New York State Hemlock Initiative

2018 Annual Report
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Mark Whitmore, Caroline Marschner, Tonya Bittner, Nicholas Dietschler, and Charlotte Malmborg

Mission

The mission of the New York State Hemlock Initiative (NYSHI) is to coordinate state-wide efforts of land owners, state and federal agencies, government officials, and concerned citizens to conserve New York State’s hemlock trees. Our research focuses on the management of hemlock woolly adelgid (HWA), a non-native invasive insect, using biological control. Additionally, our work involves public outreach to engage stakeholders and increase awareness of the threats posed by HWA and other invasive forest pests.

Executive Summary

2018 was a year of progress and rebalancing for the New York State Hemlock Initiative. We completed our first full year of biocontrol production, and released both of our focus biocontrol species at priority locations across New York. We continued to help coordinate the state and regional response to HWA, continued to participate in the national HWA program led by the USFS, conducted outreach to landowners and potential volunteers, and added new and expanded outreach tools and resources. In 2019, the NYSHI’s programs will continue to mature. With our research program, we will refine our understanding of HWA and its biocontrols, moving us closer to implementing viable biocontrol. Goals in the laboratory include a fuller understanding of the development of Leucopis spp. and Laricobius spp. in order to maximize predator survival and develop efficient lab production. We will continue our exploration for predator sources in the Pacific Northwest, including British Columbia where more cold-tolerant biotypes may be found. Releases of predators and evaluation of their establishment will continue across New York State with a focus on hard-hit areas in the Southern Catskills. In our coordination role, we will continue to collaborate with New York’s PRISMS, iMap, and hemlock conservation stakeholders to ensure that data collection and HWA management are consistent through the state. We will also continue to provide the best knowledge available to New York’s public through presentations, citizen science programs, and train the trainer activities and tools.
NYSHI’s research projects investigate HWA ecology, HWA predator ecology, and HWA predator rearing and release methods. Our research laboratory consists of office and laboratory space, three walk-in coolers for HWA, biocontrol insects and their food, four growth chambers for experiments, genetic equipment, microscopes that are critical to nearly every aspect of NYSHI’s research, tree-climbing gear, and a wide range of cages and environments for various HWA predator life phases. It also includes a greenhouse in Cornell’s entomology quarantine facility, with custom-constructed cages for working with HWA foliage from the Pacific Northwest, where most of our predators originate. In the areas around Cornell, we have potted hemlock and related conifer species, planted individual hemlocks, and planted hemlock hedges for use in field studies of HWA and its biocontrols.

2018 was a year of growth and rebalancing for the Initiative research programs. After the substantial growth of 2017, we needed to take a hard look at both our new and our long-term research projects and make some hard decisions about where to put our energy to maximize our ability to advance HWA biocontrol research in New York. This led to the addition of some new projects, balanced by the termination of others. Ultimately, these decisions will enable us to focus on collecting data that is essential to the development of a biocontrol program tailored to New York’s climate and forest health.

HWA Biocontrol Research

The core of NYSHI’s program is development and implementation of effective biocontrol options for HWA management in New York. Our biocontrol research facility enables us to investigate questions fundamental to the success of biocontrol with the four species we are currently studying. Exploration of collection sites in the Pacific Northwest is an ongoing necessity for supplying the lab with insects, and this year we surveyed colder, mountainous territory in southeast British Columbia to search for new predator populations.

We are working with two genera of predators for HWA biocontrol. *Laricobius* beetles (Coleoptera: Derodontidae) are specialist adelgid predators found throughout the northern hemisphere. Our main focus is on *Laricobius nigrinus*, a Pacific Northwest native that is one of the most common predators of HWA in those ecosystems. This is the only species that has been released in New York. We are also rearing *Laricobius osakensis*, from southern Japan, which is the origin of the biotype of HWA that we have in the Eastern US. Both *La. nigrinus* and *La. osakensis* feed on the winter generation of HWA.

The second genus we are studying is *Leucopis*, or silver flies (Diptera: Chamaemyiidae). These are flies whose larvae feed on adelgids during the spring and early summer, to compliment the winter-feeding *Laricobius nigrinus*. In the Pacific Northwest, two *Leucopis* species are abundant predators of HWA, *Le. argenticollis* and *Le. piniperda*. At this time, we rely on collecting infested foliage from the Pacific Northwest, shipping it to Cornell’s
quarantine facility, and collecting adult silver flies that emerge from caged foliage. We used these emerging adult flies for wild releases and in experiments to establish rearing in a lab colony.

**Laricobius Colony Establishment**

In late summer of 2018 we expected a large harvest of new adult *Laricobius nigrinus* beetles from our colony. The colony had been established with 2,140 wild-caught adult beetles from the Pacific Northwest in the fall of 2017, and we placed 10,012 offspring in tubs of soil medium as pre-pupae to complete development in incubators over the summer. Unfortunately, we harvested only 2% of these pupae as adults. Our smaller colony (858 pupae produced) of *La. osakensis* sourced from Scott Salom at Virginia Tech had similar results. We immediately set to work to understand what needed to be improved to assure success in the next season. These losses were not due to disease, as we have followed rigorous cleanliness standards and randomly checked dead beetles for pathogens and found none. A growth chamber malfunction killed many of the pupae due to hot temperatures. But soil tubs that were not exposed to hot temperatures also had low emergence, so two staff members traveled to Blacksburg, Virginia in November to meet with experts at Virginia Tech and go over every detail of our procedures. As a result, we revamped our procedures for winter 2018-2019. We learned that our soil medium was probably too dry. We also learned that the beetles needed more food in the larval stage and were dropping prematurely, so they weren’t ready to pupate. Finding good quality food branches with high densities of living adelgid throughout the New York winter is one of the biggest challenges for rearing *Laricobius* beetles here, so we redoubled our early collection efforts and maximized our food storage space. The current colony is also downsized by more than half from the previous year. In the fall we obtained 1,138 new *La. nigrinus* from the Pacific Northwest, 1,530 from Virginia Tech, and 200 *La. osakensis* from Virginia Tech; then 1,731 *La. nigrinus* were released (including all 188 reared in the lab, see next section), and after accounting for some mortality, we started with about 970 beetles in the rearing colony.

While we were extremely disappointed with the first year’s rearing results, we feel confident that the problems are solvable and now that the build-out is complete, we can turn more attention to building institutional knowledge and staff skills for success in rearing.

**Leucopis Research**

*Leucopis* lab rearing:
We started our lab rearing experiment with 60 parental generation flies (1:1 male-female ratio) in each of two plexiglass cages (120 parents total, 60 females). The cages were held at 20°C and 70% humidity with 11:10 photoperiod and a 3-hour dusk cycle in an environmental chamber. Flies were provided with HWA-infested twigs hydrated in floral foam, with new twigs added every 2-3 days. This experimental set-up resulted in successful reproduction by the flies. We collected a total of 51 first generation (F1) adults from the cages. The F1 individuals were collected and kept in a separate cage which then produced 12 second generation (F2) individuals. The experiment ended when we could no longer supply HWA eggs for food.

To improve outcomes in 2019, we will be investigating mating behavior to find out when each sex is mature and receptive. We will also try different methods of separating flies by species to maximize appropriate mating. If we can obtain enough flies from the western shipments, we will scale up the rearing effort to more cages. We will prolong HWA egg production on the food foliage as long as possible by manipulating storage temperatures, but when we run out of HWA eggs, we will monitor longevity of silver fly pupae. The youngest fly larvae require HWA eggs, but older larvae have been observed to feed on HWA second through fourth instars. We estimate it
takes 20-30 days to mature from egg to pupa, and 46-50 days from egg to adult. Recent data from wild collections indicate pupae can survive through summer and winter on hemlock foliage and emerge in spring. The use of lab reared pupae for release may be the production method to use for *Leucopis*.

**Leucopis Genetics:**
*Le. pineperda* and *Le. argenticollis* are both present throughout the Northern hemisphere, but feed on different species of adelgid depending on what is native in that region. On the East coast, silver flies feed on pine bark adelgid (PBA), a native adelgid that lives on native white pine (*Pinus strobus*). These populations are genetically distinct from the western US, HWA-feeding silver flies. Although HWA has been spreading in the eastern US since the 1950s, there has been no record of eastern silver fly species feeding on HWA here. Learning about the genetics and population dynamics of both eastern and western silver fly species is critical to effective use of the western silver flies as a biocontrol for HWA in the eastern US.

There are two main techniques of genetic research with *Leucopis*, DNA barcoding and microsatellite markers. These methods provide different information as described below.

**DNA Barcoding**
DNA barcoding allows identification of an organism to species using just one gene sequence. This allows us to confidently identify predacious fly larvae found on any host adelgid, either HWA or PBA. This is important because larvae of flies look similar to each other, even under the microscope, and we need to be certain of what we are finding in the field or rearing in the lab. We used DNA barcoding for three experiments; identifying flies found on PBA, looking for establishment at silver fly release sites, and surveying west coast study sites to determine emergence phenology of the two silver fly species.

We are finding multiple species from each of three families of flies (Syrphidae, Cecidomyiidae, and Chamaemyiidae) feeding on PBA in the east; so far, only 16% of flies we have found on PBA are in the genus *Leucopis*. In 2018, we used DNA barcoding to identify 248 flies from PBA. At the same time, we slide-mounted prepared and stained larval cuticles of over 200 of the identified flies, to learn what morphological details can be used in future studies to identify flies, perhaps not to species, but at least to family. This data will reveal the timing of the life cycle of native northeastern *Leucopis* species, and in what stages they overwinter. In 2019, we look forward to finding an avenue for publication of this work.

The data from PBA is part of a collaboration with the USDA Forest Service to describe the community of predacious flies on PBA here in the east. This is important because HWA could potentially serve as an alternative food for these species. A better understanding of the current baseline of native predators will allow us to thoroughly and accurately evaluate the future outcome of biocontrol using western silver flies. In 2019 we will coauthor a paper on this topic with Nathan Havill of the Forest Service.

DNA barcoding was also used to check for silver fly establishment at our release sites. We found and barcoded 10 larvae from many of our sites, but none of them were silver flies; for details, please see the section on *Leucopis spp.* 2018 release monitoring.
On the West Coast, we are trying to determine whether there are differences in emergence timing or site location for the two species of silver flies, which will impact collection and lab rearing. We barcoded 83 flies from the Pacific Northwest, and the results will be used to set up a study of *Leucopis* phenology in 2019.

**Microsatellite markers**

The second major avenue of genetic research on *Leucopis* is the development of “microsatellite markers,” which is a common technique for investigating fine-scale genetic variation such as differences among populations and even families (i.e., genealogies). These markers can detect hybridization between populations/families and between species. This class of genetic markers is unique to each species, and must be discovered through large-scale genomic sequencing. In 2018 we did just that (again in collaboration with Nathan Havill of the USDA Forest Service); using DNA from four groups (*Le. argenticollis* east and west, *Le. piniperda* east and west) we obtained full-genome sequences and searched the genomes for microsatellites. We then developed and tested 62 PCR primer pairs to find the ones that will be “informative” markers (that will show variation among the groups). We found more than enough candidate loci to test further in 2019. Our development of these markers ensures that we will be able to know exactly which players are active in the biocontrol program in the field over the long term, and if any hybridization occurs, we will be able to detect, track, and evaluate it. This technique will also allow us to evaluate reproduction in release bags, and learn about any potential genetic “bottlenecks” (reduced genetic diversity). In 2019 we look forward to obtaining many more fly samples from their native ranges to begin to describe their “microsatellite variation.”

**HWA Biological Control Releases**

*Leucopis spp. Spring 2018 Releases*

Despite a significantly larger collection effort in the Pacific Northwest, our numbers for research and release were down in 2018 compared to 2017. The variation in source fly populations in the Pacific Northwest is tied to the changes in western HWA populations, and emphasizes the need to continually search for good material from year to year. We cannot control or predict the numbers of flies that will come out in any given year, and because we had fewer flies, we could not perform all of the experiments that we hoped. Between 2017 and 2018, however, we significantly improved our fly handling and storage procedures to reduce mortality and made much better use of flies in research, despite having fewer flies overall. In 2018 we obtained a total of 2,209 silver flies, of which 1,883 were used for research and releases and over 100 were preserved for genetic studies and vouchers.

