NCDA&CS
Plant Industry Division
Annual Report
2021

Steve Troxler

Commissioner of Agriculture

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NORTH CAROLINA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES

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.

Steve Troxler

Commissioner of Agriculture

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North Carolina Board of Agriculture


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Plant Industry Division

Plant Industry Division Web Site: http://www.ncagr.gov/plantindustry/

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

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Industrial Hemp Pilot Program

Historical Perspective & Current Outlook

The Industrial Hemp Pilot Program began after the passing of the 2014 Federal "Farm Bill" that granted States and Tribes, in conjunction with universities, the ability to acquire and begin cultivating industrial hemp so long as cultivation was coupled with a research objective. The State of North Carolina established an Industrial Hemp Commission that drafted and passed a set of rules to govern our pilot program. Cultivation of industrial hemp began in July of 2017. At this time, we have had our program for 5 full years of cultivation. In that time the federal government also passed the Agricultural Act of 2018 otherwise known as the 2018 Farm Bill which deregulated Industrial Hemp from the schedule I narcotics list by setting a limit on delta-9 THC of 0.3% by dry weight. This removed industrial hemp from DEA oversight and placed it in the hands of the USDA. It also made industrial hemp a legal agricultural commodity in the United States. The 2018 Farm Bill also set a timeline for the USDA to generate a set of rules that would be the minimum standard for all states to govern industrial hemp cultivation after this "pilot program" phase. Those rules were released at the end of October 2019 and officially entered the federal register on October 31st, 2019. From that date, states have exactly one year to accept the USDA rule as written, to cede control of hemp cultivation to the USDA, or to submit for approval by the Secretary of Agriculture a custom state hemp plan. North Carolina has not yet chosen which pathway they intend to pursue. Congress, in a continuing resolution extended the pilot programs to September 30th, 2021, initially. It has since been extended to January 1st, 2022. As of January 1st, 2022, North Carolina has ceded control of its hemp program to the USDA who as of this report currently oversees hemp cultivation in North Carolina.

Applications & Licensing

The first round of approved application for the North Carolina Industrial Hemp Pilot Program were approved on March 13th, 2017 for 4 applicants one of whom was denied due to an incomplete application resulting from not being a bona fide farmer. Since the initial applications were approved, an estimated 3000+ applications have been submitted to the NCDA for approval. Duplicate licenses, applications that are incomplete, applications submitted in paper, and other reasons account for the disparity between applications received and approved license holders. Despite several hundred applications never reaching licensure we saw dramatic increases in license holder numbers each year of the program from 2017-2020. 2021 saw dramatic decrease in the amount of licenses applied for. This is mostly due to 2 factors. First, declining prices for bulk CBD biomass and the lack of viable contracts to lock in prices for farmers. Second, the unstable nature of regulation at the state and federal level and their interplay.
At the conclusion of 2017 the North Carolina Industrial Hemp Program had approximately 124 licensed growers. By the end of 2018 the NC Industrial Hemp Program had 438 licensed industrial hemp growers. This was a 353% increase in license holders from 2017. At the end of 2019 the NC Industrial hemp pilot program had 1,393 licensed growers. This marked a 318% increase in license holders from 2018. Due to an unstable regulatory environment as a result of USDA regulation, Senate Bill 315 and other factors, the rate of increase in new license holders has dropped precipitously. At the end of 2020 we had 1,525 licensed growers. This is an addition of 132 licenses amounting to about an increase of 9%. We also lost a fair number of growers who had lost interest in hemp due to low market prices, an inability to sell material, and unstable regulations. At the conclusion of 2021 we had only about 770 active license holders. This is a reduction of license holders by greater than 50%. The dramatic reduction came as a result of low market values for bulk CBD hemp, and because of a lack of renewals with the end of the pilot program looming.

Expansion of Acreage & Greenhouse

Acreage and greenhouse house space has expanded as rapidly as the number of license holders. At the conclusion of 2017 we had approximately 2,236 licensed acres and 242,554 licensed greenhouse sq. ft. At the end of 2018 we had approximately 6,077 licensed acres and 2,524,422 licensed greenhouse sq. ft. This represents a 271% increase in acres and a monumental 1040% increase in greenhouse sq. ft. At the conclusion of 2019 we had approximately 17,528 licensed acres and 6,819,492 licensed greenhouse sq. ft. This equates to a 288% increase in acreage and a 270% increase in greenhouse sq. ft. Due to an unstable regulatory environment because of USDA regulation, Senate Bill 315 and others, factors, there has been a marked decrease in the rate of growth for program acreage and greenhouse sq. ft. in the year 2020. Acreage decreased to 14,460 which is approximately a 17.5% of last year's acreage. Greenhouse sq. ft. on the other hand increased by about 3.5% up to 7,069,431 sq. ft. licensed.
Due to the loss of over 50% of license holders acreage went down by 60% with acreage at the end of 2021 being around 5,911. Similar decreases were seen for greenhouse sq. ft. with a reduction of 53% down to 3,302,843 sq. ft.

Compliance Testing

Of all the interactions that the NCDA&CS has with NC Industrial Hemp Pilot Program participants compliance testing is by far the most important. The Seed & Fertilizer staff of Plant Industry division represents the front lines of making sure that cannabis grown in the state of North Carolina complies with the federal definition of industrial hemp thereby making it legal and marketable. The Federal government defines hemp as *Cannabis sativa* L. with a delta-9 tetrahydrocannabinol concentration of no more than 0.3% by dry weight. North Carolina has, since the inception of the program, tested using GC-FID which effectively decarboxylates THCA into delta-9 THC during the testing process resulting in what is often referred to as a "Total THC" measurement of delta-9. While there is much debate about whether this is correct, or even within the language of the law, the USDA has made it abundantly clear that this is the expectation for compliance testing. North Carolina, among other states, has also allowed for scientific and testing variance rounding any result below 0.4% but above 0.3% down to 0.3%.

In year one of our program, 2017, we collected approximately 135 regulatory/compliance tests. Of those tests 14 failed by exceeding the 0.3% threshold. This is an approximate fail rate of 10% which is well within the variation of testing data seen from other states. In the year 2018, year two, we collected approximately 437 tests of which 47 failed. This is another approximate fail rate of 10%. The number of tests collected increased by 323% largely due to the 353% increase in license holders. In the most recent year, 2019, we collected 2,247 samples of which 235 failed. This is also an approximate failure rate of 10% which was as much as 4-fold less than other states in the year 2019. The number of compliance tests pulled in 2019 was 514% greater than that of 2018. Specialists pulled between 213 and 302 samples in 2019. We more than maxed out our capacity to pull samples in 2019 resulting in large quantities of worked overtime for all employees. In 2020, we took approximately 1,374 tests of which 94 failed resulting in an overall pass rate just over 93%. This is a reduction in our failure rate of approximately 64% which is significant. We believe that increases in grower competence and the presence of low THC CBG varieties contributed to this change. Our workforce was significantly more able to handle the number of samples taken this year and no additional staff were coopted or hired to handle sampling this year. COVID-19 did contribute significantly to our decreased numbers. In 2021, we took a total of 717 samples. This is a reduction in testing numbers by approximately 48% from 2020. Of the 717 samples taken 19 failed resulting in a pass percentage of 97.4% our highest to date. I believe that this reduction is largely a result of the remaining farmers being more competent, due to experience, and due to more stable strains being available for this growing season.

Initial worries about the USDA's interim final rule were partially assuaged by the release of the final rule. Initially samples would need be taken within 15 days under their rules which would have been an undue hardship resulting in many failures among other things. This was changed to 30 days which is on par with the average time between sample and harvest for our pilot program. The negligence threshold initially set at 0.5% was moved to 1.0% which is significantly more reasonable and attainable. The USDA also implement a remediation protocol further easing worries about rampant failure and farmer losses. While USDA rule will take some adjustment for North Carolina growers I believe that the modifications made by USDA to their rule and the relatively simple processes they have put in place should be easy enough to adapt to.

Registered Processors

As a part of the rules drafted by the Industrial Hemp Commission it is required that processors of industrial hemp be registered with the Industrial Hemp Commission and report the type and weight of the industrial hemp material that they processed annually.

At the conclusion of 2017 approximately 75 processors were registered in the state of North Carolina. By the end of 2018 that number was around 322. As of the end of 2019 that number is around 984 processors. This marks an increase of 429% from 2017 to 2018 and an increase of 305% increase from 2018-2019. At the end of 2020 we had approximately 1,223 processors which is an increase of about 20% over last year's numbers. Finally, in our official pilot program year, 2021 we had 1,360 processors which is an increase in about 12%.

The large increases in processors have not necessarily led to more marketing opportunities for farmers for several reasons. The primary reason being that a large percentage of the registered processors are retail or other establishments that make final products, repackage, or do some other form of tertiary processing that has little impact on the farmer and ultimately have registered as an insurance policy against police raids, product confiscation, etc. Another reason that processors are having little impact on farmer profit is that many processors do not have the money to pay farmers after they invest in the equipment necessary to do extractions and further have no downstream buyers to move the oil or other product along the manufacturing chain. The growers and the industry have gotten well ahead of the law and the market in this case, and this remains a keystone issue that will need to be solved to really move the industry forward.

Moving into 2022 the NCDA has opted to allow industrial hemp processors to continue to register on a voluntary basis. Processor registration is not a license and there is no regulatory oversight of the processors by the NCDA. The list of processors is available on the NCDA Website; **https://www.ncagr.gov/hemp/**

Plant Protection Section

Apiary Inspection Program

To protect the health of our honey bee industry, permits to sell bees are required for anyone wishing to sell queens, package bees, nucleus colonies (nucs), or hives. One hundred and seventy-one permits to sell were issued for 2021. To obtain a permit, bees must be inspected, and the producers must agree to comply with standards designed to maintain healthy colonies. Beekeepers are strongly encouraged to buy only from permitted dealers to avoid buying unhealthy or Africanized honey bees. The list of currently permitted beekeepers can be found here:
https://www.ncagr.gov/plantindustry/Plant/apiary/documents/PermitToSell2022.pdf

Our newest inspector, Ms. Bridget Gross, joined our team in March 2021. She covers a 15-county region in the western Piedmont.

One of the most devastating and difficult to control bee diseases is American foulbrood (AFB). Due to COVID-19 our inspection numbers were somewhat lower than usual. However, we are pleased to report that we had no confirmed cases of AFB during 2021. We have maintained the Special Local Need 24(c) registration for the ethylene oxide (EtO) fumigation chamber as well as a source of the EtO formulation.

The mite *Varroa destructor* persists as a major threat to the beekeeping industry in NC and is probably a contributing factor to general poor health or mortality of bee colonies. Several new miticides have been registered; however, the mites have developed resistance to some of these materials in short order and rendered these products ineffective. Currently, the list of registered products for *Varroa* control in North Carolina includes Apistan®, CheckMite+®, Api-Life Var®, Apiguard®, Mite-Away Quick Strips®, Apivar®, oxalic acid (specifically labeled for bees), 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 adverse effects 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, we again coordinated with the Veterinary Consortium to facilitate further education of veterinarians in honey bee disease diagnostics.

Beekeepers are expressing concern about pesticides, particularly the neonicotinoids, but the evidence of pesticide misuse has not been commensurate with the concern. Bee yards can be registered through the Plant Industry Division. The list of registered apiaries is sent to aerial applicators licensed in NC. The NCDA&CS 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 valid investigation and resolution. The SPCP and Plant Industry Divisions are working with EPA to develop a Managed Pollinator Protection Plan.

Another threat facing the beekeeping industry of North Carolina is the Africanized honey bee (AHB) (*Apis mellifera scutellata*), which is established in southern Florida and been found sporadically in Georgia. We are maintaining swarm traps at the ports of Wilmington and Morehead City, in order to intercept any bees coming in via ship. We hope to expand this trapping system to some of our land-based points of entry. We continue to engage in an outreach program to NC emergency response personnel to familiarize them with the potential threat of AHB. We are actively collecting 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. We are striving to have our inspectors and our lab prepared to deal with any AHB incursion or incident. **We encourage beekeepers and the general public to please let us know of any colonies that seem to be displaying any unusual behavior, especially excessive defensiveness. We want to maintain a beekeeping industry in North Carolina that is not threatened by this more defensive type of bee.**

Honey bee viruses are an issue that seems to be a growing concern among beekeepers. Currently, we do not have the capacity to provide a diagnostics service for viruses; however, we continue to enjoy a good working relationship with our friends in the NC State University Apiculture Research and Extension Program. We hope to expand our capabilities to perform some of the molecular diagnostics that they are developing. We have had the opportunity to assist them in some of their projects and would like to express our gratitude for their assistance in many of our projects.

D. Hopkins and G. Hackney

Biological Control Program

In the summer of 2020, Steven Turner, PhD resigned from his role as Biocontrol Program Administrator and in March, 2021 Gregory Wiggins, PhD started as or new Biocontrol Program Administrator. Dr. Wiggins came to NCDA&CS from the University of Tennessee with a thorough knowledge of many current biocontrol programs and a strong background of NC entomological pests.

A Multifaceted Approach for Biological Control of Alligatorweed

Alligatorweed, *Alternanthera phyloxeroides*, is an invasive aquatic weed native to South America. It was first reported in the U.S. in the late 1800's and spread throughout waterways along the coast of the southeastern U.S. Alligatorweed is now found in 12 states, including North Carolina, where it was first documented in 1967. Alligatorweed can grow to dense populations and can sometimes grow across an entire waterway or channel, restricting access and creating navigation hazards. Additionally, floating mats of alligatorweed vegetation can be dislodged by flooding and obstruct dams and other structures. Because alligatorweed can grow terrestrially as well, it has the potential to outcompete and displace native riparian and aquatic vegetation.

To mitigate the impact of alligatorweed in the U.S., a biological control program was initiated in the 1960's. This program included releasing a species of flea beetle, *Agasicles hygrophila* (Coleoptera: Chrysomelidae), a thrips species, *Amynothrips andersoni* (Thysanoptera: Phlaeothripidae) (Fig. 1), and a moth species, *Arcola malloi* (Lepidoptera: Pyralidae). These species established in areas along the Gulf and Atlantic Coasts of the U.S., in many cases suppressing alligatorweed to reasonably low levels. However, despite multiple releases in North Carolina in the 1970's and 1980's, none of these biological control species were documented to establish, as winter temperatures were too low for these species to survive.

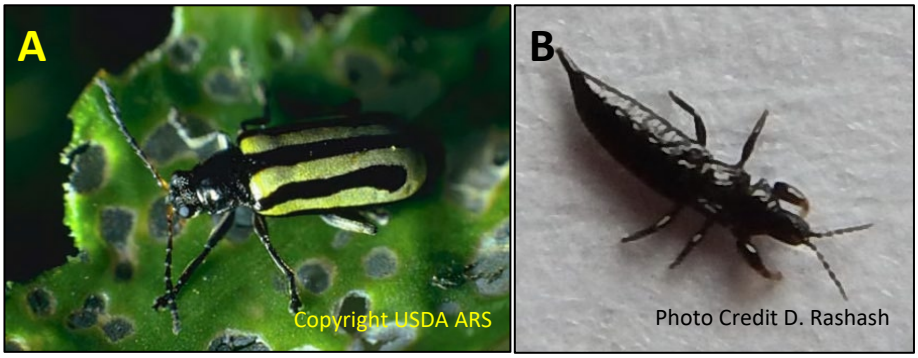


Figure 1. Biological control agents of alligatorweed studied in North Carolina: A) alligatorweed flea beetle, Agasicles hygrophila; B) alligatorweed thrips, Amynothrips andersoni.

Recently, there have been observations of *A. andersoni* and *A. hygrophila* seeming to overwinter in coastal areas of North Carolina. Populations of *A. andersoni* are thought to have been accidentally introduced in 2015, and these thrips have been recovered for several seasons since. In the case of *A. hygrophila*, it is unclear if the flea beetles recovered in 2020 are cold-tolerant individuals surviving from a previous release in the area or if they migrated to a site from a release earlier in the same year.
In light of these observations, NCDA&CS Beneficial Insects Laboratory (BIL) initiated a project to re-examine biological control agents of alligatorweed. In 2019, *A. hygrophila* from populations reared by the US Army Corp of Engineers (USACE) and *A. andersoni* collected from Jacksonville, NC, were released at three locations: Apex Lake, Apex, NC; River Park North, Greenville, NC; Wade Park, Wilmington, NC. Although recent observations of apparent establishment are encouraging, based on the release history of these species in North Carolina, the potential for establishment on a broad scale was unclear.

Due to the COVID pandemic and staffing challenges, two years had passed since releases of biological control agents were conducted at any of the NCDA&CS release sites. No releases of either biological control agent were conducted at any of the 2019 release sites. However, monitoring for presence of both *A. hygrophila* and *A. andersoni* was conducted during Spring and Summer 2021. In addition to 2019 release sites, two other locations known to have alligatorweed in Wilmington, NC (Greenfield Lake and Silver Stream), were monitored for both biological control agents. Monitoring without making in-season releases allows for assessment of establishment of biological control agents at release sites.

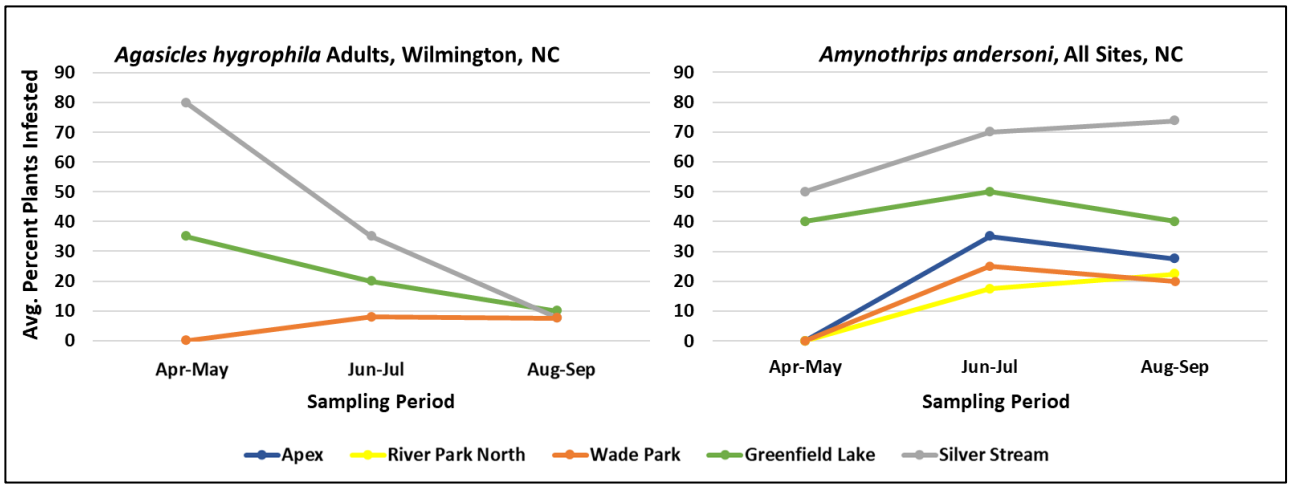


Figure 2. Collections of Agasicles hygrophila and Amynothrips andersoni in monitored sites, 2021.

Both biological control species were observed during monitoring in 2021 (Fig. 2). Populations of *A. andersoni* were found at all three release locations and estimates of their densities range from up to 22% of plants examined infested with thrips at River Park North, 25% of plants infested at Wade Park, to 38% of plants infested at Apex Lake. Additionally, thrips were also found at both Greenfield Lake (up to 35% of plants examined) and Silver Stream (73% of plants examined). Small numbers of *A. hygrophila* (8% of plants examined) were documented at Wade Park, the southernmost release site. No beetles were observed at Apex Lake or River Park North. However, beetles were found at both Greenfield Lake (40% of plants examined) and Silver Stream (up to 80% of plants examined). Because the recovery and discovery of *A. hygrophila* was unexpected, individuals were collected from Silver Stream and sent to Ian Knight, USACE, for cold-tolerance analysis. The results of that analysis are pending.

To quantify the extent of *A. andersoni* on individual plants late in the season and the life stages present, 30-50 alligatorweed plants were collected from each site in September. Overall, there were more immature thrips on plants than adults. We found that the average numbers of adult *A. andersoni* per plant ranged from 0.6 per plant at River Park North to 2.6 per plant at Silver Stream. The average number of immature thrips per plant ranged from 1.2 at Apex Lake to 4.1 at Greenfield Lake. The total number of thrips per plant ranged from 1.9 at River Park North to 6.2 at Silver Stream. Because there were several weeks of warm temperatures following sampling, the immature thrips probably continued development to adults, as larval development takes about two weeks to complete.

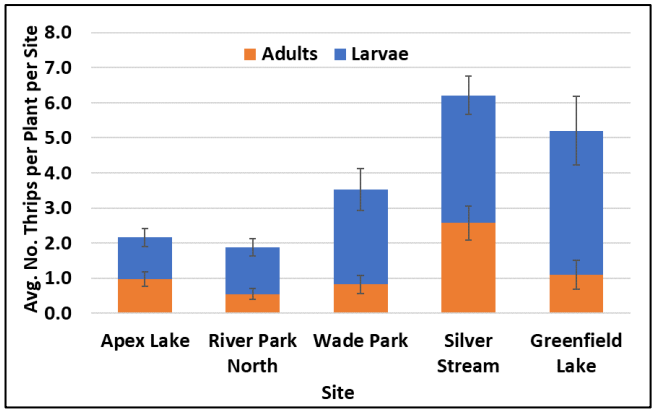


Figure 3. Average number of immature, adult, and total Amynothrips andersoni per plant, 2021.

These results are promising, as they may demonstrate the ability of *A. andersoni* and *A. hygrophila* to establish in parts of North Carolina. In the case of *A. andersoni*, it is feasible that populations of *A. andersoni* are establishing and dispersing throughout the landscape due to their greater cold tolerance. The factors contributing to recovery of *A. hygrophila* are less clear. It is possible that *A. hygrophila* may have migrated to our monitored sites from nearby releases made by other resource managers in 2021. The beetles are known to - readily disperse via flight and on floating mats of vegetation resulting from flooding. However, there were no records of flea beetles being shipped to managers within 30 miles of our sites in Wilmington. It is also possible that *A. hygrophila* has developed a level of cold tolerance and established in the southernmost areas of North Carolina. If so, this establishment also may have been aided by recent milder winters. There were only five days in the winter of 2020 and three days in the winter of 2021 when temperatures were below -4 ℃, the temperature at which *A. hygrophila* cold-induced mortality begins to occur. These shortened cold periods may have facilitated *A. hygrophila* survival and establishment. Further study is warranted to determine the level of cold tolerance of these beetle populations, as well as identify the extent of other overwintering populations of *A. hygrophila* in North Carolina to enhance future alligatorweed management efforts.

G.J. Wiggins

Biosurveillance using *Cerceris fumipennis*

The solitary ground nesting wasp *Cerceris fumipennis* continues to be utilized by the BIL as a biosurveillance tool for the efficient detection and collection of pest buprestid beetles in several locations in eastern and central North Carolina. In 2021 biosurveillance was conducted primarily at sites with known nesting aggregations of the wasp, and was also part of a study of emerald ash borer biology at a site in Wake Co. (discussed below). COVID restrictions in place at schools with ball diamonds prevented biosurveillance at several sites, and known nesting aggregations located in the mountains were not utilized to prevent overnight stays in motels.

Biosurveillance with *Cerceris* began on 19 May 21 (Robeson Co., 16 nests) and was completed on 7 July 21 (Wake Co., 2 nests); Zoe Chavis, Christine Nalepa and Nancy Oderkirk conducted the field work. A total of 429 buprestid beetles were collected during biosurveillance in 2021 (Table 1). This year common, easily recognized buprestid species were recorded, then returned to the wasps; these were most notably *Buprestis maculipennis* and *B. rufipes*. This was done to help maintain populations of *Cerceris* at our collection sites.
The only site where emerald ash borer (EAB) was collected in 2021 was at South Garner High School (Wake Co.), a site strategically positioned near a known infested ash stand and part of a separate ongoing study (see below). Sites where EAB was collected in the past but not in 2021 were Faith Christian Academy (Wayne Co.), Franklinton Park (Franklin Co.) and Spring Hope (Nash Co.).

It is of interest that *Cerceris* populations at Franklinton Park (Franklin Co.) rebounded in 2021 and was an excellent collection site. No *Cerceris* nests were found at this location when checked on 5 June in 2020, although 86 nests were found on 5 June 2019. It is possible that in 2020 *Cerceris* emerged late at this site and our timing was off.

Table 1. Buprestidae collected in North Carolina by *Cerceris fumipennis* in 2021 by site.

Dates	Location	County	No. Buprestids Collected
24 May – 18 June	Faith Christian Academy	Wayne	147
26 May	Bradford Pool	Robeson	2
27 May	Horton Park	Lee	1
6 – 30 June	S. Garner High School	Wake	126
8– 15 June	Spring Hope	Nash	11
9 June	Erwin Rec Dept	Harnett	4
10 June	Horton Park	Lee	1
24 June – 4 July	Franklinton Park	Franklin	137

Identification and processing of collected Buprestidae

Fifty-nine Buprestidae collected via biosurveillance in 2021 in the genera *Acmaeoedera, Actenodes, Agrilus, Dicerca* and *Spectralia* were shipped to cooperator Joshua Basham (USDA-APHIS) for identification to species. These identifications were received 17 Aug 21: *Acmaeoedera tubulus, A. pulchella, Actenodes acornis, A. simi, Agrilus cephalicus, A. ruficollis, Dicerca lurida, and Spectralia gracilipes.* Fifty-eight specimens (10 species) from 2021 biosurveillance with *Cerceris* were identified in-house and added to the BIL collection (Table 2).

Cooperator Joshua Basham also returned identifications and specimens sent to him over past years (2015, 2016, 2017, 2018) and these were incorporated into the collection. Included were *Agrilus celti*, *Agrilus transimpressus*, and *Agrilus pilosicollis* (the latter resulting in a publication, see below). He retained some specimens for further study.

