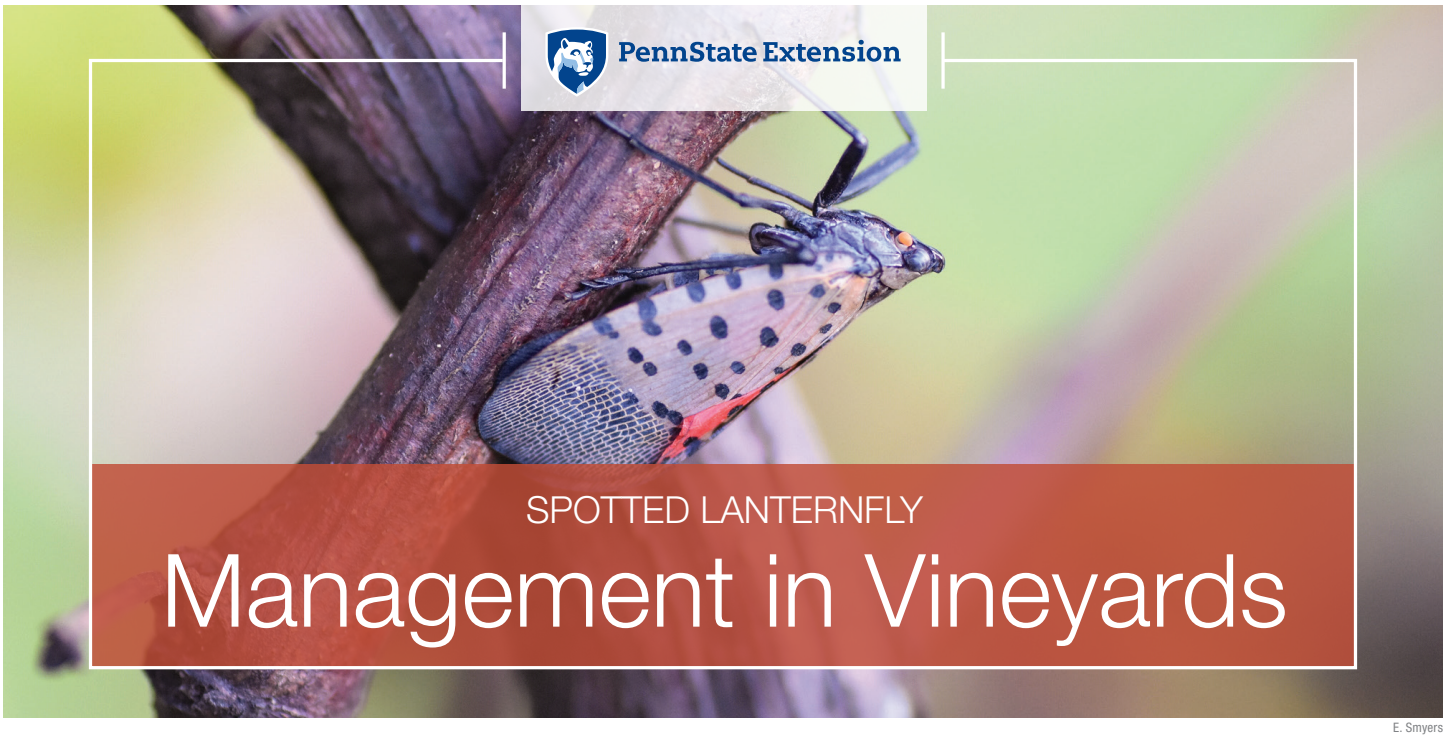

PennState Extension

SPOTTED LANTERNFLY

Management in Vineyards

E. Smyers

Spotted lanternfly (SLF), *Lycorma delicatula*, is an invasive planthopper, native to Asia, that was first detected in 2014 in southeastern Pennsylvania. As of April 2023, SLF is found in Pennsylvania, New Jersey, Virginia, West Virginia, Maryland, Connecticut, Massachusetts, Rhode Island, Delaware, New York, Ohio, Michigan, Indiana, and North Carolina. SLF feeds on many plants, including economically important crops like grapevines, cucumber, hardwoods, and ornamentals. Significant damage has been reported from SLF extensively feeding on grapevines, including reduced starch concentration in vine roots and sugar in the fruit at harvest, reduced yield in the subsequent year, and potential death of vines. This guide will review our current knowledge and best management practices for this insect in vineyards.

