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Authors
Mark Whitmore, Caroline Marschner, Tonya Bittner and Nicholas Dietschler

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, *Adelges tsugae*), a non-native invasive insect, including development of biocontrol options. Additionally, our work involves public outreach to engage stakeholders and increase awareness of the threats posed by HWA and other invasive forest pests.
The New York State Hemlock Initiative (NYSHI) includes programs in HWA management research, HWA biological control, HWA management coordination, and hemlock conservation. The global COVID-19 pandemic forced us to change the way we work beginning in March, but the work continued to progress. Research and releases received the most focus and continued to produce results, while outreach and coordination saw the most changes in structure.

- A pilot study of overwintering puparia of silver flies showed for the first time that diapausing puparia can survive the winter in Upstate New York. The study was expanded across the east coast with several collaborators.
- We launched a new research foray into the use of environmental DNA (eDNA) for detection of both HWA and its predators and completed design, testing, and proof of concept studies for these techniques. The addition of the eDNA techniques also allows us another avenue for faster and easier identification of fly eggs and larvae, which will be used in many other projects.
- We released 7,794 *Leucopis* spp. (flies) at 9 sites and 4,546 *Laricobius nigrinus* beetles at 7 sites. We recovered established *Laricobius nigrinus* and/or *Laricobius osakensis* at three additional sites, bringing the total sites for *Laricobius* establishment to 7 statewide.
- Current greenhouse capacity for rearing is 92 cages. We filled and refilled cages, using 5 sets of shipments (Feb, Mar, Apr, May, June) for a cumulative total of 178 cages. This is our greatest number of cages in a single season. The season total emergence, which ran from 2/24 through 7/13, was 10,063 flies. Cages also produced pre-pupa of *Laricobius nigrinus* beetles. A total of 9,660 immature beetles were collected resulting in 3,911 live adults in the fall, a survival rate of 40.5%.
- Three NYSHI staff members traveled to the annual 30th USDA Interagency Forum on Invasive Species, January 14-17. These meetings are organized by the federal government and include a meeting of the USDA HWA Biological Control Working Group. Our program benefits greatly from this exchange of research and management ideas and results across North America.
- Staff member Nicholas Dietschler successfully defended his Master of Science thesis on the timing of *Leucopis* adult emergence in the Pacific Northwest. This research advanced our understanding of release timing for the *Leucopis* flies in New York, which could improve management outcomes, and a peer-reviewed publication will appear in Environmental Entomology in 2021.
- Our staff surveyed over 70 hemlock stands in the Beaverkill watershed of the Catskills and inspired several landowners to treat their hemlocks.
- As a result of many factors including the pandemic, we have opted to refocus our outreach on support of regional HWA teams and on HWA management and conservation planning support. This will result in giving fewer talks, but we hope they will create a multiplier effect by targeting individuals who will implement HWA survey and management in their home regions, engaging neighbors and friends.
HWA Biocontrol Research

The core of NYSHI’s program is development and implementation of effective biocontrol options for hemlock woolly adelgid (HWA) management in New York. NYSHI conducts research on HWA and potential biocontrol predators: Laricobius beetles and Leucopis silver flies. We investigate HWA ecology and predator ecology, lab rearing, release methods, and establishment monitoring. Our research laboratory consists of office and laboratory space and a greenhouse in Cornell’s Sarkaria Arthropod Research Laboratory quarantine facility with 92 cages for working with HWA foliage from the Pacific Northwest, where we obtain most of our predators. Despite the many challenges of a global pandemic, NYSHI continued to produce quality original research in several key areas of HWA biocontrol. We investigated basic phenology and development of Leucopis spp. biocontrol insects, discovered that they are able to survive our New York winters in the pupal stage, and got started on the exciting pathway of using environmental DNA as a monitoring tool. We also topped our previous year for Leucopis spp. release numbers, and continued to rear and release Laricobius nigrinus beetles.

Biological Control: Leucopis spp (Silver flies) Research

The HWA research and management community has long recognized the need for biological control predators to feed on both generations of HWA. Feeding by Laricobius beetles alone has been shown to impact the winter generation of HWA, but the populations rebound in the spring. The Pacific Northwestern lineages of two species of silver flies are currently considered the best candidates to achieve predation on the spring generation of HWA, and are the major focus of research in our laboratory.

Collection of HWA-infested foliage from the Pacific Northwest is the foundation of our research programs. Two collection trips were conducted to the Pacific Northwest (Washington and British Columbia) this spring, to collect foliage bearing both Leucopis and Laricobius larvae. In addition, partners in the Pacific Northwest sent foliage to our lab. We use this foliage to rear HWA biological control predators for research and release. We are particularly interested in learning more about how the two species of Leucopis differ, given that they feed on the same resource. Some of our research topics for Leucopis include life cycle differences, population genetic variation, overwintering strategy, and methods for lab-rearing.
Leucopis Phenology

An early focus of our research has been the phenology of the two *Leucopis* species present on HWA in the Pacific Northwest, *Le. argenticollis* and *Le. piniperda*. We tracked temperatures and emergence from our western collections in our quarantine facility. When we account for degree day accumulation there is a clear difference between the emergence patterns of the two *Leucopis* species with *Le. argenticollis* coming first, followed by *La. nigrinus* beetle larval drop (an indicator that the HWA progrediens crawlers are hatching) and then an emergence of *Le. piniperda* adults. Our lab member Nicholas Dietschler submitted this work to Environmental Entomology, in a manuscript titled “Biological Control of Hemlock Woolly Adelgid: Implications of Adult Emergence Patterns of Two *Leucopis* spp. (Diptera: Chamaemyiidae) and *Laricobius nigrinus* (Coleoptera: Derodontidae) Larval Drop.” This paper is the thesis research for Nick’s MS Degree and is the first study to clearly define the relative timing of adult emergence for the two fly species. In much of the scientific literature on these flies in the past, the two species have been combined. Our lab takes care to separate the species in our experiments to elucidate how they are dividing the HWA prey resource. In particular we are interested in learning how potential species differences may impact biological control of HWA in New York.

Environmental DNA

Environmental DNA (eDNA) holds the promise of quickly and accurately monitoring sites for early detection of HWA infestation as well as predator establishment. In 2020 we pursued three main objectives in the development of eDNA techniques for the HWA system.