Since the departure of State Entomologist Whitney Swink, a portion of the BIL collection of Buprestidae from 2015, 2016, 2017 and 2018 had been held in Schmitt boxes awaiting further processing. These specimens were organized

Table 2. Buprestidae collected by *Cerceris fumipennis* in 2021 that were added to the Beneficial Insects Laboratory insect collection.

Species of Buprestidae	No.	Species of Buprestidae	No.
Acmaeodera tubulus	6	*Buprestis lineata*	9
Acmaeodera pulchella	4	*Buprestis maculipennis*	3
Agrilus ruficollis	2	*Buprestis rufipes*	10
Brachys ovatus	7	*Eupristocerus cogitans*	1
Buprestis consularis	8	*Phaenops aeneola*	8

and incorporated into the collection. Unusual specimens noted from these updates included: *Texania campestris*, *Agrilus masculinus*, *A. geminatus*, and *Agrilus fulgens*. Ninety-five unidentified specimens from 2015 were sent to cooperator J. Basham. Overall, a total of ~980 specimens were added to the BIL collection in 2021.

Collection of Chrysobothris (Buprestidae) for cooperator Bill Klingeman (University of Tennessee)
A total of 76 buprestids in the genus *Chrysobothris* collected in 2021 were shipped to Dr. William Klingeman (University of Tennessee) for identification and for his use in molecular studies. He identified 69 of these to species (Table 3). It was not possible to identify five specimens because they were damaged; most of these were drops (i.e., beetles collected on the ground in the vicinity of a *Cerceris* nest). Two specimens we thought were *Chrysobothris* were identified as *Dicerca punctulata*.

Chrysobothris cribraria was the most commonly collected (66.7% of collected *Chrysobothris*); it was taken at all three sites in which the genus was collected (trees in the genus *Pinus* are the host). Most notable was the collection at Faith Christian Academy (Goldsboro), where six different species were identified from 12 *Chrysobothris* collected. Another notable site was in Spring Hope (Nash Co.), where four specimens yielded three species, including the rarely collected *C. hubbardi* and *C. neotexana* (neither of which are in the NCDA collection).

Table 3. Buprestids in the genus *Chrysobothris* identified by cooperator Bill Klingeman.

***Chrysobothris* species**	**No.**	***Chrysobothris* species**	**No.**
Chrysobothris cribraria	46	*Chrysobothris quadriimpressa*	6
Chrysobothris dentipes	1	*Chrysobothris rugosiceps*	1
Chrysobothris femorata	1	*Chrysobothris sexsignata*	3
Chrysobothris hubbardi	1	*Chrysobothris shawnee*	1
Chrysobothris neotexana	2	*Chrysobothris viridiceps*	2
Chrysobothris pusilla	5		

Publication

These studies resulted in a publication in a professional journal in 2021:

Hansen, J.A., J.B. Basham, C.A. Nalepa. 2021. New adult host records for three Buprestidae (Coleoptera) rarely encountered in the United States and significant extension of the known geographic range of *Agrilus pilosicollis* Fisher. Insecta Mundi 0869: 1-6.

C.A. Nalepa

Biology of Emerald Ash Borer and its Parasitoids in Garner, NC

In 2021 we continued comparative studies of the biology of EAB with Dr. Kelly Oten and her student Ryan Bohannon (North Carolina State University, Department of Forestry and Environmental Resources) on the biology of emerald ash borer, with an emphasis on their phenology and natural enemies in NC. These studies were initiated in 2020 at the Wrenn Road Water Reclamation Facility for the City of Raleigh in Garner, NC, where ~40 acres total of green ash (*Fraxinus pennsylvanica*) was planted in three plots about 22 years ago for the purpose of treating municipal wastewater. These plots are surrounded by stands of pine, sycamore, sweetgum and bald cypress. In 2021 the trees had suffered nearly complete mortality from EAB (Fig. 1A); it is therefore likely this is the last year the site would be suitable for EAB studies.

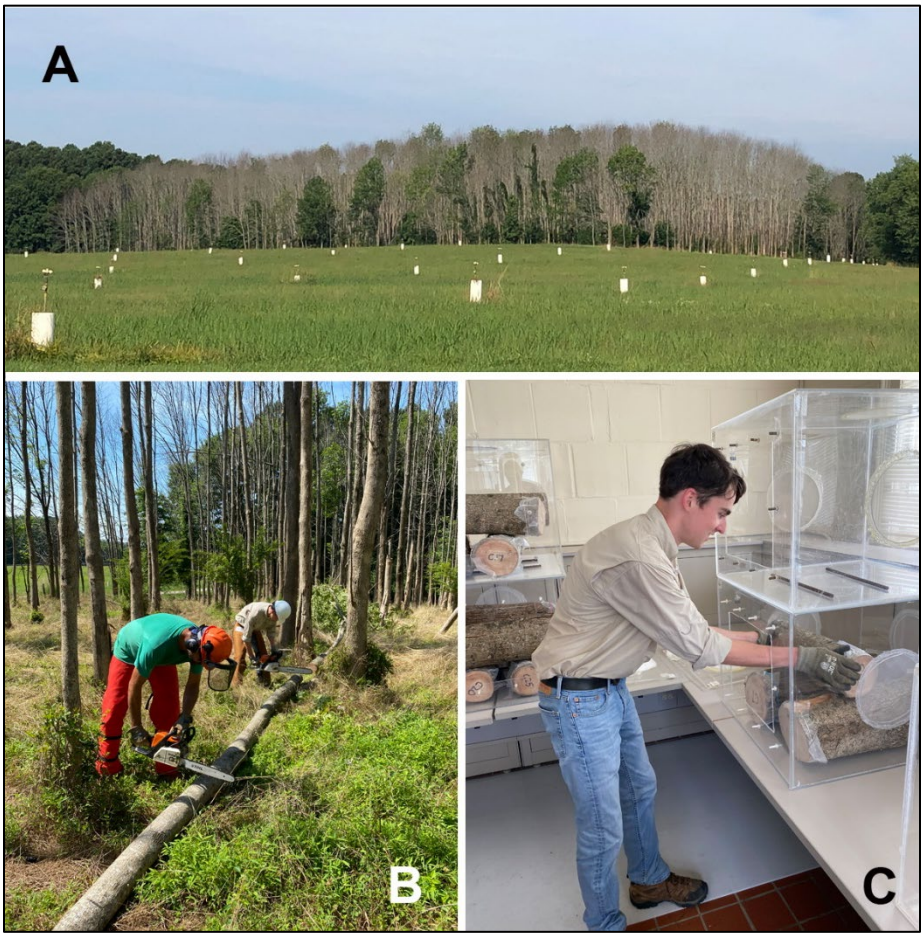


Figure 1. A) Stand of green ash at the research site in Garner, NC, photo taken 7 July 2021; note high tree mortality. B) John Eaton (foreground) and Ryan Bohannon sawing an ash bole into sections to put in emergence cages. C) Ryan Bohannon placing log sections into emergence cages at the BIL.

Screening for Native and Introduced Parasitoids of EAB at the Garner Research Site

On 14 June 2021, four EAB infested ash trees (Fig. 1A; two trees from each of two plots) at the Wrenn Road research site were cut near the soil line and bucked into 106 logs (Fig. 1B), about 55 cm in length and ranging from 8.5 – 25cm in diameter. These were brought back to the BIL, the cut ends covered in Parafilm to retain moisture, then placed into 36 Plexiglas emergence cages (61cm L x 61cm W x 49cm H; Fig. 1C). The date of the log cut was chosen to maximize detection of emerging parasitoids.

The cages were monitored daily for possible parasitoids, and collected specimens stored in alcohol. The study was broken down (logs removed from cages) 13 Aug 2021. Frass at the bottom of the cages was examined for any overlooked emerged insects (16 - 23 June 2021). All material was then labelled, and 13 vials transferred to Ryan Bohannon for further processing. John Eaton, Christine Nalepa (NCDA), Ryan Bohannon, Kelly Oten, Courtney Smith, and Abby Ratcliff (NCSU) participated in the field work and laboratory set up.

Comparative Studies of EAB Body Size and Sex Ratio

In 2021 we measured and analyzed the size and sex ratio of EAB collected by *Cerceris fumipennis*, from purple prism traps, and from green funnel traps. *Cerceris* biosurveillance was conducted at a Wake county site (a baseball diamond at South Garner High School), where a nesting aggregation was first detected in 2020; it is located about 550 meters north of our Wrenn Road research site. Biosurveillance was conducted at the aggregation on 10 days, between the dates of 6 June and 30 June 2021. A total of 126 beetles were collected by *Cerceris* at the site; 39 (31%) were EAB, 83 (66%) were *B. maculipennis,* one was *B. lineata* and 3 were *B. consularis.* On the same day that EAB samples were collected by *Cerceris*, they were stored in the freezer, and subsequently removed, measured and sexed prior to 15 July 2021.

Adult EAB collected biweekly from purple prism traps and green funnel traps by Ryan Bohannon at the Garner site were preserved in alcohol and brought to the BIL. These were measured, dissected, and sexed. Size data are summarized in Table 1 and will be compared to measurements of EAB taken from the same site in 2020. EAB sex ratio is being analyzed by Ryan Bohannon.

Table 1. Comparison of body length of female emerald ash borers using three collection techniques at our research site in Garner, North Carolina in 2021.

Technique	# Females Measured	Range Female length (mm)	Mean ± S.D. Female Length (mm)[1]
Purple prism trap	26	10.79 – 14.31	12.43 ± 0.93
Cerceris collected	23	10.14 – 13.53	12.48 ± 0.75
Green funnel trap	127	9.53 – 15.07	12.40 ± 0.90
Overall	176	9.53 – 15.07	12.41 ± 0.88

[1] No significant differences in the lengths of female EAB were detected among the three collection techniques in 2021 ($F_{2, 173} = 0.10$, $P = 0.90$).

Publication

These studies resulted in a publication in a professional journal in 2021:

Nalepa, C.A., K.L.F. Oten, M.A. Bertone. 2021. Overwintering developmental stages of emerald ash borer in North Carolina. Florida Entomologist 104(3): 213-217, doi: 10.1653/024.104.0310

C.A. Nalepa

Investigating Novel Methods to Release and Establish Silver Flies (*Leucotaraxis* spp.) and *Laricobius* spp. on Eastern Hemlock

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). Despite the establishment and impact 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. Additionally, while other predator species have been released to feed on HWA after *Laricobius* begin their dormant period during the summer months, establishment and recoveries of these predators has been sporadic. Predatory flies in the genus *Leucotaraxis* (formerly *Leucopis*) (Diptera: Chamaemyiidae) have been released but not recovered in the field (Fig. 1B). 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 project was initiated with the overall goal to enhance current biological control measures targeting HWA. The major objectives of this project are: 1) to assess the effectiveness of egg releases as a viable method to establish *Laricobius* spp. in release sites, and 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 eastern U.S. While individual studies have demonstrated *Laricobius* spp. can establish in an area from egg releases, we propose to refine rearing and release protocols that can be utilized by other rearing facilities. To refine these protocols, we will evaluate 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.

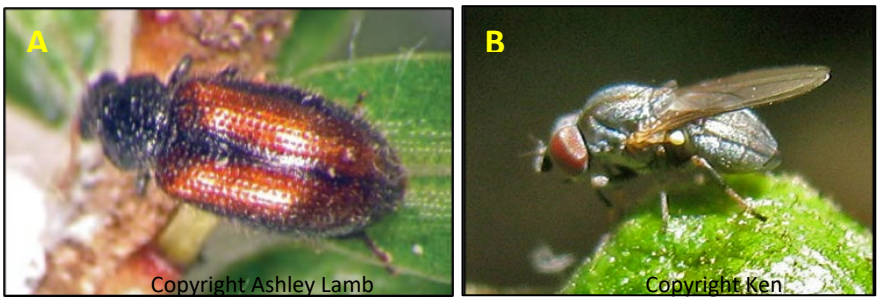


Figure 1. Predators of hemlock woolly adelgid: A) Laricobius osakensis, B) Leucotaraxis spp.

Because this project was initiated in August 2021, activities related to it are still in development. However, several milestones have been met. For this project, *L. osakensis* will be the primary beetle species on which efforts will be focused (Fig. 1A). Through cooperation with staff of USDA Forest Service, NCDA&CS Forest Service, and the Hemlock Restoration Initiative, several sites that serve as field nurseries for *L. osakensis* have been identified for use to collect these beetles for use in studies. In Fall 2021, over 100 adult beetles were collected from the field and taken to the Beneficial Insects Laboratory for visual identification and to hold in colony. NCDA&CS also is working with the Lindsay Young Beneficial Insects Laboratory, University of Tennessee to obtain lab-reared *L. osakensis*.

Several sites were examined and surveyed for use as field sites for studies, and sites for the whole-tree cage study and *Laricobius* egg release study have been identified. The *Laricobius* egg release study will be conducted at a site in McDowell County, NC, and is anticipated to begin in February 2022. The whole-tree cage study with *Leucotaraxis* spp. will be conducted at the Bent Creek Experimental Forest, Asheville, NC, and is anticipated to begin in Fall 2022 following the construction and delivery of the large cages.

G.J. Wiggins

Biological Control Initiative for Invasive Knotweeds in North Carolina

The NCDA&CS Biological Control Program in the Beneficial Insects Lab (BIL) continues to develop a new program to address invasive knotweeds in our state. Knotweeds were initially introduced as ornamentals throughout Europe and in the United States in the late 1800's and early 1900's. As is often the case, they were established without their natural enemies, and no contingency plans were in place to counter their rapid range expansion. These plants are now known to 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, as well as along highway rights-of-way and in areas under agricultural production. Further 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 of knotweed 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 knotweed-specific herbivorous insects (Fig. 1). Our Quarantine facility housed the initial seed colonies in North Carolina of two genetically distinct populations of the knotweed psyllid, *Aphalara itadori* (Hemiptera: Psyllidae). The Hokkaido biotype, from Northern Japan, is specific to giant knotweed, *Fallopia sachalinensis*, while the Kyushu biotype, from Southern Japan, is specific to Japanese knotweed, *F. japonica*, and the hybrid Bohemian knotweed, *F.* x *bohemica.* Permits for psyllid release were granted by Federal agencies in the Spring of 2020, and we have expanded the original quarantined colonies since that time. Protocols have been adapted from the guidelines of the North American project leader (Grevstad et al. 2018) as we scale up and work toward the goal of mass rearing these insects. We utilize mobile plant propagation and insect rearing carts to facilitate colony expansion (Fig. 2). During the 2020-2021 season, we were able to increase our capacity with the acquisition of additional growth carts and psyllid cages. We also conducted a new field cage assay, in which psyllid colonies successfully overwintered on host plants from five North Carolina Counties.

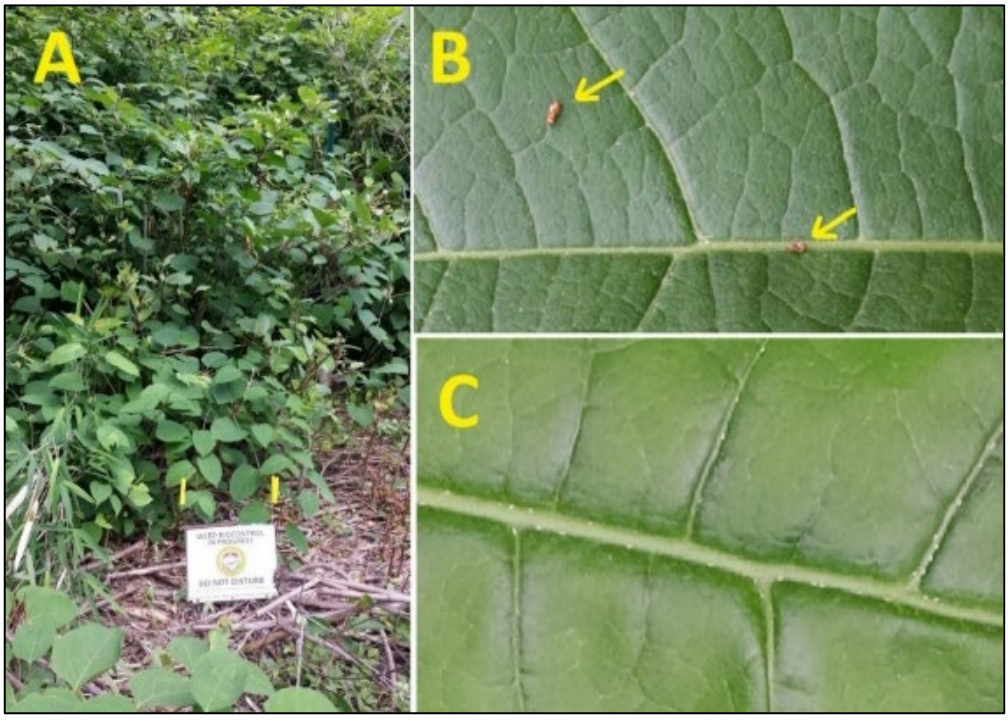


Figure 1. A) Typical knotweed site in North Carolina; B) psyllids on a knotweed leaf; C) psyllid eggs along leaf veins.

Figure 2. A) Knotweed plants under propagation; B) psyllid emergence cages; C) overwintering psyllid cages within large field cage; D) large field cage in winter.

Our current objectives are to determine whether the psyllid can overwinter and establish successfully in North Carolina. To address these objectives, we have established working relationships with property owners, local and state governmental officials, business owners, and additional stakeholders. We have conducted psyllid releases in six counties within three ecoregions of North Carolina (Fig. 3.) Protocols were updated in 2021, and more than seven thousand psyllids were released (Table 1).

Establishment of post-release psyllid populations at each site was evaluated two weeks post-release and periodically thereafter. On each date, we followed a standard protocol to survey at least ten transects within a release site for adults and eggs, which are more readily detectable than nymphs. Our observations suggested the initial establishment of one or two generations at most sites, but no evidence of psyllids later in the season. Similarly, psyllids overwintered successfully within the Field Cage, but we have no data to support this trend in the field. Our results and observations are roughly in line with those in other regions.

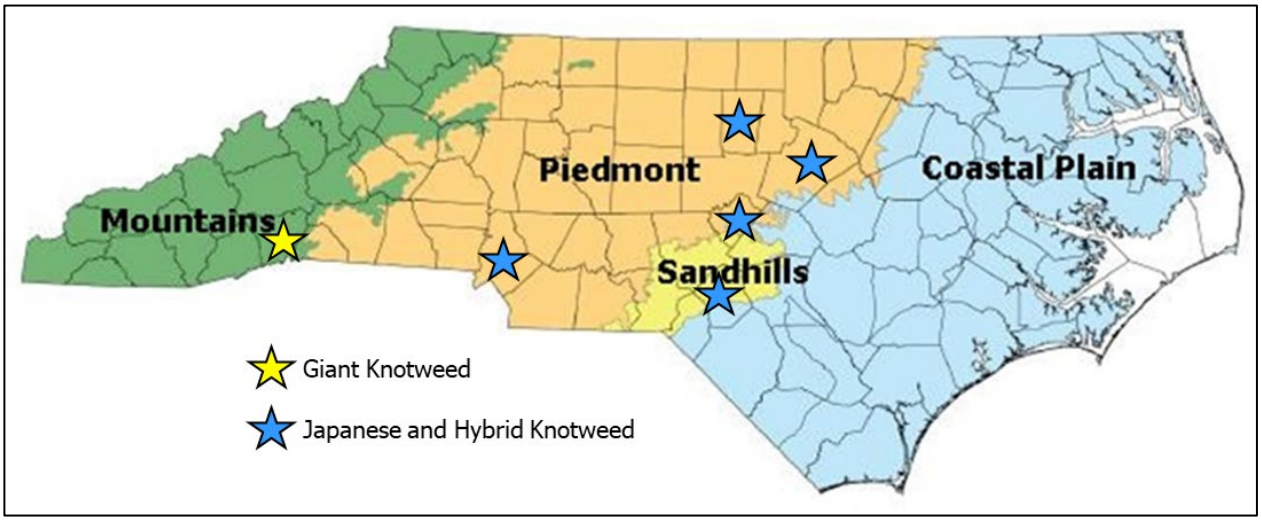


Figure 3. Knotweed psyllid release sites in North Carolina, 2020-2021.
Map modified from Vascular Plants of North Carolina website.

Table 1. North Carolina Knotweed Sites and Psyllid Releases, 2020-2021

County	Knotweed species	Psyllid biotype	Psyllids Released 2020	Psyllids Released 2021	Total # Psyllids Released
Henderson	Giant	Hokkaido	-----	1,914	1,914
Hoke	Hybrid	Kyushu	780	764	1,544
Lee	Japanese	Kyushu	835	-----	835
Mecklenburg	Hybrid	Kyushu	800	764	1,564
Orange	Japanese	Kyushu	-----	2,675	2,675
Wake	Japanese	Kyushu	1,000	1,219	2,219
		Total # Psyllids released	3,415	7,336	10,751

Climatic effects and increasingly erratic weather events presented major challenges to this work. For example, our best models predict the Spring psyllid emergence date (and hence, our planned psyllid release date) in North Carolina to occur in March, which coincides with the emergence of new plant growth. Our earliest psyllid release followed this model. However, late Spring frosts can kill the tender new plant growth, which is where psyllids prefer to lay their eggs. In fact, frost-kill occurred on knotweed plants at our first release site of 2021. Other challenges include native predators, as well as flooding, trampling, pesticide drift, and other site disturbances.

Our findings, in combination with those of other members of the North American Knotweed Biocontrol working group, will instruct our future release and control plans. We continue to improve our methods to further streamline, standardize, and increase psyllid production to expand capacity. We plan to shift toward releases into large field cages to more nearly isolate and observe host plant/herbivore processes. Finally, we are initiating collaborations at new sites that may be subjected less to disturbance. With these implementations, we expect to more clearly address the potential of this biocontrol agent for knotweeds in our region.

Reference

Grevstad, F., J.E. Andreas, R.S. Bouchier, R. Shaw, R.L. Winston, and C.B. Randall. 2018. Biology and Biological Control of Knotweeds. USDA Forest Service, Forest Heath Assessment and Applied Sciences Team, Morganton, West Virginia. FHTET-2017-03.

N.C. Oderkirk

Biological Control of Mile-A-Minute Vine with the weevil, *Rhinoncomimus latipes* in North Carolina

Mile-a-Minute vine (MAM), *Persicaria perfoliata*, is a fast-growing annual invasive weed found in riparian areas and along forest edges in the Northeastern and mid-Atlantic United States. It was first discovered in North Carolina in 2010. This weed exhibits rapid growth, prolific flowering, long-lived seeds, and an ability to overtop herbaceous and shrubby plants and even small trees (Fig.1A). These habits, in concert with its typical riparian location, make chemical control of MAM difficult. Cultivation is not very effective, because seeds can be released during the process, and plant remnants root at the nodes and re-grow. Biological control has therefore proven to be a valuable tool for an integrated management plan for dealing with this weed.
Throughout its range in the Eastern United States, biological control of MAM has been undertaken by release of the host-specific MAM weevil *Rhinoncomimus latipes* (Coleoptera: Cuculionidae). Adult weevils feed on the leaves (Figs. 1B and 1C) and larvae bore into the stems, weakening the plant and reducing seed production. MAM weevil has been reared at the Philip Alampi Beneficial Insect Lab (PABIL) of the New Jersey Department of Agriculture, which has provided weevils for release throughout the Northeastern and Mid-Atlantic states, including North Carolina. Hough-Goldstein et al. (2008) provide an overview of the biology and biological control of MAM.

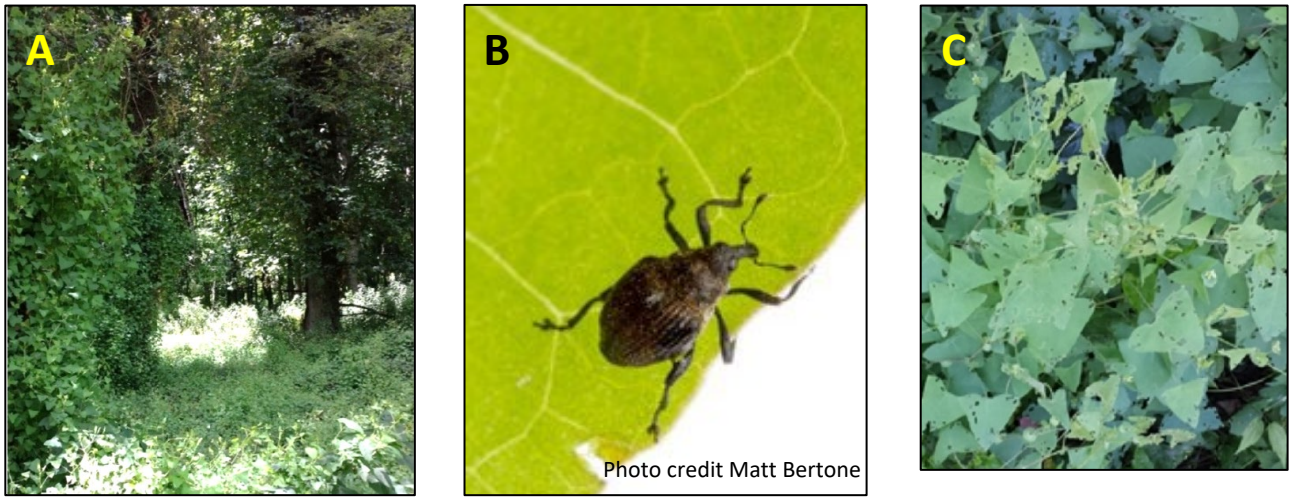


Figure 1. A) Mile-a-Minute (MAM) overgrowing vegetation at the forest edge; B) MAM Weevil, Rhinoncomimus latipes, on its host plant; C) typical early-season damage by MAM weevil (Alleghany County, 2016).

