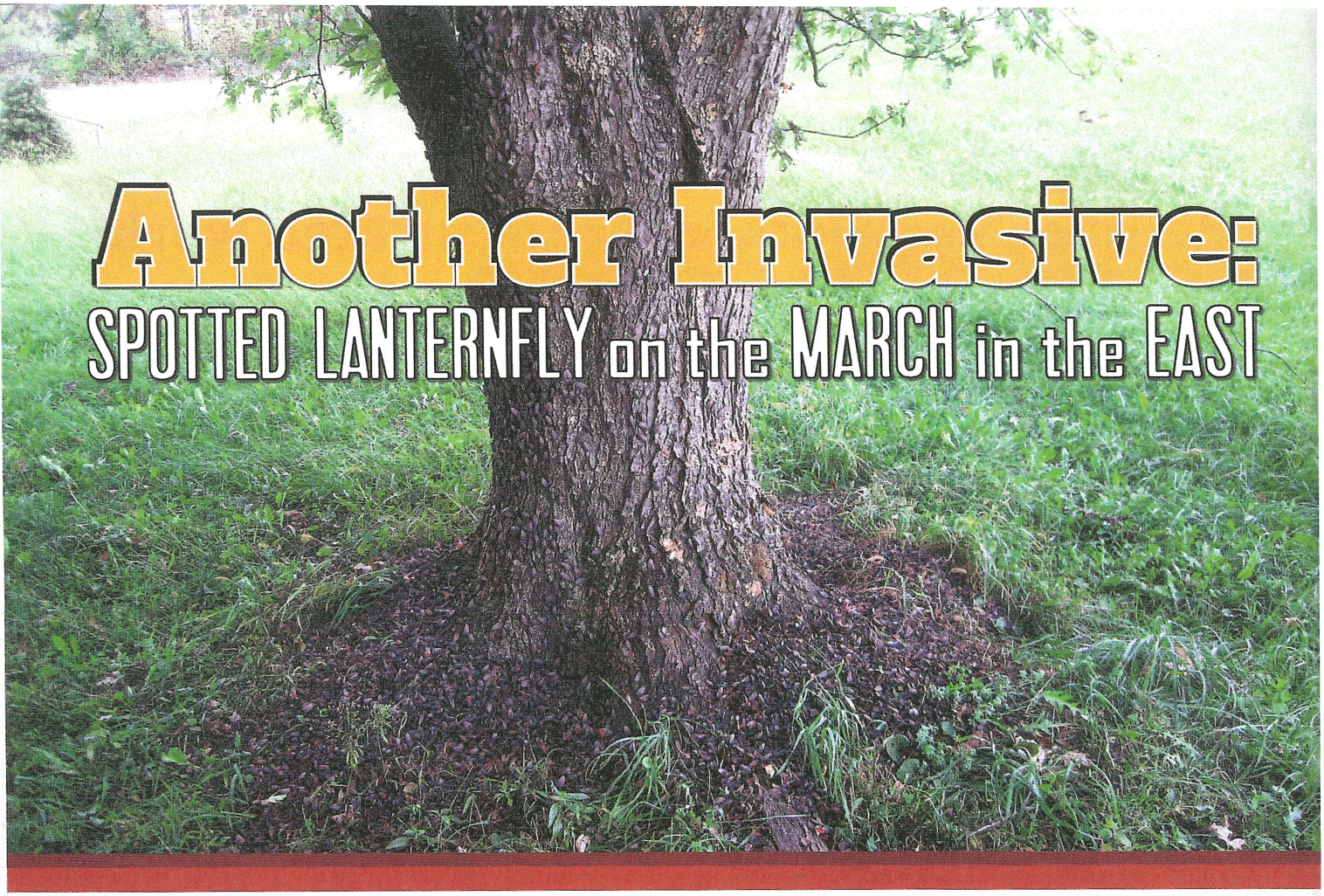


Another Invasive: SPOTTED LANTERNFLY on the MARCH in the EAST

Adult spotted lanternflies on a silver maple this past September in Pennsylvania. All photos courtesy of the authors.

By Brian Walsh and Julie Urban, Ph.D.

Here we go again, and this might be the big one.

Spotted lanternfly (*Lycorma delicatula*) is yet another invasive insect imported from Asia that is threatening our native forests, ornamentals and agriculture. In a seemingly endless parade of exotic invasives, this newcomer has established a beachhead, started to spread outward and proven to be quite complex and difficult to control.

It displays a combination of traits that make it a particularly alarming threat: Few predators will feed on it, it is relatively large in size (about an inch), it exhibits a need for near-constant feeding on plant phloem (like giant aphids) and it freely moves between and feeds upon more than 70 known (to date) hosts (Dara et al., 2015). As such, it has the potential to kill trees and shrubs outright by "bleeding" them to death or, possibly even worse, the potential to vector a pathogen. It's also important to mention that it has a predilection for grapes, stone fruits and pomes (Dara et al., 2015).