**Objective 1: Development of species-specific qPCR assays for *Leucopis argenticollis*, *Leucopis piniperda*, *Laricobius nigrinus* and HWA.** Primers were designed and tested for all target species. All assays were tested against closely related non-target species. The assay for *Laricobius nigrinus* also reacts with DNA from *Laricobius rubidus* (a native *Laricobius* species usually found on the native pine bark adelgid), so a future step will be to improve the specificity of that assay. In the meantime, we could still get useful information about potential establishment from the *Laricobius* assay, which could be followed up with additional modes of sampling for confirmation.
Initial results are exciting, indicating that eDNA is a highly sensitive technique, detecting insects at much higher rates than by visual inspection (inspection of twigs under a microscope).

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of samples</th>
<th>Positive detection rate (dissections)</th>
<th>Positive detection rate (eDNA analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adelges tsugae</td>
<td>48</td>
<td>27.1 %</td>
<td>89.6 %</td>
</tr>
<tr>
<td>Leucopis argenticollis</td>
<td>38</td>
<td>18.4 %</td>
<td>55.3 %</td>
</tr>
<tr>
<td>Leucopis pinitperda</td>
<td>38</td>
<td>31.6 %</td>
<td>89.6 %</td>
</tr>
<tr>
<td>Laricobius nigrinus</td>
<td>38</td>
<td>18.4 %</td>
<td>81.6 %</td>
</tr>
</tbody>
</table>

Objective 2: Correlate abundance of target organisms to their eDNA signal. This was done differently for HWA and for predators. For predators, we used 38 infested western foliage samples. We freeze-killed the samples at -20 C for at least 3 days before dissection, then collected information on twig length, HWA stage and density, and number of predators. Each predator was preserved for DNA identification. After dissection we washed each twig with water and used a vacuum filtration apparatus to capture eDNA from the water onto a membrane. We correlated the amount (density) of predator eDNA captured per membrane (determined by the qPCR assay) with the population density of predators on that foliage sample. These collections were possible thanks to four collaborators in Washington State: Western Washington University, Kwaiht: Center for the Historical Ecology of the Salish Sea, Tacoma Science and Math Institute, and MetroParks Tacoma.
For HWA detection, Objective 2 was approached using an unfortunate circumstance of new infestations discovered at Lake George. An observant camper on Lake George reported a sighting of HWA on the iMap Invasives app in late July. Within hours, we were notified of this discovery by NYSDEC. Within just a few days of the report we were surveying the lakeshore by boat, but surveying in summer is difficult because the bugs are tiny and black rather than covered in white wool. We first found a number of small infested spots along the shoreline, the largest near a popular boating destination called Paradise Bay. The partners raised a large group of surveyors, and in short order we were all surveying more area on the ground. We then decided to survey the popular recreational area around Shelving Rock, and unfortunately found another light infestation.

We then found HWA on Dome Island, a small oblong 15-acre island in the middle Lake George, a nature preserve managed by the Lake George Land Conservancy for the Nature Conservancy. The LGLC invited us to join them to survey the island and within half an hour we found a small number of infested trees at the south end. Climbing just one tree in the middle of the island we found HWA only in the top sample. We quickly realized this was an opportunity to study how HWA moves through an area from an assumed initiation point (south end of the island). Shoreline samples around the perimeter of Dome Island were taken by boat, with a total of 38 trees sampled. We decided to sample not only at eye level, but to climb as many trees as possible to make it a three-dimensional survey. We sampled foliage from high-, mid-, and low- level positions in the canopies of 11 trees across three sites (2 at Dome Island, 5 at Shelving Rock, and 4 at Paradise Bay).

Maps of Dome Island in Lake George. Left panel: the overall visual survey effort and HWA densities estimated from microscope counts. Right panel: the 16 quadrants and 16 trees (red markers) that were selected and climbed for eDNA samples.
In addition, we decided to test our capacity to detect environmental DNA of HWA as a potential early detection technique. Using the same stratified sampling protocol we sampled 16 additional trees at Dome Island. Foliage was collected using sterile technique to eliminate possible DNA cross-contamination between samples. The samples were sub-divided in the lab using sterile technique, with part of the sample being used for eDNA quantification and the other part dissected in the laboratory using a stereomicroscope. At least 200 centimeters of foliage per sample were measured and all living adelgids were counted to give an HWA density value (adelgids/cm). HWA density for each sample was attributed to the respective canopy strata of the tree. We are completing analysis and writing a manuscript which will report the eDNA results for Objectives 1 and 2.

Graph of visual counts (under the microscope) of the Lake George HWA infestations in 27 trees. Only 16 of the trees from Dome Island were sampled specifically for eDNA (see Maps above).

Objective 3: Development of novel eDNA capture methods in terrestrial environments.
We explored eDNA passive sampling by canopy throughfall into a collection device. This work is ongoing.
**Leucopis Overwintering in Puparia**

In the spring of 2020, adult *Leucopis argenticollis* emerged from puparia that were overwintered in an unheated shelter. This was the first time either *Leucopis spp.* had been shown to successfully overwinter on the east coast. In the fall of 2019 we had divided 115 lab-reared puparia into three groups: a control group overwintered in an environmental chamber; a “cold” site in the Finger Lakes at a mid-elevation location south of Owasco Lake; and a “warm” site located in the Lower Hudson Valley at Mianus River Gorge (collaborators: Budd Veverka and Chris Nagy).

The cold and warm site treatments were exposed to natural light and ambient outdoor temperatures. (Due to the COVID-19 pandemic, the Mianus treatment was brought to the Owasco site on March 17 to allow for daily observation after the treatment had already experienced the temperatures of fall and winter.) Each treatment was monitored daily throughout the late winter and early spring for adult emergence (Figure 1). Fall emergence lasted the longest at Mianus, and spring emergence first occurred at Owasco Lake. Overall survival was high in all treatments and was even slightly better in the outdoor sites than the lab (see table). The low temperatures experienced by the insects were -16.3 C at the cold site and -15.6 C at the warm site.

Our current understanding is that *Leucopis* offspring need HWA eggs to feed on, at least during the early instars (larval stages). Flies that emerge in the fall may be unlikely to produce offspring that could survive, because there are no HWA eggs in the fall. Therefore if a fly enters diapause, it is best for it to stay in diapause until the spring. A binomial logistic regression test showed a significantly higher chance of an adult Le. argenticollis emerging in the spring at the colder site. This bodes well for the timing of adult emergence in New York.