Extensive surveys have determined the range of MAM to be restricted to six counties in North Carolina (Fig. 2), including a recently-discovered site in Watauga County, where a previous population of MAM was thought to have been mechanically eradicated.
Weevils have been released since 2011 at MAM sites across North Carolina. The weevils have persisted at each site, and dispersal has been documented almost 5km from release sites. The Yancey County MAM population has been kept in check by mechanical removal in addition to biological control. In Guilford County, only a small MAM stand has remained, and has been kept in balance by the weevils. In other locations, plant density has consistently outgrown that of the weevil, in the absence of consistent mechanical control. This has resulted in partial suppression of the weed via previously documented reduction of plant growth and seed production.
In conjunction with the conclusion of the federal MAM biocontrol program, we received 500 MAM weevils for release in Watauga County in the late Spring of 2021. Post-release surveys confirmed the presence of the weevil throughout the summer, and we expect this weevil population to persist in the area.
Despite variable results in terms of biological control of MAM in North Carolina, we have observed consistently that MAM weevils have reliably persisted, dispersed, and produced noticeable suppression of Mile-a-Minute vine at every site where they have been released. For these reasons, we believe that the weevil will remain a viable tool, in concert with early-season mechanical controls, within an IPM program for this weed.

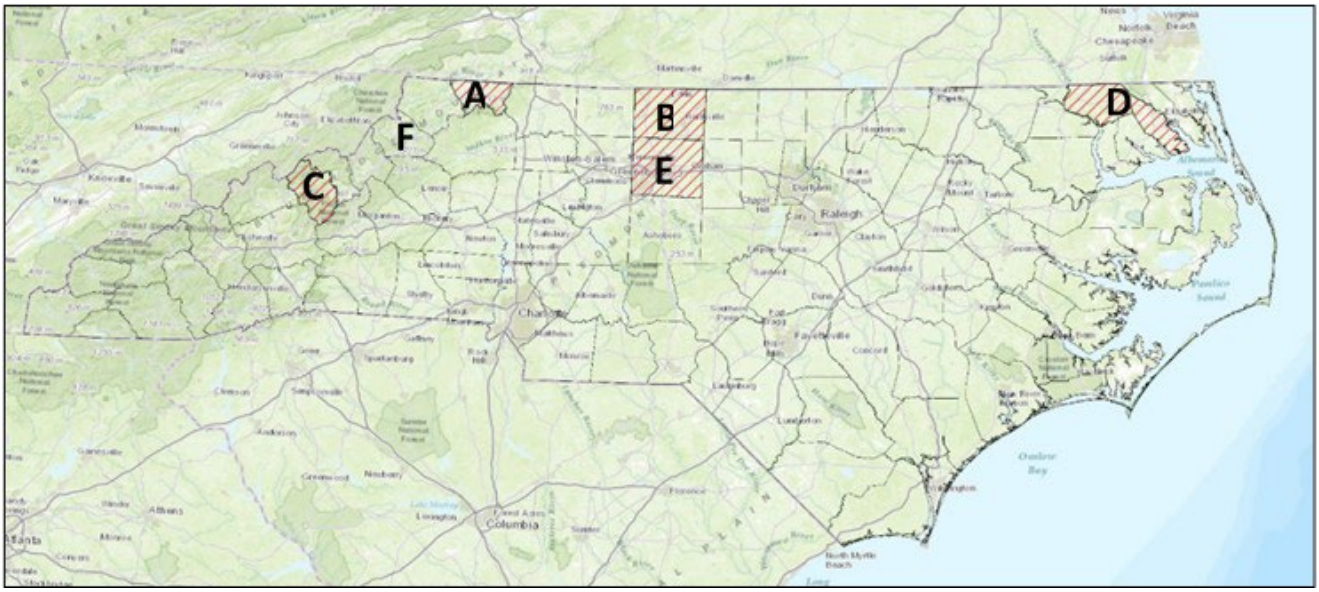


Figure 2. Mile-a-Minute detections in North Carolina Counties. Letters correspond with the order in which detections were reported. A = Alleghany, B = Rockingham, C = Yancey, D = Pasquotank and Gates, E = Guilford, F = Watauga.

This plant is easily identified by triangular leaves, spines on the stems and leaf petioles, and a modified leaf (ochrea) that surrounds each node. Its small white flowers develop into bright metallic blue, berry-like fruit in late summer. Sightings of this weed should be reported to newpest@ncagr.gov.

Reference

Hough-Goldstein, J., E. Lake, R. Reardon, and Y. Wu. 2008. Biology and Biological Control of Mile-a-minute Weed. USDA Forest Service, FHTET-2008-10.

N.C. Oderkirk

Cooperative Agricultural Pest Survey (CAPS) Program

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 2021 North Carolina CAPS program was successful in procuring funding for CAPS and Farm Bill surveys for early detection of exotic plant pests. Nine independent surveys were conducted throughout the state, covering 58 counties. Surveys included; mollusk, forest pests, oak commodity, Asian defoliators, grape commodity, solanaceous commodity, a *Phytophthora* spp. state-specific survey, box tree moth, and spotted lanternfly. Five temporary employees were hired to assist with survey efforts, including four plant pest aides and one taxonomic specialist. A total of thirty-five different exotic plant pests were surveyed from April through late October. All surveys were completed following the 2021 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 2021 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 2021 surveys, while proposals for the 2022 survey season were successfully submitted in July 2021.

CAPS Surveys

Three CAPS surveys were selected for the 2021 season in North Carolina; mollusk, forest pests and oak.

Mollusk Survey

The mollusk survey was conducted at four locations within the state in 2021 (Figure 1), exceeding our survey goal. Eight exotic taxa of mollusk were surveyed: giant African snail (*Lissachatina fulica*), Hygromiid snails (*Cernuella spp.*) and Leatherleaf slug spp. (*Veronicella spp., Belocaulus spp., Celosias spp., Laevicaulis spp., Sarasinula spp.,* and *Semperula spp.*). Both the Pest Survey Specialist (PSS, USDA-APHIS-PPQ) and CAPS Coordinator completed the surveys at four stone and tile importing locations within the state. No target pests for this survey were recovered.

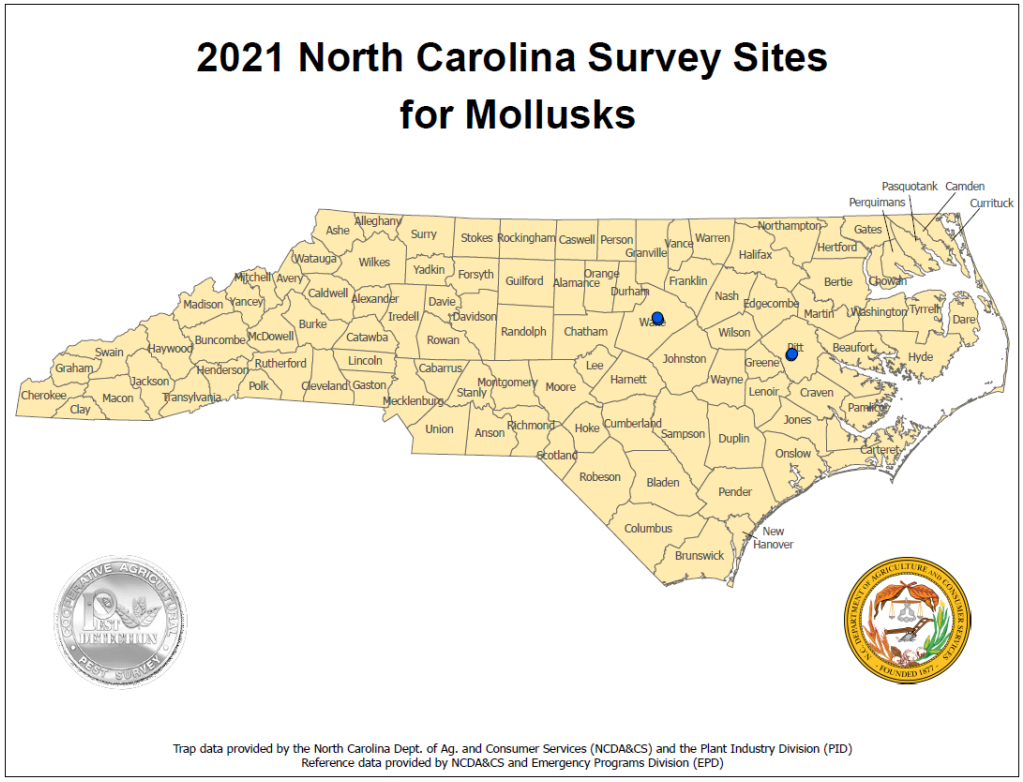


Figure 1. Map of Mollusk Survey sites, 2021

Oak Commodity Survey

North Carolina completed the 2021 oak commodity survey at 34 locations (Figure 2), surpassing the goal of 20. This survey included the following species: oak processionary moth (*Thaumetopoea processionea*, OPM), oak ambrosia beetle (*Platypus quercivorus*, OAB), and oak splendor beetle (*Agrilus biguttatus*, OSB). Oak processionary moth is a defoliating pest and oak splendor beetle is a flat-headed wood boring insect; both species can severely damage or 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 April and ended in September. Monthly visits were conducted at forty-five 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. This year, OSB was surveyed for through an intensive multi-step survey process that involved site- and tree-level visual surveys and sweep-net sampling of leaf litter. This was conducted at 10 of the locations where trapping was conducted. In previous years, we had conducted surveys by collaborating with Biological Control staff to use native *Cerceris* wasp sites. We were not able to access these sites (baseball diamonds) in 2021 due to concerns over the COVID-19 pandemic. All staff agreed that the *Cerceris* survey method is both more accurate and more straightforward to conduct; we plan to utilize this method to survey for OSB in 2022. No target pests for the Oak Commodity Survey were recovered.

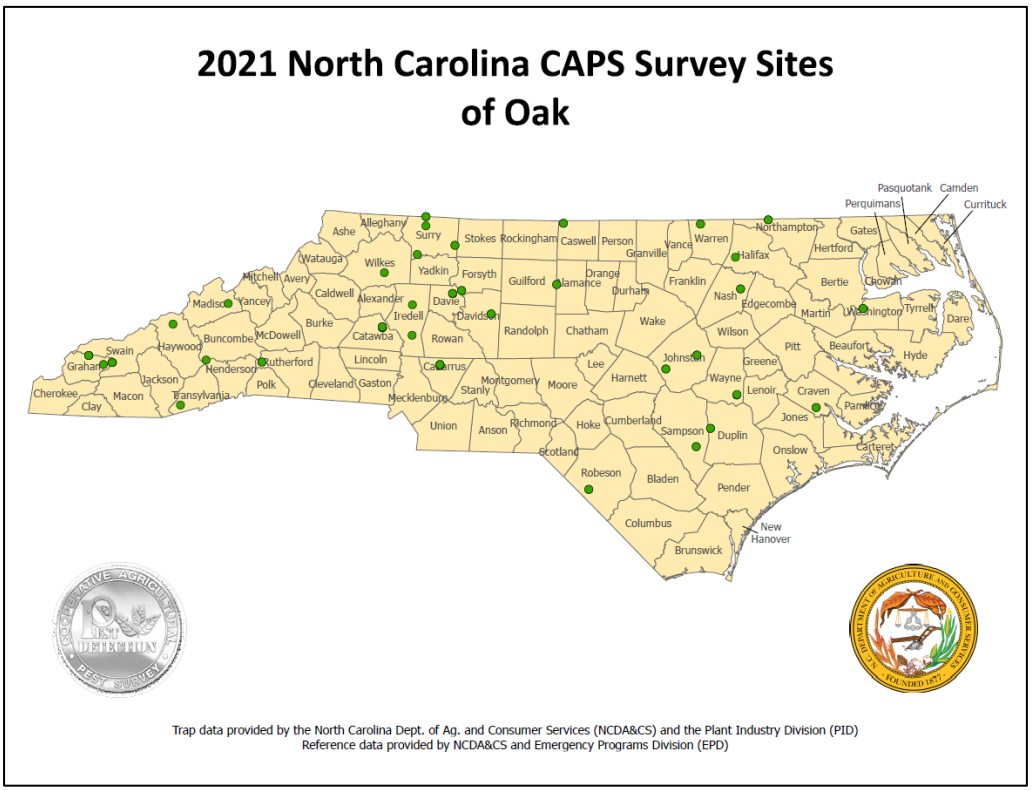


Figure 2. Map of Oak Commodity Survey sites, 2021

Forest Pests Survey

The Forest Pest survey throughout the state concentrated on Asian Longhorned beetle (*Anoplophora glabripennis*; ALB), beginning in March and concluded in October. In total, 33 sites were inspected throughout the course of the survey (Figure 3). 25 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. The SSC met with each trapper individually to provide training on signs of ALB infestation at various points in the year. Maple trees were surveyed at each site monthly, with particular thoroughness during the first inspection of the year before trees had fully leafed out. (Figure 1). No evidence of ALB infestation was observed.

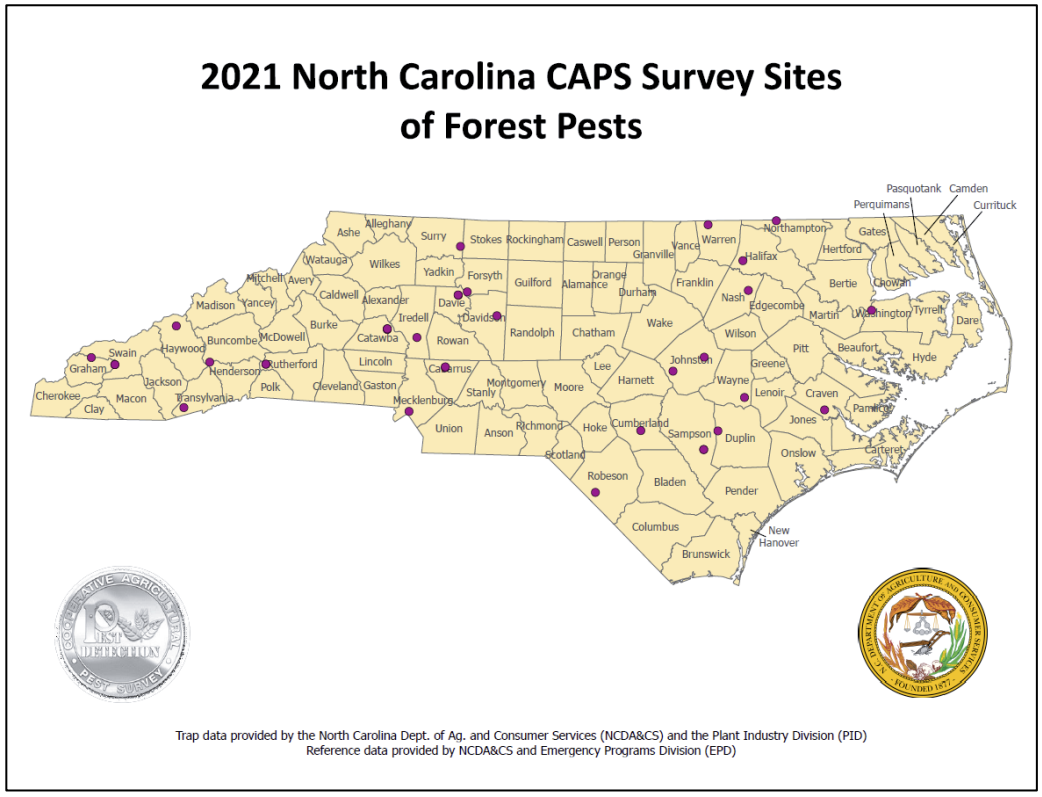


Figure 3. Map of Forest Pest Survey sites, 2021

Farm Bill (PPA 7721) Surveys

The SSC annually applies for Federal assistance for the state to conduct exotic plant pest surveys. In 2021, money for six Farm Bill surveys were awarded to NC; Box tree moth, Asian defoliators, grape commodity, solanaceous commodity, a *Phytophthora* spp. survey, and spotted lanternfly early detection/ host mapping.

Box Tree Moth

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. While it is not yet considered an official National Priority Pest, USDA has given box tree moth the highest possible risk rating in its pest prioritization process. As the 7th highest selling boxwood-producing state in the country, North Carolina joined several other states in a pilot program for early detection of BTM in 2021. Traps were placed at 30 boxwood-producing locations with a priority given to large wholesale operations beginning in May, exceeding our stated goal of 20 locations. In June 2021 we were notified that 8 private residents in North Carolina received direct shipments of boxwoods that may have been involved in a trace-forward of plants originating from Ontario and resold by a South Carolina nursery. NCDA&CS staff worked with USDA to confiscate and destroy these plants. We placed traps at the four northern locations and looped them into this survey. USDA covered trapping for the 4 locations in the Charlotte area and thus those numbers/ locations are not shown. This incident brought the total of NCDA&CS trapping locations to 34. Traps were checked once every 4 weeks through the end of October. The target pest was not detected anywhere in the state. We have requested funding to continue this survey in 2022.

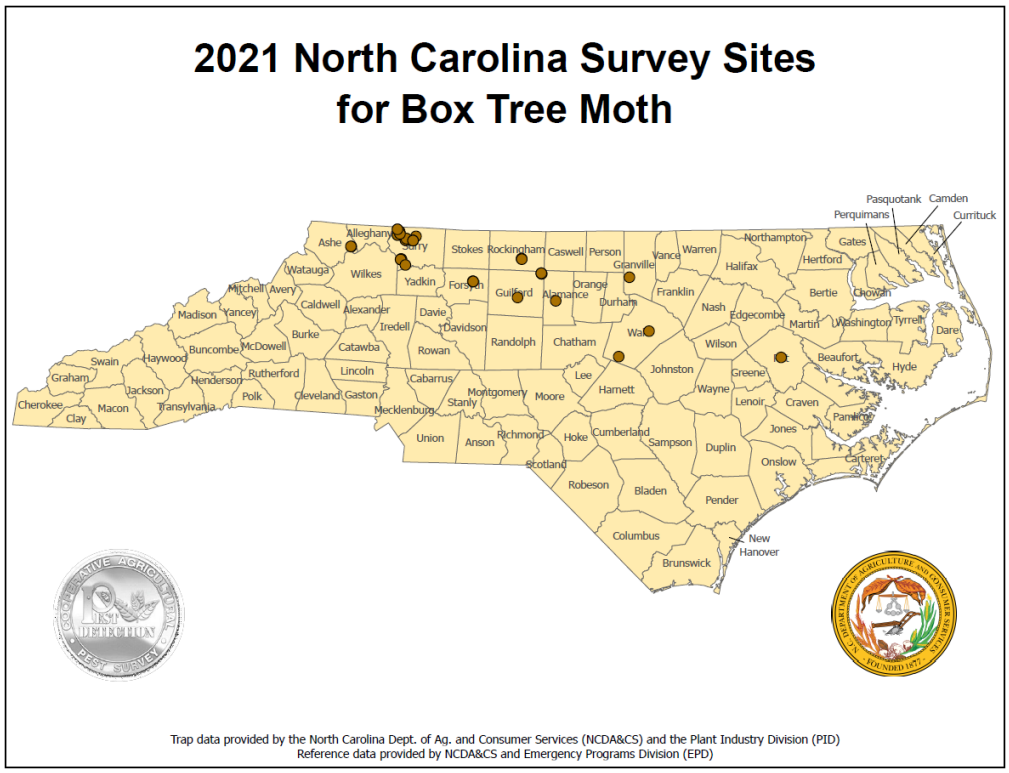


Figure 4. Map of Box Tree Moth Survey sites, 2021

Asian Defoliators

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 18 trapping locations were placed at ports of entry over a four-month period from June to September (Figure 5), 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. It was previously determined that multiple survey locations exist on larger installations, and 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.

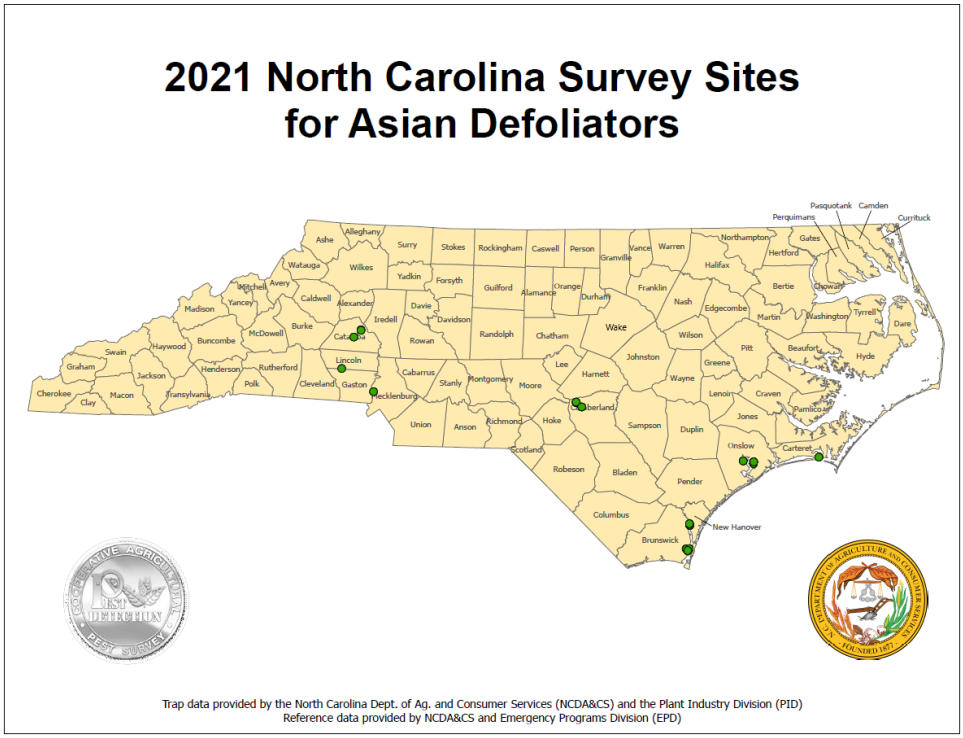


Figure 5. Map of Asian Defoliators Survey sites, 2021

Following the conclusion of the 2019 Asian defoliator survey and the arrival of a ship infested with Asian gypsy moth (AGM) eggs at the Sunny Point Military Ocean Terminal (MOTSU) in late 2019, NCDA&CS personnel participated in the rapid response effort and placed 56 additional traps throughout the base according to a risk-based grid (Figure 6). Additional traps (2-sided orange paper delta with disparlure, 56 total) were placed at MOTSU according to this grid again in 2020 and 2021 to capture any potential AGM resulting from this incident. High-density traps were changed and lures replaced once in mid-July and pulled September 21st. No AGM were recovered through these three rounds of trapping. 3 years of no detection is typically considered enough to declare eradication; thus, we do not plan to conduct additional grid trapping in 2022. As in previous years, MOTSU will still host 3 Asian Defoliator trap sites within the base at the highest-risk locations to offer continued early detection of new potential infestations.

Figure 6. High-density trapping grid, MOTSU

Grape Commodity

The Grape Commodity survey was completed at 34 locations (Figure 7), exceeding our goal of 20 locations. Vineyards surveyed included both European (*Vitis vinifera*) and native muscadine grapes (*Vitis rotundifolia*). We surveyed for four exotic species; Christmas berry webworm (*Cryptoblabes gnidiella*), spotted lanternfly (*Lycorma delicatula*), light brown apple moth (*Epiphyas postvittana*, LBAM), false coddling moth (*Thaumatotibia leucotreta*), and European grapevine moth (*Lobesia botrana*). Additional traps for LBAM were placed at 7 additional vineyards that had imported nursery stock from an LBAM-infested area of California as additional "check" to any regulatory measures followed by the originating nursery. Traps were set in June and pulled by October (Figure 4). Visual surveys for spotted lanternfly were conducted within vineyards at each visit in accordance with the approved guidelines. No target pests for this survey were recovered.

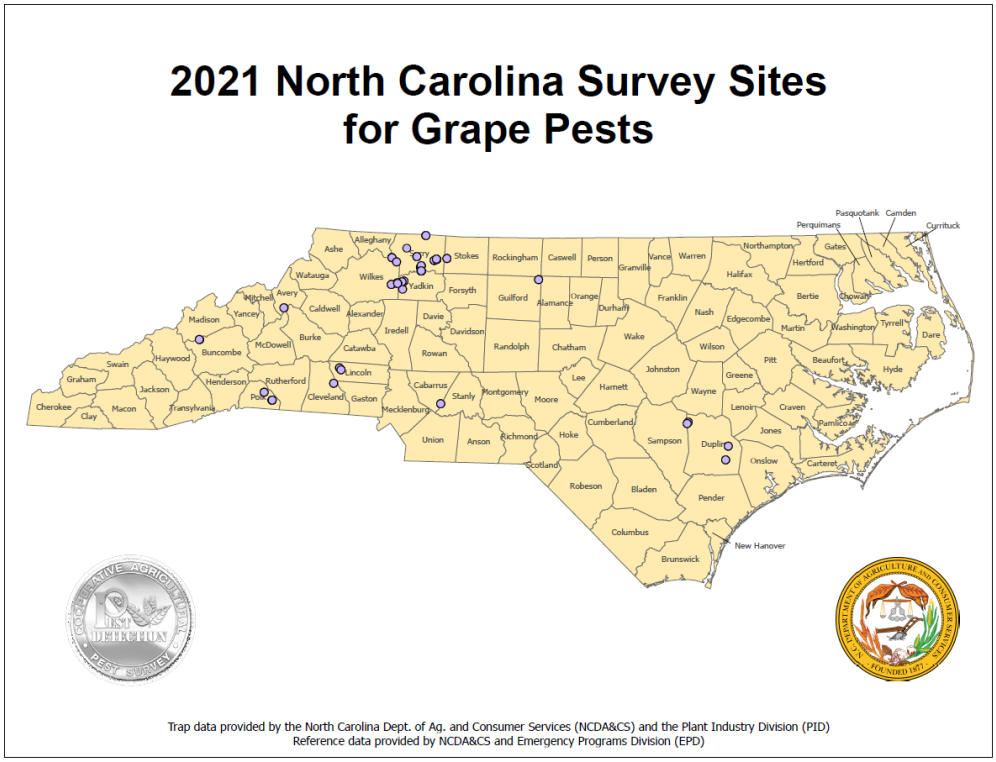


Figure 7. Map of Grape Commodity Survey sites, 2021

Solanaceous Commodity

Insect pests (field survey)

We surveyed 22 host sites that included commercial tomato, eggplant, tobacco and pepper production fields (Figure 8) for insect pests, exceeding our goal of 20 sites. Five exotic insect pests of solanaceous plants were surveyed from June-October 2021: tomato leaf miner (*Tuta absoluta*), old world bollworm (*Helicoverpa armigera*), golden twin spot moth (*Chrysodeixis chalcites*), tomato fruit borer (*Neoleucinodes elegantalis*), 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 native bollworm, *H. zea*, in South America. *H. zea* 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 *H. armigera* becomes established. Early detection and identification of this pest will limit spread to the natural environment and aid in eradication. Invasive *Helicoverpa armigera* and native *H. zea* 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 *H. armigera*. Dissections of OWB are ongoing and are expected to be completed in January 2022. No other target insect pests were recovered as a result of this field survey.