Life Cycle and Identification

SLF is not actually a fly, but a planthopper. There is one generation of SLF per year. The eggs are laid in the fall (September to November) and hatch in the spring (late April to June). Egg masses are laid on smooth surfaces (trees, outdoor equipment, vines, posts, etc.) and protected with a mud-like covering. Egg masses usually contain around 35–45 eggs each (Figure 1A). A single SLF female can lay at least two egg masses. After hatching and before reaching adulthood, SLF goes through four immature (nymph) stages. Nymphs are small (⅛ to ½ inch) and can be hard to find (Figure 1B). The first three stages are black with white spots, while the last instar is red with white dots and black stripes (Figure 1C). All nymphs are highly mobile and are strong jumpers. SLF adults emerge in July and are active until the first hard frost. SLF adults are the most obvious and easily detectable stage: Adults have black bodies with brightly colored hindwings and can fly. SLF most commonly fly in the afternoon on warm and sunny days. SLF forewings are gray with black spots; the tips of the wings are black with gray veins; and their hindwings are red, black, and white. Because SLF adults walk and jump more than fly, their wings usually remain closed (Figure 1D). Splayed wings can often be a sign of pesticide poisoning (Figure 1E).

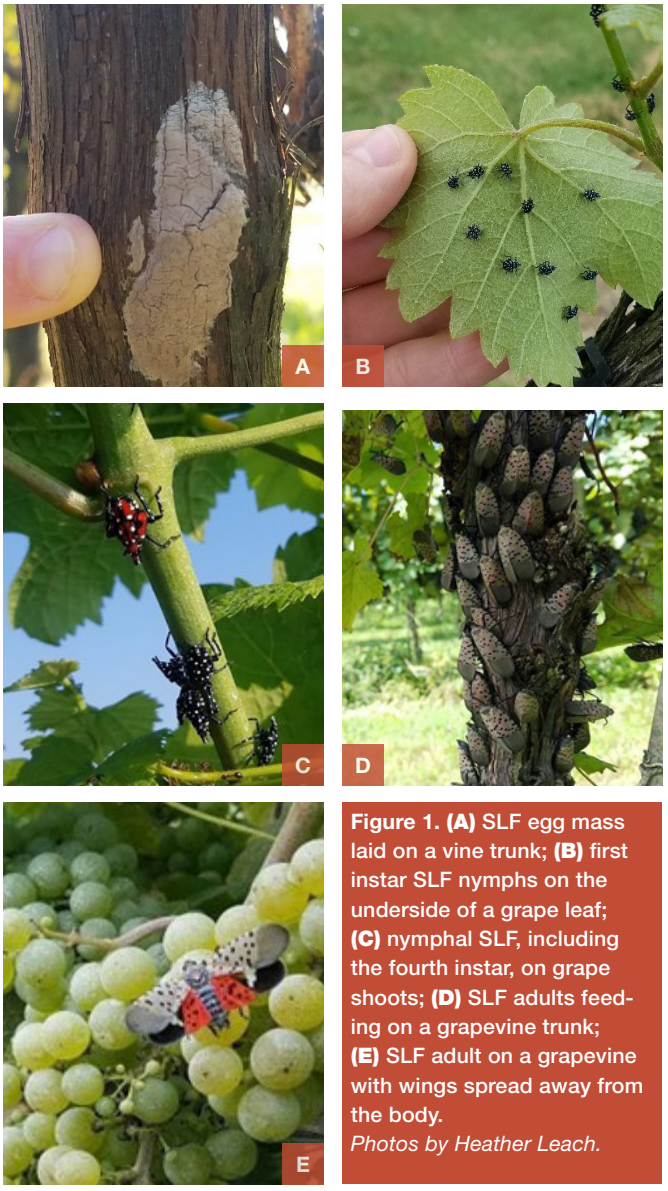

Figure 1. (A) SLF egg mass laid on a vine trunk; **(B)** first instar SLF nymphs on the underside of a grape leaf; **(C)** nymphal SLF, including the fourth instar, on grape shoots; **(D)** SLF adults feeding on a grapevine trunk; **(E)** SLF adult on a grapevine with wings spread away from the body.
Photos by Heather Leach.

Feeding Damage

SLF feed on plant phloem tissue (sap) using piercing-sucking mouthparts. Current research suggests that they prefer plants with significant turgor pressure, which could help explain why they favor grapevines. SLF utilize the nutrients provided by the plant and also rely on bacteria in their guts to help digest sap. When SLF feed in high numbers on grapevines, photosynthesis and sap flow in the plant is reduced. Heavy SLF feeding can also decrease the amount of carbohydrates (i.e., starch) and nitrogen stored in root tissues in the fall, which might compromise vine health and growth in the following year. Reductions in fruit sugar accumulation and in macro- and micronutrient concentrations in leaf tissues were also reported by the end of the season following heavy SLF feeding. Research is still in progress to establish action thresholds for SLF, though this will likely be dependent on age, variety, location, and baseline health of the vine.