<table>
<thead>
<tr>
<th><em>Leucopis</em> metrics</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds of foliage in quarantine (est.)</td>
<td>80</td>
<td>350</td>
</tr>
<tr>
<td>Adult flies collected</td>
<td>6,252</td>
<td>2,209</td>
</tr>
<tr>
<td>Adult flies released</td>
<td>NY - 2,008</td>
<td>NY - 748</td>
</tr>
<tr>
<td></td>
<td>NC - 300</td>
<td>NC - 246</td>
</tr>
<tr>
<td>Number of release sites (NY)</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Number of release bags</td>
<td>156</td>
<td>76</td>
</tr>
<tr>
<td>Number of flies used for research (proportion)</td>
<td>140 (0.02)</td>
<td>889 (0.40)</td>
</tr>
</tbody>
</table>

The NYSHI continued its partnerships with CRSIP, NYC DEP, Finger Lakes Land Trust, TNC, and NYS DEC to locate appropriate biocontrol release sites for *Leucopis spp*. in the spring of 2018. Site selection criteria included tree health, HWA infestation density, successful HWA egg laying, ecological significance,
and practical release considerations. As *Leucopis spp.* adults emerged in the quarantine facility on campus, they were checked to make sure they were clean of other organisms, sexed, and packaged for release in sets of 5 males and 5 females. These were released into mesh enclosures (“bags”) on HWA-infested hemlock branches, so their reproduction could be monitored; temperature loggers were used to learn about growing degree days for *Leucopis spp.* development in the field over the summer.

A total of 748 *Leucopis spp.* were released at 6 sites in April and May of 2018. Three of the releases were “augmented,” meaning an additional release at a site that previously had a release, and three were new sites.

Table 2. *Leucopis spp.* 2018 release location information. *=augmented release

<table>
<thead>
<tr>
<th>Locations</th>
<th>Total bags</th>
<th>Total flies released</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durand Eastman (DE)*</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Taughannock Falls State Park (TF)*</td>
<td>13</td>
<td>130</td>
</tr>
<tr>
<td>Cayuga Nature Center (CNC)*</td>
<td>15</td>
<td>135</td>
</tr>
<tr>
<td>Gosnell’s Big Woods (GBW)</td>
<td>15</td>
<td>165</td>
</tr>
<tr>
<td>Overlook Mountain (OLM)</td>
<td>12</td>
<td>120</td>
</tr>
<tr>
<td>Lindsay-Parsons Bioreserve (LP)</td>
<td>12</td>
<td>108</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>748</strong></td>
</tr>
</tbody>
</table>

In addition to the releases done by our lab, we sent 246 flies to North Carolina for experimental release in collaboration with colleagues at the University of Vermont, Oregon State University, and the USFS Southern Research Station in Asheville, NC.

**Leucopis spp. 2018 Release Monitoring**

In 2018 we monitored release sites, both for reproduction in the current year (“summer reproduction”), and for establishment at sites from previous years.

Establishment monitoring occurs in the early summer and is very labor intensive. We visited 13 sites where *Leucopis spp.* had been released from bags (i.e., bags were removed after a monitoring period) in 2015-2017. We clipped HWA-infested branch samples both from the same tree (if possible) and nearby trees, and sampled from both lower and mid-canopy or wherever HWA was abundant. The samples were returned to the lab, where each twig was carefully dissected under the microscope to look for predator eggs, larvae, or pupae. Any potential predators were collected into individual tubes and preserved with ethanol. Subsequently, we attempted to identify all of these with DNA barcoding. We found that neither eggs nor empty puparia eggs produced DNA results. There were 10 larvae found and identified, but none of them were *Leucopis*; they were generalist predators from the families Syrphidae (hover flies) and Cecidomyiidae (gall midges).

When sampling for summer reproduction in the release bags, we carefully open the bag and clip a few sample twigs at periodic intervals (15, 25, and 35 days) post-release, reclosing and leaving bags in place for several weeks to keep the flies together. In 2018, we found reproduction in bags at four of the six release sites. Live immature flies were placed with fresh food foliage in individual rearing cups and many of these matured, were mated, and produced another generation in the lab, thus showing that the generation reared in the field on eastern HWA is fully capable of reproduction. Bags that failed to show reproduction could have been affected by poor weather conditions shortly after the release. At five of the release locations, we left 4 or 5 bags in place through the winter to make it easier to survey for overwintering success in 2019.
**Laricobius nigrinus 2018 Releases and Release Monitoring**

In 2018 we conducted five releases of *La. nigrinus*, totaling 1,731 beetles. We released 251 beetles at Mianus River Gorge Preserve in January. In the late fall we released at four other sites. Harriman State Park, an OPRHP site with hedge-like hemlock structure that would be an ideal field insectary, received 201 *La. nigrinus*. Letchworth State Park, another OPRHP site, received 510 *La. nigrinus*, and two NYCDEP sites, Schoharie Reservoir and Pepacton Reservoir, also received 510 beetles each.

We put a great deal of effort into surveying all 17 previous release sites (as far back as 2008) to look for establishment of *Laricobius*. We used beat-sheet sampling, which means that we hold a square of canvas under an infested branch, beat the branch with a pole, and see what falls onto the canvas. This method is very effective for finding adult beetles so it is performed in fall and winter, on mild days when adult beetles are active. We involve as many partners and volunteers in this process as possible. By the end of 2018 we had completed surveys at 11 of the sites, and more surveys continue into 2019. We found solid evidence of establishment at four of the sites where beetles had been released in the winter of 2008/09, evidence that 10 generations have survived at these four sites.

Hybridization is known to occur between *La. nigrinus* and *La. rubidus*, a native beetle normally found preying on PBA. Beetles can be distinguished by their coloration, but hybrids can be intermediate and difficult to categorize. We sent DNA samples of most of the captured beetles to the USDA lab in Hamden, CT for analysis and Nathan Havill determined that the beetles we found were not hybrids. This is a bit surprising given that in the south, up to 12% of beetles are hybrids. Presumably, if we had a larger sample size we may detect a few hybrids; however, we don’t assume that the same pattern will establish in the north as in the south, so further research on this topic will be of great interest.

<table>
<thead>
<tr>
<th>Site description</th>
<th>Year, number of beetles, and biotype of release</th>
<th>Beat-sheet survey results (2018)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenora Glen – west side of Seneca Lake, in gorge, zone 6a</td>
<td>2009, 200, coastal biotype</td>
<td>3 <em>La. nigrinus</em> (not yet typed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 <em>La. rubidus</em> based on morphology</td>
</tr>
<tr>
<td>Vanriper Preserve in the Finger Lakes Land Trust – west side of Cayuga Lake, in gully, zone 6a</td>
<td>2014, 800, inland biotype</td>
<td>1 <em>La. nigrinus</em>, not a hybrid</td>
</tr>
<tr>
<td>Willow Point – west side of Cayuga Lake, in gully, zone 6a</td>
<td>2009, 200, inland biotype</td>
<td>1 <em>La. nigrinus</em>, not a hybrid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 <em>La. rubidus</em></td>
</tr>
</tbody>
</table>

**Hemlock Woolly Adelgid Research**

We have several ongoing research projects that inform our understanding of HWA’s life cycle, response to weather extremes, spread across New York, and location of promising biocontrol release sites. While some of these are laboratory studies conducted by staff researchers, others are community science driven. Community science research projects include HWA surveys and HWA phenology; please see our section on collaborations and outreach for detailed updates on the partnership and community science portions of these programs. In

HWA Phenology

The goal of the NYS Hemlock Initiative’s HWA Phenology Project is to support the HWA biological control program by providing a deeper understanding of hemlock woolly adelgid phenology. Observing and recording the date on which certain HWA life stages occur is important for the timely collection of food material for the biocontrol predator rearing facility, as well as timing biocontrol field releases and establishment surveys. The life stages that are most important to the success of the program are aestivation break (when HWA begin growing in the fall, when insects are called ‘Post-dormant nymphs’ in Nature’s Notebook), egg laying (in late winter, called ‘Eggs’ in Nature’s Notebook), and the emergence of crawlers (freshly hatched HWA are called crawlers, or ‘Active nymphs’ in Nature’s Notebook) from egg masses. These are likely to vary with temperature and other site considerations across NY State. Tracking phenology with citizen scientists supports several of the HWA experiments discussed in the HWA research section.

The NYSHI phenology project grew by leaps and bounds in 2018. In January, we officially became partners with the National Phenology Network (NPN), a group tracking phenology of plants and animals in the US. This partnership was brokered by the New York Phenology Project, who are also involved with the program. NPN and NYSHI constructed a landing page for HWA phenology on their website, and NYSHI’s HWA Phenology Project officially began using the USA NPN protocols and Nature’s Notebook for entering phenology observation data in the winter of 2018. Nature’s Notebook allows observers to enter observations in the field with the mobile app or enter from a computer using the Observation Deck. HWA phenology data is housed in the USA NPN’s open source database, and is available to managers and researchers worldwide. NYSHI rewrote our phenology training materials to reflect the NPN phenology terminology and data entry methods, and used the new materials to conduct ten trainings around the state. In 2017, our pilot phenology program focused on professional land managers, researchers, and dedicated volunteers. In 2018 we launched a training campaign directed towards citizen scientists along with professionals. Training events took place throughout NYS at nine locations from Western NY, Rochester, the Finger Lakes, Catskills, and Lower Hudson Valley. New protocols included multiple observational techniques, using either hand lenses or dissecting microscopes with the goal of meeting a spectrum of observational abilities.

Along with NYSHI staff, observers entered over 100 distinct observations at eight sites in 2018 between the winter/spring and fall observation periods. HWA is currently the second most observed insect in the USA NPN’s “Insect-Plant Pest” category, making up 65% of the total insect/pest phenology observations in NYS. These observations provided NYSHI staff with the necessary knowledge to conduct biological control releases in the spring and fall, conduct biocontrol establishment surveys, and collect infested foliage to feed laboratory colonies. NYSHI staff also collaborated with the USA NPN to help implement their new forest pest Pheno Forecast map products, which used HWA as a pilot organism. The Pheno Forecast maps provide real time growing degree day information that is used to alert observers when it is time to look for important developmental stages of priority forest pests. HWA observational data was then used to validate the accuracy of
the maps, showing 93% accuracy in GDD predictions by the Pheno Forecast maps. A manuscript highlighting Pheno Forecast maps as a potential management tool using NYSHI’s HWA data is being drafted by the USA NPN for submission in early 2019.

Table 3. Phenology training and participation effort in 2017 and 2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Training Events</th>
<th>Event Participants</th>
<th>Participating Observers</th>
<th>Observations Submitted (Nature’s Notebook)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>6</td>
<td>33</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>2018</td>
<td>9</td>
<td>65</td>
<td>11</td>
<td>111</td>
</tr>
</tbody>
</table>

Figure 1. Example of 2018 data displayed using the USA NPN Visualization Tool. The Visualization tool provides an interactive way to view and display phenology observation data using a wide range of criteria. The above chart uses the “Calendar” tool, displaying HWA “Yes” data recorded from January to December 2018. Displayed phenophases include “Active adults”, “Eggs”, “Active nymphs”, “Inactive nymphs”, and “Post-dormant nymphs”.