### Summary table from pilot study of overwintering *Leucopis argenticollis* emergence by season and total survival.

<table>
<thead>
<tr>
<th>Site</th>
<th>Fall emerge (%)</th>
<th>Spring emerge (%)</th>
<th>Mortality</th>
<th>Total</th>
<th>Fall emerge (%)</th>
<th>Spring emerge (%)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory control</td>
<td>3</td>
<td>27</td>
<td>7</td>
<td>37</td>
<td>8.11</td>
<td>72.97</td>
<td>81.08</td>
</tr>
<tr>
<td>Owasco Lake (cold treatment)</td>
<td>2</td>
<td>32</td>
<td>2</td>
<td>36</td>
<td>5.56</td>
<td>88.89</td>
<td>94.44</td>
</tr>
<tr>
<td>Mianus River Gorge (warm treatment)</td>
<td>9</td>
<td>25</td>
<td>3</td>
<td>38</td>
<td>23.68</td>
<td>68.42</td>
<td>92.11</td>
</tr>
</tbody>
</table>
Based on the success of this pilot study, in spring of 2020 we began a larger research project looking at the overwintering potential and field emergence patterns of both *Leucopis* species throughout the introduced range of HWA. We lab-reared over 1,000 flies of each species from eggs on eastern HWA to obtain enough puparia for this study. Two field treatments, one beginning in late July and the second in early October, will help us understand what effects warmer summer and colder winter temperatures may have.

In mid-July, lab-reared pupae of *Le. argenticollis* were sent to seven sites on the east coast and one site in Washington State for the summer treatment (see table). Summer/Fall emergence of *Le. argenticollis* was reported at all sites in the summer treatment, showing that the pupae survived transport. In early October, another batch of both species was sent to most of the collaborators for the overwinter treatment. (Because of their later development pattern, *Le. piniperda* are only represented in the winter treatment group.) All puparia will be observed through spring 2021 for adult emergence. Temperature data is being collected at each location. This research is funded through a grant from the USDA Forest Service.
Experimental setup of overwintering study for 2020-2021

<table>
<thead>
<tr>
<th>Site</th>
<th>Collaborators</th>
<th>Number of Le. argenticollis Summer/Winter</th>
<th>Number of Le. piniperda Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owasco Lake, NY</td>
<td>(Nick Dietschler – NYSHI)</td>
<td>65/65</td>
<td>57</td>
</tr>
<tr>
<td>Lake Placid, NY</td>
<td>Zach Simek (APIPP)</td>
<td>60/65</td>
<td>55</td>
</tr>
<tr>
<td>UMASS Amherst, MA</td>
<td>Joe Elkinton and Ryan Crandall</td>
<td>60/65</td>
<td>0</td>
</tr>
<tr>
<td>Western Maryland</td>
<td>Biff Thompson (Maryland DNR)</td>
<td>60/65</td>
<td>60</td>
</tr>
<tr>
<td>Blacksburg, VA</td>
<td>Scott Salom and Carrie Preston, Virginia Tech</td>
<td>60/65</td>
<td>55</td>
</tr>
<tr>
<td>USFS Southern Research Station, NC</td>
<td>Bud Mayfield (USDA Forest Service)</td>
<td>65/65</td>
<td>55</td>
</tr>
<tr>
<td>Eastern Tennessee</td>
<td>Pat Parkman (University of Tennessee)</td>
<td>60/65</td>
<td>0</td>
</tr>
<tr>
<td>Tacoma WA</td>
<td>Matt Lonsdale and Carol Brouillette (Science and Math Institute, Tacoma City Schools)</td>
<td>60/65</td>
<td>58</td>
</tr>
</tbody>
</table>

**Leucopis Development**

A major goal of our work is to determine minimum threshold, maximum threshold, and optimal temperatures for development of both species of *Leucopis*. This crucial information will help optimize *Leucopis* rearing and speaks to the climatic tolerances and possibly phenological timing of the flies throughout their life cycle. It will also detect any differences in development between the two species. The experiment was started in 2020 and will take up to three years to complete. We provided eastern HWA-infested foliage to adult *Leucopis spp.* collected in quarantine to stimulate egg-laying, then harvested the resulting eggs and tracked these individuals through the entire life cycle at different temperature treatments: 8, 12, 16, and 20 C. Each fly egg was placed on a fresh HWA-infested twig in a small deli cup, checked frequently for life stage changes, and fed with new twig pieces. In the first cohort we started over 500 *Le. argenticollis* eggs. A second cohort of *Le. piniperda* was established with a smaller sample size and omitting the lowest temperature from the treatment series. Over 150 eggs of *Le. piniperda* were started.
By closely watching the development of the flies over time, we have seen the feeding damage that the larvae leave behind. They not only devour the eggs of HWA, but also dislodge the feeding adults, which subsequently die. We have also seen larvae actively feed on crawlers and nymphs. The woolly ovisacs take on an “exploded” appearance after a fly larva has passed through the area.

To support laboratory rearing, our NY-SHI field crew collected infested eastern hemlock foliage prior to HWA egg laying and put it in cold storage. This enables us to manipulate egg laying to coincide with project needs. Foliage collections took place on NYSHI partner properties: Waterman Conservation and Education Center, Monroe County Parks, and Cotton-Hanlon Inc.

Upper panel: HWA on twig before feeding by *Le. argenticollis*. Lower panel: the same piece of twig after feeding by one larva of *Le. argenticollis*. 
**Leucopis Genetics**

Our program continues to use genetic approaches to learn about *Leucopis*. Genetic approaches require two steps, a DNA isolation step followed by analysis of the DNA usually with a PCR-based technique. DNA isolation is a time-consuming process, so we wanted to explore ways to speed it up. In late January, two staff members traveled to the USDA Forest Service facility in Hamden, CT to be trained on a Kingfisher automated DNA extraction robot in the lab of Nathan Havill, an adelgid expert and key collaborator. We were able to extract DNA from over 1,000 flies in about 2 days. Subsequently, we formed a relationship with the USDA’s R.W. Holley Center for Agriculture and Health on Cornell’s campus to occasionally use their Kingfisher machine (including for hundreds of insects trapped in British Columbia, see below).

**Leucopis Trapping**

We collaborated with Troy Kimoto, a Canadian Food Inspection Agency Forester in British Columbia, to study the efficacy of trapping *Leucopis* flies in the wild. A trap design that catches adult flies would be an important tool for biocontrol monitoring in New York, and there are no existing studies on how to trap *Leucopis* or closely related flies. The field experiment was run in Richmond, British Columbia using trifold sticky traps of either green or yellow, hung on North and South sides of western hemlock trees. Troy Kimoto and Adela Danci screened, collected, and preserved the specimens from the traps, then shipped them to us for genetic analysis. Because flies captured on sticky traps are often damaged and difficult to recognize by eye, we used the fast and highly sensitive assay designed for environmental DNA to identify the specimens.