First discovered in rural Berks County, Pennsylvania, (45 miles north of Philadelphia) in 2014 (Barringer et al., 2015), spotted lanternfly (SLF) has since spread to and been discovered in 13 counties and several other states, despite attempts by the Pennsylvania Department of Agriculture (PDA) to quarantine areas and eradicate the pest.

Adult spotted lanternfly feeding on a tree. Note the fused beak proboscis that emanates between the front two legs. The feeding site will often weep long after the feeding.

An established SLF population (adults and egg cases) has been found in Virginia, and it appears to be contained within one area. SLF has been detected in New Jersey, Delaware and Maryland. Officials have not found any established populations in any of these states, but they are continuing to conduct surveys. A single, dead SLF was found in New York, apparently associated with commercial transport of goods from the Pennsylvania quarantine area.

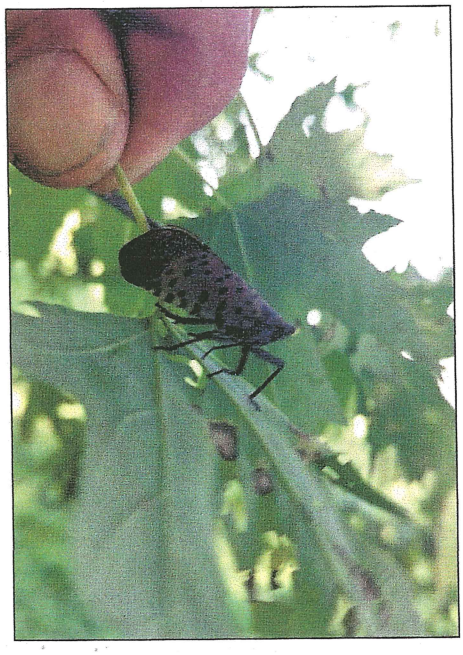
Biology and lifecycle

Spotted lanternfly is a planthopper native to China, Vietnam and Indonesia. It also has been imported into Korea, where

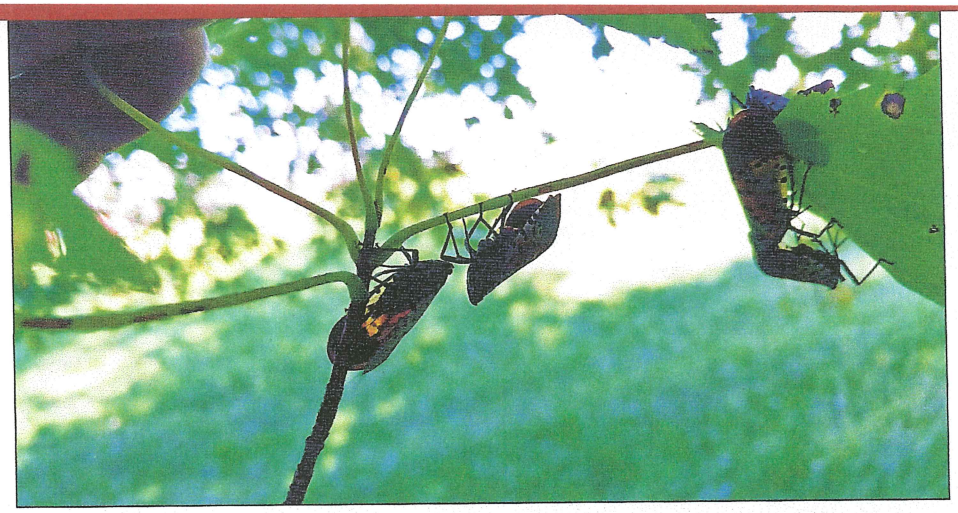
it quickly overran the peninsula and has proven to be devastating to vineyards (Han et al., 2008). It is classified in the order Hemiptera (like aphids – remember that later) in the family *Fulgoridae*. SLF is an univoltine insect, having only one complete life cycle per season. It begins its life in spring when hatching out of eggs laid the previous fall that have overwintered in masses stuck to trees, rusty metal, stones, pallets, vehicles or any other hard surface that the adult females might have encountered (Dara et al., 2015). Its proclivity to lay on man-made objects that can become mobile has certainly helped to speed its spread.

The hatch seems to be temperature dependent (Park, 2015), with a timespan of several weeks to months for eggs to develop and emerge from the individual egg masses, depending on localized temperatures and exposure. When the young larvae hatch, they are wingless nymphs that are jet black with white spots. Early instar nymphs are easily overlooked in the landscape, as they are not much larger than deer ticks.

