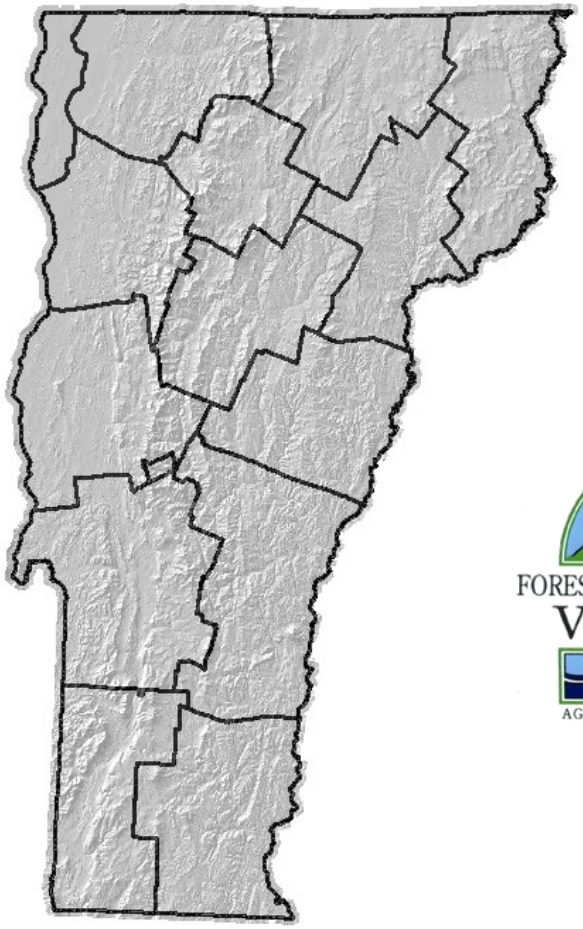
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2020



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http://www.vtfpr.org/

We gratefully acknowledge the financial and technical support provided by the USDA Forest Service, Northeastern Area State and Private Forestry that enables us to conduct the surveys and publish the results in this report. This document serves as the final report for fulfillment of the Cooperative Lands – Survey and Technical Assistance and Forest Health Monitoring programs.

FOREST INSECT AND DISEASE CONDITIONS IN VERMONT

CALENDAR YEAR 2020

PREPARED BY:

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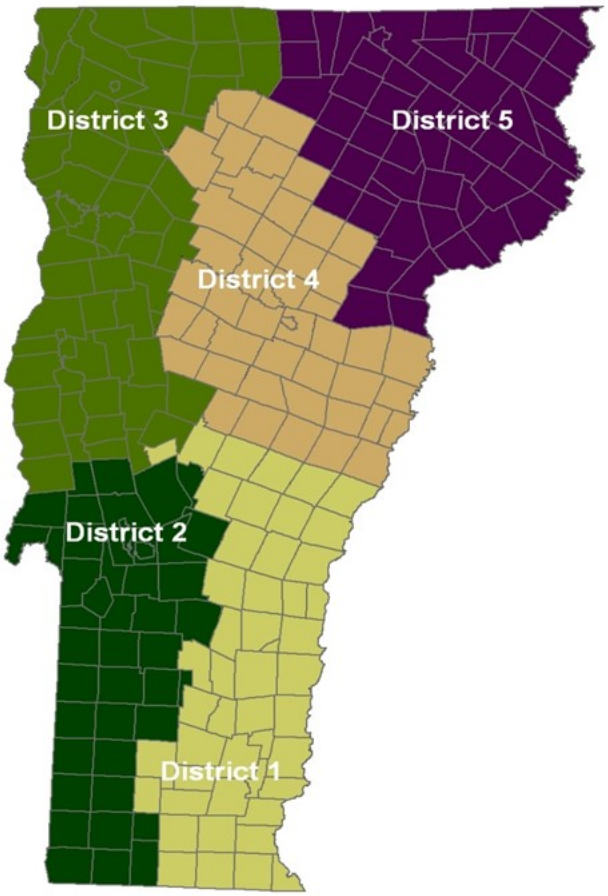

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INTRODUCTION

The report of Forest Insect and Disease Conditions in Vermont documents survey results and observations by Vermont Department of Forests, Parks and Recreation (FPR) staff in the calendar year. Activities were conducted in partnership with the US Forest Service, Vermont Agency of Agriculture, Food and Markets, USDA-APHIS, the University of Vermont, the National Weather Service, cooperating landowners, resource managers, and citizen volunteers, and were funded, in part, by the US Forest Service, State and Private Forestry.

These reports have been produced annually since 1967. In prior years, observations were summarized in the Vermont Department of Forests and Parks Biennial Reports.

The year's most significant observations and activities are summarized at the front of the report in the stand-alone Forest Health Highlights. Details follow about weather and phenology, forest insects, forest diseases, animal damage, invasive plants, and trends in forest health.

2020 brought with it the COVID-19 pandemic. This resulted in adjustments to our normal fieldwork methods. Most of our projects were able to continue however aerial survey was not able to be performed. Staff utilized fire towers, as well as summits with sufficient views to map forest disturbances.

Ground data include tree health and pest population survey results. Additional data and metadata are available through the Forest Ecosystem Monitoring Cooperative Database website or by request. Also reported are insects and diseases of trees that were incidentally observed by our staff, the public and others. Except where indicated, the lack of an observation does not mean that the insect or disease was absent.

This report is available on-line at https://fpr.vermont.gov/forest/forest-health/current-forest-health-issues-and-updates or in hardcopy format. For additional information, including defoliation maps, management recommendations, and other literature, assistance in identifying pests, diagnosing forest health problems, on-site evaluations, and insect population sampling, or to participate in invasive pest citizen monitoring, contact Forest Resource Protection Personnel or your County Forester.

ACKNOWLEDGEMENTS

Volunteers assisted with deploying and monitoring purple panel traps as part of our **emerald ash borer detection** efforts. Thank you to Rob Andergregg, Knox Johnson, Sarah Albert, Marie Ambusk, Bill Baron, Russ Barrett, Scott Bassage, Robert Brandt, Doug and Mary Burnham, Bethany Creaser, Al Crist, Jeff Cueto, Mark Dillenbeck, Tim Duclos, Craig Dusablon, Willie Franklin, Amanda Garland, Margo Ghia, Beth Deimling, Michael Gray, Jock Harvey, Katherine Hancock, Steve Justis, Stephanie Kaplan, Irwin Kuperberg, Caitlin Littlefield, Bob Little Tree, Sue Lovering, Guy Maguire, Neil Maker, Neil Monteith, Rose Paul, Anne Reed, Al Sands, Tim Scoggins, Tim Smith, Dan Steinbauer, Tim Stout, Sally Thodal, Jack Travelstead, Pieter Van loon, Caitlin Cusack, Jim White, Brendan Whittaker, Jessica Zehngut, and Robert Zimmerman who participated in this project.

Special thanks to Pieter Van Loon for helping to organize staff and volunteers from the Vermont Land Trust to monitor traps on VLT lands.

Many thanks to all the groups, towns, and organizations who took part in **invasive plant management and outreach** across the state. Huge thanks to Agency of Transportation, Agency of Agriculture, Food & Markets, Audubon Vermont, Center for Technology Essex, Forest Hero! Volunteers, Winooski Valley Park District, Vermont Woodlands Association, VT Coverts: Woodlands for Wildlife, Conservation Commissions, CISMAs, other municipal and private organizations across VT, and many others who helped to spread the word, not the plants.

The **Forest Biology Lab** received taxonomic and other assistance from Kevin Dodds, Charley Eiseman, Aaron Ellison, Steve Fiske, Ann Hazelrigg, Ron Kelley, Warren Kiel, Deb McCullough, Isabel Munck, Judy Rosovsky, JoAnne Russo, Scott Schneider, and Dave Wagner.

The **hemlock woolly adelgid program** received survey assistance from Caitlin Cusack and the Vermont Land Trust.

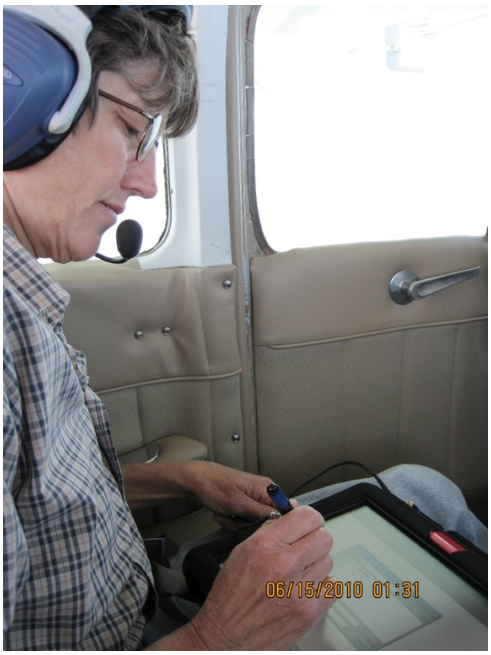
Vermonters utilized the **Report It!** feature on the VTinvasives website to report potential cases of invasive fungal pathogens, insect stressors, and early detection invasive plants. These voluntary submissions help in the early detection and rapid response of invasive species that are not yet established in the state. In addition, reports of EAB suspects helped establish a finer resolution of the extent of the EAB infestation in VT.

Support in many program areas was provided by the staff of the US Forest Service Forest Health Protection, the Vermont Agency of Agriculture, Food and Markets, University of Vermont, USDA APHIS, the US Forest Service Northern Research Station, and Vermont State Parks, as well as many others in the Vermont Agency of Natural Resources.

SPECIAL ACKNOWLEDGEMENT

Barbara Schultz and Mary Burnham, two long-serving staff members of the Forestry Division, retired from the Forest Resource Protection program in 2020. We are grateful for their contributions to our Forest Health efforts.

Throughout Barbara's 40-year career, she has been dedicated to the development of a forest health program that is grounded in science, cost-effectiveness, flexibility, and responsiveness. She was the vital State connection in forest health information management and always provided the best data possible for land managers, sugarbush overseers, landowners, and the general public. As one of Vermont's most zealous and knowledgeable advocates for protecting and maintaining healthy forests, Barbara Schultz has worked tirelessly to understand and address issues ranging from white pine decline to forest tent caterpillar epidemics. Her vibrant interest in the complex interplay between biotic and abiotic factors, and her critical understanding and ability to convey information in a pragmatic way to landowners, the general public, and her peers, made her highly respected on all fronts and a key player in regional forest health issues. Her dedication and attention to the interests and needs of the people of Vermont inspired all of us to follow suit.



Her perceptivity and listen-first approach made her an amazing advocate for Vermont. Her local and regional reputation in the field of forest health is outstanding, and she served as a respected and trusted resource, providing data state- and region-wide to anyone concerned with abiotic and biotic health issues. The popular, well-attended annual Forest Health Information Meeting was inspired by, initiated, and conducted by Barbara for over 25 years.

Her dedication and thoughtful attention to the people of Vermont permeated everything she did. Thank you Barbara for your years of dedicated service to the citizens of Vermont.

Mary R. Burnham put in her last day at the Forest Biology Lab on June 3, 2020, after more than 20 years of service to the State. Mary began work at the Forest Biology Lab as a volunteer, assisting with insect identifications and pheromone, light and sticky trap surveys. In 2000, she was hired as a year-round, part-time Environmental Scientist. Mary has a particularly keen eye for the often-minute characteristics that distinguish one species from another, and put that talent to use during many projects, including our region-wide participation in surveys for exotic woodboring beetles.

Throughout her tenure, Mary worked on projects that contributed to the distributional status of high-profile taxa important to Vermont forests, including various wood-borers (*Cerambycidae*, *Buprestidae*, *Curculionidae-Scolytinae*, *Siricidae*), defoliators (*Lepidoptera*, *Coleoptera*, and others), and sap-sucking insects (Hemiptera). Along with forest insects, she is keenly interested in dragonflies and damselflies (Odonata).

Mary has long had an interest in Vermont natural history, participating in bird surveys, BioBlitzes, advanced classes, and special seminars, Vermont Entomological Society (VES) field forays and workshops, and "sampling" fish at the end of a hook. Mary lends her expertise to the Vermont Center for Ecostudies by participating in insect survey efforts and contributing butterfly and native bee records. She also intends to continue to contribute expertise to regional BioBlitz efforts.

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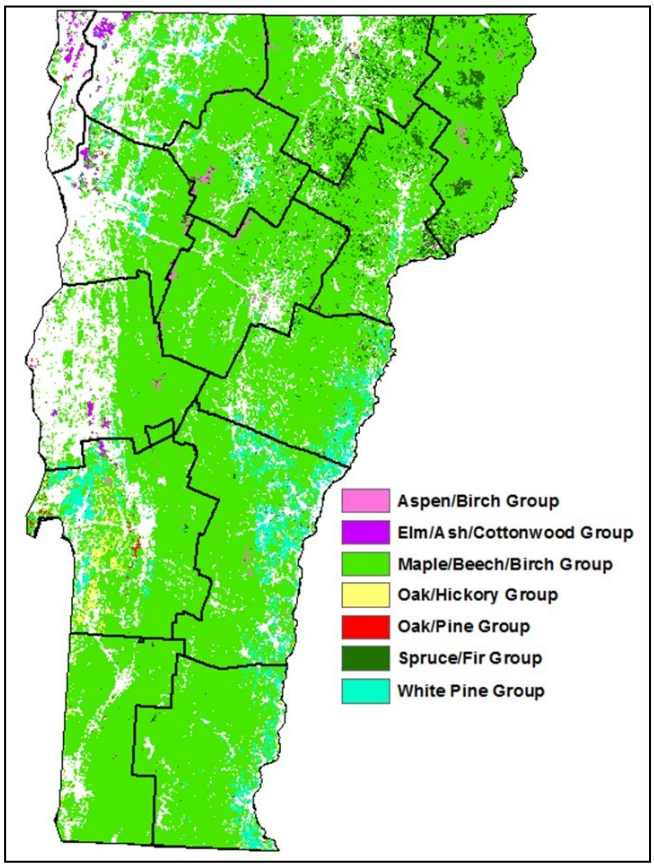
2020 Vermont Forest Health Highlights

These Forest Health Highlights summarize information from the annual report on Forest Insect and Disease Conditions in Vermont. They provide an overview of the forest resource in Vermont, forest health program highlights, a weather summary, sections on hardwood and softwood insects and diseases which are native or established in the state, a section on exotic forest pests and any status change, a summary of activities related to non-native invasive plants, and forest health monitoring results. Vermont forest health information is available online at https://fpr.vermont.gov/forest/forest-health, or you can contact us:

- for assistance in identifying pests or diagnosing forest health problems
- to request on-site evaluations or management recommendations
- to obtain defoliation maps and hard-copy publications
- to participate in invasive pest citizen monitoring

Forest Resource Summary

Vermont's forests cover about three-quarters of the state and include billions of trees. Eighty percent of the State's forest land is privately owned with 11% under Federal management in the Green Mountain National Forest and 8% managed by the State of Vermont. Sugar and red maple and eastern hemlock are the most common species by number and volume. More information on Vermont's forest inventory can be found at https://fpr.vermont.gov/forest-inventory-and-analysis-fia.



Distribution of forest type-groups in Vermont. Source: US Forest Service Forest Inventory and Analysis 2008 NLCD 2006 (Fry et al. 2011). Credit: R. Morin; data available at: www.fia.fs.fed.us/tools-data/.

Healthy forests are ecologically functional and resilient to disturbance. They are valued by communities and have the capacity to produce economic benefits. The mission of the Vermont Division of Forests is to manage for and protect healthy forests. We work with Vermont citizens to promote forest health, supporting best management practices, sustainable use, and respect for the land.

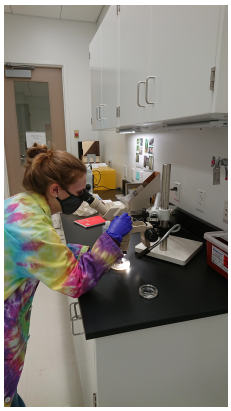
Forest Health Program Highlights

The Vermont Department of Forests, Parks and Recreation (FPR) conducts aerial and ground surveys to detect forest damage. In addition, long-term monitoring plots are inspected to evaluate forest health. FPR and the Vermont Agency of Agriculture, Food and Markets (VAAFM) collaborate with USDA agencies to survey and manage **non-native forest pests**, and with the University of Vermont (UVM) Extension on education and outreach.

This year provided challenges and opportunities due to the global COVID-19 pandemic. As the country moved toward shutting down all but essential services, and workers in Vermont were instructed to stay at home, our field season appeared to have shut down even before it started. However, over the first few months of the stay at home order, the State of Vermont and the Agency of Natural Resources (ANR) developed guidelines to allow specific types of work if all safety protocols were followed. This allowed staff from the FPR to slowly start conducting fieldwork. Surprisingly there were only a few projects impacted and most of the forest health monitoring projects were implemented. This couldn't have been done without the dedication, flexibility, and preparedness of the staff conducting these projects.

View from the top of Camel's Hump. Photo credit FPR staff.

The Department conducts an annual Aerial Detection Survey identifying and mapping forest health issues and damages. This year, mapping forest disturbances by plane was not possible, so staff headed for the hills – quite literally. After identifying standing (and climbable) fire towers, as well as summits with sufficient views, Protection Foresters visited these locations to assess forest health. This year the forest looked quite healthy and there were limited areas exhibiting damage.



Forest Pathologist, Savannah Ferreira, at the Forest Biology Lab.

The **Forest Biology Lab** is located in the Vermont Agricultural and Environmental Laboratory (VAEL) on the campus of Vermont Technical College in Randolph. This new facility houses FPR's insect collection that contains at least 1,884 different species of Vermont invertebrates, as well as a collection of semi-permanent mounts of plant material from animal, fungal, bacterial, and human-caused damages. By moving the collection to a secure space at VAEL and updating the collection's database, the preserved specimens and their records can now be easily accessed.

The lab continues to provide invertebrate identifications, tree disease diagnoses, pest management recommendations, and supports education and outreach. In 2020, our inquiries came from 13 Vermont counties, with the highest numbers from Windsor, Washington, and Windham. Insect identification was our highest inquire, followed by fungal/disease identification, forest health-related information requests, abiotic damage identification, and animal damage identification. Three percent of our inquiries were from out-of-state. We work closely with our partners at the VAAFM to provide these services.

Vermont's **firewood quarantine**, the Rule Governing the Importation of Untreated Firewood into the State of Vermont, went into effect in 2016. Untreated firewood, less than 48 inches in length, cannot be brought into Vermont unless a waiver has been granted to the person moving the firewood. In 2020, twenty-two waivers were in effect for firewood from adjacent counties in New Hampshire, New York, and Massachusetts. Waivers for wood from counties known to have EAB do not allow the importation of untreated ash firewood.

To align with the firewood quarantine and emerald ash borer slow the spread campaign, the protocol was modified regarding outside firewood entering **Vermont State Parks**. Campers were encouraged to bring no more than one night's worth of firewood regardless of the firewood's location of origin. Unless it was certified to have been heat-treated, outside firewood was confiscated, bagged, labeled, and exchanged for heat treated wood. In 2020, 210 bags of firewood were processed, compared to 8 bags of out-of-state wood in 2018. The wood originated from Connecticut, Massachusetts, New York, New Hampshire, and multiple towns across Vermont.

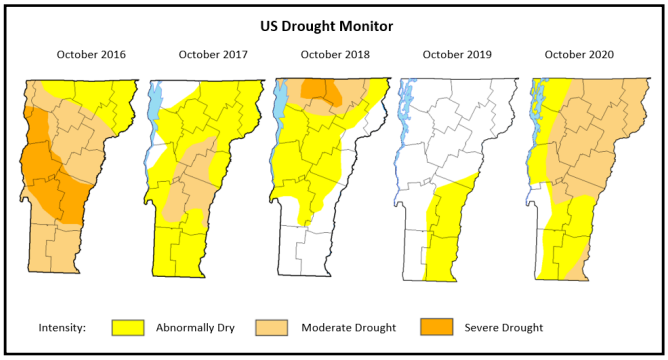
Truckload of firewood from Vermont State Parks. Photo: FPR staff

The **Vermont Forest Pest Outreach Program**, implemented by the Urban and Community Forestry Program and UVM Extension with oversight and funding provided through Vermont Agency of Agriculture, Food and Markets (VAAFM), reached 306 people at workshops, presentations, and trainings and an estimated 452,385 people were exposed to forest pest educational material through exhibits, newsletters, radio, and social media messaging.

- Workshops included: Suspect Tree Workshops where Forest Pest First Detectors (FPFDs) were trained to take photographs of trees in their regions suspected of being infested with emerald ash borer; **Rural Right-of-Way Ash Inventory Workshops** which trained volunteers to conduct inventories and map ash trees in their communities using the ArcGIS Collector app.; and a **Hemlock Woolly Adelgid Monitoring** training in Bristol.
- Over **400 trailhead signs** about emerald ash borer were posted on the state's most trafficked hiking trails. With help from FPR; the Green Mountain Club; and the Green Mountain National Forest, laminated signs about the signs and symptoms of EAB infestation were posted at popular trailheads and kiosks. Additional signs are posted at some of Vermont's natural history museums, and town forests.
- **EAB Awareness Week**. Despite COVID-19, Forest Pest First Detectors and other dedicated volunteers in 9 towns organized activities such as ash tree tagging events, ash tree walks, webinars, drawing contests, and local media coverage to raise awareness of emerald ash borer in their communities. We also partnered with the Vermont Land Trust to collect stories and pictures of notable ash trees statewide. The week received lots of media coverage, including WCAX, My Champlain Valley, UVM Extension's Across the Fence, Vermont Public Radio, the Vermont Journal, the Brattleboro Reformer, Vermont Business Magazine, and even a news channel in Boston.
- **Purple Trap Program**. This program was supported by United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) which supplied the traps, other materials, and staff support. Forty-four FPFD volunteers and FPR staff monitored 114 traps in 50 towns and 12 counties. This resulted in confirmed infestations in three new locations: West Swanton, Marshfield, and Shaftsbury.

2020 Weather Influences on Forest Health

Winter was milder and with less snow than average, but cool temperatures persisted through mid-May and delayed the start of the growing season. Indeed, many parts of the state experienced snowfall in early May, followed by higher than normal temperatures that facilitated rapid bud break. Following snowmelt, little precipitation was recorded through early June, at which point the state was classified as Abnormally Dry by the US Drought Monitor. Dry conditions continued throughout the state during the growing season, and by the end of September resulted in Severe Drought in northeastern VT (~30% of the state), with the rest of the state categorized as being in either Moderate Drought or Abnormally Dry. Despite the adverse growing conditions, little damage to foliage was observed. However, the dry weather likely contributed to slightly earlier peak foliage color in many places, as well as earlier leaf drop.

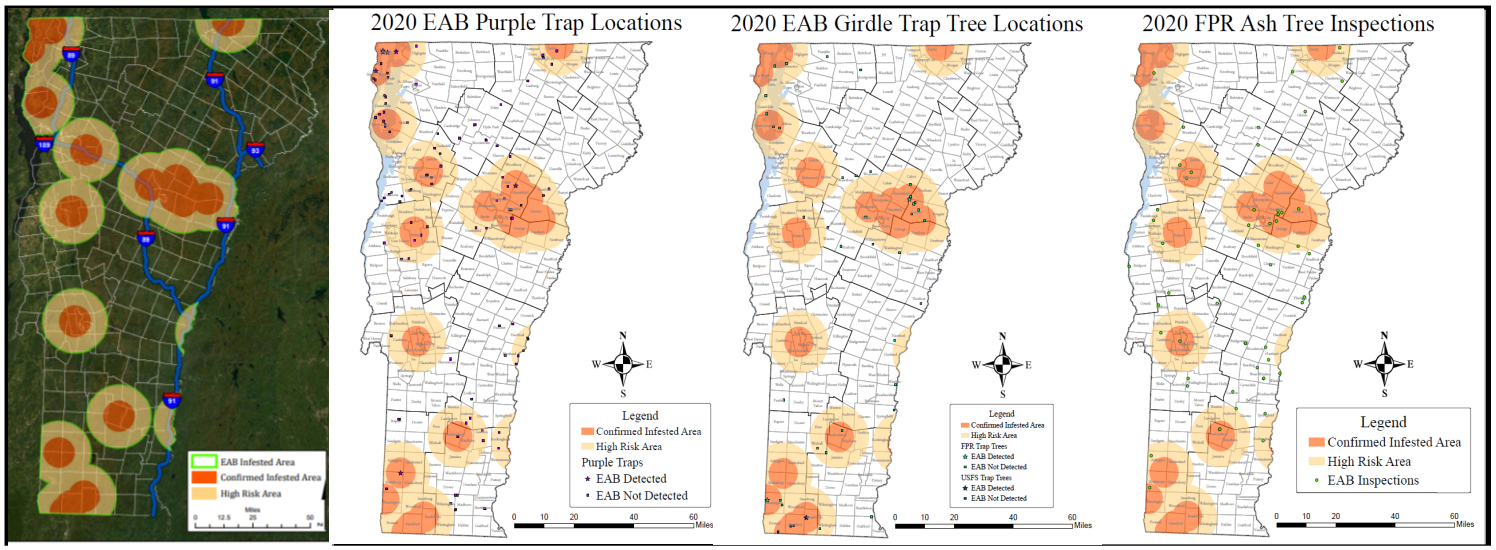


Periodic dry conditions since 2016 continue to impact tree health.
Map: NOAA/USDA/NDMC
http://droughtmonitor.unl.edu/

Sugar maple phenology was monitored for the timing of bud break and leaf out in the spring at the Proctor Maple Research Center in Underhill as part of the Forest Ecosystem Monitoring Cooperative. Initial monitoring was late to begin due to restrictions put on fieldwork associated with COVID-19. Sugar maple bud expansion was delayed by eight days compared to the long-term average, with bud break occurring on May 11. Full leaf-out was similarly delayed and occurred seven days later than the long-term average. This was not a year of heavy flowering for sugar maple.

