Spotted Lanternfly

Ad Hoc Science Advisory Panel Questions

CA Department of Food and Agriculture

Questions for the
Ad Hoc Spotted Lanternfly (SLF)
Science Advisory Panel

Detection / Delimitation

1. Were any significant infestations missed (detected too late), and if so, what factors may have been responsible for them being missed?

Yes, significant infestations were missed in almost all cases in which SLF spread large or disjunct distances. In the case of Winchester, VA in early 2018, tracing-forward was an important aspect of detection. Following detections, continued monitoring and dedicating resources to monitoring over a 2-year period is needed; also, because SLF moves between hosts, a year-round monitoring strategy is warranted as is monitoring all potential hosts in an area. In all cases, spread was not detected until population was already likely established, making possible eradication challenging at best. It is difficult to detect egg masses. Monitoring systems need to be in place. Nymphs feed on multiple hosts in disturbed areas (often including *Ailanthus altisimma*, tree of heaven (TOH)) not frequented by people, so partners need to be on-board to monitor in those areas. Access to property to monitor can be an issue (i.e., access to property around rail lines). Emphasis should be placed on monitoring around rail lines as a means of dispersal and priority site for monitoring. Also, TOH tends to be in disturbed places where people do not usually access, so managers need to look in these disturbed areas.

2. How effective are traps (compared to visual survey) in detecting/delimiting new infestations?

In general, sensitivity of traps depends on SLF density and life stage (ranges from 25-80% effective). Visual searches are more effective especially for low density SLF for older nymphs and adults. Data from 2020 and 2021 show that visual survey tends to outperform traps, especially for adults. The exception is early instars, in which case traps can outperform visual survey.

We have observed that SLF adults are especially attracted to tall objects, including tall buildings, telephone poles and light poles, and tree trunks particularly when they're dispersing in the fall. SLF will fly toward trees and such objects, land nearby and then crawl up them. We have been experimenting with the use of insecticide-treated nets in traps on poles. Some preliminary work indicates they can be about as attractive as maple trees. Tall vertical objects (at least 3-inch diameter) could be good locations to place traps for detection programs for adults; alternately, visual surveys for adults on tall objects, such as telephone poles may be useful.

Visual search has a better potential for detecting populations at low densities. However, early in the season, when small nymphs are present, traps can be better for detecting populations. One advantage to traps is that they are present for longer duration in the field, versus visual surveys that only survey a location during a single point in time. Both visual surveys and trapping have their advantages for early detection.

Late July through October is the trapping period for SLF adults in Eastern USA.

Black walnut is another potential monitoring host for nymphs (2nd, 3rd, and 4th instar nymphs; data collection and analysis in progress).

3. Are specific traps particularly useful in specific situations?

It depends on whether there is TOH or not. Tree-based traps work best when installed on TOH. Both Bug Barrier (a type of inward facing sticky band installed on tree trunks) and circle traps (modified pecan weevil traps) are similar in sensitivity to detection. Circle traps have a screen mesh that funnels insects into a small collection device (gallon bag or jar). Circle traps could be installed on trees or poles.

There might be some visual cues for part of the spectrum, but to date color of traps has shown no compelling results (see Jang et al. 2013. Spectral preferences of *Lycorma delicatula* (Hemiptera: Fulgoridae). Entomological Research 43: 115-122. https://onlinelibrary.wiley.com/doi/full/10.1111/1748-5967.12012).

An alternative method for trapping is the sentinel-tree trap, where a tree is treated with dinotefuran, then monitored at the base of tree for dead adults.

For high-risk sites (i.e., ports) circle traps installed on poles could be a good fit for detection.

4. Has a standardized approach been developed for detection/delimitation trapping?

The APHIS National Ops Guide recommends searching all properties within a 1/4 mile of a detection point (with minimum 20 points searched). When additional individuals are found, the search is extended to include a 1/4 mile radius (SAP recommends up to 2 miles, see qu. 5) from the outermost individual found. A focus on *Ailanthus* trees if present is mentioned. Such searches may occur at any time during the year, but the sensitivity of visual search is likely to vary throughout the year, with adults likely being easier to find. The ability of this approach to accurately delimit populations has not been assessed, and this approach does not incorporate estimates of the probability of missing individuals that may be present at low densities. We are not aware of any other official SOP's for survey or trapping for SLF.