They will feed on plant phloem and undergo two molts, growing in size while looking the same, before molting a third time into the fourth instar, still as nymphs. What is different for the fourth instar is the striking red color that is added to the black and white mix of the exoskeleton. Generally, in Pennsylvania, we start seeing the fourth instars in late June through July, but they have been observed as late as October. This is when many people first notice that something is amiss, although nymphs can still easily be confused with boxelder beetles or other native insects by the untrained eye.



An adult spotted lanternfly feeding on a leaf mid-rib.



Adult spotted lanternflies feeding on leaf petioles and mid-rib veins. While they cannot chew leaves, feeding can take place anywhere from exposed roots to mid rib-leaf viens.

They are extremely strong hoppers, making this a trait of SLF that is a good indicator for recognizing nymphs. If you goose one and it "pops" away with amazing speed, it is an SLF.

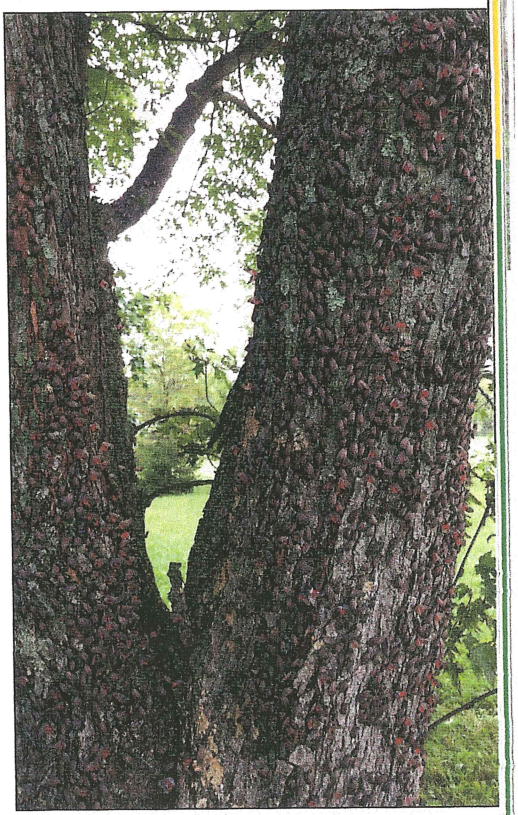
Beginning in late July, the majority of fourth-instar nymphs molt and emerge as flying adults that are difficult to mistake for nearly any other insect in our environment, as the adults are relatively large with bright and colorful wings, and they begin to disperse.

Females' abdomens begin to swell as eggs develop, and the bright yellow banding on the abdomens becomes much more evident. Eventually, adults mate and females lay one to three clutches of 30 to 50 eggs each before being killed by freezing weather, starting the cycle again for the next year. Eggs are lined up in rows and then covered with a waxy, putty-like substance that protects them through the winter, and that is an amazing camouflage on tree bark.

How it spreads

SLF is believed to have arrived as an egg mass or masses stuck to shipping material from China. Judging from early egg-case remnants, it was probably in 2012, but they went unnoticed until the fall of 2014.

SLF has shown to be unpalatable to birds (including domestic chickens, which usually will eat any critter they encounter), and only a few general predators such as spiders, wheel bugs, stink bugs and praying mantis have been observed eating them (Barringer & Smyers, 2016). Why they are so unpalatable to birds has yet to be determined, whether it is due to a self-produced defensive chemical or as a result of the SLF feeding on its favor-



Often the most vigorous tree in an area becomes "hot." This photo was taken six hours after the tree was observed to be almost completely cleared of adults from a previous "wave" by the effects of a prior dinotefuran treatment. Within 48 hours, this "wave" was also killed.

This egg mass was placed beneath a piece of exfoliating bark on a silver maple. The color and placement make detection incredibly difficult. Egg masses have been found on limbs 30 feet in the air, and under rocks in fence rows.

ite meal – *Ailanthus altissima*, commonly known as tree of heaven. Lacking any predators of great number, the population growth has been exponential.

Despite PDA's attempts to eradicate SLF through a combination of sticky bands around tree trunks to catch flightless nymphs and the establishment of systemically treated "trap trees," the population really made itself known this past summer of 2017, when simple tasks like walking into the local big box store was not possible without being pelted by crashing lanternflies. They don't land gracefully; picture the title character from the 1980s TV show "Greatest American Hero," right down to the red and black colors.

Ingestion of dinotefuran by feeding on treated trees causes adults to lose control of their wings, exposing the bright red colors beneath, before they fall to the ground. Note the wetness of the bark beneath the group.

On days with high populations of adults flying, you can often hear them "thudding" into objects such as cars and buildings. As for how well they fly, that's still an ongoing discussion. They are not agile like a dragonfly, but more like a native cicada. They fly much better and farther than grasshoppers, and they have reproduced and spread to many more square miles as adults.