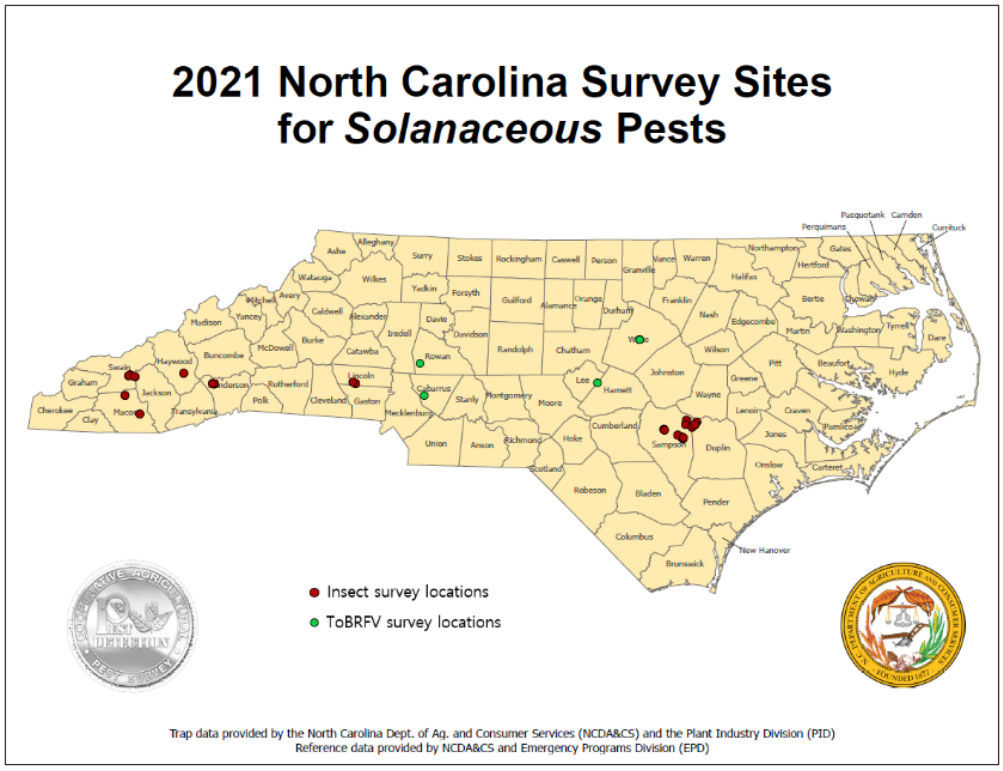


Figure 8. Map of Solanaceous Commodity Survey sites, 2021

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 tobamovirus that is fairly new to science, 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. Symptoms tend to appear in foliage first, and lead to brown lesions on the fruit that can render the product unmarketable (Figure 9). 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. Survey for this pathogen began during peak greenhouse cultivation beginning in February 2021.We were able to conduct 6 surveys at 4 locations in our first year and plan to continue these surveys in winter and spring 2022.

Figure 9. Symptoms of ToBRFV (photos by Neta Luria et al.).

Phytophthora spp.

North Carolina conducted a *Phytophthora ramorum* and *P. kernoviae* survey during 2021. Both pathogens pose a significant threat to NC forests and nurseries. *Phytophthora kernoviae*, also known as phytophthora leaf blight, is not known to occur in the U.S., but does infect important plant species including members of *Quercus*, *Magnolia*, *Rhododendron* and *Pieris*. *Phytophthora ramorum,* also known as sudden oak death, has been present along parts of the Pacific Northwest since the mid-1990s. The primary pathway for these pathogens is from trade of infected ornamental plants and since both pathogens share common hosts and affect stem and leaf tissue, a survey was developed to include both pathogens for improved efficiency. 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.

131 locations were surveyed during calendar year 2021. Of these locations, 117 locations were "big box" nursery stores that were surveyed by CAPS temporary personnel. The remainder were conducted by Specialists during routine nursery inspections. 11 samples were collected for ELISA screening by the Plant Pathologist. Of those, 3 had a pathogen belonging to the *Phytopthora* genus and were sent off for further testing. No target *Phytophthora* spp. were detected in 2021 as a result of this survey. Locations that were part of trace-forward investigations in 2021 (see Plant Pathology section) will be given top priority for survey in 2022.

In our PPA-7721 funding suggestion for 2022, we included a proposal to build a partnership with NCSU to start the process of getting an NPDN lab certified. Having a local NPDN lab will not only save on shipping costs, but also allow samples to be processed much more quickly. This ultimately will allow us to respond more quickly to plant pathogens of regulatory concern and prevent them from getting out into the environment more quickly. We have not received an announcement of funding from USDA yet but are hopeful that we will be able to pursue this goal in 2022.

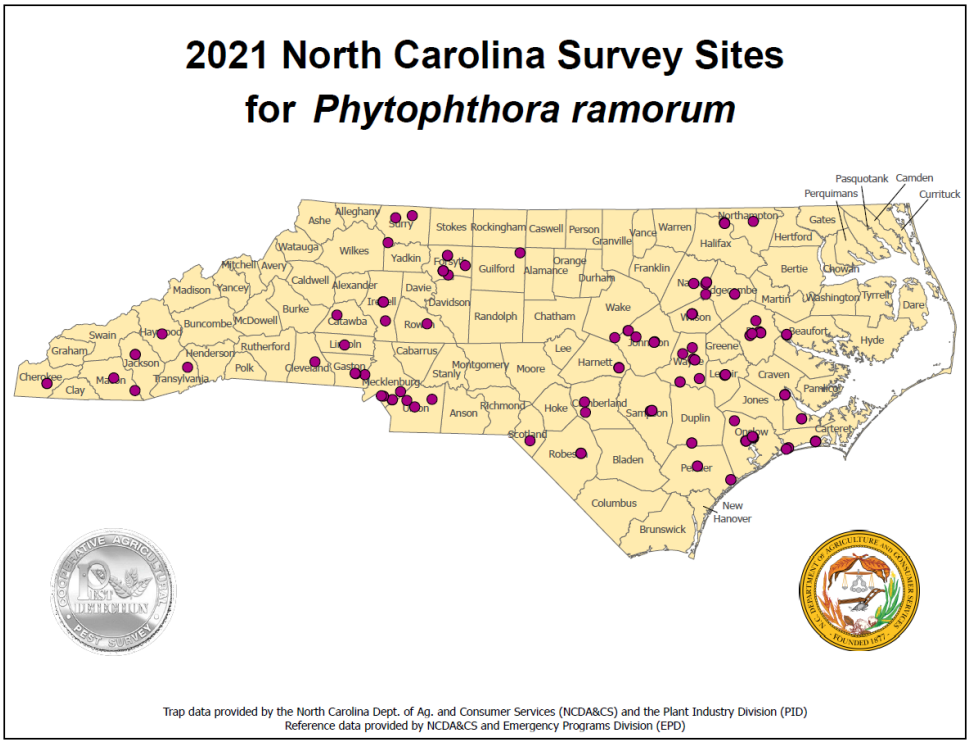


Figure 10. Map of *Phytopthora* spp. Survey sites, 2021

Spotted Lanternfly Early Detection/ Host Mapping

See Entomology section.

Entomological Programs

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

The following report summarizes the primary activities and accomplishments of the NCDA&CS Entomological Programs in 2021. Our Regulatory Entomologist position was vacated by Whitney Swink at the end of June 2021 and Paul Adams transitioned into the role in August 2021.

Sweet Potato Weevil Program

North Carolina's sweet potato production continues to be a success as demand for sweet potatoes increases 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 2021 in 46 counties, primarily in eastern North Carolina. 13,635 traps were set in 11,970 fields in approximately 96,067 reported acres (Table 1). 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 1a). Traps were deployed at an average density of one trap for every 7.54 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 2021.**

Table 1. NC Sweet Potato Weevil Field Trapping Summary (2021)

County	Mapped Field	Reported Acres	Traps Set	County	Mapped Field	Reported Acres	Traps Set
Alamance	2	1	--	Lee	17	78	23
Beaufort	6	64	--	Lenoir	319	3010	381
Bertie	148	1490	199	Martin	167	1891	243
Bladen	41	520	78	Montgomery	8	109	--
Brunswick	1	4	2	Moore	18	34	27
Camden	2	3	2	Nash	1406	9219	1370
Carteret	2	5	2	Northampton	14	234	23
Caswell	1	0.5	--	Onslow	9	55	8
Chatham	2	22	3	Orange	2	2	2
Chowan	40	482	69	Pamlico	55	304	51
Cleveland	1	3	--	Pasquotank	7	53	14
Columbus	93	579	78	Pender	49	451	59
Craven	100	586	89	Pitt	395	3744	533
Cumberland	152	1678	291	Polk	3	5	--
Davidson	3	4	3	Randolph	18	57	16
Duplin	373	3898	554	Robeson	23	626	40
Edgecombe	976	9280	1177	Rutherford	3	0.49	--
Forsyth	2	3	4	Sampson	1409	14489	1987
Franklin	107	703	117	Scotland	8	192	21
Graham	1	2	--	Stokes	1	0.125	2
Granville	61	255	66	Tyrrell	1	5	2
Greene	669	6678	701	Vance	1	0.5	--
Guilford	36	154	--	Wake	132	606	111
Halifax	288	1613	277	Warren	11	77	11
Harnett	637	4048	622	Watauga	1	0.25	--
Hertford	27	372	85	Wayne	711	6225	1030
Johnston	1547	10634	1649	Wilson	1850	11390	1463
Jones	13	105	9	Yadkin	1	1	2
				Total	11970	96067	13496

[1]Counties with traps set labeled '--' reported acres with no crop present therefore no traps were placed.

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 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 207 regulatory sites (totaling 6,710 inspections) were surveyed and **no weevils were found in storage facilities during the 2021 season.**

Figure 1. a) Green boll weevil trap baited with sweetpotato weevil lure used to survey sweet potato fields; b) bucket traps used to survey storage facilities

Sweet Potato Weevil Eradication (Phase 2)

NCDA&CS Plant Industry Division was awarded a Specialty Crop Block Grant (SCB Grant; USDA Farm Bill 2014) to determine the spatial and temporal distribution of sweet potato weevil populations in the quarantine area of North Carolina (portions of New Hanover and Brunswick Counties) with the goal using the data collected to develop a plan to eradicate the pest North Carolina. Phase 1 of the project (the population data collection phase) concluded in December 2017. We were awarded a second SCB grant for Phase 2 of the project (the eradication phase) which began January 2018. From January through March new high efficiency traps were designed and built. These traps are a modification of the traps used in Phase 1 and include a galvanized mesh "skirt" for the weevils to easily walk into the bucket traps and a solar-powered LED light that produces a green light at night to attract the weevils (Figure 2). These traps were deployed in the SPW quarantine area in April 2018 and are being checked weekly for presence of weevils. This project is ongoing and has extended past the duration of the grant (expired June 2021). Due to Covid-19, staffing shortages and other factors the monitoring of the quarantine area has faced challenges but in 2022 our eradication efforts will continue and consistent monitoring of the quarantine is planned. Additionally, a preliminary experiment for the use of entomopathogenic fungi as a control agent in the quarantine zone is being devised with the goal of implementation in 2022.

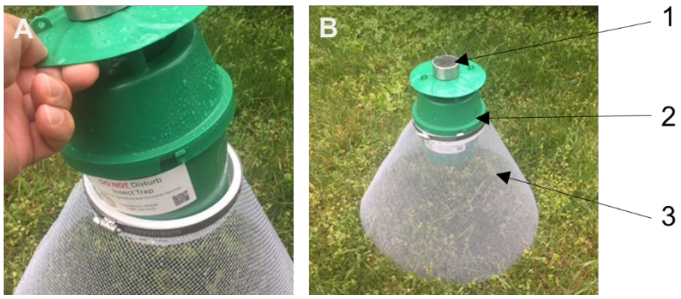


Figure 2. Details of the sweetpotato weevil trap to use in the MAT. The base of the trap is a funnel made with galvanized mesh (3). This allows weevils to walk to the bucket trap fitted within a PVC ring that holds the funnel (2). The bucket trap includes a solar cell (1) that charges an LED diode that 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.

GYPSY MOTH SLOW THE SPREAD AND ERADICATION PROGRAM

In 2021, NCDA&CS, in cooperation with USDA-APHIS-PPQ, USDA-Forest Service (USFS), and the Slow the Spread (STS) Foundation, carried out an extensive trapping, treatment and regulatory program aimed at detection and eradication of European gypsy moth (EGM), a major invasive pest of hardwood trees. The program in North Carolina is divided into two different areas, STS and Eradication, as shown in Figure 1.

Trapping

A total of 17,455 traps were set in 100 counties in NC from April to June 2021 and removed from July to September 2021 (Figure 1). Traps were baited with disparlure, the female-produced sex pheromone of gypsy moth (2-methyl-7R, 8S-epoxy-octadecane). Trap locations and data were recorded in iPad units. Trapping resulted in 2,096 adult gypsy moth males captured in 716 positive traps (Table 1).

Male moth captures in 2021 were higher than last year. Higher captures were along the Virginia-North Carolina border, along the outer banks and in the great dismal swamp area. Eleven mating disruption (MD) treatments totaling 16,909 acres and multiple delimiting grids are proposed for 2022 to follow up in high-capture locations.

Per 2021 USDA-APHIS-PPQ protocol as stipulated in the cooperative agreement AP21PPQFO000C230, trapping surveys were conducted in the Eradication area (all non-STS area). Delta traps were set in an area-wide grid of 1 trap per 3 kilometers, with some delimit areas where one trap is placed every 500 or 1000 meters to closely monitor a suspected reproducing EGM population. Funding provided by USDA-APHIS-PPQ was used to employ 9 temporary employees, buy the necessary survey supplies (including traps, lures, trap assembly supplies, and office supplies), and for operational expenses (including fuel and maintenance for survey vehicles).

In the STS area, 7 contractors set traps in 29 bid units, according to site data provided by the STS Foundation in cooperation with Virginia Tech. Delta traps were set in an overall grid of 1 trap per 2 kilometers along the northern portion of the STS area; all other portions of the STS area were trapped at a density of 1 trap per 3 kilometers. Locations with high catches the previous year or areas under evaluation from treatments in previous years were surveyed in a 500-meter or 1000-meter grid utilizing either high-density milk carton traps or delta traps. Temporary personnel and permanent NCDA&CS personnel performed quality control work at a minimum of 10% on traps set by contractors, and no significant quality issues were noted.

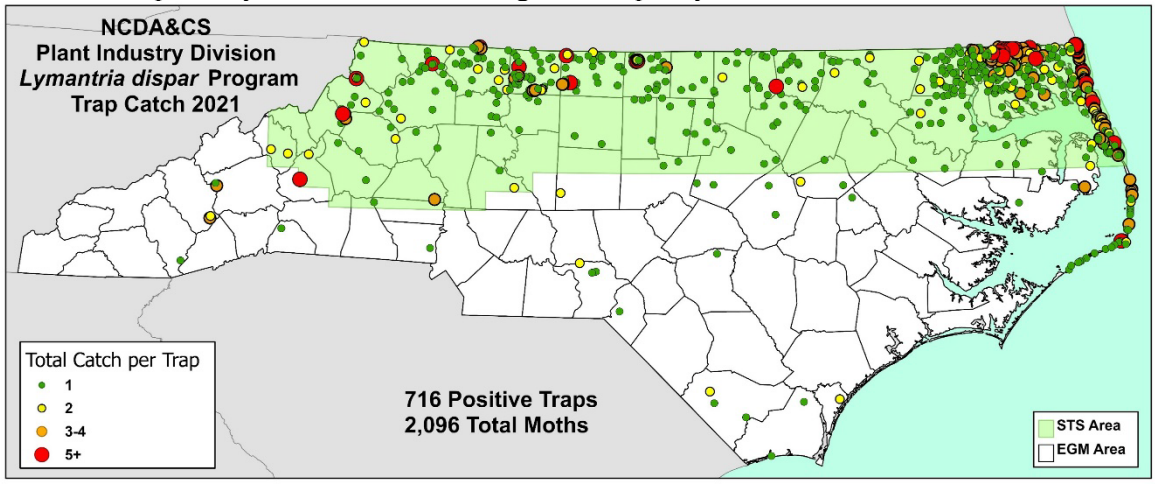


Figure 1: North Carolina gypsy moth trap catch numbers in 2021.

Table 1: North Carolina gypsy moth trap catch numbers by county.

County	Traps Placed	Positive Traps	Moths
Alamance	173	4	4
Alexander	77	1	1
Alleghany	193	13	23
Anson	152	0	0
Ashe	282	3	4
Avery	72	1	1
Beaufort	226	0	0
Bertie	295	12	13
Bladen	261	0	0
Brunswick	242	2	2
Buncombe	169	2	4
Burke	146	2	2
Cabarrus	101	0	0
Caldwell	143	6	19
Camden	139	39	154
Carteret	127	0	0
Caswell	295	22	42
Catawba	123	1	3
Chatham	195	2	2
Cherokee	99	0	0
Chowan	82	4	5
Clay	39	0	0
Cleveland	134	1	1
Columbus	263	3	4
Craven	180	0	0
Cumberland	186	1	1
Currituck	198	78	1009
Dare	297	122	222
Davidson	162	0	0
Davie	77	1	1
Duplin	233	0	0
Durham	117	5	5
Edgecombe	147	1	1
Forsyth	211	4	4
Franklin	276	7	7
Gaston	107	1	1
Gates	236	71	116
Graham	35	0	0
Granville	329	8	9
Greene	75	1	1
Guilford	274	2	2
Halifax	456	6	9
Harnett	171	0	0
Haywood	113	6	11
Henderson	102	0	0
Hertford	229	23	28
Hoke	102	0	0

Hyde	143	9	9
Iredell	180	1	1
Jackson	100	1	1
Johnston	221	2	2
Jones	115	0	0
Lee	71	0	0
Lenoir	110	0	0
Lincoln	87	0	0
Macon	91	0	0
Madison	106	0	0
Martin	127	2	2
McDowell	102	2	8
Mecklenburg	170	0	0
Mitchell	63	0	0
Montgomery	122	0	0
Moore	199	0	0
Nash	169	0	0
New Hanover	68	1	2
Northampton	356	7	9
Onslow	168	0	0
Orange	170	4	4
Pamlico	85	0	0
Pasquotank	148	23	44
Pender	209	0	0
Perquimans	145	22	26
Person	258	4	4
Pitt	188	0	0
Polk	62	1	1
Randolph	210	1	2
Richmond	130	3	4
Robeson	266	0	0
Rockingham	445	38	69
Rowan	152	2	3
Rutherford	157	0	0
Sampson	279	0	0
Scotland	89	1	1
Stanly	117	0	0
Stokes	403	41	58
Surry	389	28	49
Swain	44	0	0
Transylvania	67	0	0
Tyrrell	89	3	3
Union	182	0	0
Vance	211	8	13
Wake	249	5	5
Warren	289	15	16
Washington	100	2	2
Watauga	204	12	20
Wayne	164	0	0

Wilkes	427	13	14
Wilson	117	3	4
Yadkin	186	5	5
Yancey	115	2	4
Total	17455	716	2096

Treatment

In April 2021, two treatments of *Bacillus thuringiensis kurstaki* (*Btk*) were made to the Buxton block. This block was 450 acres and located in Dare County, which is outside of the STS area. In June 2021, four mating disruption treatments were performed within the STS area of North Carolina (Figure 2). A total of 7,672 acres were treated with 6g dosage of SPLAT GM-O (Table 2). Evaluation of the efficacy of these treatments will take place in 2022 and 2023.

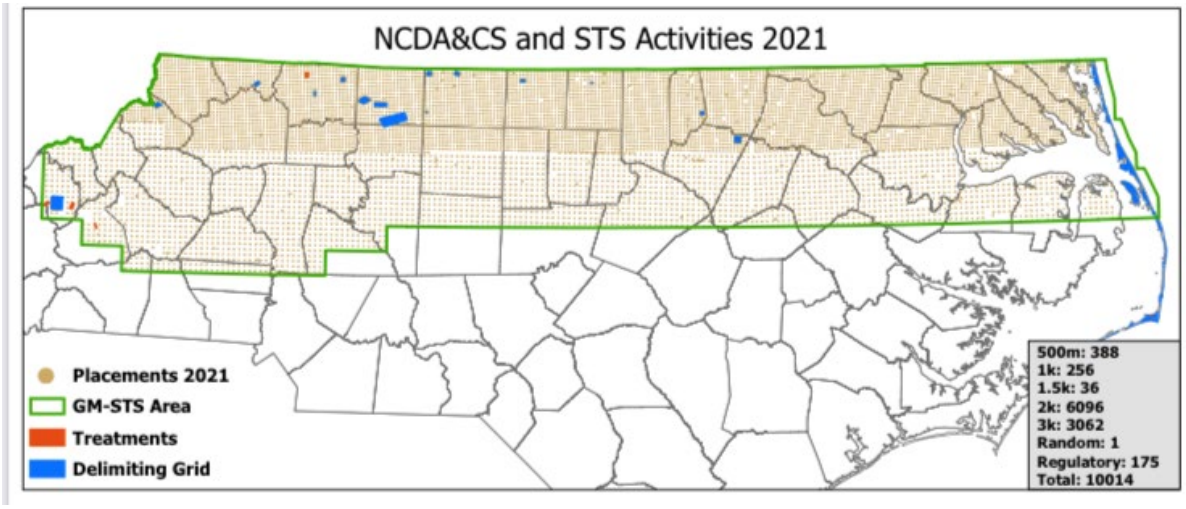


Figure 2. 2021 gypsy moth treatment site and delimiting grids.

Table 2. 2021 gypsy moth treatment, county, and acreage.

Block Name	**County**	**Product**	**Dosage**	**Acres**
Buxton	Dare	FORAY 48B	0.5 gal	450
Celo	Yancey	SPLAT GM-O	6g	2480
Lambsburg	Surry	SPLAT GM-O	6g	1993
Marion West	McDowell	SPLAT GM-O	6g	1323
Mount Mitchell	Yancey/Buncombe	SPLAT GM-O	6g	1426
			TOTAL	**8,122**

Regulatory

The gypsy moth program also seeks to mitigate the risk of artificial introduction and spread through a comprehensive regulatory program. An area that is generally infested is quarantined so that the movement of certain high-risk articles, such as logs, outdoor household articles, and nursery plants, is strategically restricted per USDA-APHIS-PPQ regulations. In North Carolina, all of Currituck County and a small portion of Dare County were quarantined in 1988. A map of the North Carolina gypsy moth quarantine area is shown in Figure 3.

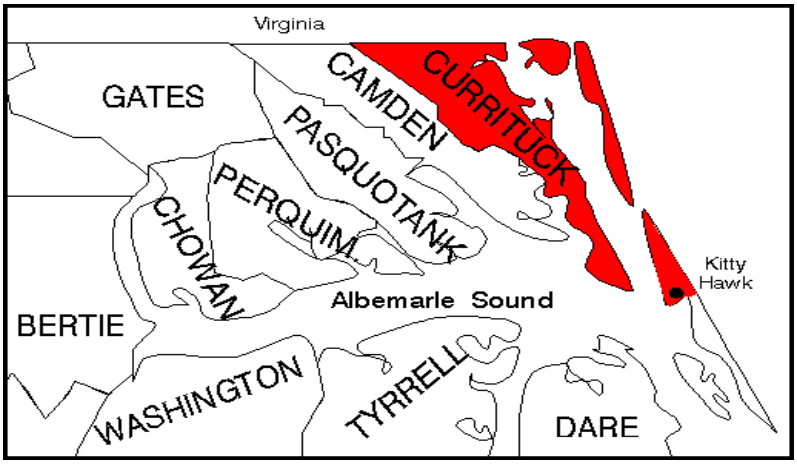


Figure 3. Gypsy moth quarantine in North Carolina, shown in red.

Regulated articles may be moved from quarantined to non-quarantined areas if the appropriate personnel undergo training and submit to the stipulations of a Compliance Agreement with NCDA&CS. These compliance agreements require inspection and/or treatment of articles to ensure that they are free of gypsy moth life stages. Several businesses and individuals received training for new staff and several new Compliance Agreements were issued.

Public education efforts are also an important part of the regulatory program. Staff visits NC Cooperative Extension and NC Forest Service offices to update county personnel on program changes. Also, program personnel monitor all high-risk locations in the STS program area by the placement and removal of traps. However, NCDA&CS receives no dedicated funding for these efforts, so the future character of the program will be determined by future allocations.

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, 2021:

Survey

Drive-by surveys were conducted in 16 counties (Alexander, Buncombe, Caldwell, Caswell, Davie, Forsyth, Granville, Haywood, Iredell, Madison, Person, Rockingham, Stokes, Swain, Transylvania and Wilkes) in NC (Figure 1; Table 1). 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 2021 IFA survey we can feel confident in our 2020 recommendations to expand the North Carolina IFA quarantine to include all or parts of Granville, Person, and Caswell Counties in 2022. 2021 IFA data also indicates additional survey efforts need to be concentrated west of Winston-Salem and more specifically in Henderson, Transylvania, Swain, Buncombe, and Haywood counties. Virginia has expanded their IFA quarantine along the North Carolina border extending beyond our current NC IFA quarantine boundaries. In 2022, 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 above listed counties a few of which are adjacent to the counties quarantined in Tennessee.