Hardwood Insects and Diseases

Emerald ash borer (EAB *Agrilus planipennis)* was detected in five significant new locations in 2020. New discoveries in Readsboro, Swanton, and Isle La Motte increased the size of existing EAB high-risk and confirmed infested areas in Bennington, Windham, Franklin, and Grand Isle Counties. A detection in Richmond was the first for Chittenden County. A detection in West Rutland, coupled with two in southwestern New Hampshire, established entirely new infestation locations and high-risk areas in southern Vermont in Rutland, Windham, and Windsor Counties. Several detections were found on purple prism traps and trap trees.



The mapped EAB Infested Area extends ten miles from known EAB locations. The EAB Infested Area indicates where the Slow the Spread Recommendations apply. Purple trap locations, girdled trap tree locations, and ash tree inspection locations for 2020.

Maps detailing known EAB infested areas in Vermont are available at VTinvasives.org. The mapped areas indicate the likelihood of EAB based on where it has been observed; EAB is not necessarily present throughout the mapped infested areas. By the time an insect is detected, it has already dispersed, so any ash within ten miles of a known EAB location is considered to be at-risk. Including these high-risk areas, the mapped infested area now includes all or part of 130 towns in thirteen counties. The infested areas are also available for download on the ANR Atlas which can be found at: https://anrmaps.vermont.gov/websites/anra5/.

Sign up for the **EAB Update Listserv** to receive notification of new detections, and please continue to look for signs and symptoms of the insect and report suspicious findings on VTinvasives.org. Resources are available to assist in slowing the spread of EAB and managing threatened resources.

Applying the **Slow the Spread Recommendations** to the mapped Infested Area reduces the risk of spreading EAB and provides time to conduct management activities. The Slow the Spread Recommendations can be found at https://vtinvasives.org/land/emerald-ash-borer-vermont/slow-spread-of-eab.

EAB biocontrol release involves securing small pieces of ash logs containing the parasitic wasps to infested trees. Photo: FPR staff

Biocontrol Release

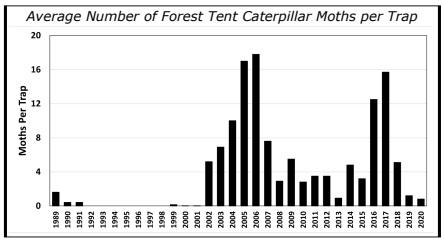
EAB biological control agents were released in two locations this year. One release site was located on LR Jones State Forest in Plainfield, the first State Forest in Vermont, as well as the first State Forest to become infested with EAB. The second site was located in the town of South Hero. The biocontrol agents, *Tetrastichus planipennisi,* are tiny stingless wasps that parasitize EAB by laying eggs in EAB larvae, where they eventually hatch and grow, and ultimately kill the EAB larvae. They are known to target EAB exclusively, and do not parasitize other insects or pose a human health risk. These biocontrol releases involve securing small pieces of ash logs that contain the parasitic wasps to visibly infested trees and allowing the insects to emerge for a minimum of two weeks before the pieces of ash logs are removed. These particular parasitic wasps (or parasitoids) are effective on smaller trees and saplings and have been shown to reduce the number of EAB larvae in young trees by as much as 50%. The goal of these releases is not to eradicate EAB (which is considered impossible in the US at this point), but to establish a self-sustaining population of the parasitic wasps that will improve ash regeneration and lessen the impact of EAB in infested areas in Vermont.

Vermont is the 30th state participating in the national EAB biocontrol program. The parasitoids were produced and supplied from the USDA APHIS, PPQ EAB Parasitoid Rearing Facility in Brighton, MI.

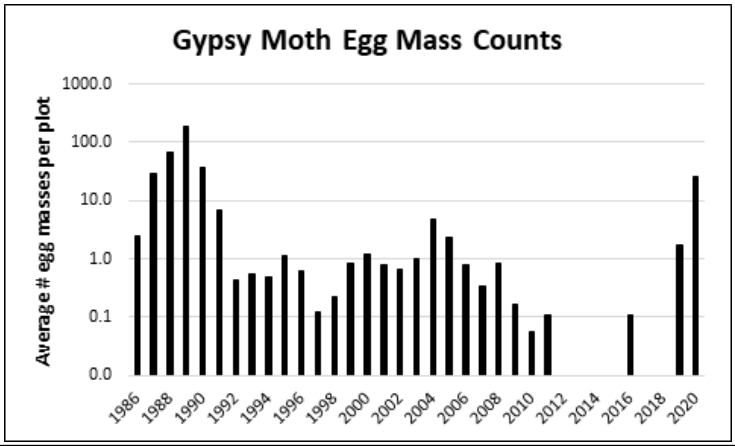
Fall webworm (*Hyphantria cunea*), a native hardwood defoliator, was reported across the state at higher than normal levels. The nests of these caterpillars are formed in late summer/early fall and towards the tips of branches. Although the nests and feeding can be unsightly, because the defoliation is happening later in the growing season, it does not have a huge impact on overall tree health. Multiple years of heavy defoliation can lead to dieback.

Fall webworm damage was seen across the state (left); close up of larva (right). Photo: FPR staff

Forest Tent Caterpillar (*Malacosoma disstria)* defoliation was not observed this year. The number of moths caught in pheromone traps confirm that the outbreak that started in 2016 has ended.



Gypsy Moth (*Lymantria dispar*) reports were received throughout the state in June and July, although no defoliation was reported or observed. The increase in their numbers is likely due to a drier than normal spring, where *Entomophaga maimaiga,* a fungus which kills gypsy moth caterpillars, was less effective than is typical. This resulted in similarly numerous reports of gypsy moth egg masses in late summer and fall. Indeed, from our long-term gypsy moth monitoring plots we documented the highest number of egg masses in recent memory. Based on these data, some level of defoliation can be expected in 2021 through areas of the Champlain Valley. The severity of defoliation will likely be influenced by spring moisture levels and the success of fungal and viral pathogens on the caterpillars.

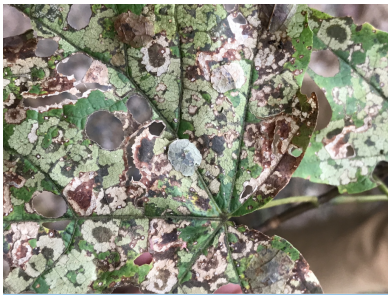


Gypsy moth egg mass counts from long-term monitoring plots in Vermont. The average counts were the highest we've seen since 1990, and we anticipate some defoliation occurring in the state in 2021.

Multiple reports were received of hardwood defoliation due to **saddled prominent** *(Heterocampa guttivitta)* throughout the state in July, though severity was light. Heavy frass rain and scattered leaf fragments on the forest floor were the most notable effects from their feeding. Despite the number of reports, no landscape-scale damage was observed.

Saddled prominent larva. Photo: FPR staff

Maple leaf cutter (*Paraclemensia acerifoliella*) damage is predominately found on sugar maples, although this insect also feeds on other hardwoods such as red maple, beech, and birch species. Larvae excise circular holes in the leaf, which is then bound together with silk, and used as protection from predators and environmental conditions.



Extensive late season damage from maple leaf cutter (left). Larva revealed between layers of leaf tissue (right). Photo: FPR staff

Pear thrip (*Taeniothrips inconsequens*) have been observed affecting beech and maple trees in central and southern Vermont this growing season. These insects feed on opening vegetation and flower buds, causing infested branches to appear tattered and stunted. High infestation levels can cause thinned crowns and premature leaf drop. For more information visit VTinvasives.org.

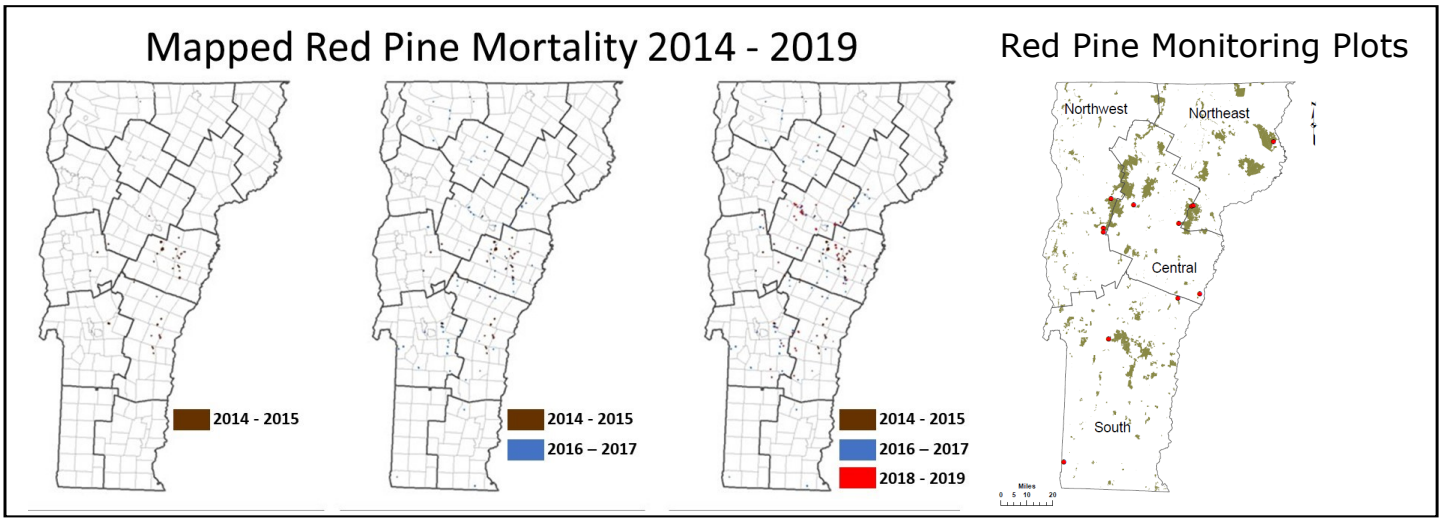
Moderate damage from pear thrips feeding. Photo: R. Kelley

Gypsy moth egg masses at long term monitoring plots. Photo: FPR staff

Softwood Insects and Diseases

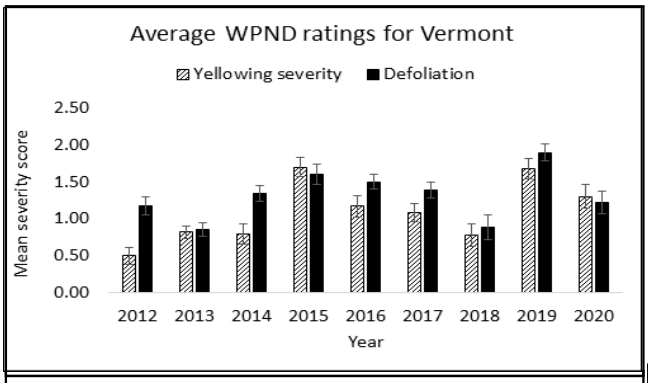
Red pine (*Pinus resinosa)* has been in a state of decline across Vermont. This year 12 red pine health monitoring plots were established throughout the state to track crown changes and sample for suspected causes. Previously, foliar shoot blight pathogens such as *Diplodia pinea, Sirococcus conigenus*, and *Pestalotiopsis* spp. have been found to contribute to this decline in central Vermont in 2019. The exotic insect, red pine scale, has not been detected in Vermont since 2015, when it was only found in two locations. Pine gall weevil has also been found extensively associated with declining red pine. Plots will try and determine if this declining pattern and fungal complex is homogenous across the state and what role if any, the insects play in this decline.

Left to right: Diplodia tip blight (Diplodia sapinea), Pine gall weevil damage caused by Podapion gallicola, and stand level decline of red pine.



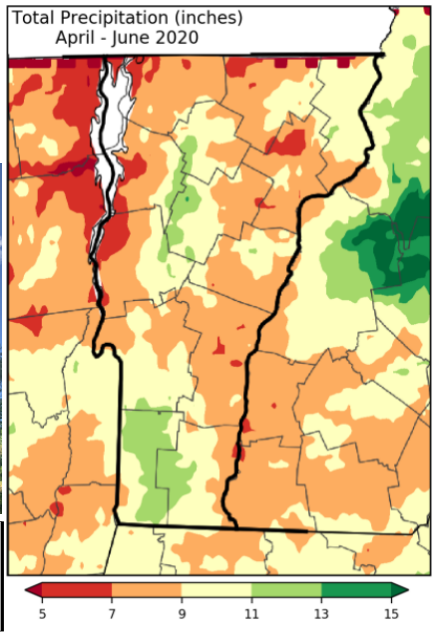
White pine needle diseases (WPND) have affected pine foliage in Vermont for the last decade, and this year was no different. While damage was lower than in 2019, significant yellowing and early needle-drop were present throughout the state.

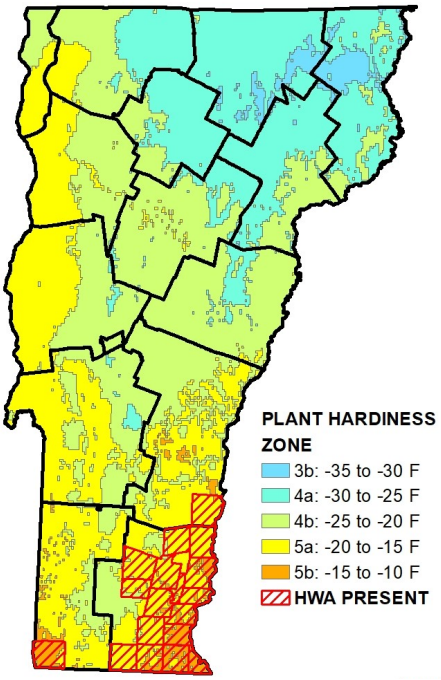
The expression of WPND is linked to the amount of humidity and moisture from the previous spring (e.g., 2020 damage is influenced by 2019 weather). Spore production typically peaks in June during shoot elongation. We expect WPND to be present again in 2021, but to be less severe than in recent years due to the dry spring in 2020.



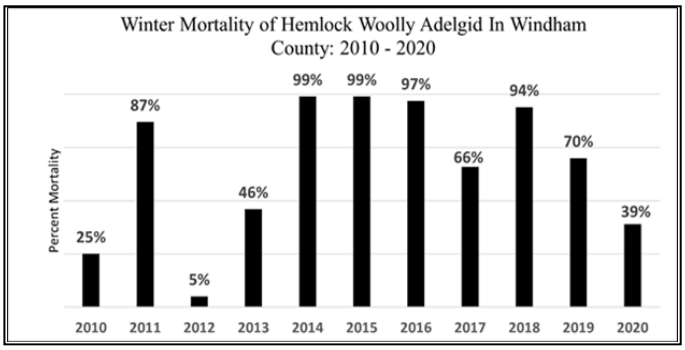
Yellowing severity and defoliation ratings on White Pine Plots, 2012-2020. Mean severity and defoliation were less in 2020 than 2019.

Needle yellowing on symptomatic white pine. Photo: FPR staff





Vermont's **hemlock woolly adelgid** (HWA *Adelges tsugae)* infestation remains primarily in Windham County, with small spots in Windsor and Bennington Counties. Much like last year, no large spread of the infested area was observed this year. Winter mortality of the insect was fairly low and the recovery rate of the summer generation was high resulting in higher than normal population counts. A new project to monitor summer mortality was initiated this season; the data was not ready in time for this publication. The average winter mortality was only 39%, well below the threshold of 91-92% mortality which restricts expansion of the population.



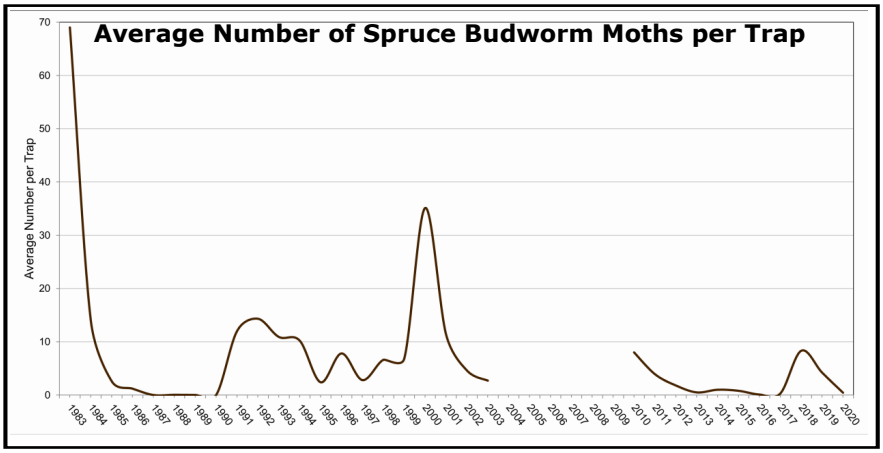
Biocontrol efforts have taken place historically in Brattleboro and Guilford, in Windham Co and Pownal in Bennington Co. In 2019, 510 beetles were released at the Brattleboro site and a newly established site at Jamaica State Park. An additional 425 beetles were released in 2020 at JSP.

Vermont's HWA infestation remains centered in Windham County, with no expansion to new towns detected in 2020 despite a low HWA mortality rate in winter 2019-20, which dropped to 39%.

Compounding the risk to hemlock, the incidence of **elongate hemlock scale** (EHS, *Fiorinia externa)* seems to be on the rise in southern Windham County due to natural spread. In addition to EHS populations present in southern Vermont, a property in northwestern Vermont was found to have EHS on planted fir stock in 2019. Treatments followed on this property and EHS was eradicated from the site. However, in August 2020, a report was received from another northwestern town (Shelburne) and EHS was confirmed. The extent of this population is being monitored and its severity will be evaluated in early 2021. Landowners affected by the new detection plan on treating their respective properties to control the insect.

Elongate Hemlock Scale observed in Shelburne, Vermont (above).Treatment of hemlock for managing elongate hemlock scale (right). Photo: FPR staff

Spruce budworm (*Choristoneura fumiferana)* trap catches declined again this year. There were an average of 0.44 moths per trap in 2020 compared to 4.2 moths per trap in 2019. Traps are deployed in Caledonia, Chittenden, Essex and Orleans Counties. Defoliation by spruce budworm is not anticipated for 2021.



Spruce budworm moth catches remain low.

Exotic Forest Pests Threatening Vermont

Established Pests:

The **common pine shoot beetle** *(Tomicus piniperda)* has been found in many Vermont counties since it was detected in the state in 1999. By federal quarantine, pine material is free to move within Vermont and through most of the region. The USDA has recently proposed lifting this quarantine. See Pine Shoot Beetle Quarantine Considerations for more information.

The USDA is deregulating two insects of importance to the forest health community, the tree-killing **emerald ash borer** and the lesser known **velvet longhorn beetle** (*Trichoferus campestris)*. The velvet longhorned beetle stows away in furniture and has been found in 9 states in the U.S. It primarily attacks fruit trees but has been found on many other hardwoods. It is not clear whether it can attack healthy trees. The USDA will no longer alert states that it has been found iñ imported material.

Please note that the state law prohibiting the movement of pests is still in place, as are the state's Slow the Spread recommendations for the movement of ash.

Pests not known to occur in Vermont:

Beech leaf disease (BLD *Litylenchus crenatae mccanniis) is* of increasing concern in New England. This disease is known to occur in Ohio, Pennsylvania, New York, and Connecticut with recent detections in Massachusetts in the towns of Plymouth, Worcester, and Blandford. Several states have established long-term monitoring plots utilizing protocols developed with the BLD Survey and Monitoring Team, a partnership between the USDA Forest Service, Cleveland Metroparks, the Ohio Division of Forestry, and the Ontario Ministry of Forestry. Vermont will be establishing plots in asymptomatic stands in 2021.

Symptoms of beech leaf disease include dark stripes and yellowing between the veins. Photo: DEC NY

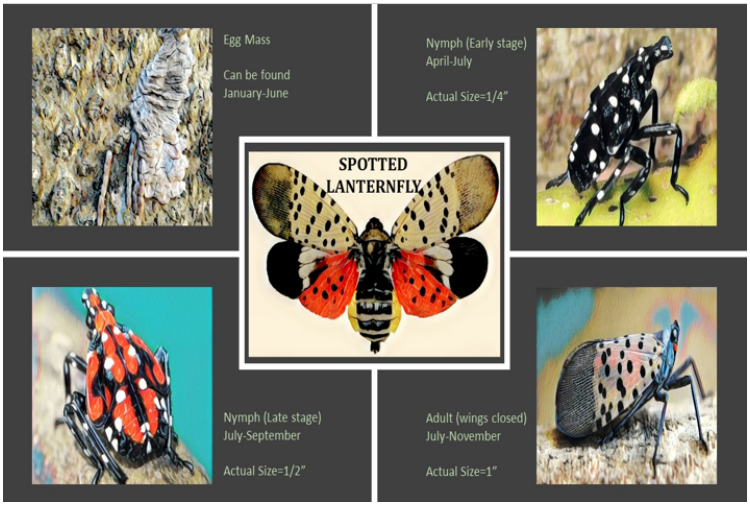
Vermont has been participating in a regional **oak wilt (***Bretziella fagacearum)* survey. This year we investigated a suspect tree in Rutland County, and samples were collected and sent to Cornell for identification. Fortunately, oak wilt was not detected. We will continue to investigate suspects as they become known. If you have seen a tree with symptoms that match oak wilt, please visit VTinvasive.org's 'Report It' feature so we can follow up on your observation. More information can be found at www.vtinvasives.org/invasive/oak-wilt.

Asian longhorned beetle (ALB, *Anoplophora glabripennis)* is not known to occur in Vermont, however education and outreach that can promote early detection remains a priority. In 2019, the insect was declared eradicated from New York City.

Other non-native insects and diseases that have not been observed in Vermont include **winter moth,** *Operophtera brumata***,** and **thousand cankers disease, (***Geosmithia morbida)*.

Spotted Lanternfly (SLF, *Lycorma delicatula*) In April of 2020 a nursery from an infested state shipped trees that had spotted lanternfly egg masses on their upper branches. The company was operating under a compliance agreement but the staff only removed the egg masses from the tree trunks, not the upper limbs. These trees were shipped to all the New England states. Many went to a nursery in NH, which then distributed the trees to clients elsewhere. NH found 14 live SLF at the nursery, and ME reported finding egg masses. VT nursery owners and landscapers received some trees from this nursery but all inspections conducted so far have been negative for SLF. CT has four towns with SLF, though not from this nursery incident.

Spotted lanternflies are planthoppers that consume some agricultural commodities like grapes and hops and can feed on trees such as red and silver maples, willows, and walnuts. They feed on more than 70 host plant species. In addition to harming food plants, they create a public nuisance by exuding honeydew, a sticky substance, on all surfaces, which then attracts sticky mold. If you see or think you see SLF, please utilize **Report It!** which can be found at https://www.vtinvasives.org/get-involved/report-it.



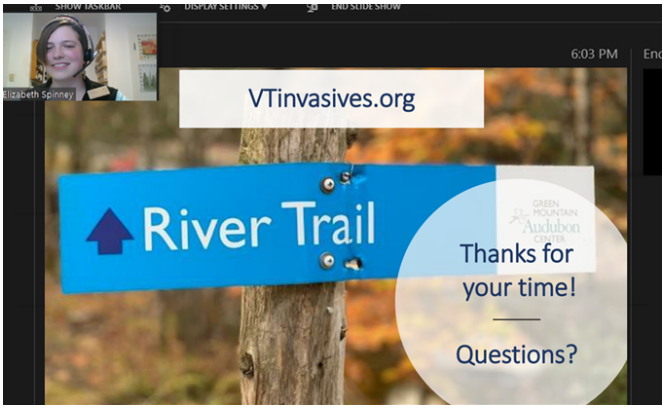
Vermont Agency of Agriculture, Food and Markets spotted lanternfly informational post card sent to resource professionals.

