NCDA&CS Plant Industry Division Annual Report 2023

Steve Troxler
Commissioner of Agriculture

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NORTH CAROLINA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES

Steve Troxler
Commissioner of Agriculture
Chairman, Board of Agriculture

Mission Statement

The mission of the North Carolina Department of Agriculture and Consumer Services is to provide services that promote and improve agriculture, agribusiness, and forests; protect consumers and businesses; and conserve farmland and natural resources for the prosperity of all North Carolinians.

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Plant Industry Division

Plant Industry Division Web Site: www.ncagr.gov/divisions/plant-industry

Facilities

Plant Industry Division-Administrative Offices and NC Seed Laboratory

Physical Address: 216 West Jones Street, Raleigh, NC 27603

Support Operations

Physical Address: 1013 Blair Drive, Raleigh, NC 27603

Biological Control Services

Physical Address: 350 East Chatham Street, Cary, NC 27511

Witchweed Program Facilities

Physical Address: 450 Smith Circle, Room 108, Elizabethtown, NC 28337

Physical Address: Agri-Expo Center, 301 Mountain Dr., Rm 204, Fayetteville, NC 28306

Physical Address: OP Owens Agri. Center, 405 Country Club Dr., Lumberton, NC 28358

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Apiary Inspection Program

Prepared by D. Hopkins & G. Hackney

The Apiary Inspection Team is currently fully staffed, with six inspectors stationed throughout the state and one laboratory technician located at the Beneficial Insects lab in Cary. Our newest inspector, Mr. Anton Joubert, joined our team in January 2024. He covers a fifteen-county region between the piedmont and the mountains and replaces Bridget Gross who left her role in March 2023. The apiary staff continues to maintain outreach booths at both the Mountain State fair in Fletcher and the NC State Fair in Raleigh as well as participating in other outreach events throughout the year.

To protect the health of our honey bee industry, Plant Industry Division requires permits for anyone wishing to sell queens, package bees, nucleus colonies (nucs), or hives. In 2023, the apiary team issued 166 permits. To obtain a permit, bees must be inspected, and the producers are required to comply with standards designed to maintain healthy colonies. Apiary Inspectors strongly encourage beekeepers to buy only from permitted dealers to avoid buying unhealthy or Africanized honey bees. The list of currently permitted beekeepers is found here: https://www.ncagr.gov/plant-industry/permit-sell-list/download?attachment

One of the most devastating and difficult to control bee diseases is American foulbrood (AFB). In 2023, NCDA&CS Apiary Inspectors inspected over 6,000 colonies, of which none were found to be positive for American foulbrood.

The mite Varroa destructor persists as a major threat to the beekeeping industry and is probably a contributing factor to general poor health and mortality of bee colonies. Several new miticides have been registered; however, the mites have developed resistance to some of these materials which can reduce efficacy of these products over time. Currently, the list of registered products for Varroa control in North Carolina includes Apistan®, Check-Mite+®, Api-Life Var®, Apiguard®, Mite-Away Quick Strips®, Formic Pro®, Apivar®, Api-Bioxal®, and HopGuard®. All of the aforementioned products are listed in North Carolina as Section 3 general use pesticides. Although chemical treatment of mites may be necessary, some miticides have been demonstrated to have adverse effects on bees. The growing use of unregistered materials may have negative impacts on honey bee health and may not be efficacious in controlling mites. This and, in some cases, the improper use of antibiotics to control diseases can further complicate useful treatment regimes. In order to reduce the improper use of antibiotics, NCDA&CS Apiary staff coordinated with the Veterinary Consortium to facilitate further education of veterinarians in honey bee disease diagnostics by hosting an apiary pest and disease training session in the Apiary Analytics Lab in the fall of 2023.

Beekeepers are expressing concern about pesticides, particularly neonicotinoids, but the evidence of pesticide misuse has not been commensurate with the concern. Bee yards can be registered through the Plant Industry Division, for notification of intended aerial application of pesticides, so that the beekeepers can take steps to protect their colonies. The NCDA&CS Apiary Laboratory technician sends the list of registered apiaries to aerial applicators licensed in North Carolina. Additionally, the North Carolina Apiary Inspectors have developed a good working relationship with the Structural Pest Control and Pesticides Division (SPCP). The SPCP responds to reports of acute bee losses and follows up according to the evidence. If a pesticide problem is suspected, timely reporting to an Apiary Inspector or the Pesticide Section is crucial for a meaningful investigation and successful resolution. The SPCP and Plant Industry Divisions are working with EPA to develop a Managed Pollinator Protection Plan.

A continuing threat facing the beekeeping industry of North Carolina is the Africanized honey bee (AHB) (Apis mellifera scutellata), which is established in southern Florida and has been found at least once in Georgia. NC-DA&CS Apiary Inspectors maintain swarm traps at the ports of Wilmington and Morehead City, to intercept any bees coming in via ship. The apiary team continues to engage in an outreach program to NC emergency response personnel to familiarize them with the potential threat of AHB. Apiary inspectors continue to collect samples of bees (particularly those from colonies with overly defensive behavior) to determine their geographic origin and their propensity for this behavior. The NCDA&CS and NCSU are collaborating in conducting this survey. At this time, none of the samples collected have been determined to be AHB. Apiary inspectors encourage beekeepers and the public to notify our staff when any colonies seem to be displaying any unusual behavior, especially excessive defensiveness. NCDA&CS – Plant Industry Division strives to maintain a beekeeping industry in North Carolina that is not threatened by this more defensive type of bee.

The yellow-legged hornet (Vespa velutina) is a new apiary threat to the southeast. Yellow-legged hornet was first discovered in Georgia, in August of 2023 and has now been found in South Carolina. The NCDA& CS apiary team developed educational identification cards for distribution that compare regulated hornet species with native or widely established look-alikes. Both the yellow legged hornet and the northern giant hornet (Vespa mandarinia) were highlighted at presentations given to bee associations during winter 2023. Beekeepers and the public have been asked to notify apiary staff of any suspected sightings of these regulated insects.

Honey bee viruses remain a growing concern among beekeepers. Currently, Plant Industry Division does not have the capacity to provide a diagnostics service for viruses; however, we continue to foster a good working relationship with our partners at the NC State University Apiculture Research and Extension Program. The Plant Industry Division Beneficial Insects Lab plans to expand capabilities to perform some of the molecular diagnostics in the near future. Apiary staff have had the opportunity to assist NC State University with some of their projects and would like to express our gratitude for their assistance in much of our work.

North Carolina Apiary Inspectors participated in the USDA National Survey of Honey Bee Pests and Diseases, during 2022–2023. The primary purpose of the survey is to protect from the possible incursion of the exotic mite, Tropilaelaps, which is a great potential threat. This work involved the cooperation of 23 apiaries throughout the State.

Biological Control Program – Section 2

Program Overview

The NCDA&CS Biological Control Program operates the Beneficial Insects Laboratory (BIL) and implements and maintains biological control projects that benefit the residents and environment of North Carolina. Biological control is the use of natural enemies to help regulate pest populations. The NCDA&CS Biological Control Program focuses on the implementation of classical biological control against invasive pest species, where the natural enemies and invasive pest are from the same region of origin (i.e., they have a coadapted ecological association) and their life cycles are synchronous with one another. Currently, we have projects that focus on managing the invasive insect species hemlock woolly adelgid and spotted wing drosophila, as well as invasive knotweeds. We have also initiated a project supporting U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) biological control efforts for spotted lanternfly.

The staff of the BIL have made significant contributions to advancing the Biological Control Program during 2023. Dr. Nancy Oderkirk, Research Specialist, leads the knotweed biological control project, as well as serving as Quarantine Officer. Martha Flanagan, Research Specialist, leads the spotted wing drosophila biological control project and assists in management of the Quarantine Facility. Both Specialists also have provided valuable input to the hemlock woolly adelgid, spotted lanternfly, and other projects and activities. Jackie Fredieu, Entomology Program Specialist, provided vital assistance with the hemlock woolly adelgid project. The BIL employed five Temporary Research Assistants during 2023. Zoe Chavis, Charles Dial, Chandler Purser, Rose Riggs, and Abby Vickery contributed to the work being conducted on all projects and activities at the BIL.

Biological Control of Hemlock Woolly Adelgid

Biological control programs focused on hemlock woolly adelgid, Adelges tsugae (Hemiptera: Adelgidae) (HWA) to this point have resulted in the mass rearing and release of natural enemies of HWA in the genus Laricobius (Coleoptera: Derodontidae) (Fig. 2.1A) and Sasajiscymnus tsugae (Coleoptera: Coccinellidae) (Fig. 2.1B). Despite the establishment of these predators on HWA, certain aspects of the biological control program could be strengthened. Laricobius species can be labor-intensive to rear, and mortality of the colony over the summer months remains a problem rearing facilities must contend with annually.

Figure 2.1. *Predators of hemlock woolly adelgid: A) Laricobius osakensis, B) Sasajiscymnus tsugae, C) Leucotaraxis sp.*

Additionally, while S. tsugae were released to feed on HWA after Laricobius begin their dormant period during the summer months, little is known of their establishment and impact at release sites. Surveys to document establishment of S. tsugae would provide a means to assess their impact on HWA populations. To provide additional predation on the summer (progrediens) generation of HWA, predatory flies in the genus Leucotaraxis (formerly Leucopis) (Diptera: Chamaemyiidae) have been released but not recovered in the field (Fig. 2.1C). This lack of recovery could be due to flies dispersing following release and not being able to find a mate. The use of whole-tree cages to contain these flies on infested trees following release may yield insight to the factors important to their establishment in the southern Appalachians.

A program was initiated with the overall goal to enhance current biological control measures targeting HWA. The major objectives of this program are: 1) to assess the effectiveness of egg releases as a viable method to establish Laricobius spp. in release sites, 2) to utilize whole-tree cages to determine the ability of silver flies (Leucotaraxis spp.) to establish on hemlock species infested with HWA in the southern Appalachians, 3) to survey for establishment of S. tsugae at historical release sites, and 4) to enhance access to predators of HWA for State and other cooperators. While individual studies have demonstrated Laricobius spp. can establish in an area from egg releases, we are refining protocols and evaluating establishment of Laricobius spp. in release sites by conducting post-release monitoring. Establishing silver flies in North Carolina would enhance the biological control of HWA, as Leucotaraxis spp. would prey on the second generation of HWA in the spring, thereby further reducing the overall levels of HWA on hemlock trees. Documenting S. tsugae at historical release sites would demonstrate long-term establishment and would guide efforts to document the impact of these beetles on HWA in the field. Enhancing access and availability of predators of HWA would improve biological control efforts targeting HWA.

Investigating Novel Methods to Release Laricobius spp. on Eastern Hemlock

For this study, L. osakensis is the primary beetle species on which efforts are focused (Fig. 2.1A). This Laricobius species is from the same region of origin in Japan as the HWA that infests hemlock in the eastern U.S., and L. osakensis has been released in the U.S. for several years. We used existing populations, as well as lab-reared beetles to obtain eggs for this study during the winters of 2022-2023 and 2023-2024.Through cooperation with staff of USDA Forest Service, NCDACS Forest Service, and the Hemlock Restoration Initiative, adult L. osakensis were collected at several sites in western North Carolina. Additional beetles were obtained from cooperators at the Lindsay Young Beneficial Insects Laboratory, University of Tennessee. To obtain eggs for the egg release study, adult L. osakensis were placed in 1-gallon containers (ca. 10 males and 10 females per container) with bouquets of HWA-infested hemlock and monitored for egg production. As eggs of L. osakensis were produced, they were counted, and twigs with similar numbers of eggs were grouped into containers to take to the field; eggs were taken to the field and placed on trees within six days of oviposition. During each year of this study 900 eggs of L. osakensis were produced in the laboratory and placed on study trees.

In cooperation with private landowners, a site in McDowell County, NC was used in 2022-2023, and a site in Cherokee County, NC was used in 2023-24. To initiate the egg-release phase of this study, in January HWA densities on 15 study trees at each site were determined by counting the number of HWA woolly masses on the apical 20 cm of four branches per tree. Beat-sheet sampling was conducted on these trees (four samples per tree), to determine the presence or absence of Laricobius nigrinus. Treatments for this study consisted of three densities of L. osakensis eggs (50 eggs/tree, 100 eggs/tree, 150 eggs/tree), and three trees per treatment level and control treatment (no eggs) were assigned. Eggs of L. osakensis were deployed on study trees in February and March by attaching twigs from the Lab with L. osakensis eggs onto study tree foliage with pipe cleaners (Fig. 2.2A). After all study trees received the assigned egg densities, no other activity was conducted at the site until the following September. This period of inactivity allowed the beetles to develop and aestivate with minimal disruption.

Figure 2.2. *Laricobius egg release study: A) hemlock branch with L. osakensis egg-laden twigs attached with pipe cleaners, B) soil emergence cages under egg release canopies.*

To initiate the collection phase of this study, the September following egg placement on trees, soil emergence traps were deployed underneath the canopies of study trees at the study sites. Larvae of Laricobius species drop to the soil and spend the summer months completing development in the soil underneath hemlock canopies; adults emerge from soil and move into hemlock canopies in the fall. Under each of the 12 study trees, three soil emergence traps (BugDorm, 60cm x 60cm x 60cm, 150 x 150 mesh) were placed under branches where eggs of L. osakensis had been deployed the previous February and March (Fig. 2.2B). Bouquets of hemlock were constructed, and one bouquet was placed in each of the 36 cages. Beat-sheet sampling was conducted on all study trees to determine if any Laricobius beetles had yet emerged. Cages then were monitored weekly through the following February. Beetle specimens collected in emergence cages and beat-sheet samples were sent to Dr. Nathan Havill, USDA Forest Service, for identification by molecular analysis.

During the 2021-2022 emergence, the first adult Laricobius were observed in cages on 20 October 2022, and the emergence period continued to February 2023 (Fig. 2.3). Based on molecular species identifications, in addition to recoveries of some of the L. osakensis released in February and March 2022, two other Larcobius species, L. nigrinus and L. rubidus, were recovered. Both species can be readily collected from hemlock infested with HWA, and the trees at this McDowell County study site seem to have established populations of each. In fact, more individuals of both L. nigrinus and L. rubidus were collected compared to L. osakensis. Nonetheless, L. osakensis was able to establish in the presence of these other two predatory species, indicating that L. osakensis may be released to supplement populations of L. nigrinus. It is unclear if one species may displace the other over time. Long-term monitoring of sites where both species are present may elucidate their interactions.

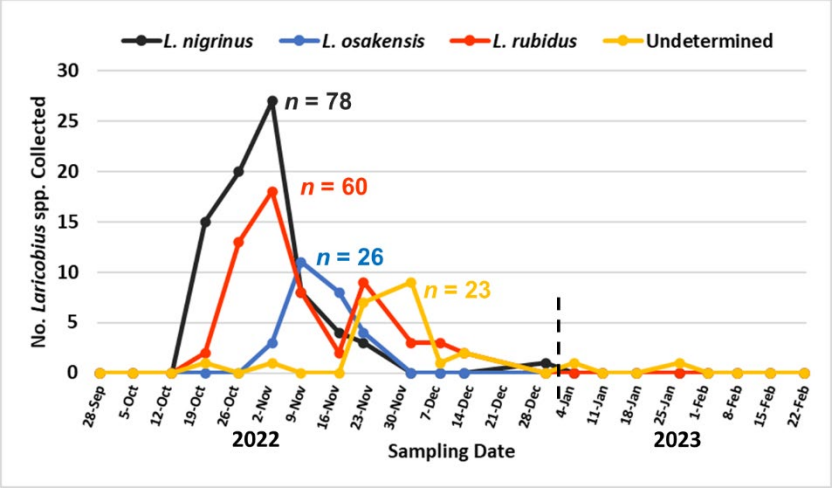


Figure 2.3. *Laricobius species collected each sampling week, egg release study, 2022-2023.*

The 2023-2024 emergence period in Cherokee County was not as successful as that observed the previous season. Only six Laricobius beetles were collected in emergence traps from October 28-November 20, 2023. This low emergence may be due to detrimental climate conditions experienced in Cherokee County during our study period. From December 23-26, 2022, Cherokee County experienced a period of frigid temperatures, where low temperatures were down to 4°F and high temperatures did not exceed 29°F. These temperatures may have caused HWA populations to experience some mortality, consequently reducing the amount of HWA for L. osakensis to feed upon. Compounding this event, Cherokee County experienced drought conditions ranging from 'Abnormally Dry' beginning October 5, 2023, to 'Extreme Drought' November 14-December 5, 2023. These dates correspond to the season of year when Laricobius species are emerging from the soil and returning to hemlock tree canopies, and hot, dry conditions may detrimentally impact soil conditions and hinder the ability of Laricobius to emerge effectively. Due to the results of this round of the emergence study, another round of the study is planned for the winter of 2024-2025.

Investigating Novel Methods to Establish Silver Flies (Leucotaraxis spp.) in the Southern Appalachians

Although Leucotaraxis spp. have been released in several locations throughout the eastern U.S., recoveries have been sporadic. To help limit dispersal, the use of whole-tree cages (Fig. 2.4) was investigated as a method to contain these flies on trees while allowing free range of movement within the tree canopy.

A hemlock nursery in Bent Creek Experimental Forest, Buncombe County, NC was selected as the site for this study. Fifteen trees were then selected for use as study trees based on HWA infestation, and infestation levels were assessed by counting woolly masses on new growth on the apical 30-cm of four branches of trees within the site. Laricobius osakensis was released previously at this site, and adults were collected during tree assessments. Prior to the initiation of the study, some trees were removed from the vicinity of the study trees to make room for the installation of the whole-tree cages.

The whole-tree cages used for this study are constructed of anti-insect UV-resistant mesh, measure about 8 m high and 6 m basal diameter and are supported by a central pole attached to the bole of the tree. A zipper runs the height of the cage allowing it to envelop and enclose a tree. Cages were deployed in the field September 2022 by NCDACS and USDA Forest Service staff (Fig. 2.4C).

Figure 2.4. *Whole-tree cage study site: A) caged tree next to uncaged control tree, B) hemlock with cage floor installed around tree base, C) NCDA&CS Plant Industry staff after completion of cage installation at study site (left to right-Bill Foote, Charles Dial, Chandler Purser, Martha Flanagan, Greg Wiggins), September 2022.*

Study trees were assigned treatments, and each treatment had three replicates. An uncaged control treatment accounts for the ambient conditions of trees and HWA in the site. A caged control-no predator treatment allows comparisons between new growth and HWA numbers on trees without predators and other treatments. A caged control-L. osakensis treatment allows ambient numbers of L. osakensis to emerge within the cage and accounts for any cage effects that may influence other treatments. A treatment with Leucotaraxis released in cages with L. osakensis excluded allows establishment of these flies without competition from L. osakensis. A treatment with both Leucotaraxis and L. osakensis provides information on establishment of Leucotaraxis on trees where L. osakensis also occurs.

To fulfill the treatment requirements for the study, a total of 50 adult Laricobius spp. were released in six study cages, with 20 per cage released on December 8, 2022, 15 per cage released January 5, 2023, and 10 per cage released January 25, 2023.

In late December 23-26, 2022, night-time temperatures reached as low as 0°F. To assess potential mortality of HWA due to low temperatures samples of branchlets from the 12 caged trees were clipped and taken to the USDA Forest Service Southern Research Station laboratory on 21 February 2023. HWA were assessed as live or dead, and an average of 18% survival was observed in the samples. Despite low surviving HWA numbers, releases of Leucotaraxis argenticollis were conducted as scheduled. The alternative would have been to wait another season for HWA numbers to rebound.

Beginning February 2023, L. argenticollis obtained from Dr. Mark Whitmore, Cornell University, NY, were released in six study cages according to treatment assignment. On February 23, 2023, about 32-33 flies per cage were released, and on March 21, 2023 about 21-24 flies per cage were released. A two-week post-release assessment visually examining hemlock foliage under the microscope found two L. argenticollis larvae.

To facilitate detection of predators in addition to conventional foliage sampling, prior to releases of L. argenticollis in cages, sampling for predator DNA residues in the environment (eDNA) was incorporated into this study. On February 14, 2023, 45 branchlets were collected according to a prescribed protocol, and samples were shipped to Tonya Bittner, Cornell University, for analysis using qPCR. Results yielded no detections of Leucotaraxis and several detections of Laricobius. A second round of eDNA sampling on May 17, 2023, detected neither Leucotaraxis nor Laricobius. This lack of detection may be due to Laricobius larvae having dropped from trees by this date, leaving scant DNA residues on the tree. Additionally, Leucotaraxis may be in puparia during this timeframe, further reducing the likelihood of detection. Additional eDNA samples will be collected during the course of this study.

Evaluating establishment of S. tsugae at historical release sites in North Carolina

In 2002, the BIL initiated rearing and releasing the lady beetle Sasajiscymnus tsugae (Coleoptera: Coccinellidae) (Fig. 2.1B), a predator of HWA. At the conclusion of this rearing and release program in 2016, over 640,000 S. tsugae beetles had been reared by the BIL. However, despite S. tsugae having been released in over 170 locations in North Carolina, little was known of their establishment and persistence at release sites.

To assess the establishment of S. tsugae at historical release sites, a survey effort focusing on recovery of S. tsugae was initiated in 2022. Release locations of S. tsugae were obtained from the Hemlock Woolly Adelgid Predator Database maintained by Virginia Tech, and 172 release sites S. tsugae were recorded in North Carolina. Surveys were conducted in 2022 and 2023. A total of 24 release S. tsugae sites were surveyed from May 24 – July 7, 2022, and 72 release sites were surveyed from April 4 – June 16, 2023 (Fig. 2.5). At each site beat-sheet sampling was conducted on hemlock infested with HWA with a uniform sampling time of 1-2 hours. Collected beetles were visually identified as S. tsugae.

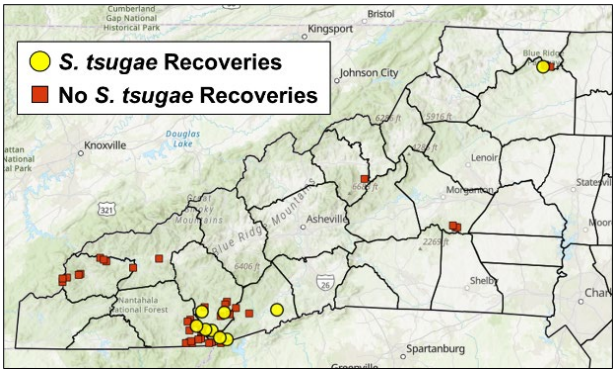


Figure 2.5. *Historic release sites surveyed, and S. tsugae recovered, 2022-2023.*

Adult S. tsugae were found in five of the 24 release sites surveyed in 2022 and in six of the sites surveyed in 2023 (Fig. 2.5). At the locations where beetles were collected, releases of S. tsugae had last been made between 2004 and 2009, so these populations have been established in these areas for several years. This finding is significant, as S. tsugae feeds on the eggs of the second summer generation (progrediens) of HWA, on which Laricobius species do not often feed. This survey effort will continue in 2024.

Enhancing Access to Predators of Hemlock Woolly Adelgid

To maintain strong predator populations in North Carolina, the BIL has initiated both laboratory- and field-based efforts to enhance access to Laricobius species. We are currently maintaining a colony of L. osakensis in laboratory conditions to supply beetles for studies and limited release. In Spring 2023, over 1,200 Laricobius larvae were produced in the BIL from adults collected in the field in Fall 2022. These larvae were placed in soil containers and maintained in growth chambers (set between 66 and 72°F) over the summer months as they completed their development and aestivated until Fall (Fig. 2.6A). Adult beetles began emerging from soil cups on October 6, 2023, and over 500 adult beetles emerged. Adult L. osakensis were placed in rearing containers, and the resulting eggs and larvae will be used to maintain and grow the colony.

Figure 2.6. *A) Soil cups containing developing L. osakensis, B) hemlock insectary area, Rendezvous Mountain.*

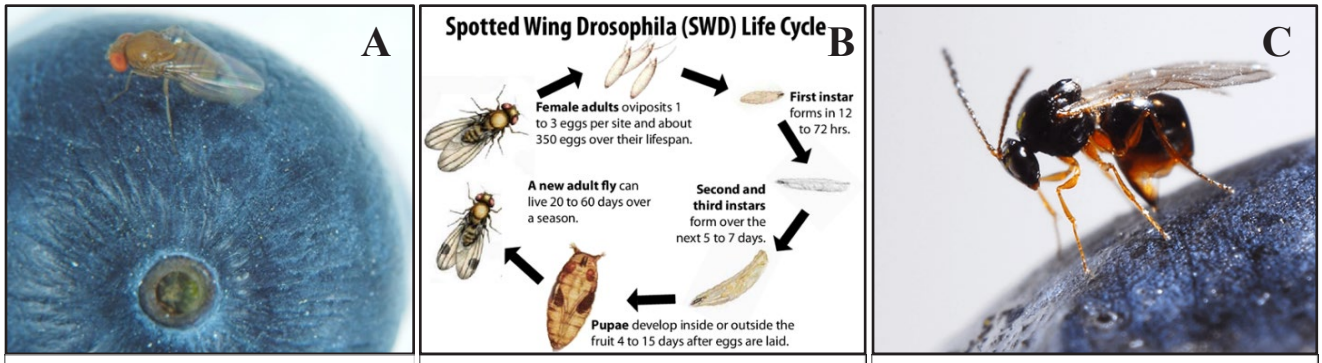
To further enhance access to Laricobius beetles, a field insectary was initiated in Fall 2023. Cooperators at the North Carolina Forest Service identified areas in Rendezvous Mountain Game Land (Wilkes County) where eastern hemlock could be planted in a natural setting and eventually be used to grow and collect Laricobius beetles. On December 19, 2023, BIL staff assisted North Carolina Forest Service staff and B.R.I.D.G.E. (Building, Rehabilitating, Instructing, Developing, Growing, Employing) Program crews in planting over 150 eastern hemlock seedlings in two existing canopy gaps (Fig. 2.6B). These trees will be monitored for growth and HWA population levels before L. osakensis will be released to produce predators in a field setting.

Biological Control Initiative for Spotted Wing Drosophila in North Carolina

Invasive spotted wing drosophila Drosophila suzukii, (Diptera: Drosophilidae), a small vinegar fly with the potential to damage many fruit crops, especially thin-skinned fruit, is native to eastern Asia. Most species of vinegar flies attack overripe or damaged fruit, lessening the impact on growers/sellers. However, spotted wing drosophila (SWD) is unique as the female can lay eggs in healthy fruit using a large, serrated ovipositor with two rows of teeth (Fig. 2.7A). Once the eggs hatch and the larvae (maggots) move around inside eating, the fruit becomes soft and unmarketable. Detection of a single SWD larva in the fruit can cause the rejection of an entire shipment, leading to high financial risk for farmers of impacted crops.