As SLF feed, they ingest large quantities of sap, filtering the needed nitrogen and proteins and excreting excess levels of sugars and water as waste products (much like aphids, scales, and other sucking insects). This excrement, called honeydew, accumulates around areas where SLF are feeding. On sunny days, you may be able to see honeydew dropping from trees. Honeydew can be attractive to ants, wasps, bees, and other sugar-loving insects. As the honeydew builds up, it is often colonized by sooty mold fungi. Sooty mold doesn't directly harm plants or the surfaces it grows on, but it acts as a barrier on the leaf and blocks photosynthesis. With high numbers of SLF, understory plants may die back because of sooty mold buildup. On grapevines, the trunk, cordons, and leaves may begin to turn black with sooty mold. Sooty mold can only persist with the honeydew to feed on and will not infect the grapevine itself. There are currently no recommendations for removing sooty mold from grapevine trunks or cordons. Sooty mold is seldom recorded on the clusters and has not been reported as a problem for marketability or wine taint. We do not know if honeydew on clusters can increase rot infection. Based on research data from 2018 and 2019, increasing levels of SLF on *V. vinifera* vines were correlated with a reduced number of clusters per shoot the following spring. It's still unclear if SLF's extensive feeding may reduce the hardiness of the vine and potentially increase bud or vascular tissue (i.e., phloem and xylem) susceptibility to winter injury. If your vines had high levels of SLF feeding in the summer or fall, you should evaluate bud injury before pruning the vines; moderate to high levels of bud injury require differing pruning strategies, such as increasing the number of buds retained to compensate for bud mortality or renewing trunks.

Phenology and Spatial Distribution in Vineyards

SLF are voracious feeders and can be extremely abundant as adults in vineyards. Adults start to appear in vineyards in August, but high populations are not typically observed until mid-to-late September (Figure 2). For vineyards that are first experiencing SLF, this phenology is typically shifted later into the season—you may not see large numbers invade the vineyard until October. After one or two years, adult SLF typically invade vineyards earlier in the season (late August). More importantly, the majority of SLF adult population within a vineyard is observed on the edge; on average, 54 percent of the SLF population is within the first 50 feet of the vineyard edge. Depending on the landscape surrounding the vineyard, the edge of the vineyard may account for even higher SLF numbers (upward of 80 percent of the population). Most SLF are observed feeding on the shoots, though later into the season more can be found on older wood (e.g., trunk and cordon). The majority of adult SLF observed in vineyards are female.

Egg masses are often found on the edge of the vineyard. Research suggests that SLF prefer to lay eggs next to an existing

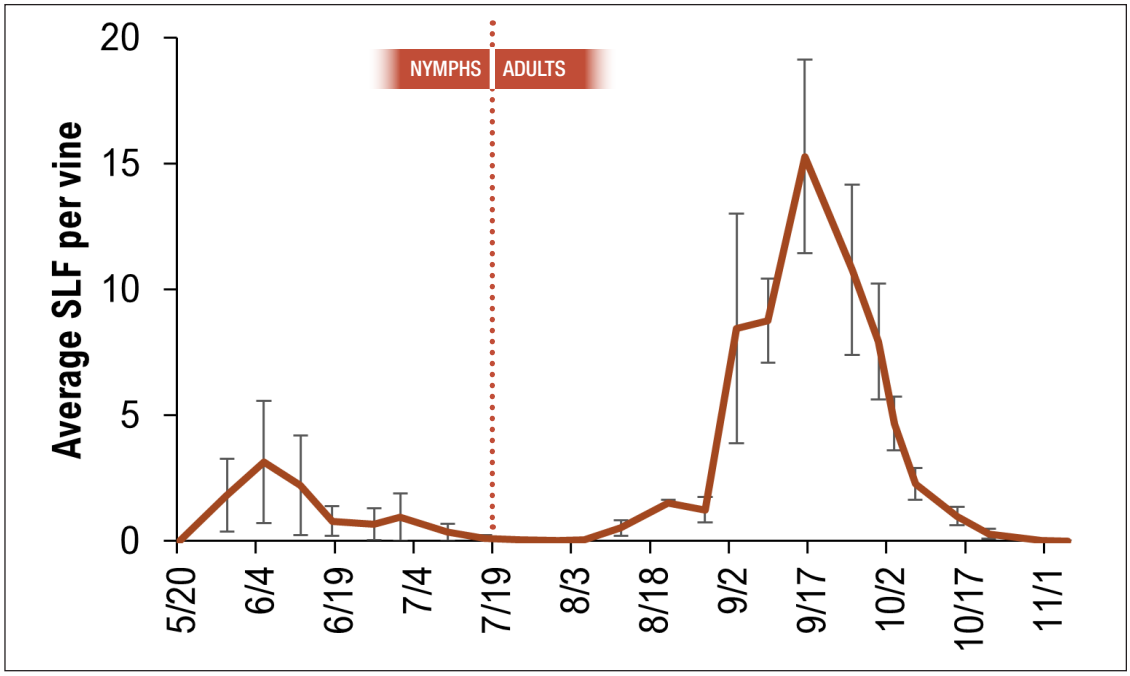

Figure 2. The average number of SLF per vine from 2018 to 2020 across eight different vineyards in Berks County, Pennsylvania.

egg mass, which means that the eggs are often found in clumped distribution (data provided by Lauren Briggs, Penn State). Most commonly, eggs are observed on the undersides of vines (thick cordons, below graft union, etc.), angled posts, and within non-galvanized metal posts.

