



State-Level Challenges to Invasive Insect Management: A Case Study of Spotted Lanternfly in the Northeast

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Abstract

Spotted lanternfly (*Lycorma delicatula*) is an invasive insect that was first discovered in Pennsylvania in 2014, and has since spread across the Northeastern United States. States in the Northeast have created quarantine zones, regulations, outreach, reporting systems, and management efforts for the control of spotted lanternfly. Despite states' efforts, spotted lanternfly continues to spread rapidly. Through professional interviews with staff members from various state agencies in Pennsylvania, New Jersey, and New York, information was compiled about the state-level response to spotted lanternfly and other invasive insects. This project examines the successes, challenges, and recommendations for the future associated with invasive insect control at the state level.

Introduction

Spotted lanternfly (*Lycorma delicatula*) was discovered in the United States in Berks County, Pennsylvania in 2014 from a report to the Pennsylvania Department of Agriculture of an “unusual pest in large numbers on *Ailanthus altissima*” (Barringer et al. 2015). Spotted lanternfly are large, 17 to 25 mm long, sapsucking insects in the leafhopper family *Fulgoridae* (Barringer et al. 2015). They complete one lifecycle per year with eggs hatching in late spring and full development, mating, and egg laying occurring before frost of the same year (Liu 2019). Spotted lanternfly feed on over 73 species of plants, including non-native and native forest species, ornamental plants, and agricultural crops (Uyi et al. 2020). Spotted lanternfly prefers feeding on tree-of-heaven (*Ailanthus altissima*) in its native and invasive range (Uyi et al. 2020). However, spotted lanternfly has shown to be capable of completing its lifecycle without tree-of-heaven, but development is slower and egg laying is reduced (Uyi et al. 2020).

Since its introduction, spotted lanternfly has spread across the northeast and has established populations in 11 states as of March 2022 (Figure 1).

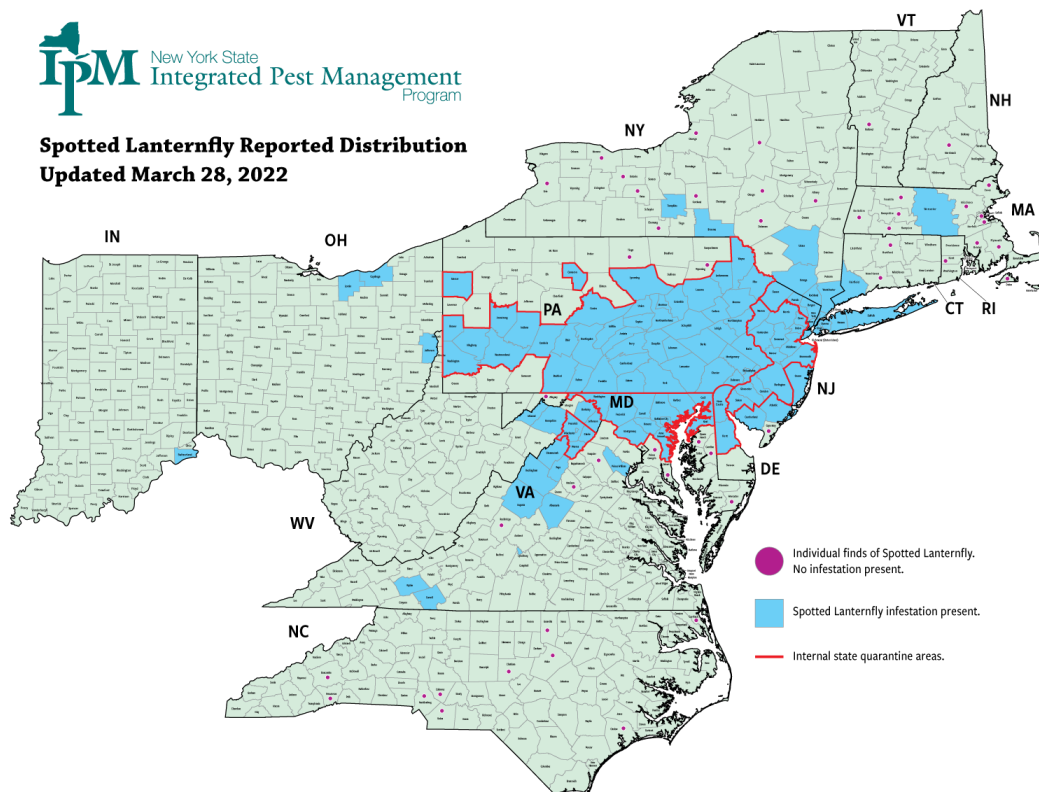


Figure 1: March 2022 Spotted Lanternfly Range Map. Spotted lanternfly has established infestations in 11 states and individuals have been discovered in 15 states. ("Spotted Lanternfly" 2022)

Spotted lanternfly is a species originally from Asia that feeds on a wide variety of host plant species, damages plants by blocking sunlight through sooty mold growth on honeydew waste, weakens host plants, and acts as a nuisance to homeowners (Urban 2020). Spotted lanternfly can disperse via short-distance spontaneous flights (10-50 m), mass dispersal events with continuous bouts of flight (up to 200 m downwind), and transportation on vehicles or trains (Wolfen et al. 2019). To compensate for poor flight capabilities, adult spotted lanternfly will climb vertical surfaces, face the direction of the wind, flutter up to 10-80 m at a time, and repeat this process to travel (Lee et al. 2019). This dispersal mechanism primarily occurs during September and October during the egg laying period (Lee et al. 2019). Spotted lanternfly has

the potential to spread across much of the Eastern United States based on climate suitability and the wide variety of host tree availabilities (Jung et al. 2017).

Tree-of-heaven (*Ailanthus altissima*), the host tree of spotted lanternfly, was first introduced in Philadelphia, Pennsylvania in 1784 and has spread rapidly since (Du et al. 2021). Early introduction of tree-of-heaven and lack of lanternfly predators have resulted in a rapid invasion of spotted lanternfly (Du et al. 2021). Spotted lanternfly egg masses overwinter to produce the next generation (Liu 2019). Each egg mass contains an average of 20-50 eggs and was found to have about a 68% egg hatch success in field studies (Liu 2019). The egg masses of spotted lanternfly are cold tolerant, which is likely correlated with the pest's ability to establish successfully (Smyers et al. 2021). The wax barrier that females produce to cover egg masses are a protective barrier that protects against harsh climatic conditions and desiccation (Smyers et al. 2021). Large numbers of eggs per egg mass, availability of host tree, suitability to climatic conditions of the Northeast United States, and ability to travel have created a major spotted lanternfly invasion.

State Quarantines and Reporting Systems

Many states have enacted quarantines to manage the spread of spotted lanternfly. Each state has produced varying quarantine restrictions, policies, and check lists for their quarantine zones. Quarantine policies for each of the infested states as of March 2022 can be found in Table 1. While many of the quarantine regulations are nearly identical, several states with established populations do not yet have quarantine regulations. Uneven policies across the infestation area in the Northeast and Mid-Atlantic can create difficulties in controlling spotted lanternfly.

Table 1: Brief summary of quarantine zones in states with established spotted lanternfly populations (“Spotted Lanternfly” 2022, “Spotted Lanternfly Notice of Quarantine” 2021, “New York: Plant Protection Regulations” 2019, “New Spotted Lanternfly Quarantine”, “Order of Quarantine and Treatment” 2021, “Spotted Lanternfly Quarantine” 2021, “Amended Quarantine Order” 2022, “Spotted Lanternfly”).