We processed over 700 specimens to find 612 *Leucopis* spp. During the time period of the study (mid-April to October), *Le. piniperda* was more abundant than *Le. argenticollis* and there was significant overlap of the two species on the traps. We pooled the species for analysis.

The distribution of catches was not equal between trap types by a Chi-square contingency test. The yellow traps deployed on the south sides of trees caught the most flies. This trapping method could prove to be useful in the future for monitoring for flies in the east.
Biological Control: *Leucopis spp.* (Silver fly) Release and Monitoring

*Leucopis spp.* for release were obtained through Pacific Northwest collections of HWA infested foliage performed by NYSHI Staff (pre-COVID) and collaborators (post-COVID). Pacific Northwest and British Columbia collaborators include Bagley Wright, Matt Lonsdale, Paul Whitmore, and Troy Kimoto. Release site priority was given to augmenting past release sites with additional individuals to bolster establishment. For the most part, we continued with free releases (not in mesh bags) as we had in 2019, except where particular research questions call for it.

One such research question was explored in the fall of 2019, when four mesh bags containing (F1) lab-reared flies were established, two in New York in the Finger Lakes region near Aurora and two in Virginia near Blacksburg. This was the first time to our knowledge that anyone tried releasing western flies that had been reared on eastern HWA, as well as the first time flies were released in the fall. All flies were identified as *Le. piniperda* and sexed. Each bag received two sets of about 10 parents of equal sex ratio. In early March of 2020 (VA bags) and in April (NY bags), we dissected all the material in each bag. Although the branches had plenty of egg-laying HWA, we did not find any life-stages of *Le. piniperda* present in any bags. We do not know exactly why they failed to reproduce, but this is an example of a small pilot project to explore new ideas and techniques.

All 2020 releases were free releases, meaning that flies were released unconfined into HWA-infested release sites. Site priority was placed on augmenting previous releases at 2019 release sites, where HWA populations and tree conditions allowed. Six releases were augmentative and three were new innoculations. Despite difficulties due to the pandemic, we were able to exceed our 2019 release total of 6,625 by over one thousand flies.

The COVID-19 pandemic negatively impacted our release site monitoring. We collected 3 shoebox-sized tubs of foliage from each of two sites: Gosnell’s Big Woods on Mar. 6 and Pepacton Reservoir on Mar. 17. The caged foliage was maintained and monitored for several weeks for fly emergence, but no flies were found.
### Table of *Leucopis* releases in 2020

<table>
<thead>
<tr>
<th>Date of Release (release type)</th>
<th>Number of Flies</th>
<th>Site of Release</th>
<th>Ownership of Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 April (augmentative)</td>
<td>1,050</td>
<td>Greater Lick Brook Conservation Area*</td>
<td>Finger Lakes Land Trust, Cornell Botanic Garden, NYS Parks</td>
</tr>
<tr>
<td>28 April (augmentative)</td>
<td>772</td>
<td>High Tor Wildlife Management Area</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>5 May (augmentative)</td>
<td>1,072</td>
<td>Pepacton Reservoir</td>
<td>NYCDEP</td>
</tr>
<tr>
<td>8 May (augmentative)</td>
<td>823</td>
<td>Mossy Bank Park</td>
<td>Town of Bath</td>
</tr>
<tr>
<td>13 May &amp; 9 June (new inoculative)</td>
<td>549</td>
<td>IBM Glen</td>
<td>Waterman Conservation Center</td>
</tr>
<tr>
<td>14 May &amp; 20 May (augmentative)</td>
<td>1,180</td>
<td>Hemlock Canadice State Forest</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>15 May &amp; 26 May (new inoculative)</td>
<td>1,274</td>
<td>Texas Hollow State Forest</td>
<td>NYSDEC</td>
</tr>
<tr>
<td>28 May (augmentative)</td>
<td>799</td>
<td>Glenora Glen</td>
<td>Private</td>
</tr>
<tr>
<td>16 June (new inoculative)</td>
<td>275</td>
<td>East Branch, Catskills</td>
<td>Private</td>
</tr>
<tr>
<td><strong>Total Released</strong></td>
<td><strong>7,794</strong></td>
<td><strong>9 sites</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Lands managed by multiple collaborators forming a contiguous protected area where hemlock hardwoods forest is the dominant forest type. Preserve lands: Lick Brook Natural Area (Cornell Botanic Gardens), Sweedler and Thayer Preserve (Finger Lakes Land Trust), and Buttermilk Falls State Park (NYSOPRHP).*
Biological Control: *Laricobius* spp. Rearing and Releases

During 2020 we reared *Laricobius nigrinus* beetles collected from western foliage in the quarantine facility. We collected pre-pupa from the foliage cages in quarantine, put them into soil media in environmental chambers, maintained appropriate levels of soil moisture and temperature, and collected emerging adults in the late summer through fall. This year we collected a total of 9,660 pre-pupae, resulting in 3,911 live adults. This represents 40.5% survival during the pupal stage, which is comparable with survival rates in other labs where these beetles are reared in colonies.

We made 9 releases of 4,546 *Laricobius* beetles in 2020; all were *La. nigrinus*. The source of beetles included 502 reared at Virginia Tech, with the remainder reared from pre-pupae in our quarantine lab. At Harriman State Park, a beat-sheet monitoring survey took place on the same day (see below) before the release of new beetles.

<table>
<thead>
<tr>
<th>Date of release</th>
<th>Number of beetles</th>
<th>Site of release</th>
<th>Ownership of site</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/18 – 3/29/2020</td>
<td>263</td>
<td>Aurora</td>
<td>Wells College</td>
</tr>
<tr>
<td>10/14/2020</td>
<td>536</td>
<td>Mianus River Gorge</td>
<td>Private Land Trust</td>
</tr>
<tr>
<td>10/21/2020</td>
<td>620</td>
<td>Lake George - Paradise Bay</td>
<td>DEC</td>
</tr>
<tr>
<td>10/28/2020</td>
<td>842</td>
<td>Harriman SP</td>
<td>State Parks</td>
</tr>
<tr>
<td>11/5/2020</td>
<td>642</td>
<td>Berlin Estate</td>
<td>Private/Protected</td>
</tr>
<tr>
<td>11/19/2020</td>
<td>519</td>
<td>Sawmill Creek</td>
<td>US Forest Service</td>
</tr>
<tr>
<td>12/4/2020</td>
<td>502</td>
<td>Mianus River Gorge</td>
<td>Private Land Trust</td>
</tr>
<tr>
<td>12/10/2020</td>
<td>520</td>
<td>Taughannock Falls SP</td>
<td>State Parks</td>
</tr>
<tr>
<td>12/23/2020</td>
<td>102</td>
<td>Taughannock Falls SP</td>
<td>State Parks</td>
</tr>
<tr>
<td>Total released in 2020</td>
<td>4,546</td>
<td>7 sites</td>
<td></td>
</tr>
</tbody>
</table>
Biological Control: *Laricobius* Release Monitoring