Seasonal Host Preference

SLF has a broad host range and has been recorded feeding on over 70 different plant species. Despite this wide host range, some plants appear to be more favorable than others. Whether a plant is heavily fed on appears to be highly dependent on what is available in the nearby landscape, the health of the plant, the time of year, and how long SLF have been present in the area. Nymphs, in particular, seem to have an especially large host range, whereas adults seem to depend more on certain hosts. Table 1 provides the key plant hosts of SLF and the time at which they are most likely to be found on these hosts; this table may help you identify problem areas with SLF adjacent to your vineyard. The plants listed in Table 1 do not represent a comprehensive list of all potential hosts of SLF, but rather the most likely transition of SLF hosts through the season. As plants begin to go dormant for winter, they are less likely to serve as a host for SLF. The patterns in host use may change with varying weather conditions, by region, and from other factors. Tree-of-heaven is a strongly preferred host; however, it is not required for SLF development.

Monitoring

As mentioned above, SLF utilize a large range of plant hosts. We recommend you monitor your vineyard and the wood edge for SLF on a regular basis (at least weekly), especially when adults are found from August to November. In the early summer, SLF nymphs are small and can be difficult to see. Nymphs tend to feed on softer tissue (at the tops of trees and herbaceous plants) and are often found on the undersides of leaves. Adults will be more likely present on the trunks of trees and can be seen flying and gliding around areas where they are feeding. If you have not yet detected SLF in your vineyard, scouting for and monitoring tree-of-heaven or other hosts listed in Table 1 is the best option to start. A comprehensive guide on identification and removal of tree-of-heaven can be found on the Penn State Extension website (**extension.psu.edu/tree-of-heaven-accurate-identification**). If there are other highly desirable hosts nearby, we recommend you focus monitoring and potential treatment on those plants. Monitoring plants can be done using either visual observations or tree traps wrapped around the trunk of trees (see below for more information on trapping). Treating ornamental trees can be done with either systemic or contact insecticides, depending on the plant type, whether SLF is feeding on the plant (or just using it as a launch point), and how long SLF is likely to be there. Our guide for landscape professionals can help you decide which approach is best (**extension.psu.edu/spotted-lanternfly-management-for-landscape-professionals**).

Biological Control

Currently, there are no known natural enemies of SLF that are thought to reduce populations in the United States. Some generalist predators (spiders, praying mantises, wheel bugs, parasitoids, etc.) will attack and eat SLF. Additionally, two species of fungal pathogens have been identified attacking SLF in Pennsylvania. One species, *Beauveria bassiana*, has been the recent focus of research for SLF management. This pathogen is commercially available as a bio-pesticide and can be sprayed to kill insect pests. In 2020 we evaluated the use of *B. bassiana* in woodlots adjacent to vineyards to reduce SLF populations. So far, these applications did not suggest control of SLF, and we do not currently recommend *B. bassiana* for use in or around vineyards. There is ongoing research to further optimize the use and

Table 1. Key plant hosts of SLF and the times they can be found on these hosts.

Host	Nymphs			Adults		
	May	June	July	August	September	October
Rose	■	■				
Grape	■	■	■	■	■	■
Tree-of-heaven	■	■	■	■	■	■
Black walnut		■	■			
River birch			■	■	■	■
Willow			■	■	■	■
Sumac			■	■	■	■
Sycamore				■	■	■
Silver/red maple				■	■	■

formulations of *B. bassiana* against SLF. Researchers have also been exploring the native region of SLF to search for natural enemies to release in the United States, and these are currently undergoing evaluations in USDA quarantine facilities.

Cultural Control

Removal of Attractive Host Plants

If tree-of-heaven is found on or near the vineyard, it could be a source of SLF populations. However, we currently have no data on whether insecticide treatment or removal of tree-of-heaven will reduce populations of SLF. Some growers have had good luck with treating the tree-of-heaven with the systemic insecticide dinotefuran as an attract-and-kill approach, and others have felt this offered little SLF control (H. Leach, personal communication). Most likely, effectiveness of this practice is dependent on the size of the SLF population surrounding the vineyard and the presence of other attractive or suitable hosts. If removing tree-of-heaven, you must use herbicide. Failure to use effective herbicide on this tree will result in more tree-of-heaven being quickly produced from the roots and stumps. Be mindful of herbicide applications on tree-of-heaven, as grapevines are highly sensitive to herbicide drift.