While known to be in Hawaii since the 1980s, SWD was first detected in the continental United States when an infestation was reported in California in 2008. Found in NC in the late summer of 2010, SWD have spread throughout most the US since that time.

SWD control presents multiple challenges. SWD is polyphagous, meaning it feeds on many different hosts, all soft skinned fruits. These include blackberries, blueberries, raspberries, strawberries, cherries, and grapes among others. Chemical control (insecticides) can be ineffective, only targeting adults, as the chemicals won't reach the eggs and larvae already inside the fruit. Depending on temperature, SWD can complete all four life stages in under 14 days (Fig. 2.7B) and an adult female can lay over 300 eggs in her lifetime. As is often the case with invasive species, part of their success is due to the lack of natural enemies. Because of the ability of SWD to encapsulate and kill the eggs of native parasitoid wasps, research has focused on identifying non-native parasitoids successful in controlling this species.



https://secure.caes.uga.edu/news/multimedia/images/2929/swdforweb.jpg

Illustration courtesy of Oregon State University

Photo by Kent Daane: https://newswire.caes.uga.edu/story/9002/swd-biocontrol.html

Figure 2.7. *A) Drosophila suzukii laying an egg in a blueberry, B) D. suzukii life cycle, C) Ganaspis brasiliensis parasitizing an SWD larva.*

In 2021 Ganaspis brasiliensis (Hymenoptera: Figitidae) (Fig. 2.7C), an Asian parasitoid wasp, was approved for release and further testing by the USDA, as initial research determined it to be an effective and host-specific biological control agent for SWD. G. brasiliensis is a solitary larval parasitoid of SWD found in overlapping ranges in east Asia. The adult female wasp inserts her ovipositor and lays her eggs into SWD larvae within the fruit. The G. brasiliensis egg hatches inside the SWD larva and over time consumes the host as it progresses through its larval, prepupal, and pupal stages. Eventually a single adult wasp emerges from the host puparium.

The NCDA&CS Biological Control Program at the BIL in cooperation with other state and federal agencies, continues to develop and assess a biocontrol strategy for invasive SWD in our state. In our second year (first full season) of the project, we performed standardized releases and intensively monitored release sites to determine establishment, seasonal phenology, and parasitism levels in both crop and non-crop habitats. Building upon our previous efforts, we also continued to refine rearing practices that produce consistent numbers of parasitoids to increase numbers for release. Our primary objectives this year were to 1) Continue to grow a lab-reared colony of G. brasiliensis, refining methodology to increase production, 2) after pre-release sampling, release G. brasiliensis at locations used for releases in 2022, and perform post-release sampling to determine establishment, and 3) perform comparative studies on the effect of temperature on the rate of parasitoid development, the impact of exposure time of G. brasiliensis to fruit infested with SWD on parasitoid reproduction, and the impact of diapause on the overall production of parasitoids

Growing Our Lab Reared Colony of Ganaspis brasiliensis

In fulfillment of the first objective, a colony of G. brasiliensis has been successfully established and continually maintained in 2023. We used blueberries infested with SWD (Fig. 2.8A) as the host material and media for rearing G. brasiliensis. Colonies of SWD and parasitoids are stable and can be manipulated when needed to produce parasitoids (Fig. 2.8B and C) for field releases and studies. Over 25,000 G. brasiliensis were reared in 2023 at the Beneficial Insects Lab, and over 5,300 G. brasiliensis were released during the 2023 season.

Figure 2.8. *A) Blueberries infested with SWD used for G. brasiliensis rearing, B) vial of G. brasiliensis aspirated from blueberry cups, C) environmental chamber with G. brasiliensis vials.*

To accomplish our second objective, we met with Hannah Levenson, North Carolina State University, regarding release sites and activities for Spring and Summer 2023. We continued to release at the three locations initially arranged in 2022 through consultation with Dr. Levenson and her cooperator, Hannah Burrack, Michigan State University. These three release sites are located at the following NC State University-NCDA&CS Research Stations (RS): Mountain Horticultural Crops RS (Henderson County), Piedmont RS (Rowan County), and Sandhills RS (Montgomery County). Both Dr. Levenson and Dr. Burrack had research plots or cooperators at these stations, and we continued to coordinate efforts with Station Directors to release in established release sites.

Performing for Field Releases

Pre-release sampling was initiated in May 2023. Wild and cultivated berries were sampled monthly and monitored for emergence of both SWD and parasitoids. To date, no G. brasiliensis has been recovered from either field-collected or trap fruit. However, another introduced but adventive parasitoid, Leptopilina japonica (Hymenoptera: Figitidae), has been recovered from all three Research Station sites. These findings may have implications for establishment of G. brasiliensis at these locations, as the interactions between L. japonica and G. brasiliensis at our sites are unclear.

To determine when to initiate parasitoid releases in 2023, populations of SWD were monitored by Dr. Levenson using liquid traps. Populations of SWD were deemed suitable and parasitoid releases began in July and continued through the end of August 2023 (Fig. 2.9A and B). Over 6700 parasitoids have been released to date (Table 2.1).

Table 2.1. Releases of *Ganaspis brasiliensis* in North Carolina, Summer 2022 and 2023.

SITE	COUNTY	Gb RELEASED 2022	Gb RELEASED 2023	TOTAL RELEASED
Sandhills Research Station	Montgomery	483	1,010	1,493
Piedmont Research Station	Rowan	486	2,155	2,641
Mtn Horticultural Crops Research Center	Henderson	451	2,150	2,601
Total to Date				6,735

Post-release monitoring was initiated following the final releases of G. brasiliensis, and closely followed the protocol from the previous year. In mid-September (approximately 12 days after the final releases), field fruit collections were performed at all three release locations. These collections included samples of any field fruit within 100 meters of the release points. This included both the crop berries and any wild berries in the vicinity. Berries were delivered to NC State University (Dr. Levenson's lab) for monitoring of any G. brasiliensis emergence.

Sentinel trapping with infested fruit was conducted approximately 30 and 60 days post release and started in late September at all three sites (Fig. 2.9C). On each date, sentinel traps baited with SWD infested blueberries were deployed at each site along the wood line. Additionally, a liquid trap with a scented lure was set up to attract adult flies. Field fruit from all three sites was again collected at the time of trap deployment and delivered to Dr. Levenson's lab for monitoring of any G. brasiliensis emergence. Fruit from the sentinel traps was retrieved 5-7 days later and returned to the lab for monitoring and identification of any parasitoid emergence.

Seven parasitoids emerged from field fruit incubated at the NCDACS BIL and have all been confirmed Leptopilina japonica. Fruit and liquid traps delivered to Dr. Levenson's lab for monitoring and analysis are still being identified, but as of this writing, no G. brasiliensis has been recovered.

Figure 2.9. *A) SWD on blackberry at research station, B) G. brasiliensis searching pokeweed for SWD larvae, C) post-release sentinel traps.*

For comprehensive coverage of all four ecoregions in North Carolina (Fig. 2.10), we identified and secured a new release site in Coastal Plains ecoregion and plan to conduct releases of G. brasiliensis there in 2024. This site, Horticultural Crops Research Station in Castle Hayne, is a research station specializing in blueberry research just outside of Wilmington, NC. We performed some site sampling over the summer and deployed "post-release" traps routinely at the same time as our other release sites in order to assess the presence of existing parasitoids. To date, no parasitoids have been recovered from samples at this site. This site will be included in G. brasiliensis releases in the upcoming field season.

Figure 2.10. *Ganaspis brasiliensis release sites, 2022-2024.*

Comparative Rearing Studies

To determine the effect of temperature on the rate of parasitoid development, three growth chambers were set at 21°C, 23° C, and 25°C. Additionally, we reared some cohorts of parasitoids at ambient room conditions (20-26°C). Development time was determined by the time between introduction of adult ovipositing parasitoids into rearing cups to when the next generation of adult parasitoids began to emerge/eclose from those cups. The shortest parasitoid development time was observed at 25°C (23 days) cohorts, compared to 25 days at 23°C, 27 days at 21°C, and 24 days at room temperatures. The greatest average number of G. brasiliensis per rearing cup were produced at 23°C (65.49 parasitoids/cup), compared to the other temperatures (52.02 parasitoids/cup at room temperatures, 36.98 parasitoids/cup at 21°C, 45.55 parasitoids/cup at 25°C).

To determine the impact of exposure time of G. brasiliensis, cohorts of berries infested with first-instar SWD were exposed to G. brasiliensis for five, six, and seven days. Parasitoids with an exposure time of seven days saw the greatest average number of G. brasiliensis emerge (55.1 parasitoids/cup), compared to exposure times of five (44.3 parasitoids/cup) and six (34.5 parasitoids/cup) days.

We also investigated temperature-related diapause on production of G. brasiliensis. Based on protocols from other cooperators, groups of wasps were held at 15°C for 4-6 months, then placed in warmer conditions and monitored for emergence. This long-term exposure to cooler temperatures was detrimental to wasp production, with only 7-8 wasps per rearing container emerging. Further work is necessary to determine favorable diapause conditions and their impact on production of G. brasiliensis.

Biological Control Assessment for Invasive Knotweeds in North Carolina

The NCDACS Biological Control Program at the BIL continues to develop and assess a biocontrol strategy for invasive knotweeds in our state. Knotweeds within the Fallopia (syn. Reynoutria) species complex, native to East Asia, were once planted widely for their ornamental value and for erosion control. They have since escaped cultivation and have become invasive throughout their introduced range in Europe, Australia, New Zealand, Canada, and the United States. These plants can spread beyond control via underground rhizomes and incidental distribution of viable plant fragments, forming stands that outcompete native plants via aggressive growth and production of allelopathic chemicals. Their unwanted presence is particularly notable within fragile riparian

habitats and forest ecotones, along highway rights-of-way, and in areas under agricultural production. Additional harm occurs as winter dieback facilitates erosion that further disrupts aquatic ecosystems and can lead to highway pavement collapse. Knotweed control presents challenges due to limited access for mechanical control, accidental transport of plant fragments, the inadvisability of herbicide applications in the vicinity of croplands and aquatic habitats, and the long-term ineffectiveness of chemical controls that have been utilized in some less-restrictive settings. Thus, initiatives have been undertaken to establish biological control as an achievable and sustainable element of an integrated management plan.

Members of the BIL are collaborating in a North American effort to control this weed by introduction of a knotweed-specific "plant flea," the knotweed psyllid, Aphalara itadori (Hemiptera: Psyllidae). The sap-feeding behaviors of knotweed psyllids result in severe leaf-curling and production of an abundance of an exudate called lerp (Fig. ¬¬¬2.11). These host-feeding consequences lead to a reduction in photosynthetic capabilities, stunted growth, and eventual death of the plant. This insect was Federally approved for release in the United States in 2020. Since then, we have been working with two genetically distinct populations of the psyllid. The Hokkaido biotype, from Northern Japan, is specific to giant knotweed, Fallopia sachalinensis, while the Kyushu biotype, from Southern Japan, prefers Japanese knotweed, F. japonica, and the hybrid Bohemian knotweed, F. x bohemica. We have verified that knotweed psyllids can overwinter in North Carolina. Our current objectives are to determine whether these psyllids can establish populations in our state, and to compare effects on knotweeds in the field with those observed in lab settings.

We maintain psyllids in our lab on knotweeds propagated from field-collected rhizomes (Fig. 2.12A). In addition, psyllids are overwintered in tents within field cages (Fig. 2.12B) to assess and retain overwintering capability and phenotypic plasticity.

Figure 2.12. *Knotweed psyllid production; A) rearing cages in the lab, B) overwintering cage in the field.*

Psyllids have been distributed via three methods: Free release within a knotweed patch, containment on a sleeved knotweed branch, and introduction of psyllid-infested plants. This year, we also conducted field cage releases. Surveys were conducted two weeks post-release and periodically during the growing season, for a minimum of 30 minutes per survey. We recorded numbers of psyllids and plant damage observed. We have released psyllids in eleven counties thus far, within all four ecoregions of North Carolina (Fig. 2.13).

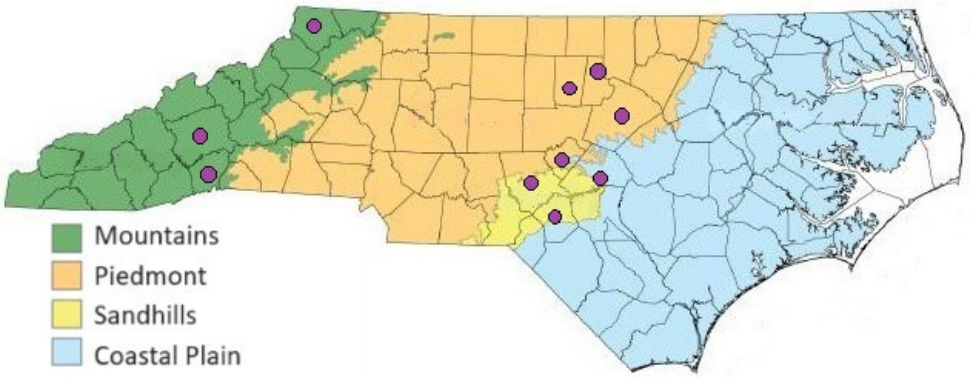


Figure 2.13. Knotweed psyllid release sites in North Carolina, 2020-2023.
Map modified from Vascular Plants of North Carolina website.

Over 63,000 psyllids have been released to date (Table 2.2). Our strategy is to release psyllids annually for three consecutive years at each viable site, and to survey annually during release years and for three additional post-release years.

We have recovered live psyllids from the overwintered field cages each year for three years, even following extended sub-freezing and near-record low temperatures for our region. We also discovered psyllids that had overwintered at one field site in 2022, where releases had been conducted the previous year. While we have confirmed that psyllids can survive winter here, we have yet to observe the stereotypical damaged plant phenology (leaf curl) observed in the lab and in the environments where these species naturally coexist. We suspect that this plant response would be rare in instances where herbivore pressure on individual plants is low due to a sparse psyllid population. To date, we have detected a post-release, concentrated psyllid population briefly at only one field site.

Table 2.2. North Carolina knotweed psyllid release sites, 2020-2023.

County	Knotweed species	# Released 2020	# Released 2021	# Released 2022	# Released 2023	Total Released
Ashe	Giant			1,200	5,500	6,700
Buncombe	Japanese				5,500	5,500
Durham	Japanese			1,200	5,500	6,700
Harnett	Bohemian			1,230	.	1,230
Henderson	Giant		1,914	2,400	5,500	9,814
Hoke	Bohemian	780	764			1,544
Lee	Japanese	835				835
Mecklenburg 1	Bohemian	800	764			1,564
Mecklenburg 2	Bohemian			2,600	5,500	8,100
Moore	Japanese			2,400	6,500	8,900
Orange	Japanese		2,675	1,200	5,500	9,375
Wake 1	Japanese	500				500
Wake 2	Japanese	500	1,219	1,200		2,919
	Total	**3,415**	**7,336**	**13,430**	**39,500**	**63,681**

Challenges to establishment and population growth could include predation by locally-existing natural enemies, site disturbances, climatic effects such as increasingly erratic weather events, and summer daylength. For example, we regularly find insect predators on the knotweeds, and predation by ants and predatory mites has been suspected or observed by some of our collaborators. Our sites have been disturbed by natural processes, including occasional flooding, and human activities, such as landscape maintenance. Climatically, degree-day models predict that overwintered psyllids should break winter diapause in this region in March, as host plants emerge. However, unseasonably late Spring frosts tend to kill the tender new plant growth, which is where psyllids prefer to lay their eggs. We suspect that temperature and drought stress might also limit development and survival of the psyllid during the heat of summer. In their indigenous range, these insects might not be subjected to the intensity of drought that sometimes occurs here. We also suspect that our maximum summer daylength, which is shorter than that of Northern Japan, might not be sufficient to elicit the most efficient reproductive capacity of the Hokkaido psyllids, which are adapted to sixteen-hour daylengths in midsummer.

To address some of these challenges, we established new field sites that have been less subject to site disturbance. We initiated a new release strategy, wherein patches of knotweeds are enclosed in field cages, in attempt to mitigate predation, disturbance, and climatic factors, while concentrating first-generation psyllids to prevent dispersal. In addition, we complemented our protocol with a late-season release using knotweed plants infested with psyllids. At each of seven release sites, 2-6 plants infested with egg, nymphal, and adult psyllids were placed among existing knotweed plants. Post-release monitoring for the 2023 late-season releases will be conducted in Spring 2024 to determine the effectiveness of this strategy.

In consideration of the imperfect climate match between extreme Northern or Southern Japan with sites in North America, researchers have sought and obtained a new strain of knotweed psyllid from central Japan. This new psyllid strain has since been tested and was recently approved for release in the United States. Central Japan has a climate and summer daylength more similar to what we experience here in North Carolina. We are optimistic about the potential of this new psyllid strain to complement the original strains, and to contribute toward a more tangible biocontrol element within an integrated knotweed control strategy in our region.

This work has been supported by the USDA and NCDACS Plant Industry Division. Psyllids have been supplied by Dr. Fritzi Grevstad, Oregon State University. We appreciate the cooperation of Raleigh Parks, Recreation, and Cultural Resources, Mecklenburg County Parks and Recreation, City of Charlotte, Charlotte-Mecklenburg Storm Water Services, Ellerbe Creek Watershed Association, Campbell University Cape Fear River Initiative, North Carolina Department of Transportation, Duke Energy, and private property owners. Our work has been presented at the NC-SC Invasive Pest Councils Joint Symposium and at the USDA Interagency Research Forum on Invasive Species.

Collecting Native Fulgoridae to Support Biological Control Testing for Spotted Lanternfly

Spotted lanternfly (SLF), Lycorma delicatula (Hemiptera: Fulgoridae), is an invasive species native to China and is a pest of many commercially and ecologically important tree species (Fig. 2.14). SLF is also an important pest of grapes in areas of establishment. It is currently found in 15 states and is projected to spread to several more. If it becomes widespread in the U.S., it is feared that SLF could negatively impact vineyards, orchards, and agricultural export. In June 2023, the BIL initiated a project to collect select native species, primarily in the family Fulgoridae, found in North Carolina to support host range testing efforts of USDA APHIS for SLF biological control.

Figure 2.14. *Spotted lanternfly adult (bugwood.org).*

Currently, USDA APHIS is conducting host range testing on the parasitoid wasp Dryinus sinicus (Hymenoptera: Dryinidae), which is from the same endemic range as SLF. If D. sinicus is to be approved for release against SLF in the U.S., extensive host testing is required to demonstrate it has little or no risk of impacting non-target native species. Adults of D. sinicus prefer to lay their eggs on the second instar nymphs of SLF, which measure 5.1 - 6.4 mm in length, so non-target species included in host range testing should have growth stages within this size range. All native species in the family Fulgoridae found in North Carolina have growth stages in this size range, and providing researchers with these native species for host range testing would be of great benefit.

The fulgorid species targeted for collection by the BIL are Amycle vernalis, Calyptoproctus marmoratus, Cyrpoptus belfragei, Cyrpoptus reineckei, and Poblicia fuliginosa (Fig. 2.15), as well as other select planthoppers. To survey for these fulgorid species, we obtained permission to utilize several natural areas where host plants were likely to occur as collection sites, including eight NCDACS Plant Conservation Preserves (PCP), two NCDACS Research Stations, and two State-managed forests. A variety of native grass species (in the genera Andropogon, Eragrostis, Muhlenbergia, Piptochaetium, Schizachyrium, and others) can serve as host plants for nymphs of A. vernalis, Cy. belfragei, and Cy. reineckei. Oak species, such as water oak (Quercus nigra), are suspected to be the main hosts of Ca. marmoratus, and winged sumac (Rhus copallinum) serves as the main host plant of P. fuliginosa. We consulted with Katherine Culatta, NCDA&CS Plant Conservation Program Botanist, to confirm the genera of potential host plant species at selected survey sites. Furthermore, we have planted select grass species and seedlings of water oak on the grounds of the BIL to serve as host plants for collected species until they can be shipped to APHIS cooperators for host range testing. We also have a colony of about 350 P. fuliginosa on winged sumac growing in field cages on the BIL grounds.

Figure 2.15. *Species of Fulgoridae recorded from North Carolina: A) Amycle vernalis, B) Calyptoproctus marmoratus, C) Cyrpoptus belfragei, D) Cyrpoptus reineckei, and E) Poblicia fuliginosa (all photos except P. fuliginosa obtained from bugguide.net).*

To survey for our target insect species during 2023, we utilized several sampling techniques, including sweep-net sampling, plant vacuuming, and light trapping, as well as visually examining plants for the presence of insects. We conducted sampling at all 12 sampling sites at least once, and we used at least two sampling techniques during each survey trip.

Because we have an existing field colony of P. fuliginosa, we did not conduct field collections for this species during 2023. Additionally, we provided about 200 nymphs and adults of P. fuliginosa from our field-caged colony to cooperators at the University of Delaware to supplement their colonies.

To date, no species in the family Fulgoridae have been collected in our 2023 surveys. Based on the collection records of previous researchers of fulgorids in South Carolina, we may have missed the period of time to collect late-instar nymphs and adults from plant sampling, and light trapping efforts may have been too infrequent.

However, we did collect late-instar nymphs and adults of two planthopper species of interest, Rhynchomitra microrhina and Scolops sulcipes (Hemiptera: Dictyopharidae) at multiple locations (Fig. 2.16). We held all live insects in cages with grasses collected from the field (Schizachyrium scoparium and a native Andropogon species). The nymphs molted to adults quickly, usually within two days of collection, but died quickly thereafter. No eggs were evident on the plants, and no nymphal emergence has been observed thus far. Plants continued to be monitored.

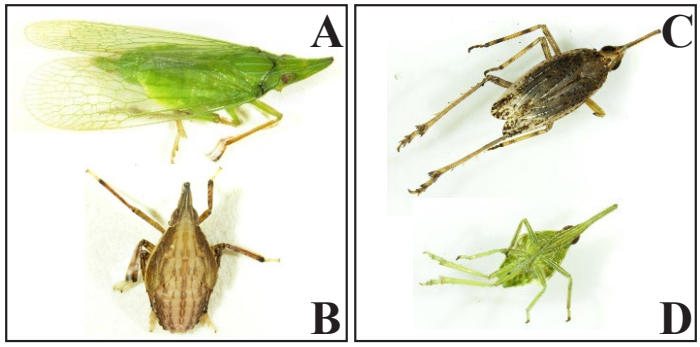


Figure 2.16. *Planthoppers of interest collected during 2023: Rhynchomitra microrhina A) Adult and B) late-instar nymph; Scolops sulcipes C) adult and D) late-instar nymph.*

These initial efforts have helped inform our target survey times and methods. We are continuing to survey for nymphs of A. vernalis, Cy. belfragei, and Cy. reineckei in grasses at field sites throughout the winter, and we plan to begin survey efforts for other species in early spring. With collection efforts during 2024 starting earlier in the season, we are more likely to find populations of our target fulgorid species. We are also expanding the number of survey sites for 2024, which should increase the likelihood of finding populations of target species. Additionally, we will prioritize shipping APHIS cooperators insects of interest as we collect them over attempts to initiate colonies, so that host range testing can be completed in a timely manner. The successful discovery and collection of these native insects will help determine the suitability of D. sinicus as a biological control of SLF.

Cooperative Agricultural Pest Survey (CAPS) Program-Section 3

Prepared by Amy Michael

The CAPS program is a national, early warning pest detection network, funded through a cooperative agreement with USDA-APHIS-PPQ for domestic surveillance of exotic plant pests. Such pests hold economic, agricultural and/or environmental importance to North Carolina (NC) and the U.S. and typically include plant pests that are not known to occur domestically. These surveys help safeguard our nation's agriculture and natural resources through early detection, especially for those pests that pass through front-line inspections at our ports of entry. Surveys also concentrate on pests of export significance which are of concern to our trading partners. The CAPS program follows guidelines to ensure that data, on a continuing basis, is scientifically valid, current and reliable. The state CAPS advisory committee helps drive and focus surveys for each state. Its core members include the State Plant Health Director (SPHD), State Plant Regulatory Official (SPRO), Pest Survey Specialist (PSS) and the State Survey Coordinator (SSC). Other members may be invited to provide guidance in their area of expertise. National and/or State level surveys concentrate on three main areas of importance; entomological, pathological or exotic weed species. Data collected from these surveys are entered into the National Agricultural Pest Information System (NAPIS).

The 2023 North Carolina CAPS program was successful in procuring funding for CAPS and PPA §7721 surveys for early detection of exotic plant pests. Nine independent surveys were conducted throughout the state, covering 59 counties. Surveys included; mollusk, forest pests, oak commodity, Asian defoliators, grape commodity, solanaceous commodity, a Phytophthora spp. survey, box tree moth, and spotted lanternfly. Additionally, the Invasive Species Outreach program continued to be administered by the CAPS Coordinator in 2023. Four seasonal plant pest aide positions were filled to conduct trapping throughout the state. One taxonomic specialist was hired to assist with dissection-based insect identification as required for some of our samples.

A total of thirty-seven different exotic plant pests were surveyed from March through late October. All surveys were completed following the 2023 CAPS guidelines, so that negative data were reportable. Several PPA 7721/ Farm Bill surveys also fall under the direction of the CAPS program. Grant applications are submitted annually to conduct survey work in solanaceous commodity (tomatoes, peppers, eggplants, etc.), Phytophthora spp. (important plant pathogens affecting nursery and natural areas), grape commodity, Asian defoliators (largely surveyed at ports of entry), box tree moth, and spotted lanternfly (early detection/ host mapping). Many of these surveys follow CAPS guidelines for how they are conducted. Survey priorities for 2023 were determined with help from the CAPS advisory committee and new survey proposals were submitted through CAPS and Farm Bill (PPA 7721). All grant proposals were funded for 2023 surveys, while proposals for the 2024 survey season were successfully submitted by early August 2023.

CAPS Surveys

Mollusk Survey

The mollusk survey was conducted as joint operation between NCDA&CS, USDA-APHIS-PPQ, and CBP at three locations within the Port of Wilmington (Figure 3.1), meeting our survey goal for the year. Eleven exotic taxa of mollusk were surveyed for: giant African snail (Lissachatina fulica), Chinese slug (Meghimatium pictum), Hygromiid snails (Cernuella spp. and Monacha spp.), Cochlicellid snails (Cochlicella spp.), and Leatherleaf slugs. (Veronicella spp., Belocaulus spp., Colosius spp., Laevicaulis spp., Sarasinula spp., and Semperula spp.). Survey locations within the port were selected by the CBP team, based on introduction, storage, and rail transport for imported containers, as well as favorable habitat/ likely establishment sites. No target pests for this survey were recovered.