Don't forget about the egg masses. SLF females lay their eggs on any hard surface, including vehicles and yard debris. They seem to particularly like slightly rough surfaces such as rusty metal and concrete. The eggs can be under a rock in a fence-row wall or as high as 30 feet up a tree on the underside of a limb. They blend well with natural surfaces, and sometimes you have to stare for several minutes before the egg mass becomes apparent to your eye, kind of like those 3D pictures of sailboats that were popular in malls in the 1990s.

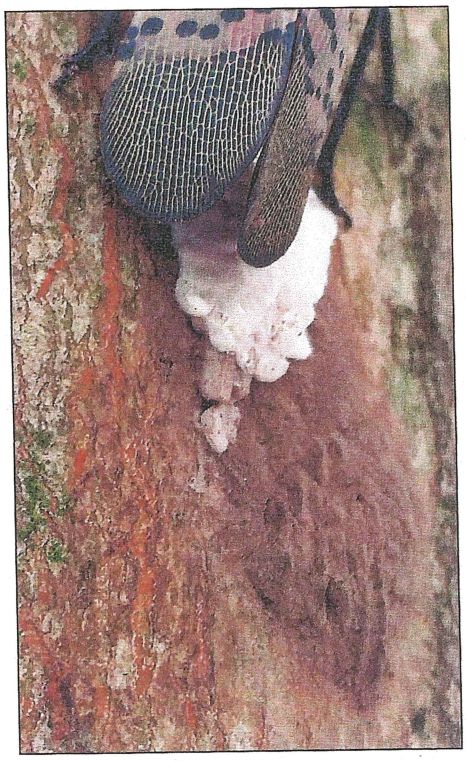
And it's really nasty

As mentioned, SLF feeds like an aphid, on the phloem of trees. They also feed nearly constantly, like aphids, and create massive amounts of honeydew (excrement) like aphids. Except these would be inch-long aphids that create volumes of honeydew that rains down from trees. Literally. It actually looks like it's drizzling under an infested tree canopy on a sunny day. With the sugar-rich honeydew comes any number of sugar-feeding insects including bees, wasps and ants.

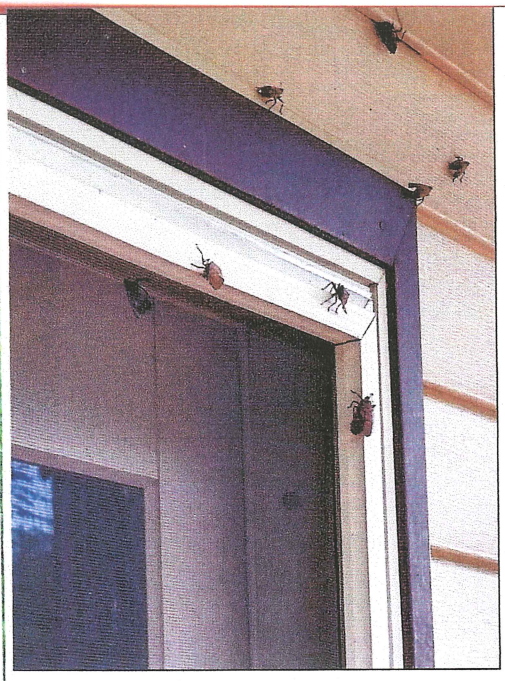
The honeydew also leads to sooty mold. Sooty mold is a black fungus that grows on the substrate provided by the sugar-rich honeydew. When it grows on agricultural products such as grapes and tree fruits, it blocks photosynthesis on leaves and stains the fruits, making them unsellable. But the fungus also permeates decking materials, both synthetic and natural, coats cars and outdoor furniture and blackens understory plants.

What's really, really nasty?

Again, as mentioned earlier, *Ailanthus altissima* (tree of heaven) is one of the favorites of SLF (more on that connection



A female covering a freshly laid egg mass. The color will quickly fade from white to the dull brown of the older egg mass that she is partially covering beneath.



Spotted lanternflies on a house. The constant barrage of adults takes its toll mentally when simply walking out your door means picking them out of your hair or off of your clothes.

later), and this past summer there was a large increase in occurrences of alcoholic slime flux noticed on Ailanthus trees with heavy SLF feeding. The slime fluxes smelled like the rancid odor of Ailanthus sap that has been distilled into a high-test spirit. Why only Ailanthus (to date) has been observed to produce these slime fluxes and what the connection is to SLF is yet to be determined, but it's fairly safe to say that the connection is more than a coincidence.

What's at risk?