STATE	ISSUING AGENCY	BRIEF SUMMARY
MASSACHUSETTS	Massachusetts Department of Agricultural Resources	No official quarantine. Checklists for residents and industries to prevent the spread of spotted lanternfly are available and recommended, but not enforced.
CONNECTICUT	The Connecticut Agricultural Experiment Station	Businesses cannot move regulated articles from the quarantine area to any other area without a compliance agreement from the Connecticut Agricultural Experiment Station or Phytosanitary Certificate. Non-business individuals must complete a checklist.
NEW YORK	New York State Department of Agriculture and Markets	External quarantine, regulated items being shipped to or through New York from the external quarantine zone must have a certificate of inspection, waybill, and loaded and handled in a way that reasonable prevents spotted lanternfly infestation.
NEW JERSEY	New Jersey Department of Agriculture	Regulated articles cannot be moved within or from the quarantine zone without taking precautions to prevent the spread of spotted lanternfly. The general public must complete a checklist. Businesses and government agencies must inspect regulated articles that are moving within the quarantine zone and must obtain a permit to move regulated articles in and out of the quarantine zone.
PENNSYLVANIA	Pennsylvania Department of Agriculture	Businesses in any state with active spotted lanternfly infestations must complete Pennsylvania's permitting process to move regulated articles within and from the quarantine zone. Individuals must complete a checklist when moving regulated articles within and from the quarantine zone.

DELAWARE	Delaware Department of Agriculture	Precautions must be taken when moving regulated articles in and out of the quarantine zone. The public must complete a checklist, businesses and agencies must have a permit.
MARYLAND	Maryland Department of Agriculture	Precautions must be taken when moving regulated articles in and out of the quarantine zone. The public must complete a checklist, businesses and agencies must have a permit.
WEST VIRGINIA	N/A	No official quarantine.
OHIO	Ohio Department of Agriculture	Individuals are asked to complete a self-inspection checklist when moving high risk articles from the spotted lanternfly infested area. Businesses may need to obtain a compliance agreement when moving items out of infested areas.
INDIANA	N/A	No official quarantine.

Similar Invasive Insects

Other invasives have similarly moved through the Northeastern United States and caused major ecological and economic damage. Emerald ash borer (*Agrilus planipennis*) is a wood boring beetle native to Asia that has caused die offs of millions of ash (*Fraxinus* spp.), an economically and culturally important tree (Herms and McCullough 2014). Emerald ash borer was able to spread widely throughout the Midwest and Northeast due partly to the transportation of firewood (Diss-Torrance et al. 2018). In response, the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) and several state agencies enacted quarantine policies that restricted firewood movement and created lumber inspection policies (Herms and McCullough 2014). However, states that did enact quarantine and inspection policies were not always effective in implementing such policies. In a study that examined effectiveness of firewood movement prevention policies in

state parks in Wisconsin, researchers showed that it is unrealistic to try to achieve 100% compliance and that compliance improves initially with education but levels off after a few years (Diss-Torrance et al. 2018). This study shows that regulations can be effective when paired with education programs and conducted in public places, such as state parks, but without education these regulations become less effective over time (Diss-Torrance et al. 2018).

Asian longhorned beetle (*Anoplophora glabripennis*) is an invasive wood boring beetle that was potentially accidentally imported from China on wood packing material to the United States in 1996 (Javal et al 2019). It was first discovered in Brooklyn, New York and has since been found in other parts of New York State, Massachusetts, Ohio, and South Carolina (Javal et al. 2019). Asian longhorned beetle bores through wood and kills economically and culturally important trees, such as deciduous urban trees (Javal et al. 2019). Asian longhorned beetle has the potential to spread throughout the northeast and cause \$669 billion of damage economically (Javal et al. 2019). Similar to emerald ash borer, firewood movement regulations were enacted to restrict the movement of this pest (Javal et al. 2019).

Hemlock wooly adelgid (*Adelges tsugae*) is a small sap-sucking insect pest of hemlock trees (*Tsuga* sp.) (Spaulding and Rieske 2010). After its arrival in 1951, hemlock wooly adelgid spread sporadically until the 1980s when the population began expanding rapidly due to movement on birds, wind, other wildlife, and by humans (Spaulding and Rieske 2010). In the Northeastern United States, there has been around 95% hemlock mortality and 50-75% defoliation of surviving hemlocks (Spaulding and Rieske 2010). Some states have introduced quarantines for hemlock wooly adelgid, such as Maine's quarantine of nursery hemlock plants

from listed infested counties (“Handle or Move Hemlock Products”). Other states, like New Hampshire, have eliminated their quarantines due to the establishment of hemlock woolly adelgid in a large portion of the state and changing management priorities (Carlson 2018).

Another similar insect pest that invaded the Northeast is spongy moth (*Lymantria dispar*). Spongy moth is a major pest issue because the caterpillar is a generalist defoliator of forests (Jankovic and Petrivskii 2013). In addition to defoliation, it has been found that spongy moth can impact carbon sequestration, nutrient cycling, and the radial growth of trees (Jankovic and Petrivskii 2013). In contrast to spotted lanternfly, the main long-distance dispersal mechanisms for spongy moth are crawling larva, windborne travel, and accidentally by humans with very little dispersal occurring by adult female moths that are flightless (Jankovic and Petrivskii 2013). Since its introduction in 1869, states and the federal government have worked to eradicate spongy moth (McManus 2007). In 1906, the federal government appropriated funds for the USDA, which later enacted a domestic quarantine for spongy moth in 1912 (McManus 2007). In 1995, the USDA developed a “Slow the Spread” management program that emphasized three management techniques including detection and eradication, suppression, and transition-zone management (Jankovic and Petrivskii 2013, McManus 2007). This program has shown to reduce the spread of spongy moth by at least 50% (Jankovic and Petrivskii 2013).

Many similarities can be drawn between spotted lanternfly and other invasive insect pests. Many states reacted to these invasions by enacting regulations to limit the spread of them, such as quarantine zones in the case of spotted lanternfly, spongy moth, and hemlock woolly adelgid, and firewood movement restrictions in the cases of emerald ash borer and Asian

longhorned beetle. Reporting systems were created for landowners, homeowners, and residents for these pests, and professional agencies and organizations stepped in to survey public and private land. For many of these pests, most states enacted similar policies to combat the spread into and throughout their respective states. In each of these cases, there were some states that enacted no policies to restrict the spread or movement of these pests. This uneven policy response has likely led to challenges of uniform control of pests across the Northeast.

There are important distinctions between spotted lanternfly and the other pests. Policies for Asian longhorned beetle, emerald ash borer, and hemlock woolly adelgid restricted movement of the object (firewood, nursery stock) that these pests are transported on, while spotted lanternfly policies do not restrict movement of the object (vehicles, outdoor equipment) and instead require people to complete a self-conducted checklist inspection of the object. Spotted lanternfly is far more mobile in the adult stage and able to spread long distances without the aid of humans, unlike spongy moth, emerald ash borer, and hemlock woolly adelgid that do not travel long distances as adults. Spotted lanternfly is primarily a pest of agriculture, as opposed to emerald ash borer, Asian longhorned beetle, spongy moth, and hemlock woolly adelgid that are pests to forests and timber products. Because these pests affect different sectors in each state, there are different agencies responsible for responding to each of them.