**Growing Degree Days and HWA Development**

Studies have shown that hemlock woolly adelgid (HWA) infestation is variable by year and by geographical location. HWA has been spreading more rapidly in the Southeast than the Northeast United States, and it is suggested that temperature has a substantial impact on the developmental rate of HWA and contributes to the variability of its spread. Our laboratory is looking into effects of temperature on development of HWA, to help understand HWA’s development in the lab for rearing purposes and to help predict population growth in the field. In late fall 2017, HWA-infested twigs from Taughannock Falls State Park were collected and placed in one of five temperature regimes (8, 12, 16, 20° C, and outdoor control) throughout the winter and spring of 2017-2018. Twigs were checked daily and the developmental stage of each adelgid was tracked until they reached reproductive maturity and began laying eggs.
In August of 2018, additional HWA-infested branches were collected from Taughannock State Park. Twigs with first instar HWA that were still in summer aestivation were placed into four different temperature treatments (8, 12, 16, 20°C). Twigs were checked daily for signs of HWA coming out of summer aestivation and beginning to grow, and were tracked until they reached maturity. Daily checks were conducted from August through December and continue into 2019. The data from this study may help us better track HWA development, and will refine our understanding of HWA’s life cycle and response to temperature. This study has revealed wide variability in HWA development even on a single twig. This study will conclude in late winter-early spring 2019.

**Winter Mortality and Supercooling**

The winter of 2017-2018 was the fifth year of winter mortality data collection for the Initiative, and the second full year of supercooling data collection. This study helps NYSHI track HWA mortality across a wide range of temperatures where it is found in New York.

Winter Mortality: Samples were collected biweekly from November into April at Durand Eastman County Park, Taughannock Falls State Park, and Mine Kill State Park. Taughannock Falls and Durand Eastman are in the 6a USDA hardiness zone, which captures the warmest conditions outside of Long Island; Mine Kill SP is in zone 5a, and is one of the coldest areas with a long-standing HWA infestation. Samples were checked for HWA mortality over the course of the winter, and cumulative mortality calculated and compared against temperature data collected at each site.

Supercooling: In January – April 2018, HWA were also tested to determine their ability to survive low temperatures (“supercooling” points, the lowest temperature the insect could survive). Our data indicate that warm periods followed by a cold snap often increase mortality, and trends are emerging relating to site differences. The supercooling data have the potential to improve our understanding of HWA sensitivity to changing temperatures over the winter, which would assist with projecting HWA mortality based on winter weather. Unfortunately, collecting supercooling data is time consuming and requires rental of sophisticated equipment, making it an expensive project. With our reduced budget in 2018/19, we made the difficult decision to stop collecting supercooling data, putting that avenue of research on hold.

The overwinter mortality dataset was continued in November of 2018, and will be continued into 2019. In 2016, we added Durand-Eastman County Park to the project, hoping to capture mortality in the mild climate along Ontario Lake. Data analysis conducted in 2018 showed that while there were small daily differences between Durand-Eastman and Taughannock Falls State Park, the new site was not significantly warmer. In order to streamline this project in the face of budget restrictions, the lake plain site (Durand-Eastman County Park) was dropped for the 2018-19 field season, eliminating four hours of travel and hours of field and lab processing time from each biweekly sampling effort. We conducted a preliminary analysis of the existing overwintering mortality dataset, and found evidence to support the hypothesis that warmer periods caused increased mortality in HWA when followed by a cold snap. We plan to move forward with full analysis and publication of the overwintering mortality dataset, including 2018-19 data.
HWA Treatment Efficacy Monitoring

In 2018, we continued to solicit information on treatment efficacy monitoring by our partners around the state. A wide range of partners are collecting treatment efficacy and longevity data, including NYS OPHRP, Cornell Botanic Gardens, and Mianus River Gorge Preserve. At our 2018 meeting we heard reports from these partners; in 2019 we will pull together treatment monitoring data into adaptive management recommendations for insecticide treatments.
Coordination and Outreach

The NYSHI collaborates extensively throughout New York on hemlock conservation. This emphasis on working with stakeholders throughout the state is integral to the success of our project. Over the last year we have increased our presence statewide, collaborating with new organizations and deepening our relationship with existing partners. These improved connections allow us to combine statewide understanding of HWA spread and management with local knowledge of communities and hemlock resources to improve hemlock conservation in NY. We continue to develop these relationships through site visits, organizing field days, coordinating outreach programs and volunteer trainings, and working with stakeholders to identify their hemlock conservation goals while further advancing HWA biocontrol research.

Collaborations

NYS Department of Environmental Conservation

The NYSHI works closely with NYS DEC, exchanging survey data, assisting with surveys at high-priority early detection sites, working with state foresters to identify priority survey and biocontrol release sites, and bringing stakeholders together to exchange information and ideas.

- In February, NYSHI coordinated with DEC, DEP, and CRISP PRISM to search for suitable biocontrol release sites in the Catskills.
- In June, NYSHI trained DEC seasonal forest pest interns to identify pine bark adelgid (PBA) and HWA biocontrol release site evaluation.
- NYSHI worked with DEC to develop a hedge solicitation program for the Catskills and Adirondacks. We created materials for a packet to be sent to potential hedge owners, built a hedge submission form on our website, and worked with DEC to target messages to private landowners and municipalities. We hope to continue with this project in 2019.
- Following up on the 2017 Prospect Mountain infestation, we continued to support survey efforts in Warren County. We co-hosted a CCE intern with Capital-Mohawk PRISM over the summer to conduct HWA surveys in Capital-Mohawk and Warren County; with another intern, she surveyed 51 sites for HWA. In addition, we hosted two conference calls with stakeholders in the northern Capitol-Mohawk/southern APIPP survey focus area to discuss how to move survey forward in the region. We developed a closer relationship with Lake George Land Conservancy (LGLC), and documented a process for false red imaging, which LGLC intends to use to help locate hemlock on their property. While the false red imaging is not a full solution for hemlock location, it may work well in the SW Adirondacks as most of their conifers are hemlock.
To expand the options for HWA survey, NYSHI conducted two HWA boat survey trainings, at Skaneateles Lake and Hemlock Lake. In 2019, we hope to expand this into a larger program focused on the SW Adirondack border.

In October, NYSHI hosted the 2018 NYS forest pest workshop at Taughannock Falls State Park. This meeting brought together DEC forest health staff, foresters, and other collaborators from around the state to discuss a wide range of forest health issues, from HWA and BWA to spotted lanternfly, forest fires, and beech leaf disease. We plan to hold a similar meeting in 2019 in conjunction with the North American Invasive Species Management Association conference in Saratoga Springs, on Thursday, October 3rd.

NYSHI provided HWA ID wallet cards to DEC staff around the state.

Partnerships for Regional Invasive Species Management

The PRISMs are the main drivers of invasive species work for each region of New York, and are primary stakeholders for NYSHI. The Hemlock Initiative expanded our coordination with PRISMS in 2018.

APIPP: NYSHI held 5 events in APIPP in 2018, including a presentation at APIPP’s HWA Affected Stakeholder meeting in January. In the summer, the NYSHI CCE intern spent two weeks surveying for NYSHI in the APIPP portion of Warren County, working in collaboration with DEC, the Adirondack Mountain Club, and the Lake George Land Conservancy. We also partnered with APIPP on a remote sensing proposal to identify hemlock resources, helped build momentum for survey in the southwestern Adirondacks, and worked with Region 5 DEC staff on a hemlock hedge outreach project. We attended the fall APIPP partner meeting.

Capital-Mohawk: Our main collaboration with Capital-Mohawk PRISM was co-hosting a summer CCE intern, Lily-Anne Trainor, who spent the bulk of her summer working on HWA surveys and outreach while also supporting other projects for the PRISM. We presented at the late winter Capital-Mohawk full partner meeting, and conducted four other outreach events in the PRISM. The Capital-Mohawk PRISM was fully involved with the effort to improve HWA survey coverage in the NW Cap/Mo-SW APIPP region, and has offered to host a pilot HWA Train-the-Trainer workshop in early 2019.

CRISP: In 2018 NYSHI led a coordinated push to identify HWA biocontrol release sites in CRISP PRISM. In February, NYSHI, CRISP, NYS DEC, NYC DEP, and Catskill Mountainkeeper conducted a two-day survey of potential biocontrol release sites. In May, 120 silver flies were released at Overlook Mountain in the Catskill Park. In the fall, 1020 *Laricobius nigrinus* were released, half at Schoharie Reservoir and half at Pepacton Reservoir. Existing release sites in the Neversink watershed were surveyed for establishment. NYSHI presented brief updates at the CRISP spring and summer partner meetings. NYSHI also conducted seven outreach presentations/hikes in CRISP in 2018 totaling 115 attendees, including three phenology trainings.

Finger Lakes: The Finger Lakes PRISM is the home of NYSHI, and we have a strong partnership; NYSHI staff sit on the PRISM steering committee and working groups, and we conducted 29 events in the PRISM. We presented at the spring full partner meeting and attended the fall partner meeting. We supported

Mark looking for HWA in the canopy. He likes to be disappointed.

Photo: Nicholas Dietschier, NYSHI
hemlock resource prioritization planning at two sites in the Finger Lakes, the Cumming Nature Center near Rochester and Mossy Bank Park in Bath.

**Lower Hudson:** We expanded our reach into the Lower Hudson PRISM in 2018, mainly through biocontrol releases in Harriman State Park and Mianus River Gorge. We held a phenology training at Green Chimneys State Park, and received phenology data from volunteers in the PRISM.

**SLELO:** SLELO is the only remaining PRISM without HWA. We continue to collaborate with the PRISM on outreach and early detection training. We wrote an article for SLELO’s 2018 winter newsletter, and provided the HWA portion of their 2018 Forest Pest Walk and Talk in October.

**Western NY:** NYSHI conducted three trainings in WNY in 2018, and conducted an online push to improve reporting for HWA in the southwestern portion of the PRISM.

**New York iMap Invasives**

New York’s iMap Invasives program run by NYS DEC has been an invaluable partner. They have been continuously supportive of our work, helpful with technical assistance, and have developed new functions within iMap to help volunteers and professional resource managers effectively track HWA infestations and management information. In return, NYSHI has coordinated the effort to flesh out the insect portions of the Survey 1-2-3 OAT app, leading to the current OAT for Forest Pests version of the app. We participated in the iMap user feedback meetings, and made a substantial push to reduce the number of unconfirmed HWA reports in iMap. NYSHI staff check all incoming HWA records, and reach out to iMap to address any problem records. In 2018, two NYSHI staff became certified iMap trainers, and conducted two iMap trainings.

**NYS Department of Environmental Protection**

We continue to work with NYC DEP to identify potential biocontrol release sites and release HWA predators on NYC DEP property. In 2018 we monitored for Leucopis establishment at four 2017 release sites on NYC DEP lands in the Neversink watershed.

**Land Conservation Programs**

We work closely with The Nature Conservancy, the Finger Lakes Land Trust, and the Cornell Botanic Gardens on hemlock conservation and biological control research. We assist with trainings and surveys, and each group has provided biocontrol release sites. In 2018, The Nature Conservancy and the Finger Lakes Land Trust each hosted one of our Leucopis releases. Our partnership with the Lake George Land Conservancy has grown, with mutual support for survey planning and implementation.

**SUNY ESF**

In 2018, NYSHI hosted an ESF graduate student, who collaborated with our lab to study ideal release densities for silver flies. We assisted with project design, provided study organisms, provided lab and office space over the summer, assisted with field and lab work, and continue to support her project into 2019.
Outreach Program

The NYSHI’s outreach program includes presentations on HWA, citizen science programs, train the trainer activities, and providing planning support to landowners, land managers and PRISMs. In 2018, our outreach to New York residents on HWA identification and management continued, and we established contact with new counties and landowners. Our network of volunteers grew, and we developed a new focus on filling in survey gaps for HWA around the state. We developed materials to help landowners prioritize hemlock management projects on their properties, and provided support for Mossy Bank Park and the Cumming Nature Center prioritization and planning efforts. We participated in the annual HWA biological control conference and the U.S. Forest Service’s HWA manager’s meeting to share knowledge and coordinate research efforts with states from Georgia to Maine.

In 2018 our outreach program continued to grow. We expanded and restructured our website to reflect our larger scope of work, provided a wide range of outreach materials, and supported survey and phenology programs around the state. We also produced quarterly newsletters and two short HWA videos, an introduction to HWA in New York and an identification video.