In the fall, we surveyed three release sites for adult beetles using the beat-sheet method. A total of 10 person-hours was logged across sites. Adult beetles were found at all three sites: one *La. nigrinus* at Harriman State Park on October 28, 4 *La. nigrinus* at Webster Park on November 5, and 2 *La. nigrinus* and 1 *La. osakensis* at Wells College/Aurora on November 9. We were excited to find that *La. osakensis* had successfully reproduced in their first year at the only site in New York where they have been released, which was a relatively small release of 133 beetles in 2019. Due to COVID-19 restrictions, we were not able to collect foliage for spring monitoring using prepupae drop as we had planned.

HWA Research

Overwinter Mortality of HWA in the Field

We have long-term data on winter mortality of HWA in New York. Due to COVID-19 we wrapped up our season for collecting samples in mid-March instead of April; in December 2020 we began collecting winter 2020-2021 data. The sites we are using in 2020-2021 are Taughannock Falls State Park, Lake George Wild Forest, and Mine Kill State Park, with monthly samples planned for December through April. Over the summer we started to analyze our long-term data set using nonparametric modeling. We intend to use both seasons from 2019-2021 to validate the model(s) that will be produced from prior data.
HWA Phenology Project

The NYSHI’s HWA Phenology Project works with volunteers and partner organizations to monitor for HWA life stages in New York. Phenology is defined as the study of periodic events in biological life cycles and how these are influenced by seasonal and interannual variations in climate, as well as habitat factors. The timing of HWA life cycle events is important for many reasons, including knowing when HWA is likely to spread (crawler hatch) and when food is available for predators. This monitoring program is easy and fun for citizen scientists and is tied into the National Phenology Network: https://www.usanpn.org/about/why-phenology.

NYSHI staff monitored HWA phenology at three sites in NY. Mine Kill State Park and Taughannock State Park were monitored in conjunction with the HWA over-wintering mortality study and a small number of trees were monitored at Cornell University. (Monitoring by NYSHI took place until COVID restrictions prevented unnecessary travel.) Two critical release sites were monitored by dedicated volunteers who have been with the project for multiple years. A new volunteer was recruited at the IBM Glen release site in Binghamton, NY and will be helping with HWA phenology observations at that site in the future.

Table of HWA Life Stage Phenology in 2020

<table>
<thead>
<tr>
<th>Site</th>
<th>HWA egg laying (progrediens eggs)</th>
<th>Aestivation break</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornell University, Ithaca</td>
<td>13 March 2020</td>
<td>21 Sept 2020</td>
</tr>
<tr>
<td>High Tor WMA</td>
<td>18 March 2020</td>
<td></td>
</tr>
<tr>
<td>Mossy Bank Park, Bath</td>
<td>27 March 2020</td>
<td>20 Sept 2020</td>
</tr>
<tr>
<td>Beaverkill, Lew Beach</td>
<td>2 Oct 2020</td>
<td></td>
</tr>
<tr>
<td>Lower Hudson Valley</td>
<td>21 Sept 2020</td>
<td></td>
</tr>
</tbody>
</table>
Coordination and Outreach

In 2020 we continued to work collaboratively with partners and stakeholders around the state. Our outreach coordination season was interrupted in March by the coronavirus pandemic, forcing us to postpone our statewide partner HWA managers’ meeting. Our outreach moved from in-person talks and trainings to online webinars. This had some benefits; we had some quite large webinars (over 50 attendees in one case). In addition, we held an abbreviated version of our planned HWA Managers’ Meeting, to communicate the essential and immediate information to partners and facilitate partner updates and connections. This event, titled NYS HWA Partner Roundtable and Discussion, was held on April 21st, and DEC provided the WebEx hosting for the event as well as state updates. Over 30 partners attended from NYS DEC, NYS DAM, NYS OPRHP, representatives of six of the eight PRISMS, and several additional partners.

One of our most extensive collaborative efforts in 2020 was our extensive coordination with DEC, APIPP PRISM, and The Lake George Land Conservancy (LGLC) delineating and planning treatment for the significant Lake George HWA find in August. Mark Whitmore spent much of his work time this fall in the Lake George region supporting this effort, with up to three additional field staff joining him for several weeks.

We had a substantial change in our outreach program this year: our intrepid outreach coordinator, Charlotte Malmborg, moved on to a PhD program at Boston University. She left behind a treasure trove of new outreach programs and materials, beautiful infographics, and strong connections with many of our partners. She will be missed, both by our team and by many of our partners around the state. Moving forward, Caroline Marschner will be picking up volunteer coordination and much of the outreach programming for NYSHI, and Zoya Mohsin has taken over our social media activities. Marshall Lefebvre has assumed responsibility for the phenology project and its volunteers. He will also be spearheading our treatment monitoring coordination with partners.

Our Train the Trainer program reached several highly motivated, well-positioned individuals within the invasive species community, and many of our partners including PRISMs are now using our materials as a springboard for their own basic HWA information events. Earlier in 2020 we also launched our prioritization tool, which provides a concrete planning strategy for hemlock conservation. Finally, our Hemlock Hunter program has provided a useful template for organized HWA searches, either at the watershed or regional scale. As a result of these factors, we have opted to refocus our outreach on support of regional HWA teams and on HWA management and conservation planning support. This will result in fewer talks, but we hope they will target individuals who will implement HWA survey and management in their home regions.
Partner Collaboration

PRISMS

- **APIPP:** The NYS Hemlock Initiative provided extensive support to the survey and delimitation of the new HWA infestation found on the shore of Lake George. We collaborated extensively with APIPP on survey and management of the Lake George infestation, providing staff time, expertise, supporting research. We worked with Emily-Bell Dinan of APIPP to support the PRISM’s HWA outreach plan for the region. As part of this survey work, we trained crews from multiple organizations to detect HWA at the absolutely most difficult time of year, when HWA are very early instar. On September 21st, Mark Whitmore participated in APIPP’s HWA Phase 2 meeting at Bolton Landing, providing expertise on hemlock populations in the region and on HWA biology and management.