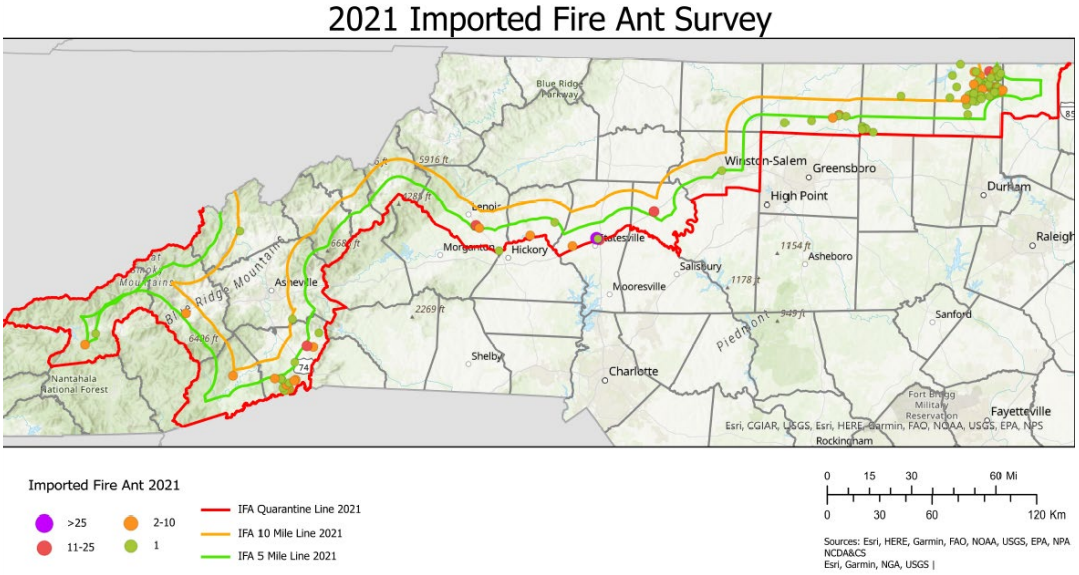


Figure 1. NC Imported Fire Ant survey results (March-October 2021). 871 data points were collected, 761 of which were reported as '0 mounds observed'; these data points are not displayed on this map

Table 1. 2021 NC Imported Fire Ant survey summary.

County	Areas Surveyed	Regulatory Action Recommended[1]	Absent	Established Sites	New Observation[2]	Total Sites
Alexander	5-mile strip from the 2021 quarantine line	No action	1	2	0	**3**
Buncombe	5 & 10 miles from quarantine & beyond	No action	19	0	1	**20**
Caldwell	10-mile strip from the 2021 quarantine line	No action	9	4	0	**13**
Caswell	10-mile strip from the quarantine line	Add 2022	159	6	0	**165**

Davie	10-mile strip from the 2021 quarantine line	No action	0	1	0	**1**
Forsyth	5 & 10 mile from quarantine line	No action	17	0	1	**18**
Granville	Remaining non-quarantined portion of county	Expansion 2022	0	1	1	**2**
Haywood	5 & 10 mile from quarantine line	No action	4	0	1	**5**
Henderson	5 miles from quarantine line	No action	99	0	16	**115**
Iredell	5-mile strip from the 2021 quarantine line	No action	3	4	0	**7**
Madison	5-mile strip from the 2021 quarantine line	No action	7	0	1	**8**
Person	10-mile strip from the 2021 quarantine line	Add 2022	243	4	56	**303**
Rockingham	5-mile strip from the 2021 quarantine line	No action	180	4	4	**188**
Stokes	5 & 10-miles from quarantine line	No action	15	0	0	**15**
Swain	5-mile strip from the 2021 quarantine line	No action	0	0	2	**2**
Transylvania	5-mile strip from the 2021 quarantine line	No action	3	0	1	**4**
Wilkes	Greater than 20 miles from quarantine line	No action	2	0	0	**2**
Total			**761**	**26**	**84**	**871**

[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, 16 blitzes were initially scheduled to be conducted in three locations across the state to enforce that operations moving regulated articles outside the quarantine area in NC are in compliance with federal and state regulations. Due to the COVID-19 pandemic, all springtime blitzes were cancelled cutting the blitz total to 8. A total of six blitzes were conducted during Fall 2021 with 4 at the I-95 Northbound weigh station in Halifax County on October 5th & 6th, 12th & 13th (Table 2). An additionally 2 at the I-77/74 Northbound weigh station in Surry County. We stopped a total of 21 trucks to inspect their load and review/record their paperwork and we collected 10 soil samples during the Halifax blitzes. At the Surry County weigh station, a new bypass system has been installed allowing trucks meeting the given requirements the ability to not stop at the weigh station. Accordingly fewer trucks came through and no regulatory stops or samples were made/taken. The last series of blitzes were to be conducted in Henderson Co along I-26 but the station was closed due to road construction. Testing of collected soil samples proved challenging since the Food and Drug Lab was in a transitional state as they moved into the Steve Troxler Agricultural Sciences building and utilizing an independent lab was cost prohibitive.

During the blitzes on October 5th, 2021 we stopped a truck hauling baled hay, some of which had clear visual signs it had been sitting on the ground which is in violation of Federal IFA regulations pertaining to the movement of baled hay and pine straw (Figure 2). The driver provided little paperwork, none of a regulatory nature, but was headed to a farm in Landenberg, PA. NCDA&CS staff placed bait around the bales of hay loaded on the truck, and after a short amount of time, live fire ants from the bales emerged. We turned the truck around and sent him back to his start destination in North Carolina and had one of our Specialists follow up on the incident at the original destination. This is the same company found to be in violation of Federal IFA shipping regulations at the 2020 Weigh Station Blitz. As a follow up to the previous offense, the company was trained, put under compliance and educated on the Federal requirements to move bailed products out of an IFA quarantine area.

Figure 2. Baled hay on truck stopped during Imported Fire Ant Blitz in 2020. . The same company was found to be in violation at an October 2021 blitz.

Table 2. IFA Blitz Spring 2021 Results

Date	Location	Trucks Stopped	Soil Samples Collected
10/05/21	Halifax Co. (I-95 Northbound)	4	3
10/06/21		5	2
10/12/21		4	2
10/13/21		8	4
10/19/21	Surry Co. (I-77 Northbound)	0	0
10/20/21		0	0
10/26/21	Henderson Co. (I-26 Westbound)	CANCELLED[2]	
10/27/21		CANCELLED[2]	
TOTALS:	**6 Blitzes[1]**	**21**	**11**

[1]Corresponds to 2 days per week and one blitz per day.
[2]Due to road construction on I-26 west towards Ashville the weigh station was closed and therefore our blitzes canceled.

Blueberry Certification Program

The blueberry maggot (*Rhagoletis mendax*; BBM; Figure 1) 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.

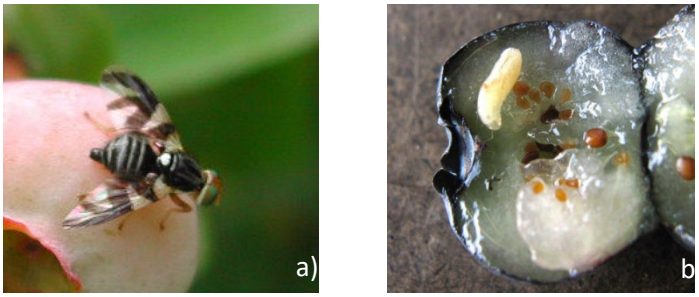


Figure 1. Blueberry maggot (Rhagoletis mendax): a) adult; b) larva inside blueberry (Photos by Rufus Isaacs, MSU)

In North Carolina, we currently have 48 blueberry farms located in four southeastern NC counties (Bladen, Duplin, Pender, and Sampson) participating in the Blueberry Certification Program. In May 2021, 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 2; the complete method can be found at http://www.ncagr.gov/plantindustry/Plant/entomology/BlueberryCertificationProgram.htm).

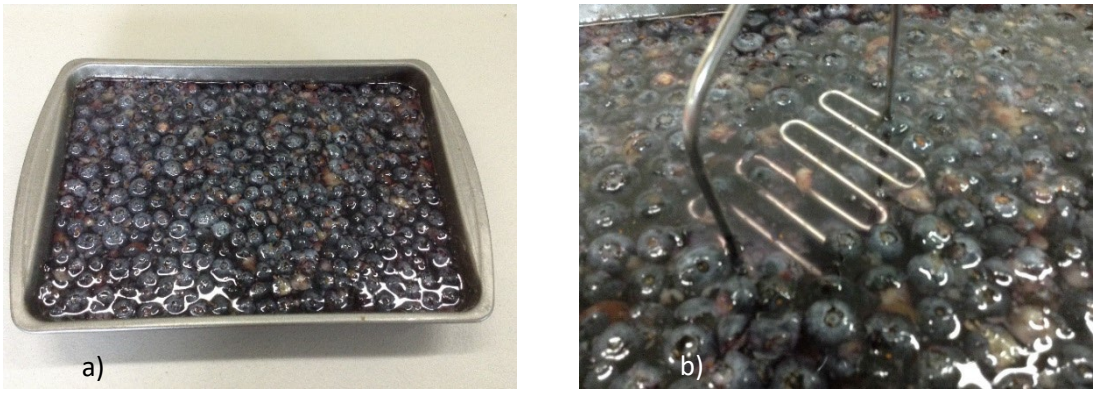


Figure 2. Salt flotation test: a) blueberries soaking in salt water solution for 10 minutes; b) close-up of flotation test showing potato masher used to gently crush berries. (Photos by Whitney Swink, NCDA&CS)

In late May, 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 single 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).

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 continued using Survey 123 in 2021 and plan to continue its use in 2022.

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 2021, a total of 363,609 acres were reported in 48 counties (Table 1). Plant Industry Division personnel surveyed cotton gins, cotton processing facilities, and ornamental cotton (n=39) in approximately 27 counties using conventional cotton boll weevil traps, like those used for sweet potato weevil field surveys (Table 2). Traps were baited with a male specific sex pheromone and checked once a month.

Table 1: Cotton Acreage by County for 2021

Anson	1,800	Greene	2,185	Pasquotank	836
Beaufort	8,774	Halifax	42,844	Pender	780
Bertie	29,995	Harnett	7,011	Perquimans	8,629
Bladen	12,823	Hertford	14,822	Pitt	21,096
Cabarrus	564	Hoke	4,116	Richmond	1,069
Camden	211	Hyde	12,132	Robeson	7,088
Carteret	670	Iredell	1,275	Sampson	12,830
Chowan	9,221	Johnston	4,480	Scotland	5,308
Cleveland	105	Jones	4,012	Stanly	9,168
Columbus	1,147	Lenoir	7,686	Tyrrell	1,610
Craven	4,046	Lincoln	98	Union	733
Cumberland	6,005	Martin	26,025	Wake	56
Davidson	1,081	Montgomery	429	Warren	481
Duplin	2,829	Nash	8,544	Washington	5,572
Edgecombe	22,913	Northampton	26,856	Wayne	7,403
Gates	13,830	Onslow	857	Wilson	1,569
Total: 363,609 acres					

Table 2. Number of Cotton Gins/Sites Survey in 2021.

Anson	1	Durham	1	Hyde	1	Perquimans	1
Beaufort	1	Edgecombe	1	Jones	1	Pitt	2
Beaufort	1	Gates	1	Lenoir	1	Robeson	2
Bertie	2	Greene	1	Martin	1	Sampson	1
Chowan	1	Guilford	1	Montgomery	1	Stanly	1
Davidson	1	Halifax	5	Nash	1	Union	2
Duplin	1	Hertford	1	Northampton	4	Wilson	1
Total Sites: 39							

Spotted Lanternfly Program

Spotted lanternfly (*Lycorma delicatula*) is a relatively new invasive insect from Asia that was first detected in the United States in Berks County, Pennsylvania in 2014. The pest has spread into and become established in portions of Delaware, Maryland, New Jersey, New York, Ohio, Pennsylvania, Virginia, Indiana, Massachusetts, Connecticut and West Virginia. In 2020, North Carolina received PPA7721 funding to continue our statewide survey for spotted lanternfly via finding and mapping host material (in this case *Ailanthus altissima*; tree-of-heaven) throughout the state. With this funding we were also able to send 4 field staff to Pennsylvania in July 2021 to receive hands-on training with state and federal SLF treatment programs during the height of treatment season in a heavily infested area. North Carolina received funding to continue host-tree based surveys through PPA 7721 again in 2021. We also began a new Specialty Crop Block agreement to increase outreach to grape and Christmas tree producers, conduct targeted surveys in production areas, and allow purchase of chemical to treat SLF if/when live insects are found in North Carolina. This funding began in January 2021 and will be in place through June 2023.

In 2021, North Carolina had the privilege of receiving USDA APHIS PPQ funding for 2 SLF trained detecting canines (Figure 1). The canine detection program utilized two current PID staff who spent 4 weeks this fall training at the USDA Detector Dog Training Center in Newnan Georgia and an additional 4 weeks training with the dogs in Winchester Virginia. The canines, Kita and Neeko, who are trained to detect spotted lanternfly egg masses, arrived in North Carolina November 10th and were deployed the following week to locations where SLF has been reported in the state. The canines will continue to be used for inspecting sites with reported SLF and high-risk businesses throughout North Carolina.

Figure 1. Chad Taylor (left) with "Neeko" and Jacqueline Fredieu (right) with "Kita" at graduation from the USDA National Detector Dog Training Program.

In 2021 NCDA staff working with the SLF program management implemented the timeline to complete a standard operating procedure (SOP) to ensure complete state and federal preparation in the event that a SLF population is found. The SOP is due to be completed in spring of 2022. In addition, we are continuing to monitor changes in treatment plans for states where SLF is established to ensure those products are labeled for use in North Carolina to treat this pest.

Since the beginning of this survey in 2019 over 21,000 tree of heaven (*Ailanthus altissima*; TOH) have been identified throughout North Carolina. Of those, roughly 7,074 tree of heaven (*Ailanthus altissima*; TOH) have been identified throughout North Carolina since June 1, 2020 (start of PPA7721 2020 funding) while conducting this survey. An additional 1,146 TOH sites have been found in 2021 (Figure 2). Field staff and other staff who respond to SLF reports or while distributing outreach will continue to report TOH at priority sights and nurseries throughout 2022. Previous years data have indicated that a clear line may be drawn going north and south breaking the state into thirds for TOH density; east, central and west. The eastern third of NC is described here as the I-95 corridor and points east which has sparsely populated TOH. Of those locations most are often associated with smaller towns usually near railroad tracks or dilapidated and abandoned buildings. Large, dense stands of this species are rare within this area. The central region has much more abundance of TOH and can readily be found growing in large clumps along roadsides, farms, rail tracks, industrial and residential areas and metropolitan areas. The central region goes from I-77 to I-95 and holds all major metropolitan areas for the state which include Charlotte, Winston-Salem, Greensboro and Raleigh. The western third of NC has very large stands of TOH and the tree is readily found almost anywhere. Depending on where the survey is being conducted common lookalikes are sumac, chinaberry and black walnut saplings.

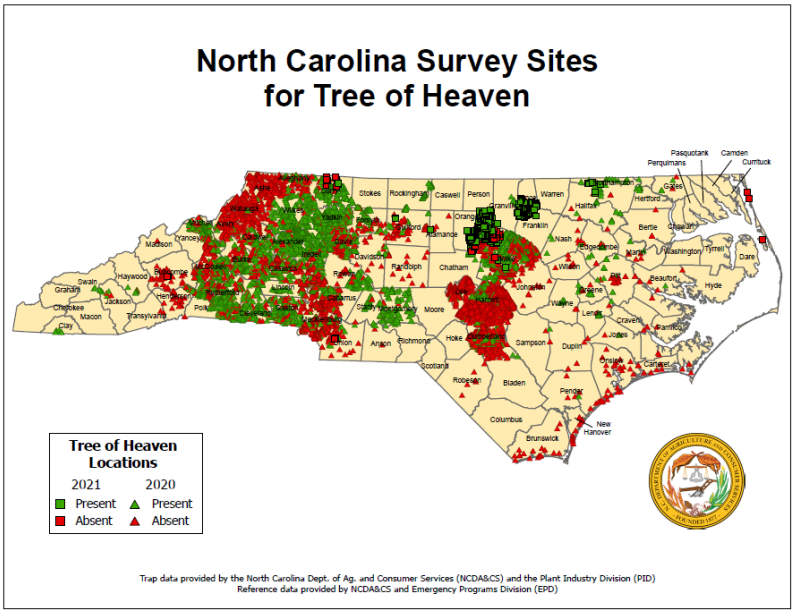


Figure 2. 2020 and 2021 Tree of Heaven Survey map

All nineteen field staff and the active participants in the SLF program management have continued to survey for TOH. These program managers provided the educational guidance to all field staff and full-time temporary help to get this work accomplished by holding numerous meetings within our group and working one on one with field staff to properly identify TOH and record it using iPads. Other program managers and their field staff were also active in helping with our survey efforts. In addition to our statewide survey we have made great effort to prepare our staff and the citizens of North Carolina for the likely future spread of spotted lanternfly into our state. We have spoken with cooperative extension agents, farmers, students, citizens and others to raise awareness of this pest and hopefully increase the number of people who are looking for spotted lanternfly.

On June 26 a living SLF nymph was reported in Corolla. Subsequent investigation revealed few hosts and no reason to believe in establishment. On August 26th, one dead SLF adult was found in southern Cabarrus County at a tape manufacturing plant adjacent to a railroad. The individual SLF was collected and surveys of the surround area and facility were conducted. Traps placed near the facility have been checked with no SLF found. Outreach materials were distributed to local businesses and parks. On September 11th we received video evidence of living SLF at an airport in Union County associated with an antique WWII plane that had been parked in Reading, PA for three months due to mechanical issues. Once the plane arrived in North Carolina the 3 living SLF were discovered, and the plane found to be covered in unknown egg masses. NCDA and USDA

responded and surveyed the entirety of the plane and scraped all found egg masses believed to be lepidopteran egg masses. A total of 11 SLF were found of which 8 were found dead. On September 23rd, a homeowner reported a sighting of an SLF nymph in Cary, NC, however there was no photo for verification. An investigation of the residence and an AmTrak station nearby resulted in no SLF found. On September 24th there were 2 dead SLF found in Butner, NC at a manufacturing company. NCDA responded to the finding and inspected the facility and surrounding area and found no further SLF. There was a potential sighting in Guilford Co. at the Gwynedd subdivision. The regional Plant Pest Specialist inspected the area and found no evidence that the report was legitimate. On September 28th a report came to NCDA through Chatham Co. extension of 2 living SLF found on nursery stock that just arrived in North Carolina from New Jersey. Three NCDA staff responded immediately and inspected the 21,000 liner plants that accompanied the shipment carrying the live SLF. Six additional SLF were found but were dead. Nursery staff found 2 more dead SLF the day after the initial inspection and a follow up inspection was scheduled for October 4th, where all 21,000 plants were reinspected. Two more dead SLF were found. The packing materials were destroyed, a trap was set on property, and the plants were required to be held for as long as possible to allow for a detector dog to return and inspect the property. Detector dog Kita inspected the property for egg masses in December 2021 and no additional SLF were found (Figure 3). On October 5th, NCDA&CS distributed a letter through the North Carolina Nursery & Landscapers Association alerting members to be on the lookout for SLF on incoming plant shipments. An additional SLF report was received through iNaturalist noting Fayetteville as the reporting location. NCDA reached out to the reporting individual but contact was never established. Outreach posters were distributed at high-risk locations throughout the general area indicated through iNaturalist and several locations will be surveyed with a detector dog early in 2022. On October 11th we received a confirmed report from a homeowner of a dead SLF adult in Morrisville, NC that came with a direct ship order of produce that originated in Pennsylvania. A follow up inspection indicated this was an isolated incident where a dead adult was trapped when the produce was packaged. Other reports from Fayetteville, Garner, Holly Springs, and Guilford County were also single reports that showed no evidence of infestation. On October 14th, 4 NCDA staff convened in Mt. Airy to scout the area for TOH and SLF in response to the finding of a population of SLF in Hillsville, VA (Figure 4). The mission was to survey and spread outreach materials to high-risk businesses. Because Carroll County, VA is situated at the gateway to both our Christmas tree producing areas and the Yadkin Valley viticultural area, letters were sent to the North Carolina Christmas Tree Association and to 3 grape grower organizations to notify these producers of infestation and to raise general awareness of SLF and reporting procedures. We also sent a notification to all Extension agents with details on concerns for specific commodities. NCDA Staff continue to evaluate the highest risk introduction sites in the state and provide training and outreach as well as increasing survey opportunities in these areas.

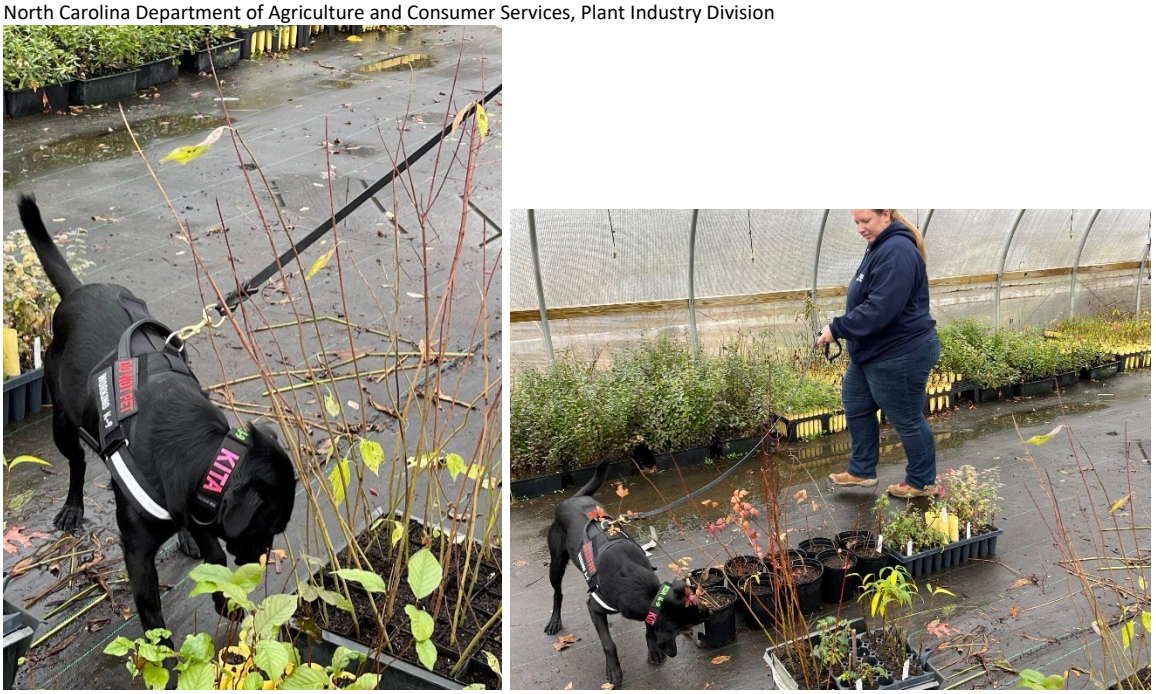


Figure 3. Kita and handler Jackie Fredieu inspecting plant material at a nursery that was shipped live spotted lanternfly.

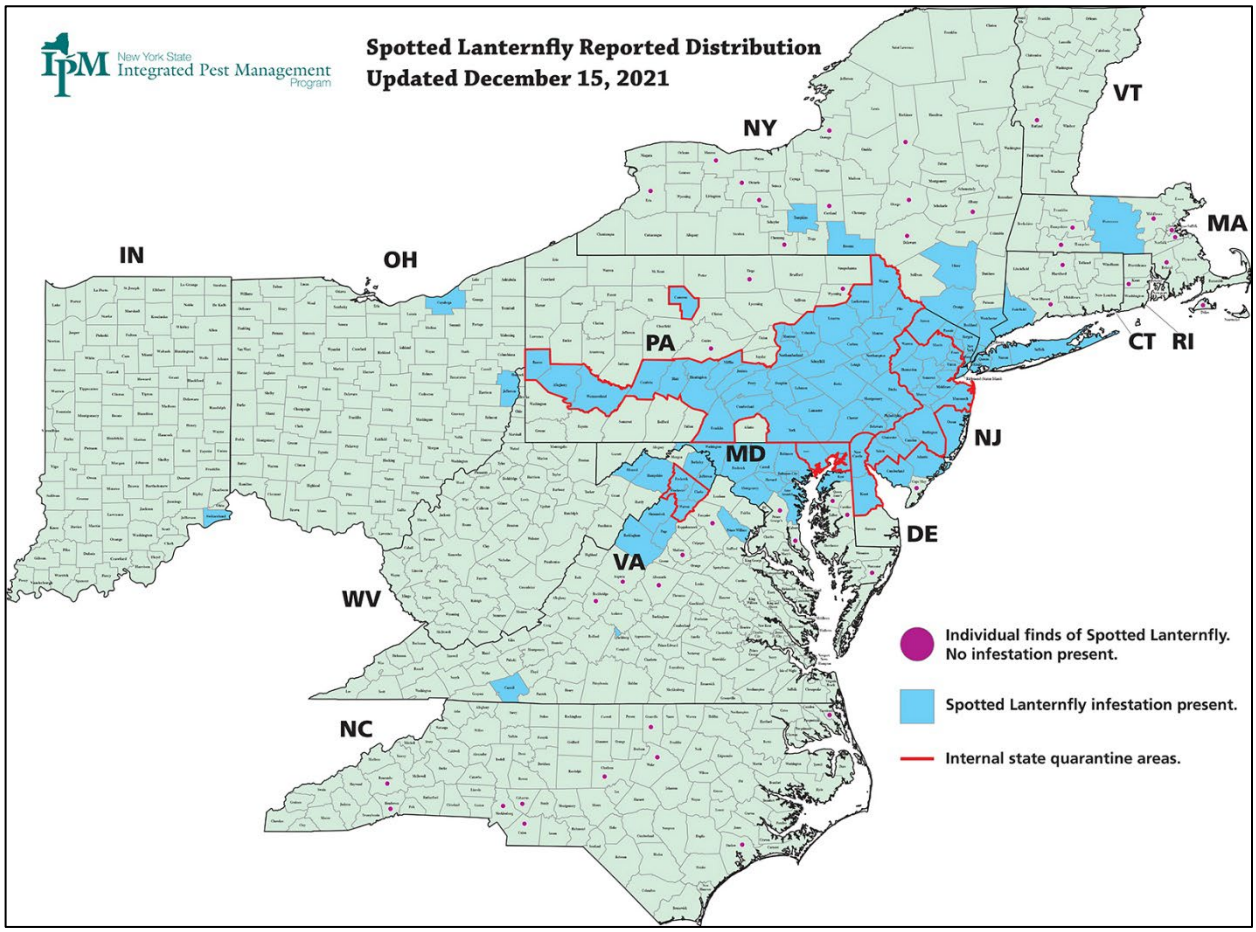


Figure 4. Reported distribution of Spotted Lanternfly at the end of 2021, including a confirmed population in Carroll County, VA. Map by Brian Eshenaur, Cornell University.