5. What is a reasonable distance to use for delimiting around a known infestation that would have a very small chance of missing a satellite infestation? Should this depend on the time of year (e.g., greater delimitation radius if adults may be present, to account for greater dispersal ability)?

Yes, the distance should depend on time of year and situation. For adults and egg masses, it's important to look out at least 1 mile, perhaps 2 miles. The distance searched should depend on the size of the population and how old the egg masses are (old, previously hatched egg mases are visually distinct from freshly laid egg masses). If you find old egg masses, you need to search further. Altoona, PA is a good example where we observed a 1.5 mile spread in 1 year. Based on experience in the eastern USA, at least 2 miles is the recommended distance to delimit a population. If you only find one SLF, you may not need to search as far. Be aware that they can move several miles in 1 year and this may depend on distribution of suitable hosts within the search radius. Depending on site characteristics (adjacent to rail, etc.) the search radius should be expanded beyond 2 miles. They will move farther if they are not finding suitable hosts nearby, especially TOH.

6. Has a risk-based model been developed for prioritizing detection efforts? If so, what variables are considered in it?

Yes, there are several risk-based models which have been developed which are more operationally focused in terms of providing input for prioritizing efforts in consideration of SLF. There are multiple variables that are used in the models to generate outputs. The models differ but consider for example such factors as temperature ranges for SLF survival and development, presence of TOH, SLF life stage, conveyance type, traffic volumes, human population levels, airports, seaports, rail, and distribution centers to produce varying estimates of potential for movement and establishment of SLF for consideration. This can be influenced by time of year and conditions where SLF is present and conditions where SLF may arrive through assisted movement in addition to distance from an SLF population. Some states have used this information to make resource decisions on survey efforts but not for prioritizing detection efforts.

Eradication

The panel recommends the using the following distances for delimitation, quarantine, and eradication:

Delimitation distance: ¼ - 2-mile radius.

Quarantine distance: 4-mile radius (may be problematic to enforce based on *P. ramorum* experience)

Eradication distance: 1/4-mile radius

For any SLF detections in California, eradication will be the immediate response and a more intensive survey approach would be desirable. Intensive surveys would be conducted within an initial ¼ mile radius (consistent with APHIS Ops Guide) but would likely extend out to the 2-mile delimitation distance, particularly when host plants are scarce. Landscape factors (urban/suburban areas will require a more extensive search area) within the initial ¼ mile area should be considered to determine the actual distance. Any SLF detections from intensive surveys would result in a new ¼ mile (or other determined radius) search radius and additional consideration of any landscape and other factors (presence of rail lines, SLF egg masses present within the suburban/urban landscape, etc.) that may lead to the need to extend the search radius.

7. What is the most effective combination of SLF eradication tools for eradication anywhere? Could these tools be used in California (taking into account California Department of Pesticide Regulations guidelines: https://www.cdpr.ca.gov/)?

Different tools are effective depending on the SLF life stages present.

Egg masses: We recommend oils and/or scraping, which can destroy egg masses, as can host plant removal and destruction via chipping (focus on TOH). For egg mass treatments, PSU has tested various petroleum oils at 5% (off label) and PPQ has seen success with an OMRI soybean oil product that is labeled for SLF egg masses (Golden Pest Spray Oil, Stoller).

Early instar nymphs (90% hatch): We recommend dinotefuran (ground or aerial application to the foliage), which has been shown to kill nymphs, and bark sprays of dinotefuran (alternative to aerial application; anything under 10 ft). Bifenthrin can also be used as a contact spray.

Adults: We recommend bark sprays of dinotefuran (base to 5 ft trunk applications), which kill adults, and bifenthrin sprays (which is recommended due to its longevity compared to other pyrethroids).

Penn State Extension bulletins contain most recent peer-reviewed information on insecticide use for management of SLF:

https://extension.psu.edu/spotted-lanternfly-management-in-vineyards

https://extension.psu.edu/spotted-lanternfly-management-for-landscape-professionals

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

TOH removal can be a valuable tool based on the individual scenario and in high-risk areas. Its effect may also be density dependent (California has Weed Management Areas that funding could be used to support these efforts). In other instances, TOH may be used as a trap crop or can be used as a monitoring site.