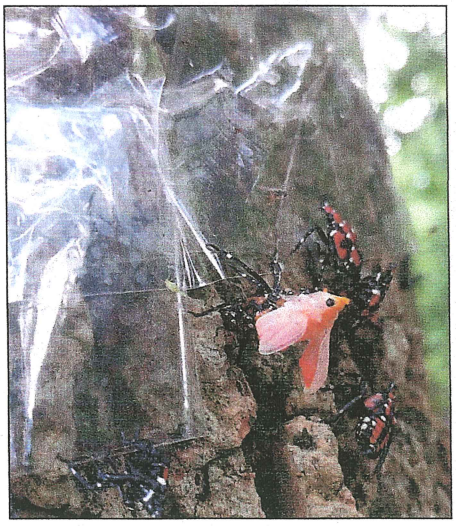
First and foremost, quality of life. Not being able to enjoy your own backyard without being pelted by crashing insects, wearing a raincoat to deal with the rain of honeydew from your shade trees and picking lanternflies out of your burger when grilling is tiresome and mentally draining. Beyond that, the long-term stakes are huge, with SLF having been shown to host on more than 70 species of trees and shrubs to date. SLF does prefer grapevines (wine) and hops (beer) and will feed on many hardwoods. Pennsylvania is the largest exporter of hardwood products, fifth-largest grape producer and fourth-largest apple producer in the country. Unchecked feeding by high SLF populations has begun to kill branches and, seemingly, some trees. The summer of 2017 was one of the wettest on record in our region and may have masked potential damages caused by unchecked sap loss.

A fourth-instar nymph with its bright red color addition. This is the last instar before becoming a winged adult.

It's not the mosquito's bite, but the malaria it's carrying

SLF may have the potential to vector pathogens. Remember the aphid reference? It's been documented that aphids have a salivary enzyme that they inject into plants to soften the tissue and increase the sap flow, much like mosquitos inject us with an anticoagulant enzyme to keep the blood flowing. That saliva is where the pathogens are transferred. SLF feeds much like an aphid. It has a fused beak that contains two stylets (hair-like feeding tubes) that it seems are inserted into stomata and lenticels (tiny gas-exchange openings in the plant surface). Observations of SLF feeding sites on trees seem to indicate feeding damage similar to what the aphid enzymes cause.

Trees have been observed to "weep" for days after the lanternflies are cleared by insecticides or a branch is removed. If this turns out to be the case, and given that the salivary ducts are nearly 5 microns in diameter (more than large enough to pass viruses and phytoplasmas), and also given that SLF adults move from tree to tree and species to species, we could have a serious problem on the scale similar to that of blue-stain fungi in the west. These observations have initiated research by scientists at Penn State University who are working to characterize SLF saliva and test SLF's potential to vector pathogens.



A nymph caught in sticky tape morphing into an adult lanternfly. The pink color changes within hours as the exoskeleton hardens.

How many are we talking about?

Last year, a large, 46-inch DBH silver maple, *Acer saccharinium* (also a preferred host in many situations), was treated. The canopy fills most of the residential backyard that it is in, and it had previously shown to be a "hot" tree in 2016. Beneath the canopy is a patio, and on the patio resides a retired research scientist and wonderful customer who is committed to help learn about SLF. She swept the patio clear of dead SLF every 24 hours. Before sweeping, she would take a representative sample of patio blocks and count the dead bodies that had fallen out of the tree. By extrapolating out the square footage of the patio, she generated a representative calculation of how many lanternflies had been killed by feeding on the systemically treated tree in a 24-hour period. The customer then documented in a journal how many she had counted. The final result? Approximately 48,000 adults killed between August 5 and October 5. The implications of that sort of population feeding on a single tree, had they gone unchecked, are that SLF feeding will be damaging, if not deadly, to a tree, as the sap loss prevents the tree from being able to store carbohydrates.

What's being done about it?

First, the community buy-in and assistance has been overwhelming since the first announcement that this invader was in town. Homeowners have engaged in egg scraping (30-50 fewer adults per egg

Fresh egg mass (circled) on a river birch.

mass scraped), logged egg-scraping numbers and locations with the Pennsylvania Department of Agriculture and employed "sticky bands" of every type, shape and homemade configuration around tree trunks to catch nymphs. Residents have largely welcomed government representatives by granting access to private lands and voluntarily complying with the quarantine that has been enacted.