Integrated Pest Management

Integrated pest management is the use of a combination of all available techniques to manage pests, including manual or mechanical, cultural, chemical, and biological means, to reduce harm to human health and the environment (Barzman et al. 2015). The main principles

of integrated pest management include prevention and suppression, monitoring, decision-making, non-chemical methods, reduced pesticide use, anti-pesticide resistance strategies, and evaluation (Barzman et al. 2015). Most invasive pest managers will develop an integrated pest management plan for dealing with new invaders that is specific to that pest species. State agencies in the Northeast often adopt an integrated pest management approach when addressing new invasive insects and will continuously evaluate successes and failures of projects to adjust their integrated management approach. The integrated pest management approach is relevant to this project because state agencies will develop these techniques for pests and adopt them to new invaders, often resulting in direct comparisons of control methods that are discussed throughout this paper.

Federal Response

The United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) takes a large role in coordinating responses to invasive insects on a federal level. USDA APHIS has taken a major role in mitigating invasive pest issues for all pests referenced in this project through enacting federal quarantine zones, coordinating response and management, assisting with surveying and reporting, and providing resources for on-the-ground work. Because USDA APHIS is a federal agency and their work largely transcends the boundaries of states, this allows for more uniform response efforts and education of invasive insects across states. State agencies largely depend on coordination, partnership, and funding from USDA for pest detection and management projects. Because of difficulties contacting USDA APHIS and this project's focus on state agencies and the specific challenges they face with

pest management, the response by USDA to new invasive pests and challenges at the federal level were not examined.

Purpose of Project

The purpose of this project was to examine how state agencies view insect pest management in terms of challenges and successes of management techniques. The compilation of this information serves as an analysis of current pest management programs and how they can be improved based on the successes and challenges from past insect pest invasions. State-level information was collected because state-level agencies and organizations face additional challenges due to the political and geographical boundaries created by the state system in the United States. Insect pests freely move across state borders while state agencies cannot. Federal agencies like USDA APHIS, nonprofits, and private companies are able to work across borders and address these invasions without the limitations that state borders create. This project focuses on challenges created by the political and geographic boundaries that state borders create as well as challenges within those boundaries.

Methodology

The primary methods for data collection for this project were informational interviews conducted with professionals who work at the state level from Pennsylvania, New Jersey, and New York. Because this study focused on professionals' agency policies and practices, it was determined to not qualify as human subjects research and did not require Institutional Review Board approval. Professionals were selected by identifying individuals who primarily worked on spotted lanternfly response in their respective states for their respective agencies. Many

individuals were identified by previous interviewees as important contacts in other agencies. Once identified, individuals were contacted via email to schedule an interview through video conferencing software (Zoom, WebEx) or by phone. Interviews consisted of 8 questions and ranged from 15 minutes to over 60 minutes.

There were challenges identifying appropriate professionals to contact in each agency because websites often did not list contact information for these individuals or only consisted of a general “contact us” form option for the agency, as was the case with Rutgers New Jersey Agricultural Experiment Station Cooperative Extension. Another challenge was that several agencies needed to approve an individual’s participation in this project, and oftentimes either never gave approval or only gave approval for pre-approved written answers to the questions. Therefore, agencies such as New York State Department of Agriculture and Markets were not interviewed while its counterpart agency in the others states was.

This project focuses on state-level responses to invasive insects, therefore professionals working at the federal-level, municipal, and local level were not interviewed. The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) was contacted for an interview because of their unique role of working with state agencies across state borders, but never responded to the request.

All interviews were conducted on Zoom, Webex, or by phone call and were recorded for audio to gather direct quotes from participants. Verbal consents for recording, direct quotes, and the use of the agency name in the project was collected. There were 8 questions asked during interviews (Appendix A). Notes were taken as reference for each interview and as back

up in the case recordings failed, which only occurred during the first few minutes of the one interview. Interview quotes were transcribed from the recordings, and filler words such as “um” and “uh” were removed from the quotes. Information collected was sorted into categories of challenges, successes, and suggestions for the future and grouped by theme.

Interview Results

There were 10 individuals interviewed for this project. The agencies and associated states that were represented in these interviews are listed in Table 2. These individuals will not be identified by name but will be referenced as professionals, employees, or staff members of their agencies. While these individuals provided professional responses to the interview questions, their views are not necessarily indicative of the views of their agencies as a whole.

Table 2: List of agencies with professionals interviewed from Pennsylvania, New Jersey, and New York and their acronyms used throughout this report.

Interview Participants		
Pennsylvania	New Jersey	New York
Department of Agriculture (PA DOA)	Department of Agriculture (NJ DOA)	Department of Environmental Conservation (NYS DEC)
Department of Conservation and Natural Resources, Division of State Parks (PA State Parks)	Rutgers New Jersey Agricultural Experiment Station Cooperative Extension (Rutgers NJAES Cooperative Extension)	Cornell Cooperative Extension (NYS CCE)
Department of Conservation and Natural Resources, Division of Forestry (PA Forestry) (Staff Member 1)		Office of Parks, Recreation, and Historic Preservation (NYS State Parks)
Department of Conservation and Natural Resources, Division of Forestry (PA Forestry) (Staff Member 2)		

Interview Comparisons and Lessons Learned

The process of obtaining professional interviews was complicated. Several professionals from state agencies either did not have time for interviews or could not get approval from their agency to participate in the project. The range in what people were allowed to talk about varied greatly. For example, one staff member interviewed encouraged their name be used in this project because they would “...probably prefer if in regards to referencing DEC, it is me so that people know where to go if I say anything bad.” In contrast, another professional could only give written, pre-approved answers to the interview questions. Another professional wished to be contacted with which quotes would be used prior to the completion of this project. This wide variety in information sharing indicates that the information shared during interviews may have been regulated by the interviewee as to avoid conflict in their job. While this project sought to provide a thorough and honest analysis of challenges of pest management in the northeast, it instead analyzed only the information that was willing to be shared.

There is a great deal of insight into pest management that the interviews themselves provided. For example, the interview conducted with the professionals from PA Extension and Rutgers NJAES Cooperative Extension lasted about 16 minutes and 17 minutes respectively, while the interview with the professionals from PA State Parks and NYS Parks lasted longer at about 28 minutes and 64 minutes respectively. While this does not indicate that employees from state parks had more knowledge than the employees from the extension offices, it was apparent that state parks had a great deal of on the ground management experience that they

were able to share. In contrast, those from the extension offices focused more on education and research and less on management, as is common for extension agents.

Many of the interviewees approached the interviews in different ways. Some people saw the interviews as a networking opportunity and wished to connect on future projects. Some people saw the interviews as an opportunity to praise partnership efforts with other agencies within their states and outside of their states. Others wanted to know what other professionals discussed during their interviews. These differing approaches also led to a wide variety of interview styles, ranging from personable and friendly to formal and professional. The professional interview method came with many limitations, but did provide valuable insight into common themes across state agencies in the northeast.

The results of the interviews were sorted into three categories: challenges, successes, and recommendations for invasive pest management. Each category was further broken down into common themes discussed during interviews.