Brown Garden Snail Survey

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 Program (Thousand Cankers Disease)

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 currently runs the TCD program and the work done on the program is covered in the plant pathology section of the NCDACS-PID-PPS annual report.

Invasive Pest Outreach Program

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.

Events & Trade Shows

As a result of the COVID-19 pandemic many of the outreach events we regularly attend were canceled or modified this year (e.g. BugFest, NC State Fair). However, we were able to quickly adapt to the virtual work world and have been able to conduct outreach through virtual presentations. Through a combination of outdoor events, virtual presentations, and advertisements, our messaging reached an estimated 1.4 million North Carolinians in 2021.

Whitney Swink, State Entomologist, modified the original 30-minute presentation on spotted lanternfly to include the most up-to-date information about the pest. The presentation covers the life cycle, behavior, signs & symptoms, and regulatory concerns of the pest. She gave the talk at the following events:

- 14 January 2021 – NC Regional Agronomists, Virtual Presentation (15 people in attendance)
- 9 February 2021 – Eastern NC Forest Health Webinar (200+ people in attendance)
- 18 February 2021 – Western NC Forest Health Webinar (200+ people in attendance)
- 4 March 2021 – Southern Appalachian Forest Entomology and Pathology Seminar (100+ people in attendance)
- 9 March 2021 – NCDA&CS Plant Pest Specialists Training Webinar (25+ people in attendance)

Following the detection of the SLF population in Carroll County, VA in late fall 2021, NCSU partnered with NCDA&CS to present this update for Extension personnel. This virtual presentation was given by Amy Michael (CAPS Coordinator) and generated multiple requests for outreach materials to be distributed throughout the state:

- 16 November 2021 – "SLF Update for NC Cooperative Extension Agents and Master Gardeners" (58 attendees)

Additional presentation(s) were given throughout the year by multiple program managers to cover SLF and other relevant entomological pests (e.g., box tree moth, emerald ash borer, European gypsy moth, imported fire ant, and spotted lanternfly):

- 9 February 2021 – Annual NC Nursery Conference (≈125 in attendance). Whitney Swink, former State Regulatory Entomologist.
- 16 November 2021 – Master Gardner Class Craven Co. Extension (≈25 in attendance). Paul Adams, State Regulatory Entomologist.
- 18 December 2021 – NC Vegetation Management Association (120+ in attendance). Allison Ballantyne, GM Program Coordinator, and Amy Michael, CAPS Coordinator.

NCDA&CS staff helped to organize the 2021 Virtual Spotted Lanternfly Summit and Ms. Swink presented a talk called "North Carolina Outreach: Lessons Learned in a State that Doesn't Have Spotted Lanternfly…Yet." For this talk she highlighted some of our outreach efforts since spotted lanternfly became a pest of concern and modifications we've made to our materials or approach based on our experiences. A few examples are highlighted below in *Advertising*.

One of the biggest outreach accomplishments to occur over the last reporting cycle was the development of a collaborative project between NCDA&CS Plant Protection Section, North Carolina State University Cooperative Extension, and the NC Forest Service called Poolside Pests (https://www.poolsidepests.com). The aim of this project is to raise awareness for both Asian longhorned beetle and spotted lanternfly by having people who own, maintain, or sell pools to check pool filters for these and potentially other invasive pests. Prior to Memorial Day weekend, we cohosted two webinars for NCDA&CS plant pest specialists, NC Forest Service rangers, and NCSU cooperative extension agents covering the history and biology of the two pests and explaining the purpose of the project. Whitney Swink co-presented along with Kelly Oten (NCSU Extension) on 18 May 2021 and 20 May 2021 to about 50 and 30 attendees, respectively. Additionally, Poolside Pests manned an outreach booth at the Southern Ideal Home Show September 17-19, 2021 at the Raleigh Fairgrounds with additional outreach booths scheduled for 2022. In addition to the webinars, we developed educational materials for this project (Figure 1) and distributed them to 45 pool supply stores across the state and at in-person outreach events in 2021. One of the goals of this Poolside Pests project was to conduct a media blitz to coincide with Memorial Day weekend. In collaboration with NCSU Cooperative Extension and the NC Forest Service we co-wrote blog posts and press releases and thankfully the media did pick up the story. As a result we are seeing an increase in people using our Regulated Pest Reporting Tool (https://apps.ncagr.gov/AgRSysPortal/PestReport/) to report suspected invasive insects.

Figure 1. Poolside Pests Outreach Card **https://www.poolsidepests.com/**

Educational Materials

In 2021 we have put to good use the outreach materials developed in 2020. We have created additionally outreach materials and have diligently distributed these materials through various outreach outlets.

As a result of national news regarding two invasive insects, Asian longhorned beetle (*Anoplophora glabripennis*) and Asian giant hornet (*Vespa mandarinia*), we developed new pest alerts that cover the biology, signs & symptoms, and how to report sightings to the proper authorities. These pest alerts have been posted to our website and were distributed to cooperative extension offices across the state. Those pest alerts remained in use for 2021 and will continue to be used.

Figure 2. Spotted lanternfly banner for NC State Fair (2019) and placed at the State Fair and Mountain State Fair in 2021

We designed a magnifying lens with a "Have you seen spotted lanternfly?" message (Figure 3) that will be used with a children's spotted lanternfly search and find activity sheet with "fun facts" about SLF on the backside that we developed (Figures 4 & 5). We shipped 100 activity sheets apiece to all 101 4-H agents throughout North Carolina. In 2021 we created invasive species activity kits for children and this sheet will be included in that kit. The kits also include an SLF origami activity developed at Purdue University, spotted lanternfly and Asian longhorned beetle pest alerts, invasive pest stickers, and SLF temporary tattoos. We have distributed hundreds of these children's packets in 2021 through numerous outreach efforts.

Figure 3. "Have you seen spotted lanternfly?" magnifying lens

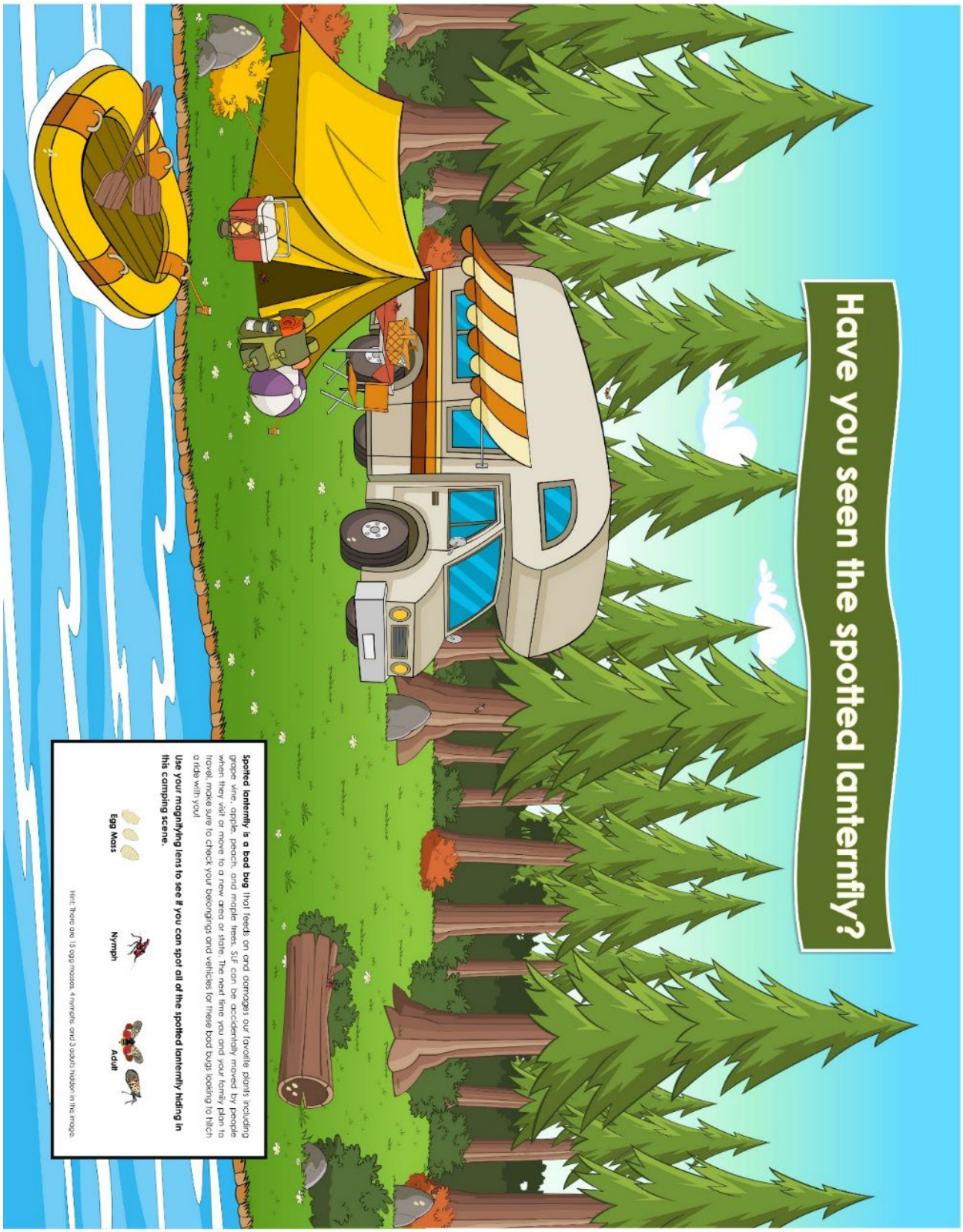


Figure 4. Spotted Lanternfly Search & Find Activity Sheet (front)

Spotted Lanternfly—a Bad Bug with Some Cool Facts

Spotted lanternfly is a bad bug that is invading the United States. **YOU** can help us find them in North Carolina. Whether you are in your yard or at the park, keep these facts in mind when hunting for this bad bug. If you find one, get your parent's help to **See it! Snap it! Report it!** to **badbug@ncagr.gov**.

They bring their own straw!

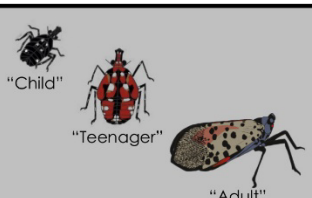
SLF have mouthparts that work like a straw. They stick their mouth into plants to suck out the sap, the way you do with a juice box. They have been seen on over 70 kinds of plants. **Have you tried 70 different juices?**

Their eggs look like silly putty

SLF protect their eggs with a gray coating that looks like silly putty or old gum. When you peel it back, you can see rows of eggs! Their eggs are camouflaged which makes them hard to find and remove.

They change colors as they get older

SLF are black with white spots when they hatch, add some red when they become teenagers, and then turn pink with black spots when they become adults.

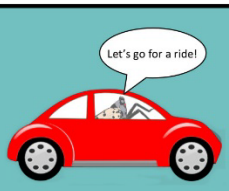


They poop honeydew!

No, not the fruit called honeydew, but a sugary water also called honeydew. When SLF drink plant sap, they drop excess sugary water onto everything below. Mold can grow in these sticky droplets too, leaving a mess and sometimes damaging the plant.

They are bad at flying—so they hitchhike instead!

SLF can't fly more than a few yards at a time on their own. They can lay their eggs on any flat surface, like cars, trains or firewood, and get moved around by humans accidentally.



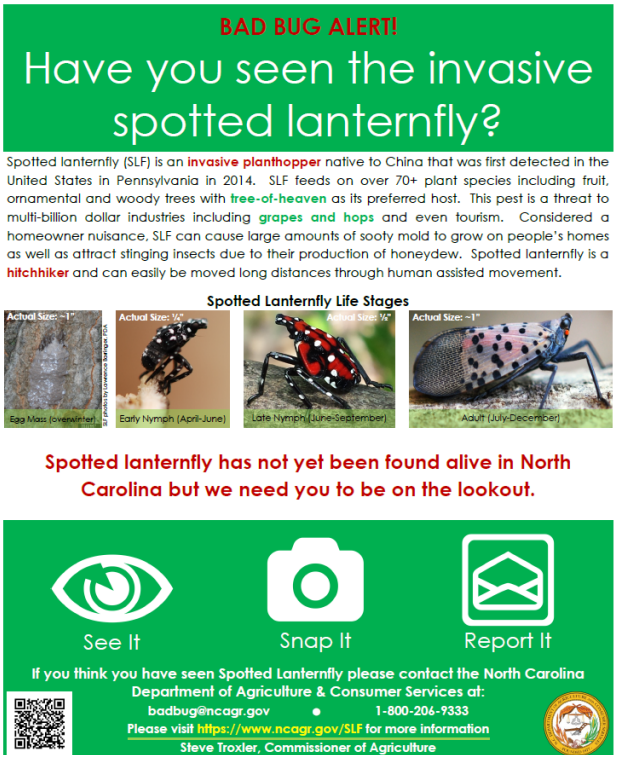
They have their own kind of PB&J

SLF's two favorite foods are grapes and tree-of-heaven, an invasive tree that smells like burnt peanut butter.

North Carolina Department of Agriculture & Consumer Services ▪ Steve Troxler, Commissioner of Agriculture ▪ https://www.ncagr.gov/SLF

Advertising

Seven print advertisements were run in North Carolina publications in 2021. One ad each was run in Carolina Country magazine, a monthly publication, and Smoky Mountain Living, a bi-monthly publication, three ads each were run in the *Triangle Gardener*, a bi-monthly publication, and in *WNC* magazine, a quarterly publication. All six ads run in *Triangle Gardener* and *WNC* magazine were full-page ads and utilized our "Have you seen spotted lanternfly?" poster (Figure 6, left). The ad run in *Carolina Country* magazine was a one-third page ad and utilized a modified version of our "See it. Snap it. Report it." message. (Figure 6, right). We plan to run these ads again in 2022 issues of *Carolina Country, Triangle Gardener, WNC* magazines. Other publications will also be considered.



Movement of Live Insects for Research, Commercial or Education Purposes

The Entomological Programs Manager evaluated approx. 125 federal applications for PPQ 526 e-Permits in 2021. 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 2021
Gypsy 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

NCDA&CS' Plant Protection Specialists inspected 2,879 nursery dealers and nurseries during the 2021 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 1,250 nurseries and 1,629 nursery dealers during the 2021 calendar year (Table 1). Of the 1,250 nurseries, 601 were registered nurseries and 649 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 an increase in nurseries, but a decrease in nursery dealers. Registered and Certified nursery licensure increased by 137 locations. An increase in e-commerce sales and heightened demand for plants due to COVID-19 consumer spending trends continues to benefit NC nurseries and nursery dealers and strengthened North Carolina's already robust green industry.

Table 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

[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 2021, 6 stop sale/movement notices wre issued for box blight (*Calonectria pseudonaviculata*) on live boxwood plants found at retail locations. In addition, 9 individual stop

sales were issued in response to a USDA-APHIS-PPQ trace forward for boxwoods direct shipped to homeowners from a mail order company associated with a confirmed box tree moth (*Cydalima perspectalis*) find. One Stop Sale was issued for 1202 Chrysanthemum plants at a NC nursery found to be infested with the federally regulated Chrysanthemum White Rust.

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 that are 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 2. In 2021, NCDA&CS staff issued 8,648 federal phytosanitary certificates and 864 state phytosanitary certificates. The nearly 18% decrease in federal phytosanitary certificates issued this year was the result of many factors including China's implementation of more strict import requirements for pine logs, increased transportation costs and other logistical issues. The significant decrease in state phytosanitary certificates was primarily due to the development of a compliance agreement inspection system for interstate movement of sweet potato cuttings to meet the NC Guava Root Knot Nematode (*Meloidogyne enterolobii*) internal quarantine. All sweet potato seeds transiting out of state still require a state phytosanitary certificate. On December 14, 2019 the European Union enacted phytosanitary regulations requiring all US agricultural commodities to ship with a federal phytosanitary certificate which caused and remains the primary reason for significant increase. North Carolina is number 1 in the nation in sweet potato production and sweet potato exports. More than half of the 8,648 federal phytosanitary certificates issued in 2021 were for sweet potato exports with lumber being a close second. In addition, federal phytosanitary certificates were issued were for lumber, logs, tobacco, cotton, cotton seed, Christmas trees, peanuts, nursery and greenhouse plants. Federal Certificates were issued for the movement of commodities to 92 countries, while state certificates were issued for 40 states, Puerto Rico, Guam and the US Virgin Islands. Nearly 22% of our federal phytosanitary certificates were for commodities going to the Netherlands, 19.6% transited to China 19.5% were to Viet Nam and 17.5% went to the United Kingdom.

Table 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

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

Plant Conservation Program

North Carolina Plant Conservation Board

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 2021 included: Dr. Damon Waitt, Julie Moore, David Hyatt, Jonathan Lanier, Esq., Dr. Bruce Williams, Jim Slye, and Dr. Gary Walker. In September, Damon Waitt left the board and recommended Mike Kunz to replace him as the representative of the NC Botanical Garden. Mr. Kunz officially joined the Board in October 2021.
In 2021, the Plant Conservation Board finalized review of public comments received regarding the proposed changes to the NC Protected Plant List. The Plant Conservation Program received 22 comments, all of which were in support of the proposed changes. The Board finalized the review of the public comments and the updated list was published May 1, 2021. The list includes endangered, threated, special concern-vulnerable, and special concern-historical species. The federally listed plants in the state are included in this list as state listed plants too. The Board confirmed they intend to update this list every five years in concert with the Scientific Committee.

North Carolina Plant Conservation Scientific Committee

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. There were no changes in the committee membership this year.
In 2021, the Committee worked with PCP staff and the Plant Conservation Board through the rule amendment process to finalize updates to the NC Protected Plant List as mentioned above. The Committee also provided input on draft documents developed by PCP Staff and state agency partners (NC Wildlife Resources Commission and NC Natural Heritage Program) to submit as a revision of the NC Wildlife Action Plan. The goal of this revision is to add plants as "Species of Greatest Conservation Need" to better address the biodiversity conservation needs in our state's primary conservation strategy. Species listed in this plan are eligible for federal funding through the State Wildlife Grant program and the efforts of PCP to include plants will greatly increase the impact of these funds on conserving North Carolina's biodiversity.

United States Fish and Wildlife Service (USFWS) Partnership

In 2021, PCP and USFWS continued a long-standing cooperative agreement related to the recovery of endangered and threatened plant species in North Carolina. 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.
Intermittently, USFWS offers funding opportunities via reverted Section 6 grants to cooperating states. Funds are awarded to high priority conservation projects, typically focusing on recovery of listed species. PCP previously received funding for two reverted funds grants, one to reintroduce two wetland species which have been extirpated in North Carolina and the other to support imperiled plant conservation efforts on state-owned lands not owned or managed by PCP. Both projects were completed at the end of 2021.
PCP was also awarded a Recovery Implementation Grant in 2019 to fund the development and production of nine management plans for Plant Conservation Preserves. This grant continues through 2024. In 2021 PCP held an open bid process and selected two contractors to complete this work.
PCP was awarded a Recovery Challenge Grant and began implementing the projects of that grant in 2021. This grant will last for five years (2021-2025) and will support research and restoration activities across eight preserves protecting Smooth Coneflower, Schweinitz's Sunflower, and Rough-leaved Loosestrife. PCP was able to greatly expand their

temporary employee field staff to accelerate the pace of preserve management with this support and substantially expand the current capacity of the program.

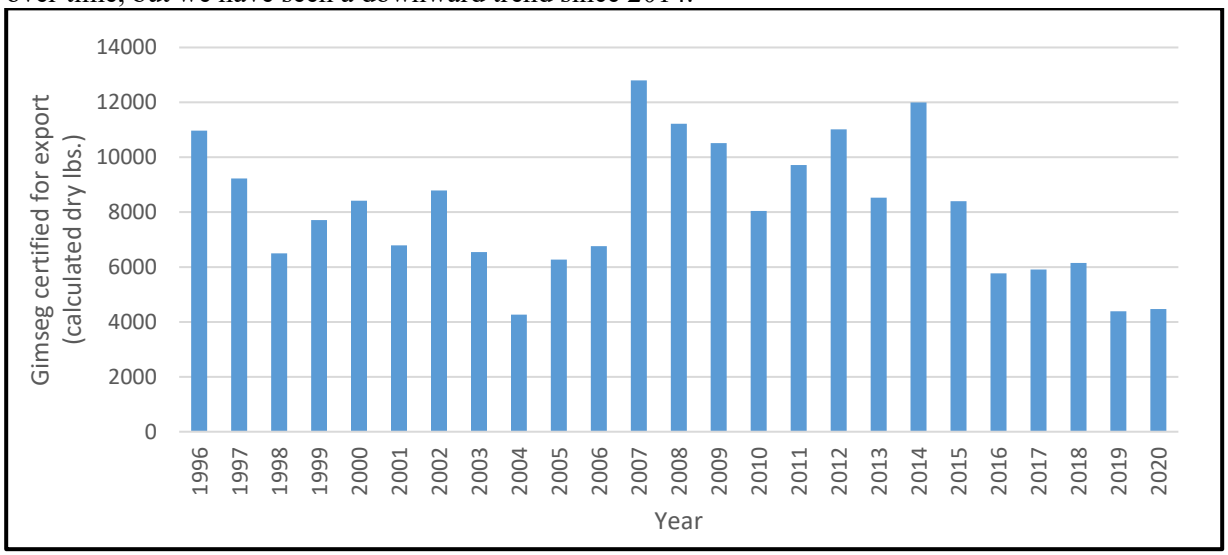
Regulatory Programs

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 quarterly 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 and sell 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 2021. 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 inspection specialists. Thirty-seven Certificates of Origin were issued for the sale of listed plants in 2021. Venus flytrap (*Dionaea muscipula*) was the most commonly certified protected plant, with 12 Certificates of Origin issued. Goldenseal (*Hydrastis canadensis*), recently relisted in North Carolina, was the second most common protected plant for which a Certificate of Origin was issued.

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.

North Carolina licensed 43 dealers for the 2020 ginseng buying season (which closed March 31st of 2021). North Carolina inspectors certified a calculated dry weight of 4,470.70 lbs. of American ginseng for export during the 2020 season. The vast majority (99.85%) of ginseng roots were wild harvested, totaling 4,463.62 lbs. (calculated dry weight), with the remainder being cultivated (4.22 dry lbs.) and woods-grown (2.42 lbs. calculated dry weight). To understand how many plants are represented by these reports of total dry weights of ginseng roots, we multiply the total weight by 300 as an approximate number of dry roots per pound. **For 2020, PCP estimates that approximately 1,339,086 American ginseng plants were harvested from the wild.** In contrast, the total cultivated and woods-grown ginseng exported amounted to approximately 1,992 plants. American Ginseng harvests and exports from North Carolina have fluctuated over time, but we have seen a downward trend since 2014.



American ginseng exports from North Carolina per year 1996-2020

Illegal harvest of American ginseng is a documented problem in North Carolina and throughout the species' range. In North Carolina, the Wildlife Resources Commission 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 2020, WRC reported a total of 69 cases/charges across 13 counties. The majority of these cases were concentrated in Haywood (15), Henderson (11), Madison (12), and McDowell (13) Counties, with 1-4 cases in each of the following counites: Avery, Buncombe, Burke, Clay, Jackson, Macon, Mitchell, Polk, and Yancey. In some cases, ginseng material was seized and reported. A total of 3,666 confiscated roots were reported along with confiscations of ginseng berries too. In 2021, WRC reported a total of 35 cases in 13 counties. From those cases, a total of 1,113 ginseng roots were confiscated. The cases reported in 2021 represent largely the same counties as those reported in 2020 but differed by the addition of Cherokee (4), Swain (2), and Graham (1) counties. There was a notable drop in cases for Haywood (4), Henderson (3), Madison (2), and McDowell (2) Counties in 2021, when compared to 2020.

Beginning in 2021, PCP has started to coordinate more directly with federal agencies that deal with illegal American ginseng harvests, name the National Park Service at Great Smoky Mountains National Park and the Blue Ridge Parkway. Reports for those two sites in 2021 totaled 3 cases in Swain County and 1 case in Jackson County. PCP is working with these multiple state and federal agencies to compile records of offenses so that the North Carolina Plant Conservation Board can act on their authority to assess civil penalties for repeat offenders involved in ginseng crimes. Parks staff have indicated that case numbers have gone down in recent years, with greater enforcement effort over the same time period. They predict that poaching has not lessened but has moved further interior to the park making detection more difficult.

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 NC Botanical Garden and Friends of Plant Conservation, PCP hosted four public education tours in 2021: Redlair Preserve in Gaston County, Suther Prairie in Cabarrus County, Green Swamp and Boiling Spring Lakes Preserves in Brunswick County, and Picture Creek Diabase Barrens Preserve in Granville County. PCP also recruited guest speakers to provide public lectures covering various research and history highlights of each of these important plant conservation areas.
PCP also partnered with FOPC for workday events across the state: one for rare species monitoring, one for rare species augmentation, and six for habitat management. 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. FOPC also supported the land management work conducted by PCP by purchasing $5,000-worth of equipment and supplies such as personal protective gear, radios, and other supplies used during prescribed fires to restore and maintain rare plant habitats.
In 2019, the NC Botanical Garden Foundation and FOPC initiated a campaign to create a new NC specialty vehicle license plate to support rare plant conservation. The plate design highlights Venus flytrap (the state's official carnivorous plant species) and uses the slogan, "Home of the Venus Flytrap". These two organizations, with support and public outreach help from PCP staff, were successful in receiving more than the minimum 500 applications by early 2020 to meet the annual legislative deadline for new plate submissions. In 2021, the bill passed the NC House unanimously. As it reached the Senate it was sent to the Rules and Operations Committee. If this plate is successful, annual revenue would be shared by NC Botanical Garden Foundation and FOPC to support rare plant conservation, including that conducted by PCP.