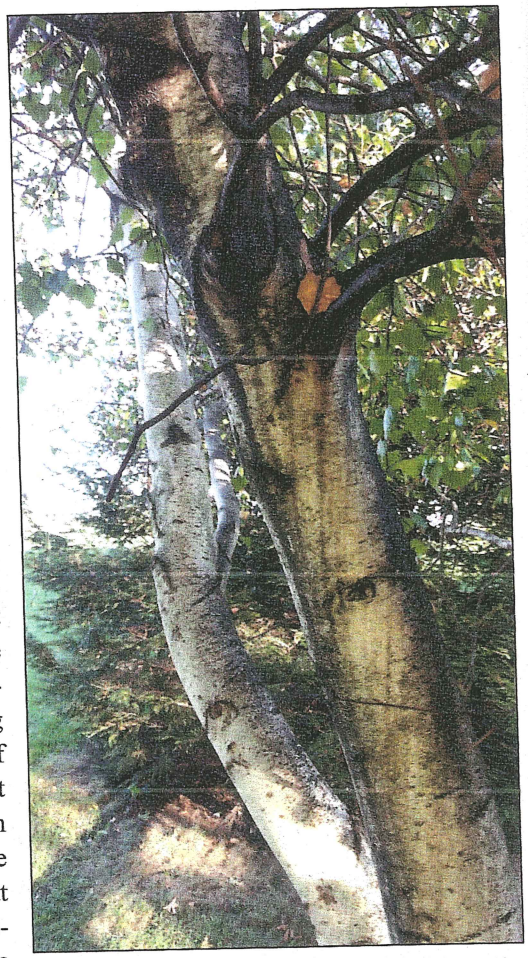
First-, second- and third-instar nymphs, lacking any red color, caught in sticky tape on a willow tree. Nymphs often travel up and down trees, making them susceptible to being caught in sticky bands.

Most of the work that has been done to kill lanternflies has been done by the PDA, and much of that work has focused on the connection to *Ailanthus altissima*. Since its first discovery in Pennsylvania, there has been a strong association made between SLF and Ailanthus. Ailanthus is definitely a preferred host, and there was an early hypothesis that SLF required Ailanthus to complete its life cycle. Whether that is an absolute requirement has yet to be proven definitively.

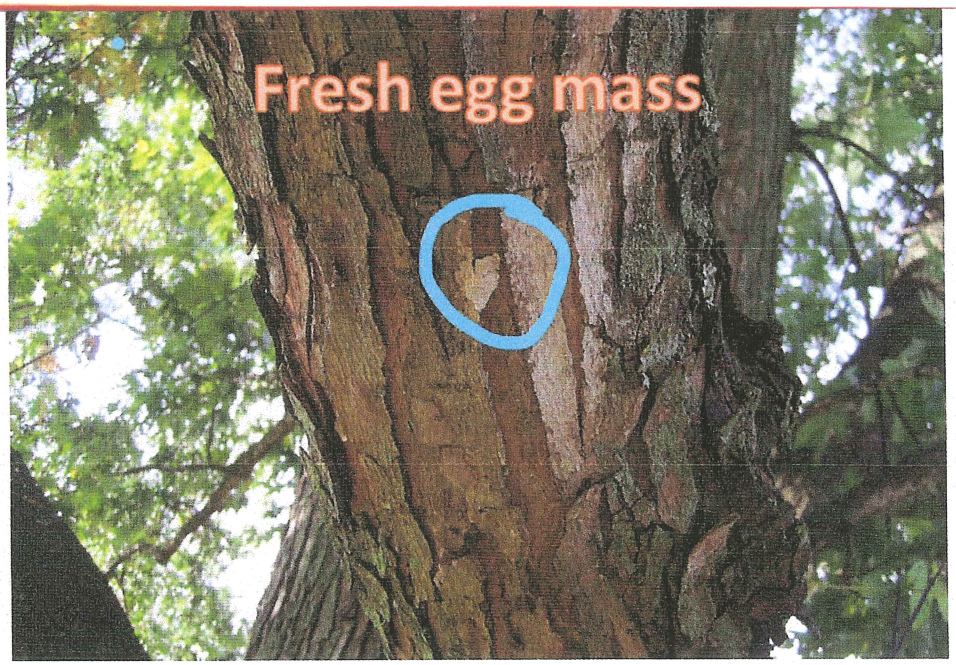
Regardless of whether the connection is absolutely required, SLF's penchant for Ailanthus has been employed in the control strategy with a "trap tree" methodology. This idea involves the killing (either mechanically or chemically) of most of the Ailanthus on a property, but leaving several male trees that are then treated with a dinotefuran product. The idea is that the lanternflies will seek out the Ailanthus trees and feed on a systemically treated tree, thus ingesting a lethal dose of insecticide.

The trap-tree method seems to work well where it is employed, and we are awaiting quantified results of the work. Unfortunately, the sheer volume of land needed to be evaluated and treated is staggering. The core area of the infestation is rugged, wooded and of relatively steep terrain. PDA has been contracting private tree care contractors to do the trap-tree work on both private and public lands. The flipside of this massive undertaking has been that PDA has not been able to address landscape trees and the effects that SLF is having on them.

