Authors Statement:

This essay was written with the purpose of informing and potentially inspiring readers about the ecological and social problems (and potential solutions) to the invasive mid-atlantic pest of the spotted lanternfly. I live in Delaware, where this bug is a common and difficult occurrence in the summer, but I found many people outside of its invasive range don't know about it. The goal of this essay was to incorporate personal experiences with this bug and research about it and its harm while providing current and in development ways to reduce that harm. This was the prompt: Students will write either A. an argumentative essay on a topic of their choosing related to sustainability (for example, identifying an as-yet unaddressed sustainability issue, critiquing current policies, or proposing an alternative to sustainability approaches); or B. creative writing assignment related to sustainability. Both options are to be supported by research.

See it? Squish it!: The Scourge of the Spotted Lanternfly

"If you see this beautiful insect, please kill it."

This message, along with the photo of an interesting looking gray, black, and red bug, was posted all over my friends' social media a few years ago. I had seen similar informational messaging plastered on state park bulletin boards when going on a hike that spring, and also briefly heard my dad, both an entomologist and a Pennsylvania native, grumble about some bugs terrorizing a tree outside of his work. Originally, I was intrigued, but not terribly alarmed; I had never personally seen any of those bugs around me in Delaware yet– but I was in for a reckoning that summer. In 2019, these bugs came to my town, and they did so with force. As a summer camp counselor for the past few years, I had to be outside for many hours at a time; over the

course of that summer, it became impossible for me to ignore the repeated screams and cries of terrified children being constantly harassed by these fairly large red and black bugs. They would jump all over our legs and fall out of the trees during our outdoor activities, day after day, and week after week. The sheer magnitude of this issue got so dire, we knew as a collective that we had to take a stand against these pesky insects. After some contemplation, I decided we could at least make this extermination battle into something the children could participate in, too: each day, I would give the camper who squashed the most of these bugs a prize– the most sought after thing a child in the hot summer months could want– an extra cup of lemonade at snack time. After a while, the problem, though still present, was thankfully less drastic at our camp. Still, at the peak, we were stepping on upwards of a hundred of these bugs a day. After months of being bombarded with so many of these insects, I couldn't help but wonder: what are they, and what do they *do*? Most importantly, I wanted to know if they have a negative impact on my community, besides just being a nuisance, and if so, how can we work to get rid of them?

If you've lived in the Mid-Atlantic region of the eastern US in the past few years, odds are you have seen this bug (or, more likely, you may have seen *many* of them). The insect in question is the spotted lanternfly (or SLF for short), scientifically known as *Lycorma delicatula*. Spotted lanternflies in their adult state are about an inch long, with long black legs, and two sets of wings, the first with red accents and the second a veiny gray with black spots (Adams 2022). Spotted lanternflies, despite their luminous name, do not light up like fireflies, though they do sport fiery petticoats in the form of their secondary red wings (MacGregor, 2020). They are invasive insects that came to the US in 2014 from East Asia, first introduced here in southeastern Pennsylvania. These pests were able to migrate to this country through international trade, most

likely on a shipment of stone. Since then, they have been able to spread rapidly through the surrounding regions, with infestations currently present in about ten states on the east coast as of the summer of 2022 (Adams 2022).

These bugs, though particularly visually interesting and even seemingly beautiful creatures, wreak havoc on people, already fragile ecosystems, and perhaps most dangerously, local economies– and now that they're here, it will be extremely difficult to contain and exterminate them all. Though they do not sting and can not bite, these planthoppers severely damage plants and already act as nuisances to millions of people throughout the eastern United States, with the potential to spread (Eshenaur, 2022). Despite quarantining efforts, the SLF is a very resilient pest, and "climate suitability… suggests SLF could survive at higher densities throughout a greater area of not only the USA, but also throughout Central and South America, Africa and Asia, and at lower densities throughout Europe," (Urban, 2020). It has become increasingly imperative to be able to spot spotted lanternflies, understand their impact and harm, and work to reduce that impact. The spotted lanternfly is already a severe problem in the US which is only getting worse, and this dangerous invasive pest harms our ecological, economic, and social prosperity; it must be dealt with through collective action and integrated pest management techniques.