For eradication, we recommend managers take an area-wide approach, rather than a host-tree specific approach (i.e., don't target just TOH). Target anything that is a known host. Efforts may be limited by pesticide regulatory restrictions.

Additional studies are needed to investigate efficacy of all neonicotinoids under field conditions, both as contact sprays and systemic applications. Some of these products are registered for use in agricultural crops. Also, development of insecticide resistance should be mitigated.

8. Are there examples of (at least local) successful eradication?

The Advisory Panel has not given up hope that eradication can be successful, but is not aware of any cases where eradication has been achieved. The most promising opportunity for one is in an area around Ithaca, NY, with *Ailanthus altissima* removal, but that was done in 2021 and it's not clear yet how effective it was. There are also ongoing efforts in Indiana and Ohio (Mingo Junction).

9. Are different combinations of eradication tools recommended for different situations? Please consider the following situations: commercial crops, residential, and natural environment.

SLF is mobile across habitats. Eradication programs often are active in multiple habitats simultaneously because of this mobility and potential for human-mediated dispersal.

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10. Are there examples of eradication failure, and if so, what factors were involved?

Eradication efforts have not been successful, but the awareness that they created produced long-term dividends with regards to management and limiting dispersal. Populations in the core of the infestation in PA wax and wane. In 2021, populations in the core appear to be lower in some areas after 6-7 years of treatments with herbicides, systemics and bifenthrin (targeted at *Ailanthus* only).

The first attempts in PA began with a sole focus only on *Ailanthus* for insecticide treatments and underestimated the distances that adults can disperse through flight. In an all-out eradication effort, all host plants should be treated that are seen to be hosting SLF. We would expect that additional hosts will be added to the list in California that do not exist in Pennsylvania.

11. Has area-wide removal of tree of heaven been done?

Yes, area-wide removal of TOH has occurred in the area surrounding Ithaca, NY, performed in 2021. Information on efficacy is currently being collected. Such efforts are resource-intensive if done mechanically or with herbicides. We remain hopeful that registration of *Verticillium nonalfalfeae* specific to TOH will be completed after a decade of development would be useful in this effort and would welcome assistance from California in achieving this. A weevil, *Eucryptorrhynchus brandti*, has also been identified and is under investigation for biocontrol of TOH. The second resubmission of a petition for field release of this biological control agent is currently under preparation.

Verticillium nonalfalfae was found on TOH in Virginia in 2008 by scientists at Virginia Tech and in Ohio in 2012 by U.S. Forest Service scientists. This promising, host-restricted biological control currently occurs over thousands of acres in these states. By 2011, natural spread of the fungus had resulted in the mortality of >30,000 TOH trees, effectively removing most TOH from the landscape at inoculated sites.

12. Does controlling tree of heaven appear to have an impact on SLF populations?

This is an empirical question that information from the Ithaca, NY treatment and treatments Penn State is initiating in the Erie County grape-growing region will inform. Additional information may be provided from trials in Virginia (to be investigated). Even after herbicide treatment of TOH, follow up is necessary because it is hard to kill and can come back after treatment.

13. How time-consuming is tree of heaven removal/killing?

Tree of heaven removal is time-consuming to the extent that it requires herbicidal treatment to kill plant tissue, and this must be done in accordance with the life cycle of tree of heaven (i.e., cannot be done while the tree is dormant). Getting permissions and access to properties with tree of heaven and securing funding to complete treatments are also time consuming (e.g., time costs experienced by PA Dept. of Agriculture, especially in early years of SLF infestation).

Additionally, *Ailanthus* is pervasive in the Pennsylvania landscape. It is highly improbable that all presence of *Ailanthus* could be identified, killed and subsequent regrowth/ new growth be eliminated in less than a decade even if an all-out concentrated effort was attempted with all adequate funding needed. The seed bank in the soil has decades, if not centuries, of build-up (Philadelphia was an original introduction of TOH in the days of Ben Franklin and John Bartram). The origins of *Ailanthus* removal and establishing trap trees began when the incorrect assumptions were made that *Ailanthus* was required by SLF to complete its lifecycle and that SLF could not fly any distance more than a few hundred meters. If either of those two presumptions had been correct, it may have been a viable strategy for eradication. We suspect that the presence of *Ailanthus* helps populations establish more quickly: we know that it's a preferred host, but we don't know that the removal of *Ailanthus* will eradicate a population.