Non-Native Invasive Plant Programs

Faced with unprecedented challenges, **non-native invasive plant (NNIP)** management efforts by the Forest Health Invasive Plant program continued in 2020 but with creative solutions to limited capacity due to hiring freezes and safety guidelines. Progress was made on control, outreach, and education made possible through several grant-funded opportunities. FPR's Invasive Plant Coordinator fielded hundreds of inquiries about invasive plants – a fantastic uptick that we hope to attribute to more people spending time in the forests and on the trails. While we could not involve volunteers directly with our efforts, it is worth noting that since 2014, 3,810 volunteers have assisted the program with direct management of NNIP in Vermont.

The Forest Hero! Network was established in late 2018, with four trainings conducted between October 2018 and October 2019. Without being able to provide in-person experiences for existing or new volunteers, the program is looking into making this training virtual, and offer a training in the spring of 2021. The Network provides training for local leadership in communities, to motivate citizens to engage in non-native invasive plant management, and is a collaboration between Vermont Coverts: Woodlands for Wildlife, FPR, and VTinvasives.org. Thirty people have completed the training.

The Invasive Plant program did offer **virtual workshops** this year, with local municipal road crews, State Parks staff, and with trail volunteers, and created a training video that was published on the ANR's YouTube site as part of a collaboration with ECHO Aquarium and Science Center.

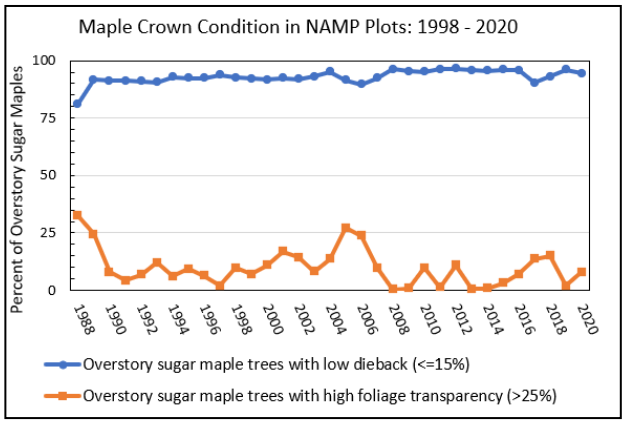


Sign of the times *– Invasive Plant Coordinator, Elizabeth Spinney, presenting a virtual workshop to Audubon Vermont trail volunteers, teaching about invasive plant ID and control.*

Monitoring Forest Health

Vermont has continued to monitor sugar maple health in sugarbushes and forest stands since 1988. In these **North American Maple Project** (NAMP) plots, 94% of overstory sugar maples were rated as healthy in 2020 (less than 15% dieback), which is slightly lower than in 2019 which was 96%. There was an increase in trees with thin foliage which was 8% in 2020 compared to 2% in 2019.

Urban FIA work continued for the fifth year in Vermont, despite the COVID-19 pandemic. This US Forest Service program parallels traditional Forest Inventory and Analysis (FIA), measuring changes to forest demography and health through a network of long-term plots. Vermont was the first state to commit to a full Urban-FIA program, targeting urban areas statewide rather than focusing on a single metropolitan area. Although all field operations were put on hold in early summer, conditions allowed for data collection to begin in early fall. In 2020, all plots (17) were completed by mid-November thanks to the efforts of the US Forest Service. Data are collected on a seven-year cycle, after which a statewide report will be published. The first full cycle will be complete for Vermont in 2022.



Sugar maple crown condition showed a slight decline in maple health monitoring plots. The dry conditions this year most likely contributed to this.

FORESTS, PARKS & RECREATION VERMONT
AGENCY OF NATURAL RESOURCES

For more information, contact the Forest Biology Laboratory at 802-505-8259 or:

Windsor & Windham Counties.....	Springfield (802) 289-0613
Bennington & Rutland Counties.....	Rutland (802) 786-0060
Addison, Chittenden, Franklin & Grand Isle Counties.....	Essex Junction (802) 879-6565
Lamoille, Orange & Washington Counties	Barre (802) 476-0170
Caledonia, Orleans & Essex Counties.....	St. Johnsbury (802) 751-0110

Forest health programs in the Vermont Department of Forests, Parks and Recreation are supported, in part, by the US Forest Service, State and Private Forestry, and conducted in partnership with the Vermont Agency of Agriculture, Food and Markets, USDA-APHIS, the University of Vermont, cooperating landowners, resource managers, and citizen volunteers. Their contributions to this publication are gratefully acknowledged. In accordance with Federal law and US Department of Agriculture policy, this institution is prohibited from discrimination on the basis of race, color, national origin, sex, age or disability.

FIGURES AND TABLES

Figures

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Tables

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WEATHER

2020 WEATHER SUMMARY

Winter 2019-2020

Temperatures for meteorological winter (December to February) were generally above average throughout Vermont, and the total precipitation was similarly above normal statewide. According to the U.S. Drought Monitor, few parts of the state were abnormally dry going into the winter, and by December the state was free of abnormal dryness.

January temperatures were 6-8 degrees above the long-term average, with precipitation totals a half-inch greater than normal. However, this precipitation largely fell as rain, with snowfall being an average of 4 inches less than normal. February temperatures were still above average, but closer to normal than January (2-4 degrees higher). Precipitation was also slightly higher than average in February but primarily fell as snow, with totals close to 5 inches greater than normal.

Spring 2020

Spring conditions were generally good for tree growth. There were no premature warm temperatures or significant late frosts. April was drier and colder than normal. May and June saw a continuation of dry weather (Figs. 1-6), and by the end of June all of the state, with the exception of the northeast kingdom, was classified as either abnormally dry or in moderate drought.

May included cool, wet episodes, with snow being present throughout much of the state through the middle of the month. However, the end of the month saw little precipitation at all, and multiple small fires occurred as a result. By June 9, northwestern Vermont was classified as abnormally dry and temperatures were above normal. These conditions continued throughout the month and the extent of drought spread as well.

This was not a year of heavy flowering for Vermont forests.

Summer 2020

Dry weather dominated the 2020 growing season, and temperatures were slightly higher than normal as well. When rain did occur, it was often through intense heavy downpours, rather than sustained rainfall. This left soil moisture levels depleted, and by the end of the summer, all of Vermont was classified as abnormally dry, in moderate drought, or in the case of northeastern Vermont, severe drought.

These conditions stressed tree health in many locations throughout the state, with chlorotic foliage present in areas with thin soils or steep slopes. However, the effects were not as severe as had been seen as recently as 2018, when affected areas displayed brown foliage through September.

Fall 2020

Drought continued into the fall (Figs. 1-6), but with the lack of brown foliage, fall color was poised to be just as vibrant as usual. The colored leaves did not persist for long though, since high winds and low moisture within trees facilitated rapid leaf drop. Whereas in 2019 there was considerable early leaf drop only for ash, most hardwood species experienced early leaf drop in 2020 (Table 2).

By the end of October, most locations in the state experienced some level of snowfall. November and December, however, provided little snowfall throughout the state and by the end of the calendar year, most of the state was still experiencing some level of drought. According to the U.S. Drought Monitor, the length and severity of this drought—present since June 2020—has the potential for ecological and hydrological impacts during the growing season of 2021.

Figures 1-9 *and* ***Tables 1-3*** *provide details on 2020 precipitation and phenological observations.*

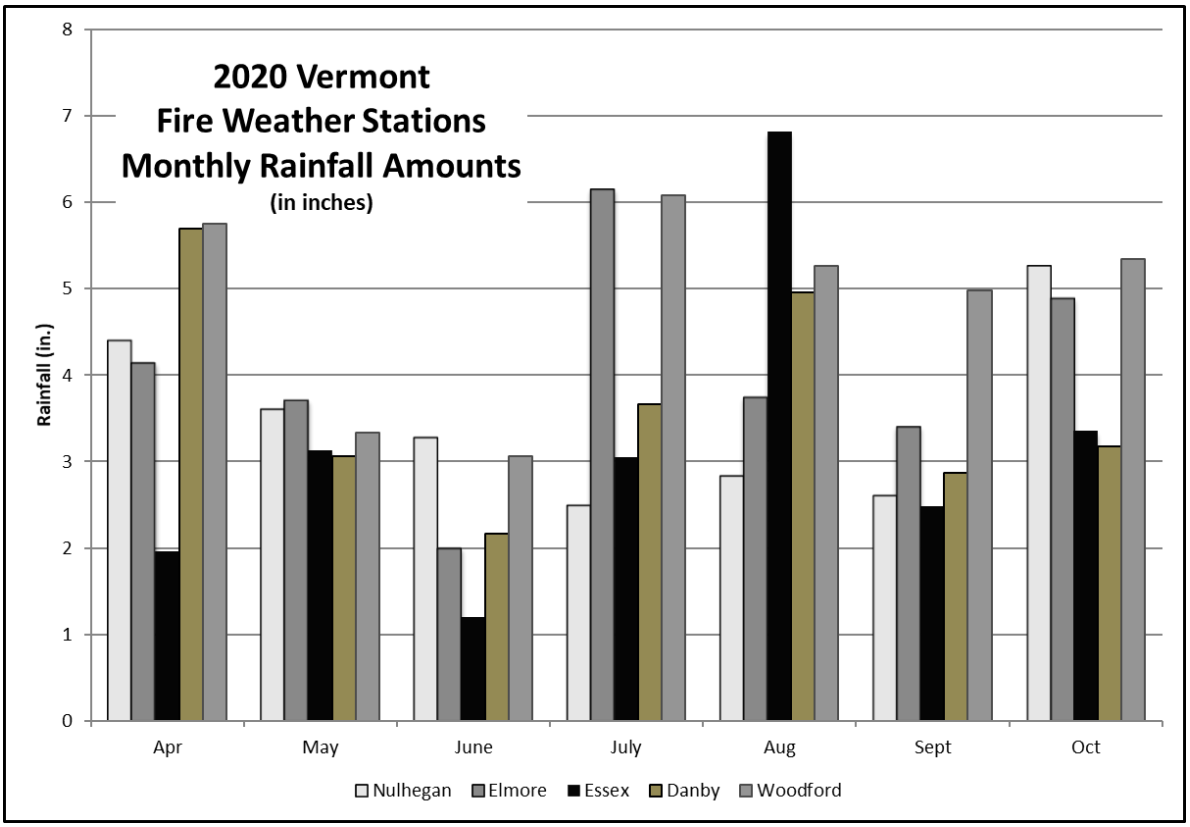


Figure 1. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, April-October, 2020.

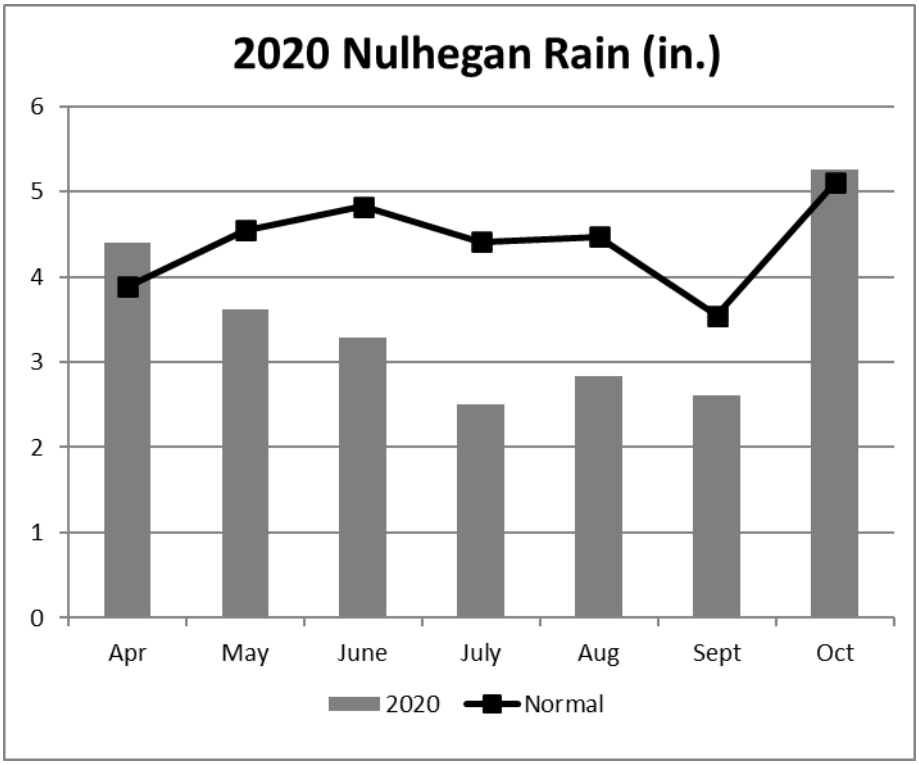


Figure 2. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, VT compared to normal during the fire season, April-October, 2020. Normal is based on 18 years of data.

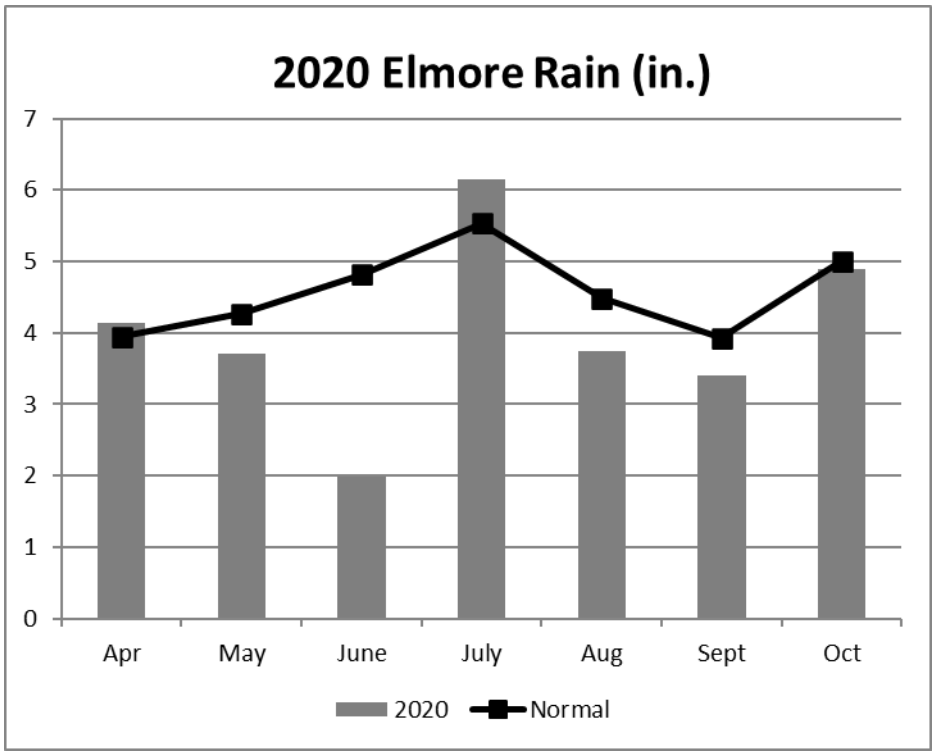


Figure 3. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, VT compared to normal during the fire season, April-October, 2020. Normal is based on 26 years of data.

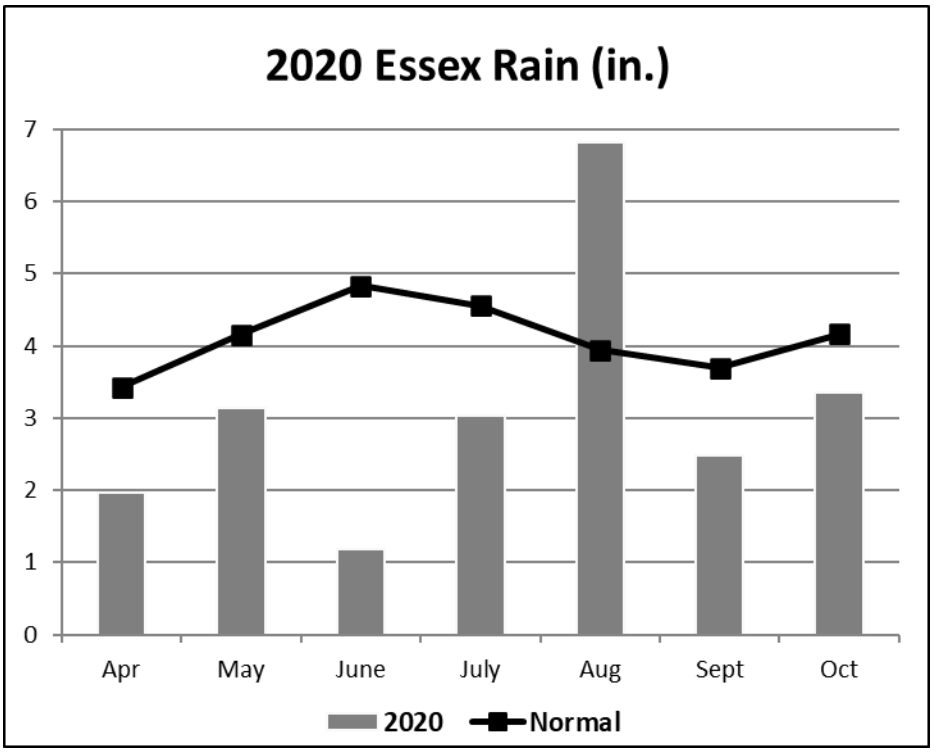


Figure 4. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, VT compared to normal during the fire season, April-October, 2020. Normal is based on 27 years of data.

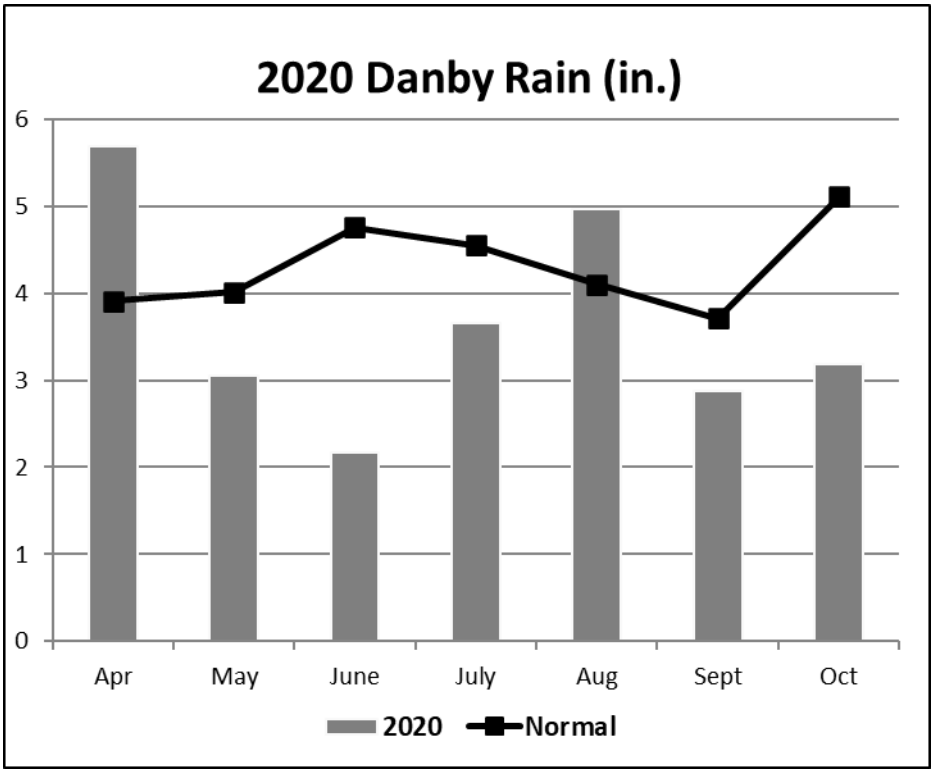


Figure 5. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal during the fire season, April-October, 2020. Normal is based on 20 years of data.

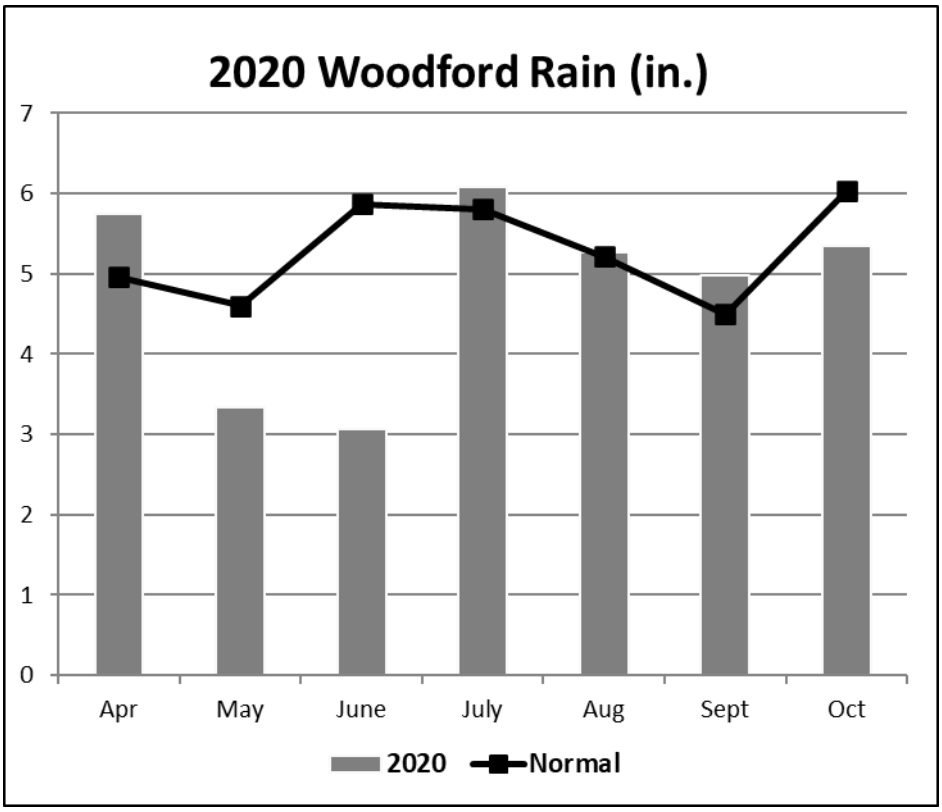


Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont during the fire season, April-October, 2020. Normal is based on 8 years of data.

PHENOLOGY

2020 PHENOLOGY SUMMARY

Spring Budbreak and Leaf Out at Mount Mansfield

Sugar maple trees were monitored for the timing of budbreak and leaf out in the spring at the Proctor Maple Research Center in Underhill as part of the Forest Ecosystem Monitoring Cooperative. Initial monitoring was late to begin due to restrictions put on fieldwork associated with COVID-19. Sugar maple bud expansion was delayed by 8 days compared to the long-term average, with budbreak occurring on May 11. Full leaf out was similarly delayed and occurred 7 days later than the long-term average (Figure 7). This was not a year of heavy flowering for sugar maple.