Citizen Science Programs

HWA Surveys

In 2018, both staff and volunteers surveyed for HWA in New York. The Initiative staff focused on surveys for biocontrol release sites; staff members worked with partners across the state to locate areas with heavily infested, healthy, smaller hemlocks with low branches. Particular effort focused in the CRISP PRISM, where hemlock decline is narrowing our options for release sites. HWA experienced significant mortality across the eastern seaboard in the summer of 2018, which has complicated survey efforts, release site location, and food collection for our colony.

Volunteer HWA surveys focused on identification of new HWA sites and description of known infestations. In particular, we encouraged our volunteers to focus the southwestern Adirondack boundary, and on survey gap areas where no information is found in iMap. 229 negative and 18 positive HWA records were submitted to iMap in the southwestern Adirondack/northern CapMo area, mainly through the CapMo PRISM with whom we have partnered for trainings and survey planning; at least 50 of those were surveys by our CCE intern stationed with CapMo. The two survey gap regions are a three-county swath along the western edge of the WNY PRISM and the eastern edge of the FL PRISM (Allegheny, Wyoming, and Genesee counties), and a four-county area that straddles the western FL, northeastern CRISP, and southwestern APIPP PRISMs (Cortland, Chenango, Otsego, and Herkimer counties). Our program helped acquire 18 new points near the western survey gap and one in it, and eight in or near the eastern survey gap. In addition, one of our
star volunteers has coordinated the “CNY HWA Survey Team”, a group of over twenty volunteers, who have committed to spend the 2018-19 winter surveying gaps in Cortland, Madison, and Chenango counties.

In 2018, 505 X-HWA records 318 positive HWA records were submitted to iMap. 295 x-HWA (58%) and 106 positive HWA reports (33%) were made by our teams or partner organizations with which we share information, provide trainings, and support planning, such as Capital-Mohawk and CRISP PRISMS, the Adirondack Mountain Club, the Finger Lakes Land Trust, and the Lake George Land Conservancy. Our staff directly provided 26 positive records and one negative report, while our CNY volunteers reported 17 negative reports.

In 2019 the Hemlock Initiative intends to increase the leverage of our training efforts by launching an HWA train-the-trainer program, modeled on the iMap train-the-trainer project that has seen such success in 2017 & 2018.

HWA Phenology

As stated in the HWA research section above, the goal of the NYS Hemlock Initiative’s HWA Phenology Project is to support the HWA biological control program by providing a deeper understanding of hemlock woolly adelgid phenology. Tracking phenology with citizen scientists supports several of the HWA experiments discussed in the HWA research section.

In 2018 we produced phenology training materials for spring and fall phenology projects, and held a series of nine trainings across the state with a total of 68 participants trained. Our program monitored spring egg laying and fall estivation break using both staff and volunteers. Sites ranged from a single motivated volunteer to staff and volunteers at nature preserves. Fifteen sites reported phenology data in New York and Pennsylvania in 2018, and HWA was the second most reported forest pest on Nature’s Notebook.

Hemlock Hedges

Hemlock hedges can make excellent locations for field insectaries, where biocontrol insects are released to reproduce and collections of their progeny are later made to release into priority areas. This is especially important for the *Laricobius* beetles, as laboratory rearing of these species is labor intensive. Hedges are useful because they have dense foliage within reach of researchers for collection, and can support dense HWA populations that in turn provide food for strong populations of biocontrol insects. In 2018 we continued to field hedge reports throughout the year, and also worked with DEC to develop a hedge survey to be sent to municipalities. We plan to implement this survey in 2019.

Biocontrol Food Resource Location

High quality food is essential for rearing predators and we were fortunate to locate ample HWA for our biocontrol facility. In Jan-April 2018, our best connection was with Cotton-Hanlon Timber Management; they have many infested hemlock, good access to their lands through logging roads, and do not intend to treat for HWA. Monroe County also supplied excellent food resources from Webster Park. By fall of 2018, the availability of food from Cotton-Hanlon was decreasing, and other sites became increasingly important. We continue to need additional food sites, especially from areas in the 6a and 6b growing zones. Sources of food material will be
a driver of success for rearing of HWA biocontrols in the lab; there will be an ongoing demand for recently infested, relatively healthy hemlock stands with high HWA populations.

Outreach Events, Tools, and Publications

In addition to the capacity building activities discussed above, the Hemlock Initiative had an active year of hosted events, presentations, outreach material development, media contacts, and publications. In 2017 the Hemlock Initiative hosted five events, presented at four scientific meetings, gave 43 presentations on HWA reaching 1,316 people. We renovated and expanded our website and Facebook page and instituted posting schedules for both platforms, produced 16 printable outreach materials, published a scientific article and two popular articles, and conducted 12 interviews with the media resulting in published articles.

Events hosted by NYshi

October 19, 2018: NYS Forest Pest Workshop, Taughannock State Park, Trumansburg NY. NYSHI worked with DEC and SUNY-ESF to coordinate a meeting to discuss forest pest issues in New York. 29 attendees discussed a range of issues, from spotted lanternfly, HWA and EAB to beech leaf disease, fire season, and oak wilt.

December 7, 2018: NYS HWA Managers Meeting Workshop. NYSHI brought together hemlock conservation stakeholders from across the state to hear updates on HWA and hemlock conservation from NYSHI, DEC, and iMap Invasives. Partners discussed early detection, best management practices, biocontrol updates, prioritization of hemlock resources, and more. For details, please see the meeting report in Appendix 2.

Extension/Outreach Publications:


Instruction Publications:


Publications

Presentations at Scientific Meetings


Media Contacts


3 October 2018. Hemlock Woolly Adelgid and biological control efforts in New York. Amy Roth, Reporter, Observer-Dispatch, Utica, NY.

NYSHI Presentations/Activities

Charlotte Malmborg. NY Forest Owners Assoc.—Southeast Adirondack Chapter Annual Meeting, NYFOA, Glens Falls NY, “Biology and Management of Hemlock Woolly Adelgid in your Forest”, 28 participants, 1.5 hours, 42 contact hours, 1/20/2018

Charlotte Malmborg. Canandaigua Lake Watershed Association Meeting, CWLA, South Bristol NY, “HWA and our Forests”, 28 participants, 1.5 hours, 42 contact hours, 1/23/2018

Charlotte Malmborg. Invasion Ecology guest lecture, Hobart & William Smith Colleges, Geneva NY, “Biology and Biocontrol of Hemlock Woolly Adelgid in New York”, 13 attendees, 1.5 hours, 42 contact hours, 1/23/2018

Caroline Marschner and Charlotte Malmborg. Capital-Mohawk PRISM Partner Meeting, Cap-Mo PRISM, Colonie NY, “Hemlock Woolly Adelgid in the Capital Region”, 40 participants, 0.5 hours, 20 contact hours, 2/15/2018

Charlotte Malmborg. HWA Presentation, CCE Warren County, Warrensburg NY, “Hemlock Woolly Adelgid: Threat to the Adirondacks”, 60 participants, 1.5 hours, 90 contact hours, 2/18/2018

Caroline Marschner. HWA Presentation, CCE Monroe County, Irondequoit NY, “Biology and Management of Hemlock Woolly Adelgid”, 11 participants, 1.5 hours, 16.5 contact hours, 2/26/2018

Caroline Marschner. Guest Lab with Cornell University’s IPM course, Cornell University, Ithaca NY, “Biological Control of HWA”, 32 attendees, 1 hour, 32 contact hours, 3/6/2018

Charlotte Malmborg. Flat Rocks Hiking Area of Cornell Botanic Gardens, Ithaca NY, “Cornell Botanic Gardens Walk and Talk”, 6 participants, 1 hour, 6 contact hours, 3/9/2018

Charlotte Malmborg. HWA Presentation, CCE Yates County, Penn Yan NY, “Biology and Management of Hemlock Woolly Adelgid in the Finger Lakes”, 14 participants, 1.5 hours, 21 contact hours, 3/12/2018

Caroline Marschner. HWA Presentation, Trumansburg Rotary, Trumansburg NY, “Biology and Management of Hemlock Woolly Adelgid”, 10 attendees, 1.5 hours, 15 contact hours, 3/15/2018

Mark Whitmore. HWA Presentation. Letchworth State Park, Castile NY, “Detection and potential control of Hemlock Woolly Adelgid”, 8 attendees, 3 hours, 24 contact hours, 3/16/2018
Charlotte Malmborg. HWA Presentation, CCE Cayuga County, Moravia NY, “Biology and Management of Hemlock Woolly Adelgid”, 10 participants, 1.5 hours, 15 contact hours, 3/19/2018

Charlotte Malmborg. HWA Presentation and Training, CCE Onondaga County & Skaneateles Lake Association, Skaneateles NY, “Hemlock Woolly Adelgid in your Watershed”, 14 participants, 2 hours, 28 contact hours, 3/24/2019

Mark Whitmore and Charlotte Malmborg. HWA Training Event, Durand Eastman Park, Rochester NY, Biocontrol Release and HWA Survey, 55 participants, 3 hours, 165 contact hours, 4/4/2018

Charlotte Malmborg. HWA Presentation and Training at Saratoga Spa State Park, NYS Office of Parks, Recreation & Historic Preservation, Saratoga Springs NY, “Hemlock Woolly Adelgid: Biology, Management, and Early Detection”, 22 participants, 2 hours, 44 contact hours, 4/10/2018

Caroline Marschner. CRISP PRISM partner meeting, Shokan NY, “NYSHI Update”. 20 participants, 5 minutes, 1 contact hour, 4/19/2018

Charlotte Malmborg. Forest Pests in the Catskills, CCE Sullivan County, Liberty NY, “Biology and Management of HWA in the Catskills”, 15 participants, 1.5 hours, 22.5 contact hours, 4/20/2018

Nicholas Dietschler. NY Forest Owners Assoc. Spring Meeting, Syracuse NY, “Biology and Management of HWA in Your Forest”, 35 participants, 1.5 hours, 52.5 contact hours, 4/21/2018

Charlotte Malmborg. Finger Lakes Community College Horticulture Club Meeting, FLCC, Canandaigua NY, “Biology and Biological Control of HWA”, 20 participants, 1 hour, 20 contact hours, 4/23/2018

Mark Whitmore. Guest lecture with Cornell University DNR Forest Ecology class, “Forest pests and climate change”, Ithaca NY, 5/1/2018

Caroline Marschner. Finger Lakes PRISM Meeting, FL PRISM, Geneva NY, “Finger Lakes PRISM Hemlock Woolly Adelgid Update”, 29 participants, 0.5 hours, 14.5 contact hours, 5/3/2018

Charlotte Malmborg. HWA Presentation, Stonehedge Elementary School, Camillus NY, “Forest Pests for Fifth Graders”, 150 participants, 0.5 hours, 75 contact hours, 5/23/2018 and 5/24/2018

Charlotte Malmborg. Forest Pest Updates and iMapInvasives Training, CCE Tioga County, Owego NY, “HWA and Biocontrol Updates in New York”, 25 participants, 0.75 hours, 18.75 hours, 6/6/2018

Mark Whitmore. HWA Boat Survey Training, Dept. of Environmental Conservation, Skaneateles Lake, 5 participants, 3 hours, 15 contact hours, 6/28/2018

Nicholas Dietschler. HWA Phenology Training, CRISP-PRISM, Mt. Tremper NY, “HWA Phenology in New York”, 3 participants, 2 hours, 6 contact hours, 7/11/2018

Charlotte Malmborg. HWA Presentation and Training, NYS Office of Parks, Recreation & Historic Preservation, Voorheesville NY, “Hemlock Woolly Adelgid: An Invasive Pest”, 24 participants, 2 hours, 48 contact hours, 7/13/2018

Charlotte Malmborg. Catskill Forest Festival, NY DEP, Margaretville NY, “Hemlock Woolly Adelgid: A Threat to New York’s Forests”, 30 participants, 1 hour, 30 contact hours, 7/28/2018