Challenges of Invasive Pest Management

Pesticide

Pesticide was often referenced throughout the interviews across all states as a challenge to spotted lanternfly and other invasive insect management. One theme in particular that was discussed was the laws and requirements for pesticide use. In the three states examined, pesticides must be used in accordance with the label, which includes only applying to pests specified on the label. The NYS CCE staff member commented on this particular pesticide law, stating about new pests, “Sometimes it's not on the product labels, and so it takes a while for

the manufacturers to change their labels to make it legal for growers or consumers to use [on the pest].” While Pennsylvania was the first state infested with spotted lanternfly, New Jersey did not discover the first infestation in the state later, and New York did not discover the first infestation in the state until 2020 (“Spotted Lanternfly”). However, there are still few products labeled for use on spotted lanternfly. Similarly, the NYS Parks professional expressed frustration understanding the proper license category needed to control spotted lanternfly early in the infestation in the state, commenting,

We wanted to do some treatments at a site and we didn't have...a solid understanding on what applicator license or category applicators would need to treat in certain scenarios. And so, is it a 2, is it a 3A, is it a 9? And then this mixed messaging on what it can and cannot be and who can get Category 9 certification and who cannot. And it was just a lot of confusion in that area, and so you're relying on other agencies to provide that information for you, but they might not readily have it or know it.

Pesticide applicators must be licensed in the proper category to be able to apply pesticide for those particular pests or in those particular conditions. For example, Category 2: Forest Pest Control allows applicators to “control pests in forests, forest nurseries, forest seed production areas, and forested areas within urban settings” (“Certification Categories”). However, Category 9: Regulatory Pest Control allows “state, federal or other governmental personnel who use, or supervise the use of pesticides in the control of regulated pests” (“Certification Categories”). The staff member from NYS Parks noted that there was mixed messaging about which license

category was needed to control spotted lanternfly and whether it qualified as a “regulated pest”.

In all three states, individuals identified pesticide bans or reduction policies and actions taken by their agencies to reduce the use of certain pesticides. Pesticide bans were referenced by Rutgers NJAES Cooperative Extension. In New Jersey, a commonly used invasive insect pesticide, imidacloprid, is undergoing a ban across the state due to its harmful effects on pollinators (Rhoads 2020). The professional from Rutgers NJAES Cooperative Extension addressed this in the interview, stating,

Our governor just signed into law a bill that makes imidacloprid a restricted use material...But that basically means if you don't have a state applicators license, you cannot buy it and apply the material or supervise the application. So they've essentially taken imidacloprid out of the hands of every general public person in the state.

The Rutgers NJAES Cooperative Extension professional discussed the challenges created by this ban in terms of pesticide resistance. They mentioned that typically, imidacloprid and dinotefuran are used in an alternating method to prevent the pest from becoming resistant to one chemical. With the ban, “it takes a tool away” when combating the pest and resistance. New York State Parks has an established pesticide-reduction policy to reduce the amount of pesticide used on state park land and the staff member from the agency commented on this policy stating that they are “an agency that tries to reduce its pesticide use, and especially an agency where we might deem we're not going to treat with an insecticide. Or we might say insecticides will be our last resort. We're not going to actively use them.” The employee from

PA Extension also referenced pesticide-reducing methods, stating, “I think it's certainly a challenge if people are trying to use reduced pesticide inputs or organic practices. And we're working on some methods that perhaps could be used in those sorts of situations.” Pesticide reduction policies and bans mean that private businesses, homeowners, and state agencies must rely on lower pesticide usage and other means of control, such as manual or biological control methods.

A common theme across interviews was the frustration with homeowners and private citizens applying homemade concoctions that they found on unreliable sources like social media. The professional from PA Extension described issues they noticed with at-home remedies,

We've had a lot of anecdotal cases where people have reactively done things that were not safe using household products like automotive products...to kill lanternflies that aren't labeled...And that kind of information is so out there, it's so available on social media especially, then people find it, and then they don't realize that, you know, there are concerns about the safety of that, those products, using any of those products, either for the tree health or for the safety of the person who's making the application.

PA Forestry staff members also cited the difficulty with control techniques. Because tree-of-heaven can be so interspersed among native vegetation, there is no effective way to broadcast spray contact insecticides from helicopters or boom sprayers. As staff member 1 from PA Forestry noted, “The only way to kill [spotted lanternfly] is to go tree by tree,” which

can take a great deal of time and resources. Pesticide can be an important control technique for new invasive pests, but also presents a great deal of challenges for state agencies.

Research

The amount of information available about spotted lanternfly was cited as a major challenge for several agencies. The employee from PA Extension commented on the need for more research-based information, stating, “The data that we have at the moment isn't making a really clear picture for being able to predict threshold levels for action. And that's, you know, a future goal or we're continuing to work toward that. We'd like to get to that point.” South Korea has much more research published about spotted lanternfly, but there were issues getting much of it translated from Korean to English, as staff member 2 from PA Forestry noted. They also discussed similarities when other pests were first discovered in the United States. For example, staff member 2 stated, “For most invasive species, when they first detect in the new area, it's always that information is always very, very rare. And for example, when the emerald ash borer, when we first detected it in Detroit, there was only a one-page summary from China, that's all we got.” Researchers have needed to conduct original research on spotted lanternfly to better understand it, and because this takes time and money, there is still little research-based information about it.

In a more general sense, PA State Parks stated a major challenge for the Northeast as a whole “would be a bit of the unknown... we don't know if there will be any long-term impacts to something like red maple or other native species...That may be the greatest challenge. It might turn out to be no big deal, and everyone can breathe a sigh of relief.” The professional from PA Extension also commented on the unknown long-term effects of spotted lanternfly,

stating, “But the nuisance issue and long-term health effects on trees that we don't really understand yet is another part of it.” Similarly, PA DOA commented on the discovery of spotted lanternfly and the lack of knowledge about how it would behave in Pennsylvania, stating,

We didn't know for sure whether it was going to persist in Pennsylvania because it seemed as though it...had been in that location for at least a couple of years before we found it based on old egg masses...but at that point, it hadn't proliferated. We didn't know whether it was going to. Could have just stayed localized and never been a big deal. And unfortunately, that's not how it panned out now.

The lack of information, and research-based information in particular, about spotted lanternfly, its invasiveness in the Northeast, and its long-term impacts have created a major management challenge for state agencies dealing with it.

Research to guide management was another issue mentioned by some of the agency professionals interviewed. NYS Parks discussed the challenges of collecting data about spotted lanternfly and using that data to guide management, commenting that one of the major challenges for the agency was “collecting all the information that is also forever changing because it is a relatively new pest to the states. So even when you have something done or close to being done, the research changes and the guidance then changes...and so you're just trying to be as specific and vague as possible to address a wide variety of scenarios.” Similarly, staff member 1 from PA Forestry discussed how the agency was using methods for research and management without knowing if they were effective yet, commenting of researchers, “We

can't wait for you to get it published and wait to see what actually works so well.” They concluded with, “Research is right there as the most important [issue].”

Funding

Funding was a commonly described challenge to spotted lanternfly and invasive pest management. When the employee from Rutgers NJAES Cooperative Extension was asked the question about challenges, they stated “Funding at the beginning.” The staff member from PA DOA also commented on the lack of funding initially for new invasive insects, stating,

Upfront funding to be able to jump on a pest like that, you know, state budgets are prepared in advance and the budget is what it is. So if a bug comes in and you have to deal with it and there's no funding source for it, you have to scramble for emergency funding, which you can sometimes get. But of course, everything takes a little bit of time.

Similarly, NYS Parks mentioned that a major challenge for controlling new invasive pests is “not having funding or funding not coming when you need it.” Staff member 1 from PA Forestry echoed a similar idea by saying, “Having resources available when you detect something, that's the problem.” Agencies are not only concerned with receiving funds, but also the timeliness of those funds.