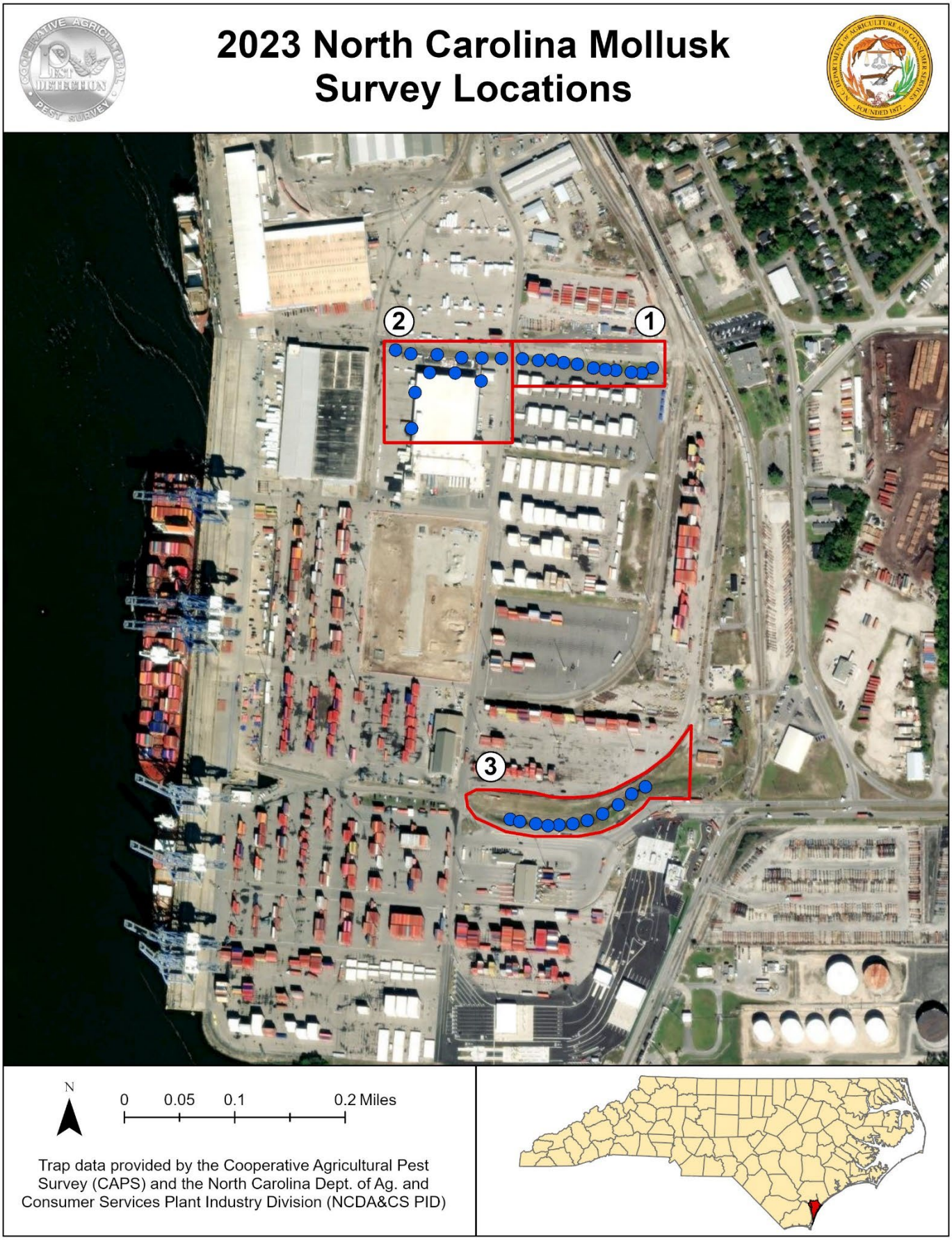


Figure 3.1, Map of Mollusk Survey sites, 2023

Oak Commodity Survey

North Carolina completed the 2023 oak commodity survey at 36 locations (Figure 3.2), surpassing the goal of 20. This survey included the following species: oak processionary moth (Thaumetopoea processionea, OPM) and oak ambrosia beetle (Platypus quercivorus, OAB). Oak processionary moth is a defoliating pest that can kill host trees through heavy feeding. The oak ambrosia beetle carries an additional threat in the form of the pathogen Japanese oak wilt (Raffaelea quercivora). Trapping for the insects included in this survey began in late March and ended by early November. Monthly visits were conducted at all locations for lure replacement, sticky card collection or trap replacement. Bi-weekly visits for the OAB multi-funnel trap were accomplished to limit the decomposition rate of beetle specimens so identification could be possible. Samples from the OAB traps were screened by the taxonomic specialist. No target pests for the Oak Commodity Survey were recovered.

Forest Pests Survey

The Forest Pest survey throughout the state concentrated on Asian Longhorned beetle (Anoplophora glabripennis; ALB) and Oak Splendor Beetle (Agrilus biguttatus; OSB). ALB is capable of infesting and killing healthy trees across 12 genera. The primary impact of this pest in infested areas of the US has been in maples (Acer spp.), which is the second-most abundant tree genus in North Carolina.

ALB surveys began in March and concluded in October. In total, 185 visual surveys for ALB were conducted at 99 sites (Figure 3.2). Twenty-one of the sites surveyed are shared with the Oak Survey, as the rest stops, campgrounds, and sawmills share the pathway risk of infested log introduction. Maple trees were surveyed at each of the 21 shared sites 3 times per year coinciding with key points in ALB phenology: once at the beginning of the survey season before maple trees have fully leafed out, once during predicted adult emergence (May-July), and once in the month prior to leaf fall to target stressed trees. The remaining 39 locations were visited only once as a response to suspicious damage noticed by the surveyor. No evidence of ALB infestation was observed.

OSB sampling had previously been conducted through native Cerceris wasp sampling in the state from 2016-2019. This sampling method is incredibly efficient, as the wasps bring buprestid beetles back to their burrows, and are easily separated from their prey by sweep-netting. CAPS personnel selected 4 baseball fields with high Cerceris populations in the eastern and central regions of the state for sampling (Figure 3.2). Over 30 specimens were recovered and screened. An additional 34 sites across eight western and central NC counties were scouted for Cerceris presence, but wasp burrow density was not sufficiently high to conduct OSB survey at any of these locations. Their populations may have been impacted by heavy rains in June. No OSB were recovered as a result of these surveys. However, we were contacted by a USDA Entomologist Identifier who was interested in screening our bycatch for new species and/or ranges for native buprestids. Two years worth of samples (over 100 beetles) were sent and we will be contacted if any species result in a new publication.

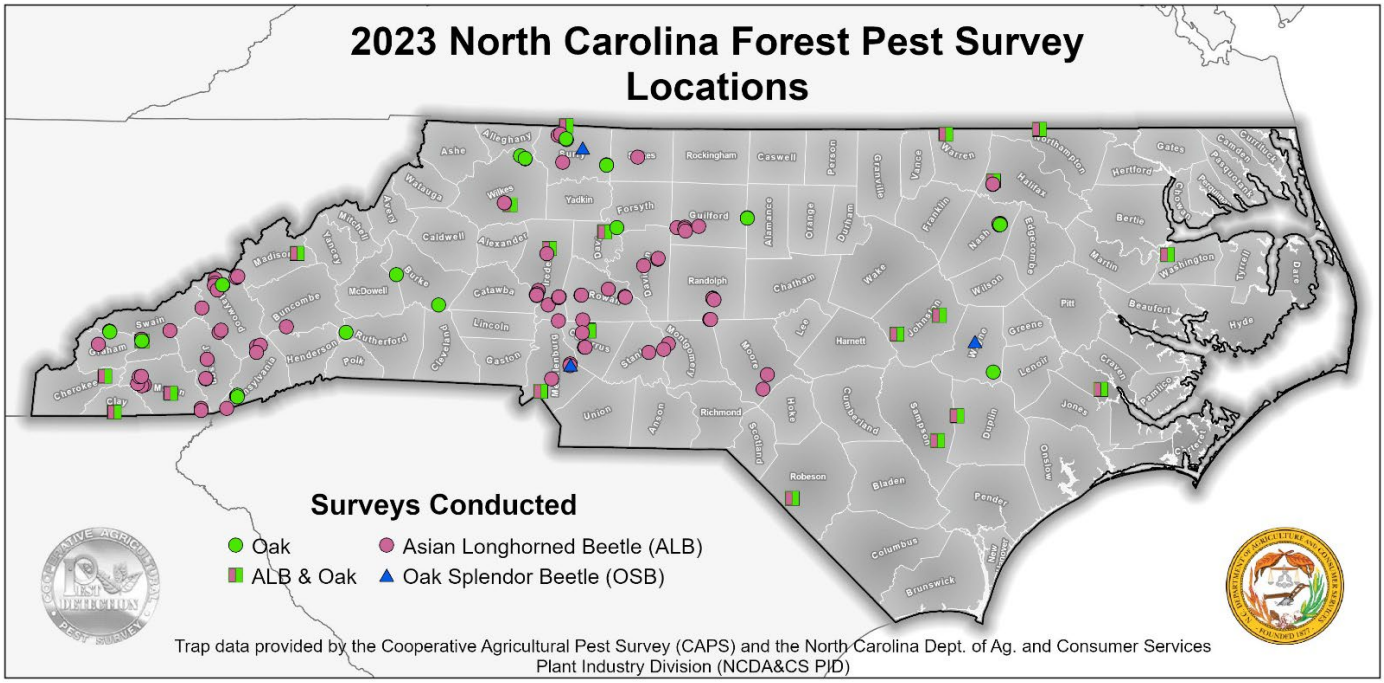


Figure 3.2 Map of Oak and Forest Pest Survey sites, 2023

PPA 7721 Surveys

The SSC annually applies for Federal assistance for the state to conduct exotic plant pest surveys. In 2023, money for 7 cooperative agreements funded by the Plant Protection Act §7721 were awarded to NC. These included 5 early detection surveys, 1 emergency pest response program, and 1 outreach program. Detection surveys included box tree moth, Asian defoliators, grape commodity, solanaceous commodity, and a ramorum blight (Phytophthora spp.) survey (see Plant Pathology Programs). The rapid response plan for Spotted Lanternfly included statewide early detection/ host mapping surveys conducted by CAPS personnel (see Entomological Programs).

Asian Defoliators Survey

Nine exotic plant pests were surveyed under Asian defoliators; Asian Gypsy Moth (Lymantria dispar asiatica), Okinawa gypsy moth (L. albescens), Japanese gypsy moth (L. dispar japonica), Hokkaido gypsy moth (L. umbrosa), Rosy Moth (L. Mathura), Nun Moth (L. monacha), Pine Tree Lappet (Dendrolimus pini), Masson Pine Moth (D. punctatus) and Siberian Silk Moth (D. sibiricus). Locations included rest areas, ports of entry, and military installations. An introduction of any of these exotics would have serious implications for North Carolina forests. Host trees for these pests are considered economically important and include oak, pine, ash, elm, maple and walnut.

A total of 16 trapping locations were placed at ports of entry over a four-month period from early May to late September (Figure 3.3), meeting our survey goal of 15-20 locations. Monthly site visits were used to replace sticky cards and/or lures. Typical survey sites include rest areas, deep water ports, and military installations. Multiple survey locations exist on larger installations which may include a combination of several forms of conveyance including deep water ports with rail yards, airstrips or a combination thereof. These are important pathways for this survey and are prioritized accordingly. All samples were collected at the servicing of each trap and screened for the presence of target pests. No target pests for this survey were recovered.

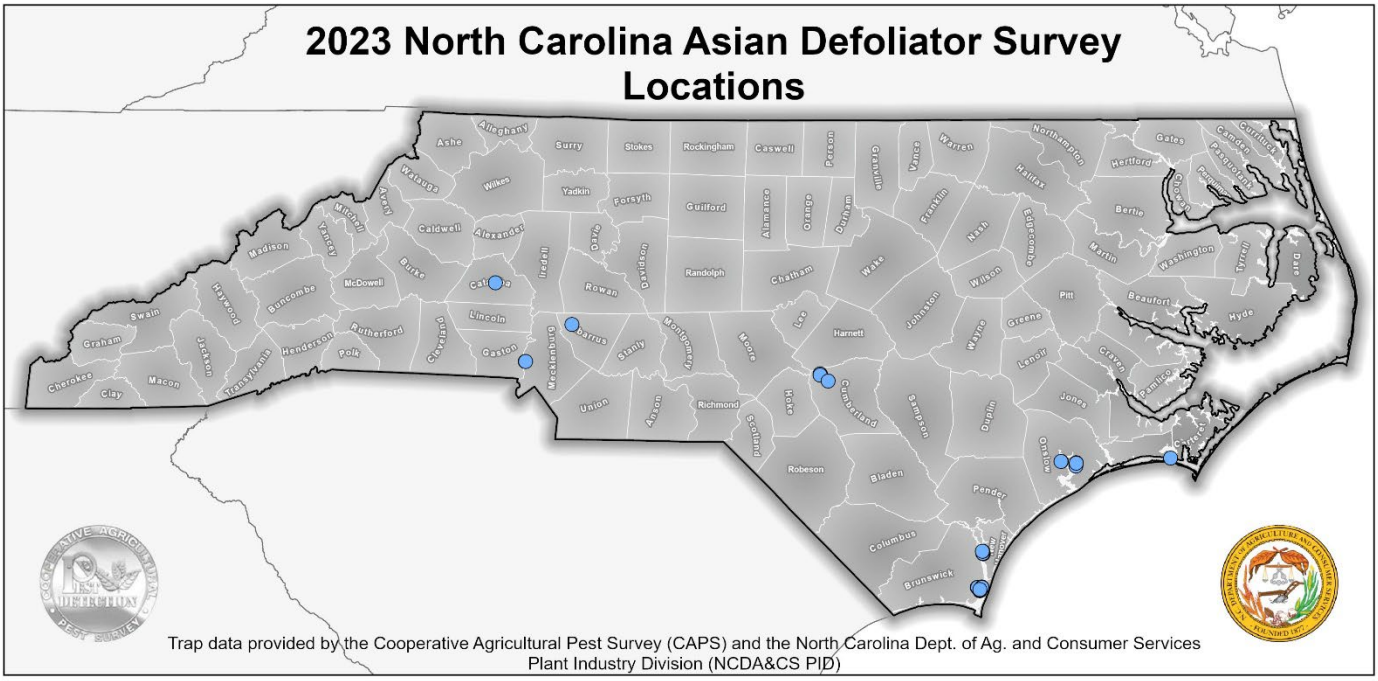


Figure 3.3 Map of Asian Defoliators Survey sites, 2023

Grape Commodity Survey

The Grape Commodity survey was completed at 27 locations (Figure 3.4), exceeding our goal of 20 sites. Vineyards surveyed included both European (Vitis vinifera) and native muscadine grapes (Vitis rotundifolia). We surveyed for three exotic species; Christmas berry webworm (Cryptoblabes gnidiella), spotted lanternfly (Lycorma delicatula; SLF), and European grapevine moth (Lobesia botrana). Traps were set beginning in late May and were pulled in October (Figure 4). Visual surveys for spotted lanternfly were conducted within vineyards at each visit in accordance with the approved guidelines. Circle traps were also set at each vineyard as an additional potential detection method, but these did not replace monthly visual surveys. No target pests for this survey were recovered within vineyards.

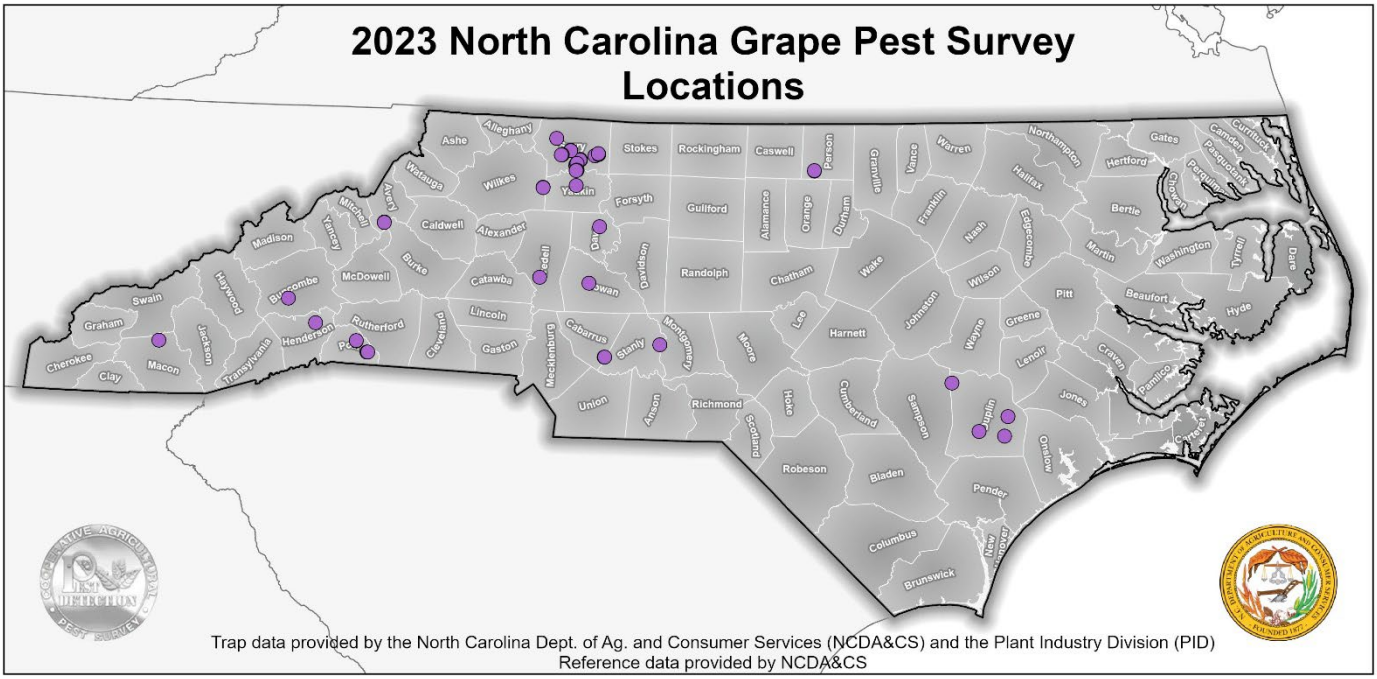


Figure 3.4 Map of Grape Survey sites, 2023

Solanaceous Commodity Survey

Insect pests (field survey)

We surveyed 25 host sites that included commercial tomato, eggplant, and pepper production fields (Figure 3.5) for insect pests, exceeding our goal of 20 sites. Seven exotic insect pests of solanaceous plants were surveyed from May-October 2023: tomato leaf miner (Tuta absoluta), old world bollworm (Helicoverpa armigera, OWB), golden twin spot moth (Chrysodeixis chalcites), tomato fruit borer (Neoleucinodes elegantalis), silver Y moth (Autographa gamma), false coddling moth (Thaumatotibia leucotreta), and cotton cutworm (Spodoptera litura). All are regarded as being highly destructive pests of solanaceous crops and pose a significant threat to North Carolina agriculture as the state has host material and climate conducive to supporting these exotics.

Old world bollworm is known for quickly developing levels of resistance to commonly used insecticides, including resistance to transgenic crops using Bt. Capable of long-distance migration, it may adapt to environmental conditions if it becomes too warm or dry. Economically, it is one of the costlier pests and reports of serious losses up to 100% are common in infested areas. It has also shown a propensity to hybridize with the native New World Bollworm, (Helicoverpa zea, NWB) in South America and Puerto Rico. NWB is already a leading pest in several NC commodity systems, and there would be potential for rapid sharing of resistant genes between these species if OWB becomes established. Early detection and identification of this pest will limit spread to the natural environment and aid in eradication. Invasive OWB and native NWB are impossible to distinguish by their external appearance. A taxonomic specialist was hired to conduct genitalic dissections on all Helicoverpa spp. collected in this survey to rule out positive identifications for OWB. While several state including NC saw increased that bycatch of NWB was much higher in 2022 compared to previous years, bycatch was much closer to normal levels in 2023.

No target insect pests were recovered as a result of this field survey.

Tomato Brown Rugose Fruit Virus *(greenhouse survey)*

In summer 2020, USDA issued a call for a new pest to be added to solanaceous surveys. Tomato Brown Rugose Fruit Virus (ToBRFV) is a relatively new tobamovirus that was first discovered in Israel in 2015. It has since been detected in several countries including Mexico and has been intercepted in several US states. This virus can affect several solanaceous crops (tomatoes, peppers, and eggplants). Symptoms tend to appear in foliage first, and lead to brown lesions on the fruit that can render the product unmarketable. While it can be seedborne, this virus spreads mechanically and can quickly contaminate entire production systems. Greenhouse-grown tomatoes appear to be the most susceptible. 2023 was the second full calendar year of ToBRFV surveys being conducted throughout the state. Surveys were led by the Plant Pathologist and CAPS Coordinator, often with help from the area Plant Protection Specialist.

Tomato Brown Rugose Fruit Virus (ToBRFV) surveys are typically conducted in winter and spring to correspond with the typical greenhouse production of tomatoes and other solanaceous plants in North Carolina and are led by the State Survey Coordinator and State Plant Pathologist. In all cases, visual surveys are conducted and any symptomatic and/ or suspicious plants are screened by sampling using AgDia ImmunoStrips for ToBFRV, in accordance with USDA-APHIS-PPQ's New Pest Response guidelines.

Our first survey occurred in January 2023. This was triggered by a trace back event when tomato seedlings in another state tested positive for ToBRFV after being sent from a North Carolina operation that works solely in grafting seedlings for redistribution. No symptomatic plants were observed, but random plants were sampled and tested negative by AgDia ImmunoStrip.

Additional ToBRFV surveys were conducted on May 17, 2023 at 2 locations in Stokes County. These locations were geared toward hothouse production, and all contained mature, flowering-to-fruiting plants. One sample was taken at one of the Stokes County greenhouses and the sample tested negative by ImmunoStrip.

The ToBRFV activities in 2023 prompted us to review our survey methods at a fundamental level. And we successfully argued for the need to be able to conduct more molecular screening for invasive pathogens. We have since utilized state funds to acquire an ABI QuantStudio 5 machine capable of conducting the NPPLAP-approved real-time PCR protocol for detecting ToBRFV. One of our institutional goals for several years has been to acquire NPPLAP certification to screen for invasive plant pathogens (including ToBRFV and ramorum blight). We intend to utilize this screening tool to the fullest extent possible in future survey efforts. This will greatly improve our chances of detecting any future plant disease outbreaks earlier on, and hopefully reduce the scale of regulatory intervention.

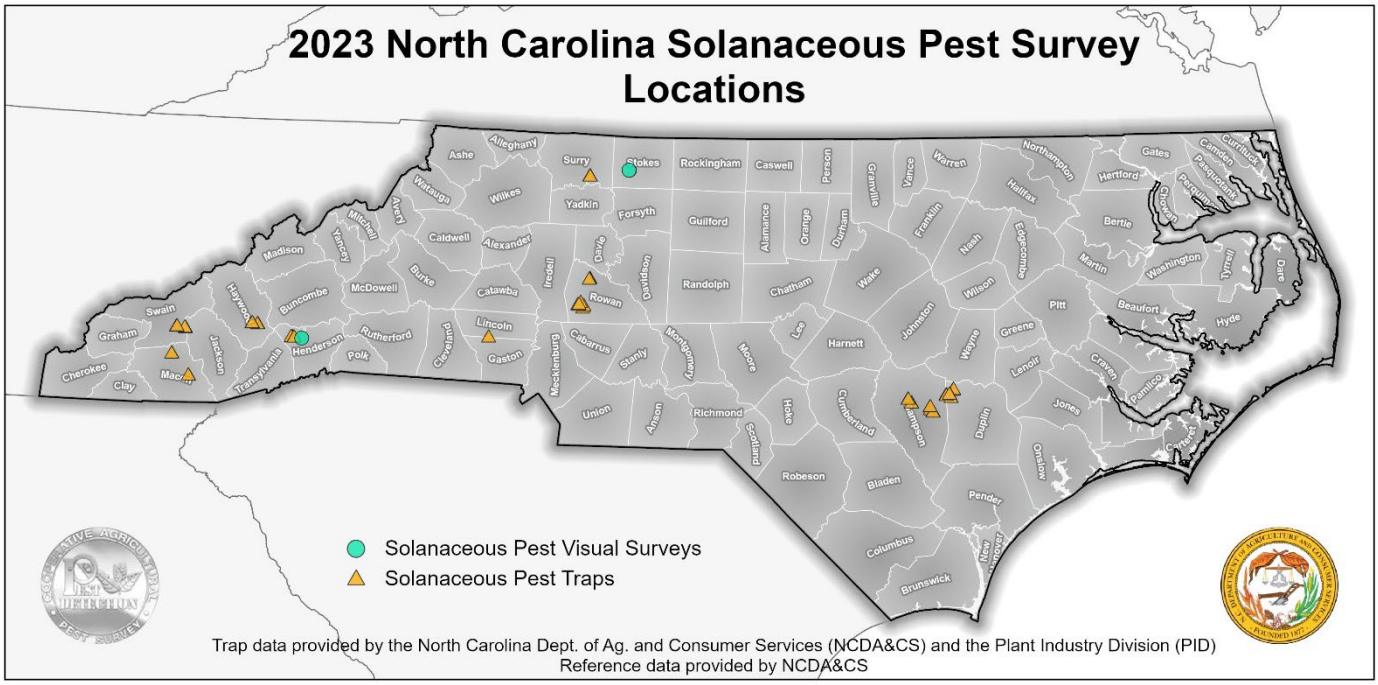


Figure 3.5 Map of Solanaceous Survey sites, 2023

Box Tree Moth Survey

The Box Tree Moth (Cydalima perspectalis, BTM) is an emerging pest of boxwood (Buxus spp.) throughout Europe, and was recently detected in Ontario, Canada in 2018. After completing a successful pilot trapping program for early detection at nurseries and coordinating with USDA-APHIS-PPQ to confiscate plants related to a BTM trace-forward from 8 locations in 2021, we petitioned to repeat this survey in 2022 and 2023. The residences related to the trace forwards in 2021 were surveyed by USDA-APHIS-PPQ and are not reflected in our survey data.

Traps were placed at 20 boxwood-producing locations with a priority given to large wholesale operations beginning in April 2023, exceeding our goal of 15 sites. Traps were checked once every 4 weeks through the end of October. The target pest was not detected as a result of our surveys anywhere in the state.