14. Does the "trap tree" strategy work for eradication? If so, how does that method compare to other chemical methods of eradication?

We have not seen it work for 2 years of field studies in Lewistown, Altoona or Huntington. No empirical information is available for 2nd part of the question. Trap trees fall more under the management approach than eradication.

15. Is biological control (e.g., *B. bassiana*) effective in eradication of SLF and/or TOH?

We have intensively tried *Beauveria* over two years. We obtained 50% control on our first year, with what, in retrospect, were probably ideal conditions of weather, application method (hydraulic handgun), and experimental design (split plots). We did a much more intensive trial at our Blue Marsh site involving three applications with both water and oil-based formulations and were unable to show any effect at all. Due to low relative humidity in California, *B. bassiana* may have limited potential in most areas and under most agricultural crop conditions.

Verticillium nonalfalfae was discovered in Pennsylvania in a very unhealthy stand of TOH. It has proven to be remarkably specific to tree of heaven in 10 years of follow-up studies. Inoculation of a few trees in a stand has resulted in the death of the entire stand of TOH (additional info in answers to Q 11). The EPA requires it to be registered for use in controlling TOH. Due to insufficient funding, that work is proceeding slowly.

16. What is the optimal post-eradication follow-up time that would allow time for treatment to work but also minimizing delay in case further action is needed? Does it depend on time of year (life stages present), landscape/situation, etc.?

For contact sprays, surveys can be done after two to four days, as the insecticides are contact and fast-acting. If you have treated for eggs, you should also plan to treat for nymphs at 90% hatch. After two to four days, passive traps should be deployed and can be used to monitor for nymphs. Ongoing monitoring should visit the site weekly for one month, and monthly thereafter for the remainder of the season. For season-long treatments, ongoing monitoring (at weekly intervals) is necessary during the season. During the adult migration phase, additional survey activity should be done. Monitoring should continue for up to three years to search for adults.

17. What patterns of life-stage detections indicate that eradication of SLF is no longer feasible?

Given that various life stages are extremely difficult to detect, and with how patchily SLF are distributed across the landscape, life-stage pattern is not a valid index of feasibility of eradication, although egg mass counts in the same areas over two years provide some useful information. Egg masses are the only life stage that don't move unless they are transported. Given experience with other insects, indicators that eradication is infeasible are likely to be more related to infested area than to life-stage. Eradication efforts are more likely to be successful if populations are detected early.

Quarantine

18. What should be the quarantine trigger (e.g. # of individuals, finds within certain period of time, life stages present, proximity of finds to each other, proximity to production agriculture, residential area, or natural env.)?

In agreement with CDFA language (with modification highlighted related to distance): "Any of the following shall be sufficient evidence of an infestation: One viable egg mass, one living nymph, one living visibly mated female, or two living adults found in the environment *within 4 miles of each other* within one year."

19. Should the quarantine boundary be based on county or other geopolitical boundaries or a certain distance from infestations?

The quarantine boundary should be based on distance, not on geopolitical boundaries. The distance will be determined based on detection and delimitation surveys.

20. What is a reasonable distance from known infested sites for a quarantine?

Estimates of dispersal ability are used to establish distance for quarantine. If delimitation is in a 2-mile radius, then quarantine boundary should be double that at 4 miles.

21. What should be the criteria for expanding a quarantine?

Additional finds of any live individuals or viable egg masses within the quarantine area should then become epicenters for additional expansions of the quarantine area using the same radius of 4 miles.

22. How many life cycles (=years) since the most recent SLF find should a quarantine last?

Quarantine should last two full years from the date that SLF is found. Intensive monitoring (following recommendations described previously) should be put into place during this quarantine period. After two years with no detections (following initial intensive search and monthly follow up), the quarantine can be lifted, but three years with no detections are required for eradication to be declared. For example, if an individual was found on April 1, 2022, the earliest the quarantine could be lifted would be April 1, 2024, should no additional individuals be found during intensive ongoing monitoring. In this example, monitoring to confirm eradication must continue through to April 2025.

We note that the SLF life cycle may differ in climates that are warmer than its currently invaded range in the United States, which may alter recommendations.