First things first, in order to be able to contain and work to exterminate spotted lanternflies, people need to be able to identify them. They have a few different stages in their lifecycle, each being visually distinct. First, they start as egg masses. These masses can be present on many different types of host surfaces, including trees, walls, rocks, and other outdoor structures, both natural and manmade (Leach et al., 2021). Egg masses can be both covered or uncovered with

mud-like coverings, initially distributed on them as a thick white secretion from the female lanternfly, and then drying to appear as brown patches on the host surface, eventually

looking simply like a smear of dried mud (Eshenaur, 2022). Female SLFs usually lay up to two masses in a year, with each at about 30 to 60 eggs; they are visible from September until they hatch in the early spring (Pugh, 2021). Once they hatch, the insects go through their nymph stage, typically starting around April. They have four developmental stages, known as instars, during this phase. Each instar, the bugs roughly double in size (Leach et al., 2021). They start their first instar at about an eighth of an inch long, with black bodies and white spots, and are often confused with other types of insects, like ticks, due to their unassuming appearance at this early stage. At the later instars, they gain some of their signature red appearance, growing to about half an inch with newly red and black bodies, while maintaining their white spots (Leach et al., 2021). All the nymph stages, from first to fourth instar, can not fly. Lanternflies are in a group of insects known as planthoppers, which means they have very strong prominent hind legs for jumping from place to place and plant to plant. The nymphs have these strong back black legs and get around by jumping and walking (Pugh, 2021). Finally, after the nymph stage, the lanternflies reach their adult form, visible from July to November. They have wings and can fly at that point, though not very well or far; they maintain their strong legs and still get around mostly by walking, jumping, and gliding (Pugh, 2021). These adults look differently when sitting than they do flying, with their dazzling red under-wings revealed only when they do briefly take flight (Leach et al, 2021).

In all their life stages after hatching, lanternflies have the capability to harm plants. They are born with piercing mouthparts, similar in concept to that of a mosquito. Instead of blood, these

insects prefer to feast on plant material. In their nymph states, they often like to consume herbaceous plants like perennial weeds, flowers, and tender new tree growth (Leach et al., 2021). They commonly like to remain on plants for only a day or two before hopping, often in groups,

to their next host. Frequently, they feed high up in trees to get to the new growth, making them particularly difficult to see or reach (Leach et al., 2021). In contrast, the adults have more developed mouthparts, preferring more woody material to feed on, including vines and the more developed parts of trees. Some of their favorite hosts are maples, black walnut, hops, grapevines, and particularly fellow invasive species from Asia, the “tree of heaven” (Eshenaur, 2022). In addition to sucking plant material from their hosts and damaging them from the inside, this ingested sap contains high levels of sugar which they excrete in a waste product known as “honeydew” (Leach et al., 2021). This waste can be seen falling from trees on sunny days, is attractive to sugar loving insects, and dangerously, can be colonized by a mold called “sooty mold” which grows black on the plants; this impacts both the plants which have been directly fed and subsequently excreted on as well as those which are below it and have been coated from fallout (Pugh, 2021). This mold does not directly harm the plant, but it does lead to plant damage by blocking photosynthesis. It is also known to leave very difficult to remove stains, which can impact people and cause further damage to property as well as just plants (Leach et al., 2021). The sooty mold is hard to miss, despite its already noticeable staining appearance, because it also has a distinct and foul smell, like a sugary vinegar (MacGregor, 2020).

Lanternflies are an increasingly visible pest, from their fairly large bodies, large group-like swarms, and sooty mold stains and smells. This visibility increases their social harm and social nuisance factors, and “in addition to reducing residents' quality of life, SLF likely reduces

property values, as has been documented for other sap-feeding tree pests," (Urban 2020). Though an irritant to people, and harmful to over 70 species of plants, the lanternflies are technically "not known to kill plants except for [tree of heaven], black walnut saplings, and grapevines," (Leach et al., 2021). Still, while this overall damage to plants is already a major

concern ecologically the US faces with spotted lanternfly infestations, their net evil worsens when you take into account how costly they can and have been to our economic sector. Some of their favorite foods happen to be important agricultural outputs, particularly grapes, which is one of the three plants they are known not to just damage, but to kill. In terms of other important crops they are known to likely to feast on, the list encompasses "almonds, apples, apricots, cherries, maple, oak, pine, nectarines, peaches, plums, poplar, sycamore, walnut, willow [and more]," (MacGregor, 2020).