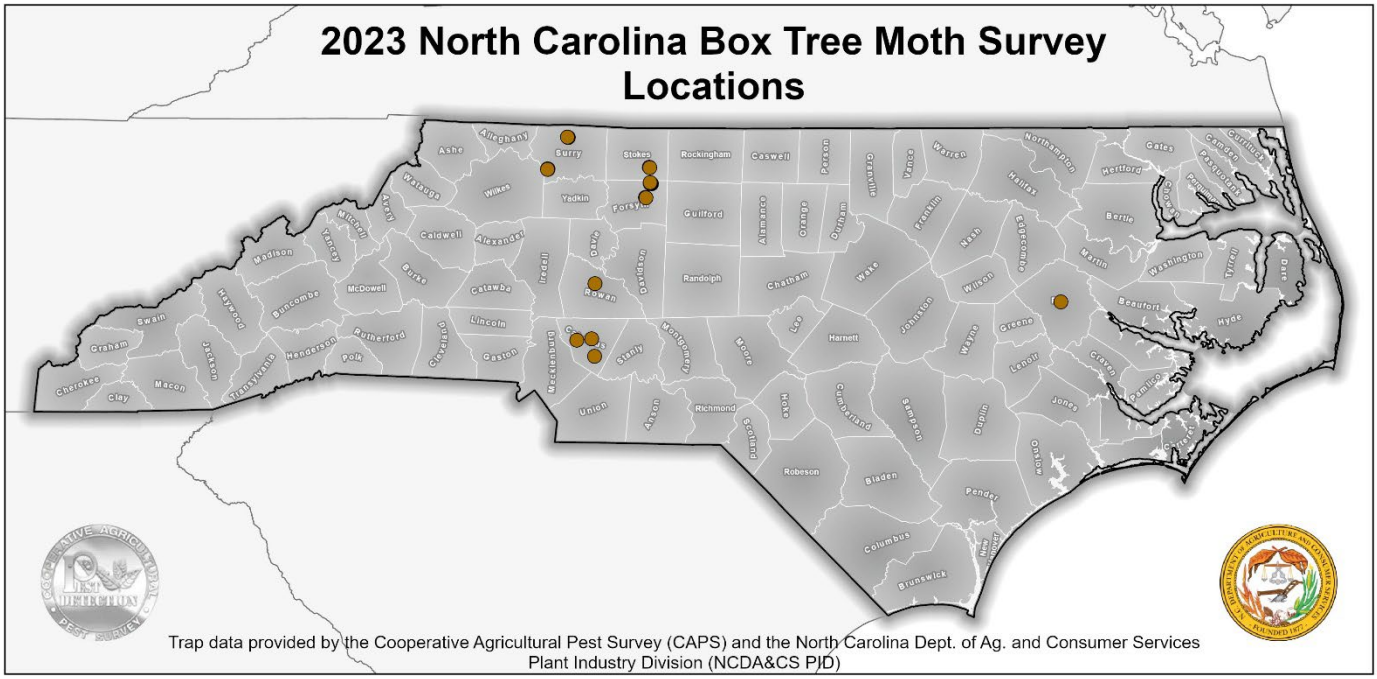


Figure 3.6 Map of Box Tree Moth Survey sites, 2023

Invasive Species Outreach

The Invasive Pest Outreach Program (funded by USDA PPA7721) supports public outreach centered on invasive pests. An ongoing central goal of this program is to help prevent the spread of invasive pests throughout North Carolina. The impacts and benefits from conducting statewide invasive pest outreach will result in quicker detection of incipient populations of pests, lead to a greater number of individuals reporting pests, and cause positive behavioral changes from the public that reduce the negative impacts of invasive pests and aid with slowing their spread. This in turn will help protect million- to billion-dollar nursery, forest, and agricultural industries. Through a combination of presentations, advertising, and in-person events, messaging reached an estimated >1.9 million North Carolinians in 2023 (Table 3.1).

Messaging was spread broadly throughout the state both geographically and to residents that may not be engaged with plant industries through events like BugFest, the Autumn Leaves Festival in Mt. Airy, and at home exposition shows in Raleigh, Wilmington, and Greensboro. At these events and through partnerships with extension offices and other organizations we were able to distribute an estimated 36,381 units of educational materials including several things that were printed in previous agreement years (Table 3.2). Several items were updated and reprinted to replenish stock. Many of our pest alerts historically had maps showing contact information for our Plant Pest Specialists' areas and their contact information. However, high turnover in recent years have created the need for us to update these pest alerts faster than we can distribute them. To try to avoid this issue, we have begun reformatting them by adding more pest identification photos and directing readers to our website or office number to get to their current Specialist.

The home shows in particular helped us to further messaging for our Poolside Pests program, a combined early detection/ outreach program that encourages folks who find suspect ALB or SLF in their pool filters to use our reporting tool and engage with both statewide and local extension programs. Poolside Pests is a collaborative project between NCDA&CS Plant Protection Section, North Carolina State University Cooperative Extension, and the NC Forest Service Forest Health section (www.poolsidepests.com).

We renewed our paid social media campaign after the extremely successful engagement rates seen in 2022. Our first carousel targeting Kernersville only encouraged viewers to prevent the spread of SLF, while campaigns in the greater Piedmont-Triad area and Mecklenburg County encouraged early reporting (Figure 3.7). This campaign ran from the week before Labor Day through late September to get this information in front of users to coincide with both peak SLF adult mating season and peak leaf-change tourism travel dates for these areas. Target audiences included but were not limited to farmers, outdoor enthusiasts, gardeners, transportation and moving professionals, and homeowners. This campaign amassed 253,274 impressions primarily on Facebook with a Click Through Rate (CTR) of 6.97%, greatly surpassing the industry average CTR of 0.93% and outpacing the previous year's 6.19% CTR (Table 3.3). This messaging was reinforced through interaction with homeowners at the Greensboro Home Show and a collaborative presentation with Forsyth County Extension. Given the tremendous success of this awareness campaign, we plan to use targeted social media campaigns again in the future.

Table 3.1 Summary of Events and Advertisements in 2023

Outreach Type	**No. of Events**	**Estimated No. Impressions/ Attendees**
Banner Display only	2	347,278
Outreach Booth	15	957,399
Presentation (in-person & virtual)	13	363
Print Advertisement	13	351,000
Social Media Campaign	3	253,274
Total Reached	**48**	**1,909,314**

Table 3.2 Summary of Outreach Materials Produced and Distributed in 2023

Title	No. Printed	Est. No. Distributed
Children's Activity Packs*	0	1,330
SLF Origami**	1,500	1,330
SLF Origami instructions**	1,500	1,330
SLF Temporary Tattoos**	3,000	1,330
ALB Pencils**	0	1,561
ALB Pencil Sharpeners**	1,000	1,230
ALB Pest Alert**	2,500	1,330
ALB Look-alike guide	0	0
BTM Pest Alert	300	197
SLF Banners	0	7
SLF Poster	300	92
"Don't Move SLF" Poster	200	56
SLF Pest Alert**	4,500	1,565
SLF Look-alike guide	500	0
TOH/CB ID guides*	2,500	1,230
SLF ID Cards	1,500	906
SLF Sticky notes**	0	1,529
SLF Pens	0	1,901
SLF Rack Cards	1,300	600
SLF Air Fresheners	3,000	2,622
SLF Winestopper Coaster	0	5,500
SLF Trouble's brewing Coaster	0	9,500
Poolside Pests flyer	0	451
Poolside Pests magnets	0	500
SLF Riker Mounts	0	4
IFA Pest Alerts	0	128
WPBR Pest Alerts	0	125
YFH Pest Alerts	0	26
PLS Pest Alerts	0	1
TOTAL	**23,600**	**36,381**

*Children's activity packs include pest alerts for both SLF and ALB, one ALB pencil, one ALB pencil sharpener, and additional materials produced in prior agreement years (e.g., SLF search-and-find activity). Materials included in the pack are counted again under each separate line (e.g.; 1,330 ALB pencils in packs + 231 individually distributed pencils = 1,561 pencils total distributed).
**Activity pack item

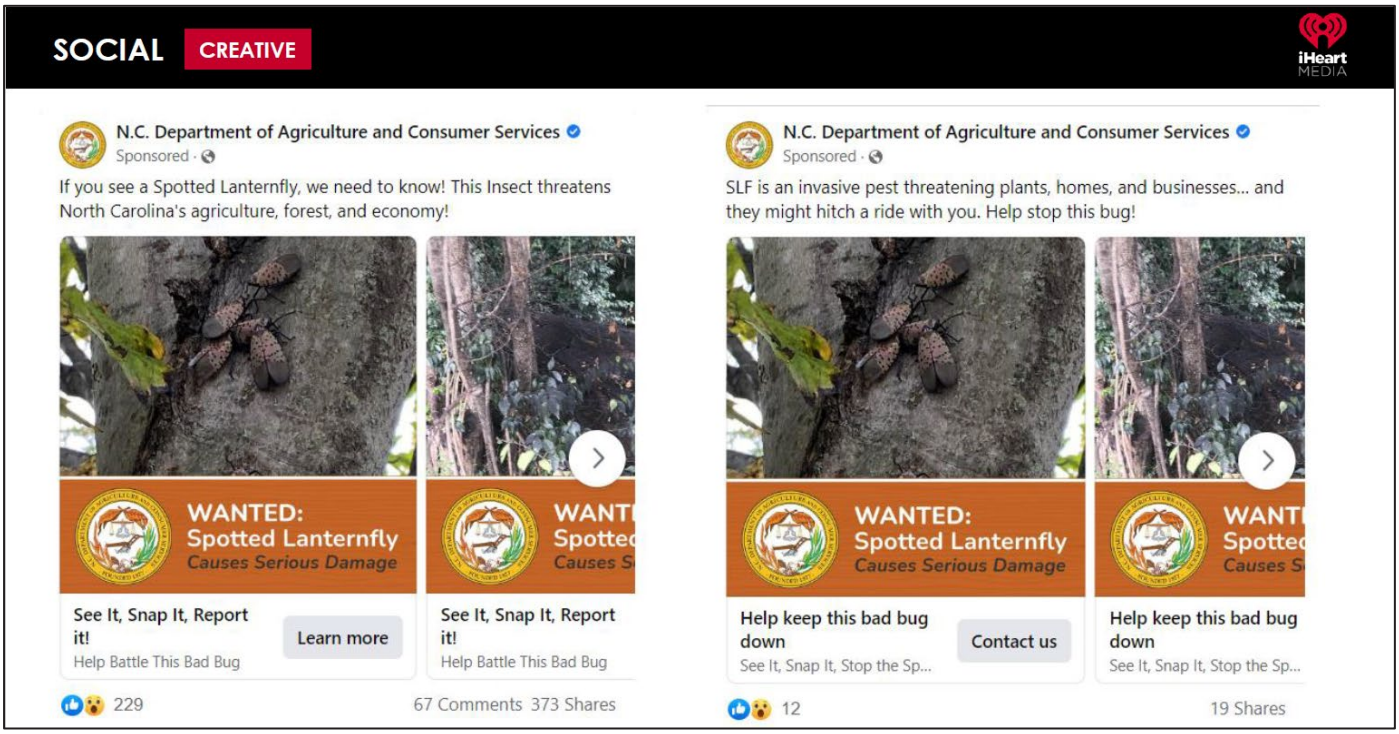


Figure 3.7 Social media campaign messaging. Carousel 2 (left, "Early Detection") was shared where SLF infestations are not known to occur, and Carousel 1 (right, "Stop the Spread") was shared in the Kernersville infestation area.

Table 3.3 Social Media Campaign Metrics

Title	Run Time	Total Impressions	Creative	Target Area	Total Clicks	Click Through Rate
Early Detection	8/29-9/30/2022	100,391	Carousel 2	Greater Triad area (Greensboro, Winston-Salem, High Point)	8,982	8.97%
Stop the Spread	8/29-9/30/2022	25,023	Carousel 1	Kernersville	748	2.99%
Early Detection	9/30-10/15/2022	62,378	Carousel 2	Surry County	1901	3.05%
TOTAL	**8/29-10/15/2022**	**187,792**	-	-	**11,631**	**6.19%**

Entomological Programs – Section 4

Prepared by Paul Adams, Entomological Programs Manager, Amy Michaels CAPS Program Coordinator, Sara Lalk Gypsy Moth Program Coordinator, and James Goethe, GIS Analyst

SWEET POTATO WEEVIL PROGRAM

North Carolina's sweet potato production continues to be a success as demand for sweet potatoes remains steady in the national and international markets. The success of the sweet potato industry in NC is attributed to several factors including an efficient marketing strategy and strong research programs at state universities aimed at developing new and better varieties of sweet potatoes. Additionally, at NCDA&CS Plant Industry Division, we manage an intensive regulatory program intended to keep the sweet potato weevil (Cylas formicarius; SPW), the most important pest of sweet potatoes in the world, out of production areas in NC. SPW is a pest of regulatory concern that can significantly affect the NC sweet potato industry by 1) reducing yields in affected fields, 2) damaging the quality of infested sweet potatoes, 3) increasing the production cost for farmers, and 4) imposing restrictions to the movement of sweet potato from affected to non-affected areas in NC and outside of NC.

Our mission at NCDA&CS Plant Industry Division is to implement effective plant pest programs to reduce the risk of accidental introductions of SPWs into NC sweet potato production areas and to mitigate and eradicate weevil populations that might have been introduced to the state in order to protect the NC sweet potato industry. Early detection and rapid response (EDRR) of weevil detections is instrumental for a successful eradication program. Our most important tool for EDRR is surveys. Every year, surveys are conducted throughout the state using traps baited with lures containing a female-produced pheromone that attracts male sweet potato weevils. These traps are deployed in production fields, regulatory sites including but not limited to storage, processing and packing facilities, micropropagation greenhouses, and/or any other sites where regulated articles for sweet potato weevil are found. Traps are also deployed in the NC sweet potato weevil quarantine area in New Hanover and Brunswick counties to monitor potential movement of sweet potato weevils into the production areas and to conduct research.

Field Surveys

Field surveys were conducted from September through mid-October 2023 in 48 counties, primarily in eastern North Carolina. Reported acreage indicated 8,181 fields totaling 64,089 acres were intended for planting in 2023 (Table 4.1). NCDA estimates on number of traps necessary for 2023 based on historical trap set data indicated approximately 10,135 traps would be set. Actual trap set numbers totaled 10,570 with 344 traps being in unreported fields meaning our estimate was accurate to within less than 100 traps. Trap set was done following the established guidelines and protocols developed by the Southern Plant Board (SPB) in 1995. Traps were deployed at a minimum of one trap per 10 acres with a minimum of two traps per field (exceptions were made if a field was under two acres). Conventional green boll weevil traps were used because of their low cost (Figure 4.1a). Traps were deployed at an average density of one trap for every 7.26 acres and left in the field for an average of 30 days. These values are in accordance with the established SPB sweet potato weevil survey guidelines. Custom-made georeferenced pdf maps were used in mobile devices (iPad minis) to navigate and locate sweet potato fields and to collect data including time and date of trap set, field type (reported, unreported, and absent), and coordinates (latitude and longitude) for each trap set. Data collected during the trap pull process include the trap condition (lost, damaged, good) and the number of weevils found. **No weevils were found in field surveys during this period in 2023.** Of the 10,570 traps placed 9,549 were collected in good condition which is approximately a 90% success rate. The remaining 10% were either missing, damaged, or inaccessible. Weather events and harvest prior to trap retrieval account for most of this 10%.

Table 4.1: *Number of Traps set per county and the reported number of fields and acres in 2023.*

County	Rep. Fields	Rep. Acres	Traps Set	County	Rep. Fields	Rep. Acres	Traps Set
Avery	1	0.25	2	Lee	6	29.61	11
Beaufort	150	555.2063	93	Lenoir	252	2428.49	405
Bertie	59	508.8	73	Martin	86	1059.36	147
Bladen	12	155	30	Moore	14	25.53	17
Brunswick	1	2.81	2	Nash	1100	6969.3	1436
Cabarrus	1	1.69	2	Onslow	3	3.6	4
Camden	1	3.06	1	Orange	3	4.89	4
Carteret	2	3.66	4	Pamlico	23	131.73	29
Chowan	27	245.79	51	Pender	2	50	0
Columbus	24	137.51	40	Pitt	408	3405.45	478
Craven	2	3.6	6	Polk	2	4.4	4
Cumberland	76	643.32	94	Randolph	0	0	8
Duplin	98	1024.42	236	Richmond	4	86.06	11
Edgecombe	855	7872.87	951	Robeson	18	320.27	30
Forsyth	0	0	1	Rockingham	3	3.5	3
Franklin	34	236.94	62	Sampson	1253	12895.88	2042
Gates	8	87.84	15	Scotland	9	259.64	27
Granville	53	199.92	51	Stokes	1	0.7	2
Greene	300	2815.65	606	Transylvania	0	0	1
Guilford	5	18	17	Wake	138	703.89	111
Halifax	117	860.78	140	Warren	8	32	5
Harnett	444	2756.41	453	Wayne	326	2835.87	867
Henderson	1	0.1	1	Wilson	1211	7781.22	1249
Hertford	11	118.91	21	Yadkin	3	1.82	6
Johnston	1026	6803.59	1202	**Totals**	**8,181**	**64,089.336**	**11,051**

Regulatory Sites

Sweet potato regulatory sites include but are not limited to storage facilities, processing plants, micropropagation units and greenhouse operations growing ornamental sweet potatoes and were surveyed all year long. Because of the inter- and intra-state movement of sweet potatoes these regulatory sites are a high-risk pathway for the introduction of sweet potato weevil. Universal moth traps (or bucket traps) were used instead of the conventional green boll weevil traps in the field because of the higher trapping efficiency (Figure 4.1b). For these operations, a minimum of two traps (one inside and one outside) were set per structure containing sweet potatoes. Traps were placed in strategic locations where sweet potatoes are stored and/or in and around the locations outside the buildings were sweet potatoes are loaded or unloaded. Lures were changed in each trap once a month and data collection was accomplished using the same procedure detailed for the field surveys. A total of 184 unique regulatory sites (totaling 5,178 inspections) were surveyed and **no weevils were found in storage facilities during the 2023 season.**

a)  b) 

Figure 4.1. a) Green boll weevil trap baited with sweet potato weevil lure used to survey sweet potato fields; b) bucket traps used to survey storage facilities

Sweet Potato Weevil Quarantine

North Carolina, despite leading the U.S. in sweet potato production, has an infestation of sweet potato weevil (Cylas formicarius). Fortunately, these infestations are confined to two coastal communities of North Carolina in Brunswick and New Hanover counties where a quarantine has been established to protect sweet potato production areas. Since the discovery of these populations the goal has been eradication.

In 2023, all traps in the quarantine areas were in place and checked consistently 1 time per month. As it stands, since 2018 we have used the same 10 delimiting grids (labeled A-J) for monitoring and eradication purposes. Of the 7,874 weevils caught this year 96.75% were caught in Brunswick County (delimits H-J) and more specifically in delimit area I which accounted for 90.39% of all weevils caught (Figure 4.3). This trend is consistent with previous years data for both county and delimit area. Brunswick county consistently produces more weevils and those weevils have always been localized to the I delimit grid which is both the largest delimit and has the highest host density. The host in this case is Seaside or Beach Morning Glory (Ipomoea imperati), a perennial flowering vine and relative of the sweet potato, that is found on the dunes of Caswell Beach in Brunswick County. In contrast, sweet potato weevils in New Hanover County are subsisting on an assemblage of other annual morning glory species growing in disturbed habitats like roadsides and undeveloped residential lots. As is typical, we see weevil populations expanding rapidly in late summer (August-September) and often rise through December when cold temperatures force both the weevil and its host to recede, bottoming out in late winter to early spring (February-April) (Figure 4.4).

In 2023 the data collected during this project has been harmonized and basic analyses was performed to understand how this population has behaved over time within and across years spanning from 2015 to present day. Consistent monitoring will continue in 2024 and, given that host destruction is not available as a control method, M.A.T. will be used as funds allow and the use of entomopathogenic fungi will continue to be explored and if possible, implemented in 2025.

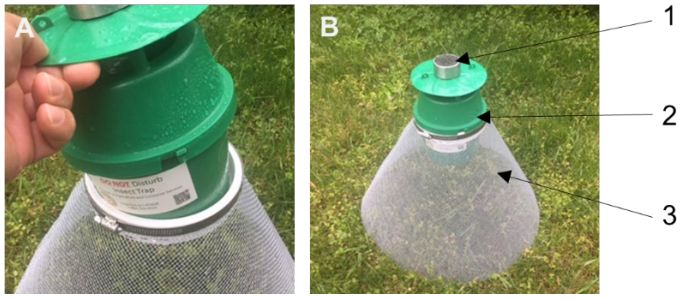


Figure 4.2. a. Details of the sweet potato weevil trap to use in the MAT. b. The base of the trap is a funnel made with galvanized mesh (3). This allows weevils to walk to the bucket trap fitted within a PVC ring that holds the funnel (2). The bucket trap includes a solar cell (1) that charges an LED diode that produces a green light shown to attract more weevils. The diode is activated late in the evening when weevils are active and deactivated when there is sunlight.

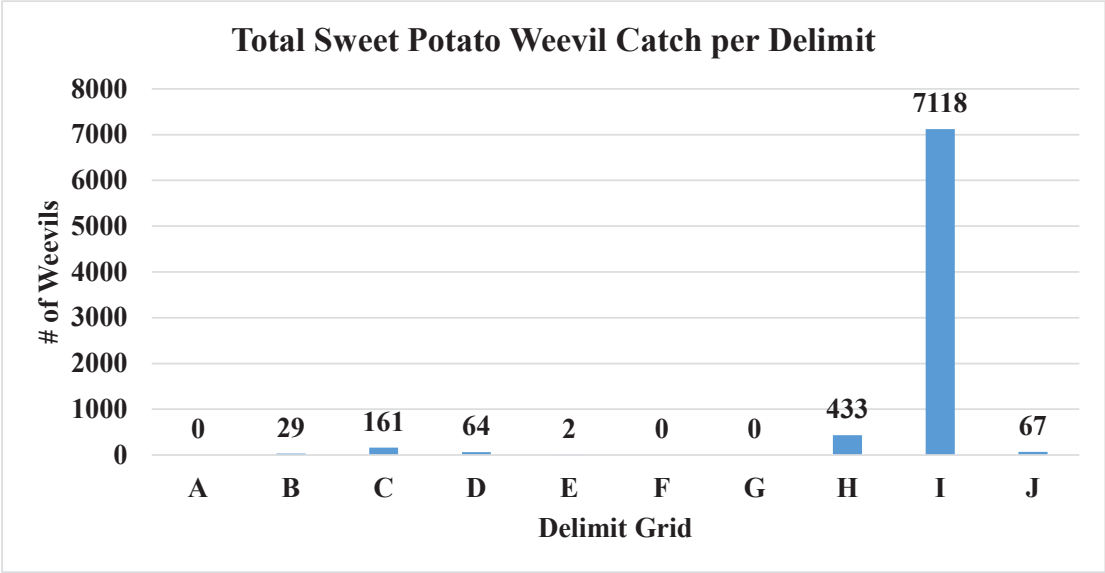


Figure 4.3: Total annual catch of sweet potato weevils within each of the 10 delimit areas. Delimits H-J are in Brunswick Co. at Caswell Beach while the others are in southern New Hanover Co.

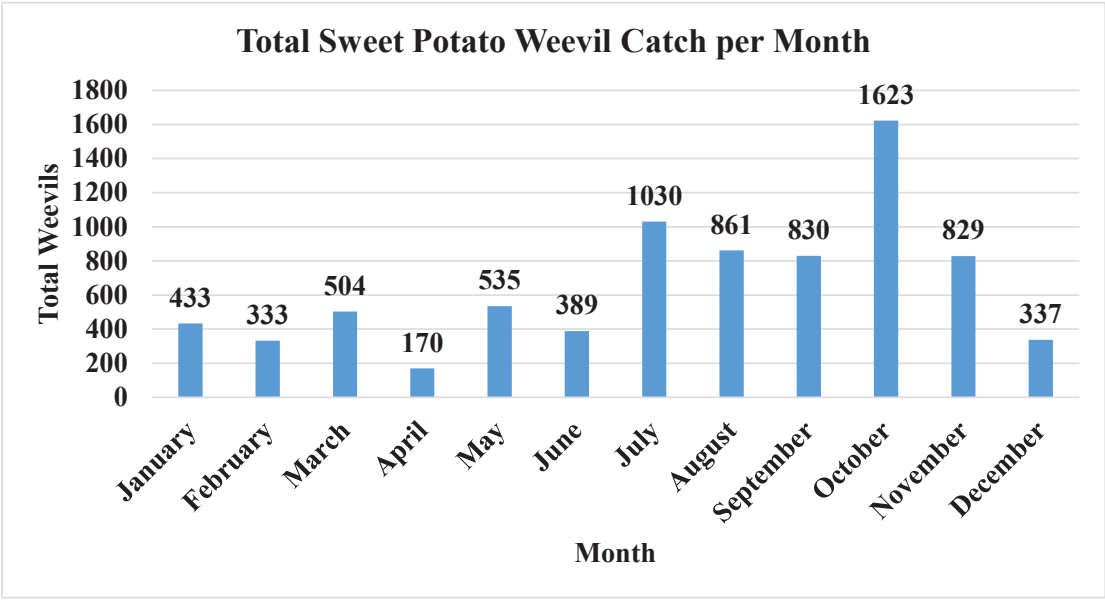


Figure 4.4: Total weevils captured per month across delimits.

SPONGY MOTH SLOW THE SPREAD AND ERADICATION PROGRAM

Spongy Moth Control Program

Spongy (formerly gypsy) moth (species name: Lymantria dispar) is an invasive species first established in parts of the U.S. in 1869. Spongy moth caterpillars feed on over 300 species of trees and shrubs in the United States and are considered one of the most destructive insect pests threatening our rural and urban forests. NCDA&CS has proudly helped to contain the spread of this pest for 42 years, and the spongy moth survey and management programs are among the most successful invasive species management programs in the United States to date. In North Carolina the program is divided into the Slow the Spread Foundation-funded slow the spread action area (STS) and the USDA APHIS-funded eradication area (EGM) (Figure 4.5). The program includes annual detection surveys (trapping), pest mitigation (treatment), outreach, and regulatory activities which are outlined below.