Home of the Venus Flytrap license plate design

Other Outreach and Partnerships

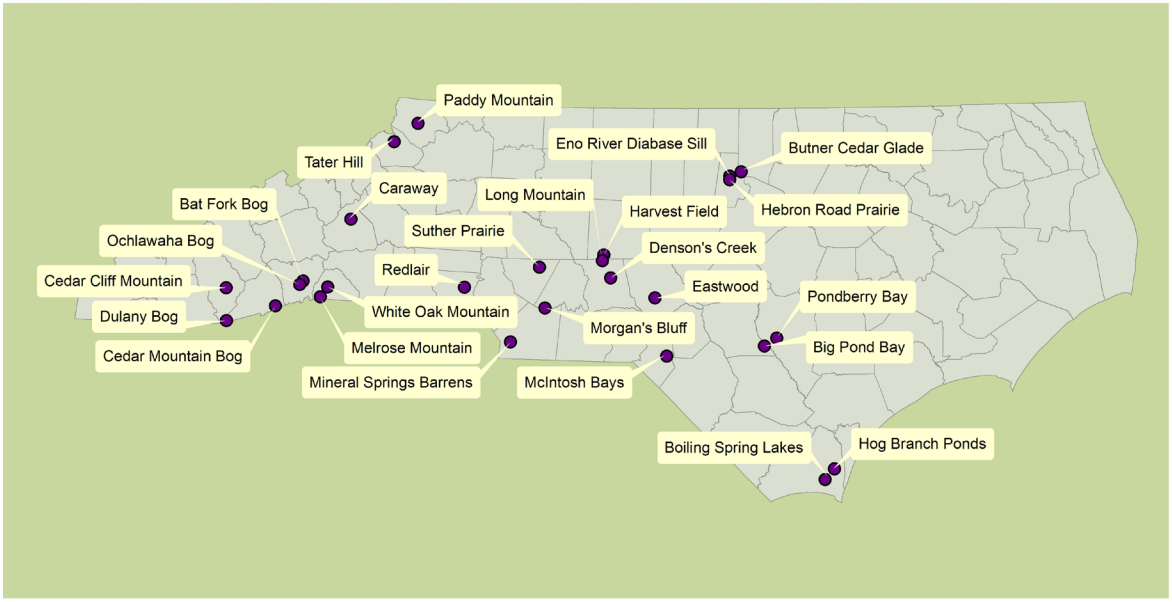
The Plant Conservation Program is a member of several statewide or regional conservation partnerships. Examples include the Bog Learning Network, the Southern Blue Ridge Fire Learning Network, Southeastern Plant Conservation Alliance, and the Greater Uwharrie Conservation Partnership. In 2021, PCP worked with the NC Natural Heritage Program and the NC Botanical Garden to reinitiate the Rare Plant Discussion Group Annual Meeting for 2022. PCP has worked to coordinate this meeting with these two groups for over 20 years until the past two years during the coronavirus pandemic. In late 2021, the planning committee set the agenda for a 2022 meeting of plant conservation professionals from around the state to share updates on research, surveys, and discuss other pertinent topics.

PCP Staff has also provided leadership the development of the first North Carolina Plant Conservation Alliance which met in December 2021. The goals of this partnership of plant conservation organizations and agencies is to maximize positive outcomes from our 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 addition, PCP outreach to the public includes special presentations and by filling information requests. In 2021, PCP staff gave invited public lectures for NC Wildlife Federation and Venus Flytrap Champions as well as tour groups on the above-mentioned field trips.

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. 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. 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 (see map below).



PCP Preserves of North Carolina

In 2021, PCP was awarded two minigrants from the NC Land and Water Fund (LWF). The LWF minigrant program is designed to cover the closing costs of land donations for conservation purposes. PCP was approached by private landowners interested in donating their property to be added to two separate Plant Conservation Preserves, Redlair Preserve in Gaston County and Boiling Spring Lakes Preserve in Brunswick County. Both projects are slated to close in early 2022.

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. In part, 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. In some cases, PCP works with other agencies and landowners to complement management of their lands for the benefit of rare plants and habitats.

In 2021, 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. *montana*), and Swamp Pink (*Helonias bullata*)- Continued habitat restoration at Cedar Mountain Bog and Dulany Bog Preserves in Transylvania and Jackson Counties respectively
- Pondberry (*Lindera melissifolia*) and Pondspice (*Litsea aestivalis*) – Continued habitat restoration at Pondberry Bay Preserve in Sampson County
- Heller's Blazing-star (*Liatris helleri*) and Road Mountain Bluet (*Houstonia montana*) – Restoration at Paddy Mountain Preserve in Ashe County

Additional Preserve Management- general

At the McIntosh Bays Preserve in Scotland County, PCP staff held two workdays to mark the preserve boundary with purple paint in accordance with the NC Landowner Protection Act and installed preserve signage. Three chain gates were installed, and trespassing hunter activity was addressed with the neighboring landholders.

At the Tater Hill Preserve in Watauga County, PCP Staff installed a "beaver deceiver" (pipe to allow water flow) at a road crossing where beaver activity was causing flooding of a neighbor's right-of-way access through a small portion on the southern extent of the preserve. The design was modified from existing examples to best address the situation at the dam location and avoid exterminating the beavers. Assessments at two months and six months after installation show the beaver deceiver is functioning as designed with little intervention after installation. This solution supports both the bog habitat and the human use of this portion of the preserve, while allowing beaver activity to continue downstream.

Invasive species control

PCP continued control efforts of Japanese Stiltgrass (*Microstegium vimineum*), Japanese False Hawksbeard (*Youngia japonica*), and English Ivy (*Hedera helix*) at the Caraway PCP Preserve in McDowell County with a volunteer workday to handpull these species prior to seedset. Thus far, Japanese Stiltgrass and Japanese False Hawksbeard are not directly impacting the rare plant population; however, these two species prefer very similar habitat to the imperiled species so controlling this species at this site is a particularly high priority.

At Butner Cedar Glade Preserve in Granville County, control of invasive species continued with a more thorough effort and more man hours than previous years. Efforts were focused on addressing Japanese Stiltgrass, Tree-of-heaven (*Ailanthus altissima*), English ivy, Chinese Wisteria (*Wisteria sinensis*), and Japanese Beefsteak (*Perilla frutescens*). Woody encroachment of small Eastern Cedars was reduced using mechanical methods and hand tools.

PCP staff reinitiated control efforts of Chinese Privet at Morgan's Bluff Preserve (Stanly County), where privet is a persistent problem on the river bluff. Removal effort was concentrated around one of only two populations of Wright's Cliffbrake (*Pellaea wrightiana*) known to our state.

PCP staff led a volunteer workday at the Cedar Cliff Mountain Preserve in Jackson County focusing on removing invasive species along an old logging road. Workday participants used a mixture of manual and mechanical thinning methods on Multiflora Rose (*Rosa multiflora*), Chinese Privet (*Ligustrum sinense*), Japanese Stiltgrass, and Japanese False Hawksbeard.

Prescribed burning

Prescribed burning is one the most pressing management needs across the Preserve system to enhance rare species populations and improve habitats for these species. With assistance and support from NC Forest Service and other partners, PCP staff conducted eight controlled burns across five counties this past year. Among the burns completed in 2021, prescribed fire was implemented for the first time in an oak-hickory forest at Redlair Preserve in Gaston County and PCP coordinated with Three Rivers Land Trust to complete a controlled burn at Suther Prairie for the first time since 2016 and the first time under PCP ownership.

Many planned burns could not be completed due to burning restrictions in place during periods of unsuitable weather. Additionally, many NC Forest Service personnel were dispatched to western states to help suppress wildfires this season leaving fewer available resources for prescribed burning in North Carolina. PCP continues to be responsible for all phases of burn planning and preparation as well as mop-up after the burns were conducted.

Prescribed burns that occurred on PCP Preserves in 2021.

Preserve	County	Burn Unit	Date	Acres	Target species
Eastwood	Moore	2AK	2/25/2021	56	Longleaf pine communities
Pondberry	Sampson	4B	2/25/2021	15	Longleaf pine communities
Eno River Diabase Sill	Durham	2A	3/4/2021	10	*Echinacea laevigata, Baptisia aberrans, Scutellaria leonardii*
Eno River Diabase Sill	Durham	4ABC	3/7/2021	5	*Echinacea laevigata, Baptisia abarrans, Lithospermum canescens*
Eno River Diabase Sill	Durham	3B	3/10/2021	6	*Echinacea laevigata, Baptisia abarrans, Lithospermum canescens*
Eastwood	Moore	2C	3/15/2021	22	Longleaf pine communities
Redlair	Gaston	3A	4/6/2021	27	Introductory/Entry fire
Suther Prairie	Cabarrus	-	4/7/2021	10	*Lilium canadense, Oenothera perennis*

Rare Species Monitoring

Understanding the current status and trends of the populations we protect is very important. To that end, PCP has been collecting flowering data on several species across the state. In 2021, 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)
- Swamp pink (*Helonias bullata)* - Henderson, Transylvania Cos. (2 sites)
- Schweinitz's sunflower (*Helianthus schweinitzii*) - Randolph, Montgomery, Union, Gaston Cos. (4 sites)
- Smooth coneflower (*Echinacea laevigata*) - Durham, Granville Cos. (5 sites)
- Mountain sweet pitcher plant (*Sarracenia jonesii*) - Transylvania Co. (1 site)
- Heller's blazing star (*Liatris helleri*) - Ashe Co. (1 site)
- Michaux's sumac (*Rhus michauxii*) – Durham Co. (1 site)

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

- Cuthbert's Turtlehead (*Chelone cuthbertii*) – Transylvania Co. (1 site)
- Tall Larkspur (*Delphinium exaltatum*) - Durham Co. (1 site)
- Appalachian Dwarf Huckleberry (*Gaylussacia orocola*) - Transylvania Co. (1 site)
- Lax Mannagrass (*Glyceria laxa*) - Henderson Co. (1 site)
- Dwarf-burhead (*Helanthium tenellum*) - Scotland Co. (1 site)
- Canada Lily (*Lilium canadense*) - Cabarrus Co. (1 site)
- Sandhills Lily (*Lilium pyrophilum*) - Moore Co. (1 site)
- Hoary Puccoon (*Lithospermum canescens*) - Durham Co. (1 site)
- Balsam Ragwort (*Packera paupercula* var. *paupercula*) - Granville Co. (1 site)
- Piedmont Fameflower (*Phemeranthus piedmontanus*) - Granville Co. (1 site)
- Awned Meadow-beauty (*Rhexia aristosa*) – Scotland, Sampson Cos. (2 sites)
- Mountain Purple Pitcherplant (*Sarracenia purpurea* var. *purpurea*) – Transylvania, Jackson Cos. (3 sites)
- Small-leaved Meadowrue (*Thalictrum macrostylum*) - Henderson Co. (1 site)

Plant Pathology Program

Report for period January 1, 2021 through December 31, 2021

Chrysanthemum white rust

Chrysanthemum White Rust (CWR), caused by the fungus *Puccinia horiana P. Henn.*, is a quarantine significant pest in the United States (Title 7, Code of Federal Regulations, Part 319.37 and 319.74). Importation of certain *Chrysanthemum* (including *Dendranthema*), *Leucanthemella*, and *Nipponanthemum* species are prohibited from several countries, territories, and possessions due to the potential of this organism to be transported with prohibited host articles. When CWR is found in the United States, the States and APHIS cooperate to eradicate the disease (USDA-APHIS, Last Modified: May 18, 2021).

The pathogen requires living host tissue to grow and reproduce. Infected plants do not always express symptoms during hot and dry conditions. Symptoms usually appear during cooler (40-73F), high relative humidity (96-100%) conditions. The pathogen can be spread via air-borne spores produced by the fungus on infected plant materials. Contaminated soil, litter, dead leaves, gardening equipment, clothes, shoes, and hands can also facilitate the spread of the fungus in greenhouses.


Symptoms of Chrysanthemum white rust (CWR), small, white to yellow spots, up to 4 mm wide, on the upper surface of the leaf (left) and pustules form on the underside of the leaf (right)

Detection and Eradication of CWR in North Carolina in 2021

In August 2021, a nursery owner in Buncombe County contacted our office and Regional Pest Specialist about a possible find of the disease in their greenhouse Chrysanthemums. Samples of symptomatic plants were taken by Reginal Pest Specialist, Sue Dial. Disease confirmed by North Carolina State University Plant disease and insect clinic and later by USDA Beltsville Labs. The disease was likely introduced to the nursery through infected plant material from sources outside of North Carolina.

Regulatory actions were taken immediately after the confirmation of the disease. All symptomatic host plants and host plants within 1-meter radius of the infected plants were destroyed according to USDA protocol. Destruction were carried out by Western Region Supervisor, Chad Taylor, Regional Plant pest specialist, Sue Dial, and Regulatory plant pathologist, HT Tseng. Over 1,200 containerized chrysanthemum plants were destroyed. Follow up treatments of myclobutanil were completed by the nursery and follow up inspections were conducted by the Regional Plant pest specialist. The disease is eradicated in North Carolina.

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 were infected by the disease were 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.

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 Statement 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 facilitate this program, the NCSU Plant Disease and Insect Clinic assays samples collected during this process at no charge.

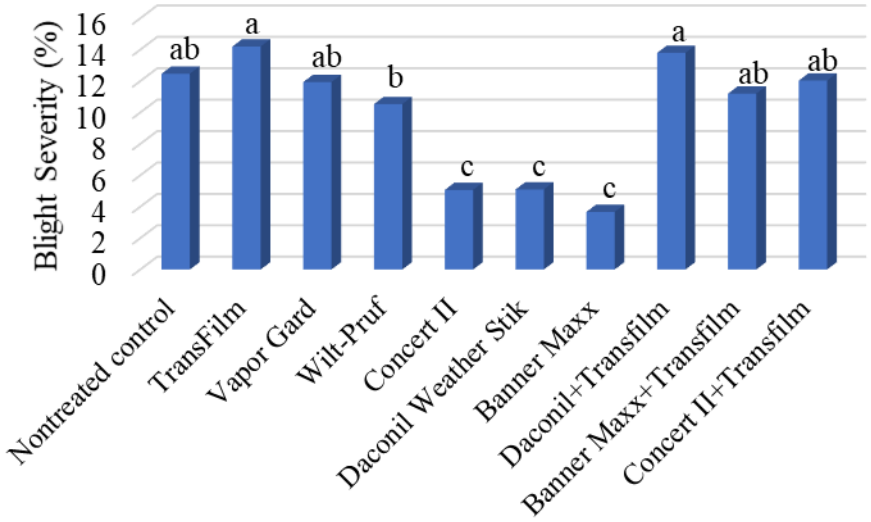
In 2021, NCDA&CS updated the stipulations of the compliance agreement, focused on buy-in inspection and record keeping, and renewed list of the program participants. As of December 2021, there are eighty-nine participants in the program. Currently, States with established external quarantine against the boxwood blight pathogen are Tennessee and Pennsylvania, however other states prohibit the pathogen under their Plant Pest Law.

Boxwood Blight Field Trail

In 2021, we collaborated with Dr. Chuanxue Hong of Virginia Tech to conduct a series of on-farm field trails as part of the Boxwood Blight Insight Group (BBIG). BBIG is a team of scientists working together on an USDA National Institute of Food and Agriculture – Specialty Crop Research Initiative (SCRI) project, in partnership with stakeholders and international collaborators. This transdisciplinary team and its partners aim to safeguard boxwood from the blight disease.
Trials were set up to determine the efficacy of three anti-desiccant products and six biological control agents as alternatives to fungicide for the management of the blight disease on boxwood under field conditions. Vardar Valley boxwood cultivar growing in a farmer's field in western North Carolina were used in the first year of the trial. The experiment was designed by Dr. Chuanxue Hong and Dr. Olanike Omolehin of Virginia Tech. Treatments and disease evaluation was conducted by a joint effort of Dr. Hong, Dr. Omolehin, and Amanda Taylor of NC Cooperative Extension, Western regional Supervisor Chad Taylor, Regional Specialist Ginger Hemmings, and State Plant Pathologist, HT Tseng, PhD.

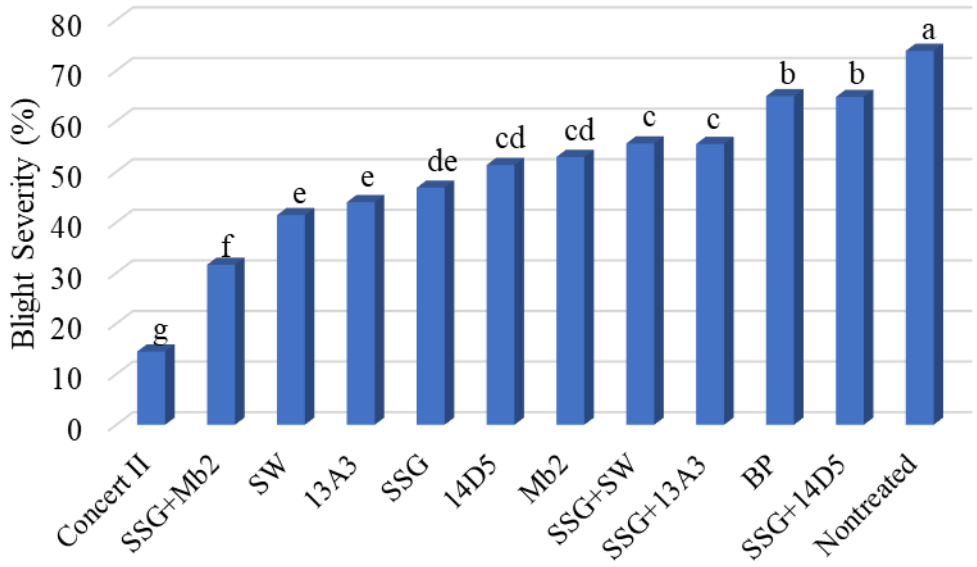

Boxwood field trail. Chad Taylor applying the fungicide treatments (left) and disease assessment (right) by NCDA and NC extension (left to right: Amanda Taylor, HT Tseng, Chad Taylor, and Ginger Hemmings)

For the anti-desiccant trail, ten treatments of the three anti-desiccant products, Wilt-Pruf, Vapor Gard, and TransFilm, fungicide controls; Concert II, Daconil and Banner Maxx, and combinations of TransFilm with each of the three fungicides were tested. Disease assessment including % leaves blighted and % defoliation was done monthly beginning from April through November of 2021. Overall disease pressure at this field was less than 20%. Disease assessment results at the end of the season is shown in figure below.



Boxwood blight severity on test plants of ten different treatments evaluated in the anti-desiccant trial in 2021 as measured by percentage of leaves diseased.

For the biological control trail, twelve treatments comprised of the six biological control agents (BCAs); five bacterial strains (SW, SSG, BP1024, 14D5, 13A3) and one fungal isolate (Mb2), Concert II fungicide controls, combinations of BCAs, and non-treated negative control were tested. Treatment was done twice (one in May and the other in August). Disease assessment including % leaves blighted and % defoliation was recorded monthly from May through November. High disease pressure in the field portion where this BCA trial was conducted (>70% blight infection). Disease assessment results at the end of the season is shown in figure below.



Boxwood blight severity on test plants of twelve different treatments as measured by percentage of leaves diseased.

Sudden Oak Death (SOD) 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 2020 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 tree species that are susceptible. Hosts that are commonly found in container nurseries includes rhododendron, camellia, viburnum, pieris, and kalmia.

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

Survey – see CAPS section

SOD Trace-forward/trace-back notifications
Three trace forward notifications issued by USDA were received in 2021:
January 2021: Four SiteOne locations have received various numbers of Pieris and Rhododendron plants from Advance Ornamental, OR. Shipping dates ranged between July and October 2020, total of 113 plants. Three regional plant pest specialists were involved with this TF investigation. Invoices were acquired from all four locations, but the plants were all sold. Specialists inspected the locations for any symptomatic plants. Two samples with suspicious symptoms were collected but were tested negative of Phytophthora by ELISA.
May 2021: Two Lowe's locations in eastern NC received a total of 1,768 plants, including confirmed positive taxa, from Means Nursery, OR. The TF notification from USDA did not specify shipping dates. One regional plant pest specialist was involved with this TF investigation. No symptomatic plant was found during the investigation. Notably, the two locations were inspected prior (April 20) to receiving the TF notification as NC received advanced notification through CAPS web site Notify report.
June 2021: Two nurseries located in western NC received a total of 242 plants, including confirmed positive taxa, from Advanced Ornamentals, OR. Plants were shipped in April. One regional plant pest specialist was involved with this TF investigation. Both nurseries report having bought the plants from Advanced Ornamentals through brokers. No advance notification was received by NCDA through the required notification system from Advance ornamentals. Most plants were sold by the time Specialists were alerted to contact the nurseries. There were a few confirmed positive taxa left on site, but no plants with symptoms of Phytophthora were found.
As of today, no confirmed positive cases were found in North Carolina.

New disease detected: Vascular streak dieback (VSD) of woody ornamentals
Over the past year, dieback has been observed on multiple plants including Maple, Redbud, and Dogwood. This dieback is associated with vascular streaking, dead liners, epicormic shoots, tip dieback, burnt/blighted leaves, chlorosis, stunted plants, and no/poor root development.


Symptoms of dieback on red maple; Streaking/marbling in multiple years' wood
In late 2019, one single red maple tree in a field grown nursery displayed unexplained dieback symptoms was reported to NC extension. The sample was sent to NCSU plant disease and insect clinic for diagnostic. A slow growing fungus that could not be cultured in the absence of the wood piece was recovered from the discolored wood of the. In February 2020, a joint effort of PDIC and USDA Beltsville lab conducted molecular diagnostic and identified the fungus as *Ceratobasiduim theobromae*. The fungus is known to causes vascular streak dieback on cacao (*Theobroma*

cacao) in Southeast Asia. Cacao is the only common host of *C. theobromae* although rare infection of seedlings of avocado (*Persea americana*) has also been found. Both cacao and avocado are native to tropical America, yet *C. theobromae* is not previously known to occur in America, it seems likely that the fungus is associated with one or more native species of plants in its range of distribution, perhaps as an asymptomatic endophyte.
Due to limited research on other potential hosts and the difficulty in researching the fungus, the confirmation of pathogenicity of this fungus on woody ornamental hosts (Koch's postulate) has not been completed. Currently, this issue has been identified in seven counties in NC, as well as Tennessee and most recently Georgia.
NCDA is working with NCSU and other universities to identify the cause of dieback. The first step is 100% identification the causal agent or contributing factors. This requires pathogenicity confirmation and more genetic sequencing on the isolated fungi.
Symptomatic plants should be sampled and tested. Growers are encouraged to prune out 12" below the area of necrotic tissue. Plants with vascular streaking in the main trunk should not be sold.

Guava Root Knot Nematode (*Meloidogyne enterolobii*)
Guava Root Knot Nematode (GRKN) is a nematode first found in China. The first US find of GRKN was in Puerto Rico in 1988, then in southern Florida in 2002 on ornamental plants. The first identification of GRKN in North Carolina was on cotton in Wayne County in 2011. This pest was not of regulatory concern at the time as it was not associated with crop movement that could spread the nematode. In 2014 GRKN was identified on NC sweet potatoes and in 2018 a shipment of uncertified sweet potato seed sent out of state transferred the nematode and sparked regulatory action. On October 1, 2018, NC issued an internal quarantine for the entire state on GRKN to prevent the spread of this pest through sweet potato seed, sweet potato plants with roots and soil, used equipment, and any other article that could spread GRKN.
A Compliance Agreement program was established in 2019 as a condition of issuance of certificates or permits for the movement of sweet potato. Any person engaged in purchasing, assembling, exchanging, handling, processing, utilizing, treating, or moving such article may be required to sign a compliance agreement stipulating that he or she will maintain such safeguards against the establishment and dissemination and comply with such conditions. The compliance agreements are renewed at the end of 2021.
Packing and shipping facilities were inspected by Regional Plant Pest Specialists for GRKN. When sweet potato with suspicious symptoms were found, the entire lot was held for further inspection. Samples were taken and molecularly diagnosed by NCDA&CS Nematology Lab. In 2021, one hundred and forty samples were collected during packing facility inspections. Any lot with confirmed positive sweet potato were required to be destroyed or processed in a North Carolina facility.
In order to safeguard the NC sweet potato industry, NCDA&CS is constantly reviewing and will update the regulations continuously regarding GRKN.

Export: Disease certification requirements and pathogen distribution information

Most agricultural commodities exported to foreign countries and to some U.S. states must meet certain requirements with regard to plant pests. Countries and states differ as to what is perceived as a plant pest risk. The Plant Pathologist received and handled requests from Field Specialists for assistance with interpretation of plant disease and nematode certification requirements and determination of pathogen distribution.

Export: Nematode certification

California has import requirements concerning reniform and burrowing nematodes. To assist nurseries that wish to send plants to California, Field Specialists collect soil samples and submit them to the NCDA&CS Nematode Assay lab according to procedures developed by the Plant Pathologist, who also provides oversight for this program. A sampling table based on numbers 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 has the responsibility of adding comments to address state-specific concerns regarding each application. USDA-APHIS-PPQ issues final approval or denial of each application. All plant pathogenic organisms are subject to this requirement. The risk associated with each organism is evaluated to ensure that adequate safeguards are listed in the conditions of the permits. During 2021, pathogenic species permit applications were evaluated which included fungi/oomycetes, bacteria, nematodes, and viruses.

Vegetable Plant Inspections

The Vegetable Plant Certification regulation requires weekly inspections and certification of vegetable plants grown in NC for sale to commercial growers. There were no vegetable plant nurseries certified under this regulation during this reporting period. The NC Crop Improvement Association (NCCIA) certifies a large number of sweet potato cuttings and "seed" under its certification program. Because NCCIA certification requirements meet or exceed the standards of the vegetable plant regulation, NCDA&CS accepts inspections and certification tags of NCCIA in lieu of its own.