23. How effective have quarantines been in eastern states in limiting spread of SLF?

Quarantines protocols in PA were established when we had little information on the pest. In hindsight, PA was working from infested areas outward and therefore, to date, quarantines have not gotten ahead of the spread. Limiting spread is more likely in California now that we know more the biology and behavior of SLF. Particularly noted by the panel was an underappreciation of the role of transportation corridors. Transportation corridors (rail, trucks, motor vehicles) are a pathway to spread to new areas. To date, quarantines have been effective with respect to increasing public awareness and in making sure that there are no restrictions in shipment of goods to other areas out of the quarantine region. That detections of SLF are in the news in other areas most recently (e.g., Kansas, Kentucky, Indiana, etc.), and that SLF is so broadly reported upon suggest that quarantines contribute to awareness and presumably reduction of spread. The panel is not aware of any strong economic impact due to limitations on goods export, suggesting quarantines may provide other areas with a sense of security or willingness to continue to receive goods from SLF-infested areas.

24. What significant (high-risk) pathways are most challenging to regulate? Has there been an article or pathway that has been especially onerous to enforce compliance upon?

Railways present a challenge because of difficulty in gaining access to their properties. Many new infestations are being found in railway switchyards. Also, regulation of air transport pathways (e.g., cargo planes) may potentially present a challenge, as these have been implicated in SLF being transported to other states, including CA. We are also concerned about ports and major highways. There are many ports and major highways that still have *Ailanthus* on their property in PA. Shipping containers, including personal moving containers, along with trucks, can be pathways. Goods such as beehives should be inspected for SLF egg masses. Movement of military equipment could be problematic if not inspected for egg masses.

25. Are there situations where a quarantine is not advisable (for example, pathways of artificial spread are not significant)?

Given the challenge of detecting SLF populations at any life stage, it is not clear at this time that there are any pathways of potential spread that may not be problematic.

26. How can egg masses be removed from conveyances, etc. besides hand removal? Will power-washing work?

The strength of the flow from a power washer (connected to an AC outlet or battery operated) is likely to work, as long as the egg masses are totally removed and eggs are destroyed. We recommend that this method as well as heat be tested to confirm effectiveness. PPQ is currently testing hot water treatments for SLF egg masses and they are fairly sensitive to heat.

27. How risky is movement of the following from a quarantine area?: leafy vegetables, fruit, containerized nursery stock, green waste, biomass.

Eggs have not been observed on harvested fruit or leafy vegetables; thus leafy vegetables and fruit are unlikely to be risky, as the early instars are those that are capable of, and more attracted to, feeding on live plant tissues. However, rigid container used to hold leafy vegetables, fruit, or other commodities could harbor adult SLF and/or egg masses if they are exposed to the environment during fall or winter. Therefore, risk should be assessed with respect to calendar, and less on type of good.

Containerized nursery stock has the potential to be a high risk for movement of eggs and mobile stages. PPQ has documented movement of SLF egg masses via nursery stock into New Hampshire. Green waste of woody plants has the potential to harbor egg masses; it can also have mobile stages, but these tend to not survive very long on severed tissues. The risk lies in transporting the raw materials to green waste facilities. There is likely no risk in transporting adequately composted materials. Likewise, green materials that are chipped are unlikely to be at risk of causing spread.

28. Is red wine pomace that has been through fermentation a sufficient mitigation against eggs?

Egg masses are not known to be on grape clusters, and mobile stages are unlikely to survive the fermentation process. It seems unlikely that eggs could survive this process, given our experience with other pests (*Planococcus ficus*, *Lobesia botrana*) and fermentation conditions (high CO_2, prolonged submergence), but we do not have empirical evidence for SLF.

29. Could SLF eggs survive on white wine grapes to the pomace stage (has not been fermented, but has presumably been pressed and immersed in fluid)? If so, what mitigations are required?

Yes, eggs could survive the press but given that they are not on grape clusters this is a non-issue. Solarization would be a likely mitigation strategy if eggs are ever found on grape clusters or leaves after harvest. Although we consider is unlikely, nymphs and adults may be able to survive the press, so we recommend testing this. Risks of nymphs and adults is highest in mechanically harvested grapes.

30. Can SLF survive processing of grapes into raisins?

No.

31. Can a systems approach work for unprocessed table grapes (with and/or without chemical treatment)?

SLF does not lay eggs on or feed on grape clusters, thus the grapes themselves are low risk. But concerns could arise if any SLF life stages inadvertently get into grape boxes when fruit is packed in the field. Inspection of the boxes (inside and out) for egg masses and other life stages could be part of a systems approach. Insecticide programs routinely used for leafhoppers, sharpshooters and mealybugs will be an integral part of any table grape systems approach.