Exclusion Netting

Over-the-row exclusion netting can be used to protect vines from SLF. Our research suggests that this netting can reduce SLF by up to 99.8 percent on the vines. Note that unlike over-the-row bird netting, this netting will need to be secured tightly on the sides and bottom to exclude SLF (Figure 3). In addition, to prevent entry of adult SLF, exclusion netting needs to be of a finer mesh than what is commonly used for bird netting. SLF may attempt to feed through the netting when the shoots contact the netting on the top and sides, but this was seldom observed in our studies. While we did not observe difference in disease pressure from downy mildew or bunch rot, sugar content of the fruit was slightly lower (0.5° Brix on average), likely due to decreased light penetration to the canopy. The net could increase disease pressure under particular environmental conditions. The nets may be an option for small-sized vineyards due to the labor needed for installing and removing them.

Using Traps

Placing circle traps around trees or banding trees with sticky tape can be useful monitoring tools for vineyards that have not yet detected SLF. However, use of traps is not a recommended control tactic around vineyards, as it is very unlikely to reduce the population. If using sticky bands, bycatch of nontarget insects (bees, butterflies, natural enemies, etc.), birds, and mammals (squirrels, bats, etc.) is likely. A wildlife barrier (e.g., window screening) should be built over the trap to prevent this bycatch. More details on trapping can be found on the Penn State Extension website.

Mechanical Destruction of Eggs

Scraping SLF egg masses and placing them permanently in an alcohol solution (e.g., rubbing alcohol, hand sanitizer) and physical destruction of eggs (smashing) are other approaches to kill SLF. Destruction of eggs might help reduce nymph populations in the spring, but it may not reduce or prevent SLF from infesting a vineyard, especially during the adult stage. It is important to remember that SLF lay their egg masses on many surfaces,

Figure 3. Exclusion netting (DrapeNet, Chazy, New York) used to protect vines from SLF. Note that this netting is tightly closed on the sides and bottom to prevent entry by SLF.

Figure 4. SLF egg masses laid on **(A)** peeling bark of a grapevine trunk, **(B)** the inside of metal posts, **(C)** wooden posts, and **(D)** vineyard trellis equipment. *Photos by Heather Leach.*

including posts, trees, outdoor equipment, and furniture. In vineyards, they are found most commonly underneath cordons, on the vines, and on metal and wooden posts (Figure 4). In addition, the majority of egg masses laid on trees are found above a reachable height (8 feet). As a result, destruction of egg masses is unlikely to significantly affect the bottom-line population in the vineyard. However, some vineyards have reported consistently large numbers of egg masses within their nongalvanized metal posts. Burning these posts with a propane torch, without damaging the grapevine, is a quick way to destroy many egg masses. If you are scraping the egg mass, we recommend you use a hard, flat tool (e.g., putty knife, plastic card) and scrape the egg mass downward into a container. Once finished, submerge all egg masses in alcohol. They can also be smashed, but you need to be sure you are applying pressure to the entire egg mass, or you may miss some eggs. Eggs burst open when they are smashed.

Chemical Control

Egg Masses

Based on studies done from 2018 to 2020, some insecticides have ovicidal action. All studies were done on intact egg masses (with covering) from February to April. Of the 9 insecticides evaluated, none offered 100 percent mortality to the egg masses tested. The use of chlorpyrifos (Lorsban), which was previously recommended as an effective ovicide for SLF, is no longer allowed as all uses on food crops were cancelled in early 2022. JMS Stylet Oil (paraffinic oil) at a 3–5 percent rate offered control ranging from 50 to 80 percent mortality, with the higher rates offering greater control (please consult the product label for legal rate guidance). Note that egg mortality in control treatments was naturally up to 35 percent. For the same reasons described above, using ovicides in vineyards for control of SLF is often not recommended. First, egg masses can be found throughout the landscape, including the vineyard, the pole barn, the woodlot, and your neighbor's property. Second, the efficacy of ovicides is greatly dependent on coverage; good coverage on hidden egg masses (e.g., beneath peeling bark) may be difficult. Third, efficacy of available insecticides is better for nymphs than egg masses, making nymphs an easier and more successful target. That being said, the use of ovicides could be appropriate in some specific situations.