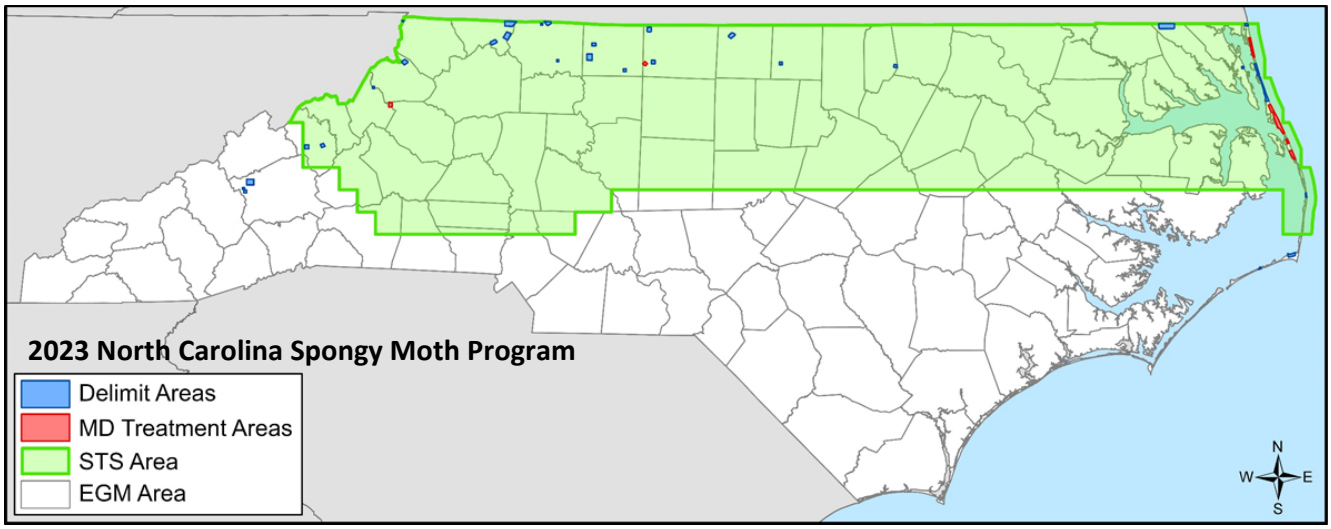


Figure 4.5.: Spongy moth program areas and 2023 spongy moth treatment site and delimiting grids

Trapping and Treatment

In 2023, 17,351 traps were set across North Carolina between April and May and removed between July and September 2023. 10,437 traps were set in the STS-funded action area (highlighted in green in Figure 4.5) by contractors, and 6,877 traps were set in the APHIS-funded eradication area by NCDA&CS personnel. An additional 395 traps were placed at high risk/regulatory sites across the state as well. Traps were baited with disparlure, the female-produced sex pheromone of spongy moth (2-methyl-7R, 8S-epoxy-octadecane) and trap locations and data were recorded with iPad units and submitted to the national Slow the Spread database. Trapping resulted in 1,140 adult spongy moth males captured in 523 traps (Table 4.2).

Table 4.2 :North Carolina spongy moth trap catch numbers by county, arranged by percentage of traps with at least one spongy moth capture.

County Name	Traps Placed	Positive Traps	Moths	% Positive
Yancey	110	32	172	29%
Haywood	170	36	106	21%
Alleghany	210	42	175	20%
Surry	386	57	71	15%
Gates	236	33	39	14%
Camden	156	21	50	13%
Graham	32	3	6	9%
Stokes	353	31	110	9%
Rockingham	429	36	67	8%
Caswell	298	22	25	7%
Watauga	203	14	34	7%
Currituck	197	13	36	7%
Avery	78	5	6	6%
Buncombe	209	12	40	6%
Person	271	15	15	6%
Granville	329	17	18	5%
Mitchell	64	3	4	5%
Pasquotank	147	6	8	4%
Vance	196	8	8	4%
Hertford	226	9	10	4%
Wilkes	426	16	17	4%
Ashe	283	9	10	3%
Cherokee	97	3	4	3%
Cleveland	135	4	4	3%
Jackson	102	3	4	3%
Forsyth	208	6	6	3%
Warren	291	8	8	3%
Yadkin	186	5	8	3%
Davie	76	2	3	3%
Swain	41	1	1	2%
Chowan	84	2	2	2%
Macon	90	2	2	2%
Burke	145	3	3	2%
Henderson	103	2	2	2%
Rutherford	157	3	3	2%
Guilford	272	5	5	2%
McDowell	109	2	3	2%
Northampton	349	6	6	2%
Bertie	297	5	5	2%
Wake	251	4	4	2%
Transylvania	64	1	1	2%
New Hanover	67	1	1	1%
Edgecombe	145	2	3	1%
Nash	170	2	2	1%
Alamance	172	2	3	1%

Lincoln	86	1	1	1%
Orange	172	2	2	1%
Franklin	215	2	7	>1%
Randolph	218	2	2	>1%
Halifax	445	4	4	>1%
Columbus	269	2	2	>1%
Caldwell	142	1	1	>1%
Perquimans	146	1	1	>1%
Rowan	153	1	4	>1%
Davidson	165	1	2	>1%
Mecklenburg	170	1	1	>1%
Iredell	178	1	1	>1%
Dare	184	1	1	>1%
Chatham	198	1	1	>1%
Alexander	78	-	-	-
Anson	152	-	-	-
Beaufort	238	-	-	-
Bladen	252	-	-	-
Brunswick	243	-	-	-
Cabarrus	103	-	-	-
Carteret	120	-	-	-
Catawba	125	-	-	-
Clay	40	-	-	-
Craven	179	-	-	-
Cumberland	184	-	-	-
Duplin	233	-	-	-
Durham	114	-	-	-
Gaston	108	-	-	-
Greene	74	-	-	-
Harnett	173	-	-	-
Hoke	104	-	-	-
Hyde	130	-	-	-
Johnston	220	-	-	-
Jones	115	-	-	-
Lee	73	-	-	-
Lenoir	116	-	-	-
Madison	104	-	-	-
Martin	129	-	-	-
Montgomery	122	-	-	-
Moore	199	-	-	-
Onslow	164	-	-	-
Pamlico	89	-	-	-
Pender	218	-	-	-
Pitt	187	-	-	-

Polk	66	-	-	-
Richmond	136	-	-	-
Robeson	267	-	-	-
Sampson	272	-	-	-
Scotland	90	-	-	-
Stanly	117	-	-	-
Tyrrell	86	-	-	-
Union	183	-	-	-
Washington	100	-	-	-
Wayne	168	-	-	-
Wilson	119	-	-	-
Total	**17351**	**535**	**1140**	**3%**

Trapping surveys in both the STS-funded action area and APHIS-funded eradication area were conducted in accordance with national program protocols. Orange, coated-paper sticky traps were set at least 3 kilometers apart throughout the southern portion of North Carolina, though traps were set at a closer 2 kilometer spacing in within 30 miles of the Virginia border and 1 kilometer or less spacing in some areas to characterize suspected reproducing spongy moth populations. Funding provided by USDA-APHIS was used to employ 9 temporary employees, purchase survey supplies (including traps, lures, trap assembly supplies, and office supplies), and for operational expenses (including fuel and maintenance for survey vehicles) within the eradication area. In the STS-funded action area, eleven contractors set traps in 29 bid units. Temporary personnel and permanent NC-DA&CS staff performed quality control inspections on a minimum of 10% of the traps set by contractors, and no significant quality issues were noted.

The greatest number of moths were detected in the mountainous western portion of the state, from the Virginia-North Carolina border south through the Maggie Valley area. (Figure 4.6).

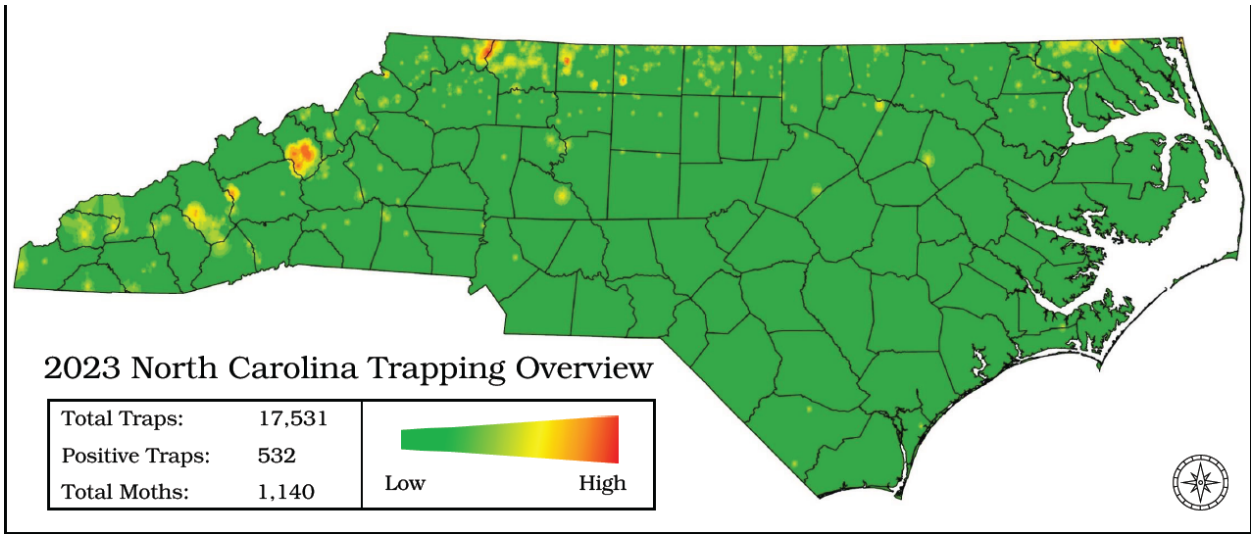


Figure 4.6: Spongy moth trapping results indicate the above areas with potential population establishment (red and yellow).

As a result, ten mating disruption (MD) treatments totaling 29,921 acres are proposed for summer 2024 (Table 4.3). Multiple higher density trapping grids are planned as well to allow accurate characterization of suspected spongy moth populations in high-capture locations.

Table 4.3: Locations of mating disruption treatments planned for 2024.

Block Name	County	Product	Dosage	Acres
Cumberland Knob	Alleghany	SPLAT GM-O	6g	10,900
Leicester	Buncombe	SPLAT GM-O	6g	756
Cruso	Haywood	SPLAT GM-O	6g	6,129
Ellisboro	Rockingham	SPLAT GM-O	6g	745
Hanging Rock	Stokes	SPLAT GM-O	15g	844
Walnut Cove	Stokes	SPLAT GM-O	6g	454
Zionville	Watauga	SPLAT GM-O	6g	437
Bowditch	Yancey	SPLAT GM-O	6g	5,250
Eskota	Yancey	SPLAT GM-O	6g	2,338
Pensacola	Yancey	SPLAT GM-O	6g	2,068
			TOTAL	**29,921**

Treatment

In June 2023, six mating disruption treatments were performed in North Carolina. A total of 19,223 acres were treated with 6g dosage of SPLAT GM-O (Table 4.4). Evaluation of the efficacy of these treatments will take place in 2023 and 2024.

Table 4.4: Locations of mating disruption treatments in 2023.

Block Name	County	Product	Dosage	Acres
Grandfather Mountain	Caldwell	SPLAT GM-O	6g	1,417
Belews Lake	Rockingham	SPLAT GM-O	6g	1,004
Corolla	Currituck	SPLAT GM-O	6g	3,128
Oregon Inlet	Dare	SPLAT GM-O	6g	2,184
Roanoke Island	Dare	SPLAT GM-O	6g	742
Kitty Hawk	Dare	SPLAT GM-O	6g	8,362
			TOTAL	**19,223**

Outreach

Opportunities for public interactions are an important part of spongy moth management success and allow this program the chance to learn from members of the public's lived experience and understanding of spongy moth establishment risks that are otherwise difficult to see from charts and data. The program has benefitted from the time, words of encouragement, and constructive criticisms that have been shared to this point, but outreach and stakeholder engagement is a continual process. Meetings with local and tribal personnel are planned for updating and receiving feedback on anticipated 2024 program activities. New and updated digitally available spongy moth resources continued to be developed for outreach events, and materials will be printed as needed.

Regulatory

The final component of the spongy moth control programs in North Carolina is regulatory management. The risk of additional movement and establishment of spongy moth beyond their natural spread is reduced by strategically restricting movement of high-risk regulated articles including timber products, outdoor household articles, recreational vehicles, and trees and woody shrubs out of generally infested areas pursuant to North Carolina and USDA regulations (02 N.C.A.C. 48A.1500 et seq., C.F.R. 7 §301.45(e)). In North Carolina, all of Currituck County and a small portion of Dare County were quarantined in 1988 and remain our only federally quarantined spongy moth areas (Figure 4.7).

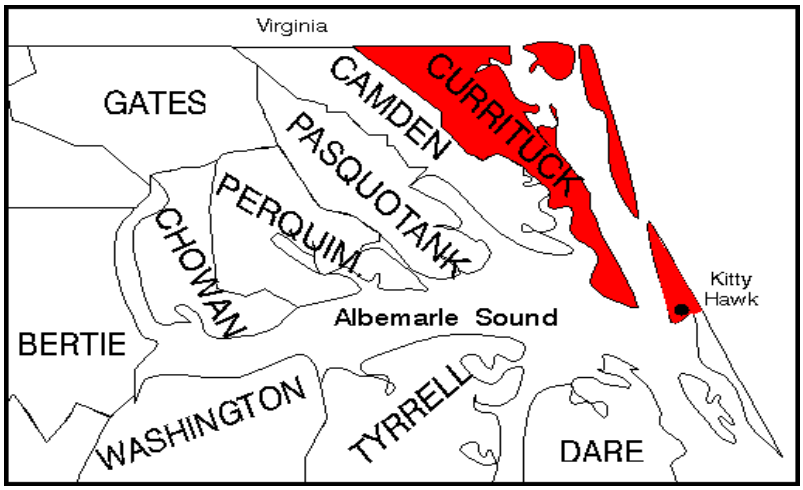


Figure 4.7: Spongy moth quarantine area in North Carolina, shown in red.

Regulated articles may be moved from quarantined to non-quarantined areas if the appropriate personnel within organizations undergo training and obtain a compliance agreement from NCDA&CS. These compliance agreements require inspection and/or treatment of articles to ensure that they are free of spongy moth life stages. Several businesses and individuals received training for new staff in 2023 and multiple new compliance agreements are being processed. Restructuring of the spongy moth compliance agreement issuance process to reduce personnel burden and streamline overall compliance levels began in 2023 and is still ongoing.

IMPORTED FIRE ANT PROGRAM

The Imported Fire Ant (Solenopsis invicta; IFA) continues to be a serious pest in the southern United States with infestations occurring in fourteen states. North Carolina is on the leading edge of the expanding range of fire ants. Currently, 77 of North Carolina's 100 counties are either partially or entirely infested. NCDA&CS' objective is to prevent the artificial spread of IFA from infested areas to non-infested areas through regulatory actions.

The following report summarizes the NCDA&CS survey and regulatory activities conducted for the Imported Fire Ant Program from January 1 to December 31, 2023:

Survey

Drive-by surveys were conducted in 16 counties in NC yielding 259 data entries (Figure 4.8; Table 4.5). Data was collected using iPads and the ESRI Survey 123 for ArcGIS application and included new IFA mounds and established sites. The option to choose '0 mounds' was included and indicates sites with no mounds reported. This was used to show the areas surveyed in all counties (negative controls). Based on the results of the 2023 IFA survey we have not elected to expand our quarantine. However, the data seems to indicate that IFA may be established in parts or all of several western counties not previously quarantined and successive years of data will lead to their quarantine. 2023 data also confirms our suspicions from 2022 that IFA are present in far western counties but was not previously supported by survey data due primarily to the lack of available temporary labor in the western regions of the state. Survey plans for 2023 and subsequent years have corrected this issue. Virginia has expanded their IFA quarantine along the North Carolina border extending beyond our current NC IFA quarantine boundaries. In 2024, we will continue to survey the NC-VA border along the newly expanded VA IFA quarantine line and to address the survey needs of the below listed counties a few of which are adjacent to the counties quarantined in Tennessee.

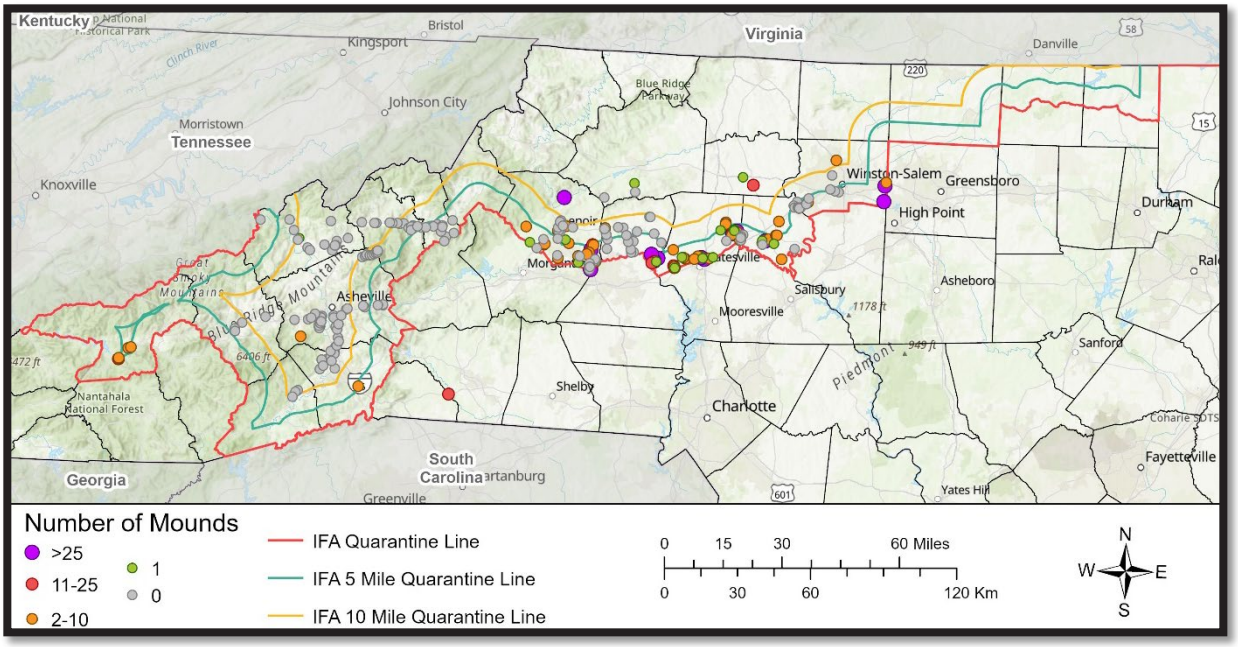


Figure 4.8: NC Imported Fire Ant survey results (January-November 2023). 263 data points were collected, 161 of which were reported as '0 mounds observed'.

Table 4.5. 2023 NC Imported Fire Ant survey summary.

County	Areas Surveyed	Regulatory Action Recommended[1]	Absent	Established Sites	New Observation[2]	Total Sites
Alexander	5 & 10 miles from the quarantine	No action	18	0	7	**25**
Avery	5 & 10 miles from the quarantine	No action	1	0	0	**1**
Buncombe	5 & 10 miles from the quarantine	No action	41	0	2	**43**
Caldwell	5 & 10 miles from the quarantine	No action	18	4	17	**39**
Davie	5 & 10 miles from the quarantine	No action	17	0	18	**35**
Forsyth	5 & 10 miles from the quarantine	No action	6	1	5	**12**
Haywood	5 & 10 miles from the quarantine	No action	4	0	0	**4**
Henderson	5 & 10 miles from the quarantine	No action	9	0	1	**10**

Iredell	5 & 10 miles from the quarantine	No action	2	7	27	**36**
Madison	5 & 10 miles from the quarantine	No action	13	1	0	**14**
Mitchell	5 & 10 miles from the quarantine	No action	11	0	0	**11**
Swain	5 & 10 miles from the quarantine	No action	0	1	4	**5**
Transylvania	5 & 10 miles from the quarantine	No action	3	0	0	**3**
Wilkes	Greater than 20 miles from quarantine line	No action	2	0	1	**3**
Yadkin	Greater than 20 miles from quarantine line	No action	1	0	2	**3**
Yancey	5-mile strip from the quarantine line	No action	15	0	0	**15**
Total			**161**	**14**	**84**	**259**

[1]"No action" when numbers are not enough to justify a regulatory action. "Expand" when partially quarantined counties have shown significant numbers of IFA mounds above the quarantine line. "Add" when there is conclusive evidence that a significant number of IFA mounds are detected in a county where no previous mounds have been reported.
[2]For the purposes of this table new observations are only recorded for presence of mounds. If a new observation was recorded but there were no mounds present that is recorded on the 'Absent' column of this table.

Regulatory

As part of the IFA program's regulatory activities, 12 blitzes were scheduled to be conducted in three locations across the state to ensure that operations moving regulated articles outside the quarantine area in NC are in compliance with federal and state regulations. A total of 11.5 blitzes were to be held in 2023 with 8 days in the spring and 3.5 days in the fall. Dates and locales are given in Table 4.6 below. NCDA&CS stopped a total of 21 trucks to inspect their load and review/record their paperwork in Spring of 2023. Of those 21 trucks we collected 6 soil samples. In Fall of 2023 4 days were completed with one blitz being cut short due to an unforeseen break down of a truck blocking the scales at the weigh station. On those 4 days, 2 trucks were stopped, and 0 samples were taken.

Table 4.6. 2023 IFA Blitz Summary

Date	Location	Trucks Stopped	Sample Taken
03/07/23	Halifax Co. (I-95 North Bound)	3	3
03/08/23		5	1
03/14/23		0	0
03/15/23		6	2
03/21/23	Iredell Co. (I-40 East Bound)	5	0
03/22/23		0	0
03/28/23	Henderson Co. (I-40 West Bound)	2	0
03/29/23		0	0
10/10/23	Halifax Co. (I-95 North Bound)	0	0
10/11/23		½ Day Canceled	
10/24/23		0	0
10/25/23		2	0
Totals		**23**	**6**

BLUEBERRY CERTIFICATION PROGRAM

The blueberry maggot (Rhagoletis mendax; BBM; Figure 4.9) is a serious pest of both lowbush and highbush blueberries. Infestations of this pest lead to unmarketable berries, reductions in yield, and increased production costs. The maggot is native to eastern North America and is found in the eastern United States, including North Carolina. While native to Nova Scotia, New Brunswick, and Prince Edward Island, the pest was detected in Ontario and Quebec in the mid-1990s—two regions where the maggot had not previously been known to exist. As a result, Canada regulates R. mendax to prevent spread of BBM into provinces that are currently free of this pest. The Blueberry Certification Program (BCP) was initiated by the Canadian Food Inspection Agency (CFIA) in 1999 to facilitate the movement of fresh blueberries while managing the risk of further spread of the blueberry maggot into non-infested areas of Canada.

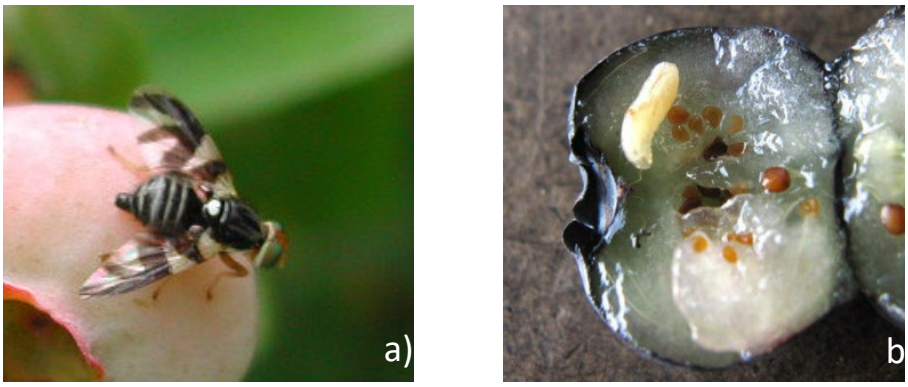


Figure 4.9. Blueberry maggot (Rhagoletis mendax): a) adult; b) larva inside blueberry (Photos by Rufus Isaacs, MSU)

In North Carolina, we currently have 20 blueberry farms located in four southeastern NC counties (Bladen, Duplin, Pender, and Sampson) participating in the Blueberry Certification Program. In May 2023, we mailed out the annual blueberry maggot flight letter informing all growers in the program that they should begin their internal audits. All growers are required to perform a brown sugar or salt flotation test on their berries every three days starting from when they receive their flight letter until they are done packing and shipping for the season. The flotation test involves soaking two pints of gently crushed berries in either a sugar or salt solution for 10 minutes to observe whether any maggots float to the surface (Figure 4.10; the complete method can be found at https://www.ncagr.gov/divisions/plant-industry/plant-protection/entomological-services/blueberry-certification-program).

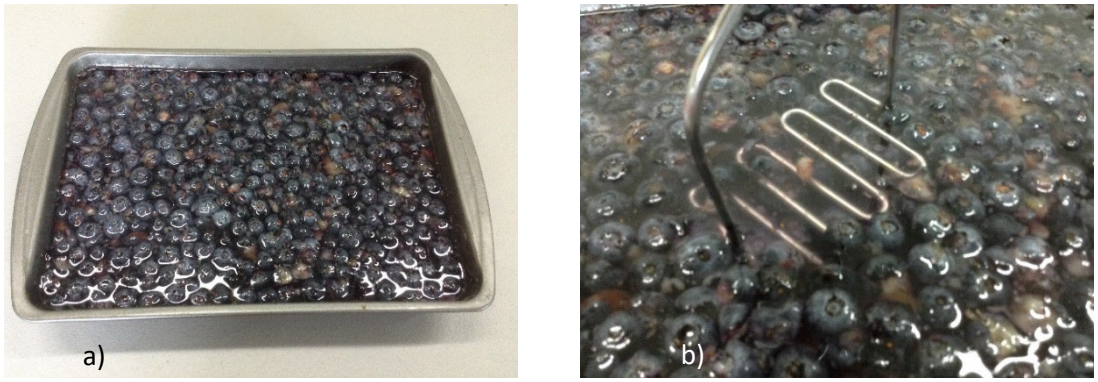


Figure 4.10. Salt flotation test: a) blueberries soaking in salt water solution for 10 minutes; b) close-up of flotation test showing potato masher used to gently crush berries. (Photos by Whitney Swink, NCDA&CS)

In late May and Early June, NCDA&CS Plant Protection personnel began traveling to each farm to perform the annual regulatory audit. The NCDA&CS audit consists of performing the flotation test and checking the calendar spray treatment and/or trapping records (if utilizing IPM) to ensure the growers are following the CFIA BCP regulations. Every grower in the program elected to use the salt solution (as opposed to the brown sugar solution). The results were negative for all audits performed (both internal and regulatory). A total of 29 inspections were conducted this year for 20 farms. All 20 farms opted to use calendar spray treatments at all inspected locations. There were 135 spray treatments done by these 20 farms and 24 salt/sugar flotation tests all of which were negative for blueberry maggot.