- **Capital Region:** We worked with the Capital Mohawk PRISM (CapMo) to identify and evaluate potential biological control release sites. The survey crew consisted of Nicole Campbell and Kristopher Williams of CapMo and Nick Dietschler of NYSHI. Members of each site organization were present at each respective survey. Three sites were identified for a collaborative survey effort on November 12th. Sites evaluated were Copake Falls at Taconic State Park, High Falls Conservation area in Philmont, and the Huyck Preserve in Rensselearville. We also worked with Huyck Preserve to prioritize their hemlock resources for survey and management.

- **Catskills:** Our technician Kate O’Connor worked full-time in the CRISP region, conducting HWA surveys, outreach, and release site scouting. She worked with several large landowners to plan and execute HWA treatment on their properties. She will continue working in the Beaverkill watershed in 2021 as a new staff member of Catskill Mountainkeeper. In addition to Kate’s work, NYSHI participated in CRISP’s partner meetings and their strategic planning workshops.

- **Finger Lakes:** Our home PRISM is where most of our significant volunteer teams work. We have two long-standing phenology volunteers in the western Finger Lakes, and the CNY HWA Survey Team is active in the eastern Finger Lakes (Onondaga, Cortland, and Madison counties). In addition, NYSHI supported the development of the Owasco Lake Hemlock Hunters team, including mapping and prioritization of hemlocks in the watershed, gathering tax lot information for outreach, information sessions for the lake association, and training the volunteer group both remotely and through socially distanced field training.

- **SLELO:** NYSHI continued to coordinate SLELO staff to support their volunteer and staff surveys of hemlock, including participation in the SLELO forest pest workshop and HWA information talks. We also worked with SLELO and iMap staff to incorporate the key field assessment components of the prioritization metric into iMap’s Forest Pest Survey 1-2-3 app.

- **WNY:** We worked with the WNY PRISM to conduct two HWA survey trainings (49 trained) and provided a range of maps for survey work.
• **iMap Invasives**: NYSHI continues to be an active partner with iMap. NYSHI staff confirmed 79 iMap records in 2020, and encouraged engagement with iMap in all of our trainings and talks. NYSHI staff and trainees added 157 confirmed positive reports and 150 negative reports of HWA into the iMap database. NYSHI helped iMap staff add prioritization metrics to the Forest Pest Survey 1-2-3 tool, and participated in the iMap Invasives user feedback meetings on October 21-22.

Statewide/State Agencies

• 4/21/2020: HWA Partner Roundtable and Update. DEC provided WebEx hosting for the event as well as state updates. Over 30 partners attended, including staff from NYS DEC, NYS DAM, NYS OPRHP, six of the eight PRISMS, and several additional partners. DEC and Parks worked with NYSHI to finalize two prioritization metrics, one for individual landowners and one for regional land managers. Each constitutes a Word document explaining the prioritization process and Excel file for scoring stands or sites. All three partners tested the metrics, and the final product was presented in July at the national HWA Manager’s meeting.

• NYSHI supported the Lake George survey and delineation efforts, and released biocontrols around the state.

• NYSHI trained DEC and collaborators staff on HWA survey in August and September 2020
Citizen Science Programs

Pacific Northwest HWA Survey

We began working with the Forterra Green Cities Partnership on surveying for hemlock woolly adelgid infestations in Washington State. The Green Cities Partnership coordinates volunteer efforts in green spaces of 14 municipalities in the Seattle Metro area and in Snohomish County. We are working with the Green Cities Coordinators to get volunteers to report HWA populations in city parks.

Hemlock Hunters

The Hemlock Hunters volunteer program trains volunteers to survey for hemlock and HWA in New York forests, and to submit their findings to NYSHI. Our Hemlock Hunters program grew substantially in 2020, with 21 new volunteers and 28 surveys completed in 2020. Our volunteer CNY HWA Survey Team, lead by Master Naturalist Steve Kinne, conducted 16 of these surveys. They focused mainly on the Skaneateles watershed, and located new HWA infestations on the eastern side of Skaneateles in the southern third of the lake. They reached out to landowners in the area to gain access to adjoining properties, and extended those surveys along infested gorges. They also conducted intensive surveys at Bear Swamp State Forest, and found no HWA in some extensive and beautiful stands – a spot of bright news.

We also had an additional team form in the Owasco Lake watershed headed by Dana Hall. We provided a prioritized map of the watershed’s gorges using our prioritization tool and information available through aerial imagery, and a list of landowners with conifers within those gorges. Dana built a survey team, reached out to town managers and the tax lot office, and conducted outreach to line up survey locations for 2021.

MyHemlock

The MyHemlock volunteer program is targeted towards landowners or regular visitors to an individual property, and trains volunteers to survey one stand twice a year for HWA. Twelve new volunteers signed up for this program in 2020, and 12 new MyHemlock sites were registered and 7 update reports.

HWA Phenology

The NYSHI’s HWA Phenology Project worked with volunteers and partner organizations to monitor HWA phenology throughout New York State. Phenology was monitored by volunteers at two locations in the western Finger Lakes, and by partners in the lower Hudson Valley. This enabled us to better time biocontrol releases when food was available to predators, a critical component of our program.
Train the Trainer

In early 2020 two NYSHI Train the Trainer members held trainings, with 32 individuals trained to recognize and report HWA. Over the year these trainees began providing basic HWA talks in their areas, allowing our outreach staff to focus on volunteer training and support and the prioritization tool project in the second half of the year.

- 3/9/2020: “HWA Presentation and Hike” by Saratoga PLAN (NYSHI TRAINER NETWORK EVENT) at the Galway Public Library/ Hennig Preserve, Galway NY. 3 hours, 13 attendees, 39 contact hours. Monica Dore of Lake George Land Conservancy presenting.
New Publications and Outreach Materials

Publications

Outreach Materials
Hemlock Prioritization Tool: In 2020 we released hemlock prioritization toolkits for landowners and regional land managers. These tools are for use by land managers who are planning which hemlocks to survey or manage on their property or properties. Often the number of hemlocks under management exceed the available resources for conservation effort, making thoughtful selection of hemlock stands for conservation a critical step in forest management planning. This tool helps land managers think through the benefits of individual hemlock stands or properties, and weigh the merits of each from a range of perspectives including terrestrial ecology, aquatic ecology, cultural resources and sustainability.

2020 Winter Hemlock Tribune: the NYSHI winter quarter newsletter.

2020 Fall Hemlock Tribune: the NYSHI fall quarter newsletter includes articles by a range of NYSHI staff on tree climbing, HWA in the Adirondacks, biocontrol research, Beaverkill surveys, and eDNA’s potential role in HWA management.