Grape production specifically is a billion dollar market in the United States, valued at about 6 billion dollars annually (MacGregor, 2020). In terms of grapes, the damage from the SLF has already started. Grape farmers in the Pennsylvania region are already seeing major negative impacts from their lanternfly infestations, like John Landis, who was interviewed two years ago by the Smithsonian and who reported having "lost many productive plants to lanternfly [in 2019] and expects to lose more," (MacGregor, 2020). Some farmers have lost acre upon acre of previously healthy crops to lanternfly related damage, hurting not only their livelihood, but their local economies. Often, the burden of managing this bug is placed directly on the farmers themselves, who have to put money and manpower into killing the pests, removing them from crops, and quarantining them from spreading even more (MacGregor, 2020). These costs are mounting for many farmers, like grape producer Don Eaton, also from PA, who reported putting

an estimate of “maybe $150,000 of real costs put to the pest [in 2019]. [That] year I lost maybe half a million dollars to customers who were afraid to buy from us because of our location,” (MacGregor, 2020). Things got so bad for Don Eaton he had to sell his farm; with the compounding issues of two pandemics, one of Covid-19 and the other of the lanternfly infestation, he could not keep his business going. And he isn’t a lonely metric: many farmers

across the region have been feeling the effects of lanternflies, and it will only get worse as the pest continues to spread (MacGregor, 2020). Already, researchers are beginning to see dire complications arising from infestations, and have shown that “the impact of heavy SLF feeding across consecutive years can be devastating to… vineyards,” (Urban, 2020). From grapes to ornamentals to apples, the SLF can and will lead to major damages of billions of dollars worth of crops, putting farmers out of business and hurting the food sector and the economy at large.

Because of the severe damage of the spotted lanternfly, many states who have already been exposed are working to quarantine it from spreading to other places. This requires a knowledge of how the SLF expand their territory. They do this in two major ways: jumping or flying to new hosts, and hitchhiking (Eshenaur, 2022). “On their own, they are able to move 3 to 4 miles by walking, jumping and flying,” and they often move in large groups or swarms when choosing new hosts (Eshenaur, 2022). Their swarming behavior is more prominent in the late summer and early fall, where the SLF are more active and more likely to move to previously uninfested areas and plants (Urban, 2020). Still, this is not the most common way lanternflies move to new places. According to the New York State Integrated Pest Management department at Cornell University, “transportation by human activity is the most common form of movement and the main reason SLF populations have not been contained,” (Eshenaur, 2022). This is indeed

how they got to the US in the first place, and is also the main challenge to states and counties working to quarantine the particularly resilient pest.

To stop the SLF and prevent further infestations and damage, farmers, researchers, and governments have been working to develop and utilize integrated pest management techniques. Integrated pest management (or IPM) has many factors, including "prevention and suppression, monitoring, decision making, non-chemical methods, reduced pesticide use, anti-pesticide

resistance strategies, and evaluation," (Adams 2022). The main goal of IPM is to work to solve a pest issue or infestation without severe harm to the people and environment surrounding the specific problem. Pesticides, while recognized as a way to reduce SLF concentration and hopefully overall negative effect, are often severely harmful to the surrounding environment, especially a class of pesticides known as neonicotinoids (MacGregor, 2020). These specific insecticides are so "effective," they kill almost all insects in the target area, including those that are environmentally beneficial, like pollinators; they are also often toxic to many non-insects, like birds and fish (MacGregor, 2020). Still, when pesticides are used or must be used, like in severely infested agricultural settings, there are ways in reducing their harm to both people and the planet, many of which have been compounded by the lanternfly researchers at Penn State University (Leach et al., 2021). These include always only choosing an EPA approved pesticide, never applying more than the label suggests, choosing the least toxic insecticide available for the severity of your infestation (i.e. avoiding neonicotinoids), and using pesticides only as a last resort (Leach et al., 2021). Many goals of the IPM approach to SLF infestations focus heavily on pesticide reduction, though this usage may still be an unfortunate reality for many infested areas, agricultural or otherwise, in combating the problem.

Despite this, there are many IPM strategies both being actively used and actively developed to target this issue. A common one in use already is physical traps and other simple methods for directly catching and killing lanternflies. Some of these include funnel-style "circle traps," which can easily be made with common household materials, and sticky band traps, which are most useful when put on or around trees to catch nymphs and adults crawling up and down the target tree (Leach et al., 2021). These traps are more effective for residential or smaller scale operations, and are less effective in reducing SLF in larger areas like entire farms or

forests; nonetheless, they can still be beneficial for homeowners and in reducing the amount of SLF on one's property (Eshenaur, 2022). Sticky band traps in particular have the unfortunate side effect of often producing bycatch of helpful and nondisruptive animals and insects, including pollinators or birds; nets can be installed over them to prevent this, as the SLF is usually caught by walking up the tree and not flying directly into the sticky band (Leach et a., 2021). "Evaluation of other trap designs is underway, as well as testing of additional lures that have recently been identified" to increase accuracy and reduce bycatch of SLF traps (Urban, 2020).