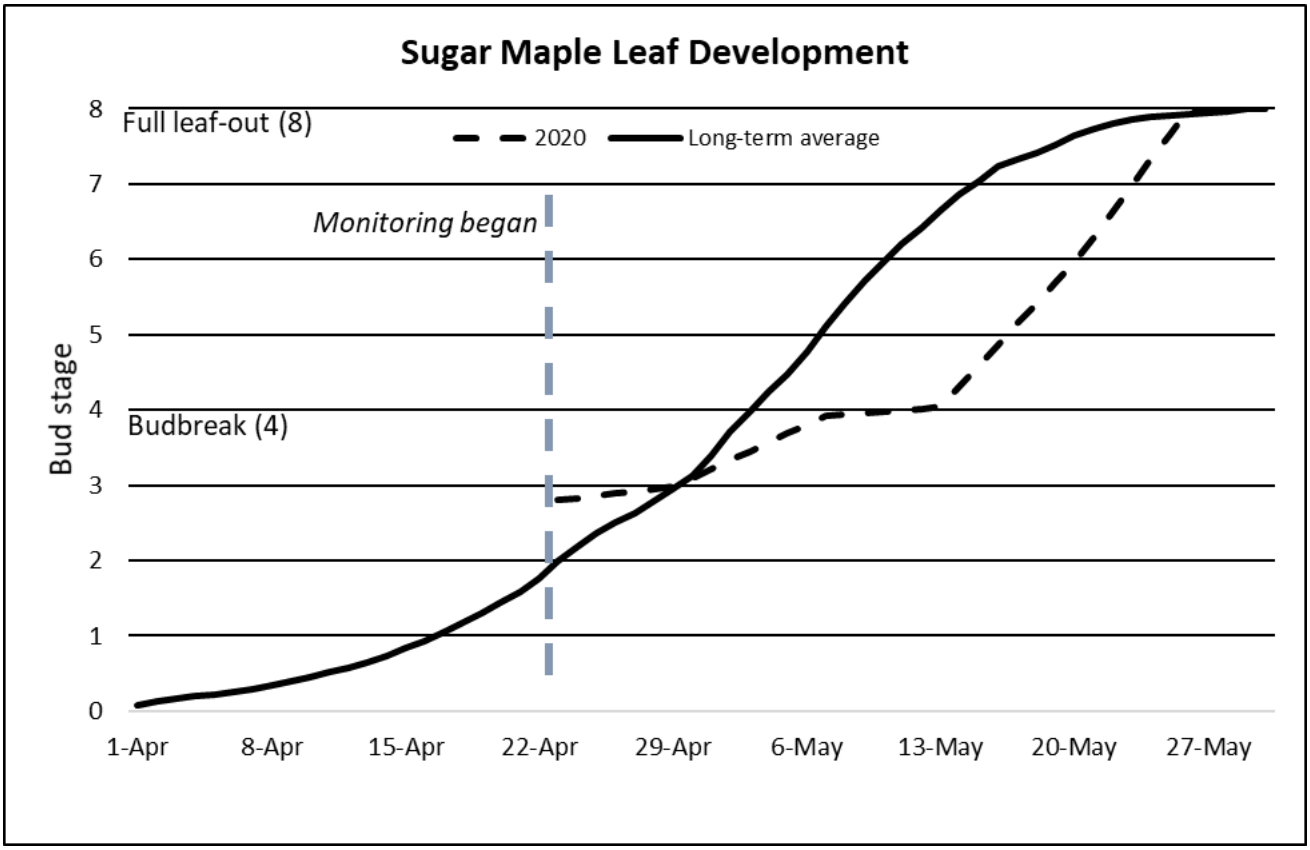


Figure 7. Sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

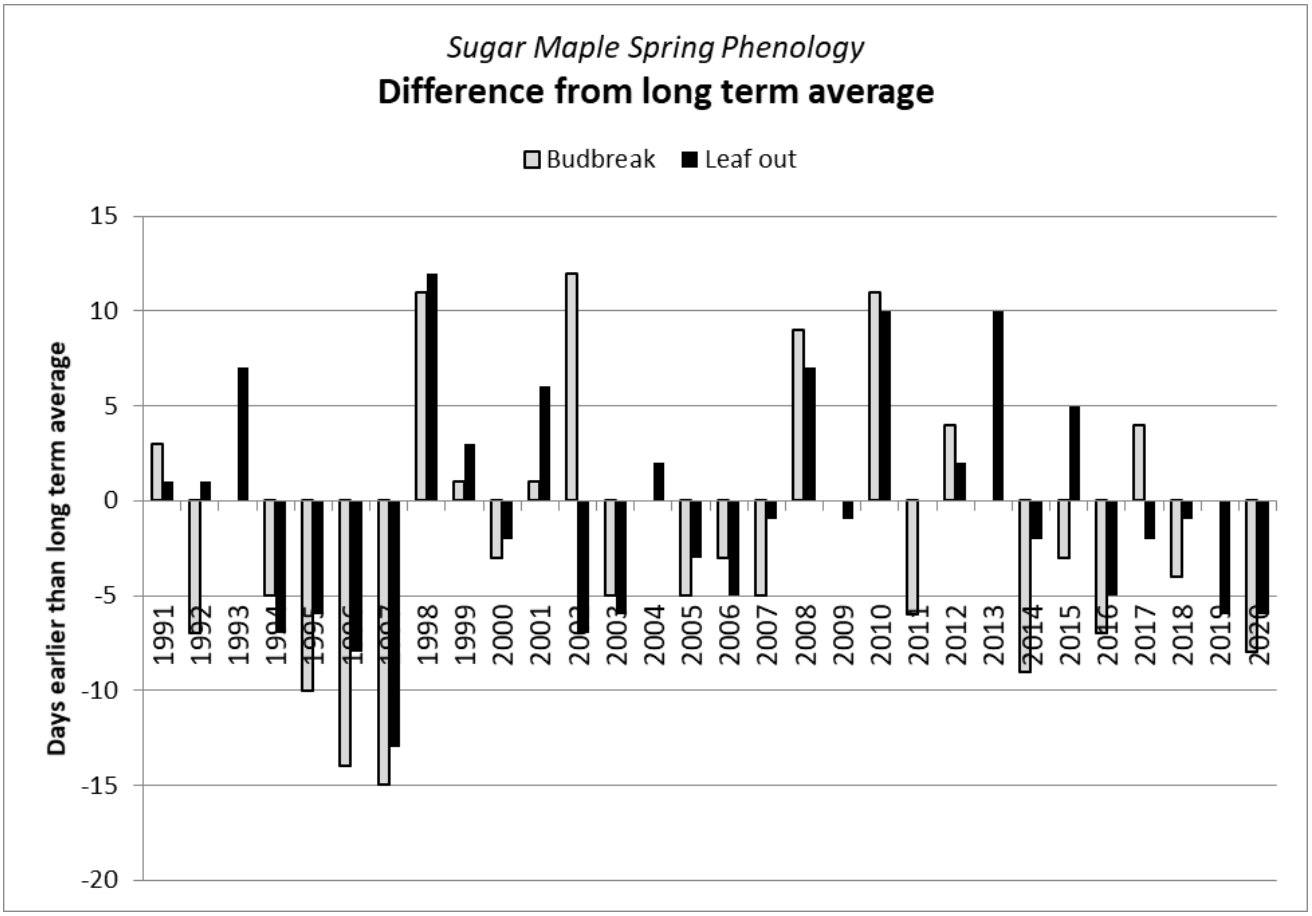


Figure 8. Difference from long-term average of sugar maple budbreak and leaf out at Proctor Maple Research Center, Underhill, VT.

Fall Color Monitoring at Mount Mansfield

Trees at three elevations in Underhill at the base of Mount Mansfield were monitored for the timing of peak fall color and leaf drop (Fig. 9). Field data recorded included the percent of tree expressing fall color, as well as the portion of the crown where leaves have fallen. These two measures are integrated to yield an "estimated color" percentage, which helps to indicate when a given tree has the most foliage with the most color present in the fall.

In general, the timing of peak color for most species at upper elevations (2200' and 2600') was earlier than the long-term average in 2020. Peak color was close to the long-term average for those trees at 1400'. The color developed rapidly this year, but leaves fell quickly due to the drought. Full leaf drop occurred earlier than average for most species, especially at the lowest elevation. The growing season length for sugar maple at 1400' was four days shorter than the long-term average (Table 1).

Figure 9. Timing of fall color (Figure 9a-9f) and leaf drop was monitored at three elevations on Mount Mansfield in 2020: 1400 feet at the Proctor Maple Research Center, and 2200 and 2600 feet near Underhill State Park. Five species are monitored: sugar maple, red maple (male and female trees), white ash, paper birch, and yellow birch.

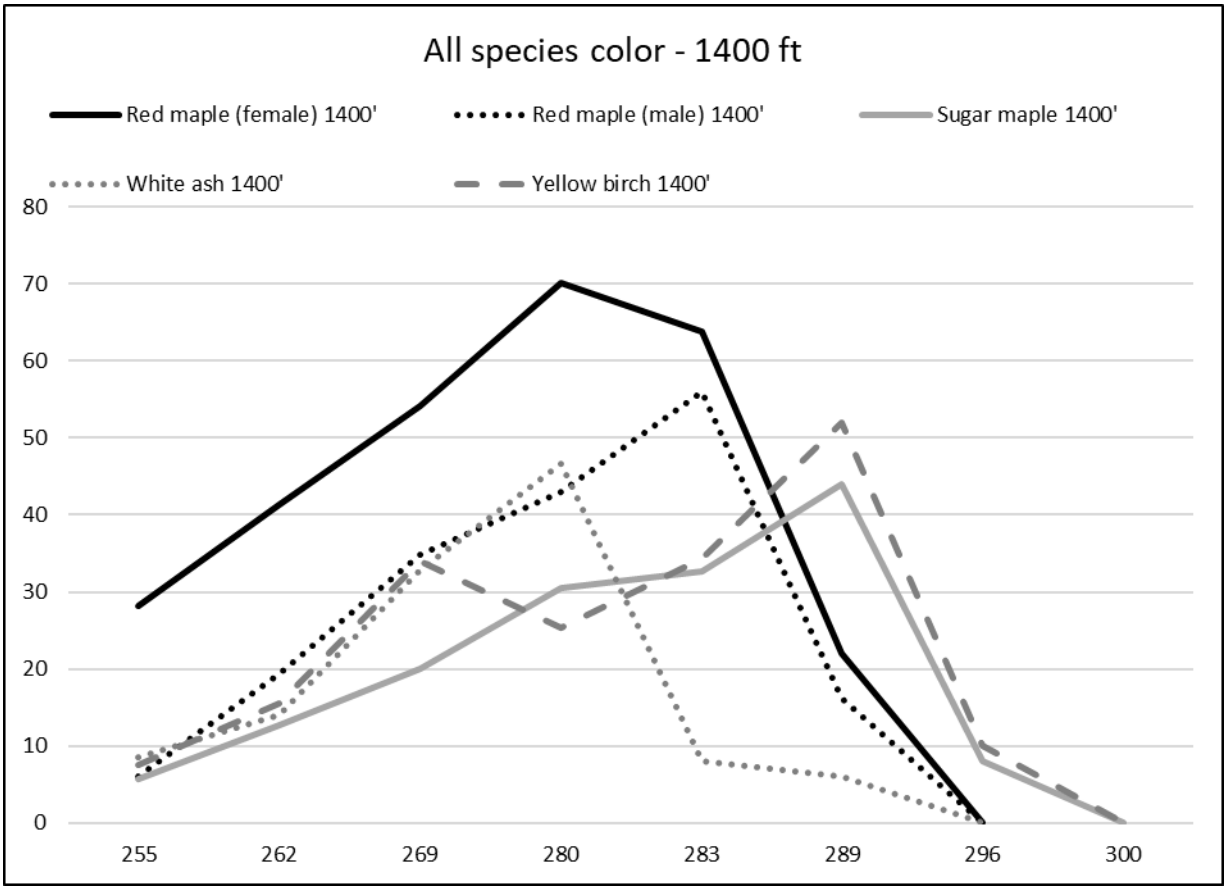


Figure 9a.

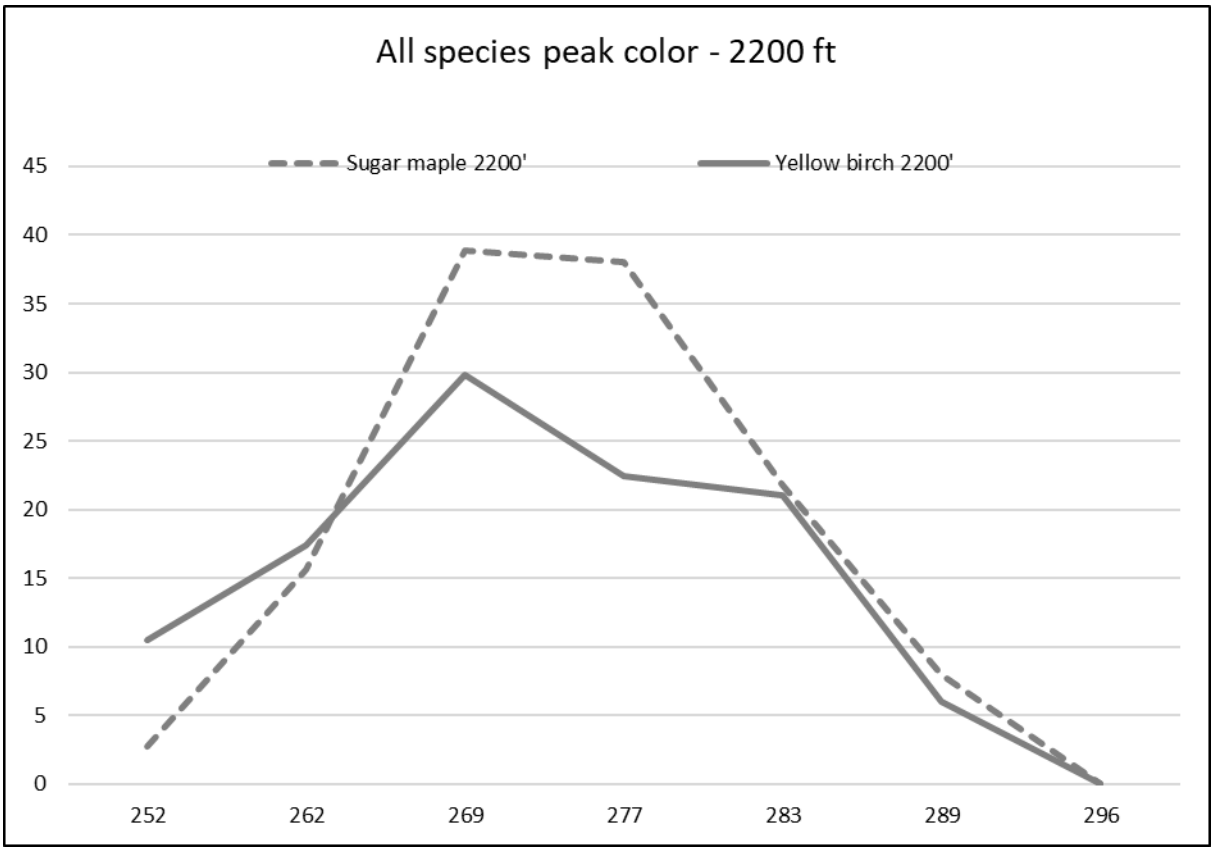


Figure 9b.

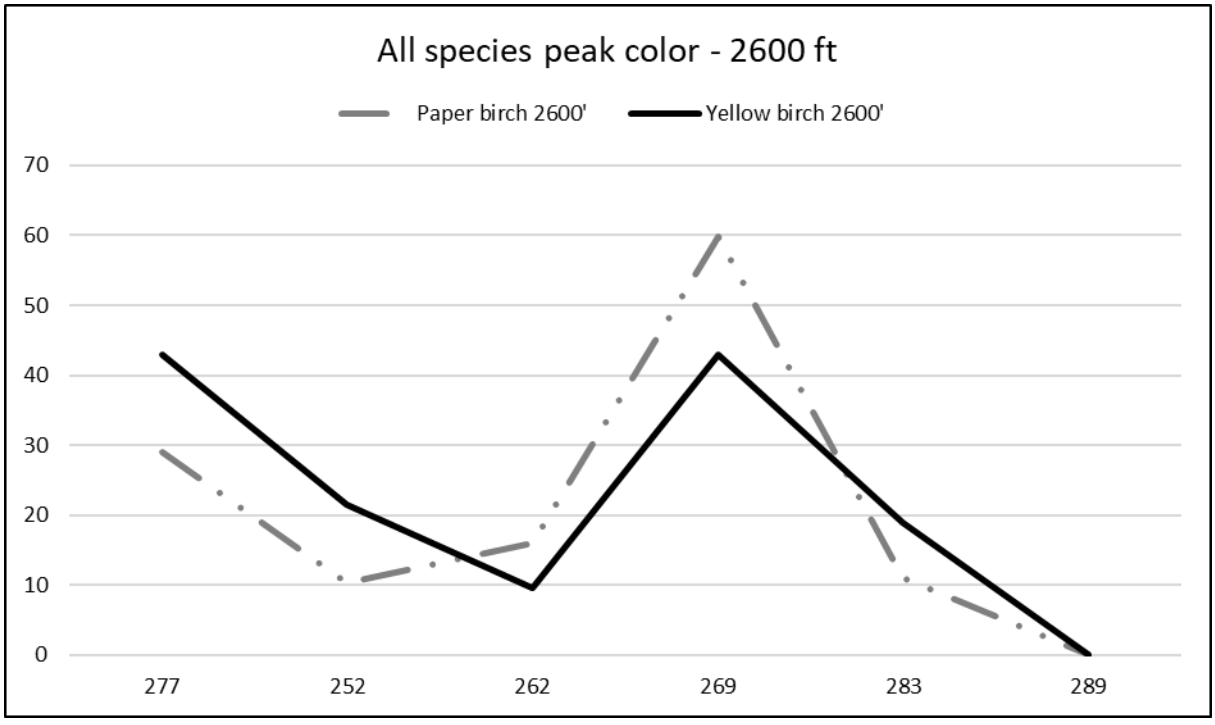


Figure 9c.

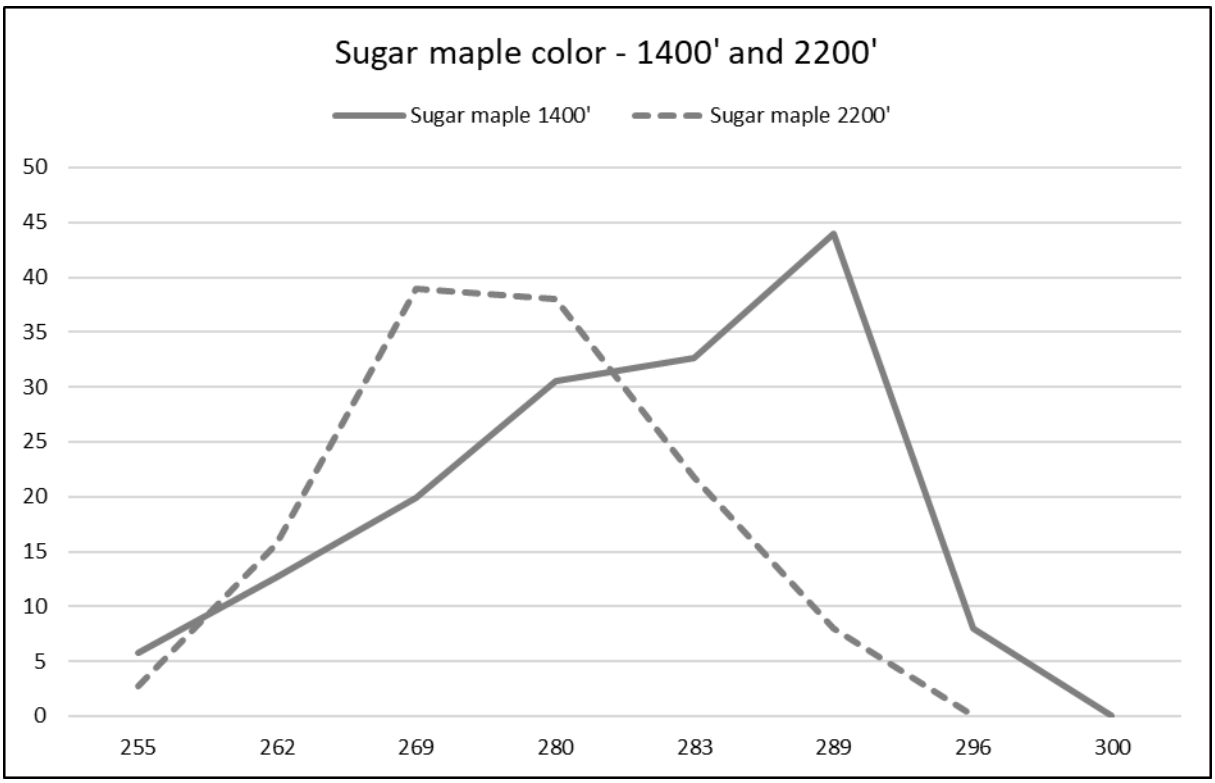


Figure 9d.

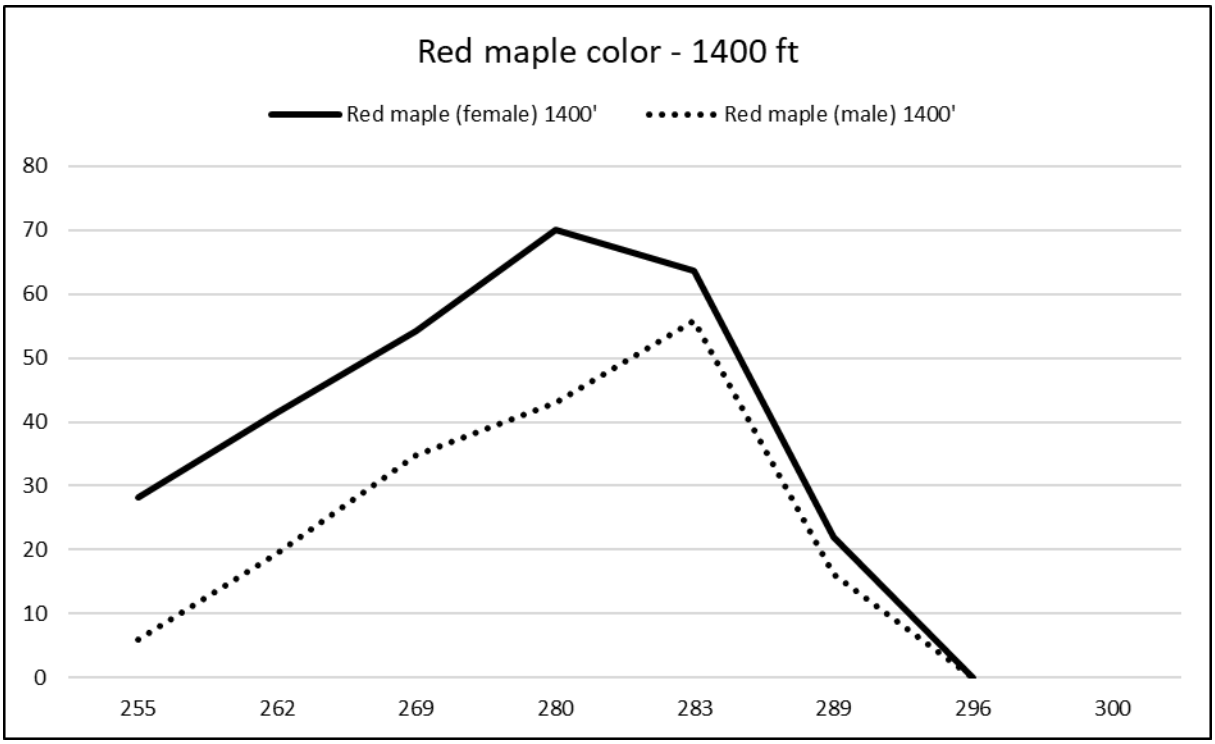


Figure 9e.

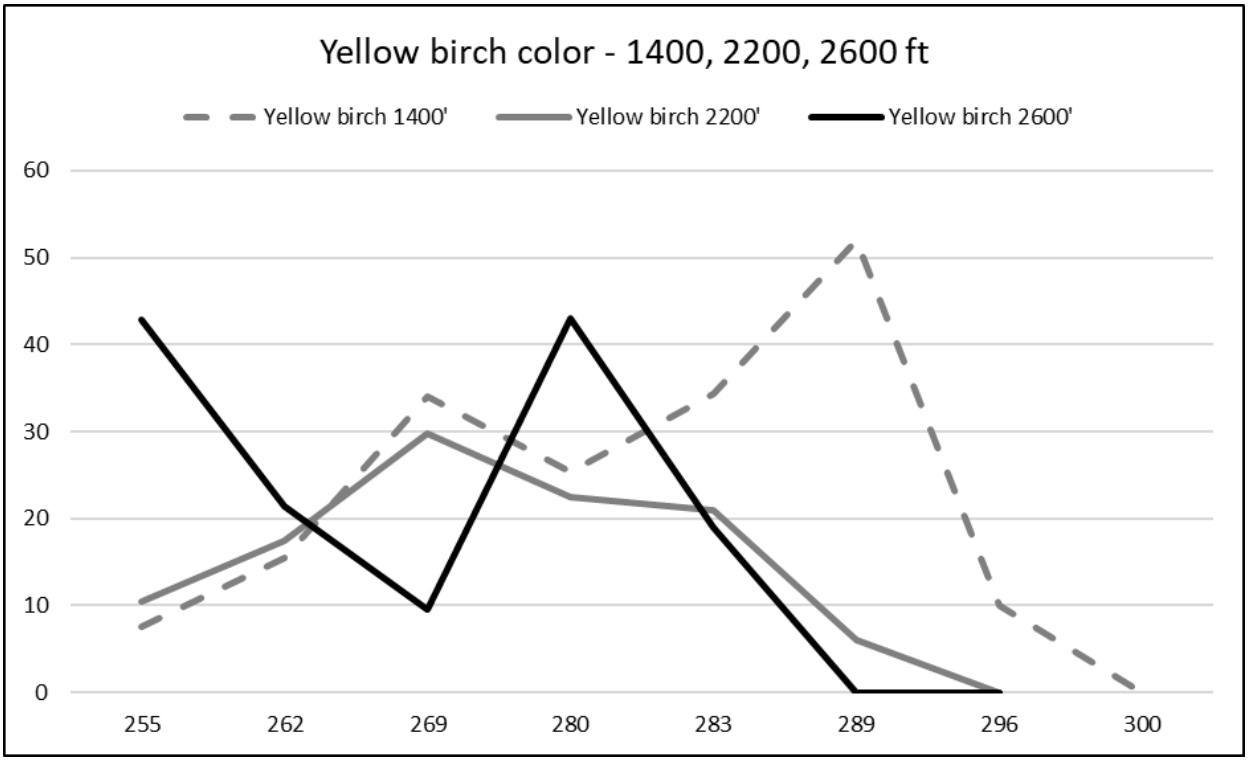


Figure 9f.