Regulatory Weeds Program

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 by North Carolina Plant Pest Law under 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 statutes set forth by the state legislature. The primary objective of the program is to eradicate, restrict movement, 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. Additional programmatic activities may include issuance of scientific permits for movement of regulated articles, nursery inspections with Field Specialists state-wide and issuance of phytosanitary certificates.

Executive Summary

The 2021 Regulatory Weeds Program was successful in administering treatment to sites where regulated noxious weeds were positively identified. The program handled many weeds in 2021 which 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*). In most cases, the area Field Specialist and Regulatory Weeds Specialist along with Support Operations staff work together in providing 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. The aquatic dealers database is updated annually, and inspection sheets given to Plant Pest Specialists for completion each year. For the 2021 season, 108 aquatic dealers were inspected out of 170 across the state. No noxious aquatic weed detections were reported at aquatic plant dealers in 2021.

Cogongrass (*Imperata cylindrica*)

NCDA&CS works in conjunction with NC Dept. of Transportation (NCDOT) in identifying and controlling regulated weeds along roadsides wherever they occur in the state. With help from NCDOT, control was maintained for trouble spots occurring along roadsides in Sampson and Pender Counties. We will continue this effort in the future as efficiency is gained with more staff available to survey and treat.

Figure 11. A patch of cogongrass prior to treatment

Purple Loosestrife (*Lythrum salicaria***)**

A Class B State Noxious Weed, and eradication efforts have been ongoing since 1997. Both Forsyth and Henderson Counties have infestations of this weed and are being treated with the hopes of someday reaching eradication. Treatments were accomplished using triclopyr. These treatments are found to be quite effective especially after several applications throughout the season to catch all plants that may have emerged later and to prevent further seed dispersal. Two sprays were completed at the sites in Forsyth County (Figure 2). These sites typically include right of ways beneath power lines where infestations are usually the heaviest. Treatments will continue for the 2022 season.

Figure 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 3) which can penetrate the skin causing irritation, hence its name. It is problematic along roadsides, ditches, rights-of-way, pastures and row crops. As an annual grass, it spreads through seed. Estimates for seed production are around 3,000+/plant and upwards if given optimal conditions (Figure 4), with seeds remaining viable for 3-5 years. Seeds are dispersed mainly through wind, birds, mowing equipment and roadside machinery. It has been noted that itchgrass has exhibited some level of allelopathy.

The battle for control with this weed has been ongoing in Robeson County since 1983. There are at least 6 separate areas located around the town of Rowland that are being monitored and treated. Application of glyphosate were made to areas where plants were observed. For several years, infested areas have been noted as being largely improved from years previous. During 2021, NCDOT helped treat 5 miles of roadside and we plan to treat areas in early spring 2022 with NCDOT to push back against locations where we have observed germination. We also plan to treat on foot with backpack sprayers before seed development and prior to any roadside mowing operations.

Figure 3. Short hairs present along leaf sheaths

Figure 4. The seed head of an itchgrass plant.

Tropical Soda Apple (*Solanum viarum*)

As a Federal noxious weed, tropical soda apple is a threat to NC agriculture since it outcompetes 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, separate survey dates were conducted at one location in Sampson County during 2021 to identify and pull tropical soda apple (Figure 5). Surveys were focused where previous hot spots existed and were carried out on ATV for the approximately 7,000 ac location. A total of 145 plants were identified and pulled for the season. Plants are carefully pulled to ensure fruit to do not escape. Rogued plants are placed in heavy duty paper bags for incineration.

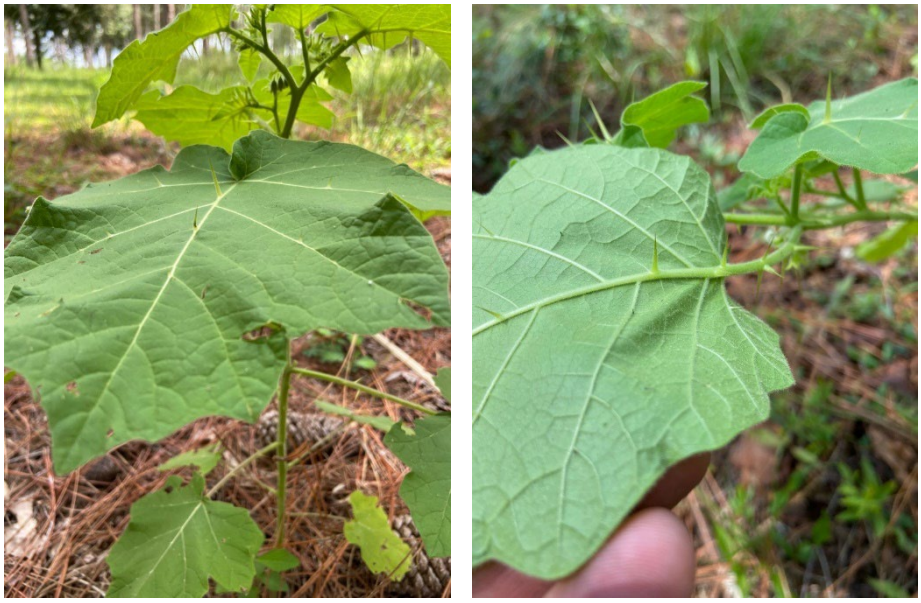


Figure 5. A lone tropical soda apple plant showing off its large thorn-like prickles above leaf (left) and below leaf (right) surface.

Giant Hogweed (*Heracleum mantegazzianum*)

Watauga County remains the only county in NC where giant hogweed has been positively identified. A total of 25 plants were sprayed over four locations. These locations are surveyed annually within the county by the area Field Specialist. This is in addition to the many calls received by the public, which take this part of the survey all over the state. There are several lookalikes which can lead to a mistaken belief that someone has giant hogweed. In each of these calls during 2021, it was determined no further positively identified cases for this weed existed. In many instances a determination was able to be made from a digital photo. When a determination could not be reached a visual inspection was conducted.

Wooly Frogsmouth (*Philydrum lanuginosum*)

Initially found in August 2016, this Guam native served as a first find in the U.S. Initially treated in late 2016 and 2017, no treatment was done in 2018 because the plant could not be found. In 2019 wooly frogsmouth was found not only in the original pond, but also in a nearby pond. Treatments began again in 2019 and 2020. The 2020 survey revealed good control for plants found along the water's edge while below the waterline plants can escape treatment. The NCDA&CS is working with NC Wildlife Resources Commission in pursuing additional treatment options. It was determined that pumping the water out of the pond may be a viable option for 2021. The main pond, where the infestation was first observed, was pumped down during one afternoon and one full morning. The pond level went down approximately 18 inches and allowed for us to treat plants that would have otherwise been submersed (Figure 6). The lime green plants folded over along the edge of the pond are wooly frogsmouth. Approximately two weeks after treatment the landowner provided pictures that details very good control (Figure 7). Note the absence of wooly frogsmouth. We plan on doing the same type of treatment in 2022, but with different and more powerful pumps so treatment can be accomplished in one day.

Figure 6. Pond after being pumped down approximately 18 inches and prior to treatment.

Figure 7. Pond approximately 2 weeks after treatment.

Tropical Spiderwort (*Commelina benghalensis*)

The exact point of introduction for this plant remains unclear, however information does exist going back to the 1930s where it could be found widespread throughout Florida. As an annual weed in temperate climates and herbaceous perennial weed in the tropics, tropical spiderwort (aka Benghal dayflower) is found in only 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 (approximately 170) within the genus. Two look-a-likes for this species include *C. communis* (Asiatic dayflower), a non-native and non-noxious weed and *C. diffusa* (spreading dayflower), a native species. Both above and below ground flowers are self-fertile.

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) continues treatment. A much larger infestation on Cherry Research Station has also been closely managed and much progress has been made due to a large-scale fumigation treatment in 2020. Close monitoring of this site yielded no positive identifications in 2021.

Figure 8. Several tropical spiderwort plants growing at a location close to NCSU. Plants are still present after years of managing the area.

Beach Vitex (*Vitex rotundifolia*)

As a prostrate-sprawling woody shrub, Beach Vitex was once touted as an erosion controller and dune stabilizer in the 1980s, however, beach vitex (Figure 9) eventually became known to do the opposite. 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 can 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.

About a decade ago the Beach Vitex Task Force completed their survey and management of this noxious dune vine. A recent U.S. Fish and Wildlife grant was completed by a third party aimed at conducting survey and additional research on this plant. Our path forward for the management of this weed was to springboard from the work accomplished by this grant and the third-party grantees. Unfortunately, efforts to reach out to the involved parties were unsuccessful.

Reports of re-infestations received during the 2021 season increased over the previous season. When a call of an infestation came in from Duck, NC (Figure 10) we began a different approach in combatting this weed. With the help of a local coordinator who was able to assemble a strong group of volunteers, three of our staff visited and educated this wonderful group on exactly how the Task Force once treated this plant in hopes of eradication. Since many of the coastal communities already have ordinances against this plant, it is our hope that working closely with each community, such as what was accomplished with Duck, that those towns will see the virtue of removing this plant through concerned citizens that are active in their community. Several new contacts have been made with coastal Public Works Departments that have employees capable of treating such infestations. We look forward to working closely with those communities that reach out for infestations they find and will continue our vigilance and outreach/education where those infestations occur.

Figure 9. Beach vitex along the Outer Banks. This location had been mowed repeatedly and stems can clearly be seen trying to evade this unintended management. Bluish/green colorations along the stem indicate where treatments were completed.

Figure 10. Volunteers applying the prescribed herbicide treatment to a large clump of beach vitex, Duck NC.

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). A related species (*O. ramose*) was first found in Texas, 1981 and by the early 1990s *O. minor* (Figure 11) was present in VA, two locations in SC and GA. It is not clear how NC became infested with *O. minor,* only that sometime in the mid to late 1990s the state began an eradication program for it. 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 or more, *O. minor* is parasitic to clover in Haywood and Mitchell Counties. 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.

A total of 101 plants were observed and destroyed at a livestock market in Haywood County. A total of more than 400 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 11. *Orobanche minor* plant in flowering phase.

Yellow Floating Heart (*Nymphoides peltata)*

We were able to visit each infested site of yellow floating heart at least twice for treatments with a few locations receiving three visits (Figure 12). Statewide, there were 11 sites and of these 3 were observed for the first time to be negative. A decision to consider an infested site eradicated for yellow floating heart will be given upon the third year when no infestation can be detected. A couple new sites of yellow floating heart were identified in 2021. In 2021 only one additional site was added. Continued persistence should pay off in 2022.

Figure 12. All three photos taken from the same location;(A) completion of our first treatment (7.9.21), (B) completion of our second treatment (9.8.21), (C) Upon completing our third treatment (9.28.21).

Witchweed (*Striga asiatica*)

The USDA has been a long-term and faithful supporter of eradicating this federal and state noxious weed (Figure 13). Their continued support ensures forward progress is made as we continue to march down a path towards eradication of this plant. Our early temporary employees were hired in early June 2021 to begin survey work. Survey and treatment efforts were in full swing by the beginning of July when all temporary employees were brought on-board.

The Witchweed Program has long used 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 a field has been considered eradicated and no longer requires survey or treatment.

One newly infested field (Sampson County, 42 acres) was observed in 2021. This is further reflected when considering that it was Sampson County that saw the only increase in infested acreage of the five counties registering positive for witchweed. All other counties either stayed the same or had fewer infested acres (Table 1).

2021 brought with it an end to the ethylene shortage the project had experienced in prior years. This was a welcomed change with 13 treatments covering 78 acres using ethylene. One new forty-two acre field was discovered in Sampson County, raising the county total to just over 80 acres. This increase gives Sampson County the only county to be designated with an increase and for a second year. During 2022 further effort will be placed on surveying more of Sampson Co. to prevent any escapes. Overall, total acres managed for 2021 for both infested and release phases is 2,377.3.

Figure 13. A witchweed plant near its host.

Table 1. Number of infested farms, fields and their totals by county for 2020 and 2021.

County		No. of Farms	No. of Fields	Infested Acres	
Bladen	**2020**	**28**	**49**	**498.00**	
	2021	**30**	**49**	**459.00**	
Cumberland	**2020**	**16**	**16**	**162.50**	
	2021	**14**	**14**	**147.60**	
Pender	**2020**	**3**	**3**	**30.50**	
	2021	**3**	**3**	**30.50**	
Robeson	**2020**	**13**	**17**	**356.30**	
	2021	**10**	**13**	**323.10**	
Sampson	**2020**	**1**	**1**	**38.00**	
	2021	**2**	**2**	**80.20**	
Total	**2020**	**69**	**102**	**1,085.30**	
	2020	**59**	**81**	**1,040.40**	

Table 2. A summarization for total acres managed in 2021.

Total Acres in Infested Category	**1,040.40**
Acres Transferred from Infested to Release Category	**147.60**
Total Acres in Released Category	**1,336.90**
Total Acres Managed by Program	**2,377.30**
Total Acres Treated	**1,168.25**
Total Acres Surveyed	**24,970.30**
New Acres in Program	**-42.2**
Net Loss of Acres	**147.2**

Seed and Fertilizer Section

The mission of the Seed and Fertilizer Section is to improve the profitability and sustainability of agriculture in the state by ensuring the seed, fertilizer, lime, and other soil additives offered for sale in North Carolina meet prescribed standards and are properly labeled.

The mission of this section is accomplished by:

- Ensuring that all locations that offer seed, commercial fertilizers, agricultural liming materials, landplaster, and soil additives for sale in the state are registered.
- Implementing a sound regulatory compliance program by conducting inspections and sampling of seed and fertilizer offered for sale in the state.
- Implementing seed purity, germination, and other specialized laboratory tests in support of the seed regulatory and service programs.
- Implementing a joint federal/state administered biotechnology permitting and inspection program.
- Conducting the fertilizer bioassay and endophyte testing programs.
- Coordinating activities of the N.C. Seed Board such that complaints regarding the failure of agricultural or vegetable seed to produce or perform as labeled or warranted are heard and responses are provided.

The Seed and Fertilizer Section includes 24 staff members with responsibilities and accountability for administration, field services and North Carolina Seed Lab functions. The total budget for the Seed and Fertilizer Program for 2020-21 was $1,787,406 including a state appropriation of $823,741 and receipts of $963,665. Revenues included receipts from licenses, registration fees, and tonnage fees.

Seed and Fertilizer Field Programs

During the fiscal year 2020-21 the Seed and Fertilizer Section remained very active providing services to producers and individuals within North Carolina and some service to non-residents of the state. Administrative staff was responsible for issuing 4,834 licenses for business that sold wholesale and retail seed. During the 2020-21 fiscal year 583 fertilizer licenses were issued to companies manufacturing or distributing fertilizer products. These products were sold through chain and private retail outlets and through 204 farm supply outlets.

Seed and Fertilizer Field Staff are responsible for conducting inspections and sampling seed and fertilizer offered for sale in the state. The staff also implements a regulatory program to ensure full compliance with laws and regulations. An overview of program accomplishments is provided in Table 1.

Seed and Fertilizer Field Staff also provided support to the North Carolina Department of Transportation by collecting 170 samples to be utilized on highway projects. The lab tests performed on these seed lots detected several violations and as such remain a critical part of the program.

Commodity prices on all major crops generally remained above the long-term average and this was reflected in additional tonnage being applied. Along with traditional fertilizers, producers also took advantage of animal and poultry waste to provide nutrients to their crops.

Table 1 Seed and Fertilizer Program Inspection and Regulatory Activities, FY 2020-21

Number of Seed and Fertilizer Dealer Visits:	1,072
Seed and Fertilizer Samples collected	
Official Seed Samples	3,108
Official Fertilizer/Lime Samples	833
Regulatory Compliance Program	
Seed Stop Sales Issued	22
Seed Stop Sales Issued and Resolved on Site	90
Seed Stop Sales (N.C. Seed Lab)	122
Fertilizer Stop Sales Issued	0
Fertilizer Stop Sales Issued and Resolved on Site:	6

Table 2 and Table 3 provide additional information on fertilizer and lime samples taken by field staff and subsequently analyzed to ensure compliance with applicable statutes and regulations.

Table 2 Data of fertilizer samples analyzed for the current and previous fiscal years

		FERTILIZER SAMPLING AND TONNAGE				
Year	#Samples	#Compliant	%Compliant	Tonnage Reported	Tonnage Sampled	%Sampled
2020-21	244	199	81.55	1,609,398	487	0.03
2019-20	746	526	70.51	1,446,692	2375	0.16
2018-19	433	325	73.33	1,448,395	3176	0.21
2017-18						
2016-17	1,010	636	62.97	1,505,275	16,627	1.07
2015-16	899	605	67.30	1,556,575	13,809	0.92
2014-15	1,081	730	67.53	1,504,612	18,862	1.25
2013-14	1,374	1,058	77.00	1,497,209	22,309	1.48
2012-13	1,228	868	70.68	1,509,378	21,920	1.59

Table 3 Data of lime and landplaster samples analyzed for the current and previous fiscal years.

LIME SAMPLING AND TONNAGE						
Year	#Samples	#Compliant	%Compliant	Tonnage Reported	Tonnage Sampled	%Sampled
2020-21	289	267	93.08	815,746	5258	0.64
2019-20	66	52	78.78	856,282	925	0.11
2018-19	133	107	80.45	665,174	3,911	0.59
2017-18				826,733		
2016-17	680	505	74.26	909,685	31,767	3.49
2015-16	571	505	88.44	731,932	28,539	3.90
2014-15	587	510	86.88	741,188	28,757	3.88
2013-14	646	498	77.00	831,854	28,620	3.44
2012-13	692	615	88.87	825,596	33,941	4.11

N.C. Seed Laboratory

The North Carolina Seed Laboratory is responsible for providing laboratory support for both the regulatory and service areas including the state's seed dealers, producers, university researchers and consumers. The work of this laboratory provides critical seed testing data needed to make management decisions regarding seed stock and for labeling purposes. For 2020-21, the North Carolina Seed Laboratory conducted 3,108 regulatory seed tests and 10,506 service seed tests. These tests involve required testing for purity and germination. Multiple tests are generally conducted on each of the samples submitted with 14,647 individual tests carried out. Additional special tests included tetrazolium, accelerated aging, cool test of cotton, cold test of hybrid corn, phenol, Round-up Ready™ tolerance, sand, and moisture testing. There were 1596 special tests conducted during the fiscal year. All official regulatory samples taken during the fiscal year 2020-21 represent testing for a total of 57,841,994 pounds of seed offered for sale in North Carolina. See Figure 1 and Figure 2 for more information on the various seed tests performed in the laboratory.

The Seed and Fertilizer Section continued to implement the endophyte testing service. A number of grasses, including tall fescue and perennial ryegrass, contain a fungal endophyte which has a beneficial relationship with the grass host. The tall fescue endophyte, *Neotyphodium coenophialum* (previously *Acremonium coenophialum*), lives exclusively inside plants, and can only be detected through laboratory analysis. This endophyte has been proven to give the plant insect, disease and drought resistance, as well as enabling the plant to be more tolerant of overgrazing. Though very beneficial to tall fescue plants, this endophyte produces chemicals which are toxic to a variety of animals. In North Carolina, fescue toxicosis is especially a problem in horses and cattle. A total of 2 Endophyte pasture samples were processed for producers, both in-state and out-of-state.

The staff of the North Carolina Seed Laboratory remains active in the Association of Official Seed Analysts and the Association of American Seed Control Officials. At the state level, program staff remains active in the North Carolina Seedsmen's Association and the North Carolina Crop Improvement Association.

Joint Collaboration with USDA, Biotechnology Regulatory Services

Seed and Fertilizer Section staff worked with USDA, Biotechnology and Regulatory Services (BRS) to jointly administer a federal/state biotechnology and permitting program. Primary responsibilities included reviewing permits and acknowledgements provided through USDA-BRS for laboratory, greenhouse, and field tests of genetically engineered crops. For this period, NCDA&CS staff reviewed a total of 147 notifications and permits. A joint project with USDA-BRS continued during this period involving NCDA&CS staff conducting field inspections of *Notification and Permit Release Sites*, including pharmaceutical/industrial trials. During this time period there were 0 field inspections conducted by NCDA&CS field staff. As a prerequisite for participation in the project, all field staff were required to participate in training conducted by USDA-BRS focusing on workflow, confidential business information, and steps in effectively completing a field inspection.

North Carolina Seed Board

The responsibility of the North Carolina Seed Board is to review complaints from individuals who may have suffered damage from the failure of agricultural or vegetable seed to perform as labeled or warranted, or as a result of negligence. Performance issues related to seed purity, seed germination, varietal purity, percent weeds, inert material, other crop seed and test date are potential issues to be addressed by the Seed Board. For the 2020-21 fiscal year time period, the Seed board did not conduct any investigations.

North Carolina Tobacco Variety Evaluation Program

The Tobacco Variety Evaluation Program continued in joint cooperation with N.C. State University. Samples from 31 flue-cured tobacco seed lots were obtained for planting grow-outs in the variety testing program. The Tobacco Seed Company approved for sale in North Carolina a total of 67 different varieties from four different seed companies.

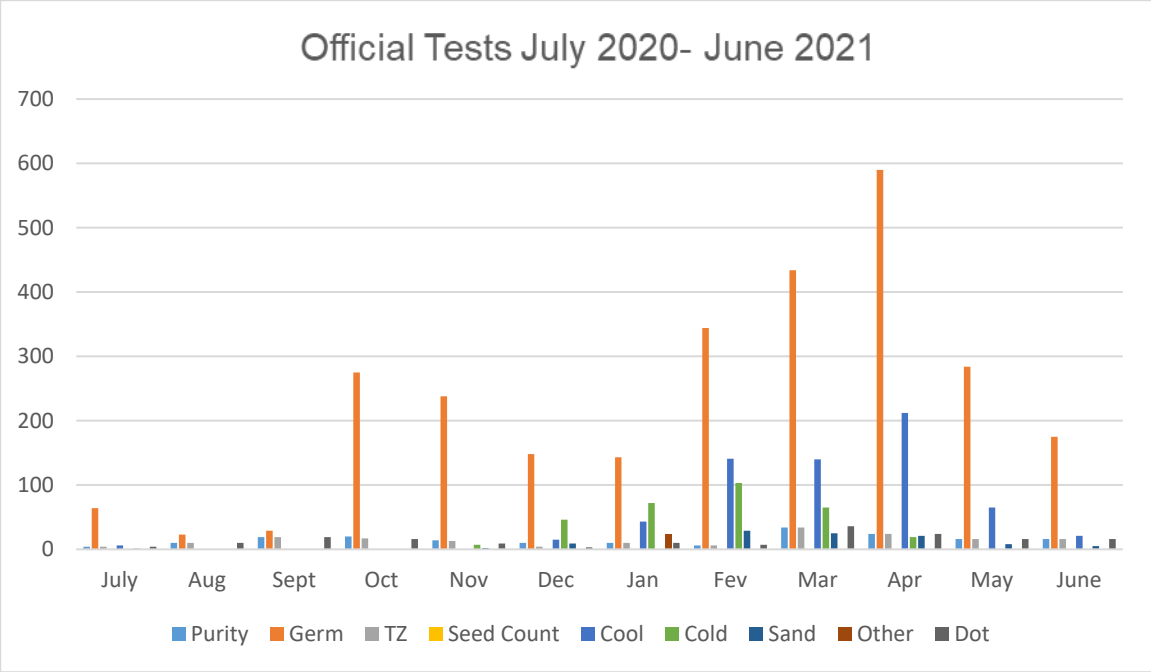


Figure 1 Seed Laboratory Official Tests

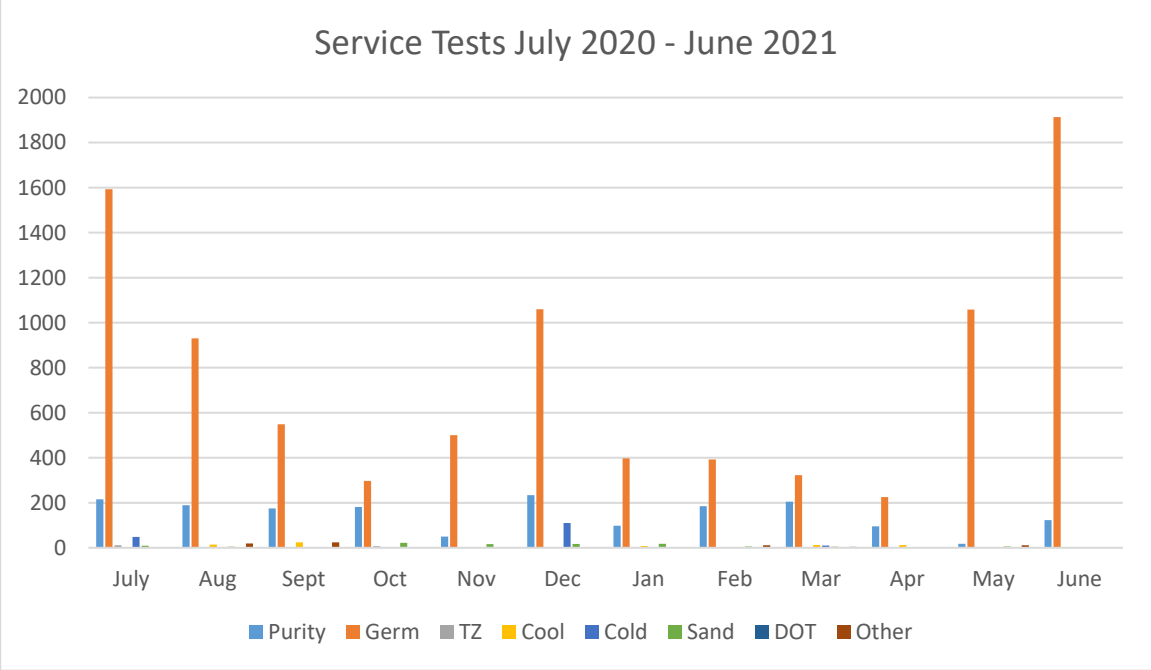


Figure 2 Seed Laboratory Service Tests