Since the population really exploded in 2017, homeowners have begun taking matters into their own hands. Some are concerned with the health of their trees, some are trying to do their part to stop the spread of lanternflies and some are flat out obsessed with killing every lanternfly they encounter, even counting how many they have gotten with a fly swatter (some getting into the thousands with their counts). Spraying kerosene on adult SLFs on trees has been one of the worst home remedies



***Sooty mold on white birch,* Betula papyrifera.**



Fresh (circled) egg mass and older egg masses below it (not circled).

reported. Bleach, rubbing alcohol and cases of wasp spray follow closely behind. Some have reached out to licensed, professional pesticide applicators for help.

As with any natural disaster, the scam work has begun. Unscrupulous businesses (including at least one national company) have been selling SLF treatments for building foundations, spraying trees long after a heavy freeze killed all living adults and preying on homeowners' fears and lack of knowledge.

To date, dinotefuran as a bark-banded application or injection has been the most effective strategy tested. Imidacloprid has provided very mixed results, depending on the application method, size of the tree and timing. Further studies will be re-examining pesticide efficacies again this year. Contact insecticides work well enough, but lack the systemic qualities of dinotefuran, and these bugs just keep coming. Once the dispersal behavior begins, it's not uncommon to have a tree cleared by insecticide treatment in the morning and six hours later have it covered by hundreds, if not thousands, of newly arriving adults. They seem to move in waves, often with a day or two or three in between movements. That dispersal time runs roughly from the beginning of August through early October, when the egg-laying behavior is in earnest and cold weather slows them down.

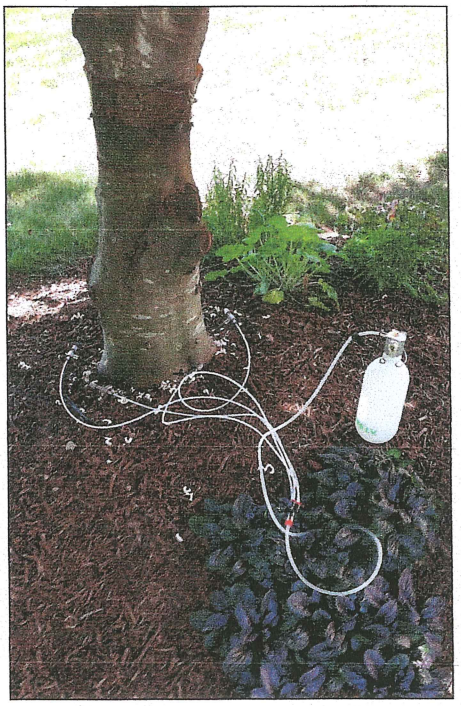
Where we are now

One side effect of the hyper-localized invasion and the focus on Ailanthus and agricultural commodities early on has been a lack of funding for studies to determine the effects of SLF on other trees. This past summer saw branch diebacks, some tree death and some very strange symptoms in trees that were heavily fed on, but those observations have to be qualified scientifically. Thankfully, lawmakers are waking up to this threat and funding is becoming available to start really ironing out many of the lifecycle, feeding and movement details of SLF, and to ramp up efforts on the ground.

What you should do

Be aware of and on the lookout for this insect. It is very probable that, despite best efforts, spotted lanternflies have hitched a ride out of the quarantine. They may have moved as egg masses on materials, or there may have been a bred female who took a ride on a vehicle. Early detection and subsequent action may prove beneficial in containing new outbreaks. Penn State Extension has a tremendous amount of information available on the web. (https://extension.psu.edu, enter "spotted lanternfly")

If you find this bug, capture one for positive I.D. or at least get a picture, and immediately notify your appropriate state agency *and* the U.S.D.A. Don't assume that the person you speak to will understand what you are talking about. If you need non-bureaucratic assistance, reach out to us.



Bark banding or trunk injection with systemic neo-nicitinoids has been the best option to date to kill both nymphs and adults. This organic injection of a neem derivative showed good results as a feeding disruptor.

The upside

This bug doesn't sting, bite or do structural damage to buildings. Perhaps it could be worse?