Nymphs

Limited information is available on the threat that the immature stages of SLF (nymphs) pose to grapevines. In general, low populations of nymphs are observed in vineyards and often occur when high numbers of eggs were deposited on the vines and posts in the fall. The nymphs are susceptible to a broad range of insecticides, including those that might be used for the control of Japanese beetles. It is still important to monitor for populations of nymphs in your vineyard and apply treatment as needed. In some cases, spot treatments may only be needed for dense populations of nymphs (i.e., more than 10–50 per vine). Nymphs have not been observed reinfesting vineyards like adults do, so typically only one application of insecticide is necessary (if at all). Residual activity is not needed for the nymphs, so short-acting compounds (e.g., zeta-cypermethrin, malathion, carbaryl) are recommended.

Nymphs generally do not need to be controlled in vineyards unless large numbers of SLF egg masses are found in the vineyards or adjacent habitats the previous fall. Also, the insecticides listed in table 2 are even more effective on the nymphs and generally have a much longer residual activity, so controlling nymphs is much easier. For example, dinotefuran (Scorpion/Venom) and bifenthrin (Brigade/Bifenture) have consistently given control of the nymphs for 3–4 weeks. The use of Danitol in the summer for SLF nymph control will minimize the normal increases in pest mites that result using other pyrethroids as it is also an effective miticide. Currently, economic threshold trials are being conducted at Penn State Fruit Research & Extension Center in Biglerville on mature grapevines to determine how many SLF nymphs or adults per vine can cause economic injury and the number of seasons of recurring insect feeding that cause vine death. Current thinking is that nymphs, unless in overwhelming numbers, are not causing significant damage and are easily controlled by insecticides targeting other grapevine pests such as grape berry moth or Japanese beetles.

Adults

Adults may appear in your vineyard in July or August, but they could arrive in September or October. Many of the same insecticides that are effective at killing the nymphs are also good at controlling the adults: dinotefuran (Scorpion/Venom), imidacloprid (Admire Pro), beta-cyfluthrin (Baythroid), bifenthrin (Brigade, Bifenture), fenpropathrin (Danitol), thiamethoxam (Actara), carbaryl (Carbaryl, Sevin), and zeta-cypermethrin (Mustang Maxx). In general, we recommend using longer-residual products during the heaviest period of reinfestation, which tends to be in September. Be mindful of preharvest intervals (PHIs) on the labels and your harvest date. Pyrethroids have the longest residual activity evaluated to date. Closer to harvest, you may need to apply products with shorter PHIs, which generally don't have long residual activity for SLF. Therefore, these products may require repeated applications for adequate control (Table 2). Remember that SLF is primarily a pest on the edge of the vineyard—only treating the edge of the vineyard (the first 50 feet) may be just as effective as treating the entire vineyard. A modified sprayer or cannon sprayer could be used to only treat the edge of the vineyard for SLF, which would save time and reduce insecticide input. In 2020 we found a cannon sprayer (CIMA Cannon Spray Head, BDI Machinery, Macungie PA.) to be equally effective at killing SLF with a border sprayer, compared to spraying the entire vineyard with an over-the-row sprayer.

Before applying any insecticide, you must read and follow the label to be sure you are making a legal application with timings and rates, and have appropriate personal protection equipment (PPE), reentry intervals (REIs), preharvest intervals, and warnings for pollinator protection. Visit **www.CDMS.net** to check for the most up-to-date label information. While SLF have only one generation per year, you should rotate the use of different insecticide classes or modes of action for SLF throughout the season to reduce the likelihood of insecticide resistance. Be mindful that you are preventing insecticide resistance for not only SLF but also other common vineyard pests such as fruit flies. The use of pyrethroids and other broad-spectrum insecticides may flare up secondary pests such as mites, leafhoppers, or aphids.

Additional products registered for use in grapes have been tested against SLF adults and have not shown great efficacy at the rates labeled, which tend to be only about 2/3 the rates for the same products on tree fruit. Products not effective in field trials against SLF adults are not listed in Table 2 and include the following active ingredients: imidacloprid (Admire Pro, Provado), indoxacarb (Avaunt), phosmet (Imidan), Assail (acetamiprid), flonicamid (Beleaf), sulfoxaflor (Closer), flupyradiferone (Sivanto), Spinosad (Spintor, Entrust), spirotetramat (Movento), spinetoram (Delegate), and chlorantraniliprole (Altacor).