32. Grape leaves and petioles for analysis are sometimes shipped for analysis. What safeguards are necessary, if any? Inspection?

Individuals collecting leaf and petiole samples need to be sure they are free of all SLF life stages. If canes are collected, they need to be free of all SLF life stages, including eggs, prior to being transported out of the field. The lab receiving shipments should have SOPs and a compliance agreement for properly disposing of plant materials.

33. Regarding green waste: Would the following be sufficient to mitigate risk:

A. Grinding, shredding, chipping, or chopping to one-inch size. If not, what size would be sufficient?

Yes. A study by the USDA on chipping is most relevant to this question (Cooperband, M. F., Mack, R., & Spichiger, S. E. 2018. Chipping to destroy egg masses of the spotted lanternfly, Lycorma delicatula (Hemiptera: Fulgoridae). Journal of Insect Science, 18(3), 7, 1-3.). https://doi.org/10.1093/jisesa/iey049

B. **Grinding, shredding, chipping, or chopping and piled for use in biomass/cogeneration/fuel/livestock feed, etc. and is not used as compost or mulch.**

Yes.

C. **Solarization with or without grinding, etc. Solarization is currently used to control vine mealybug in winery waste.**

Solarization is likely effective against SLF, but we're not aware of any studies to confirm this.

Impact

34. What industries have been affected both directly (e.g., crop damage) and indirectly (regulatory) by SLF?

The industry most directly affected in terms of crop damage is the grape industry. One vineyard was killed by SLF attack even with intensive sprays, and SLF infestation significantly raises insecticide and application costs for vineyards. PSU has ongoing research to test if SLF can carry any vine diseases. Some nurseries have reported stock damaged from SLF feeding, but it has not been definitively proven that this damage was due primarily to SLF and not to other unassessed factors. Two nurseries have reported tree damage from feeding and multiple nurseries have incurred permanent staining damage from sooty mold blackening the bark (white birch, Styrax, etc.), making them unsaleable.

In terms of regulatory impacts, the other industries that have reported economic impacts are nurseries and Christmas tree growers. Economic impacts on these industries (and the timber industry) in PA have primarily been from the cost of implementing best management practices due to quarantine issues. Major stone and pome fruit crops and hops in PA have thus far not experienced economic damage.

In some manner, all businesses that are in quarantined counties are impacted by the additional training, documentation of movement and inspection times required to conduct business. In some cases, the loss of production time can be significant if all quarantine rules and record keeping are actually being observed and taking place. Lack of enforcement has meant that we do not have any idea how many businesses are actually following the rules.

We have also heard complaints from various businesses concerning nuisance-based anxiety from the public experiencing SLF, particularly in the fall, when SLF engages in flight in high numbers (e.g., SLF climbing up office buildings, etc.) but these are incidental and not yet reported systematically for any given industry.

35. How significant has SLF impacted Korean vineyards?

Korean grape production, at least in areas experiencing SLF infestations, seems to be primarily for table grapes. The impact of SLF was different than that in the US, as it was primarily due to sooty mold growth on grape clusters, not actual damage or death to vines. In Korea, growers enclose grape clusters in netting to prevent honeydew deposition and subsequent sooty mold growth. As such, the economic impact there would be due to the labor and time costs of enclosing clusters in netting. SLF damage in peach orchards and vineyards in Korea has since been greatly reduced as damaging populations are now limited to a few hotspots. This was thought to be due to the movement of Chinese parasitoids into the region.

36. How have vineyards been impacted in the eastern United States? What factors have affected the degree of impact and how (management practices, site conditions, drought, etc.)?

Vineyards have been impacted in terms of vine damage (including decreased blooming the season after damage), and cost and time associated with additional insecticide treatments. The degree of vine damage is certainly impacted by climatic conditions, specifically winter temperatures, as SLF feeding is associated with increased vine cold susceptibility (that is, they are more likely to have freeze damage at temperatures that are slightly less cold than those that typically damage them). Vineyard visitation (tourism) and use as events spaces are also negatively impacted because SLF numbers coming into vineyards in fall is considered a nuisance to vineyard visitors.