Communication and Education

Messaging was often brought up during interviews as a challenge for state agencies. As NYS CCE noted, there was no federal messaging about spotted lanternfly and it was largely left up to each agency within each state. Because of the lack of federal messaging and the differing goals between agencies, several state agencies had differing views of how messaging should be

conducted and what message they wanted to provide for the public. For example, NYS DEC commented on the benefits of “squishing” events and how “empowering” that kind of messaging had been for the public. The public had taken ownership of spotted lanternfly control through squishing and stomping events. Similarly, the staff member from NJ DOA discussed how they have moved from “see it report it” messaging to “see it stomp it” to help control the population. In contrast, the professional from NYS CCE expressed concerns about “see it stomp it” messaging and that it “...might be equating this to if I see any insect, I should kill it right away, when of course, most insects are beneficial to us.” To further illustrate the point that they do not agree with “see it stomp it” messaging, the professional from NYS CCE described their education methods, stating, “The one thing we're doing is educating, saying this insect does not bite. It doesn't sting. It doesn't become a pest in the home. It doesn't even cause dieback on landscape trees. So we're getting that message out there first and then, yeah, if you want to step on them, go ahead. But that's not first from us.”

Another challenge with messaging related to the visibility of spotted lanternfly. In contrast to emerald ash borer and hemlock woolly adelgid which are elusive and difficult to see, spotted lanternfly are large, colorful, and swarm. As the staff member from PA DOA stated, the problem was much more visible. News agencies picked up the story of spotted lanternfly in Pennsylvania, New Jersey, and New York and published headlines such as “States Expand Efforts to Squash Spread of Dangerous Insect” and “We Must Come Together and Kill the Dreaded Spotted Lanternfly” (Claudio 2022, Carlson 2021). Articles like these were quickly circulated through social media. The professional from PA Extension discussed how they have “...done a lot of work on trying to get people to just not panic. There's been so much in the

media about spotted lanternfly and I think there was a lot of fear that ensued.” NYS CCE also talked about the panic that media headlines had created and that in an area in Pennsylvania, “The police had to send out a message... ‘Don't call 9-1-1.’ It was clogging up their lines.” The NYS CCE staff member also described a story about getting sent a video from Brooklyn outside of a subway station and said,

Some college kids got out and they wanted to take the video of the insect to get it confirmed, right? Because they knew early on that we wanted anyone to report this. But you can hear...the college kids in the background saying, ‘Oh my gosh, look at that. I've heard about this. It's poisonous, right?’ And then somebody said, ‘Oh my God, Jake's going to die.’ You know, they were joking around, but I guess Jake had touched it earlier.

The NYS CCE staff member’s story highlights the challenges of getting the proper messaging out to people and stopping the spread of misinformation on social media and traditional media. The professional from NJ DOA similarly discussed how “sometimes the public can get overly worried due to all the messaging out there. It’s not the end of the world and will have little effect on the average homeowner and their yard.”

The staff member from PA DOA also noted challenges with educating and communicating to the public. During the beginning of the infestation, they noted issues getting permission to access private properties to conduct surveys, and that “in some cases, when there's no visible problem, just in general, some people are skeptical about having, you know, the government, any government agency or entity, enter onto their property.”

The NYS Parks employee discussed the challenges associated with communication across state agencies. In reference to the confusion surrounding pesticide licensing and category requirements, they commented, “I just think it's potentially a long history of not having clear communication across not only agencies, but within agencies. One part of an agency not effectively communicating with another part of the agency...I always boil it down to communication. A lot of barriers that we have are effective communication.”

Federal Response

A few professionals noted the lack of a coordinated federal response as a challenge for spotted lanternfly management. The employee from NYS CCE referenced the lack of federal messaging, stating,

I think if there was a little bit more federal management of it, managing the messaging and the control tactics, it could have been helpful...I don't want to sound like I'm down on the federal agencies, but for this pest, it might have been helpful and it still might if they kind of recognized it as a federally quarantinable pest, which I don't think it is.

The NYS CCE staff member is describing how some pests are federally quarantinable, like Asian longhorned beetle, but is unsure if spotted lanternfly would be. Despite this, federal messaging could have been helpful to guide state agencies.

The professional from NYS Parks also commented on their frustrations working with USDA. They stated,

I have been a little frustrated with federal USDA. They aren't the greatest communicators...I feel like there's a long history where...people feel like they can, just because state parks are public lands, they can just go on them and trap and survey, so on and so forth, without any prior discussion with state park staff. And that is an extreme frustration of mine. USDA did that at the very beginning...they were not the biggest beacons of communication. Since then it's gotten much better. I complained, and they've been much better at it and so much so that they'll reach out to me specifically. And I think just part of that was them just not knowing. I don't think it was spiteful.

While the professional acknowledges that the lack of communication was not intentional, this anecdote demonstrates difficulties with communication and understanding of state policies and procedures on the part of USDA.

The Pest Itself

Many professionals expressed frustration with the pest itself, often citing its ability to spread and reproduce as a major management challenge. PA Forestry staff members described the availability of its preferred host, tree-of-heaven, and its ability to hitchhike through human assistance as a major challenge in the northeast. PA Forestry staff member 2 also discussed the difficulties in preparing for new invasive pest species even when states know they are coming, stating,

Early detection rapid response when you find [the pest] at the early stages is normally easier to deal with if you're dealing with the eradication or treatment. But for all the

invasive species we kind of always get caught off guard because although we know about it, but by the time you got it, it's still like a panic attack from many states.

Staff member 2 is describing how early detection and rapid response to manage the new pest before it becomes established is easier and less resource intensive than eradicating or mitigating the pest after it becomes established.

Spotted lanternfly was dissimilar to past pest invasions, as a lot of professionals noted during their interviews, and it was therefore difficult to apply lessons learned from other invasive pests to the spotted lanternfly infestation. When asked about lessons learned from previous insect pests, many professionals described how different managing spotted lanternfly was because of differing goals between spotted lanternfly management and emerald ash borer or Asian longhorned beetle management. For example, the New York State Parks employee described,

Lanternfly is very much an agricultural pest for the most part and a human experience pest, but it's not a forest health pest. So DEC typically doesn't participate in those types of things or historically hasn't. I should say it really would only impact us with our visitor base and so on and so forth. So, it's not like we historically would have an active management with spotted lanternfly because we don't have vineyards or anything like that.

Similarly, the differences in how previous invasive insects had behaved and how visible they were to the public compared to spotted lanternfly also led to difficulties applying previous

invasive pest control methods and education to spotted lanternfly management and vice versa.

As the employee from PA DOA describes,

We did take some of those lessons, mostly with education and making sure people are aware and to keep an eye out for it. Keeping an eye out for emerald ash borer wasn't too useful because it's a pretty cryptic bug. You don't even know it's around until your trees are dying, but spotted lanternfly is different. It's big, it's colorful, it's in your face, it's in your backyard, so people can identify that pretty easily.

The behavior, feeding preferences, damage caused, and overall visibility of spotted lanternfly is different from other invasive pests and therefore previous management, education, and outreach methods were not useful for managing the spotted lanternfly invasion.

The PA State Parks professional described the operational challenges in the parks, including honeydew and sooty mold covering equipment and visitor complaints. The professional described how “field managers have responsibility for an individual site or a complex park and a handful of satellite parks...and they are the ones who are in the areas where the spotted lanternfly infestation sort of exploded. They're the ones who had to deal with the visitor complaints and questions.” Spotted lanternfly and its effects on natural resources and park visitor experience created challenges not only for natural resources staff, but for park managers and operational staff members at the parks as well.