Table 2. Insecticides for SLF

Active Ingredient	Trade Name(s) Tested	Class (IRAC Group)	Toxicity to Bees	Rate Per Acre	PHI (days)	REI (hours)	Target Life Stage Tested	Longevity of Product (days)*	Efficacy Rating
Bifenthrin	Brigade 10WSB Brigade 2EC/ Bifenture 2EC**	Pyrethroid (3)	High	16 oz 6.4 fl oz	30	12	Adults	7	Excellent
Beta-cyfluthrin	Baythroid 1EC	Pyrethroid (3)	High	3.2 fl oz	3	12	Adults	7	Excellent
Fenpropathrin	Danitol 2.4EC	Pyrethroid (3)	High	21.33 fl oz	21	24	Adults	21	Excellent
Zeta-cypermethrin	Mustang Maxx 0.8EC	Pyrethroid (3)	High	4 fl oz	1	12	Adults	0 (knockdown only)	Excellent
Dinotefuran	Venom 70DF/ Scorpion 35SL	Neonicotinoid (4A)	High	3 fl oz/ 5 oz	1	12	Adults	3–5	Excellent
Thiamethoxam	Actara	Neonicotinoid (4A)	High	3.5 fl oz	5	12	Adults	3–5	Excellent
Carbaryl	Sevin XLR Plus/ Carbaryl 4L	Carbamate (1A)	High	2qt	7	12	Adults	0 (knockdown only)	Good to Excellent
Malathion	Malathion 8F	Organophosphate (1B)	High	1.88 pt	3	12	Adults	0 (knockdown only)	Excellent
Paraffinic oil	JMS Stylet Oil	Mineral oil (n/a)	Low	3%	14	4	Eggs	—	Good

*Longevity of product can vary depending on weather conditions, coverage, etc. The longevity listed is what we determined in our field insecticide studies using 4-year-old vines.

**Bifenture EC has a 24(c) label amendment for SLF in Pennsylvania to apply twice (once at preharvest and once at postharvest or twice at postharvest) at the maximum labeled rate. The PHI is 30 days.

Registrations and labels may change, and human error is always possible. You must read and follow the most current label before applying any pesticide. The trade names listed here are examples of products that have been tested on SLF; this list is not an endorsement of any product. Other products with the same active ingredient and rates will likely offer similar control as what is shown above.