37. What agricultural systems are most likely to be affected in California?

Grapes are likely to be the most affected commodity in California. SLF management programs based on neonicotinoids and pyrethroids would need to be integrated with management programs for mealybugs, sharpshooters and leafhoppers, and run the risk of causing secondary pest outbreaks of pests such as spider mites, due to their potential impacts on biological control. SLF may also pose quarantine issues for exported table grapes if SLF inadvertently gets into boxes of fruit. Additionally, proposed CDPR restrictions on neonicotinoid use in grapevines (and other crops) in California have the potential to limit grape growers' abilities to adequately respond to SLF infestations while simultaneously attempting to control other invasive pests (esp. vine mealybug and glassy-winged sharpshooter).

The potential for California crops to be impacted by SLF is currently being investigated. Besides grape and hops, other crops that could be impacted by SLF nymphs include peach, English walnut, cucurbits, legumes, avocado, kiwi berry, hemp, fig, cane berries, and strawberry (https://extension.psu.edu/spotted-lanternfly-survivorship-and-damage-to-specialty-agricultural-crops-2021). Lumber, ornamentals and Christmas trees can be impacted by regulatory requirements. Given the extremely broad host range of SLF, particularly in the early nymphal stages that feed upon herbaceous plant tissues, it is likely that a large number of additional crops may be impacted if they are located near other hosts infested with SLF. In general, leafy greens, Brassicaceae, and Solanaceae have thus far not been impacted.

38. What environmental impacts have resulted? What are the most affected ecosystems?

Negative environmental impacts of SLF control programs are most likely to be associated with increased pesticide use. Neonicotinoids and pyrethroids that serve as the basis for chemical control programs can both have negative environmental impacts if not used safely.

The most affected ecosystems are those in and near to mixed use, human disturbed or inhabited environments. SLF can be found deep in mature northern hardwood forests, but it's more of a transient presence, unless *Ailanthus* is present. They congregate in higher numbers near the edges or in the interties of suburbia. Impacts from sooty mold growing on honeydew produced by SLF can significantly reduce photosynthesis of plants, potentially impacting understory plants that provide food for wildlife, and sooty mold is a nuisance in residential areas.

39. What natural ecosystems in California are most likely to be affected?

Agricultural and green industry producing areas and human inhabited ecosystems (e.g., parks) are most likely to be affected. Rangelands, oaks, and conifer dominated forests are unlikely to be affected. Riparian zones that contain mixed deciduous trees such as poplars, willows, sycamore, wild grape, and California black walnut can be affected.

40. What degree of impact has there been to quality of life (nuisance)?

In areas of high infestation, quality of life is significantly negatively impacted, due to presence (and fear of) flying adult SLF, fear of SLF severely damaging or killing trees and plants in one's yard or garden as well as acting as a stressor on trees, honeydew and tree weeping attracting stinging Hymenoptera and flies, sooty mold growth on understory plants, grass, decks, etc. There are reports of reduced house prices.

Spread

41. What commodities and conveyances are highest risk for movement of egg masses?

Trains, campers, trailers, rigid agricultural containers (e.g., apple bins) and other conveyances as well as personal storage containers that remain stationary for a period of time in infested areas, especially during egg deposition in the fall are the highest risk of conveyance spread. Nursery stock including Christmas trees are at high risk of conveyance as they can contribute to spread of egg masses on actual material being purchased and transported. Timber or lumber can also be infested with egg masses, so the industry uses BMPs to prevent movement of eggs within the quarantine. Construction equipment that remains on a given site before movement to another site is also a concern. It appears that a lot of the movement along railroad tracks may have been from adult SLF, flying in and around box cars and hitchhiking.

42. Are there commodities or conveyances that pose a high risk of moving hitchhiking nymphs or adults?

Active life stages of SLF can be transported via hitchhiking on rail lines, trucks and cars, and air transport (esp. cargo). This was previously addressed for commodities and conveyances (Question 6).

Management

43. What are the best (taking into account California DPR guidelines) conventional and organic methods for control in:

- **A. vineyards**: https://extension.psu.edu/spotted-lanternfly-management-in-vineyards
- **B. stone fruit**: unlikely to need treatment, except perhaps peach
- **C. forests**: unlikely to need treatment
- **D. backyards:** https://extension.psu.edu/spotted-lanternfly-management-guide
- **E. any other agricultural systems likely to be impacted in California:**

If other commodities in California are impacted, neonicotinoids and pyrethroids can serve as the basis for chemical control, but specific guidelines for other commodities have not been developed. Oils have been tested for treatment of egg masses. Cultural methods include netting, discing, host free periods and host plant removal. Trapping doesn't substantially reduce populations.