The employee from Rutgers NJAES Cooperative Extension described a major challenge for the Northeast as “...the lack of ability to stop [spotted lanternfly], it's going to continue to spread and I don't think there's really anything that we can we can do. We might be able to

slow it. We might be able to, say, protect an individual vineyard from it, but we're not going to eradicate it." Several agencies expressed a similar notion of eradication not being possible.

The staff member from PA DOA reflected on the beginning of the spotted lanternfly infestation in Pennsylvania and that it was likely too difficult to have eradicated the pest even if they knew how bad it could have been. The staff member stated, "The bug just reproduces too quickly. The egg masses are too cryptic, so to wipe it out probably would have been a monumental task. Even though the population was relatively limited, it might have been a little bit too expansive, even at that point to hope for eradication." The staff member from NYS Parks also commented on the difficulty of managing spotted lanternfly, stating "I want to say the hardest thing about spotted lanternfly management so far is the ever-evolving situation and the complexity behind spotted lanternfly as a pest." NJ DOA echoed these ideas and stated spotted lanternfly "reproduce rapidly and spread rapidly, making eradication impossible." Spotted lanternfly is a difficult pest to manage in the Northeast due to its invasive traits and the difficulty of eradicating it once established.

Successes

Communication and Education

While communication and education were commonly cited challenges for spotted lanternfly management, nearly all of the professionals interviewed also described successes related to communication and education surrounding the spotted lanternfly infestation. As the NYS DEC staff member noted, "One of the biggest challenges when it comes to addressing invasive species in general is making the public aware of it." All states discussed successes in

making the public aware of spotted lanternfly. Staff member 1 from PA Forestry highlighted the outreach and training by their agency and PA Extension, noting of Pennsylvania citizens, “If you don’t know about spotted lanternfly, you must not watch the news!” The professional from PA DOA similarly highlighted the partnerships between agencies and private companies such as the State Conservation Districts, rail line companies, and PA Extension to provide trainings, outreach, and educational materials. The professional from PA Extension acknowledged successes within their organization that they “...have educated a lot of people, and I think that we have probably helped a lot of people avoid making those kinds of mistakes with using household products and directed them to effective, you know, better management options.” The professional from PA Extension was also able to achieve messaging that prevented panic, stating “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”. In New Jersey, Rutgers NJAES Cooperative Extension also noted successes of awareness of spotted lanternfly, control strategies, and recommended pesticides. The professional from NJ DOA also commented that “the public outreach has been very successful. [They] think most of NJ’s citizens know what [spotted lanternfly] is and that they can get information on our website.”

The staff member from PA Extension also noted the success of state-to-state collaboration, noting that “as [spotted lanternfly] moves into new states, I continue to hear from people, you know, that they’re asking for our perspective and experience and then they share what they’re seeing, you know, in their areas. So I think we’ve had a good relationship with all of the surrounding states, really.”

In New York, agencies also described similar successes. The staff member from NYS CCE has also declared outreach to be successful, saying “I'd say one of the successes is that we've gotten the word out about this insect.” They also noted that the outreach to the grape grower community was particularly successful and that they are “...informing the growers and maybe empowering them so that they don't have to panic because, you know, they've seen the images of the dead vineyards in Pennsylvania and know that some of the establishments there stopped planting grapes for a few years, and I just I think we're helping prepare our grape growers for this.” The NYS CCE staff member further used the term “empowerment” to describe how outreach events involving “See It, Stomp It” messaging could allow people to feel as if they have the ability to do something about the spotted lanternfly infestation. They stated, “You see all the ‘squish spotted lanternfly’ type stuff, you know, like, oh yeah, is it effective? Who cares? The public is actually participating and they're feeling good about it, you know?” However, the NYS Cornell Cooperative Extension employee also indicated that the “See It, Stomp It” messaging created negative feelings toward insects and they have had outreach success without using it.

The NYS DEC staff member also described the public empowerment created from spotted lanternfly because it “was one of the first invasive species that was pretty and stood out like a sore thumb.” The visibility of spotted lanternfly allowed the public to get directly involved in reporting sightings and “squishing events.” The NYS DEC staff member also noted the usefulness of the public as a resource and described how they were able to help so significantly in the case of spotted lanternfly, 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. It wasn't a professional looking for it and finding it. It was the public going, 'Hey, I saw some outreach material. I saw the picture of this really pretty looking moth that you call the spotted lanternfly, and I think I got it here. I'm going to take a picture with a cell phone.'

The visibility of spotted lanternfly helped to teach the public about invasive pests and reporting tools. The NYS DEC staff member was hopeful that these skills the public learned from spotted lanternfly could translate to reporting other invasive pests.

Information Sharing

Similar to outreach and education, information sharing between states was noted as a success by almost all professionals interviewed. Pennsylvania was the first and only state to have spotted lanternfly infestations for several years after its discovery in 2014. Because of this, Pennsylvania state agencies, researchers, and universities had some of the only research on spotted lanternfly. Professionals from PA Extension and PA Forestry discussed conversations they had with South Korean researchers and efforts to get publications translated from Korean to English. When spotted lanternfly arrived in New Jersey, the staff member from Rutgers NJAES Cooperative Extension described how Pennsylvania was beneficial in providing research-based information. Similarly, the staff member from NYS DEC spoke highly of the information sharing by Pennsylvania and other states, noting, "They're very forthcoming with all of the different ways that they addressed dealing with the lanternfly. Their successes, their failures, and then that just compounded itself when New Jersey got it and Virginia got it and, you know,

we all sort of work together as a community to try to address this pest.” The NYS CCE professional also described the benefits of information sharing with Pennsylvania, stating “we’re really lucky in that Pennsylvania has been so open.” The NYS Parks professional also said “Pennsylvania has been great” when asked about interstate collaboration. They were able to directly learn from PA State Parks about the challenges spotted lanternfly posed to parks operation, stating, “State parks, we had a great conversation with them and they actually alluded to some challenges that we might have...They said a lot of insects were coming in the bathhouses, especially when the weather got colder and their skylight had a lot of spotted lanternfly.” Nearly all agency professionals interviewed in New York and New Jersey commented on how appreciative they were of Pennsylvania’s willingness to share information.

Nearly all of the Pennsylvania professionals noted that they were a major source of information for the Northeast as spotted lanternfly spread. The PA Extension staff member noted that they were able to get research-based information, and the staff members from PA Forestry also noted their ability to contribute to the research on spotted lanternfly. A staff member from PA Forestry also commented on information sharing with other states, that “they were all asking us the questions” about spotted lanternfly because of their experience with it. The professional from PA DOA noted their contributions to information sharing by stating, “we’ve shared information about our how we set up our quarantine. Other states have followed suit and pretty much use the exact same language as our quarantine.” They also noted that when spotted lanternfly appeared in Indiana, they “actually went out there for a week with [their] Pennsylvania staff and assisted them with control and showed them how you do things.” There seems to be universal agreement among all professionals interviewed that it was

incredibly beneficial to have information from Pennsylvania's experience with spotted lanternfly and that this information has directly affected other states' policies and management.