Media Coverage
The NYS Hemlock Initiative was covered in many media reports of the Lake George HWA infestation in late summer and fall of 2020, often in company with DEC, the Lake George Land Conservancy, APIPP PRISM, and the Fund for Lake George all featuring. There were also a few articles that covered our work with the Owasco Watershed Lake Association (OWLA), supporting survey of priority hemlocks on private property in their watershed.

July 23, 2020, Auburn Citizen: Our volunteer and the leader of OWLA, Dana Hall, wrote a piece on HWA mentioning our program: “Hall: HABs, HAW and progress in the Owasco flats”.

August 11, 2020, NNY360/Watertown Daily Times: “Second infestation of invasive hemlock woolly adelgid confirmed in Adirondacks” by Ellis Giacomelli. Mentions NYSHI and uses several links to our website; quotes website.
September 10, 2020, Adirondack Explorer: “Hemlock woolly adelgid found on nearly 250 acres along Lake George”, by Gwendolyn Craig. Contains and interview with Mark Whitmore.

September 11, 2020, Adirondack Daily Enterprise: “DEC to manage second hemlock woolly adelgid outbreak in Adirondacks” by NYS DEC. Mentions NYSHI’s partnership for survey.

September 12, 2020, Albany Times Union: “Hemlock-killing invasive found in Fort Ann area” by Gwendolyn Craig. Includes quotes from Mark Whitmore.

September 12, 2020, NYS 360/Watertown Daily Times: “Treatment plan developed for invasive hemlock woolly adelgid in Adirondacks” by Ellis Giacomelli. Contains the same NYSHI mentions as August 11 article.

September 17, 2020, The Post-Star: “Second infestation of hemlock woolly adelgid also found in Dresden and Fort Ann” by Post-Star staff. Mentions NYSHI’s partnership for survey.

September 18, 2020, Auburn Citizen: “OWLA: How to be lake-friendly and watershed-aware” by Gilda Brower. Mentions NYSHI and the HWA volunteer team formed to survey Owasco Lake watershed properties.

September 28, 2020, Adirondack Almanack: “DEC and partners announce effort to prevent spread of hemlock woolly adelgid” by NYS DEC. Mentions NYSHI as regional partner in development of HWA management.

October 3, 2020, The Evening Tribune: “County officials briefed on destructive insect species”, by staff reporters. Covers Mark Whitmore’s presentation of HWA information to the members of the Inter-County Association of WNY and the Inter-County Legislative Committee of the Adirondacks.

October 9, 2020, Observer Today: “DEC, agencies team to help fight invasive species”, by unknown author. Covers the MOU that sustains both NYISRI and NYSHI, with a description of NYSHI’s work and a quote from Mark Whitmore.

October 10, 2020, The Post Star: “Hemlock woolly adelgid identified on Dome Island”, by Chad Arnold. Covers the Dome Island/Lake George infestation, including a conversation with Mark Whitmore.

October 13, 2020: WNYT/News Channel 13 coverage of HWA infestation in Lake George basin, including an article and three TV news clips. The article and two of the news segments include NYSHI staff and interviews of Mark Whitmore in addition to DEC staff.

October 31, 2020, The Post Star: “Crews moving quickly on Dome Island to eradicate invasive insect” by Chad Arnold. Mentions and quotes Mark Whitmore of NYSHI.

November 2, 2020, Adirondack Daily Enterprise: “Crews move quickly to save hemlocks” by Chad Arnold. Mentions NYSHI and quotes Mark Whitmore.
November 6, 2020, Adirondack Explorer: “Keeping the invasive bugs at bay: foresters and researchers track and attack spreading insects” by Gwendolyn Craig. Mentions NYSHI’s involvement with the Lake George HWA response and quotes Mark Whitmore within the framework of a larger forest pest article.

November 12, 2020, Adirondack Explorer: “Predator beetles released on Lake George to eat hemlock-killing bug” by Gwendolyn Craig. Covers biocontrol release at Lake George and quotes Mark Whitmore.

November 14, 2020, The Post Star: “Predatory beetle unleashed to fight invasive insect in Lake George basin” by Chad Arnold. Covers biocontrol release at Lake George and quotes Mark Whitmore.

November 16, 2020, News10: “Predatory beetle deployed around Lake George to keep fight invasive insect in check”, video/news spot with interview from Mark Whitmore and covers the release of Laricobius beetles at Lake George.

November 18, 2020, NNY 360/Watertown Daily Times: “Adirondack hemlocks treated for invasive woolly adelgid” by Ellis Giacomelli. Covers Lake George treatment and discusses NYSHI as one of the survey partners and links to website for HWA ID materials.

November 18, 2020, Adirondack Almanack: “Update on Lake George hemlock woolly adelgid treatment” by NYS DEC. Mentions NYSHI as a partner in survey effort.’


December 10, 2020, Auburn Pub/The Citizen: “Eco Talk: Hemlock woolly adelgid still a threat to local trees” by Judy Wright. Discusses the NYSHI biocontrol research program and links to our website.

December 18, 2020, The Highlands Current: “The Fading Forest, Part II” by Brian PJ Cronin. Part of a three-part series on forest pests and forest health, this one focuses on hemlock woolly adelgid and NYSHI’s work at Harriman State Park.


Talks and Trainings

Scientific Presentations

March 4 2020. N. Dietschler. “Silver Flies (Leucopis spp.): The Future of HWA Bio Control?” Presentation at the Maryland Department of Natural Resources Forest Pest Conference, New Germany State Park MD, Western Maryland. 20 minutes, approx. 50 attendees, 16.3 contact hours.


July 28, 2020. A. Kirtane. “Status of eDNA Projects.” NYS HWA Managers’ Meeting, remote attendance, 6 minutes, 125 attending, 12.5 contact hours.

July 28, 2020. C. Marschner. “Hemlock prioritization tool.” NYS HWA Managers’ Meeting, remote attendance. 10m, 133 attending, 22.6 contact hours.

General Talks and Trainings

Our talk schedule was different from previous years. The coronavirus epidemic eliminated most in-person events after mid-March, except for a few socially distant, masked, small field trainings for HWA survey and for the extensive training and field-work supporting DEC in the Lake George survey and delineation. We continued to provide trainings to audiences around the state remotely through the rest of the year.

The other change to our general talks is an intentional shift of focus from general HWA ID and reporting talks. Our Train-the-Trainer project provided the tools necessary for many partners, especially PRISM staff, to provide this level of training themselves. We continued to provide these talks, especially when supporting watershed or regional survey efforts, but focused more on talks supporting our volunteer programs.