In 2017, we began using Survey 123 to record data collected during the audits which fine-tuned the data collection process through use of a "smart form" (a form that modifies the input fields based on the data being collected; e.g. if a grower is using the calendar spray program the form will not ask you questions about IPM trapping results). We continue to utilize Survey 123.

COTTON BOLL WEEVIL PROGRAM

Field surveys for the cotton boll weevil (Anthonomus grandis) were coordinated and carried out by the NC Cotton Boll Weevil Eradication Foundation. In 2023, a total of 375,185.7477 acres were reported in 65 counties (Table 4.7). Plant Industry Division personnel surveyed cotton gins, cotton processing facilities, and ornamental cotton in 32 counties totaling 515 individual inspections using conventional cotton boll weevil traps across 13 different specialist regions (Table 4.8). Traps were baited with a male specific sex pheromone and checked once a month.

Table 4.7: Cotton acreage by county in North Carolina for 2023.

County Name	Total Acreage	County Name	Total Acreage
ALAMANCE	0.0000	LEE	0.0000
ANSON	4,054.7500	LENOIR	6,588.4900
BEAUFORT	7,178.4920	LINCOLN	268.8900
BERTIE	31,958.4720	MARTIN	25,956.9100
BLADEN	16,770.0468	MECKLENBURG	0.0000
BRUNSWICK	0.0000	MONTGOMERY	0.0000
CABARRUS	767.9260	MOORE	0.0000
CAMDEN	152.5700	NASH	10,375.1700
CARTERET	484.2050	NORTHHAMPTON	29,312.0918
CATAWBA	0.0000	ONSLOW	703.5900
CHOWAN	11,501.1201	ORANGE	0.0000
CLEVELAND	61.4100	PAMLICO	0.0000
COLUMBUS	867.3820	PASQUOTANK	1,077.8400
CRAVEN	3,824.4000	PENDER	0.0000
CUMBERLAND	5,224.8870	PERQUIMANS	11,414.5634
CURRITUCK	0.0000	PITT	10,900.7697
DAVIDSON	0.0000	RANDOLPH	1,048.1600
DUPLIN	1,962.4700	RICHMOND	1,534.9520
DURHAM	0.0000	ROBESON	10,367.3194
EDGECOMBE	32,387.6168	ROWAN	0.0000
FORSYTH	0.0000	RUTHERFORD	0.0000
FRANKLIN	250.9400	SAMPSON	6,187.2000
GATES	13,446.7468	SCOTLAND	5,237.0270
GRANVILLE	0.0000	STANLY	7,775.1239
GREENE	7,962.8150	TYRRELL	5,313.6900
HALIFAX	40,174.9249	UNION	1,331.1300
HARNETT	8,247.9250	WAKE	42.1100
HERTFORD	14,355.6710	WARREN	521.3500
HOKE	4,518.6830	WASHINGTON	3,939.1100
HYDE	11,521.1571	WAYNE	2,771.0600
IREDELL	1,393.0200	WILSON	3,305.1250
JOHNSTON	5,953.6350	YADKIN	0.0000
JONES	4,192.8100	**Total**	**375,185.7477**

Table 4.8: Cotton site inspections of traps placed inside and outside facilities or ornamental cotton grow sites per inspector region per county for 2023.

Inspector	County Name	# of Inspections
Andrew Allen*	Forsyth	1
Andrew Allen*	Guilford	2
April Bauder	Durham	11
April Bauder	Wake	5
Bonnie Faulkner	Greene	2
Bonnie Faulkner	Jones	2
Bonnie Faulkner	Lenoir	3
Cassie Kelm	Chatham	6
Chris Carter	Bladen	12
Chris Carter	Cumberland	6
Chris Carter	Sampson	20
David Pearce*	Beaufort	12
David Pearce*	Craven	2
Derreck Long	Halifax	123
Derreck Long	Northampton	72
Heidi Humlicek*	Mecklenburg	1
Jensen McLamb	Hoke	10
Jensen McLamb	Robeson	4
Joe Davenport	Bertie	48
Joe Davenport	Chowan	26
Joe Davenport	Gates	24
Joe Davenport	Hertford	27
Joe Davenport	Hyde	25
Joe Davenport	Perquimans	24
Juliet Whitehurst	Edgecombe	9
Juliet Whitehurst	Martin	10
Juliet Whitehurst	Nash	1
Juliet Whitehurst	Pitt	10
Sam Harris	Anson	2
Sam Harris	Stanly	2
Scott Cannady*	Duplin	11
Scott Cannady*	Wilson	2
13	**32**	**515**

**Indicates an inspector whose region is vacant due to retirement or departure from NCDA: PID.*

SPOTTED LANTERNFLY PROGRAM

Spotted Lanternfly Overview

Spotted Lanternfly (Lycorma delicatula) (SLF) is a relatively new pest in North America. Discovered in Berks County, Pennsylvania in 2014, SLF has since spread to 17 states which include: Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Ohio, Michigan, Indiana, West Virginia, Maryland, Delaware, Virginia, Illinois, Kentucky, Tennessee and since June 23, 2022 known to infest parts of North Carolina. At present, there are over 130+ host species for this insect including maples, birches, oaks, sycamores, roses, grapes, apples, and many others. Two preferred hosts for this pest that North Carolina has in abundance are Tree of Heaven (TOH, Ailanthus altissima) and Chinaberry (CB, Melia azedarach), both of which support SLF populations in

their native range and are generally considered invasive in the U.S., thrive in disturbed habitats like railway and highway right of ways. The greatest risk of spread for SLF is through human assisted means via trucking, rail, and generally via interstate commerce and shipping. Accordingly, there are clear patterns indicating that SLF has reached these 17 states in a short 9-year span in this manner. Seeing this threat expanding, North Carolina was very proactive and received both specialty crop and PPA-7721 funding to do work related to spotted lanternfly preparedness like outreach to vulnerable industries, surveys for Tree of Heaven, and the acquisition of materials that would be needed to treat an infestation. Without those outreach efforts, it is unclear whether we would have discovered our known infestation by now or not. North Carolina has had two full seasons of treating for SLF at the Kernersville infestation and continue to receive reports from varying North Carolina locales with reports of SLF. Each report continues to be investigated based on perceived risk. Both citizen reports and management activities are discussed below.

SLF Reports

In calendar year 2023, Plant Industry Division received approximately 100 citizen reports of invasive insects, the vast majority of which were for Spotted Lanternfly. Of those reports, 85% were from outside of the primary infestation area. Less than 5% of reports are for non-SLF insects or other groups such as hammerhead worms, northern giant hornet, or Asian longhorned beetle. Investigations of these sites yielded only two significant findings.

The first was in Buncombe Co. The resident had relocated from Pennsylvania to the greater Asheville area and had brought lawn furniture that was stored outside with them to North Carolina. Since the resident had knowledge of the SLF life cycle, they alerted NCDA immediately when the first nymph was spotted. NCDA field staff responded to the report with a detector canine in tow. One egg mass was found and destroyed. The homeowner found an additional nymph after the initial investigation which they killed just like the first. Surveys were conducted in the surrounding area by one temporary employee through mid-October. Tree of Heaven was mapped, but no SLF were found.

One survey finding of SLF in Surry County in July warranted treatment. On July 12th while performing a monthly trap check and visual survey (see “Circle Traps”), the trapper observed SLF adults. The parcel borders an SLF-positive county in Virginia. Treatment crews were deployed the next day and all but one TOH were killed with triclopyr 3. The remaining tree where the first SLF was found was treated with Transtect. It has the most exposure to incoming vehicles and will function as a “trap tree”. On follow-up surveys, no additional live SLF were detected at this location in 2023. NCDOT owns and manages the parcel in question. We have begun working with them on preventative treatment plans for 2024. They have the capacity to utilize drones for aerial applications of pesticides. While they applied for a PPA 7721 grant to conduct pilot treatments at this site, they were not approved for funding. They are actively exploring DOT-funded opportunities to conduct these treatments. If they are successful, we will continue to partner with them for future treatments.

Additional follow up site visits for these two locations are planned in the spring of 2024 to make sure no population is established. Other reports where living or dead spotted lanternfly were reported include Washington, Alamance, Durham, and Wake counties. Follow up investigations at these sites yielded no additional findings or suspicions of establishment but will be followed up on as time allows by detector canines in 2024. The vast majority of reports remain misidentifications with giant leopard moth, various stinkbugs, hibiscus scentless plant bug nymphs, and boxelder/milkweed bugs being the most commonly mistaken for SLF.

Kernersville Infestation Management

Treatment

NCDA&CS rekindled operations on the first week of April by treating with Bifenthrin for newly emerged nymphs on April 4th – April 6th. This was approximately 1 week after the first nymphs were noted on March 27th. Future treatments in early spring likely need bumped back into April if other programs allow for it, to capture a greater percentage of emerged nymphs. Increased residual activity of usable products could also be extremely valuable at this time, as an alternative. Our second planned Spotted Lanternfly treatment occurred the week of June 26th-June 30th. We utilized 7-9 staff each day to apply Transtect to TOH on priority parcels via backpack sprayers. We also utilized triclopyr-3 applied foliarly or in conjunction with tree girdling to remove various diameter TOH when possible. While this week was extremely productive, visual surveys indicated a slight expansion of the outer bounds of our infestation zone and another round of spraying was scheduled. To accommodate more people for extended treatment we utilized a local hotel in the Kernersville area to house staff coming from long distances. This brought our treatment crew numbers up from 7-9 per day to 8-13 per day. This was the last treatment carried out under this agreement. Table 4.9 summarizes the extent of the work accomplished during calendar year 2023. One additional bifenthrin spray was executed in October where only one day of spraying was conducted due to an inability to justify bifenthrin spray due to reduced SLF adult numbers at this time.

Table 4.9: *Treatment totals for calendar year 2023 treatment activities.*

Buffer Size	Total Parcels Treated	Total Acres Treated*	% Of Treated Acres	Total DBH	Gallons of Transtect
Quarter Mile	14	85.7	47.2	1251	10.4
Half Mile	14	79.2	21.0	991	8.3
One Mile	30	471.1	30.1	3940	32.8
Two Mile	70	1316.5	18.7	8485	70.7
Five Mile	11	156.2	0.4	3460	28.8
TOTALS	139	2108.6	117.4	18127.0	151.1

**- indicates total acres of parcels treated not the exact acreage receiving treatment.*

Winter Egg Mass Surveys and QC

Winter egg mass surveys began in earnest in December of 2022 although we recognize now that we can likely begin in November since SLF seem to move very little and die off, regardless of environmental conditions, in November. This phenomenon was monitored in late 2023 where adults seemed more persistent in the environment into early December. We believe this extended adult persistence is due to very mild November weather. The winter egg mass survey has 2 main goals: 1) Quantification of egg mass surveys in parcels where live SLF were detected in 2022 & 2023, and 2) A quality control "grid survey" of 10 x 1 sq. mi. grids outside the detection areas of SLF. Each of the grid survey areas were deemed high risk by virtue of having businesses associated with out-of-state shipping or travel (e.g., shipping centers, horse training facilities, etc.) for winter 2022-2023 and randomly assigned in winter 2023-2024.

During the winter of 2022-2023, a total of 442 sites were surveyed for egg masses yielding 381 sites with egg masses present totaling 1,807 egg masses on 20+ species of tree/plant/vine. Egg mass surveys ran from December 7th, 2022 – May 16th, 2023. All eggs appeared to have hatched by April 19th, over a month before some northern states see complete hatch. Figure 4.11.a shows how many egg masses were found on which tree species or species groups (e.g. oaks). This graph does not reflect preference or density of egg masses per tree species, however; the average number lain on TOH was 3.4 masses/tree while some willow trees had over 50 masses/tree.

The egg mass survey for winter 2023-2024 began on November 27th. By year end 2023, 92 sites had been surveyed. Across the 68 positive sites, a total of 131 egg masses were found. The furthest egg mass at present is approximately 5 miles west of the estimated centroid of the infestation while the majority of finds were within 1.75 miles of that centroid. Host tree oviposition data are shown in Figure 4.11.b. NCDA temporaries and permanent staff surveyed 156 parcels of which 41 parcels were positive for SLF egg masses.

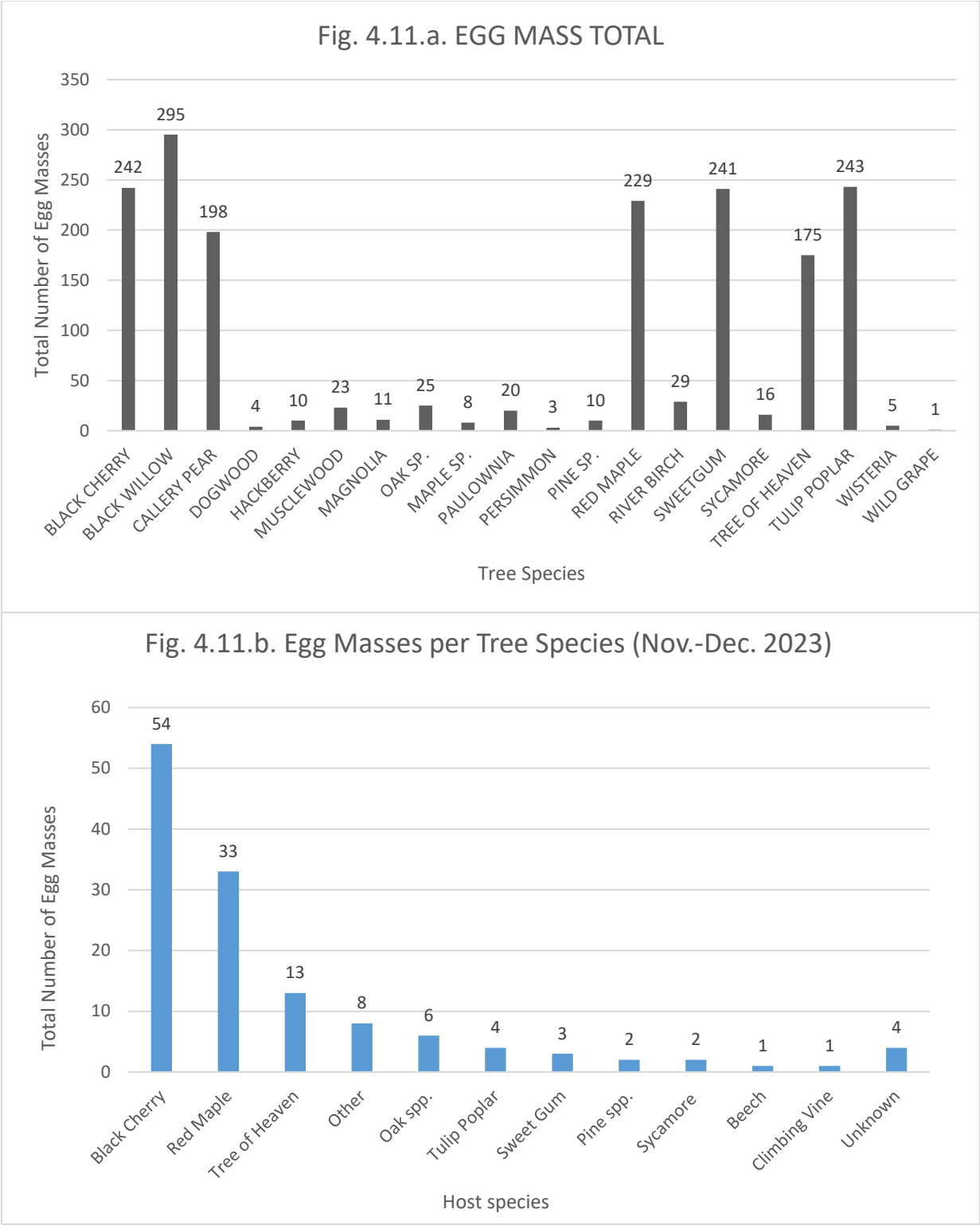


Figure 4.11: *Extent and scope of egg mass surveys performed during winter 2022-2023 (a) and November – December 2023 (b). (NOTE: Other is made up of mulberry, hackberry, holly, mimosa, unidentified and others. Climbing vines include honeysuckle, wild grape, poison ivy, etc.)*

Statewide SLF Survey

7 PID temporary employees conducted visual surveys for SLF and its preferred host trees, (tree-of-heaven and chinaberry tree) and placed circle traps at a total of 60 high-risk locations throughout the state (Table 4.10). All data were collected through an ESRI Field Maps application created by our GIS Specialist James Goethe.

Host Tree Visual Survey

Approximately 1,084 sites were inspected for TOH and spotted lanternfly throughout North Carolina while conducting this survey during calendar year 2023 (Figure 4.12). In total, 7 temporary employees and 22 full-time employees participated in this survey in 2023. Since the statewide survey first began in 2020, we have surveyed 94 of our 100 counties. The remaining 6 counties are on the eastern and western extremities of our state, have low climate suitability for TOH, CB, or both, and are either very rural and/or host large wildlife refuges, reducing the likelihood of pest introductions. While improvements are constantly being made, no major changes were implemented in 2023, but rather, the changes previously implemented were used to good effect in data collection.

Circle Traps

Circle traps with a methyl salicylate lure were placed by CAPS trappers at locations vulnerable to SLF by high introduction or high damage risk. Visual surveys were conducted at each of these locations every month, in addition to servicing the traps. Sixty total traps were placed in 2023, of which 27 were placed at vineyards, 22 along transportation pathways, 9 tourism areas, and 2 previous SLF report sites. These were placed primarily in conjunction with other CAPS survey traps that share pest introduction risk/ vulnerability, such as the Grape Commodity and Asian Defoliators surveys. Spotted lanternfly was detected at one of these sites in Surry County by the CAPS surveyor (see "SLF Reports" above).

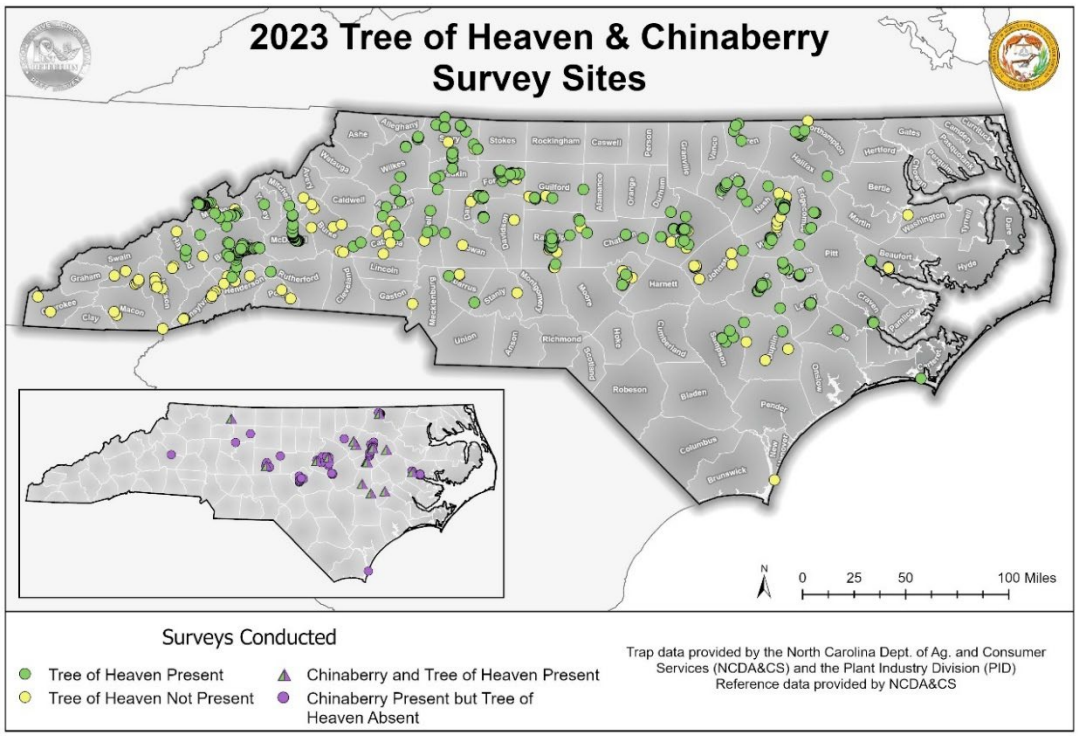


Figure 4.12: *A. altissima (TOH) and M. azedarach (CB) observations in North Carolina in 2023.*

Table 4.10. *SLF statewide survey activities 2023 (excluding infested area)*

Survey Detections	Reporting period (2023)	Total (all years)
Infested tree detections	1	1
Tree-of-heaven sightings	752	11,954
Chinaberry sightings (TOH present)	19	119
Negative tree of heaven sightings	328	2,723
Chinaberry sightings (TOH absent)	113	1,260
Circle trap survey locations (thru Dec. 2023)	60	133
Counties surveyed	53	94

BROWN GARDEN SNAIL PROGRAM

The brown garden snail (Cornu aspersum; BGS) was intentionally and illegally introduced into a small area in Kill Devil Hills (Dare County), North Carolina in the mid-1980s as part of a project intended to raise and sell these mollusks to restaurants and businesses (heliculture farming, which is prohibited in North Carolina). BGSs are a non-native species of mollusk that can be a potentially destructive pest for agriculture, and specifically the nursery industry.

Since BGS was reported in North Carolina, and a small population was established in the Kill Devil Hills area, NCDA&CS has been monitoring and containing its spread with periodic applications of molluscicides (Sluggo®) and by manually killing snails.

WALNUT TWIG BEETLE (THOUSAND CANKERS)

The walnut twig beetle (Pityopthorus juglandis) is a vector of a serious disease of forest trees affecting primarily black walnuts (Juglans nigra) and butternuts (Juglans cinerea) called thousand cankers disease (Geosmithia morbida; TCD). Our plant pathologist no longer operates this program, but we do still identify walnut twig beetle for NC Forest Service. The provided specimens for 2023 were negative for walnut twig beetle.

MOVEMENT OF LIVE ARTHROPODS FOR RESEARCH, COMMERCIAL, OR EDUCATION PURPOSES

The Entomological Programs Manager evaluated approx. 163 federal applications for PPQ 526 e-Permits in 2023. The large number of applications to move insects into North Carolina reflects the continued strong market in entomological research, commerce, and education in the state conducted by our public and private institutions.

CURRENT INSECT QUARANTINES IN NORTH CAROLINA

Regulatory Species	**Quarantines as of December 2023**
Spongy Moth (*Lymantria dispar*)	**Currituck County** and a small portion of **Dare County.** Quarantine area remained unchanged relative to 2017.
Imported Fire Ant (*Solenopsis invicta*)	Expanded to include all of Alamance, Burke, Guilford, Jackson, and McDowell counties. A total of **77 counties** are under entire or partial quarantine in NC.
Sweetpotato weevil (*Cylas formicarius*)	Coastal areas of **Brunswick** (Caswell Beach) and **New Hanover** (Carolina Beach and Kure Beach) counties.

Nursery Certification Program

Prepared by Joy Goforth

NCDA&CS' Plant Protection Specialists inspected 4,058 nursery dealers and nurseries during the 2023 season.

A license issued by the NCDA&CS is required by any person selling nursery stock in North Carolina. Nursery stock is defined as "all wild or cultivated plants or parts thereof, trees, shrubs, vines, bulbous plants and roots, grafts, scions and buds." Excluded in North Carolina's definition of nursery stock are "annual plants; cut flowers; tree, field, vegetable, flower or other true seeds; decorative plants or plant parts without roots not intended for propagation; and perennial plants intended for indoor use that are produced in North Carolina." A nursery license is required for any person growing and selling nursery stock whereas a nursery dealer license is required for any person obtaining and re-selling nursery stock. These licenses certify that plant material has been inspected for and is apparently free from potentially harmful quarantine pests and must be renewed yearly.

The NCDA&CS Plant Protection Section licensed 1,360 nurseries and 2,698 nursery dealers during the 2023 calendar year (Table 5.1). Of the 1,360 nurseries, 672 were registered nurseries and 688 were certified nurseries. A registered nursery has less than one acre of nursery stock and does not sell outside the state. A certified nursery has one or more acre of nursery stock and/or sells outside the state.

The data show a slight increase in nurseries and nursery dealers. The green industry remains incredibly strong in North Carolina and interstate shipping of plant material has been bolstered by increased online sales and homeowner direct shipments. The continuing uptick in nursery licensure has been fueled by small producers wanting to sell at Farmer's Markets and local venues and small nursery or backyard producers who wish to market their plants online.

Table 5.1. Number of NC nursery and nursery dealer licenses by year[1]

Calendar Year	Number of Licenses by Category			Total Number of Licenses	
	Registered Nursery[2]	Certified Nursery[3]	Nursery Dealer[4]	Nurseries (Registered & Certified)	Nurseries & Dealers
2014	590	654	2,782	1,244	4,026
2015	594	612	3,188	1,206	4,394
2016	642	651	2,957	1,293	4,250
2017	620	646	2,858	1,266	4,124
2018	515	610	2,043	1,125	3,168
2019	504	602	1,697	1,106	2,803
2020	498	615	1,879	1,113	2,992
2021	601	649	1,629	1,250	2,879
2022	643	660	2,796	1,303	4,099
2023	672	688	2,698	1,360	4,058

[1] Data based on receipt of license fees.
[2] Registered nursery – a location with less than once acre of nursery stock with no sales outside the state.
[3] Certified nursery – a location with one or more acre of nursery stock and/or sales outside the state.
[4] Nursery dealer – a location where nursery stock is sold, usually to the end user, but not actually grown.

The primary objective of Plant Industry's Nursery Program is to facilitate the movement of nursery stock while preventing the introduction and spread of quarantine plant pests into and within North Carolina. The movement of infested nursery stock represents one of the ways plant pests may be moved from one location to another and has the potential to directly impact both wholesale and retail nursery operations. North Carolina works to prevent such outbreaks by coordinating with other states and nursery industry to bring awareness of threats to the state.

Stop sale/movement notices are issued when high levels of pests and/or prohibited plants are noted. Plants can either be treated and/or destroyed when a stop sale/movement notice is issued. Plants can be released for sale/movement if testing of the material confirms they are free of the suspected pest(s). In 2023 five (5) official Stop Sales were issued for regulatory violations. Four (4) stop sale/movement notices were issued for Pieris japonica shipments from California associated with a Phytophthora ramorum (Sudden Oak Death) positive and one (1) individual stop sale/movement notices was issued for boxwood blight at a retail nursery.