Less actively used but currently promising IPM methods of spotted lanternfly reduction include various biological control methods. This includes finding a predator for the SLF; while there is no natural predator for the SLF in the US, researchers from Penn State University's Entomology department have proposed multiple biological control interventions. There are currently "two naturally occurring fungal pathogens, *Beauveria bassiana* and *Batkoa major*" and "three parasitoids [that] have been identified [which] attack SLF: *Ooencyrtus kuvanae*, an egg parasitoid previously introduced to control gypsy moth, and two parasitoids found in China, *Anastatus orientalis* and *Dryinus browni*, that have been imported to… labs in the USA for

further study," (Urban, 2020). These control methods are just some of the complex, wide range of IPM measures researchers and governments have and can be working on expanding to further combat the spotted lanternfly problem in the US and beyond.

Despite the importance and necessity for research and increased scale of IPM control methods, one of the most common and simple rhetorics for decreasing the impact of the SLF has been to straightforwardly communicate the message of "stopping the spread;" the overall effect of this has been to simply attempt to ensure they do not have the ability to harm any new and uninfested areas. Many state departments of agriculture have enacted quarantines for their

specific jurisdictions in the pursuit of this goal, though there has so far been little coordinated federal response to this pest specifically (Urban, 2020). Along with these quarantines, many states require businesses who deal with goods the SLF could inhabit, including agricultural outputs, lumber, plant material, and more to get a SLF permit; "this means that no life stage of SLF can be transported on any commercial goods or vehicles of transport in the quarantine," (Urban 2020). The idea of stopping the spread is not just one for researchers, transporters, and farmers– it extends to actions the general public can take, with people being encouraged in different ways to check themselves and their vehicle when traveling to and from SLF infested areas (Leach et al, 2021). Collective action from the public has so far been one of the most common and effective methods of control for the SLF, and people are and have been "encouraged to look for the insect to ensure not to inadvertently transport it, to report SLF when observed out of the quarantine zone, and to make reasonable effort to control SLF on their property," to help mitigate damage (Urban 2020). Often, this messaging epowers members of the public that if they see lanternflies they should step on them, creating a way for everyday people

to become involved in reducing the impacts of this invasive pest. This has frequently been communicated down through the catchy mantra “see it, squish it” (Adams, 2022).

While most state departments of agriculture and SLF researchers agree the public is a major factor in working to decrease the impact of the SLF, some disagree to what extent and through what messaging. Some, like the New York Department of Environmental Control, have commented on the empowering nature of the “stop the spread” and “see it, squish it” messaging to members of the public, as well as the added benefit of hopefully reducing populations (Adams, 2022). Others, like the New York Cornell Cooperative Extension, have discussed potential danger with these types of outreach, in that the public “…might be equating [the “see it

squish it” messaging] to ‘if I see any insect, I should kill it right away,’ when of course, most insects are beneficial to us,” (Adams, 2022). What most agencies and states agree on, however, is to properly educate the public on what the spotted lanternfly is, what it does, how it really impacts our communities and environment– and what they can do about it. The SLF researchers from Penn State have discussed the impacts of SLF education and outreach, saying “we're trying to get people to just, you know, don't panic and consider the research based information that we have and choose a solution or management action that would work for them,” (Adams, 2022). Overall, public engagement and education around the spotted lanternfly has been critical, and officials from New York state have discussed the extent of how this outreach has affected their lanternfly control, stating “the public was the foremost entity for which we were informed of the existence of spotted lanternfly for the first time in New York City, for the first time in upstate New York, for the first time everywhere,” (Adams, 2022). While the “see it, squish it” messaging

may be flawed in the eyes of some, collective public action around spotted lanternfly infestations has and will continue to be a critical part in managing and identifying the SLF all across America.

It is an unfortunate reality, but summers in the mid-atlantic region of the US will most likely be marked with the image of the spotted lanternfly– or, more likely, many of them– from now on. But being able to identify the SLF, understand their impact and harm, and knowing how to properly manage them is extremely increasingly important for farmers, researchers, and the general public alike. IPM techniques, like reducing and managing pesticide use, creating and employing traps, and finding and expanding biological control methods can work to reduce the harm and amount of lanternfly infestations. Additionally, expanding on and educating about social control methods and collective action from the public can empower people, reduce

misinformation, and create a positive overall effect on reducing SLF populations and overall harm. Though the spotted lanternfly may be extremely resistant, the US must also work to resist their invasion of our environment, our society, and our economy.

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