Marshall LeFebvre. Catskill Mountainkeeper hike, Woodstock NY, “HWA Hemlock Appreciation Hike”, 35 attendees, 3 hours, 105 contact hours, 7/28/2018

NYSHI staff. Catskill Forest Festival tabling. 7/28/2018.
Nicholas Dietschler. HWA Phenology Training, Tanglewood Nature Center, Elmira NY, “HWA Phenology in New York”, 4 participants, 2 hours, 8 contact hours, 8/9/2018

Caroline Marschner. CRISP Partner meeting, Walton, NY, “NYSHI Update”, 12 participants, 5m, .9 contact hours, 8/19/2018

Charlotte Malmborg. Hiram Lake Association Meeting, HLA, Arcade NY, “Hemlock Woolly Adelgid: Biology, Management, and What You Can Do”, 24 participants, 1.5 hours, 36 contact hours, 8/19/2018

Charlotte Malmborg. Catskill Mountainkeeper hike, Woodstock NY, “HWA Hemlock Appreciation Hike”, 10 attendees, 3 hours, 30 contact hours, 7/28/2018

Nicholas Dietschler. HWA Phenology Training, Green Chimneys, Carmel NY, “HWA Phenology in New York”, 4 participants, 2 hours, 8 contact hours, 8/26/2018

Caroline Marschner. Chautauqua County Forest Pest Council meeting presentation, Roger Tory Peterson Institute, “HWA in Western New York”, 13 participants, 1.5 hours, 19.5 contact hours, 9/7/2018

Nicholas Dietschler. HWA Phenology Training, Roger Tory Peterson Institute, Jamestown NY, “HWA Phenology in New York”, 5 participants, 2 hours, 10 contact hours, 9/7/2018

Nicholas Dietschler. HWA Phenology Training, Rondout Neversink Stream Program, Claryville NY, “HWA Phenology in New York”, 14 participants, 2 hours, 28 contact hours, 9/8/2018

Charlotte Malmborg. HWA Presentation and HWA Phenology Training, CCE Columbia-Greene, Acra NY, “HWA Biology and Management and HWA Phenology in New York”, 4 participants, 2 hours, 8 contact hours, 9/10/2018

Nicholas Dietschler. HWA Phenology Training, Ellison Park, Rochester NY, “HWA Phenology in New York”, 11 participants, 2 hours, 22 contact hours, 9/11/2018

Nicholas Dietschler. HWA Phenology Training, NYS Office of Parks, Recreation, & Historic Preservation—Minnewaska State Park, Kerhonkson NY, “HWA Phenology in New York”, 3 participants, 2 hours, 6 contact hours, 9/14/2017

Nicholas Dietschler. HWA Phenology Training, Arnot Forest, Newfield NY, “HWA Phenology in New York”, 20 participants, 2 hours, 40 contact hours, 9/23/2018

Caroline Marschner. HWA Presentation and Training, HWA survey group, Chittenango NY, “HWA and the NYS Hemlock Imitative”, 31 participants, 2 hours, 62 contact hours, 10/13/2018

Charlotte Malmborg. Guest Lecture, Hobart & William Smith Colleges, Geneva NY, “Hemlock Woolly Adelgid and Biological Control Efforts in New York”, 13 attendees, 2 hours, 26 contact hours, 10/16/2018

Mark Whitmore. NYS Forest Pest Workshop, Taughannock State Park, Trumansburg NY, “HWA Update”, 24 participants, 1/2 hour, 12 contact hours, 10/19/2018

Charlotte Malmborg. HWA Presentation, Lake George Land Conservancy, Bolton Landing NY, “HWA in the Adirondacks”, 4 participants, 1.5 hour, 6 contact hours, 10/19/2018

Charlotte Malmborg. HWA Presentation, Lake George Land Conservancy, Queensbury NY, “HWA in the Adirondacks”, 3 participants, 1.5 hour, 4.5 contact hours, 10/20/2018

NYSHI Staff. Cornell University’s Insectapalooza, Ithaca NY, HWA Activity Table, 10/20/2018

Charlotte Malmborg. 2018 Forest Pest Walk & Talk with SLELO PRISM, Forest Park NY, “HWA Training and Hike”, 10 participants, 3 hours, 30 contact hours, 10/26/2018.
Nicholas Dietschler. Biocontrol Release Site Monitoring Training, Hemlock-Canadice State Forest, Hemlock NY, 7 participants, 2 hours, 14 contact hours, 11/5/2018

Nicholas Dietschler. Biocontrol Release Site Monitoring Boat Survey Training, Hemlock-Canadice State Forest, Hemlock Lake, 3 participants, 1.5 hours, 4.5 contact hours, 11/5/2018

Nicholas Dietschler. Biocontrol Release Site Monitoring Training, Texas Hollow State Forest, Odessa NY, 5 participants, 3 hours, 15 contact hours, 11/6/2018

Caroline Marschner. HWA presentation at the Catskill Mountainkeeper 2018 Angler’s Symposium, Claryville NY, “HWA and the NYS Hemlock Initiative”, 53 participants, 1.5 hours, 79.5 contact hours, 11/9/2018

Nicholas Dietschler. Biocontrol Release Site Monitoring Training, Canandaigua Lake Watershed Assoc., High Tor Wildlife Management Area, Naples NY, 15 participants, 3 hours, 45 contact hours, 11/12/2018

Caroline Marschner. NYSHI Update in Biocontrol Flash Briefing portion of the CCE Agricultural In-Service, Cornell University, “NYSHI Update”, 80 participants, 7 minutes, 9.3 contact hours, 11/13/2018

Nicholas Dietschler, Mark Whitmore, Charlotte Malmborg, Caroline Marschner. HWA Managers Meeting Workshop, NYS Hemlock Initiative, 35 participants, 6 hours, 210 contact hours, 12/7/2018

Charlotte Malmborg. HWA Presentation, CCE Warren County, Warrensburg NY, “Hemlock Woolly Adelgid: Biology, Management, and Biocontrol Updates”, 35 participants, 1.5 hours, 52.5 contact hours, 12/15/2018

Caroline Marschner. HWA ID Training, Manilus Public Library, Manilus NY, “Hands-on HWA ID”, 9 participants, 1.5 hours, 13.5 contact hours, 12/20/2018

Outreach Going Forward

In 2019, we will continue outreach and coordination efforts at the PRISM, state, and regional levels. We will continue to work with volunteers and partners to fill HWA survey gaps and to support survey efforts in the SW Adirondacks. We will also launch an effort to expand lake surveys for HWA in the SW Adirondacks, working with partners in that region to increase survey efforts from water. We will reach out to land trusts and watershed organizations to support survey and management planning. We will work with DEC to deliver the hedge materials produced in 2018 to municipalities and landowners in the Adirondacks. We will deliver our landowner prioritization metric and work with partners to incorporate as much science as is available into that metric. We will continue to encourage phenology reporting in New York and beyond. Finally, we will launch an HWA Train-the-Trainer program, with the goal of expanding the reach of basic HWA messaging around the state.

Acknowledgements

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Our PRISM partners for their tireless work and partnership on hemlock conservation around the state.

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The Finger Lakes National Forest for their support and collaboration.

The National Forest Service for their support, cooperation, and hemlock conservation efforts from Maine to Georgia.

The Adirondack Mountain Club for their continuing collaborations in volunteer training, survey work and education.

The administrative staff of the Department of Natural Resources at Cornell University for their technical, administrative, and fiscal expertise.
Appendix 1. DEC Contract Points & Deliverables

Contract Points

The contract contains a two-part plan for this phase of the NYSHI:

1) Train volunteers and professionals to assist the NYSHI project.
   We held eight workshops providing information to professionals and trained 543 individuals in HWA ID.

2) Research methods of HWA predator production, release, establishment, and efficacy at the Cornell HWA Biocontrol Research Laboratory.
   We conducted this research and used it to set our priorities and protocols for our laboratory work.

Train volunteers and professionals to assist the NYSHI project:
Activities to be covered include:

- Develop educational materials and a website for outreach and training.
  - New website constructed and refined
  - Webpage for training published
  - Powerpoint for training published on website
  - Facebook page revitalized
    - Regular postings
    - 178 followers

- Detection of HWA infestations.
  - 233 positive HWA detections entered in our iMap project by staff, professional partners and volunteers; 675 entered in 2017 overall, more than any previous year
  - 120 negative HWA points entered in our iMap project by staff, professional partners and volunteers; 1235 entered overall in 2017

- Reporting HWA development over the growing season, or phenology, to assist in determining when and where predators can be effectively released.
  - 12 volunteer sites reporting HWA phenology data in 2017; data indicated change from 2016 and provides the first year of data to establish trends across the state
  - 3 sites of full HWA phenology recorded by NYSHI staff

- Assist in the evaluation of predator establishment.
  - All 2017 Leucopis release sites monitored for first-generation establishment
  - Six pre-2017 Laricobius release sites monitored for establishment

- Location of abundant HWA populations for use in the Biocontrol lab for growing predators.
• Abundant HWA-infested foliage collected from Cotton-Hanlin and Highland Park; more sites identified for use in future years

• Assist in the evaluation of insecticide treatment efficacy.
  o Worked with Finger Lakes Land Trust and Mianus River Gorge to develop treatment efficacy protocols and data collection tools

Research methods of HWA predator production, release, establishment, and efficacy at the Cornell HWA Biocontrol Research Laboratory:

A number of tasks will be required to continue our work on HWA predators:

• Collection of Silverflies (*Leucopis argenticollis*, and *Leucopis piniperda*) in the Pacific Northwest (PNW) for use in stocking lab colonies and for wild release.
  o Over 4,400 silverflies collected for protocol development and wild release; 2,008 flies released in New York across ten sites; see Table 1 (1,658 by NYSHI, 350 by the Cary Institute)

• Genetic analysis of *Leucopis* spp. collected in the PNW and in NY to establish accurate taxonomic relationships.
  o Samples of local and PNW *Le. argenticollis* and *Le. piniperda* collected for genetic analyses; sample results will be returned in April 2018

• Investigate temperature and daylight in the lab for optimal *Laricobius nigrinus* development, survival, and synchrony with HWA.

• Investigate different pupation mediums for optimum *Laricobius* survival.

• Investigate methods of establishing a lab colony of *Leucopis* spp.
  o We investigated existing literature and spoke with the rearing facilities in Virginia and North Carolina, and these three items have already been determined. See Salom, S M, L T Kok, A B Lamb, C Jubb. 2012. Laboratory rearing of *Laricobius nigrinus* (Coleoptera: Derodontidae): a predator of the hemlock woolly adelgid (Hemiptera: Adelgidae). Psyche, (2012)9p. We focused our efforts on better understanding of HWA life cycles in New York and the variability within those populations, which is critical data for biocontrol releases.

• Conduct experiments to establish prey consumption rates for *Laricobius* and *Leucopis*.

Project Outputs/Deliverables

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<th>Task/Product/Deliverable Description</th>
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<td>Educational materials developed. Powerpoint presentations for training and pamphlets for reference</td>
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</tr>
<tr>
<td>3</td>
<td>Number of volunteers trained to report on HWA phenology</td>
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Appendix 2. NYS HWA Managers’ Meeting Report

Report of the 2018 NYS HWA Managers’ Meeting
Cornell Botanic Gardens, Nevin Welcome Center, December 7th, 10am – 4pm

Executive Summary

The 2019 HWA Managers Meeting was an opportunity to share projects and insights from organizations around the state that are concerned with hemlock conservation. State agency representatives, land managers, and participating groups from around the state gathered to discuss updates from the New York State Hemlock Initiative and New York’s Department of Conservation, considerations for hemlock prioritization, new tools to aid in management efforts, and management strategies currently employed. There were 26 individual organizations represented at the meeting this year, sharing expertise and outlooks from throughout New York.

