raisin Rootstock and Nutrient Study at Kearney REC**
Matthew Fidelibus, UC Davis

10:00 AM **Spray Technology on Mechanized Pruning Vineyard System**
Peter Ako Larbi, CE Specialist, UC ANR

10:30 AM **Vineyard Mealybug Management**
Kent Daane, UC Berkeley

11:00 AM **Wine Grape Rootstock study at Oakville Station**
Justin Tanner, UCCE San Joaquin County

11:30 AM **Rootstock Drought Resistance (Pending)**
Megan Bartlett, UC Davis

12:00 AM **Lunch and Discussion**

1.5 hours of DPR and 4 hours of CCA credits have been applied.

Our programs are open to all potential participants. Please contact the UCCE Fresno County office (two weeks prior to the scheduled activity) if you have any barriers to participation requiring accommodation.

550 E. Shaw Avenue, Suite 210-B, Fresno, CA 93710 (559) 241-7515

UNIVERSITY OF CALIFORNIA
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SAVE THE DATE

GRAPE DAY

Tuesday, August 12, 2025
8:00am - 12:00pm

UC Kearney Agricultural Research

and Extension Center
9240 S Riverbend Ave
Parlier, CA 93648

DPR and CCA CEUs will be applied for