44. Are biological controls effective in SLF management (e.g., *B. bassiana*)?

Biological insecticide*:* *B. bassiana* was described above in Q. 15. This approach may be unlikely to work in California due to climatic conditions.

Parasitoids: Resident egg parasitoids are ineffective. An egg parasitoid and a nymphal parasitoid that have been discovered as natural enemies of SLF in China are being evaluated as candidate biological control agents of SLF in the United States. Their attack rate against United States non-target hosts and their synchrony with our climatic conditions are being evaluated before they can be approved by the United States Department of Agriculture for release. Only the eggs parasitoid is being considered at this time as a candidate for release in California.

<u>Predators:</u> Generalist predators feed on SLF but do not provide significant control.

45. Does control of tree of heaven have an impact on SLF numbers/damage? If so, what level and type of control is necessary and in what situations is it effective?

Two avenues of biological control of *Ailanthus altissima* are being investigated, with one likely being of more likely immediate use than that the others. That's the fungal pathogen, *Verticillium nonalfalfeae*, which is discussed above. A weevil, *Eucryptorrhynchus brandti*, has also been identified and under investigation for biocontrol of TOH. The second resubmission of a petition for field release of this biological control agent is currently under preparation.

Information concerning the effectiveness of *Ailanthus* removal will or may be available based on efforts NY Ag and Markets took in the Ithaca, NY area. Penn State is now initiating comparable efforts in the Erie County grape growing region (see Q. 13).

Basic biology

46. What are the preferred hosts?

The most current information on the host list can be found in: Lawrence Barringer, Claire M Ciafré, Worldwide Feeding Host Plants of Spotted Lanternfly, With Significant Additions From North America, Environmental Entomology, Volume 49, Issue 5, October 2020, Pages 999–1011, https://doi.org/10.1093/ee/nvaa093.

Host preference depends on SLF life stage; immatures have a much broader host range than older nymphs and adults. There are hundreds of plant species in California that have not been assessed as hosts in this literature.

47. What plants in California (crops, ornamentals, and natives) not yet known as hosts are likely to be hosts?

See Question #37.

48. Is SLF likely to become established in California, and if so, where?

Yes, SLF is likely to become established in any areas in California capable of supporting agriculture.

Factors affecting risk of establishment will likely include temperature, relative humidity and habitat suitability (distribution of preferred hosts).

49. Have SLF abundances shown any patterns that cannot be attributed to control? If so, what factors may have been involved (e.g. are certain climatic situations likely to suppress or promote population growth/dispersal)?

There is a reported reduction in SLF numbers in the area that was most strongly infested during the earlier years of SLF establishment in PA. However, no numbers have been sufficiently recorded to assess this change over time, and such quantification of SLF numbers is highly complicated by the fact that SLF populations, even within a small geographic area, are very highly patchily distributed and vary across the life cycle, due to extreme mobility of SLF nymphs and adults.

50. What are the natural dispersal abilities of nymphs versus adults in one year (miles per year)? Does this depend on type of landscape?

We know from mark-release-resight studies led by PSU researchers that 1st through 4th instar nymphs can move 50 m in a 10-day period, but the average displacement was much less (around 13m), likely because many individuals found suitable food and stopped dispersing. Based on SLF observations in areas well away from suitable host plants, it appears that adults can move at least 500 m, a third of a mile.

At the granular (direct observation) level, captures of naturally flight-dispersing adults show that 95% of them are unmated. They usually make reiterative low-level flight-bouts of only ca. 50-100m per bout before having to land due inability to create much lift. Presumably if they find a suitable tree to feed on, they move no farther. Flight-dispersing adults have been observed to be attempting to feed once they have landed. On the occasional days when meteorological conditions generate rising air currents, the typically low-level flight-dispersing adults have been observed to be lifted upward by rising currents to 50 meters high or more and seen to be transported several hundred meters downwind. It is highly probable that they can be transported at least several kilometers downwind in a single long-duration flight-bout such as this.