Table 1. Estimates of peak color based on percent color and percent of foliage present. Length of long-term averages differ by species, with trees at 2600 ft having a 22-year record, red maple and white ash a 26-year record, sugar maple at 1400 ft a 30-year record, and all other trees a 29-year record. The color was considered "peak" when the highest integrated value of color and leaf presence occurred.

Peak color		
	Long-term Average (Day of year)	2020 Data (Day of year)
Elevation 1400'		
Red maple (Female)	280	280
Red maple (Male)	284	283
Sugar maple	287	289
Yellow birch	285	283
White ash	279	280
Elevation 2200'		
Sugar maple	277	269
Yellow birch	276	269
Elevation 2600'		
Yellow birch	276	269
Paper birch	269	269

Table 2. Progression of leaf drop for trees at three elevations on Mt. Mansfield. Day of year when either 50% of foliage had dropped or more than 95% of foliage had dropped are included for both this year, and the long-term average.

Leaf drop				
	50% leaf drop		> 95% leaf drop	
	Long-term Average (Day of year)	2020 Data (Day of year)	Long-term Average (Day of year)	2020 Data (Day of year)
Elevation 1400'				
Red maple (Female)	289	286	300	295
Red maple (Male)	290	285	300	294
Sugar maple	290	289	303	298
Yellow birch	288	290	298	298
White ash	285	281	296	291
Elevation 2200'				
Sugar maple	282	278	295	294
Yellow birch	279	275	292	291
Elevation 2600'				
Yellow birch	279	277	289	288
Paper birch	272	275	286	287

Table 3. Average dates of sugar maple budbreak, end of growing season (leaf drop), and length of the growing season at the Proctor Maple Research Center in Underhill, VT.

Year	Date of Budbreak	Date of End of Growing Season	Length of growing season (days)
1991	4/28	10/15	171
1992	5/7	10/13	159
1993	5/4	10/18	167
1994	5/6	10/14	161
1995	5/13	10/19	159
1996	5/14	10/22	161
1997	5/16	10/14	151
1998	4/17	10/15	181
1999	5/5	10/19	167
2000	5/9	10/17	161
2001	5/4	10/15	164
2002	4/18	11/5	201
2003	5/9	10/28	172
2004	5/4	10/27	175
2005	5/2	10/27	178
2006	5/2	10/16	167
2007	5/7	10/22	168
2008	4/22	10/15	175
2009	4/30	10/29	182
2010	4/22	10/26	187
2011	5/7	10/19	163
2012	4/16	10/16	186
2013	5/3	10/15	165
2014	5/12	10/20	161
2015	5/6	10/30	177
2016	5/9	10/31	175
2017	4/29	10/29	183
2018	5/7	10/30	176
2019	5/3	10/26	176
2020	5/11	10/24	167
Long term Aver-	**5/3**	**10/21**	**171**

HARDWOOD DEFOLIATORS

Forest Tent Caterpillar (FTC), *Malacosoma disstria*, defoliation was not detected in 2020. Despite the limited aerial survey conducted this year, no reports of defoliation were received, nor were incidental observations recorded. Moth traps were once again deployed in 2020 to assess current FTC populations and gauge the risk of defoliation in 2021. An additional ten trapping locations were established this year to provide a more comprehensive statewide assessment. The average number of moths per trap declined again this year (0.8 moths/trap) from the already low number of 2019 (1.2 moths/trap; Figure 10, Table 4). This confirms that the recent outbreak is now over.

In total, 156,718 acres were mapped as defoliated by FTC between 2016-2019, with 132,164 acres defoliated just once, 22,134 acres defoliated twice, and 2,420 acres defoliated three times. Defoliation data are available on the ANR Natural Resources Atlas. Additional analyses can be found in the 2018 and 2019 Forest Insect and Disease Conditions in Vermont reports.

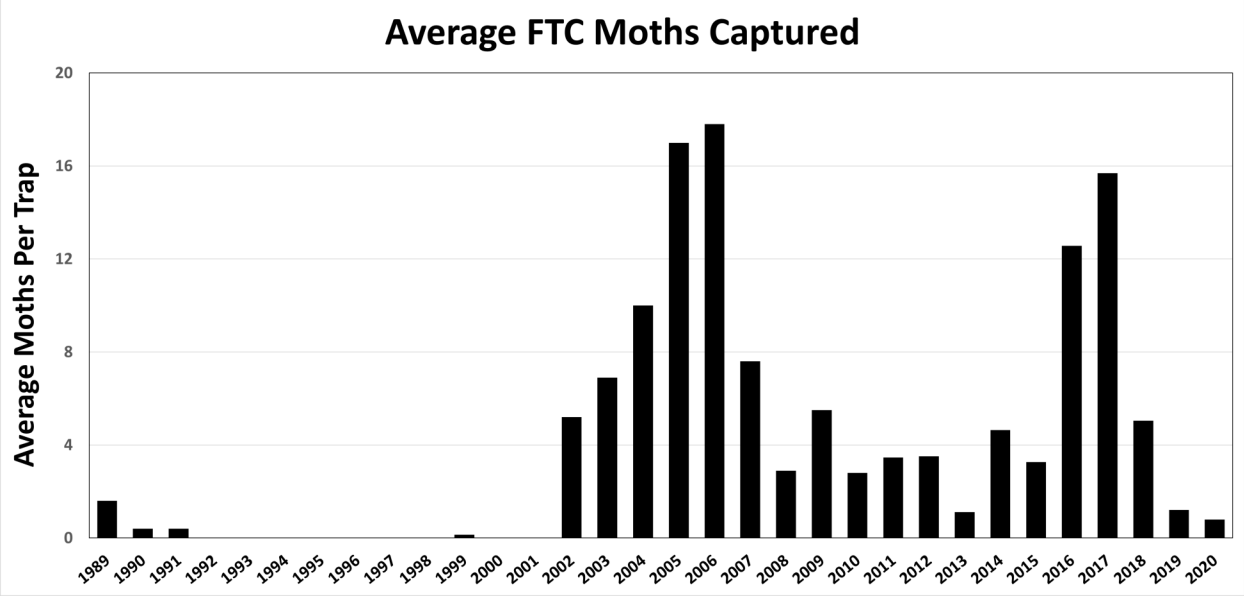


Figure 10. Average number of forest tent caterpillar moths caught in pheromone traps 1989-2020. Three multi-pher pheromone traps per site, with PheroTech lures, were used in 2020.

Table 4. Average number of forest tent caterpillar moths caught in pheromone traps, 2002-2020. Three multi-pher traps baited with PheroTech lures were deployed at each of the 23 survey locations.

Site	Year																		
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Castleton	----	----	----	17	17.3	8	1	4.7	1	1.7	0.3	2.3	1.7	1.7	14.0	13.3	8.7	0.7	1.3
Fairfield (NAMP 29)	----	1.3	1.7	----	4.3	4.7	4	10.3	2.0	6	4	1.7	3.3	1.3	1.3	8.0	2.0	0.0	0.3
Huntington (NAMP 027)	9.2	6.7	10	15.7	16	6.3	4.3	4.3	2.7	6.3	6	1.7	2.7	0.0	10.3	11.0	6.0	0.7	0.0
Killington/Sherburne (Gifford Woods)	6.9	9.7	20	15.3	21	17.3	7.3	8	2.7	0	1.0	0.7	6.0	5.3	8.3	18.7	6.7	0.3	0.0
Manchester	----	----	----	----	----	----	0	5.7	3	1	0.7	0.3	1.3	10.3	12.0	19.3	3.7	0.7	0.3
Rochester (Rochester Mountain)	5.0	4.7	9	4.7	29	10.3	0.7	----	0.3	0	0	0	3.5	2.3	9.0	7.3	2.0	0.0	0.3
Roxbury (Roxbury SF)	16	14.7	13.3	7.3	22	22.7	8.0	2.7	7.0	2	1.5	1.7	6.3	5.7	29.0	15.0	3.3	0.3	0.0
SB 2200 (Stevensville Brook)	3.8	11.7	18.3	23.3	35.3	6.3	5.7	10	2.7	6.3	8	0.3	5.3	2.7	7.3	29.0	6.7	1.7	0.3
Underhill (VMC 1400)	3.6	3	0.3	7.3	9.3	2.7	1.3	8.3	5.7	8.3	7.7	0.3	5.7	0.7	14.3	11.3	2.7	1.0	0.3
Underhill (VMC 2200)	3	7	6.3	11.7	6.3	4.7	1.3	4.3	2	2.7	4.7	0.3	2.5	1.3	3.7	9.0	3.0	0.3	0.0
Waterbury (Cotton Brook)	2	0.7	1.3	41	22.3	0.3	1	5	3.3	4.3	7	0.3	9.3	5.7	36.3	15.7	3.3	0.3	0.3
Waterville (Codding Hollow/Locke)	0	2	1.3	17.7	24.7	2.7	2.3	1.3	3.0	4.3	3	1	12.5	3.3	13.3	28.3	13.3	2.7	1.3
Dillner Farm Mont-gomery	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	4.3	18.0	4.3	0.0	0.0
Vershire (NAMP 37)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.7	0.3
Wilmington (NAMP 25)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2.7	4.7
Westminster (NAMP 21)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.7	0.0
Woodstock (NAMP 24)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	2.0
Lincoln (NAMP 34)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	0.0
Albany (NAMP 3)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	0.67
Glover (NAMP 1)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	1.0
Norton	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	8.3	4.0
Victory	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	0.3
Rupert (Merck Forest)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.3	0.67
Average	**5.1**	**5.8**	**8.3**	**17**	**17.8**	**7.6**	**2.9**	**5.5**	**2.8**	**3.5**	**3.5**	**0.9**	**4.8**	**3.2**	**12.5**	**15.7**	**5.1**	**1.2**	**0.8**

Gypsy Moth, *Lymantria dispar*, was confirmed to have caused very local defoliation in Swanton. Feeding activity was not reported elsewhere. However, egg masses have been observed much more frequently than in recent years, and numbers have increased substantially in focal area monitoring plots (Figure 11 and Table 5).

Data from focal area plots suggest that defoliation is likely to be observed in the Champlain Valley (western Vermont) in 2021, and could occur elsewhere throughout the state as well. We will be monitoring the severity and extent of defoliation as the growing season begins. One year of defoliation is unlikely to cause substantial damage to most trees, but repeated defoliation can have significant impacts on tree and forest health. The fungus *Entomophaga maimaiga* helps control populations of gypsy moths when spring conditions are wet and/or humid. The dry weather in spring 2020 may have allowed gypsy moth populations to expand and could explain the greater number of egg masses found this year.

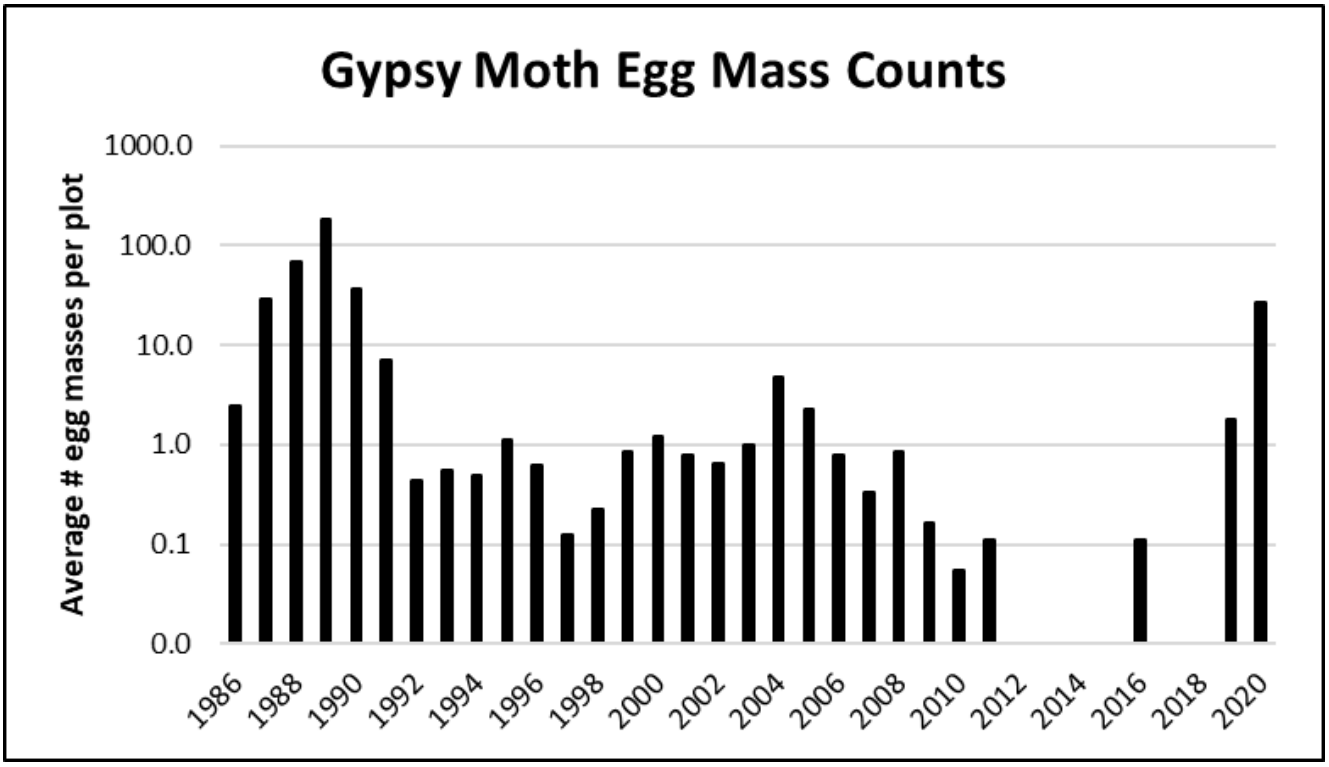


Figure 11. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 1987-2020. Data reflect the average egg mass counts from ten locations, with two 15-meter diameter plots per location containing burlap-banded trees.

Table 5. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 2003-2020. Counts are the average of two 15 meter plots per location containing burlap-banded trees.

Site	Town	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Arrowhead	Milton	1.5	2.5	0	0	0	2.5	0	0	0.5	0	0	0	0	0	0	0	0.5	28
Brigham Hill	Essex	2.5	2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	82
Ft. Dummer	Guilford	0	——	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	2
Minard's Pond	Rocking-ham	0.5	2	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	2.5	15
Mount Anthony	Bennington	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perch Pond	Benson	0	0	0.5	1	0	0.5	0	0.5	0	0	0	0	0	0	0	0	2	106.5
Rocky Pond	Rutland	0	0	0.5	3	3	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5
Sandbar	Colchester	3	1.5	0	0	0	2.5	0.5	0	0	0	0	0	0	0	0	0	0.5	2.5
Tate Hill	Sandgate	0	30	18	3	0	1.5	0.5	0	0	0	0	0	0	1	0	0	6	0.5
Average		1	4.4	2.3	0.8	0.3	0.8	0.2	0.06	0.11	0	0	0	0	0.11	0	0	1.8	26.3

Maple leafcutter, *Paraclemensia acerifoliella*, caused the most observable damage to hardwoods in the state during late summer and early autumn in 2020, often causing hardwood forests to appear brown and pink prior to the onset of typical fall colors. Defoliation by maple leafcutter (MLC) does not typically impact tree health because it occurs so late in the growing season.

The acreage depicted below (18,503 acres; Figure 12) likely underestimates the total amount of defoliation that occurred in 2020. Our mapping for MLC was limited to observations from summits and fire tower lookouts throughout the state due to the cancellation of our aerial detection surveys (see *Introduction*).

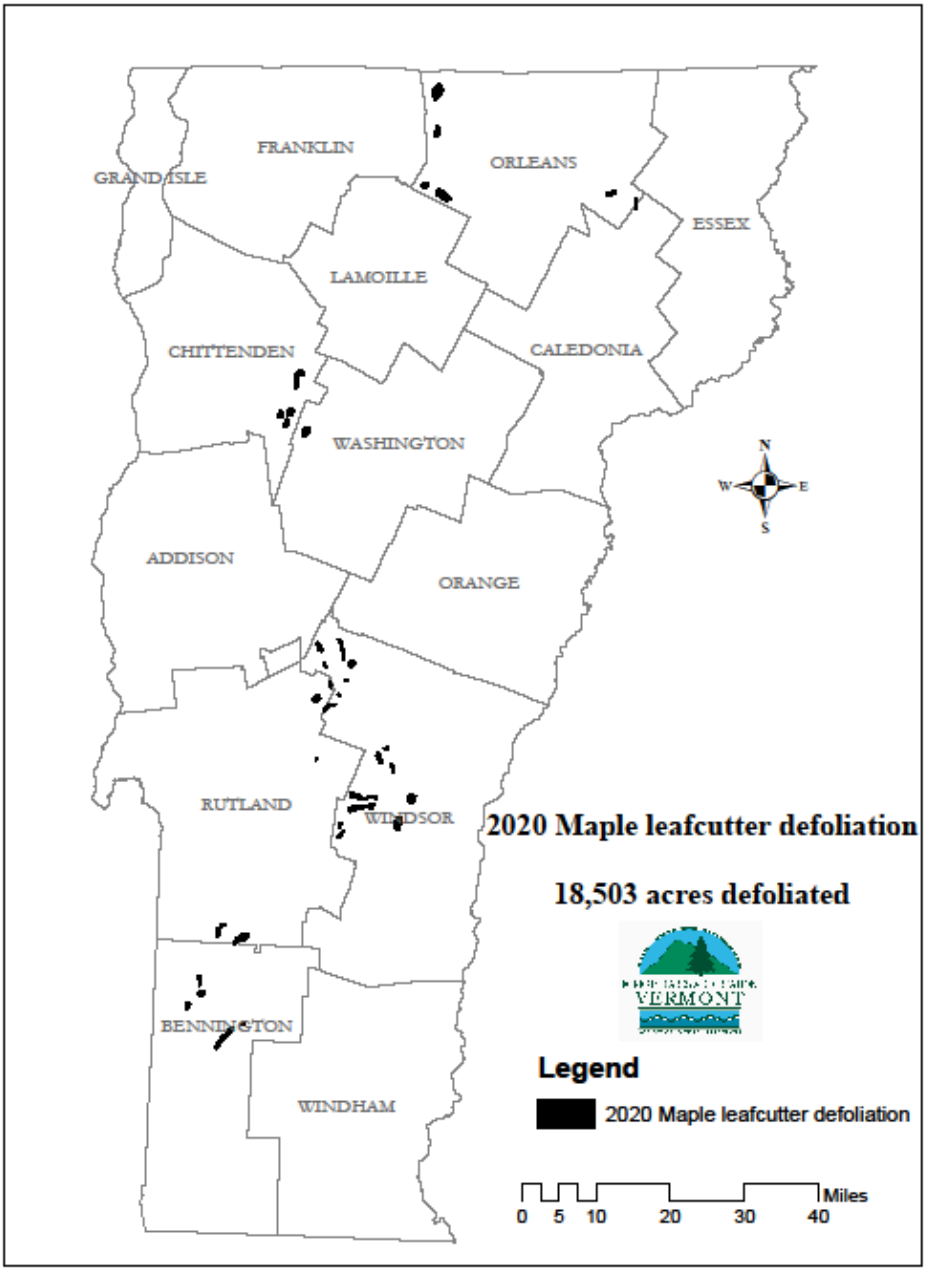


Figure 12. Maple leafcutter defoliation 2020. Mapped area includes 18,503 acres, which is most likely underestimated due to cancellation of the aerial detection survey.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Birch leafmining sawflies	*Messa nana, Fenusa pusilla,* and others.	Birch	Northeastern Vermont	Injury observed by August.
Birch leaffolder	*Ancylis discigerana*	Birch	Northwestern Vermont	
Brown-tail moth	*Euproctis chrysorrhoea*	Hardwoods		Not observed or known to occur in Vermont.
Bruce spanworm	*Operophtera bruceata*	Hardwoods	Western Vermont	
Cherry scallop shell moth	*Hydria prunivorata*	Cherry	Statewide	Occasional nests observed, minimal damage.
Eastern tent caterpillar	*Malacosoma americanum*	Cherry and apple	Widely scattered	Populations remain low.
Euonymus caterpillar	*Yponomeuta cagnagella*	Apple	Bethel	Heavy defoliation on ornamental street trees.
Fall webworm	*Hyphantria cunea*	Hardwoods, especially cherry and ash	Statewide	Remains widely noticeable, including heavy defoliation along roadsides with webbing covering entire trees.
Forest tent caterpillar	*Malacosoma disstria*	Hardwoods	Statewide	*See narrative*
Green-striped mapleworm/ rosy maple moth	*Dryocampa rubicunda*	Sugar maple	Statewide	Larvae occasionally observed, often in association with saddled prominent.
Gypsy moth	*Lymantria dispar*	Hardwoods	Statewide	*See narrative*

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Hickory tussock moth	*Lophocampa caryae*	Hardwoods	Statewide	Larvae frequently observed in late summer. Populations decreased from 2019 reports, no defoliation reported.
Imported willow flea beetle	*Plagiodera versicolora*	Autumn willow	Pownal	
Isabella tiger moth	*Pyrrharctia isabella*	Hardwoods	Statewide	Only light feeding, but overwintering pupae noticeable.
Japanese beetle	*Popillia japonica*	Many	Statewide	Observed in gardens, but tree injury not reported in 2020.
Large grey dagger moth	*Acronicta insita*	Hardwoods	Windham	
Maple leafcutter moth	*Paraclemensia acerifoliella*	Sugar maple, occasional yellow birch and beech	Statewide	Populations high. *See narrative* .
Maple trumpet skeletonizer moth	*Catastega aceriella*	Sugar maple	Statewide	Occasionally observed, but negligible damage.
Oak shothole leafminer	*Japanagromyza viridula*	Red oak	Statewide	Characteristic feeding damage widely observed in June.
Orange-humped mapleworm moth	*Symmerista leucitys*	Maple	Southern Vermont	Similar to 2019 levels.

OTHER HARDWOOD DEFOLIATORS

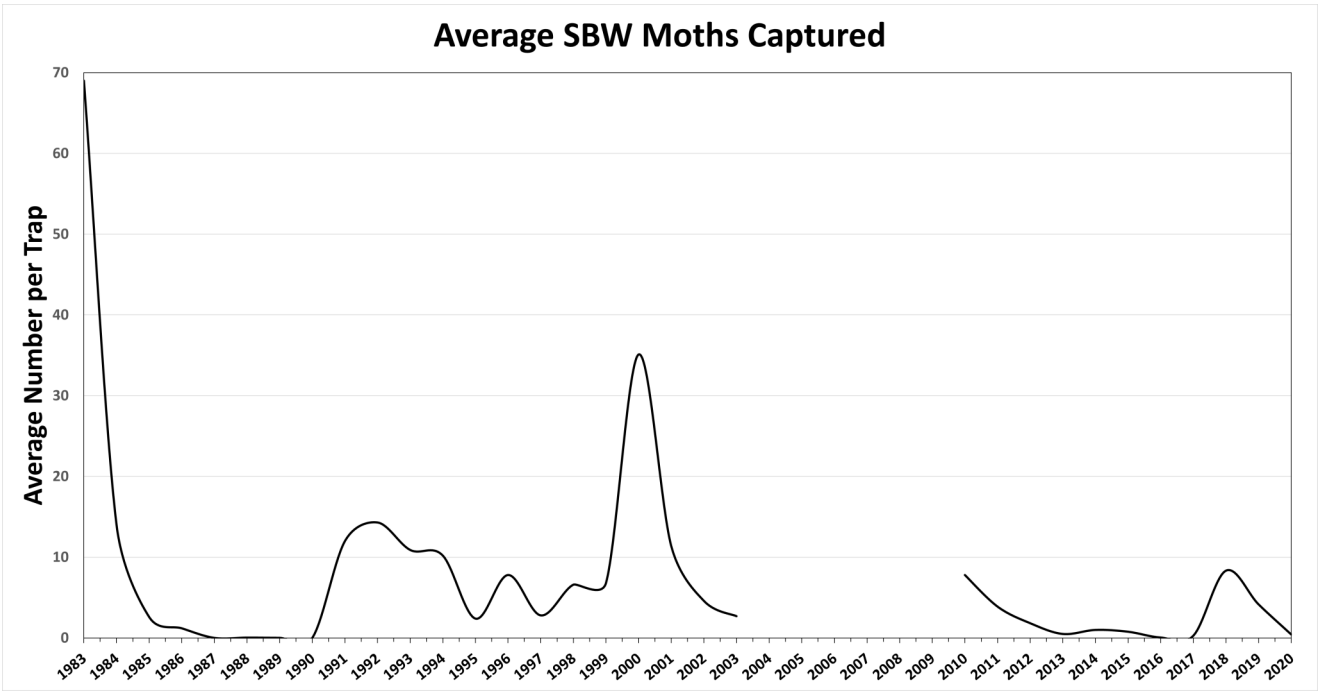
INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Saddled prominent moth	*Heterocampa guttivata*	Sugar maple	Widely scattered; Especially southeastern Vermont	Increase from 2019. Caterpillars widely observed, with occasional frass "raining" but only light "window feeding" observed.
Spiny oak sawfly	*Periclista albicollis*	Red oak	Waterbury	
Splendid dagger moth	*Acronicta superans*	Birch	Groton	Larvae occasionally observed in late summer.
Spring cankerworm	*Paleacrita vernata*	Many	Statewide	Increase from 2019.
Spotted sawfly	*Macremphytus lovetti*	Hardwoods	Londenderry	Observed in ornamentals.
Ugly-nest caterpillar	*Archips cerasivoranus*	Small choke cherry trees	Washington County	Moderate damage, abundant caterpillars. Leaves turned into nests/tents
Winter moth	*Operophtera brumata*	Hardwoods		Not observed or known to occur in Vermont.