Phytosanitary and Export Certification Program

Within the Phytosanitary and Export Certification Program, Plant Protection Specialists issue phytosanitary certificates to growers and/or brokers to facilitate movement of agricultural commodities to other states and to other countries. Phytosanitary certificates indicate that inspections and other specific requirements of the importing states or countries have been met. State certificates are used for movement within the U.S., and federal certificates are required for movement to another country. Countries and states vary greatly in what they require for various types of commodities such that careful research and interpretation of requirements are needed for each request for phytosanitary certification.

A phytosanitary certificate provides documentation that a plant, plant part, or plant-based product has been inspected and is apparently free of harmful pests. Each state and country has very specific import phytosanitary requirements tailored to protect their agricultural industries and natural environment from potentially harmful pests.

The NCDA&CS Plant Protection and Export Certification Specialists facilitate interstate and international movement of plants, plant parts, and plant-based products by issuing both state and federal phytosanitary certificates to NC growers and brokers. State and federal phytosanitary certificates are issued for interstate and international movement, respectively. The NCDA&CS is responsible for implementing the state export program while the USDA is responsible for implementing the federal export program. However, the NCDA&CS works in collaboration with the USDA to issue federal phytosanitary certificates to support international export of plant-based products from NC.

Primary use of the USDA PCIT (Phytosanitary Certificate Issuance and Tracking) System to issue federal certificates began in October 2009. The number of federal and state phytosanitary certificates issued using the PCIT system is included in Table 5.2. In 2023, NCDA&CS staff issued 9,389 federal phytosanitary certificates and 1,682 state phytosanitary certificates. North Carolina Agricultural exports remain strong and a significant job responsibility for field staff. The majority of the NCDA&CS issued federal phytosanitary certificates in 2023 continue to be for sweet potatoes and lumber exports. During the calendar year, federal phytosanitary certificates were also issued for lumber, logs, tobacco, cotton seed, corn, soybean, blueberries, stevia, hemp, Christmas trees and cut greenery, science kits containing plant material, peanuts, houseplants, nursery and greenhouse plants and other exported agricultural commodities. Federal Certificates were issued for the movement of commodities to 95 countries, while state certificates were issued for 38 states, Puerto Rico, Guam and the US Virgin

Islands. 40% of our federal phytosanitary certificates were for commodities going to the European Union with sweet potatoes destined for Netherlands being the top recipient of certificates issued by NCDA&CS. An additional 18.7% of the 2023 federal phytosanitary certificates were issued to the United Kingdom, 17.4% were to Viet Nam and 11.6 % transited to China. Phytosanitary certificates issued for shipments to China continue to be on the decline. Canada and Mexico combined comprise less than 9% of the phytosanitary certificates issued in 2023.

Table 5.2. Number of phytosanitary certificates issued through the PCIT[1] system

Fiscal Year	Federal				State
	Plant or Plant Part	Re-export	Processed Plant Product	Total	Total
2010/2011	2,781	21	0	2,808	323
2011/2012	4,221	13	18	4,252	206
2013 (Calendar Year)	5,830	15	134	6,658	412
2014 (Calendar Year)	6,980	32	172	7,184	348
2015 (Calendar Year)	6,560	21	162	6,743	561
2016 (Calendar Year)	7,140	17	199	7,356	703
2017 (Calendar Year)	7,932	15	91	8,038	580
2018 (Calendar Year)	7,729	15	18	7,762	951
2019 (Calendar Year)	9,179	24	30	9,233	3,191
2020 (Calendar Year)	10,529	16	1	10,546	1,903
2021 (Calendar Year)	8,635	13	0	8,648	864
2022 (Calendar Year)	9,677	16	0	9,693	813
2023 (Calendar Year)	9,677	16	0	9,693	1,683

[1] PCIT = Phytosanitary Certificate Issuance and Tracking (USDA web-based application)

Plant Conservation Program – Section 6

Prepared by Julian Wilson

Governance

The Plant Conservation Program (PCP) meets quarterly with members of the NC Plant Conservation Board (the Board) whose seven members are appointed by either the Governor or the Commissioner of Agriculture for four-year terms. Board members in 2023 included: Julie Moore (Chairperson), David Hyatt, Jonathan Lanier, Esq., Dr. Bruce Williams, Jim Slye, Dr. Gary Walker, and Mike Kunz. Dr. Matt Estep was appointed to fill the position vacated by Dr. Gary Walker in October 2023. PCP also meets regularly with members of the NC Plant Conservation Scientific Committee. This seven-member committee primarily consists of positions designated to the committee by law. Members include Dr. Alan Weakley (chair), Dr. Richard Braham, Dr. Johnny Randall, Hervey McIver, Brenda Wichmann, Dr. Shannon Currey, and Jerry Reynolds. In 2023, the positions held by Dr. Johnny Randall, Brenda Wichmann, and Hervey McIver all experienced turnover. The position representing the NC Botanical Garden was held by Dr. Johnny Randall until September 2023. Mike Kunz has been appointed to fill that position going forward. The position representing the NC Natural Heritage Program, previously held by Brenda Wichmann, was not filled until the hiring of Andy Walker in January 2024. In the interim, Misty Buchanan representing the interests of the NC Natural Heritage Program on the Scientific Committee. The position representing a Conservation Organization has not yet been filled, previously held by Hervey McIver of The Nature Conservancy.

Staffing

In 2023, PCP experienced significant staff changes. The Plant Conservation Program Manager position was vacated by the departure of Lesley Starke in March 2023. Julian Wilson, the new Plant Conservation Program Manager, was hired and transferred from her previous position with the NC Forest Service in September 2023. The Administrative Assistant position previously held by Lori Wright was vacant until Anabela Ramalho was hired in May 2023. These two positions represent half of PCP's full-time staff. Other full-time staff include Geoff Austin, Land Management Ecologist, and Katherine Culatta, Botanist and Research Specialist. Grant funds from the US Fish and Wildlife Service (USFWS) currently fund Katherine's position as well as several part-time field technicians: 1 (Kathryn Loughran) in the mountains, 2 (Jacob Cochran, vacant – previously Ben Pugh) in the Raleigh/Durham area, 1 (Nathan Jones) in the Charlotte area, and 3 in the coastal plain (Miller Caison, HL Rich, and Barry McQueen).

United States Fish and Wildlife Service (USFWS) Partnership

In 2023, PCP and USFWS continued a long-standing cooperative agreement related to the recovery of endangered and threatened plant species in North Carolina. In September of 2022, the Cooperative Agreement was updated to include at-risk species, or species being reviewed for listing by the Service. This was the first update to this document since it's origination in 1981. No substantive changes were made to this agreement in 2023. Grant funds obtained via this cooperative agreement provide critical recovery resources to North Carolina each year. This funding covers the program's research specialist position and a portion of the remaining funds support PCP temporary employees for part of the year. More specifically, the funding from this partnership supports imperiled plant monitoring; preserve management targeted towards federally-listed, candidate, and at-risk plant species; and regulatory programs including protected plant permit evaluation and issuance.

PCP has multiple ongoing projects funded by various USFWS grants including developing management plans for Plant Conservation Preserves and research and restoration for endangered plant species.

Regulatory Programs

The Plant Conservation Program is responsible for the protection and conservation of the NC Protected Plant List which currently includes 462 species, of which 28 are also federally listed. One of the protections for state listed plant species is that wild collection and the sale of wild individuals are both prohibited without a permit from PCP. Thus, the PCP staff convenes regular meetings with an interagency panel to review permit requests affecting these protected plant species. PCP reviews permit requests from individuals, research institutions, agencies, and others requesting to move or collect protected plants, including all state and federally listed plant species in North Carolina. This permit requirement applies to transplant and rescue projects, nurseries which propagate, sell, and export protected species, as well as many scientific research projects. The review process incorporates input from the US Fish and Wildlife Service, NC Natural Heritage Program, and advisory capacity from NC Botanical Garden.

Twenty-two protected plant permits were issued, and several additional requests were evaluated during 2023. This includes 11 research permits, 8 rescue or introduction permits, and 3 non-nursery Certificates of Origin. PCP works with the Plant Protection Section to issue Certificates of Origin for protected plant species being propagated for sale as part of the nursery inspection process carried out by PID plant pest specialists. Seventy-three Certificates of Origin were issued for the sale of listed plants in 2023. Twenty-three listed species had Certificates of Origin, the most common being Venus flytrap (Dionaea muscipula), with 21 Certificates of Origin issued. Bristle-leaf Sedge (Carex eburnean) was the second most common protected plant for which a Certificate of Origin was issued, with 16 issued in 2023. Goldenseal (Hydrastis canadensis) had been the second most commonly certified protected plant in 2022 (10 issued), but only one certificate was issued in 2023.

PCP also administers the American ginseng (Panax quinquefolius) dealer licensing program for North Carolina. North Carolina American ginseng dealer licenses are issued annually prior to the opening of the harvest season which begins September 1st and ends December 31st. Licensed dealers may buy and sell ginseng during the buying season and must submit purchase records to PCP no less than once per month throughout the season. Copies of all purchase records must be retained by the dealers for inspection along with the roots at the time of certification for export. Copies of all export certificates are also submitted to PCP to help track not only the level of harvest per year in the state, but the volume exported as well. In the 2023 season, PCP licensed 25 resident and 10 non-resident ginseng dealers.

For North Carolina's 2022-2023 ginseng buying season (which closed March 31st of 2023), plant pest specialists inspected and certified a calculated dry weight of 4,431 lbs of American ginseng for export. The vast majority (97.62%) of ginseng roots were wild harvested, totaling 4,325 lbs. (calculated dry weight), with the remainder being wild simulated (97.59 lbs. calculated dry weight) and artificially propagated (8 lbs. calculated dry weight). To understand how many plants are represented by these reports of total dry weights of ginseng roots, the standard is to multiply the total weight by 300 as an approximate number of dry roots per pound. **For 2022-2023, PCP estimates that approximately 1,329,300 American ginseng plants were harvested from the wild in North Carolina.** Although this number fluctuates year to year, PCP estimates that over 1 million plants are harvested for export every year.

Illegal harvest of American ginseng is a documented problem in North Carolina and throughout the species' range. In North Carolina, the Wildlife Resources Commission (WRC) has partnered with NCDA to facilitate the enforcement of legal protections for this species. The Commission provides an annual report of processed ginseng crimes in their 8th and 9th Districts. In 2023, WRC law enforcement staff reported a total of 55 cases/charges across 12 counties. Most of these cases were concentrated in Haywood (13), Macon (11), and Jackson (8) counties, with 1-4 cases in each of the following counties: Buncombe, Burke, Cherokee, Graham, Madison,

McDowell, Mitchell, Polk, and Yancey. This was a notable increase in cases compared to only 24 cases in 2022 (2021 - 35 cases, 2020 - 49 cases). There are four counties which have had one or more violations in each of the four reporting years: Haywood, Macon, Madison, and McDowell.

In some cases, ginseng material was seized and reported. In 2023, officers seized 3,823 roots, a vast majority of which were confiscated during a single case in which 1,470 roots were seized. The total roots seized in 2023 was a significant increase from a relatively low 740 roots confiscated in the 2022 harvest season. Prior years were higher, with over 3,600 roots confiscated in 2020 and over 1,100 in 2021.

Friends of Plant Conservation

The Plant Conservation Program's closest partner is the Friends of Plant Conservation, Inc. (FOPC), a non-profit membership organization dedicated to supporting the mission of PCP. FOPC helps with fundraising and expands PCP's capacity for education and outreach as well as stewardship of the Plant Conservation Preserves. In partnership with NatureServe, PCP hosted a public education tour at Picture Creek Diabase Barrens, an important plant conservation area in Granville County. FoPC also secured funding from USFWS Partners program for habitat restoration work that concluded in 2023 on a PCP preserve and neighboring private land.

PCP also partnered with FOPC for workday events across the state: four for rare species monitoring, four for habitat management, and one for a graduate-level research project. The habitat management workday tasks ranged from removal of invasive species to planting of native plants. PCP staff prepared content for FOPC social media posts and newsletter articles regarding the hands-on conservation and management strategies being employed to protect and recover imperiled species across the state. In 2023, FOPC also supported the land management work conducted by PCP by purchasing over $8,000 of equipment and supplies to restore and maintain rare plant habitats.

Other Outreach and Partnerships

The Plant Conservation Program is a member of several statewide or regional conservation partnerships. Examples include the Bog Learning Network, the Southern Blue Ridge Fire Learning Network, Southeastern Plant Conservation Alliance, the Sandhills Conservation Partnership, and the Greater Uwharrie Conservation Partnership. In 2023, PCP collaborated with NC Botanical Garden and NC Natural Heritage Program staff to plan and host the Rare Plant Conservation Discussion Meeting on April 4, 2023 at the NC Botanical Garden. This annual one-day meeting had been suspended during the COVID-19 pandemic. The 2023 in-person meeting brought together approximately 80 people including state and federal agency staff, university students and faculty, and representatives of conservation non-profit organizations to share presentations and hold discussions and pose questions regarding rare plant research. PCP staff presented on general program updates and the conclusion of a USFWS Partners grant project with FoPC. These meetings provide a good opportunity for PCP to keep current on ongoing research and communicate with current and future partners in rare plant conservation.

PCP Staff has also provided leadership in the development of the first North Carolina Plant Conservation Alliance (PCA). The goals of this partnership of plant conservation organizations and agencies is to maximize positive outcomes from collective efforts in plant conservation and where possible, to leverage resources to be efficient and effective. Within the southeast region, most of the states have developed such alliances and coordinate at the regional level through the Southeastern Plant Conservation Alliance. By working together this way, the member groups anticipate more strategic recovery actions for the most imperiled plants in the southeast. In past years, representatives from NCBG, NHP, and PCP have spearheaded NC PCA efforts. Due to staff changes and turnover at all three organization in 2023, minimal progress was made but coordination efforts are anticipated to pick up in 2024.

In addition, PCP outreach to the public includes special presentations and by filling information requests. In 2023, PCP staff gave invited public lectures for the NC Native Plant Society at Morrow Mountain and advised Camp Butner on fire management.

North Carolina Plant Conservation Preserve System

The Plant Conservation Program, through the Plant Conservation Board, has the regulatory mandate to establish conservation programs for the long-term sustainability of the state's native flora. One of PCP's primary approaches to this is the establishment and management of Plant Conservation Preserves to protect imperiled plant species (Figure 1). These Preserves are the only state-managed lands selected and designed specifically for the conservation of plant species. Due to concerns about resource damage and plant poaching, access is generally limited to guided tours or to visits authorized by written permission issued by PCP. PCP Preserves serve as study sites for researchers of various disciplines including botany, geology, and herpetology. Fifteen preserve access permits were issued for research ranging from botanical projects to geology research to insect surveys in 2023. To help educate and engage the public about rare plants and their conservation, PCP conducts guided preserve tours and gives presentations and lectures for the public throughout the year in collaboration with the Friends of Plant Conservation. The Preserve system consists of 26 Preserves distributed across North Carolina covering close to 14,500 acres (see map below).

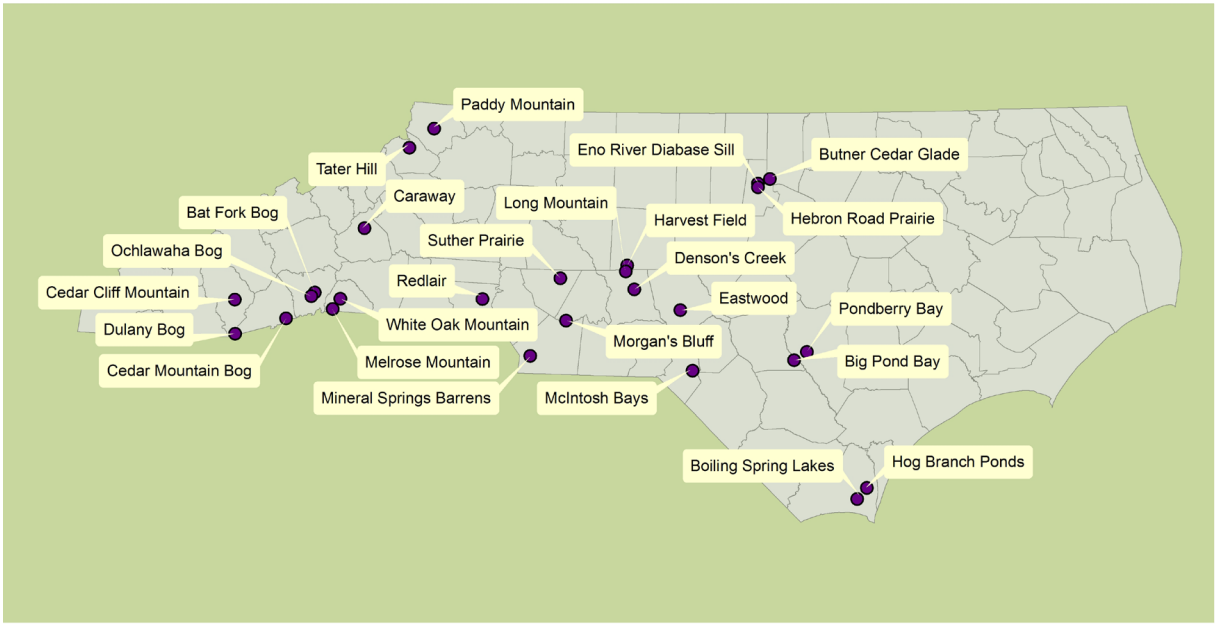


Figure 6.1. ***PCP Preserves of North Carolina***

Preserve Management

Management and protection of Plant Conservation Preserves and other selected sites is a key component of the NC Plant Conservation Program's (PCP) efforts to recover listed plant species in North Carolina. Active management is needed to meet the intent of the Endangered Species Act, which has the stated goal of conserving the ecosystems upon which listed species depend. Many of the sites where these species occur have been degraded by lack of management and/or incompatible land-use practices; active management as well as restoration efforts are urgently needed at these sites. PCP routinely works with other agencies and landowners to complement management of their lands for the benefit of rare plants and habitats.

In 2023, PCP staff focused on habitat restoration for the following projects and sites:

- Bunched Arrowhead (Sagittaria fasciculata)- Continued habitat restoration at Bat Fork Bog and Ochlawaha Bog Preserves in Henderson County
- Smooth Coneflower (Echinacea laevigata)- Continued habitat restoration in multiple protected sites in Durham and Granville Counties
- Schweinitz's Sunflower (Helianthus schweinitzii)- Continued habitat restoration at four PCP Preserves located in Gaston, Union, Randolph, and Montgomery Counties
- Rough-leaved Loosestrife (Lysimachia asperulifolia) and Venus Flytrap (Dionaea muscipula)- Continued habitat restoration at Boiling Spring Lakes and Hog Branch Ponds Preserves in Brunswick County
- Mountain Sweet Pitcherplant (Sarracenia jonesii), Mountain Purple Pitcherplant (S. purpurea var. mon tana), and Swamp Pink (Helonias bullata)- Continued habitat restoration at Cedar Mountain Bog and Dula ny Bog Preserves in Transylvania and Jackson Counties respectively
- Pondberry (Lindera melissifolia) and Pondspice (Litsea aestivalis) – Continued habitat restoration at Pond berry Bay Preserve in Sampson County
- Northern Oconee Bells (Shortia brevistyla)—Continued habitat restoration at Caraway Preserve in Mc Dowell County.
- Canby's Dropwort (Tiedmannia canbyi) and associated species—Continued habitat restoration at McIntosh Bays Preserve in Scotland County
- Sandhills Lily (Lilium pyrophilum)—Continued habitat restoration at Eastwood Preserve in Moore County
- Canada Lily (Lilium canadense)—Continued habitat restoration at Suther Prairie Preserve in Cabarrus County

Invasive species control

Invasive species control remains one of the most time and resource intensive habitat management strategies employed at the PCP Preserves. Invasive species control is also one of the most important habitat restoration strategies land managers use to maintain high quality rare species habitats. There are a multitude of important invasive species, some with regional importance including, but not limited to, Japanese Stiltgrass, Japanese Honeysuckle, Wisteria, Chinese and Japanese Privet, Japanese False Hawksbeard, Kudzu, Reed Canary-grass, American Bittersweet, Porcelainberry, Lesser Celandine, Tree of Heaven, Princess Tree, Chinaberry, Multiflora Rose, Marsh Dewflower, Purple Loosestrife, and several more. PCP uses a variety of control methods all custom fit to the sensitivity of the site. Where effective and safe PCP staff use herbicide in the most selective application method appropriate. Where herbicides are unsafe, staff use mechanical methods to remove plants.

Table 6.1. Prescribed burns that occurred on PCP Preserves in 2023.

Preserve	County	Burn Unit	Date	Acres	Target species
Cedar Mountain Bog	Transylvania	1ABC, 3ABC	4/13/2023	49.6	Mountain bog community
Eastwood	Moore	1EF	1/20/2023	131	Longleaf pine communities
Eno River Diabase Sill	Durham	1AB	4/21/2023	13	Shortleaf-oak-hickory
Pondberry Bay	Sampson	2AB, 4A, 5CD	2/28/2023	315	Longleaf pine communities
Suther Prairie	Cabarrus	N/A	9/6/2023	10	Piedmont prairie community

Rare Species Monitoring

Understanding the current status and trends of the populations we protect is very important thus PCP has been collecting flowering data on several species across the state. This year census and/or population monitoring work was conducted for the following federally listed species:

- Bunched arrowhead (Sagittaria fasciculata) - Henderson Co. (2 sites)
- Canby's dropwort (Oxypolis canbyi) - Scotland Co. (1 site)
- Heller's blazing star (Liatris helleri) - Ashe Co. (1 site)
- Michaux's sumac (Rhus michauxii) – Durham Co. (1 site)
- Mountain sweet pitcher plant (Sarracenia jonesii) - Transylvania Co. (1 site)
- Pondberry (Lindera melissifolia) – Sampson Co. (1 site)
- Rough-leaved loosestrife (Lysimachia asperulifolia) – Brunswick Co. (2 sites)
- Schweinitz's sunflower (Helianthus schweinitzii) - Randolph, Montgomery, Union, Gaston Cos. (4 sites)
- Smooth coneflower (Echinacea laevigata) - Durham, Granville Cos. (5 sites)
- Swamp pink (Helonias bullata) - Henderson, Transylvania Cos. (2 sites)
- White irisette (Sisyrinchium dichotomum) – Polk Co. (2 sites)

Additional state-listed and rare plant surveys/monitoring conducted this year:

- Canada lily (Lilium canadense) - Henderson and Cabarrus Cos. (2 site)
- Carolina hemlock (Tsuga caroliniana) – Ashe Co. (1 site)
- Hoary puccoon (Lithospermum canescens) Durham and Granville Cos. (5 sites)
- Savanna milkweed (Asclepias pedicellata) – Brunswick Co. (1 site)
- Eastern Prairie Wild Blue Indigo (Baptisia aberrans) – Durham Co. (1 site)
- Cuthbert's turtlehead (Chelone cuthbertii) – Transylvania Co. (1 site)
- Keeled bulrush (Isolepis carinata) – Union Co. (1 site)
- Wright's cliffbrake (Pellaea wrightiana) – Stanly Co. (1 site)
- Quillwort arrowhead (Rhexia aristosa) – Scotland (1 site)
- Georgia aster (Symphyotrichum georgianum) – Union Co. (1 site)
- Veined skullcap (Scutellaria nervosa) – Granville Co. (1 site)

Plant Pathology Program

Tomato Brown Rugose Fruit Virus (ToBRFV)

Tomato brown rugose fruit virus (ToBRFV), a Tobamovirus in the family Virgaviridae, was first identified in 2014 (Luria et al., 2017). ToBRFV has caused severe economic impacts in greenhouse-grown tomatoes (Solanum lycopersicum) and peppers (Capsicum spp.) by rendering the fruits unmarketable. On tomatoes, typical fruit symptoms include yellowing, yellow spots, green grooves, deformation, and, rarely, irregular brown spots; leaves, particularly young leaves, of tomato plants infected by ToBRFV exhibit mild to severe mosaic symptoms with dark green bulges, narrowness, and deformation; disease incidence can range from 50 to 100 percent. The virus affects mainly protected production (greenhouses and screenhouses), but outbreaks have been recorded in the field (González-Concha et al., 2023; Salem et al., 2016; Yan et al., 2019).

On November 15, 2019, APHIS issued a Federal Order imposing restrictions on imports of tomato and pepper seed lots, transplants, and fruit from all countries where tomato brown rugose fruit virus exists. These actions went into effect Friday, November 22, 2019.

Figure 7.1, Symptoms of Tomato brown rugose fruit virus. Upper left: leaf mosaic on tomato; upper right: narrowing and blistering of tomato leaf; lower right: symptoms on green fruits; lower right: fruit with irregular maturation (EPPO Global Database).

Reference:
González-Concha, L., J. Ramírez-Gil, G. Mora-Romero, R. García-Estrada, J. Carrillo-Fasio, and J. Tovar Pedraza. 2023. Development of a scale for assessment of disease severity and impact of tomato brown rugose fruit virus on tomato yield. European Journal of Plant Pathology 165(3):579-592.
Salem, N., A. Mansour, M. Ciuffo, B. Falk, and M. Turina. 2016. A new Tobamovirus infecting tomato crops in Jordan. Archives of Virology 161(2):503-506.
Yan, Z., H. Ma, S. Han, C. Geng, Y. Tian, and X. Li. 2019. First report of Tomato brown rugose fruit virus infecting tomato in China. Plant Disease 103(11):2973.

ToBRFV positive detection in North Carolina

In mid-May of 2023, NCDA&CS and USDA APHIS determined that a broader survey and sampling approach would need to be conducted to determine if the pathogen had spread throughout a grafting facility following a USDA APHIS PPQ trace back investigation. As part of the USDA led survey, one hundred and seventy-nine samples of host plants were taken and delivered to the Texas A&M University NDPN lab for molecular testing. USDA-APHIS-PPQ made the determination to destroy all Solanaceous host seedlings at the facility in accordance with federal regulatory guidelines (See CAPS survey for details).

As of now, no other known case of ToBRFV has been found in North Carolina.

Thermal imaging detection trail for bacterial wilt, caused by *Ralstonia solanacearum*

Ralstonia solanacearum is a soil-born bacterium that causes bacterial wilt on a diverse range of host plants, including tomatoes, peppers, tobaccos, geraniums, and blueberries. USDA considers R. solanacearum to be a select agent because the pathogen has the potential to pose a severe threat to plant health. R. solanacearum can be further classified to race, based on host range, and biovar, based on their biochemical abilities to utilize a carbohydrate panel. If the race and biovar of R. solanacearum are confirmed to be race 3 biovar 2, crops may be impacted by diseases such as brown rot of potato, bacterial wilt of tomato and eggplant, and southern wilt of geranium.