With the release of our prioritization tool, we have the ability to better support large landowners and regional groups in hemlock conservation planning. This portion of our work increased in late 2020, and continue to grow into 2021.

NYSHI conducted 28 general trainings in 2020, for a total of 201 contact hours with audiences around the state.
Presentations

- 1/8/2020: “Forests and Forest Pest Interactions” Finger Lakes Community College Speaking of Nature Seminar, Muller Field Station, Honeoye NY. 19 attendees, 1.5 hours, 28.5 contact hours. Nicholas Dietschler presenting.
- 2/10/2020: “Hemlock Woolly Adelgid: An Invasive Threat to a Foundation Tree” SLELO PRISM/Nature Up North presentation at Wachtmeister Field Station, St. Lawrence University, Canton. 2 hours, 7 attendees, 14 contact hours. Charlotte Malmborg presenting.
- 3/13/2020: “Forest Park HWA Walk and Talk” presented with the SLELO PRISM at Forest Park, Camden NY. 2 hours, 11 attendees, 22 contact hours. Charlotte Malmborg presenting.
- 4/2/2020: Conserving the Foundation: Keeping Hemlock Trees in Adirondack Forests, Zoom Webinar co-hosted by APIPP PRISM. 1 hour, 56 attendees, 56 contact hours; Charlotte Malmborg presenting.
- 4/24/2020: Our “Gorges” Forests, Zoom Webinar. 1 hour, 46 attendees, 46 contact hours; Charlotte Malmborg presenting.
- 5/1/2020: A Pest in the West: Hemlock Woolly Adelgid in Western New York, Zoom Webinar. 1 hour, 8 attendees; Charlotte Malmborg presenting.
- 5/8/2020: Detect to Protect: HWA in the Capital-Mohawk Region, Zoom Webinar. 1 hour, 23 attendees, 23 contact hours; Charlotte Malmborg presenting.
- 5/15/2020: Caring for the Catskills: Saving Hemlocks From an Invasive Threat, Zoom Webinar. 1 hour, 8 attendees, 8 contact hours; Charlotte Malmborg presenting.
- 5/22/2020: Hemlocks on the Hudson: HWA in the Lower Hudson and Long Island Regions, Zoom Webinar. 1 hour, 9 attendees, 9 contact hours; Charlotte Malmborg presenting.
- 5/29/2020: Keeping Hemlocks Healthy: HWA in the St. Lawrence-Eastern Lake Ontario Region, Zoom Webinar. 1 hour, 11 attendees, 11 contact hours; Charlotte Malmborg presenting.
- 6/9/2020: HWA Hunters Program Training 1, Zoom Webinar. ½ hour, 3 attendees, 1.5 contact hours; Charlotte Malmborg presenting.
- 6/11/2020: MyHemlock Program Training 1, Zoom Webinar. ½ hour, 2 attendees, 1 contact hour; Charlotte Malmborg presenting.
- 6/16/2020: HWA Hunters Program Training 2, Zoom Webinar. ½ hour, 5 attendees, 2.5 contact hours; Charlotte Malmborg presenting.
• 6/23/2020: HWA Hunters Program 3, Zoom Webinar. ½ hour, 3 attendees, 1.5 contact hours; Charlotte Malmborg presenting.
• 6/25/2020: MyHemlock Program, Zoom Webinar. ½ hour, 3 attendees, 1.5 contact hours; Charlotte Malmborg presenting.
• 9/4/2020: HWA in the Adirondacks. Train-the-Trainer hosted event presented through CCE Warren County, remote attendance. 1 hour, 28 attending, 28 contact hours, Dan Carusone presenting.
• 9/7/2020: HWA in the Catskills. HWA ID and management information session to the Neversink Homeowner’s Association, Frost Valley YMCA. 35 attending, 1 hour, 35 contact hours, Kate O’Connor presenting.
• 9/18/2020: Hemlock Woolly Adelgid in the Adirondacks. Presented to the NYS Association of Counties, remote attendance. 45m, 42 attendees, 31.5 contact hours, Mark Whitmore presenting.
• 9/23/2020: Hemlocks in the Catskills: 2020 Update. Presented through the CCE Catskills Agroforestry Center, remote attendance. 1 hour, 7 attendees, 6 contact hours, Caroline Marschner presenting.
• 10/7/2020: “Owasco Lake: HWA 2020 Update”, hosted by the Owasco Lake Watershed Association and NYSHI remotely. 1 hour, 15 attendees, 15 contact hours; Caroline Marschner presenting.
• 10/16/2020: “Owasco Lake Hemlock Hunter Training”, presented remotely to the Owasco Hemlock Hunters volunteer group. 1.5 hours, 10 attendees, 15 contact hours; Caroline Marschner presenting.
• 10/29/2020: “Calling All Hikers – Protect Your Hemlocks” hosted by SLELO PRISM; remote presentation. 1 hour, 10 attendees, 10 contact hours; Caroline Marschner presenting.
• 11/13/2020: “Owasco Lake Hemlock Hunter survey training” in-person training with social distancing at private residence on the east side of Owasco Lake. 2 hours, 10 attendees, 20 contact hours; Caroline Marschner presenting.

Virtual Outreach
Our website continued to grow in 2020, with expanded treatment and hemlock conservation planning materials added. The website had over 6000 users, a 40% increase from 2019, and 13,000 pageviews. At the end of 2020 the website had 166 subscribers, 47 more than 2019. Both website traffic and new subscribers were particularly heavy in the last quarter, as media attention focused on HWA after the Lake George infestation. Our Facebook page following grew to 720 from 600 in 2019; we posted 79 posts, a mix of event advertisements, sharing of partner messages, and information on HWA and HWA activities. Our Instagram had similar activity to our Facebook page; we ended 2020 with 587 followers, up from 424 in 2019.
Acknowledgements

Special Thanks To

The New York State Department of Environmental Conservation, Invasive Species Coordination Unit for their support, guidance, and partnership.

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

Dr. Marc Goebel of Cornell University for his collaboration on hemlock research.

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Steve Kinne for his tireless work coordinating the Central New York HWA Survey Team, a group of 30 volunteers responsible for many new HWA data points and coalition building work in central NY.

Dana Hall for his leadership and hard work conducting outreach, survey, and management planning in the Owasco Lake Watershed.

The administrative staff of the Department of Natural Resources at Cornell University for their technical, administrative, and fiscal expertise.