Hardwood defoliators not reported in 2020 include alder flea beetle, *Altica ambiens* ; American dagger moth, *Acronicta americana* ; beech leaftier, *Psilocorsis sp* .; birch skeletonizer moth, *Bucculatrix canadensisella* ; dogwood sawfly, *Macremphytus tarsatus* ; dusky birch sawfly, *Croesus latitarsus* ; elm spanworm moth, *Ennomos subsignaria* ; large aspen tortrix, *Choristoneura conflictana* ; locust leafminer, *Odontata dorsalis;* maple webworm moth, *Pococera asperatella* ; mountain ash sawfly, *Pristiphora geniculata* ; oak skeletonizer moth, *Bucculatrix ainsliella* ; red-humped oakworm moth, *Symmerista canicosta* ; rose chafer, *Macrodactylus subspinosus* ; satin moth, *Leucoma salicis* ; spotted tussock moth, *Lophocampa maculata* ; sycamore tussock moth, *Halysidota harrisii* ; ugly-nest caterpillar moth, *Archips cerasivorana;* viburnum leaf beetle, *Pyrrhalta viburni* ; white-marked tussock moth, *Orgyia leucostigma;* willow weevil leafminer*, Isochnus sequensi;* yellow-necked caterpillar, *Datana ministra* .

SOFTWOOD DEFOLIATORS

Spruce Budworm (SBW), *Choristoneura fumiferana*, are native softwood defoliators commonly found in our Vermont forests. In consecutive years of severe outbreaks, trees may experience complete defoliation which can lead to dieback and mortality of infested hosts. Spruce budworm moth trap catches in Vermont declined to an average of 0.44 moths per trap, compared to an average of 4.2 moths per trap in 2019. Traps were deployed in Caledonia, Chittenden, Essex, and Orleans Counties in 2010-2020. Catches decreased at all locations, including the Underhill site, which continued to have higher moth numbers than other sites (Figure 13, Tables 6-7). We do not anticipate defoliation by spruce budworm in 2021.

Figure 13. Average number of spruce budworm moths caught in pheromone traps 1983-2020. Trapping was discontinued, 2004-2009. Average of six locations in 2020.



Trap Location	Town	Latitude	Longitude
Steam Mill Brook WMA	Walden	44.48385	-72.25364
Willoughby S.F.	Sutton	44.69555	-72.03616
Tin Shack/Silvio Conte	Lewis	44.85915	-71.74222
Black Turn Brook S. F.	Norton	44.99521	-71.81300
Holland Pond WMA	Holland	44.97610	-71.93103
VMC 1400	Underhill	44.52570	-72.86477

Table 6. Locations of spruce budworm pheromone traps in 2020. Note: the trap site in Willoughby State Forest is in the town of Sutton rather than Burke, as designated in some earlier reports.

Table 7. Average number of spruce budworm moths caught in pheromone traps, 1991-2020. Trapping had been discontinued from 2004-2009. There were three traps per location, one location per town, in 2020.

County and Town	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Essex Norton	3	10.7	5.7	2.3	1	1	1.3	26	34.7	29.7	17.7	1.3	2	5.3	1	1.3	0.7	0	0.3	0.3	0.3	6.0	1.3	0.0
Orleans Holland	3.3	11	2.3	1.3	0	1.7	1.3	5	4.7	29.3	5	5.7	3.7	6	8.0	1	0.7	1.7	1.3	0.0	0.3	9.0	1.0	0.0
Caledonia Walden	17.7	17.7	13	14.3	3	6.3	2	4.3	5	85	16.7	9.7	3.7	6.7	1	0.7	0	0.3	1.0	0.0	0.0	4.0	3.3	0.3
Essex Lewis	2.0	2.7	0.67	2	0	0.67	0	8	4.3	14	6.7	1.3	1.7	5.7	0.3	0	0	0	0.0	0.0	0.0	2.6	0.3	0.0
Chittenden Underhill	31.7	29	16	53	11.7	30.3	3.7	6	13.3	24.7	11.3	14.7	3.7	19	11.3	8	1.3	3.7	1.7	0.0	1.0	26.3	18.3	1.7
Caledonia Sutton	3.5	2.3	6	3	0	2	3.7	7.3	6	30	15	3	1.7	4	1.7	0	0.3	0.3	0.3	0.0	0.0	2.0	0.7	0.7
Average	**10.2**	**12.2**	**7.3**	**12.7**	**2.6**	**7.0**	**2.0**	**9.4**	**11.3**	**35.5**	**12.1**	**6.0**	**2.8**	**7.8**	**3.9**	**1.8**	**0.5**	**1.0**	**0.8**	**0.1**	**0.3**	**8.3**	**4.2**	**0.4**

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Arborvitae leafminer	*Argyresthia thuiella*	Arborvitae	Northern Vermont	Ornamental.
Eastern spruce budworm	*Choristoneura fumiferana*	Balsam fir and spruce	Statewide	See narrative.
European pine sawfly	*Neodiprion sertifer*	Red pine	Statewide	
Larch sawfly	*Pristiphora erichsonii*	Larch	Hartland	

Softwood defoliators not reported in 2020 included balsam fir sawfly, *Neodiprion abietis* ; hemlock looper, *Lambdina fiscellaria* ; introduced pine sawfly, *Diprion similis;* pine false webworm, *Acantholyda erythrocephala;* rusty tussock moth, *Orygia antigua;* yellow-headed spruce sawfly, *Pikonema alaskensis;* spruce needleminer, *Taniva albolineana* ; web-spinning sawfly, *Pamphiliidae* ; white pine sawfly, *Neodiprion pinetum.*

SAPSUCKING INSECTS, MIDGES, AND MITES

Balsam Woolly Adelgid (BWA), *Adelges piceae*, populations remain mostly low. Due to aerial survey restrictions, we were not able to document new tree mortality in 2020 for areas where BWA-initiated mortality was previously reported. In past years, especially in central and northeastern Vermont, occasional dying landscape trees with characteristic symptoms such as gouting and topkill were observed. During 2019 aerial surveys, 942 acres of fir dieback and mortality attributed to BWA were mapped as compared to 3,434 in 2018 and 5,615 in 2016 (Table 8).

Table 8. Mapped acres of balsam woolly adelgid-related decline 2016-2020.

County	Acres Mapped			
	2016	2017	2018	2019
Addison	107	0	0	0
Bennington	69	0	0	17
Caledonia	1,096	412	807	211
Chittenden	51	0	0	0
Essex	736	20	1,082	0
Franklin	59	0	5	0
Grand Isle	0	0		0
Lamoille	683	13	188	174
Orange	1,101	320	322	53
Orleans	518	399	316	252
Rutland	240	122	88	0
Washington	895	279	561	235
Windham	57	4	9	0
Windsor	4	72	56	0
Total	5,616	1,641	3,434	942

Elongate Hemlock Scale (EHS), *Fiorinia externa*, continues to be noticeable in Windham County. It was first detected in the towns of Brattleboro and Guilford in 2014. A location in Charlotte, VT was confirmed to have EHS in 2019, but the population was present on small ornamental fir trees and was eradicated. However, EHS was also detected in 2020 in Shelburne, VT. The homeowners in this area have committed to treating the infested trees in 2021. EHS may co-occur with hemlock woolly adelgid, and symptoms of stress have been observed on trees infested with both insects.

Hemlock Woolly Adelgid (HWA), *Adelges tsugae*, continues to threaten hemlock trees in southern Vermont, especially in combination with drought and elongate hemlock scale. Similarly to last year, traditionally infested sites are still infested, with spread into Weathersfield in Windsor County due to low winter mortality and higher population counts.

Due to aerial survey restrictions, no hemlock decline related to HWA was mapped during aerial surveys. In the past, drought was observed to be the primary cause of symptoms on unhealthy hemlock trees in 2019 aerial surveys, a trend that would have likely been observed this year.

As of 2020, known infested counties that were surveyed included Windham, Windsor, and Bennington counties. High-risk counties that adjoin the known infested counties that were also included in the 2020 survey included Rutland and Orange counties. High risk areas, plant hardiness zones 5a and 5b, in Windsor County were also surveyed since Windsor County is only known to be infested at its southernmost edge.

Twenty four sites in five counties were surveyed (Table 9), with a positive find in Ft. Dummer State Park, a site previously known to be infested, and in Weathersfield a newly infested site. The shift to the county by county surveying resulted in coarser "resolution" and may account for the fact that no expansion of the infestation was observed.

Table 9. Sites inspected for the presence of hemlock woolly adelgid (HWA) by visual survey, winter 2019-2020.

County	Town	Number of Sites	Positive for HWA
Windsor	Springfield	1	0
	Weathersfield	1	1
Rutland	Danby	1	0
	Fair Haven	1	0
	Hubbardton	1	0
	Mendon	1	0
	Poultney	2	0
	Wallingford	3	0
Orange	Fairlee	1	0
	Thetford	7	0
	Strafford	1	0
	West Fairlee	1	0
Windham	Guilford	1	1
Addison	Bristol	1	0
	East Middlebury	1	0
Total		23	2

Overwintering mortality was assessed at four sites which have been monitored since 2010. The average winter mortality was 39%, this is below the threshold of 91 or 92% that restricts expansion of the infestation (Table 10, Figure 14).

Table 10. Assessment of hemlock woolly adelgid winter mortality over the 2019-2020 winter. Data from four assessment sites include location, date, number of HWA ovisacs collected, number of HWA that were dead, number of HWA that were alive, and percent mortality.

Site	Date	Total Number	Number Alive	Number Dead	% Mortality
Brattleboro	3/23/2020	473	351	122	26%
Jamaica	3/23/2020	513	367	146	28%
Townshend	3/18/2020	1069	272	797	75%
Vernon	3/18/2020	1237	921	316	26%

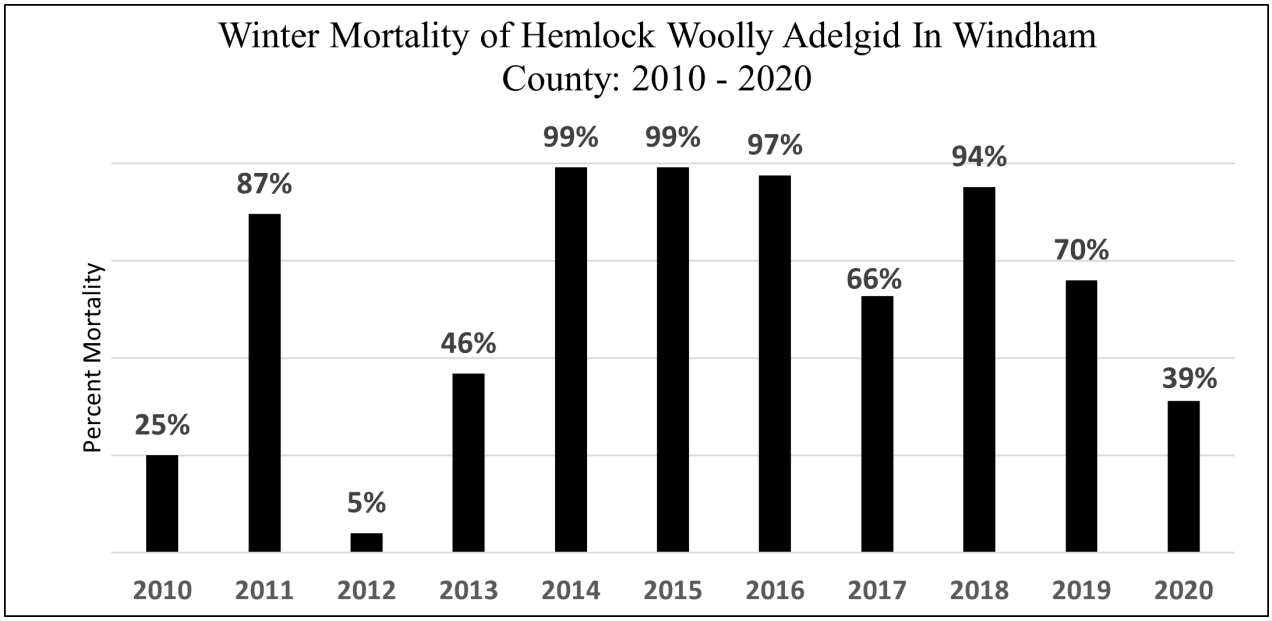


Figure 14. Average overwintering mortality of hemlock woolly adelgid at four sites in Windham County, 2010-2020.

We continue to maintain five HWA impact monitoring plots. In 2020, monitoring assessments were done at the Atherton Meadows Wildlife Management Area, and Townshend State Park. Diameters were re-measured, and crowns were assessed for live crown ratio, crown density, crown transparency, and crown position. In general, the crowns seemed to be smaller and thinner than in the previous monitoring.

Biocontrol efforts in 2020 used 425 wildlings of the predatory beetle *Laricobius nigrinus*, captured from Whidbey Island, WA, and were released at Jamaica State Park this fall. In 2019, this beetle was obtained from the rearing laboratory at Virginia Tech and was released between a previous release site in Brattleboro (510 adults), and for the first time in Jamaica State Park (510 adults). Follow-up monitoring in winter and spring had no recoveries. All sites where *L. nigrinus* had been released in 2017 and 2019 were surveyed for the beetle in 2020, but none were recovered.

Table 11. Assessment of hemlock woolly adelgid mortality over the 2020 summer. Data from one assessment site includes location, date, number of HWA ovisacs collected, number of HWA that were dead, number of HWA that were alive, and percent mortality.

Site	Date	Total Number	Number Alive	Number Dead	% Mortality
Jamaica	11/13/2020	3356	1558	1798	54%

Surveying for summer mortality of HWA was conducted for the first time this year at Jamaica State Park. Dead HWA did not break aestivation or the dormancy period that this insect enters during the summer months. The reasons why summer mortality happens are still being researched, but some studies suggest that warming temperatures and excessive sunlight increase mortality.

Pear Thrips, *Taeniothrips inconsequens*, trapping to track populations in our long-term monitoring plot at the Proctor Maple Research Center in Underhill was not conducted in 2020 due to COVID-19 work restrictions at the time.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Ash plant bug	*Tropidosteptes amoenus*	Ash	Widely scatttered	
Balsam twig aphid	*Mindarus abietinus*	Balsam and Fraser fir	Widely scatttered	Only light damage reported on Christmas trees.
Balsam woolly adelgid	*Adelges piceae*	Balsam and Fraser fir	Northern Vermont	See narrative.
Beech erineum mite	*Aceria ferruginea*	Beech	Widely scatttered	
Beech scale	*Cryptococcus fagisuga*	Beech	Widely scatttered	See Beech Bark Disease narrative.
Brown marmorated stink bug	*Halyomorpha halys*	Many	Shelburne	Found inside a house.
Crimson erineum mite	*Aceria regulus*	Maple		
Eastern spruce gall adelgid	*Adelges abietis*	Spruce	Southern Vermont	Observed on regeneration.
Elongate hemlock scale	*Fiorinia externa*	Hemlock and balsam fir		See narrative.
Erineum gall mite	*Aceria elongatus*	Maples	Northwestern Vermont	
Hickory leaf stem gall aphid	*Phylloxera caryaecaulis*	Hickory	Huntington	
Hemlock scale	*Hemiberlesia ithacae*	Hemlock	Charlotte	Confirmed by USDA-ARS.
Hemlock woolly adelgid	*Adelges tsugae*	Hemlock		See narrative.
Pear thrips	*Taeniothrips inconsequens*	Maples and beech	Southern Vermont	See narrative.
Pine bark adelgid	*Pineus strobi*	White pine	Northeastern Vermont	Light population.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Pine needle scale	*Chionaspis pinifoliae*	Hemlock and red pine	Widely scattered	See Red Pine Decline and Mortality Narrative.
Red pine scale	*Matsucoccus resinosae*	Red pine	Only confirmed from Orange and Rutland Counties.	Not observed in Vermont since 2015. Also see Red Pine Decline and Mortality.

Sapsucking Insects, Midges and Mites that were not reported in 2020 include ash flowergall mite, *Aceria fraxiniflora* ; balsam gall midge, *Paradiplosis tumifex* ; beech blight aphid, *Grylloprociphilus imbricator* ; black treehopper, *Acutalis tartaria* ; boxelder bug, *Boisea trivittatus* ; cinara aphids, *Cinara* sp.; conifer root aphid, *Prociphilus americanus* ; elm cockscomb aphid, *Colopha compressa* ; lacebugs *Tingidae;* leafhoppers, *Cicadellidae* ; oak leaf blister mite, *Aceria triplacis* ; oystershell scale pine, *Lepidosaphes ulmi* ; leaf adelgid, *Pineus pinifoliae* ; pine spittlebug, *Aphrophora parallela* ; spider mite, *Tetranychidae* ; sumac gall aphid, *Melaphis rhois* ; woolly alder aphid, *Paraprociphilus tessellatus.*

BUD AND SHOOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Oak twig pruner	*Anelaphus parallelus*	Red oak	Widely scattered	Commonly observed in ornamentals.
Pine gall weevil	*Podapion gallicola*	Red pine	Widely scattered	Commonly observed in areas of red pine mortality.
White pine weevil	*Pissodes strobi*	White pine and other conifers	Statewide	Shoot mortality in July continues at low levels.

Bud and Shoot Insects not reported in 2020 included balsam shootboring sawfly, *Pleroneura brunneicornis;* common pine shoot beetle, *Tomicus piniperda.*

ROOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Japanese beetle	*Popillia japonica*	Many	Statewide	See hardwood defoliators.

Root Insects not reported in 2020 included Asiatic garden beetle, *Maladera castanea* ; broadnecked root borer, *Prionus laticollis* ; conifer root aphid, *Prociphilus americanus* ; conifer swift moth, *Korsheltellus gracilis;* June beetle*, Phyllophaga spp.;* Oriental beetle, *Exomala orientalis* .

BARK AND WOOD INSECTS

Emerald Ash Borer (EAB), *Agrilus planipennis*, was first discovered in Vermont in February 2018, and new detections continued in 2020. As a result, EAB has now been confirmed in eleven counties in the state. We continue to send specimens from new counties to a USDA APHIS identifier, while specimens from new towns within counties known to be infested are confirmed by FPR or VT Agency of Agriculture, Food and Markets' identifiers.

Emerald ash borer was detected in many significant new locations in 2020. New discoveries in Bennington, Readsboro, Swanton, and Isle La Motte increased the size of existing EAB high-risk and confirmed infested areas in Bennington, Windham, Franklin, and Grand Isle Counties. A detection in West Rutland, coupled with two in southwestern New Hampshire established entirely new infestation locations and high-risk areas in southern Vermont in Rutland, Windham, and Windsor Counties. Additionally, EAB was detected in Richmond, marking the first positive identification in Chittenden County. For the first time in Vermont, a confirmed infestation of EAB was found on state land at LR Jones State Forest in Plainfield, as well as Kettle Pond State Park in Marshfield. EAB was detected in Plainfield in 2018 but was not detected in LR Jones before this winter.

Maps indicating known EAB-infested areas in Vermont (Figure 15) are posted at vtinvasives.org. The mapped areas indicate the likelihood of EAB based on where it has actually been observed; EAB is not necessarily present throughout the mapped infested areas. By the time the insect is detected, it has already dispersed, so any ash within ten miles of a known EAB location is considered to be at-risk. Including these high-risk areas, the mapped Infested Area now includes all or part of 145 towns in thirteen counties. The infested areas are also available for download on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/.

EAB inspections continued in Vermont in 2020 and were conducted in response to many landowner or FPR staff requests. Additionally, the Report It! feature at vtinvasives.org allowed users to submit locations, symptoms, and/or photographs of suspect trees. These submissions were reviewed by FPR and Agency of Agriculture, Food and Markets (AAFM) staff and relayed to district Protection staff to investigate. These yielded additional EAB finds in 2020.

Because the entire state was within the federal quarantine in 2020, USDA APHIS did not conduct any trapping efforts in the state for EAB. However, through the multi-agency Forest Pest Survey and Outreach Program, 30 volunteers were trained to hang and monitor purple prism traps. As a result, at least 114 traps were deployed in 50 towns throughout the state (Figure 16).

Girdled trap tree surveys are the most sensitive technique currently used for the early detection of EAB. Between May 5 and June 19, 38 ash trees were girdled across 11 Vermont counties. Girdled trees were predominantly on state or municipal land in both infested and uninfested areas (Figure 17). Beginning in early October and completed by December, protection staff felled the girdled trees and peeled back their bark in search of EAB presence or damage. EAB was positively identified in trap trees in Bennington and Kettle Pond State Park in Marshfield. The USDA Forest Service peeled an additional 4 trap trees across the southernmost portion of the Green Mountain National Forest, finding EAB in Readsboro.

Over the course of the year, we responded to many observations of possible EAB. These resulted in a follow-up site visit to 48 locations to inspect ash trees (Figure 18).

The State of Vermont's management strategy continues to focus on recommendations to Slow the Spread of EAB and recommendations for managing ash in urban and forested landscapes.

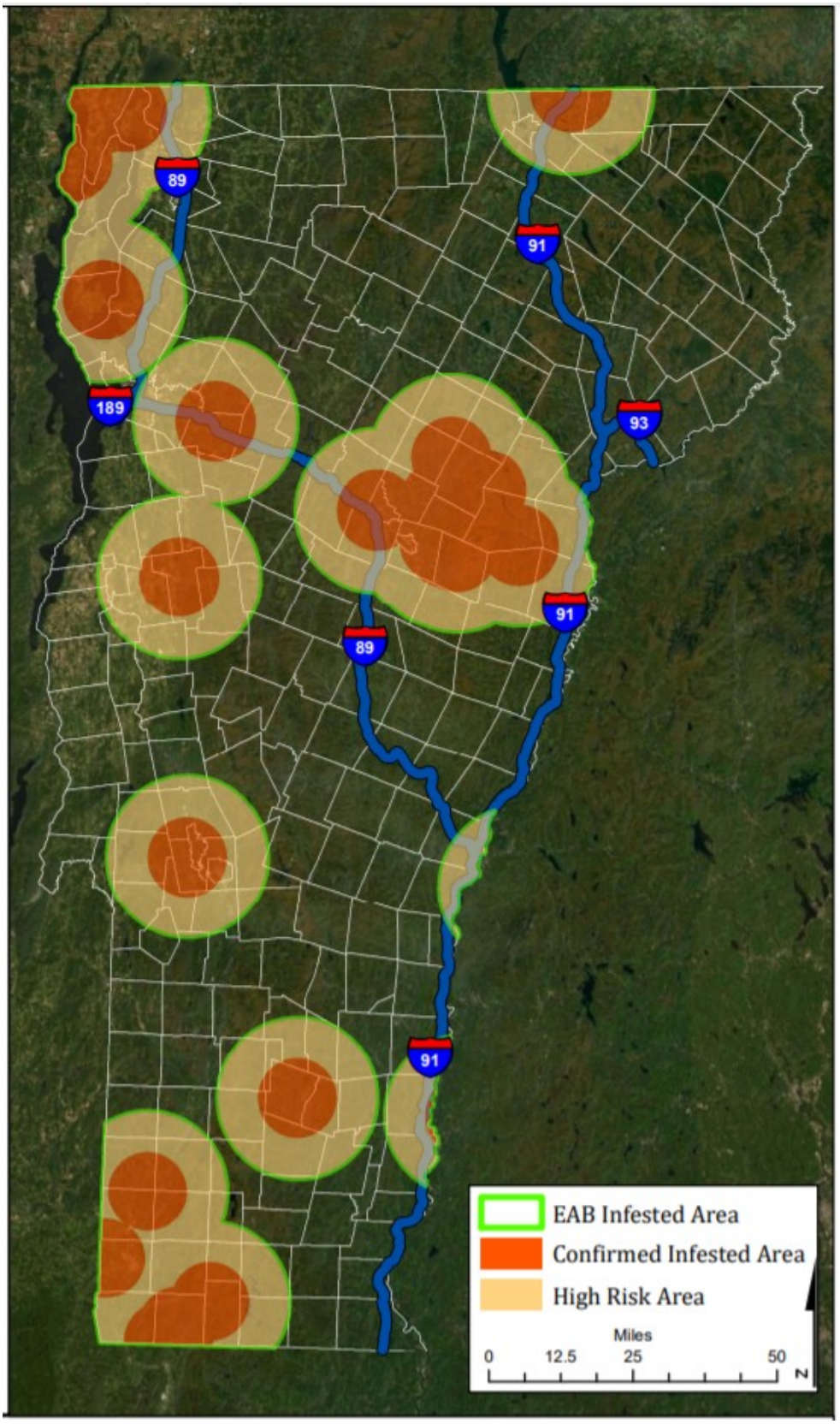


Figure 15. The mapped emerald ash borer infested area in December 2020. Locations where the presence of the insect has been confirmed are at the center of the dark orange. The "confirmed infested areas" are within five miles of these locations. High-risk areas extend five miles from the outside of the confirmed infested areas; EAB is likely expanding into and present in some of these areas. The mapped infested area now includes 145 towns in 13 counties.