In April 2020, APHIS confirmed the detection of R. solanacearum race 3 biovar 2 in a U.S. greenhouse that had purchased geranium cuttings from an offshore production facility. This is the first confirmed detection of this pathogen in a U.S. greenhouse since 2004. On June 11, 2020, APHIS and its State partners successfully completed actions to eliminate the pathogen from U.S. greenhouses.

Early symptoms of bacterial wilt can be missed easily as it resembles temporary wilting due to lack of water. This wilting is caused by the bacterium interfering with the translocation of water in infected host plant tissues. Infected plants may not be able to effectively dissipate heat through evapotranspiration (as a normally functioning leaf would be able to), thus appear slightly hotter than healthy plants. There may be thermal (infrared) foliar symptoms that are displayed prior to the presentation of diagnostic symptoms that could be useful for early disease detection. This concept has been demonstrated in other vascular pathogens such as Xylella fastidiosa (Martinez et al. 2023).

A collaborated trail with Dr. Alejandra Huerta's lab at NCSU and Dr. Paul Severns's lab at University of Georgia was conducted to evaluate the use of infrared imaging to detect bacterial wilt. Geranium, tomato, and tobacco plants were inoculated with local isolates of R. solanacearum and thermal camara was used to examine the plants for temperature differences.

Figure 7.2, Advanced symptoms of bacterial wilt on geranium (Left, USDA) and example of infrared imaging of geranium plant inoculated with *Ralstonia solanacearum*. Plant on the left, uninoculated control, plant on the right was inoculated with *R. solanacearum*.

Overall, under a controlled environment, plants infected with bacterial wilt displayed slightly higher average temperatures, ranging from a 0.5 to 1.25 degree C increase compared to uninoculated control. However, if applying this technology in a production greenhouse, more variables need to be considered. For example, any water droplet on the leaf will display as a cool spot on the plant, the placement and spacing of the plants on the greenhouse bench may experience air circulation and varying level of evapotranspiration. More research is needed. The thermal imaging approach can potentially serve as a preliminary screening during inspection. A more accurate laboratory sample diagnostic will still be required.

Reference:
Guzman Martinez, M.; Oliver, J.E.; Severns, P.M. Evidence of Xylella fastidiosa Infection and Associated Thermal Signatures in Southern Highbush Blueberry (Vaccinium corymbosum Interspecific Hybrids). Plants 2023, 12, 3562.

Boxwood Blight

Boxwood blight, caused by the fungus, Calonectria pseudonaviculata, is a major disease issue for nurseries that are growing boxwood. No boxwood species (Buxsus spp.) or varieties are completely immune to the pathogen. Typical symptoms of boxwood blight include leaf spots or blotches, rapid defoliation, and stem lesions. Leaf symptoms are most abundant during the growing season, whereas stem lesions are visible year-round (Castroagudín et al. 2020). In order to prevent the disease from spreading further into landscaping, boxwood plants found in certified nurseries and nursery dealers that are infected by the disease are destroyed, along with all host plants within a 10-feet radius.

Reference: Castroagudín V.L., Yang, X., Daughtrey, M.L., Luster, D.G., Pscheidt, J.W., Weiland, J.E., and Chouch J.A. 2020. Boxwood blight disease: a diagnostic guide. Plant health progress. 21:291-300.

Figure 7.3, Symptoms of boxwood blight (left to right): leaf spots on new growth, dark brown to black stem lesions, and underside of leaves with fungal sporulation.

Boxwood Blight Compliance Program

In February 2012, NCDA&CS developed an optional "Boxwood blight Statement Program". Under the program, a NC nursery receives a statement to accompany shipments into other states. The participating nurseries are signees to a compliance agreement and follow best management practices to prevent the introduction and spread of boxwood blight. The stipulations of the compliance agreement focus on buy-in inspection and record keeping. Plant Industry Division works with NC State University Plant Disease and Insect Clinic to assay samples for the presence of boxwood blight.

As of December 2023, there are ninety participants in the program. Currently, Tennessee and Pennsylvania are the only two states with established external quarantine for boxwood blight that require participation in a boxwood blight compliance program administered by the state.

Sudden Oak Death (SOD)/Ramorum blight caused by *Phytophthora ramorum*

Sudden oak death (SOD), caused by the fungal-like oomycete, Phytophthora ramorum, is a major threat for the North Carolina nursery industry and natural forests. The pathogen has been identified on well over 100 diverse species of plants, hosts include hardwood and conifer trees, shrubs, herbaceous plants and ferns. An official list of host plants as of 2022 is maintained by the USDA APHIS as part of federal quarantine. P. ramorum establishment in eastern US forests could be devastating, as there are several important susceptible tree species. SOD hosts that are commonly found in container nurseries include rhododendron, camellia, viburnum, pieris, and kalmia.

Figure 7.4, Symptoms of *Phytophthora ramorum* infection on common nursery hosts.

The Plant Pathologist participates in bi-monthly, national conference calls pertaining to the Sudden Oak Death program and provides summaries to the Plant Pest Administrator. Bi-monthly conference call participants routinely discuss issues such as: changes to national regulations, current trace-forward/trace-back investigations, updates from regulated states, on-going research, and workshop/training announcements.

For complete list of regulated hosts and plants proven or associated with P ramorum:
https://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf

For more information:
https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/phytophthora-ramorum/sod

SOD Trace-forward/trace-back notifications

One trace forward notification issued by USDA was received in June 2023. A nursery in Transylvania County received material from a confirmed positive nursery in Washington County, Oregon. All host materials at the Transylvania County nursery were inspected. A total of 17 samples were collected and forwarded directly to Plant Disease Diagnostic Clinic at Cornell university for qPCR identification. Fortunately, all samples came back negative for P. ramorum by qPCR

As of today, no confirmed positive cases were found in North Carolina.

SOD Survey

The primary pathway for the pathogen is from the trade of infected ornamental plants. A survey was developed to check plant materials that were likely to be imported from west-coast states. All suspect samples are screened for the presence of Phytophthora spp. using Enzyme Linked Immunosorbent Assay (ELISA) with positive samples forwarded to a USDA National Plant Diagnostic Network (NPDN) Lab for further diagnostics.

One hundred and seventy-six (176) locations were surveyed during in 2023. Twenty-nine (29) samples were collected for ELISA screening by the Plant Pathologist. No target Phytophthora sp. was detected in 2023 as a result of this survey.

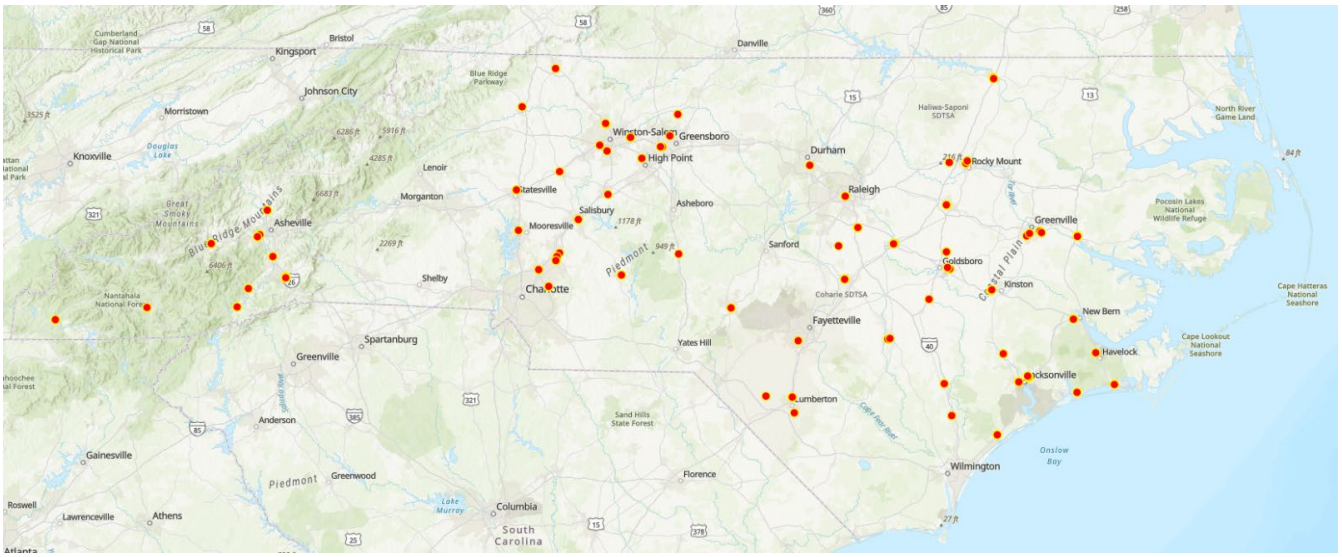


Figure 7.5, Map of *Phytophthora ramorum* survey sites, 2023.

Certified Seed Potato Program

In response to industry need, a certified seed potato program was developed by NCDA&CS – Plant Industry Division in 2023. North Carolina produced seed potato is desirable for export as there due to reduced shipping cost to Southeastern states and central America as compared to the west coast. NCDA&CS worked with USDA-APHIS-PPQ to participate in the State National Harmonization Program (SNHP) through a cooperative agreement that establishes harmonized standards to control the spread of seed potato diseases. North Carolina Crop Improvement Association (NCCIA) is the authorized certifying entity for the seed potatoes. Mandatory program disease testing was conducted by North Carolina State University, Micropropagation and Repository Unit (NCSU MPRU) and NCDA&CS plant pathology program.

During the 2023 season, a preliminary 5-acre test field of seed potatoes with seven different varieties was produced, disease tested, and certified. The seed potatoes associated with this trial shipment were effectively exported to Cuba.

Export: Disease certification requirements and pathogen distribution information

Agricultural commodities exported nationally and internationally must meet plant pest phytosanitary requirements as directed by the state or country. NCDA&CS provides support to producers to ensure shipments meet all export requirements. The Plant Pathologist receives and evaluates requests from NCDA&CS Plant Pest Specialists for assistance with interpretation of plant disease and nematode certification requirements and determination of pathogen distribution related to export certification.

Export: Nematode certification

California has an external quarantine for reniform and burrowing nematodes. To assist nurseries that wish to send plants to California, Plant Pest Specialists collect soil samples and submit them to the NCDA&CS Nematode Assay lab according to procedures developed by the Plant Pathologist. A sampling table based on number of plants or area sampled was developed by the Plant Pathologist. Using this table enables growers to pre-determine costs prior to sample collection and submission. Reniform and burrowing nematodes have not been found in any NC nursery. Reniform nematode was found in eight NC counties under agronomic field conditions, but burrowing nematode has never been found at any location.

Permits: Movement of plant pathogens for research and other purposes

USDA-APHIS-PPQ Form 526 ("Application and Permit to Move Live Plant Pests or Noxious Weeds") permits the movement of plant pathogens and other pests into NC for research, diagnostic identifications, or commercial uses. The Plant Pathologist holds the responsibility of evaluating all pathology related permit requests to address state-specific concerns as the state designated subject matter expert. USDA-APHIS-PPQ issues final approval or denial of each application taking under advisement the concerns of the state. All plant pathogenic organisms are subject to this permitting requirement. The Plant Pathologist evaluates the risk associated with each organism to ensure adequate safeguards are listed in the conditions of each permit. During 2023, one hundred and nine (109) pathogenic species permit applications were evaluated which included fungi/oomycetes, bacteria, nematodes, and viruses.

Regulatory Weeds Program - Section 8

Program Objective

The North Carolina Regulatory Weeds Program protects North Carolina agriculture and native plant ecosystems from the harmful impacts of state and federal noxious weeds. The regulation of noxious weeds is authorized under North Carolina Plant Pest Law, Article 36 of Chapter 106, in conjunction with State Noxious Weeds Administrative Code (Title 02, Chapter 48, subchapter A, rule number/section .1700) which defines and lists our state noxious weeds. The NC Administrative Code is meant to interpret and expound on statutes set forth by the state legislature. The primary objective of the program is to eradicate, restrict movement of, treat and/or manage regulated federal and state noxious weeds. This is accomplished by conducting surveys and enacting control measures, such as eradication efforts, that lead to effective management of areas associated with infestations.

Executive Summary

The Regulatory Weeds Program was successful in applying treatments to sites where regulated noxious weeds were positively identified. Primary plants of concern included beach vitex (Vitex rotundifolia), yellow floating heart (Nymphoides peltate), purple loosestrife (Lythrum salicaria), tropical spiderwort (Commelina benghalensis), cogongrass (Imperata cylindrica), tropical soda apple (Solanum viarum), wooly frogsmouth (Philydrum lanuginosum), itchgrass (Rottboellia cochinchinensis), giant hogweed (Heracleum mantegazzianum), small broomrape (Orobanche minor) and witchweed (Striga asiatica). Area Field Specialists, Regulatory Weeds Specialists, and Support Operations staff worked together to provide treatment schedules for effective management or eradication of state and federal noxious weeds. The following provides further information about these treatments across the state.

Aquatic Dealer Inspections

Aquatic dealer inspections are an important activity as they help filter out unwanted invasive plants from entering the trade through aquariums and water gardens and are accomplished as a supplement to the aquatic nursery inspections. 96 aquatic dealers were inspected across the state, no stop-sale orders were issued.

Cogongrass *(Imperata cylindrica)*

NCDA&CS collaborates with NC Dept. of Transportation (NCDOT) to identify, and control regulated weeds along roadsides. NCDOT is responsible for spraying along roadside areas, and the NCDA&CS-Plant Industry team is responsible for treating on private land. Cogongrass treatments were applied mainly in Sampson and Pender Counties. A new infestation was brought to our attention by NC Forest Service (NCFS) in Brunswick County (figure 8.1). This site was treated immediately and represents our largest singular infestation. The NC Forestry Service (NCFS) performed a prescribed burn to help with future chemical applications in 2024. It is estimated that treatments over the past several years across all sites have reduced known infestations by greater than 90 %.

Figure 8.1. *Cogongrass in 2023 in Brunswick Co. Before (A) and after (B) treatments.*

Purple Loosestrife *(Lythrum salicaria)*

Purple loosestrife is a Class B State Noxious Weed, and efforts to manage it have been ongoing since 1997. Areas infested with Purple Loosestrife within Guilford and Henderson Counties are being treated with triclopyr herbicide with the goal of complete eradication. Triclopyr has proven to be effective when multiple applications are utilized. Multiple applications are required to kill later emerging plants and to prevent seed dispersal.
Three treatments were completed at the sites in Guilford County (Figure 8.2). These sites typically include right of ways beneath power lines where infestations are usually the heaviest. Treatments will continue into the 2024 season. Purple loosestrife is extremely difficult to eradicate because of its prolific seed production and longevity of the seedbank. Annual treatments of infested areas with herbicide remain the best way to combat this noxious weed.

Figure 8.2. *A hand-pulled specimen of purple loosestrife from Guilford County.*

Itchgrass *(Rottboellia cochinchinensis)*

This federal and state noxious weed produces hairs on leaf sheaths (Figure 8.3) which can penetrate the skin causing irritation, hence its name. It is problematic along roadsides, ditches, rights-of-way, pastures, and row crops. It is an annual grass that spreads by seed and can produce up to 3,000 seeds/plant. Seeds remain viable for 3-5 years and are dispersed mainly through wind, birds, and roadside mowing equipment.

Robeson County has been the center of the eradication effort since 1983. At least 6 separate areas around the town of Rowland are being monitored and treated. Pre-emergent and post-emergent herbicides are the main tools used to control Itchgrass. Itchgrass management is a collaborative effort between the North Carolina Department of Transportation (NC DOT), farmers with Itchgrass present on their farms, and NCDA&CS invasive weed program personnel. NC DOT has treated several miles of roadside and will continue with this effort in 2024. Participating farmers treated wood lines and ditch banks located away from main roads, where it was inaccessible to NCDA staff. The combined effort proved to be successful in 2023.

Figure 8.3. *Short hairs present along leaf sheaths (A). The seed head of an itchgrass plant and independent seed (C).*

Tropical Soda Apple *(Solanum viarum)*

Tropical soda apple is a Federal noxious weed and is a threat to NC agriculture since it outcompetes with vegetable crops and serves as an alternate host for many important pathogens for solanaceous species. These include potato leafroll virus, potato virus Y, Gemini virus, cucumber mosaic virus, tomato mosaic virus, and tomato mottle virus. Prominent members of this genus include tomato, pepper, potato, and eggplant. Three surveys were conducted in July, September, and November at one location in Sampson County to identify and remove tropical soda apple (Figure 8.4). This 7,000-acre site remains the only known infestation of this weed in the state. Surveys focused where Tropical Soda Apple was previously found and were carried out on ATV. A total of 150 plants were identified and pulled for the season. This represents about 30 fewer plants compared to last season. Plants are carefully pulled to ensure fruit does not drop. Rogued plants are placed in heavy duty paper bags and incinerated.

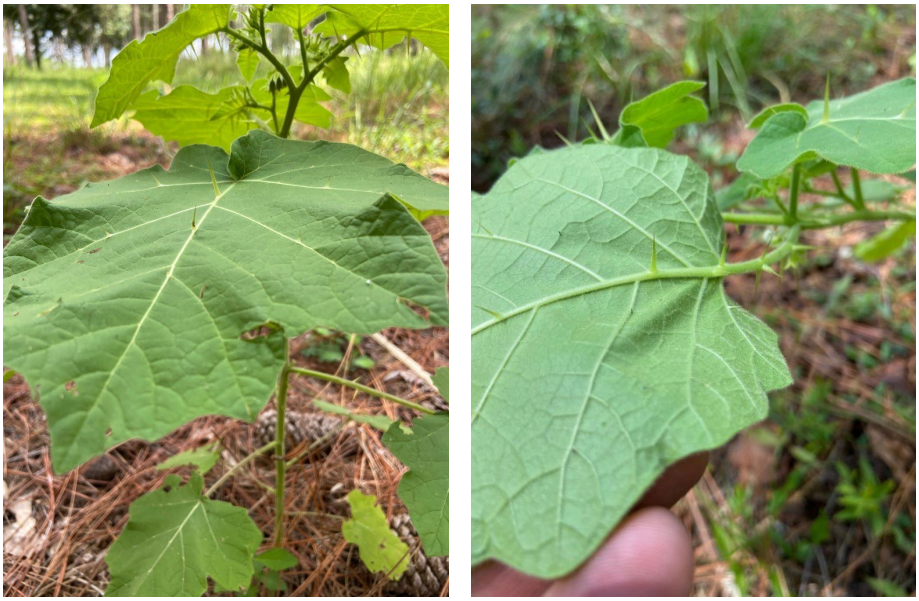


Figure 8.4. *A lone tropical soda apple plant showing off its large thorn-like prickles above leaf (left) and below leaf (right) surface.*

Giant Hogweed *(Heracleum mantegazzianum)*

Watauga County remains the only county in NC where giant hogweed has been positively identified (Figure 8.5).

All known locations are surveyed annually by the area Field Specialists and treated prior to seed set. Discovery of new locations is aided by concerned residents through the division's website reporting tools, phone calls, and emails. Fortunately, no other cases have occurred outside of Watauga County. Identification is complicated by the several lookalikes including cow parsnip (Heracleaum lanatum), elderberry (Sambucus canadensis), Angelica (Angelica atropurpurea) and poison hemlock (Conium maculatum).

Figure 8.5. *A couple giant hogweed plants prior to herbicide treatment.*

Wooly Frogsmouth *(Philydrum lanuginosum)*

Wooly Frogsmouth was initially found and treated in August 2016 in NC; it is a native species of Guam. Treatment of two ponds has continued since 2016 with the help of NC Wildlife Resources Commission. The control strategy has been modified over the years to include plant removal (rogueing) prior to and after herbicide applications, lowering of pond water level, and an herbicide treatment to exposed plants. Pumping down pond levels by 18 inches allows for better contact to exposed plants that would have otherwise been submersed (Figure 8.6). Rogueing in July and September have improved efficacy of the control strategy (Figure 8.7).

Figure 8.6. *Pond after being pumped down and prior to herbicide treatment.*

Figure 8.7. *Wooly Frogsmouth found in post treatment in a survey conducted in September 2023. These plants were hand rogued.*

Tropical Spiderwort *(Commelina benghalensis)*

Tropical Spiderwort is an annual weed in temperate climates and herbaceous perennial weed in the tropics. Tropical Spiderwort (aka Benghal dayflower) is only found in a couple locations within NC. This weed can tolerate many herbicides, especially glyphosate. The presence of subterranean spathes on rhizomes differentiates C. benghalensis from other species within the genus. Both above and below ground flowers are self-fertile is another identifying characteristic. C. communis (Asiatic dayflower), a non-native weed and C. diffusa (spreading dayflower), a native species, can be mistakenly identified as Tropical Spiderwort.

Benghal dayflower is a serious regulated weed that can become out of control if not managed early. A small, actively managed infestation originally found in June of 2015 near North Carolina State University (Figure 8.8) continues treatment through today. A much larger infestation on Cherry Research Station has also been closely managed and much progress has been made toward eradication due to a large-scale fumigation treatment in 2020. Close monitoring of this site has yielded no positive finds to date.

Figure 8.8. *Several tropical spiderwort plants growing at a location close to NCSU. Plants are still present after years of managing the area. A steady decline in the number of plants found at this location has been noted. These were the only plants observed at this site in 2022.*

Beach Vitex *(Vitex rotundifolia)*

Beach Vitex was originally planted as erosion control and dune stabilization in the 1980s due to its prostrate, sprawling behavior, however, beach vitex (Figure 8.9) eventually became known as a beach and dune liability. Native grasses such as sea oats, American beachgrass and panic grasses are more proficient at holding sand in place due to their root structure. Beach vitex will outcompete these native grasses and since it lacks a root system necessary to trap sand and reduce erosion, it was placed on the NC noxious weed list in 2009.

A different approach to treating Beach Vitex has been developed due to the increasing number of reports of infestations received over the past several years. Typically, a confirmed beach vitex site would be treated by our division. These treatments required more resources and labor than available because several visits are required to reduce and eventually eradicate Beach Vitex at each site. The new approach was first implemented in 2021 in Duck NC, it relied on local coordinators who were able to assemble groups of volunteers. Plant Industry staff were deployed to educate the volunteers and demonstrate treatment protocols with the hope of widespread eradication within towns (Figure 8.9). Since many of the coastal communities already have ordinances against this plant, it is our hope that working closely with each community so that those towns will see the virtue of removing this plant through concerned residents that are active in their community. Each year more communities reach out as we provide the necessary information to help in their eradication effort. Our goal is to continue working with local residents and municipal employees very much like our 2021 Duck visit, which served as a proving ground for these "seaside seminars" and how this weed will be managed moving forward. It is our intent to continue in this way, disseminating information and providing the example for treatment by visiting those communities that request help when they observe an infestation of beach vitex, so we can continue to manage this noxious weed.

Figure 8.9. *Beach vitex infesting a property on Topsail Beach. Photo on left was taken in early July 2022 when we made an initial treatment. Photo on right shows beach vitex removed from the dune after six treatments, September 2023.*

Small Broomrape *(Orobanche minor)*

Orobanche minor is a parasitic weed of many broadleaf plants, with origins in North Africa and the Middle East. This herbaceous annual weed gets all its nutrients from the hosts it attaches itself to (obligate parasite). Seeds are described as being dust-like with estimates of 5,000 to 50,000 seeds per plant with a long-lived seed bank of 7-10 years. O. minor is parasitic to clover in Haywood and Mitchell Counties (Figure 8.10). Movement of hay from currently infested fields and pasturelands is prohibited. The potential does exist for this to be a pest of many broadleaf row crops including tomato and tobacco.

Plants infesting several locations are surveyed annually and destroyed at a livestock market in Haywood County. Additional plants were hand pulled from all infested locations and chemical treatments done to omit clover from pastures infested with Orobanche were accomplished. Repeated annual surveys and follow-up treatments are necessary for this weed.

Figure 8.10. *Orobanche minor in flowering phase, parasitizing clover.*

Yellow Floating Heart *(Nymphoides peltata)*

We were able to visit each infested site of yellow floating heart three times for treatments in 2023 (Figure 8.11). Several locations were found to be visibly free of yellow floating heart during part of the season. To be declared eradicated, a site must be declared free of yellow floating heart for three consecutive years. No new infestations were observed or reported in 2022 and 2023.

Figure 8.11. *Two photos of the same location. Photo on left, from August 2020, our first look prior to treatments. Photo on right, from August 2023, showing yellow floating heart being eradicated.*

Witchweed *(Striga asiatica)*

The Witchweed eradication project is financially supported by USDA-APHIS: Plant Pest and Quarantine (PPQ). Their continued support ensures progress is made as we work toward eradication of this plant (Figure 8.12). The Witchweed Program utilizes a point system for monitoring field treatment schedules. Three phases govern this system; Infested, Release and Terminated. New fields positively identified with witchweed have a point status of 0-4.9 and are in the infested phase. At most, one point may be awarded per year. Once a field reaches 5 points, it begins the release phase where at minimum it will remain for 10 years. The last phase, termination, means that area is considered eradicated and no longer requires survey or treatment.

Figure 8.12. *A witchweed plant in flower.*

Table 8.1 shows total infested farms, fields, and acres for the five quarantined counties in the state. A decrease in total numbers of farms, fields and acres was observed at the conclusion of 2023. Table 8.2 displays overall totals of where acres landed for 2023. The program terminated 429 acres and graduated more than 200 acres from the infested phase to the release phase. 2023 represents an unusual year in that numbers representing such a sharp downward trend in our eradication process are not typically this steep. It is estimated that in 2024 total managed acreage will be below 2,000 acres.

Table 8.1. *The number of farms, fields and infested acres per county for 2022 and 2023.*

County		No. of Farms	No. of Fields	Infested Acres
Bladen	2022	33	53	490.2
	2023	30	53	557.0
Cumberland	2022	14	14	148.8
	2023	8	8	95.6
Pender	2022	3	3	30.5
	2023	3	3	30.5
Robeson	2022	10	13	323.1
	2023	5	10	240.9
Sampson	2022	2	2	80.2
	2023	2	2	80.2
Total	2022	62	85	1,072.8
	2023	48	76	1,004.2

Table 8.2. *A summarization for total acres managed.*

	2023
Total Acres in Infested Category	1,004.2
Total Acres in Released Category	1,006.5
Total Acres Managed by Program	2,010.7
Total Acres Treated	1,491.1
Total Acres Surveyed	28,369
Acres Transferred from Infested to Release	217.9
New Acres in Program	0
Net Loss	429.2