NYS Hemlock Initiative Update

The NYS Hemlock Initiative reared three predator species for biocontrol of HWA in 2018: *Laricobius nigrinus*, *Leucopis piniperda* and *Leucopis argenticollis*, all from the Pacific Northwest. NYSHI released 1700+ *Laricobius* and 1000+ *Leucopis* in 2018. Establishment has been verified for four *Laricobius* release sites with up to F10 generation at the oldest sites; *Leucopis* reproduced successfully at release sites, but overwintering establishment has not been verified. NYSHI is actively seeking infested foliage collection sites to support our biocontrol colonies, particularly sites in growing zones 6 and 7. The NYSHI outreach program trained over 800 people to identify and report HWA in 2018, received 82 phenology records from NY and PA on Nature’s Notebook. A revamped website for the program provides a range of new outreach materials. NYSHI plans to trial an HWA train-the-trainer program and a new lake survey program for the southwestern border of the Adirondacks in 2019. NYSHI presented a prioritization metric to rank hemlock stands or properties for...
conservation, focused on single-site or multi-site use rather than regional efforts. A functional metric will be published on our website in January 2019; we will also reach out to the PRISMs to develop a regional prioritization tool.

**Partner Updates**

The **NYS Department of Environmental Conservation (DEC)** conducted summer surveys for HWA, planned treatments for priority sites near the Adirondacks, and assisted APIPP and the APA with the revision of the Adirondack Invasive Species Guidelines. DEC proposed establishing a multi-agency/partner clearinghouse for HWA information, which was well received by meeting partners. **iMap Invasives** had a very successful year for HWA presence/absence records, and rolled out new tools in advance of a substantial upgrade to iMap 3.0 in 2019. **The Forest Ecosystem Monitoring Cooperative** have produced a project titled “New York HWA stream corridor impact assessment.” Riparian corridor assessments of projected hemlock basal area loss are presented in a variety of riparian buffer widths and spatial scales. There is a story map of the project at [https://arcg.is/1D1LXe](https://arcg.is/1D1LXe), and the data archive for the program is at [https://www.uvm.edu/femc/data/archive/project/hemlock-woolly-adelgid-riparian-losses-new-york](https://www.uvm.edu/femc/data/archive/project/hemlock-woolly-adelgid-riparian-losses-new-york).

**Roundtable Discussions**

Participants presented their management strategies and treatment monitoring protocols. The group discussed treatment methods, what treatments to use near water, and what management methods to encourage in areas of range expansion for HWA such as the Capital-Mohawk/APIPP border. NYSHI will send their informal imidaclorpid literature review to all participants. NYS OPHRP, NYS DEC, Mianus River Gorge, and NYSHI presented their treatment monitoring protocols. Expanding treatment monitoring to include nearby stream habitats where possible/appropriate was discussed. Funding options for HWA management programs suggested included the federal HWA treatment funds available through annual proposals packaged by DEC and Parks; if you have protected lands and are interested in this program, please contact Jason Denham of DEC. A recent RFP for invasive species management may be appropriate; please see details [here](https://www.uvm.edu/femc/data/archive/project/hemlock-woolly-adelgid-riparian-losses-new-york). Funds may be made available to the PRISM system through GLRI; details will be released in January. NYS DOT and NYS OPHRP have a biannual trail grant program that might be applicable for hazard hemlock treatment, particularly along motorized trails and long trails like the Finger Lakes Trail.

With so many entities concerned with the state of hemlocks in New York, coordination with partners around the state is critical. We thank all of our partners, funders, and collaborators for joining us at the 2018 HWA Managers Meeting and supporting the mission of the Hemlock Initiative.
In person:
Spencer Barrett, Capital Mohawk PRISM
Kristopher Williams, Capital Mohawk PRISM
John Thompson, CRISP PRISM
Dan Snider, CRISP PRISM
Chris Olney, Finger Lakes Land Trust
Jason Gorman, Finger Lakes Land Trust
Tim Noon, Finger Lakes National Forest
Jeanne Grace, City of Ithaca
Kevin Vorstadt, City of Ithaca
Becky Sibner, NYS Office of Parks, Recreation, and Historic Preservation
Nick Marcet, NYS Office of Parks, Recreation, and Historic Preservation
Mathew Bilz, NYS Office of Parks, Recreation, and Historic Preservation
Matt Brinka, NYS Office of Parks, Recreation, and Historic Preservation
Chris Tcimpidis, Bevan Forestry, Inc
Zack Simek, APIPP PRISM
Jonathan Rosenthal, Ecological Research Institute
Jason Denham, NYS Department of Environmental Conservation
Carli Fraccaroli, NYS iMap Invasives
Todd Bittner, Cornell Botanic Gardens
Carrie Brown-Lima, NYS Invasive Species Research Institute
Budd Veverka, Mianus River Gorge Preserve
Mark Quinn, Monroe County Parks
Thom Allgaier, NYS Department of Agriculture and Markets
Jerry Carlson, NYS Department of Environmental Conservation
John Graham, NYS Department of Environmental Conservation
Karen Rauter, Roundout Neversink Stream Program
Charlotte Malmborg, NYS Hemlock Initiative
Kate O’Connor, NYS Hemlock Initiative
Caroline Marschner, NYS Hemlock Initiative
Mark Whitmore, NYS Hemlock Initiative
Nick Dietschler, NYS Hemlock Initiative
Isis Caetano, NYS Hemlock Initiative
James King, NYS Hemlock Initiative
Robert Duckett, Duckett’s Timber & Tree Care
Tracy Yardley, Duckett’s Timber & Tree Care

Remote attendance:
Hilary Mosher, Finger Lakes PRISM Coordinator
Megan Pistolese, SLELO PRISM Ecological Education/Outreach Coordinator
Zack Simek, APIPP PRISM Terrestrial Coordinator
Chris Zimmerman, TNC New York Conservation Ecologist
Paul Gallery, TNC New York Stewardship Coordinator
Alex Novick, Lake George Land Conservancy Land Steward
Jim Duncan, Forest Ecosystem Monitoring Collaborative
Alexandra Kosiba, Forest Ecosystem Monitoring Collaborative
Radka Wildova, Ecological Research Institute
Meredith Taylor, NYC DEP
Sarah Hoskinson, NYC DEP
Robert Cole, NYS DEC
Kristina Ferrare, CCE Onondaga
Shannon Fabiani, CCE Onondaga
Biocontrol Overview

A range of biocontrol species have been studied for HWA management on the East coast. The earliest was Sasajiscymnus (=Pseudoscymnus) tsugae, a focus of release. This was widely released from the southern edge of hemlock’s range into Maine but establishment has been minimal. There were two release sites in the Hudson Valley in the early 1990’s, and no recoveries have been made. Even though this is available commercially, it’s not a viable option for NY. The NYS Hemlock Initiative works with the most common predators of HWA in Pacific Northwest; Laricobius nigrinus, Leucopis piniperda and Leucopis argenticollis. We are also rearing small numbers of Laricobius osakensis from the Virginia Tech lab; this species is a Japanese beetle that has established well in the southern US but has not yet been released in NY.

There are two known strains of Laricobius nigrinus: the coastal PNW strain collected from west of the Cascade Mountain range in Oregon, Washington, and southern British Columbia. The interior strain have been beetles collected from Idaho, where temperatures are much colder. Both strains have been released in New York, and both have established here. This year Mark found some HWA in some locations of interior BC, which may be a source for another cold-adapted Laricobius nigrinus strain.

HWA in the northern US is prone to precipitous population declines in the winter, due to winter temperatures cold enough to cause high mortality. However, the spring generation of HWA emerges before hemlocks produce new growth for the year, and the extra space freed up by winter HWA mortality benefits the spring generation. This largely reverses the population declines caused by cold winter weather, a phenomenon called the spring rebound (See Fig 1).

Figure 1. HWA life stages, showing the mechanism of the spring rebound. Infographic produced in 2018 by Charlotte Malmborg of NYS Hemlock Initiative.
Laricobius species adults are winter feeding; they feed on the overwintering sistens HWA generation. Laricobius larvae then feed on the eggs of the spring progrediens generation. This may have two limitations. The first is that the high overwintering mortality found in the north may limit Laricobius populations from thriving. The second is that any population reductions caused by Laricobius may be partially replaced by the spring progrediens rebound. This is why we believe a suite of biocontrol species feeding on both HWA generations are necessary for effective management of HWA in New York.

The silver fly species (Leucopis spp.) we are currently studying are spring predators; the larvae feed on the eggs and potentially early instars of both generations of HWA. To date we have been collecting these flies as larvae on western hemlock foliage, rearing them to adulthood in Cornell’s insect quarantine facility (SARL), and using adults for releases and to develop rearing protocols and genetic baselines for the biocontrol program.

Another spring predator is Scymnus camptrodromus, a Chinese adelgid-feeding beetle. This insect is near approval for release by USDA APHIS, but the small colony in the US used to develop the necessary information for the permitting process recently collapsed. We hope to acquire a fresh collection of this species, complete the permitting process, and experiment with its rearing and release in New York.
Biocontrol Rearing

2018 was our first full year of biocontrol rearing in our new facility at Cornell. We had good success with our preliminary research into rearing *Leucopis*, and we kept our *Laricobius* colony alive through a full life cycle. We did not have good production of *Laricobus* this year, but were still able to release over 1,700 beetles in NY. Some of the beetles were supplied by the Virginia Tech rearing facility.

In order to improve *Laricobius* production for 2019, our technicians visited the Virginia Tech *Laricobius* rearing facility and developed several modifications to our protocol. The most straightforward issue is that the health and fecundity of predator insects is directly related to food quality, and HWA winter mortality reduces the quantity and perhaps quality of food available. We are working on strong collections early this winter to buffer against that issue, and are actively seeking food collection sites in the warmer portions of the state. **If you have a property in growing zones 6 or 7 and are willing to let us harvest some HWA infested hemlock branches, we would like to build a partnership with you.** Another issue is regulation of soil moisture during pupation, which we will address by changing our soil mixture and our moisture regulation process to more closely mimic those of the Virginia Tech facility. More areas to look at are proper proportion of beetles to food, beetles per jar, and refining our handling of beetle larvae as they drop from foliage.

This spring we successfully reared over 2000 flies from our spring PNW collections. Also in 2018, we became the first to rear two generations of silver flies in the laboratory. We hope to continue to refine these species’ rearing technique in 2019. Our main hurdle will be manipulating HWA development to provide HWA eggs for the silver flies to feed on when required.

NYSHI Field Projects

Biocontrol Releases: Silver Flies

In 2018 we released 1022 silver flies across seven sites (one in partnership with SUNY ESF for a master’s project studying *Leucopis*). We visited these sites several times over the summer to check for establishment (see Table 1 below). Reproduction was verified at five of the six release sites. Weather was an issue for the two release sites where little or no reproduction was recorded.

We have yet to find silver flies overwintering at the 2015 or 2017 release sites, so establishment in New York has yet to be verified. We are currently only sampling foliage at ground level; next year we hope to include some collections in other parts of the tree canopy. One of the challenges of biocontrol work is a typical lag between release and verification of establishment. As no one has found establishment yet, we don’t know what that lag will be for this species. We will continue to check sites each year.

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Table 1: Silverfly establishment sampling. Data from sampling periods where all release bags were in the field and sampled. Sites are Durand-Eastman County Park (D-E), Taughannock Falls State Park (TF), Cayuga Nature Center (CNC), Gosnell’s Big Woods (GBW), Overlook Mountain (OLK), and Lindsay-Parsons Bioreserve (LP). Data is cumulative for twig length sampled, egg, larva, and pupae.

Biocontrol Releases: Laricobius nigrinus
This year, we had the good fortune to verify establishment at two additional sites and continued presence at two more sites, bringing us up to a total of 5 sites with established La. nigrinus in NY. One of these sites was the original NY release site, which is in its tenth generation of La. nigrinus. Over 20 volunteers assisted with La. nigrinus searches this fall, and we are training NYS ORPHP and NYS DEC staff to survey on their properties. The very wet fall in 2018 limited the number of sites we were able to sample so far; we will continue to check release sites as weather permits through the winter and early spring, and will experiment with larval sampling in spring of 2019.