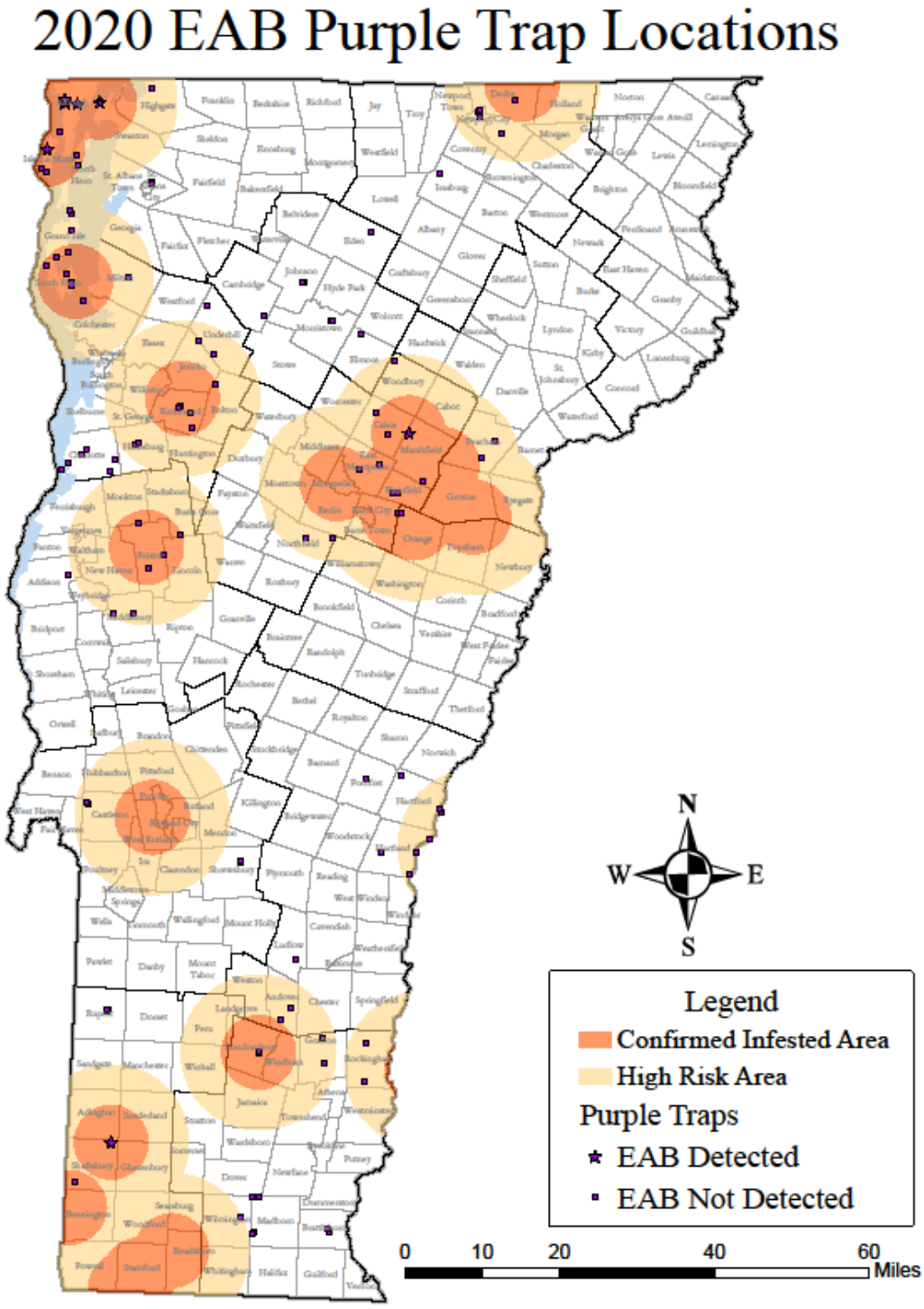


Figure 16. Approximate locations of purple pheromone traps for emerald ash borer, deployed by volunteers, in 2020. At least 78 traps were deployed. In early August, adult EAB were collected on traps in two locations in Alburgh.

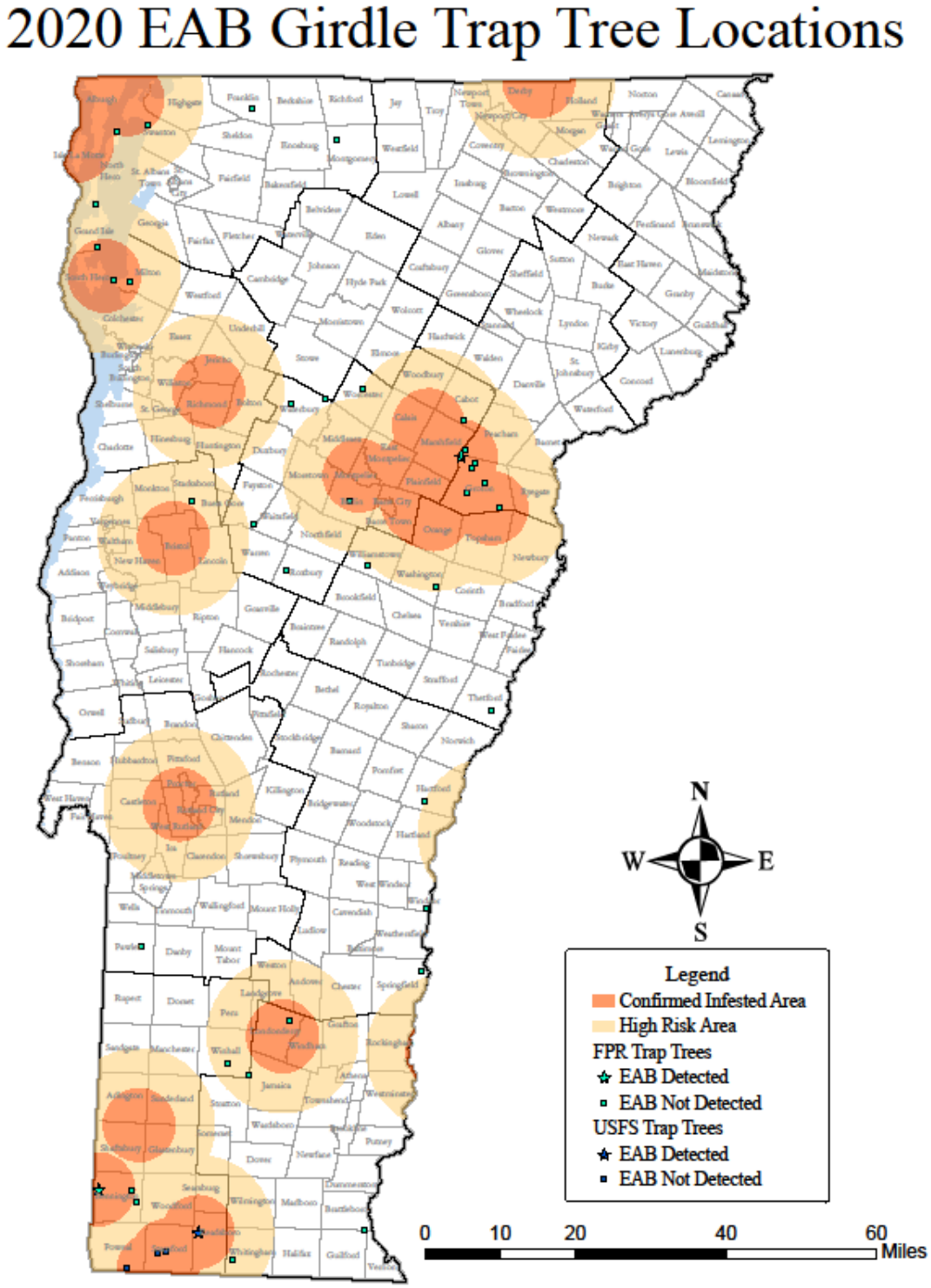


Figure 17. Location of girdled trap trees on state and private lands in Vermont in 2020. A single ash was girdled and later peeled, at each location. Three trees containing EAB were found in the state as a result.

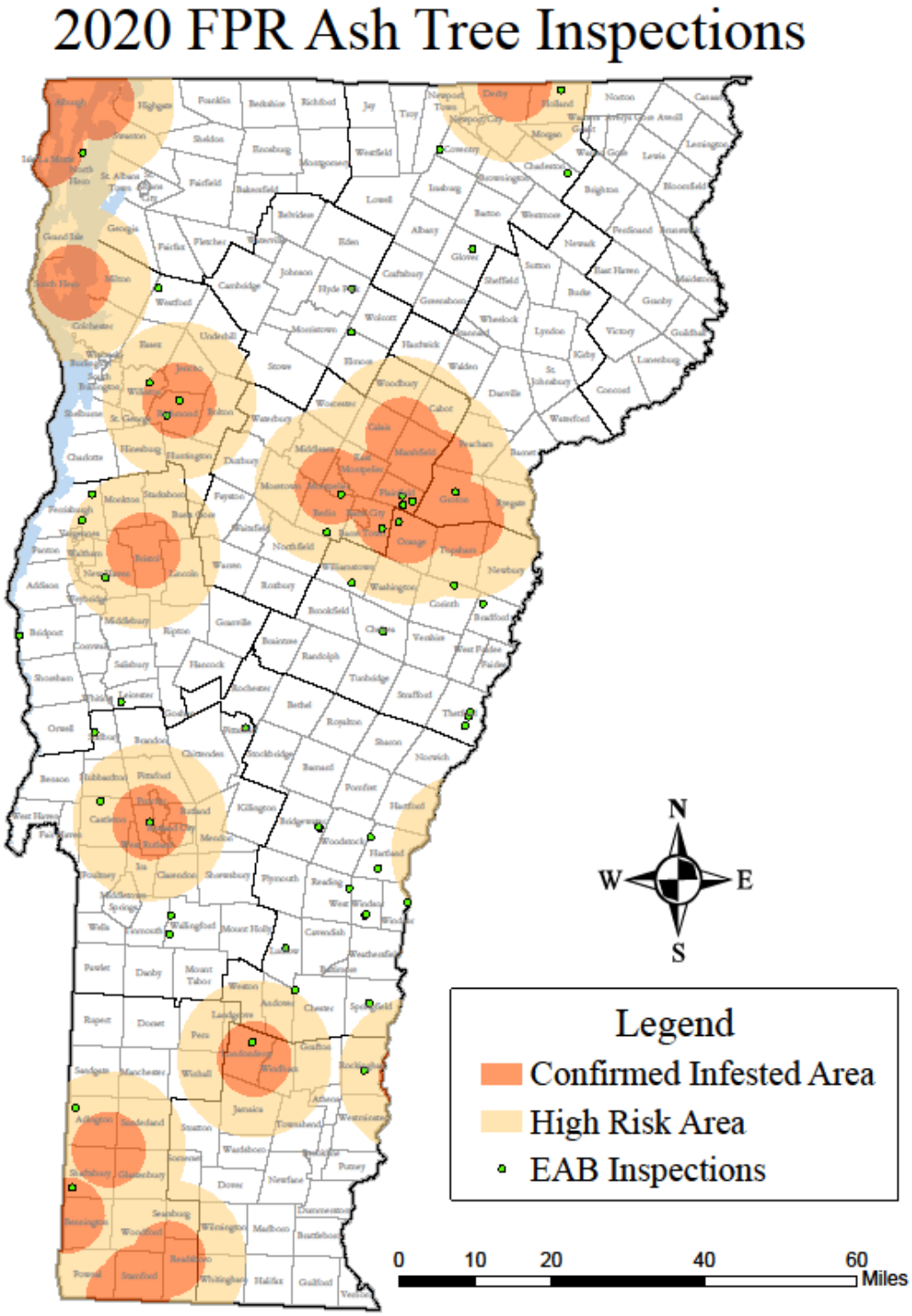


Figure 18. Locations where additional ash tree inspections were made in 2020 as a result of reports from the public or through incidental observations.

The **Vermont Forest Pest Outreach Program**, implemented by the Urban and Community Forestry Program and UVM Extension with oversight and funding provided through the Vermont Agency of Agriculture, Food and Markets (VAAFM), reached 306 people at workshops, presentations, and trainings and an estimated 452,385 people were exposed to forest pest educational material through exhibits, newsletters, radio, and social media messaging. Special projects included:

Rural Right-of-Way Ash Inventory Workshops trained volunteers to conduct inventories and map ash trees in their communities using the ArcGIS Collector app.

Over **400 trailhead signs about emerald ash borer** were posted on the state's most trafficked hiking trails. With help from FPR; the Green Mountain Club; and the Green Mountain National Forest, laminated signs about the signs and symptoms of EAB infestation were posted at popular trailheads and kiosks. Additional signs are posted at some of Vermont's natural history museums, and town forests.

EAB Awareness Week - Despite COVID-19, Forest Pest First Detectors and other dedicated volunteers in 9 towns organized activities such as ash tree tagging events, ash tree walks, webinars, drawing contests, and local media coverage to raise awareness of emerald ash borer in their communities. We also partnered with the Vermont Land Trust to collect stories and pictures of notable ash trees statewide. The week received lots of media coverage, including WCAX, My Champlain Valley, UVM Extension's Across the Fence, Vermont Public Radio, the Vermont Journal, the Brattleboro Reformer, Vermont Business Magazine, and even a news channel in Boston.

Purple Trap Program - This program was supported by the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) which supplied the traps, other materials, and staff support. Forty-four FPFD volunteers and FPR staff monitored 114 traps in 50 towns and 12 counties. This resulted in confirmed infestations in three new locations: West Swanton, Marshfield, and Shaftsbury.

EAB Biocontrol Release—biological control agents were released in two locations this year. One release site was located on LR Jones State Forest in Plainfield, the first State Forest in Vermont, as well as the first State Forest, to become infested with EAB. The second site was located in the town of South Hero. The biocontrol agents, *Tetrastichus planipennisi*, are tiny stingless wasps that parasitize EAB by laying eggs in EAB larvae, where they eventually hatch and grow, and ultimately kill the EAB larvae. They are known to target EAB exclusively, and do not parasitize other insects or pose a human health risk.

These biocontrol releases involve securing small pieces of ash logs that contain the parasitic wasps to visibly infested trees and allowing the insects to emerge for a minimum of two weeks before the pieces of ash logs are removed. These particular parasitic wasps (or parasitoids) are effective on smaller trees and saplings and have been shown to reduce the number of EAB larvae in young trees by as much as 50%.

The goal of these releases is not to eradicate EAB (which is considered impossible in the US at this point), but to establish a self-sustaining population of the parasitic wasps that will improve ash regeneration and lessen the impact of EAB in infested areas in Vermont. Releases will continue in 2021 at these locations and will include an additional two species (*Oobius agrili* and *Spathius galinae*) of biocontrol agents.

The **State Parks Firewood Exchange Project** continued for the 12th year. Along with the many COVID-19 induced changes to the 2020 camping season, the protocol was modified to reduce the amount of outside firewood entering Vermont State Parks. In order to slow the spread of invasive pests, campers were encouraged to bring no more than one night's worth of firewood into Vermont State Parks, regardless of the firewood's location of origin. Unless it was certified to have been heat-treated, outside firewood was confiscated, bagged, labeled, and exchanged for heat treated wood as campers began their stays at Vermont State Parks. In the 2020 camping season, **210 bags of firewood were confiscated**, compared to 8 bags of out-of-state wood in 2018 (Table 12) . The confiscated wood originated from Connecticut, Massachusetts, New York, New Hampshire, and multiple towns across Vermont. Emerald ash borer beetles, larval galleries, and exit holes were discovered in firewood confiscated from Jamaica State Park, while firewood confiscated from Little River State Park contained EAB galleries.

Table 12. Numbers of bundles of firewood brought into Vermont State Parks from 2009-2020. From 2009-2012, firewood from over 50 miles away was exchanged. From 2013-2019, wood was exchanged if it was brought in from out of state. In 2020, all untreated firewood brought into parks that could not be burned in the first night was exchanged.

Year	Number of Bundles of Firewood
2009	212
2010	379
2011	158
2012	136
2013	148
2014	51
2015	46
2016	64
2017	27
2018	31
2019	10
2020	210

Sirex Woodwasp, *Sirex noctilio*, was recovered in one trap deployed as part of the AAFM and USDA APHIS trapping effort for non-native wood-boring insects in 2020. This insect has been trapped in twelve Vermont counties since 2007 (Table 13). No new observations of *Sirex*-infested trees were reported, with the only known location in Jericho.

Table 13. Locations in Vermont where *Sirex noctilio* has been collected by APHIS, AAFM and FPR.

Year	Town	County
2007	Stowe	Lamoille
2010	Burlington	Chittenden
2012	Brattleboro	Windham
2012	Montpelier	Washington
2013	East Burke	Caledonia
2013	Jericho	Chittenden
2013	Randolph	Orange
2013	Swanton	Franklin
2013	Randolph	Orange
2013	Island Pond	Essex
2014	Island Pond	Essex
2014	Swanton	Franklin
2014	Ryegate	Caledonia
2015	Burlington	Chittenden
2016	Rockingham	Windham
2016	Middlebury	Addison
2016	Rutland	Rutland
2017	Burlington	Chittenden
2017	Burlington	Chittenden
2017	Burlington	Chittenden
2017	Rutland	Rutland
2018	Lyndon/Lyndonville	Caledonia
2018	Hardwick	Caledonia
2018	Newport	Orleans
2018	Royalton/South Royalton	Windsor
2018	Lyndon	Caledonia
2020	Randolph	Orange

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Asian longhorned beetle	*Anoplophora glabripennis*	Various hardwoods		Not observed or known to occur in Vermont.
Native ash borers	*Neoclytus acuminatus, Cerambycidae, Neoclytus caprea*	Ash	Statewide	Ash cerambycid larvae widely observed while following up on EAB suspect trees. Trees involved are usually dead or dying.
Black spruce beetle	*Tetropium castaneum*	Spruce, pine, fir and larch		Not observed or known to occur in Vermont.
Eastern ash bark beetle	*Hylesinus aculeatus*	Ash	Scattered statewide	Mulitple inquiries initiated by galleries from people concerned about emerald ash borer.
Emerald ash borer	*Agrilus planipennis*	Ash	Widely scattered	See narrative.
Ichneumon wasps	*Megarhyssa sp.*	Sugar maple	Northeastern Vermont	
Japanese cedar longhorned beetle	*Callidiellum rufipenne*	Arborvitae and other conifers		Not observed or known to occur in Vermont.
Northeastern sawyer	*Monochamus notatus*	Conifers	Milton	Adult.
Southern pine beetle	*Dendroctonus frontalis*	Pine		Not observed or known to occur in Vermont.
Sugar maple borer	*Glycobius speciosus*	Sugar maple	Scattered throughout	Stand-level damage occasionally significant.
Turpentine beetles	*Dendroctonus* spp.	White pine	Scattered throughout	Observed in stands stressed by white pine needle diseases.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Whitespotted Sawyer	*Monochamus scutellatus*	White pine and other conifers	Throughout	We continue to receive adults submitted as Asian longhorned beetle suspects.

Other Bark and Wood Insects not reported in 2020 included ambrosia beetle, *Heteroborips seriatus* ; ant-like longhorn, *Cyrtophorus verrucosus* ; bronze birch borer, *Agrilus anxius;* brown prionid, *Orthosoma brunneum* ; brown spruce longhorned beetle, *Tetropium fuscum* ; carpenterworm, *Prionoxystus robiniae* ; eastern larch bark beetle, *Dendroctonus simplex* ; elm bark beetles, *Hylurgopinus rufipes* and *Scolytus multistriatus* ; hemlock borer, *Phaenops fulvoguttatus* ; locust borer, *Megacyllene robiniae* ; pigeon tremex, *Tremex columba* ; round-headed apple tree borer, *Saperda candida;* spruce beetle, *Dendroctonus rufipennis.*

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Pip gall wasp	*Callirhytis operator*	Red Oak	Springfield, Woodstock	In several locations with heavy acorn production.

Fruit, Nut and Flower Insects not reported in 2020 included acorn plum gall wasp, *Amphibolips*

STEM DISEASES

Dieback from **beech bark disease,** caused by *Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*, were not mapped this year due to aerial survey restrictions.

Bark symptoms remain common and crown symptoms are increasingly noticeable in mid-summer. This may be due to dry conditions that increased the survival of beech scale crawlers, the success of bark infections, and tree vulnerability. In addition, the 2019-20 winter had no prolonged cold snaps, and deep snow in some locations protected scales at the base of trees.

Oak wilt, caused by the fungal pathogen *Bretziella fagacearum*, is a vascular tree disease of oak trees, which causes rapid decline and mortality in infected hosts. Due to the fast progression of this disease, it is thought to be introduced to the United States, however, its exact origin is unknown. This pathogen was first documented in Wisconsin in 1944 and has currently not been observed in Vermont. This pathogen can spread large distances through a variety of bark and sap-feeding beetles as well as locally, through root graphs. Humans can expedite the spread by moving infected firewood or transporting insect vectors.

This pathogen has currently been reported in 22 states, with the most recent being in New York in 2008. Due to recent detections in New York State, Vermont and nearby states are participating in a regional effort to monitor for this pathogen. In Vermont, the primary detection method is outreach, with an estimated 1,300 contacts through newsletters and social media and 312 contacts through workshops in 2020. As a result of this effort, one suspect was reported in 2020, and samples were sent to Cornell for lab testing. Both molecular and fungal culturing testing verified that this tree was oak wilt negative. As of 2020, this pathogen has not been reported in Vermont.

OTHER STEM DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Ash yellows	*Candidatus phytoplasma fraxini*	White ash	Southern and Northwestern Vermont	Remains heavy in scattered locations. See ash dieback.
Beech bark disease	*Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*	Beech	Widespread	See narrative.
Black knot	*Dibotryon morbosum*	Cherry	Scattered throughout	Remains common at normal levels, especially on off-site black cherry.
Bot canker of oak	*Diplodia corticola*	Red oak	Weathersfield	
Butternut canker	*Sirococcus clavigignenta-juglandacearum*	Butternut	Widespread	Remains stable, with most butternuts showing signs of the disease. Infections are now obvious on some trees developed by grafts from healthy butternuts and outplanted 2012-13.
Caliciopsis canker	*Caliciopsis pinea*	Eastern white pine	Rockingham	Associated with heavy mortality of small poles under an oak canopy.
Coryneum twig blight	*Coryneum spp.*	Red oak	Weathersfield	
Decay fungi	*Polyporus spp.*	Hardwoods	Widespread	
Diplodia tip blight	*Diplodia pinea*	Red pine	Statewide	See Red Pine Decline and Mortality and Foliage Diseases Other.
Dutch elm disease	*Ophiostoma ulmi; Ophiostoma himal-ulmi; Ophiostoma novo-ulmi*	Elm	Scattered throughout	Similar to other years. Dead trees commonly observed along roadsides.
Eastern mistletoe	*Phoradendron leucarpum*	Hophornbeam	Central Vermont	
Golden canker pagoda dogwood	*Cryptodiaporthe corni*	Pagoda dogwood	Southern Vermont	

OTHER STEM DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Nectria canker	*Nectria galligena*	Hardwoods	Scattered throughout	
Oak wilt	*Bretziella fagacearum*			Not observed or known to occur in Vermont. See narrative.
Red ring rot	*Phellinus pini*	Eastern white pine	Scattered throughout	Common in stressed or overstocked stands.
Sirococcus tip blight	*Sirococcus conigenus*	Red pine	Peacham	See Red Pine Decline and Mortality and Foliage Diseases Other.
Sydowia blight	*Sydowia polyspora*	Red pine	Statewide	See Red Pine Decline and Mortality.
Thousand cankers disease	*Geosmithia morbida* and *Pityophthorus juglandis*	Walnut		Not observed or known to occur in Vermont.
White pine blister rust	*Cronartium ribicola*	Eastern white pine	Scattered throughout	Generally a decrease from a recent spike in occurrence that began in 2009.