Collaboration

Several professionals interviewed spoke of the successes of working with others within their own agency and outside of their agency. The staff members from PA Forestry talked a great deal about quick buy-in from the department's administration. They were able to quickly and effectively communicate to leadership to get the support and resources needed to address spotted lanternfly. Staff member 2 affirmed this idea by noting that staff member 1 was a "good advocate to leadership." PA Forestry and PA DOA professionals discussed the creation of a \$1 million reserve fund in the budget for any other pest that may arrive in the state and act invasively.

The professional from NYS DEC described the successful collaboration between agencies in New York State, starting with the creation of an incident command system that created a clear structure of management. They also noted their successful partnership with the NYS Department of Agriculture and Markets and how valuable that collaboration was in the early stages of reporting and controlling spotted lanternfly. The NYS CCE employee discussed the Spotted Lanternfly Summit, an annual virtual conference on spotted lanternfly management and research, and mentioned that it's "...a great example of, you know, multistate collaboration and sharing". The employee from Rutgers NJAES Cooperative Extension also mentioned the Spotted Lanternfly Summit and their participation in it, and the NJ DOA employee echoed that the "SLF Summit each year...is very helpful to all of the states who have SLF or are worried

about it.” The NYS Parks staff member affirmed their statements, saying, “I think collaboration in general has been a great success with spotted lanternfly.”

The PA State Parks staff member noted successes with collaboration on spotted lanternfly due to past collaboration on other pests, stating, “because of past collaboration on other insect pests, we do have a fairly good working relationship with our sister agency Bureau of Forestry and the Department of Agriculture.” The staff member from PA State Parks also noted that because of this past collaboration, “when the Department of Ag had funding, we were well positioned to take advantage of it.” For PA State Parks, collaboration led to increased resource sharing to help manage the new pest.

Recommendations

Coordinated Federal Effort

A few agencies noted the federal effort in invasive pest issues. For example, the professional from DEC discussed how important the federal government is when managing invasive pests by noting, “One of the biggest challenges is that a state specifically cannot really manage invasive species alone. And one of the biggest partners in assisting with that management of invasive species is, as you can imagine, the federal government.” Another professional noted there was a coordinated federal effort by USDA APHIS to detect and eradicate certain pests, such as Asian long-horned beetle. However, the professional NYS CCE described the lack of a coordinated federal response and messaging for spotted lanternfly. This lack of a coordinated response in messaging across the northeast became clear when professionals talked about their differing opinions on “See It Stomp It” or spotted lanternfly

squishing messaging, such as NYS CCE and NYS DEC described. Furthermore, better working relations with federal agencies could help avoid conflicts like NYS Parks described with USDA trapping on state park land without permission.

Collaboration

One of the most highlighted successes and lessons learned was the need for clear collaboration early with an effective command structure. The staff member from NYS DEC discussed how successful the command system was for New York State to learn about the spotted lanternfly invasion before it arrived in the state. The command structure consisted of agencies that would work on invasive pest management, and allowed for early action when spotted lanternfly first arrived in New York.

In reference to data collection techniques, the staff member from NYS Parks noted that “the most important thing in...invasive management is standardized data collection and being able to capture all that data in a way that you can use to manage it, and that involves working with partners to develop a method that can be utilized to the best extent to everyone.” Through collaboration with other agencies, data collection should be standardized to ensure that the collection method is usable across agencies and the data collected can be managed by all agencies.

Collaboration between state agencies within each state and between states led to better information and resource sharing. Increased collaboration on current invasive pests as well as collaboration for future invasive pests can help agencies be better positioned to address natural resource threats and receive resources needed to address them.

Preparedness

Several professionals emphasized the need for preparedness when responding to new invasives. The professional from NYS DEC discussed how the agency “reacted” to the emerald ash borer invasion and used that as a lesson to create the incident command system for spotted lanternfly. This system allowed for the quick response and creation of the spotted lanternfly working group in New York that contains representatives from many agencies and organizations.

Staff member 1 from PA Forestry praised New York State’s Partnerships for Regional Invasive Species Management (PRISMs) system. In 2005, the New York State Invasive Species Task Force proposed the formation of the PRISMs, which are 8 regional working groups composed of representatives from state agencies, nonprofits, Friends groups, private companies, and interested citizens (“PRISMs”). Each PRISM works on regional invasive species problems through sharing resources, creating management prioritization lists for invasive species, conducting early detection rapid response surveys, providing volunteers, and other activities as needed. Staff member 1 from PA Forestry described the successes of the PRISMs in detecting new invasives and creating a system that is not reactionary. They noted that Pennsylvania hopes to adopt a similar system for managing invasive species, and mentioned that there is an already established Pennsylvania Invasive Species Council. Staff member 1 from PA Forestry stated, “We’re copying what New York did. We’re establishing PRISMS. We’ve already done all the legwork. We have a program in place, an implementation plan in place...It hasn’t passed yet, but in [the governor’s] proposed budget, he put forth \$3.5 million for the establishment of PRISMs. I did the budget, it’s going to cost \$7.8 million plus another \$700,000

to give extra staff support to the Department of Ag. But at least it's a start because then you've got just like your PRISMs in New York.” While Pennsylvania does not have all of the resources that the professionals from PA Forestry were hoping for, it is a beginning of a system to be better prepared for new invasive pests in the state.

Another key area that was referenced during interviews was the need to prepare a clear message to the public. The PA State Parks staff member summed this up when they stated, “I think one of the things that our bureau would have done differently is better prepare what our communication message was, you know, what can homeowners do about it? What are the risks? All of that really distilled down those talking points and get ready so that people were a little more prepared.”

The professional from Rutgers NJAES Cooperative Extension also touched on preparedness and how they should have done more sooner. They stated, “I think we probably would have started our educational campaign earlier. I mean, we did start the year before [spotted lanternfly arrived], but we probably should have done a better job...And so, you know, the fact that it had been in in Pennsylvania for almost 10 years before it got here, we knew what was going on over there and we really didn't do anything.”

The professionals from NYS Parks and PA Forestry noted difficulty with achieving preparedness. The NYS Parks staff member commented, “There will never be a way for us to be 100% prepared for any type of pest, even though we know it's coming. Often it takes an impact in a quote ‘disaster’ for any type of movement to occur, whether that is financially or support from someplace else or whatnot. So we even know when we try to be proactive, often...you just

can't for a variety of reasons.” Similarly, staff member 2 from PA Forestry commented on the difficulty of preparedness by other states and stated,

By the time they got [the pest], they're still not ready to deal with it because this is never what you expected... But my point is, you got to apply all those general principles for invasive species management: early detection is the key and then you respond quickly with resources. Normally the states are kind of slow to respond. By the time you say, 'We need this kind of funding, we need this kind of technical support, we need this kind of, you know, political support'. But it's normally not always there at the beginning, only when the damage gets big and really caught people's attention. Yeah, this is a problem. Why don't you deal with this earlier when we told you three years ago? But nobody really thinks it's going to be that bad.

PA Forestry staff member 2's quote emphasizes that often by the time agencies are ready to respond to new invasive pests, resources are slow to be distributed by the state and often there is little management that is done before the infestation reaches visible and damaging levels.

Increased Interstate Cooperation

While many professionals praised the information sharing between states, there were still barriers to this. For example, the NYS Parks employee noted that while PA State Parks was able to provide valuable information about their experienced in public parks with spotted lanternfly infestations, the employee from NYS Parks was not allowed to cross the state border to see the infestation and its effects for themselves, stating, “For me to get approval to cross

state boundary is very, very difficult, if not impossible.” Similarly, staff member 1 from PA Forestry spoke of their experience with interstate cooperation:

When I worked in Delaware in the early 90s, when Asian longhorned beetle hit New York City, we put together a road trip of our federal people and us and some others, and we drove up to New York City to watch them do control work and surveying and monitoring, and actually did the same thing here when I got to Pennsylvania. We took...two of our staff, and we went over to New Jersey and we looked at their infestation.