Upcoming field activities:
This winter we will be focusing on food collection for our colony, La. nigrinus establishment surveys (adult surveys over the winter and experimental larval surveys in the spring), spring La. nigrinus releases and surveys including canopy sampling. We are seeking partner assistance with finding suitable food collection sites and release sites for both biocontrol species.

HWA Biocontrol Releases in New York

Figure 3. Release sites for HWA biocontrols by the Whitmore lab/NYS Hemlock Initiative.
NYSHI Outreach Program

Our outreach program continues to grow as we reach out to new partners and build new programs and materials to support hemlock conservation around the state. This fall we have built materials for a train the trainer program modeled on the iMap Invasives train-the-trainer network. We are planning to try these materials with two model groups this winter, one with Capital-Mohawk PRISM and one with NYS OPRHP. We are also planning to pull partners together to discuss lake surveys for HWA next summer in the northern Capital-Mohawk/southern APIPP region, to enhance the survey efforts in the region. If you are interested in lake surveys, please contact Carri Marschner at cam369@cornell.edu.

Our phenology program grew in 2018, and with 82 records in Nature’s Notebook it is the second most recorded forest pest in the National Phenology Network (after tent caterpillars).

We produced a range of new outreach materials that are available on our website, as well as the infographics included here.

We launched a pine bark adelgid (PBA) survey effort in 2018 to support our silverfly genetics project documenting baseline genetics of eastern and western silverflies. Information on the program is available at our website. If you find a robust PBA infestation on white pine anywhere in the Northeastern US, please let us know.

We trained over 800 people to identify and report HWA in 2018, and look forward to continuing to work with volunteers and partners to support hemlock conservation and HWA management in New York.

Prioritization Roundtable

NYSHI has been working on a prioritization tool for hemlock conservation since 2016. We started by holding workshops with three PRISMs that cover the range of infestation stages in New York: CRISP has had HWA for many years and is seeing extensive hemlock decline and mortality particularly in the south of the PRISM; Finger Lakes is partially infested but also has uninfested areas; and APIPP was uninfested when we held the meeting. From these meetings we developed a list of factors to consider in prioritizing hemlocks for conservation, which we grouped into categories (hemlock stand information, aquatic ecosystem impacts, terrestrial ecosystem impacts, cultural factors, sustainability). We originally intended to construct a GIS based prioritization tool, but the lack of hemlock location information across the state made such a tool ineffective. In 2018 we reimagined the tool as a more basic scoring metric, to help landowners of individual or multiple properties to rank their hemlock resources for conservation. Brad Mudrzynski of CC Environment & Planning, a consulting firm out of Batavia, NY, worked with us to develop an Excel metric for scoring hemlock stands for survey in early 2018, and NYSHI used this as the basis for the new scoring metric for hemlock management. This tool has a written explanation of the various factors with a suggested weight for each factor (low, medium, high), and an associate Excel table (for either one or many properties) where a weighted score for each factor can be entered.

In October, NYSHI worked with the Cummings Nature Center near Rochester, NY to try out the draft metric. The Nature Center has nearly 100 acres of hemlock, which we separated into 9 stands for evaluation. Initially the main concerns of the Center were minimizing erosion and protecting their existing educational opportunities at the Center. Over the course of our prioritization effort, it became clear that one of their hemlock stands is a primary forest hemlock swamp, with a rare population of spreading globeflower. Because of the wide range of ecological
characteristics between the stands, the prioritization metric did a good job of identifying specific stands for conservation. The process also raised questions, however:

- How do we feel about making the unique/rare species or ecosystem (hemlock swamp, old growth) higher than anything else in importance? General consensus was that this should still be in the metric so it can be weighed against other factors, but should be weighted very heavily as these are extremely high priority sites from an ecological perspective. We will clarify that we mean primary forest when we say old growth – sites that have never been plowed, whether they still have very old trees or not. Also, the rare species need to be something that is actually depending on the hemlock ecosystem, not something that just happens to be nearby. Climate resilience should also be considered in the metric.

- Should metric include watershed vulnerability = percent hemlock within watershed? Unqualified yes.

- Diversity metric? Mixed – no suggestions of an available data set that would work for this, and Radka specifically was thinking that the low diversity in hemlock stands would make this a poor tool.

- Should this metric be geared more towards flexibility, so it can be modified to meet the needs of landowners, or standardization, so that results can be compared across sites? The general consensus was that flexibility was critical for a landowner-scale metric, but that to use the metric to prove the importance of a site for grants there should be standardization. We will make this tool as flexible as possible, and work with the PRISMs to develop a more standardized tool for regional prioritization in 2019. This consistency will make it easier to compare results over time as well. NYSHI will reach out to PRISM leaders and other statewide stakeholders in 2019 once the landowner tool is finalized and published.

DEC Update

DEC conducted extensive surveys for HWA this year using their summer forest health teams. This is no longer an early detection effort, but the focus is on locations where HWA has not yet been found. 2018 was the second year of treatment on Prospect Mountain to continue to treat within legal limits per acre. The site was treated in November of 2018 with imidacloprid and dinotefuran; DEC intends to return in 2019 to continue this project. No live HWA were found, although old ovisacs were detected. Plotter Kill was also scheduled for treatment this fall, but the very wet, cold fall kept the staff from treating. The plan is to treat in the spring of 2019 before the current generation reproduces (or at least before the spring generation settles into aestivation). This ongoing project is a collaboration between DEC, Schenectady County, and the Capital-Mohawk PRISM. Anchor Diamond in southern Schenectady is a town park where HWA was found this summer by Capital-Mohawk PRISM; treatment of ~10 acres near a protected wetland are planned for spring of 2019 as a partnership between DEC, Capital/Mohawk PRISM, and the Ballston Spa Town government. For both Anchor Diamond and Plotter Kill, tree tagging and GPS location for the planned treatments were completed this fall.

Important work has been ongoing with the Adirondack Invasive Species Guidelines. The "Inter-Agency Guidelines for Implementing Best Management Practices to Control Invasive Species on DEC Administered Lands of the Adirondack Park" were adopted as an addendum to the MOU between DEC and APA in 2007, and provide approved best management practices for invasive plant management projects in the Adirondacks. In 2016, Mark Whitmore reached out to the APA regarding the importance of early intervention for HWA management; this started the ball rolling to incorporate HWA into the Guidelines. In 2017 and 2018, APIPP worked with DEC to expand the scope of this document to include forest pests, and incorporate BMPs for HWA. This revision was approved by the APA in the spring of 2018. This allows for rapid response to HWA found in the Adirondacks. 2018 also saw the first enforcement of the Part 575 prohibited/regulated invasive species regulation. A shipment of infested HWA from the mid-Atlantic affected several nurseries in New York. NYS DEC enforced a financial penalty, along with reporting requirements if the offending nursery wishes to conduct further sales in New York.
HWA related objectives for DEC in 2019:
- Conserve hemlocks on public and private lands
- Perform and support HWA surveys on all lands, especially uninfested lands
- Participate in lakeshore surveys
- Continue to support the NYS Hemlock Initiative
- Conduct treatments at Prospect Mountain, Plotter Kill, Anchor Diamond, and potentially Hemlock/Canadice SF, with other sites as needed while keeping enough funds in reserve to deal with any other forest pest outbreaks that may arise.
- Executive approval of a draft HWA management plan

Jason Denham proposed a multi-partner HWA database for surveys, monitoring, treatment, biocontrol, web map services, which would provide real time data updates to managers, rather than managers waiting for the next manager meeting or other opportunity to compare notes. This would be a multi-partner HWA database that could support DEC, ORHRP, NYSHI, PRISMs, USFS, DAM, and others, and be compatible with the iMap 3 platform. Data could include surveys, monitoring, treatment, biocontrol releases, and webmap services. Jason is imagining something on ArcGIS Online, which DEC has used to good effect with spotted lanternfly coordination. FEMC (whose talk follows the DEC update in the notes) may be another good option for this, as it is a clearinghouse for ecological information relevant to the Northeast. NYISRI might be able to provide support as well if this is a priority for invasive species work in New York. Managers are mostly using OAT, another Survey 1-2-3 app, or Collector for large data gathering projects; it would be convenient if whatever platform is decided on can support these software in addition to Excel, etc. Standardizing data fields collected across projects would certainly help with this effort. If there were a public-facing side of this tool, it could be used to support citizen science engagement in HWA projects. The exact location of biocontrol releases would need to be protected if there is any public facing component to the site.

iMap Invasives Update

In 2018, 366 positive and 611 negative HWA records were entered into iMap by December 3rd. In total, 1,436 positive HWA records have been submitted across 44 counties, by 138 users in 42 organizations. 3,131 negative records have been recorded, covering 43 counties, 35 organizations and 123 users.

Currently, iMap users can use the mobile app to upload presence/absence data to iMap, with species, location, and photographic data attached. The Survey 123 data collection app in beta testing for 2018 accepts much more detailed observation, assessment, and treatment data; it currently uploads to ArcGIS Online rather than iMap. There is also a beta version of OAT with additional forest pest fields, which is particularly applicable for HWA projects.

In 2019, iMap will upgrade to iMapInvasives 3.0, the first full overhaul of the iMap system. The web interface will be mobile friendly for field entry in locations with cell service, and the iMap “Classic” mobile app will remain in use as well for presence/absence data, with fields for species, landscape, and area of interest information. Data entered via the OAT or OAT forest pest Survey 123 forms will be crosswalked to iMap three automatically at set times (probably weekly). iMap 3.0 will have more streamlined bulk uploading capabilities, and the ability to build web map services around the iMap 3.0 data. iMap 3.0 will also include customizable data collection, Americas view in addition to state views, better capacity to visualize change over time for documented infestation, and an improved user experience. The iMapInvasives Certified Trainers Network has been very successful in 2018, and will continue into 2019 with new information for iMap 3.0 to update certified trainers.
The Forest Ecosystem Monitoring Cooperative is a partnership of Northeastern state agencies, the University of Vermont, and the USDA Forest Service, which promotes the efficient coordination of multi-disciplinary environmental monitoring and research activities among federal, state, university, and private-sector agencies with common interests in the long-term health, management, and protection of forested ecosystems. The mission of the Forest Ecosystem Monitoring Cooperative is to serve the northeast temperate forest region through improved understanding of long-term trends, annual conditions, and interdisciplinary relationships of the physical, chemical, and biological components of forested ecosystems. It maintains an online database and project library, conducts outreach and education programs, and supports coordination of the region’s forest ecosystem interests. The FEMC manages over three decades of Vermont’s forest ecosystem data, and is actively adding data sets from the surrounding states. This information is intended to benefit research, natural resource management, education, and public interest. The Cooperative serves as a hub of forest monitoring and research efforts, bringing together practitioners from a range of disciplines and institutions to work together on monitoring and assessing forested ecosystems in the northeastern forest region. The FEMC maintains a long-standing, diverse repository of monitoring and research data relevant to forest ecosystem structure, health and function. The repository includes datasets unique to the archive, region-specific extracts of data maintained by other organizations, and links to datasets hosted elsewhere.

The FEMC has a project titled “New York HWA stream corridor impact assessment.” There is a story map of the project at https://arcg.is/1D1LXe, and the data archive for the program is at https://www.uvm.edu/femc/data/archive/project/hemlock-woolly-adelgid-riparian-losses-new-york. The project goal is to identify riparian corridors at risk of potential hemlock losses due to HWA to help guide selection of research locations to study the impact of hemlock loss on water quality and quantity, and to identify priority areas for land managers to monitor, and potentially manage HWA infestations. It does not take into account HWA infestation severity, but the magnitude of potential hemlock losses should HWA become established. Using 50’, 100’, and 200’ buffers of stream corridors and projected basal area losses due to HWA for 2013-27 published by the USFS, the project created a map of projected basal area loss in both square feet/acre and percent of total stand basal areas in riparian buffers of New York. They then provided that data as stream buffer segments and as a set of generalized values (mean, max, etc) for watersheds and sub-catchments. These results differed from the USFS product of basal area loss per subcatchment, as FEMC focused on hemlocks near streams. The FEMC product may help groups interested in water quality preservation to better focus their hemlock conservation efforts.