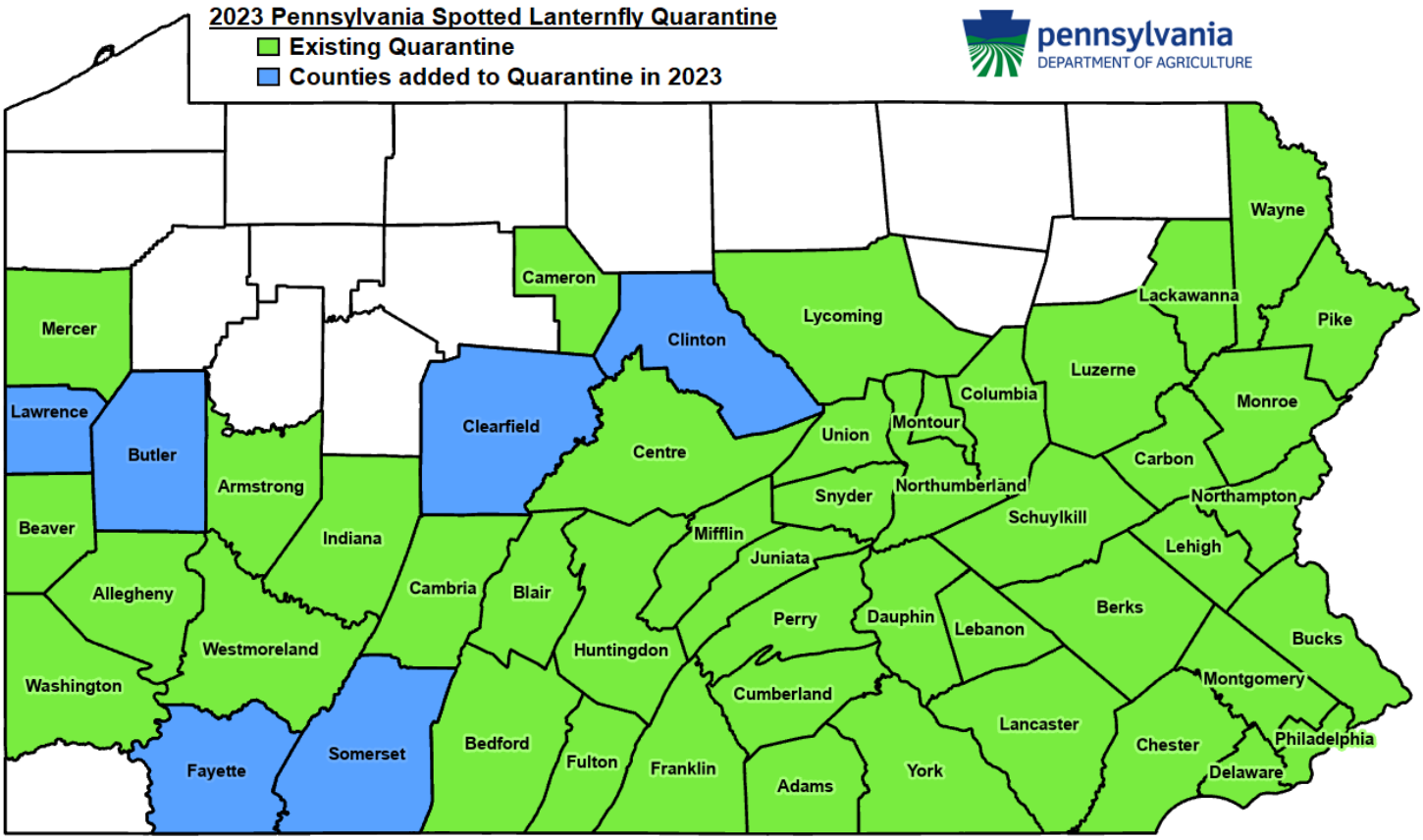

Figure 5. Counties within the SLF quarantine zone in Pennsylvania. *Last updated February 2023*.

Postharvest Management

After mating and laying eggs in the fall, SLF have been observed to become less active and eventually die. Typically, SLF populations decline in vineyards after the first week of November. However, since the harvest of most grape cultivars occurs in September or October, it is likely that you will continue to have SLF populations in your vineyard after harvest, and we recommend postharvest insecticide applications. In this case, you can use products with a longer residual for longer control and to reduce the number of applications you need. After egg masses have been laid (late November), scout your vineyard and surrounding wood edge for egg masses to identify potential hotspot areas for nymphs next year.

Building and Tasting Room Control

Many wineries that have outdoor-tasting areas have reported nuisance problems from SLF and complaints from customers. Typically, this only occurs at problematic levels during the active flight period (mid-September). If you can identify a main source of the SLF population (e.g., a nearby tree), treating this source with insecticide could alleviate the flight activity. Because this flight period is relatively short, a long-lasting pyrethroid (e.g., bifenthrin or beta-cyfluthrin) could be used on the plants or structures where SLF are found crawling or flying. Keep in mind that you must use insecticides labeled for this purpose. Some wineries have also utilized exclusion netting or shade cloth as a way to keep SLF out of the outdoor-tasting areas with good success. In general, it is a good practice to encourage customers to be aware of SLF and check their vehicles and belongings before they travel so that they do not bring SLF elsewhere.

Quarantine Regulations

If you conduct business within the SLF quarantine in Pennsylvania and move products, vehicles, or other conveyances within or out of the quarantine (Figure 5), the Pennsylvania Department of Agriculture requires that you obtain an SLF permit. The permit training is free and can be taken online. The permit ensures you and all employees have been properly trained on the identification and biology of SLF, and your vehicles and shipments are inspected and found to be free of SLF before moving. SLF adults can be found crawling all over many surfaces, including harvest bins, tractors, trucks, etc., so you must be sure that all of these materials are free of SLF. Businesses receiving shipments of fruit or juice within the quarantine zone must also hold an SLF permit. If a business that needs an SLF permit is caught without one, fines may be issued. Specific questions about the permit can be directed to **SLFPermit@PA.gov.** Other states have quarantines and permit requirements for this pest, and there is reciprocity of these permits between states.

Summary

1. SLF may cause significant damage to grapevines, including reduced carbohydrate and nitrogen levels in root tissues, sugar concentration in fruit, and reduced yield. The degree of damage is likely dependent on the level and duration of SLF infestation, overall health of the vine, winter conditions, and other stressors placed on the vine.
2. Adult SLF are the most problematic in vineyards and arrive from late August through November. Nymphs are typically not problematic and should only require one insecticide application timed after the egg hatch early in the season, if any.
3. Monitor your vineyard and surrounding vegetation regularly for SLF: especially tree-of-heaven and other highly desirable hosts (e.g., wild grapevines, black walnut).
4. If SLF is present in large numbers (more than 10–20 per vine), consider applying insecticides or utilizing exclusion netting. Finding only a few SLF throughout the vineyard may not warrant a spray. Targeted insecticide sprays at the border of the vineyard.
5. After applying insecticides, continue to monitor weekly and spray as needed. SLF adults are susceptible to many insecticides, but they quickly reinvade your vineyard from the surrounding landscape, making them difficult to control.
6. If you had significant feeding from SLF in the summer or fall, check bud mortality and consider leaving more buds on the vine when pruning to avoid winter injury.
7. If you're conducting business in the Pennsylvania quarantine zone, you must get an SLF permit from the Pennsylvania Department of Agriculture.

We encourage you to stay up to date by checking our website, attending regular extension meetings, or contacting your local extension educator. Research on this important pest is ongoing, and information may change as we learn more about this insect. Be sure to check online for updated versions of this fact sheet. *Last updated by David Biddinger, Flor Acevedo, Michela Centinari, Greg Krawczyk, and Cain Hickey in April 2023.*

Prepared by Heather Leach, Michela Centinari, David Biddinger, Greg Krawczyk, and Flor Acevedo.

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