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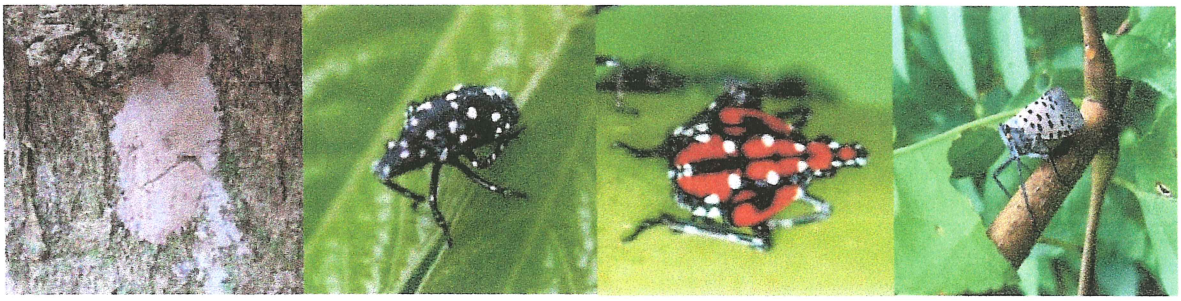
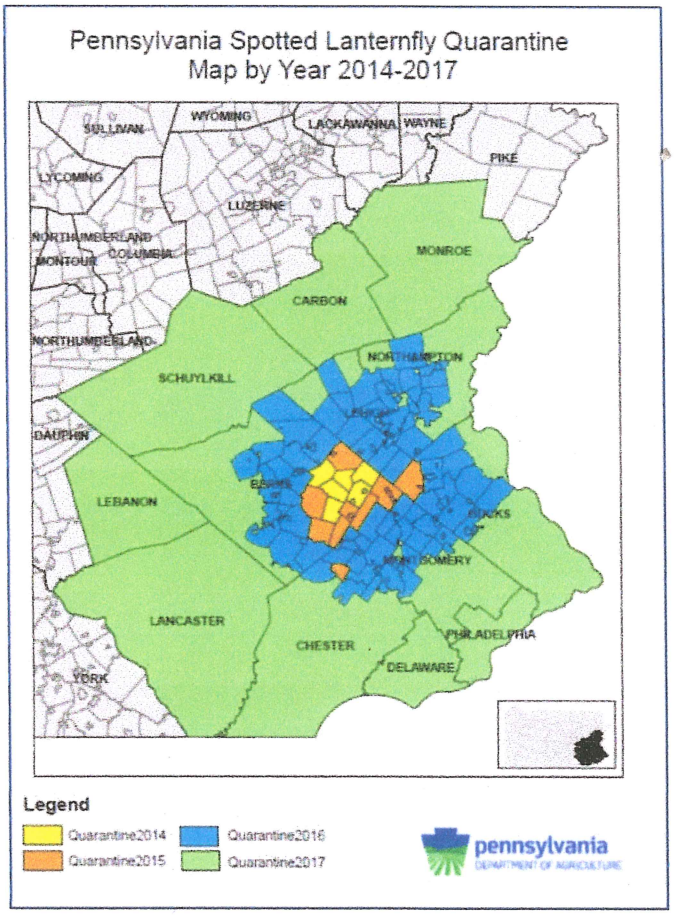
Dr. Julie Urban is a senior research associate in the Department of Entomology at Penn State University. She holds a Ph.D. in Evolutionary Biology with experience in performing a variety of DNA-sequencing-based investigations of insects. She is currently conducting research investigations of the invasive spotted lanternfly in Pennsylvania funded by the Farm Bill (FY2015, FY2016, FY2017) in order to determine origin(s) of the Pennsylvania introduction, and to assess spotted lanternfly for bacterial and fungal, associates and impacts and control of SLF on grape.

Bud swelling was observed in maples that were heavily fed on by lanternflies while the trees were in full leaf. While a correlation is not yet proven, treated trees and trees not fed on did not exhibit this response, which is reminiscent of a defoliation event.



N.J. SPOTTED LANTERNFLY REPORTING GUIDELINES

The Spotted Lanternfly, *Lycorma delicatula* (White), an invasive planthopper, has been discovered in Berks County, Pennsylvania. It is native to China, India, Vietnam, and introduced to Korea where it has become a major pest. This insect has the potential to greatly impact the grape, hop, small fruit, vegetable and horticultural industries. Early detection is vital for the protection of New Jersey businesses and agriculture. It is an excellent hitchhiker, so if you travel to and from the current quarantine area in Pennsylvania search your vehicle, your clothing and the load thoroughly. If you find a spotted lanternfly report it!



Identification:
The Spotted Lanternfly adult is approximately 1 inch long and a half-inch wide at rest. The forewing is grey with black spots and the wings tips are reticulated black blocks outlined in gray. The hind wings have contrasting patches of red and black with a white band. The legs and head are black; the abdomen is yellow with broad black bands. Immature stages are black with white spots, and develop red patches as they grow.

What to do: If you see egg masses, scrape them off, double bag them and throw them away. You can also place the eggs into alcohol, bleach or hand sanitizer to kill them.

Collect a specimen: Specimens of any life stage can be turned in to the New Jersey Department of Agriculture's lab for verification.

Take a picture: A photograph of any life stage (including egg masses) can be submitted to SLF-plantindustry@ag.nj.gov.

Report a site: If you can't take a specimen or photograph, call the New Jersey Spotted Lanternfly Hotline at 1-833-223-2840 (BADBUG0) and leave a message detailing your sighting and contact information.