The staff member from NJ DOA confirmed this style of interstate cooperation from Pennsylvania, stating, “When no other states had [spotted lanternfly], PA invited people out to see the infestation in person.” Interstate cooperation allows agencies and professionals dealing with new invasive pests to see infestations first hand in other states and learn directly from those who are managing them on the ground.

Prioritization

Several professionals discussed how they wished they had controlled tree-of-heaven before spotted lanternfly arrived in their state. PA State Parks discussed how they should have prioritized mapping and removals of tree-of-heaven. The professional from NYS Parks also discussed how as soon as they knew spotted lanternfly was spreading, they should have created a solid inventory of tree-of-heaven in the parks and started removals before spotted lanternfly arrived in the state.

While each pest species is different in terms of host species, movement, visibility, and biology, using lists of potential future pests and knowledge from nearby states that are invaded before the pests arrive could allow the states more time to manage resources and prepare for the arrival of the pest. PA DOA talked about using the USDA list of potential future pests and using that to prioritize management efforts.

In a broader sense, the NYS Parks staff member talked about shifting invasive species priorities to match the reality of what is seen on the ground. They stated,

I think that is a huge problem that we are beginning--at least I am beginning--to start grappling with is this theoretical side of invasive species and often we manage invasive species because they are invasive species. Because they're there. You know what I mean? But theoretically, what is our goal here? But you cannot simply manage everything...there are times and places where it might be better to leave an invasive species on the landscape than manage it.

They also commented on shifting priorities in the face of climate change, stating, "That theoretical discussion doesn't happen often, and I think that is our biggest challenge in invasives...is trying to shift our mind from a manage everything because it's not native, it's not invasive and so on and so forth. And then going into that, how do we prioritize... that type of aspect, especially in a changing climate?" Having larger discussions about these shifting priorities in the face of the realities on the ground and climate change could help agencies reprioritize management efforts during future pest invasions.

Resources

A common theme among interviews was the need for readily available resources. Nearly all professionals discussed issues with funding, and several of the Pennsylvania professionals discussed the newly created reserve fund for future pests. Reserve funds like Pennsylvania's can allow agencies to quickly respond to new invasive pests, educate the public, and manage natural resources before the pest becomes established. Staff member 1 from PA Forestry commented on the usefulness of this reserve fund, stating "it's now in the budget so that if another pest comes up, at least in Pennsylvania, you already got a pot of money and that you can throw it at that problem while you're still working on money from the feds."

The PA Forestry professionals discussed staffing issues for responding to new invasives. Staff member 1 from PA Forestry noted, "We're a state agency. We can't be everywhere. I have a very large, in comparison to other states, forest health staff. I've got 10 people in the field and then I've got people like [staff member 2] and...another forest entomologist who handles all our data. I got a forest pathologist. We can't be everywhere...I got twenty-one people in our division of which, you know, 19 are actually people that work in the field." Adequate staffing and resources like the soon to be established PRISMs in Pennsylvania will provide additional "boots-on-the-ground."

The NYS Parks staff member commented on the resource of the public. They described how many of the first observations of spotted lanternfly in New York State came from reports from the general public. They noted the missed opportunity of using the public as a resource to the agency, stating, "I wonder if we tried to mobilize public participation more than just public education, would we have been able to find it faster? I can't think of an example where, like,

there was a huge marshaling of public surveyors.” Similarly, the staff member from NYS DEC also noted that “spotted lanternfly has been able to really easily educate the public on what an invasive species is, what it looks like, and how to spot it, and what to do when you do spot it.” These skills can then be translated to other pests and allow state agencies to utilize the public’s help during future invasions.

Pesticide

Pesticide was discussed extensively by nearly all of the professionals interviewed, and a great deal of suggestions were described. PA Extension described the difficulties with getting the information out about proper control techniques, and suggested that there needed to be efforts to get messaging out early and effectively about products that should or should not be used. Similarly, the professional from NYS Parks indicated that clearer guidance on which applicator category was necessary for new pests would have been helpful early on in the infestation.

The professional from NJ RAES Cooperative Extension expressed concern about pesticide resistance and losing tools for combatting invasive insects as a result of pesticide bans. More research and labeling for additional products to be used on invasive insects could help mitigate issues with pesticide resistance. Furthermore, having more products labeled for new invasive insects earlier in infestations would increase the pesticide resources for state agencies to use to control them. There needs to be clearer messaging surrounding pesticide for the public and professionals and additional tools for professionals to use to control invasive pests when other products are banned.

Conclusion

Spotted lanternfly and other invasive insects have highlighted challenges and successes of current invasive pest management strategies by state agencies. The interviews with professionals in Pennsylvania, New Jersey, and New York illustrated the difficulty in anticipating pest management challenges for new invasive insects and that the need for partnerships and information sharing within and between states is critical for successful management. Similarly, research and resources are necessary for understanding the overall magnitude of the effects of the invasive pest on the environment, human health, and/or economy and for effectively developing a management strategy for the pests. State agencies are continuously reassessing management strategies and resource needs to address new invasive pests, and policies, procedures, and systems are continuously enacted to assist with pest control programs.

This study serves as an examination of the state-level response to new invasive insects only. Future study could examine the federal response from USDA APHIS to spotted lanternfly and other invasives. Additionally, there are non-profits and private companies that work in multiple states across state lines in the Northeast that could be examined for how they perceive each state's response to spotted lanternfly. Examining responses at the federal and local levels could create a robust analysis of how invasive pest management is handled in the Northeast.

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Appendix A: Interview Questions

1. Can you say your name and your role with your agency/organization?
2. What is your agency's role in invasive pest management in your state?
3. What are some of your "lessons learned" from EAB and ALB management? How did you or will you apply those to SLF management?
4. What challenges have you or your agency faced with SLF management?
5. What do you perceive to be the biggest challenges associated with SLF management in the Northeast?
6. What do you perceive to be successes of SLF management by your agency?
7. What was your experience working with other states on SLF management?
8. If you could go back in time, is there anything you or your agency would do differently in regards to SLF management, response, policy, or anything else?

Appendix B: Interview References

Anonymous Staff Member. Pennsylvania Department of Agriculture. Zoom Interview. 2 Feb. 2022.

Anonymous Staff Member. PennState Extension. Phone Interview. 18 Feb. 2022.

Anonymous Staff Member. Pennsylvania Department of Conservation and Natural Resources, Bureau of State Parks. Phone Interview. 18 Feb. 2022.

Anonymous Staff Member 1 and Anonymous Staff Member 2. Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry. Zoom Interview. 28 Mar. 2022.

Anonymous Staff Member. New York State Office of Parks, Recreation and Historic Preservation. WebEx Interview. 7 Mar. 2022.

Anonymous Staff Member. New York Department of Environmental Conservation. Zoom Interview. 4 Feb. 2022.

Anonymous Staff Member. Cornell Cooperative Extension. Zoom Interview. 4 Feb. 2022.

Anonymous Staff Member. Rutgers New Jersey Agricultural Experiment Station Cooperative Extension. Zoom Interview. 17 Mar. 2022.

Anonymous Staff Member. New Jersey Department of Agriculture. Written Interview. 11 Mar. 2022.