Statistics from the study:

- ~45% of NYS riparian buffer area at risk of hemlock loss
- <0.002% of riparian buffer area had projected losses ≥15% of the total BA
- 4000-7000 ac of stream buffer area
- Central and southern portions most at risk for potential riparian buffer degradation
- Some stream corridors may experience BA losses of >40 ft2/ac and >20%
- Could influence water quantity and quality adjacent to large population centers
  - e.g., New York City
- Because of the large pixels used to represent loss, the width of the riparian buffer did not drastically influence the projected losses
Review Management Strategies Throughout the State

At Mianus River Gorge, there was a big drought in 2016 and the overstory trees started dying. Treatments were initiated to preserve the remaining hemlocks, with a goal to treat 1600 trees over three years. 564 trees over 12” in diameter that grew on slopes were treated in the first year; in the second year the staff were more experienced and were able to treat more trees. The west side of the river has been treated, and treatments are now $31,000 and some private donation funds targeted at hemlock conservation are still available, so the preserve staff have increased their total goal to over 2,000 trees being conducted on the east side. The preserve also includes a 2,100 acre parcel that is disjunct from the main preserve; they may use this to experiment with treating an entire area rather than selecting priority trees. For restoration in areas with hemlock mortality, the staff are cataloguing open areas in hemlock forests, removing invasive species, and replanting with native trees/shrubs (and occasionally hemlocks). 500 trees from the state nursery have been planted so far; the preserve is outside the Trees for Tribs geographic area, so the plantings are unrelated to that program.

State Parks has conducted extensive treatments in priority hemlock stands for several years, and in Minnewaska State Park (SP) have found potential reinfestation of trees treated in 2014. Nick M. will be checking on them as soon as he can this winter. Becky Sibner monitored a variety of treatment years that had HWA on them this past year, and while overall tree health is improving she is still finding low levels of HWA on the treated trees.

Cornell Botanic Gardens had a partially failed treatment at the Fisher Tract old growth forest, and as a result use the upper end of the treatment application level to ensure full efficacy with imidacloprid. The cost/benefit of using more imidacloprid vs multiple visits encourages heavier application rates. The upper limit of imidacloprid applied per acre is reached more quickly, so the Gardens spread out treatments over several years.

The Finger Lakes National Forest has treated all of their priority stands except the designated control area (to check treatment efficacy), and are planning to retreat in 2019 at Caywood. Most treatments have been Core-Tect tablets, but since Caywood also has an EHS infestation the Forest uses a tank mix of imidacloprid and Safari (Safari is also effective on EHS) at that site. Scale was first observed in 2015/16, and treated trees are relatively scale free. These trees are in poor health due to significant damage prior to the first treatment and the additional stress of hemlock borer (a secondary pest on ailing hemlock); repeat treatments are intended to maintain the progress made in hemlock health.

There is no evidence of pesticide resistance development at present; imidacloprid is a neurotransmitter blocker, which is not a mode of action prone to development of resistance. Adaptation to colder temperatures, however, has already been documented in HWA. Balsam woolly adelgid (BWA) was originally predicted to be confined to coastal areas, and is now killing trees near Lake Placid and found near treeline on Mt. Washington. Mark started to see movement of BWA into colder areas in the late 70s, to give a feeling for the adaptation time frame for that pest.

The situation at Lisha Kill, an infested property near the leading edge of the HWA infestation close to Adirondack hemlock populations, raises the question of using biocontrol in leading edge infestations. NYSHI doesn’t think that biocontrol is a good option for this situation, as the insects will not provide control for several years in the best case scenario, all the while the infestations will be producing progeny near the Adirondacks which could start an infestation. A set of BMPs for HWA management in leading edges of the state’s HWA infestation would be helpful, perhaps a multiple-page handout with the suite of management tools and resources including efficacy of various treatment options. Another leading edge issue is private land owners who are unwilling to manage HWA infestations. So there are two issues here: parcel level management options vs a statewide plan for management of a pest moving.
through the state. If we are serious about protecting the Adirondacks, what is our plan just south of there? How do we focus outreach and education efforts and make sure early infestations are effectively managed?

If pesticide treatment is not an option, is removal of all infested hemlocks and a 200’ buffer around them to clear lightly infested trees a cultural management option?

Several of the ecological benefits of hemlock impact aquatic systems, so hemlock treatment is often focused on riparian corridors. Imidacloprid is toxic to all insects including aquatic ones, and there are no label restrictions on its use near water.

Different organizations have imposed self-imposed guidelines for imidacloprid application near water, based on the caution of the managers of those organizations. The USFS contracted a risk analysis of the imidacloprid and dinotefuran in 2007 (available online, potentially with an updated executive summary) and their guidelines took those results into account.

CBG uses a 100’ buffer where they use stem injection rather than basal bark spray or soil drench. DEC will, DEC will treat right up to the water using basal bark applications when managing priority early infestations, to make sure the infestation is managed. FLNF and Mianus River Gorge use CoreTect tables 50’ or more from water and basal sprays within 15’; they do not treat within 15’. Parks does bark application to 25’, and then trunk injection.

Elizabeth Benton has conducted detailed research on the movement of imidacloprid applied through soil drench application in the Great Smoky Mountain National Park. She has found that imidacloprid does leave the system eventually, doesn’t bioaccumulate, and doesn’t impact other classes of life other than insects. In a nine year study, years 1 and 2 she did show evidence of imidacloprid and a decrease in macroinvertebrate species. In years 3 and 4 there was no difference, and in years 5-9 treated areas had better macroinvertebrate communities than untreated areas. The studies are on the NYSHI website along with the Forest Connect talk featuring Dr. Benton’s research. Elizabeth Benton and Rich Cowles are also studying the threshold of toxin presence necessary for HWA control; this will help inform treatment longevity. They recommend a treatment dose curve based on a range of parameters in which they are fairly confident. Soil moisture, respiration activity, and other factors are all important. Improved monitoring of efficacy is critical to refine our BMPs.

Review of treatment monitoring through the state

At State Parks, treatment monitoring is conducted through a combination of ground surveys and limited tree climbing. This protocol is under review, with dual goals of reducing effort for typical treatment monitoring and to support the new grants for Finger Lakes SPs that require more in-depth monitoring. Given Becky’s findings of low level HWA infestation on treated trees with improving health, HWA absence doesn’t seem to a good measure of treatment efficacy; the Finger Lakes programs are shifting to repeat monitoring of individual branches for health and infestation levels over time. The main drawback is the increase in effort for this type of monitoring.

At Mianus River Gorge, 50 trees were randomly selected as long-term gap light analysis, and other in-house comparative photography methods are also being used. The staff are considering using tennis ball surveys to track infestation near treated trees and in adjoining sites. Tom Horton from ESF and some students will be looking at mycorrhizal fungus on treated and untreated hemlocks, and in primary and secondary forests.

DEC has experimented with HWA monitoring in the upper canopy using drones, but that rotor wash made crisp photography difficult. Jason Denham is considering if there is a way to collect physical samples via drone rather than relying on photography. Drone photography was used to monitor new hemlock growth at Prospect Mountain, but the protocol is still under development and drone time is scarce given the demands on the DEC drone program from other projects. If approval is granted, they will continue to work on the protocols at Lisha Kill this spring. The police and
governor’s office now manage permissions of overflights of public lands, and the 90 day lag between application and permission makes biological survey work difficult.

Treatment monitoring method may need to vary based on the treatment application method, as each method has weaknesses (striping for stem injection, etc). Parks has tree level treatment information, and early lapsing treatments occur on more than injected trees. Becky has heard of patchiness in imidacloprid distribution through the tree canopy, but some of the Parks trees with early treatment efficacy loss were also treated with Safari. There is some evidence that a drought after treatment impedes translocation, dramatically reducing treatment efficacy.

Options for treatment monitoring include canopy sampling, slingshot sampling, checking for new growth in early summer with binoculars, and visual estimates of infestation and tree health. The development of an infestation threshold is appealing, and Mark W thinks the threshold should be whether the tree is able to sustain new growth. No protocol for this method has been developed at present. Mark W would like to see canopy sampling in combination with Velcro balls and the slingshot launcher to see how the methods compare potentially on Parks properties where permanently wired climbing setups for monitoring are already in place.

Given the discussion on imidacloprid and dinotefuran in aquatic systems, some organizations are monitoring streams near treatments to document either impact of chemical treatments or impact of hemlock preservation/loss. Most partners are interested in these programs. The Lake George Land Conservancy are on their second year of annual stream and wetland monitoring in the watershed. The Roundout Neversink Stream Program is building a stream monitoring program with USGS right now, and will try to add hemlock impact monitoring as well.

Outreach and education

People like their hemlock trees and don’t want to lose them, and there has been more people being open to treatment of them. The HWA movie has been really helpful for education, both describing the ecological importance and human emotional connection with hemlocks and explaining why management is critical. However, there are still many people who absolutely are against any pesticide use.

Education on multiple fronts is critical, but no matter what you do some folks won’t come on board. Kris Williams finds that when he has a serious conversation about the pros and cons of hemlock loss, the relative risks of hemlock loss vs targeted treatment, people are much more able to think critically about this specific issue.

Charlotte Malmborg of NYSHI has created a short report on the current state of imidacloprid/hemlock research, phrased in a readily accessible language, which she will clean up and share with the group. Charlotte can also provide a graphic. Consistent messaging around hemlock conservation and treatment options is critical.

Every couple of years there is action from individuals within New York who want to ban all pesticide use in NY. DEC educates those groups on the DEC’s practices each time this arises.

Funds for treatment on public lands

The HWA Initiative manager at the Forest Service, Noel Schneeberger, wanted to make sure NY land managers were aware of funds available for HWA treatment on any protected lands. The one stipulation is that submission for these funds must organized by DEC and Parks, who can bundle the various proposals from NY together and submit the
package for funding. In the past DEC and Parks have submitted separately as there is currently no way to share funds between DEC and Parks; they are hoping to resolve this in the next year. DEC has historically asked regional managers for treatment requests. If we put this together with Parks, maybe we’ll get more response. Hemlock-Canadice SF is now interested in treatment, and Jason Denham has written an HWA management plan that specifies the need for treatment; hopefully these will encourage more response from other state forest managers. DEC also has funds for protected lands available left over from last year. If managers of protected lands are interested in applying for treatment funds, contact Jason Denham for next year (December)’s federal funding application.

In January there might be up to ½ million available to PRISMs through Grants.gov GLRI – maybe municipalities as well. The specifics are not currently known, but keep an eye out in January.
Once the state budget comes out every year, there are often EPF funds available for invasive species suppression projects. Keep an eye out for that as well; these funds are specifically for be non-state lands.

There are also recreational trail program grants through DOT & Parks every other year to groups external to Parks. Parks just funded treatment along trails, so that might be a possibility for external groups as well. They will send that information along to the group. Protecting hazard trees, esp motorized trails (snowmobiles) and long continuous trail segments (FL Trail, etc).

**Next Steps**

-NYSHI will incorporate comments, talk to ERI, publish the landowner prioritization tool and reach out to PRISMS to talk about scaling/rigidizing the tool for PRISMS.

-Please email Carri cam369@cornell.edu if you are interested in being involved in the lake survey conversation for N CapMo/S Adirondacks.

-Please email Nick Nd283@cornell.edu with any potential silverfly release sites for next spring. Fingers crossed we find a lot out west!

-Contact Charlotte cm933@conrell.edu with fun new outreach ideas.

-Parks and DEC will talk about ways to share funds so they can apply jointly for FS funds. The group is interested in a data sharing service: if you are interested in that group, email Jason Denham and he will set up a call with us, John Marino, Nick, etc.

-Parks will share the information on the recreational trail program grants through DOT & Parks.

-Becky is working on a monitoring protocol for monitoring and stream protocol. She will send a draft to the group for comments, and we can move forward with that as a starting point for standardized monitoring.