Other Stem Diseases not reported in 2020 included chestnut blight, *Cryphonectria parasitica* ; crown gall rust, *Puccinia coronata* ; cytospora canker, *Leucostoma kunzei* ; eastern dwarf mistletoe, *Arceuthobium pusillum* ; fireblight, *Erwinia amylovora* ; hypoxylon canker, *Hypoxylon pruinatum;* phomopsis twig blight, *Phomopsis spp.;* sapstreak, *Ceratocystis coerulescens* ; scleroderris canker, *Ascocalyx abietina;* verticillium wilt, *Verticillium albo-atrum;* woodgate gall rust, *Endocronartium harknessii;* yellow witches broom rust, *Melampsorella caryophyllacearum.*

FOLIAGE DISEASES

Needle Diseases of White Pine (WPND) were common again this year, attributed to a complex of fungal species including brown spot needle blight (*Lecanosticta acicola*), *Lophophacidium dooksii, Bifusella linearis,* and *Septorioides strobi*. Trees indicated as "healthy" at the beginning of monitoring (2012) have experienced lower levels of chlorosis and defoliation than those deemed initially "unhealthy". Decline and mortality of white pine have been observed in stands that have had multiple years of needle damage where other stress factors are also present such as wet site conditions, wind impact, or wounding. Weak pests and pathogens, such as turpentine beetles, Caliciopsis canker, and Armillaria root rot have been observed in some stressed stands.

The US Forest Service, in cooperation with the University of New Hampshire and other affected states, continues to investigate this malady, including studies to clarify the roles of needlecast fungi and weather. As part of this project, we are monitoring plots in Plymouth, Richmond, St. Johnsbury, and Springfield (Figures 19-21). Data from these plots suggest general trends, but likely underestimate the severity of damage across the landscape since some of our original trees have died, thereby reducing the sample size. Vermont, neighboring states, and the US Forest Service are pursuing efforts to expand our sampling in future years.

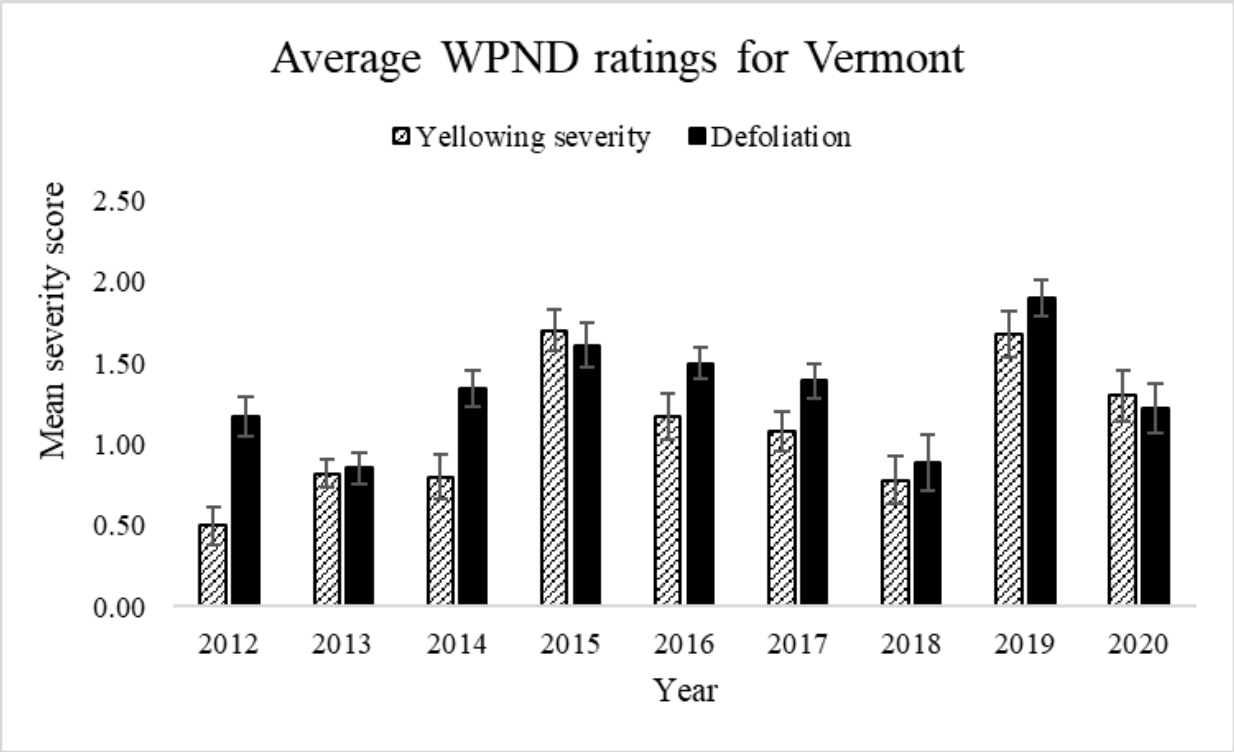


Figure 19. Average trends in yellowing severity and defoliation for all trees sampled at four sites in Vermont between 2012-2020. Data presented are mean severity scores (0 = no chlorosis/defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

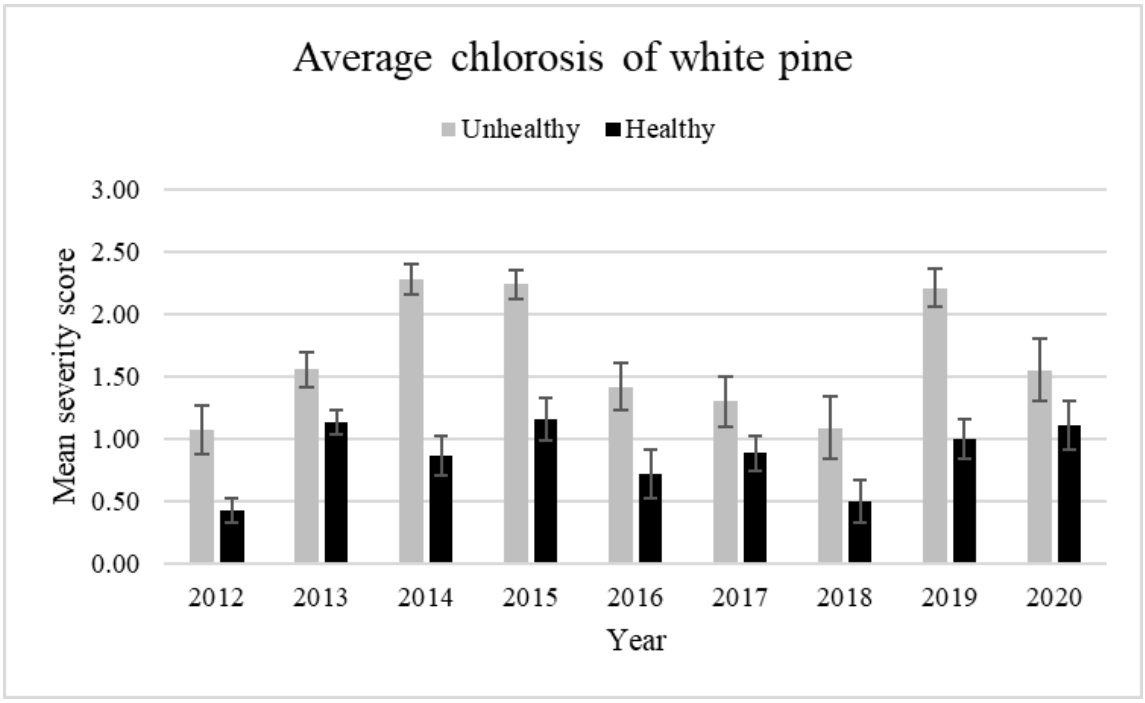


Figure 20. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed between 2012-2020 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

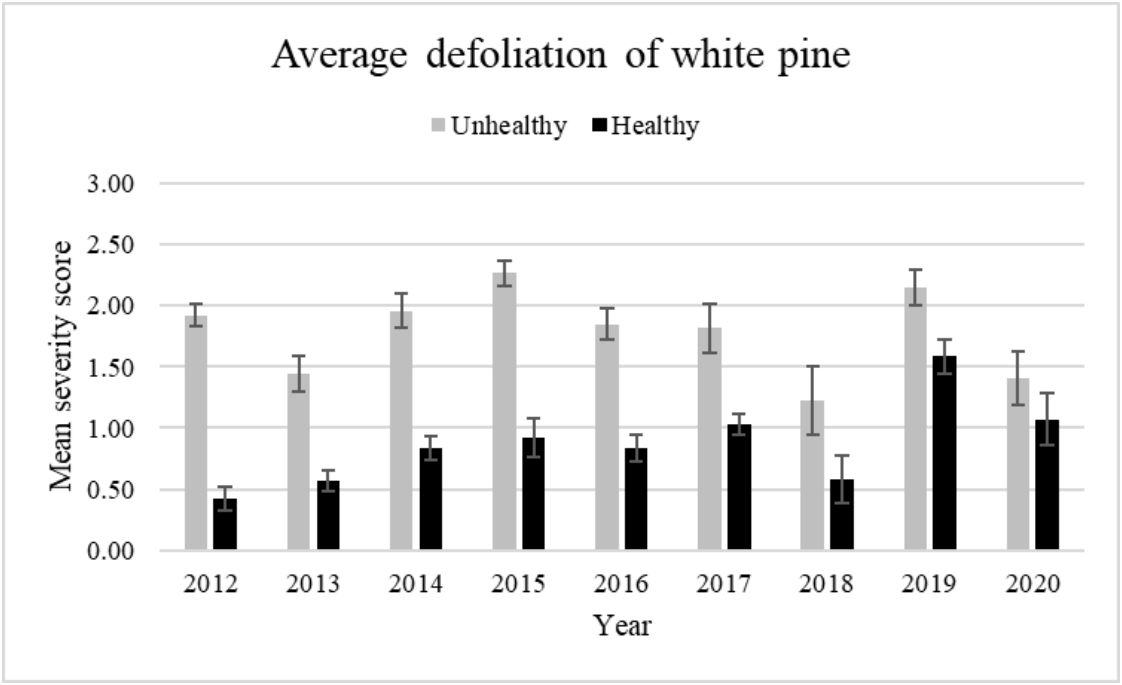


Figure 21. Defoliation severity of unhealthy and healthy white pines surveyed between 2012-2020 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Anthracnose	*Glomerella spp.* ; *Apiognomonia spp* .	Maple, oak	Statewide	Increase from recent years.
Apple scab	*Venturia inaequalis*	Apple	Statewide	Heavy late season defoliation of wild apples, increase from 2019.
Balsam fir needlecast	*Lirula sp.*	Balsam fir	Statewide	Commonly observed on ornamental and christmas tree plantings.
Birch leaf fungus	*Septoria betulae*	Birch	Statewide	Similar to 2019 levels.
Brown spot needle blight	*Lecanosticta acicola*	Pines	Statewide	Thin crowns, some decline, and heavy early needle drop. Increase from 2019. See needle diseases of white pine.
Cedar apple rust	*Gymnosporangium juniperi-virginianae*	Apple	Statewide	
Diplodia shoot blight	*Diplodia pinea*	Red pine	Statewide	See Red Pine Decline and Mortality and Stem Diseases Other.
Giant tar spot	*Rhytisma acerinum*	Norway maple	Statewide	Similar to 2019 levels, but still mostly light damage.
Red band needle blight	*Dothistroma septosporum*	Red pine	Statewide	See Red Pine Decline and Mortality.
Rhizosphaera needlecast	*Rhizosphaera kalkhoffi*	Many	Statewide	Mortality of ornamental blue and white spruce continues due to heavy defoliation in the past.
Sirococcus tip blight	*Sirococcus tsugae*	Red pine	Peachem, VT	See Red Pine Decline and Mortality and Stem Diseases Other.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Speckled tar spot	*Rhytisma punctatum*	Maple	Northern VT	Similar to 2019 levels, but still mostly light damage.
Sydowia blight	*Sydowia polyspora*	Red pine	Statewide	See Red Pine Decline and Mortality.
White pine needle decline	*Bifusella linearis, Lecanosticta acicola, Lophophacidium dooksii, Septorioides strobi*	Eastern white pine	Statewide	Increase from recent years. See needle diseases of white pine.

Foliage diseases not reported in 2020 included crown rust, *Puccinia coronata;* dogwood anthracnose, *Discula destructiva* ; fir-fern rust, *Uredinopsis mirabilis* ; phyllosticta leafspot, *Phyllosticta sp* .; poplar leaf blight, *Marssonina* spp.; powdery mildew, *Erysiphaceae;* septoria leafspot, *Septoria aceris* ; tubakia leafspot, *Tubakia dryina* .

ROOT DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Armillaria root rot	*Armillaria* spp.	Many	Statewide	

Root Diseases not reported in 2020 included heterobasidion root disease, *Heterobasidion annosum;* schweinitzii root and butt rot, *Phaeolus* schweinitzii.

DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

Red pine decline: Red pine (*Pinus resinosa*) has been in a state of decline across Vermont. Previously, foliar shoot blight pathogens such as *Diplodia sapinea*, *Sirococcus conigenus*, and *Pestalotiopsis* spp. have been found to contribute to this decline in central Vermont in 2019. To try and determine if this declining pattern and fungal complex are consistent across the state, 12 red pine health monitoring sites were established during the summer of 2020.

Preliminary plot establishment and sampling 2019:

The first monitoring site selected was a 50-acre, 100-year-old red pine plantation in Groton State Forest in the town of Peacham. Harvest was completed in late winter of 2019 to reduce hazards near trails and roads and to salvage lumber. Four acres were left as a reserve for monitoring.

Sampling occurred in the summer. Two trees within the reserve were felled for branch collection. One tree was more symptomatic than the other. Samples from each tree were submitted to USFS entomologists and plant pathologists for further analysis.

USFS Entomologist Kevin Dodds reported that there was no red pine scale found on submitted branch samples. Both trees had spider mites. Pine gall weevil (*Podapion gallicola*) was confirmed in each tree. USFS Plant Pathologist Isabel Munck reported *Diplodia pinea, Sirococcus conigenus,* and *Pestaliopsis* spp. shoot blight(s) on stunted shoots and cone scales.

Plot establishment and sampling 2020:

Including the initial Groton site established in 2019, 12 monitoring sites were selected across the state (Figure 22). Sites were divided evenly among 4 geographical regions: Northeast (NE), Northwest (NW), Central (C), and Southern (S). At each of the 12 monitoring sites, 4 permanent plots were established. The plot design is a fixed radius, 35ft. All red pine within the plot were tagged and measured. Azimuth, location, diameter at breast height (DBH), and crown position were all measured and recorded. The following crown metrics were observed and recorded: live crown ratio (LCR), crown density, dead shoots and location, crown transparency, and needle discoloration. Plots will be remeasured annually for 5 years. The summary of establishment data is below in Table 14.

Table 14. Average of red pine crown measurements by region in 2020.

Region	DBH (in.)	LCR (%)	Density (%)	Dead Shoots (%)	Transparency (%)	Discoloration (%)
C	14.8	34.2	47.9	25.4	35.1	25.4
NE	15.7	34.2	41.7	30.1	51.5	8.5
NW	14.5	42.4	46.8	13.8	33.3	13.3
S	13.2	31.7	46.7	12.9	29.9	12.9

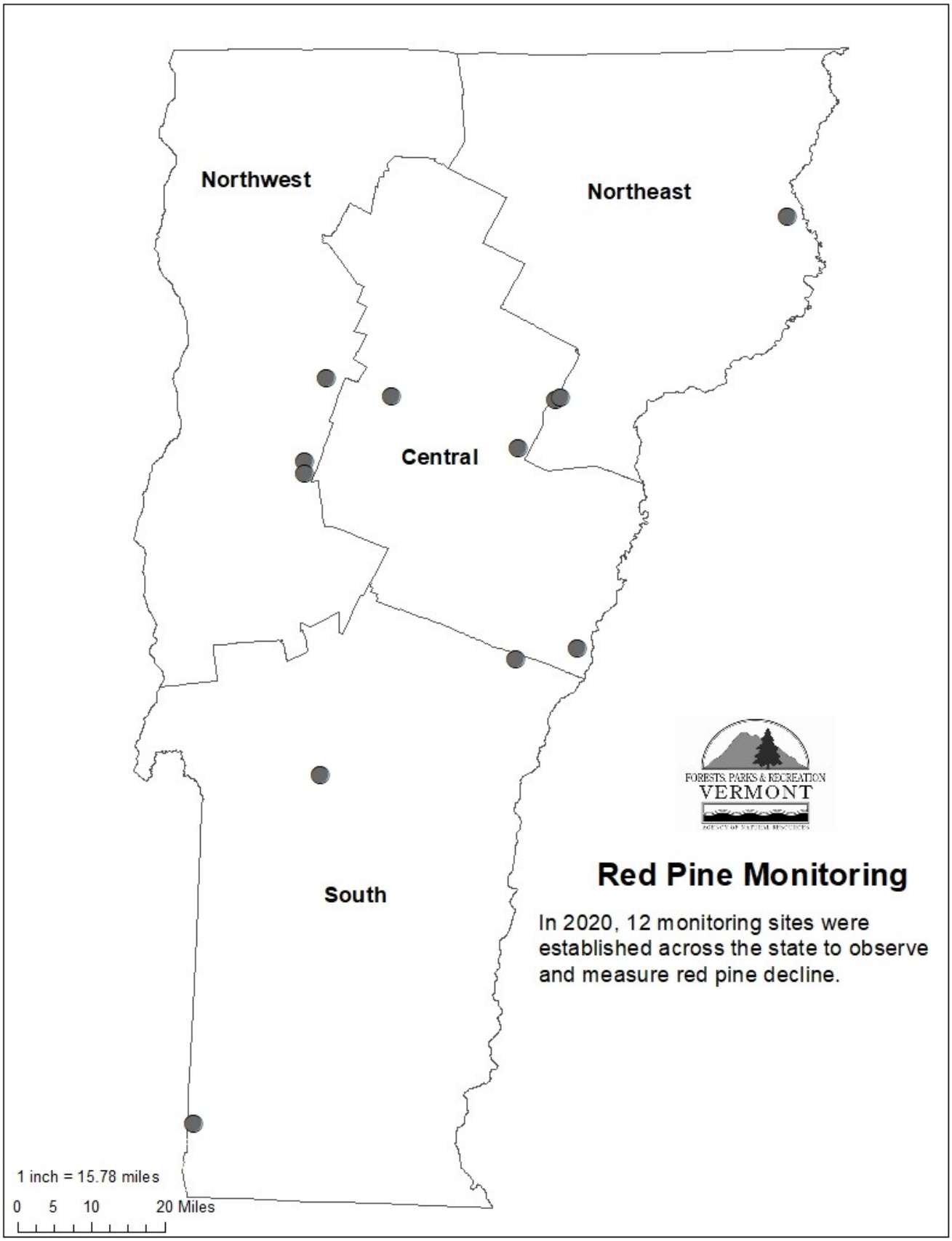


Figure 22. Red pine decline plots established in 2020.

Sampling: This year, 10 out of the 12 total sites were destructively sampled to assess foliar pathogens and insect stressors (Table 15). Two established sites (Perry Hill and Aitken State Forest) were not sampled due to safety concerns. Crown metrics and tree measurements as described above were observed on the sampled tree before felling. Canopy position of all trees was co-dominant.

Table 15. Crown measurements for sampled trees in 2020.

Location	Region	DBH (in.)	LCR (%)	Crown Density (%)	Dead Shoots (%)	Dead Shoot Location (B M, T, S)	Crown Transparency (10%)	Needle Discoloration (10%)
LR Jones State Forest	C	14.6	40	50	10	S	30	10
Thetford Hill State Park	C	11.9	30	50	10	S	30	20
Groton State Forest	NE	14.2	20	50	10	S	30	50
New Discovery State Park	NE	13.4	20	20	80	B, M	70	30
West Mountain WMA	NE	14.1	50	50	10	S	30	10
Camels Hump State Park: Duxbury	NW	9.7	30	40	10	S	30	10
Camels Hump State Park: Lincoln	NW	8	50	50	10	S	30	10
Camels Hump State Park: Starksboro	NW	9.5	30	50	10	S	30	10
Charles Downer State Forest	S	18.3	30	40	10	S	30	10
Whipstock Hill WMA	S	12.1	30	50	10	S	30	10
Perry Hill State Park	C	Not sampled due to safety restrictions.						
Aitken State Forest	S	Not sampled due to safety restrictions.						

Standard red pine health metrics for an asymptomatic, open-grown red pine were established as having a crown density of 50%, dead shoots of 10%, crown transparency of 30%, and discoloration of 10%. Average crown density for our destructively felled and sampled trees were 45%, 5% less than our standard; average dead shoots were 17%, 7% higher than our standard; average crown transparency was 34%, 4% higher than our standard; and average discoloration was 17%, 7% higher than our standard.

Felled red pine trees were micro-sampled on the main bole at DBH and on symptomatic branches in the canopy with a sterile bone marrow biopsy tool; a small 0.5 -1 mm diameter tool that penetrates the tree (approx. 1- 2 mm) to excise outer bark tissues to the vascular cambium (Stauder et al. 2019). Symptomatic needles were also harvested from the canopy. All plant tissue was surface disinfested with a 1:9 commercial bleach: water solution (bark plugs for 14 minutes, needles for 3 minutes), and plated on potato dextrose agar with antibiotics. Fungal isolates were identified and sub-cultured as they appeared. Fungal isolates were identified based on morphology, and a representative subset was PCR sequenced to amplify their ITS gene region to confirm morphology identification.

Foliar pathogens observed across the state included diplodia tip blight (*Diplodia pinea* symptoms at 10/10 sites, isolated from 9/10 sites), and sydowia blight (*Sydowia polyspora* symptoms at 10/10 sites, isolated from 10/10 sites). Insect pests observed included signs of pine weevil gall (*Podapion gallicola*, 9/10 sites), pine needle scale (*Chionaspis pinifoliae*, 9/10 sites), and sawflies (9/10 sites).

To determine how these insect stressors and pathogens have impacted growth over the past few years, cross-sections were taken at the base of live crown (BLC) and diameter at breast height (DBH) from the 10 sampled trees. This winter, FPR staff will be conducting tree-ring analysis to quantify any growth reductions these complexes may have caused.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Ash dieback	White ash	Scattered statewide	Remains heavy in scattered locations. Increase attributed to ash susceptibility to drought.
Black cherry symptoms	Black cherry	Orange county	In multiple locations, black cherry had thin crowns, premature leaf drop, and scattered mortality. Causal agent(s) unknown.
Drought damage	White ash	Southeastern and central Vermont	Premature late-summer defoliation was common, and attributed to drought.
Fire damage	Many	Widely scattered	82 fires in 2020 totaling 116 acres. See weather for drought conditions.
Frost damage	Beech, maple	Statewide	
Hardwood decline and mortality			See Forest Tent Caterpillar.
Heavy seed	Ash, red oak, white cedar, white pine	Statewide	Thin crowns due to heavy seed were commonly observed. See Anthracnose.
Larch decline	Eastern larch	Widely scattered	Although not mapped during aerial surveys, there were reports of declining larch. See eastern larch beetle.
Logging-related decline	Many	Widely scattered	An occasional cause of tree symptoms. 919 acres mapped.
Ozone injury			Ozone monitoring plots were discontinued in 2018.
Salt damage	Eastern white pine	Widespread	While not unusually severe, foliar browning was common in late winter.
Red pine mortality	Red pine	Statewide	See narrative.
Wet site related decline	Many	Statewide	Only 248 acres of new symptoms were mapped.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
White pine needle damage	Eastern white pine	Statewide	See Foliage Diseases.
Wind damage	Many	Scattered Statewide	20 acres mapped. Wet spring soils led to windthrow. See 2020 Weather Summary.
Winter Injury	Fir	Bennington county	Recently planted Christmas trees.

Other Diebacks, Declines, and Environmental Diseases not reported in 2020 included air pollution injury, birch decline, chlorosis due to rainfall, hail damage, ice and snow breakage, spruce decline.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Squirrel	Maples, Oaks	Statewide	Populations were lower in 2020, but some damage observed
Woodpecker	Wood products; Ash spp., Balsam fir, Mountain ash	Statewide	Scattered throughout the state.

2020 INVASIVE PLANT SUMMARY

Non-native invasive plant management (NNIPM) efforts continued in 2020, with progress on **Education, Outreach, and Capacity Building** made possible through several grant-funded opportunities. The statewide Invasive Plant Coordinator within FPR led two virtual workshops, created two YouTube videos, and one collaborative Prezi for a variety of stakeholders. A special recorded training on woody NNIPM was created and shared via Agency of Natural Resources social media in collaboration with the ECHO Aquarium and Science Center and has garnered 167 views. The Coordinator also worked with multiple state departments and agencies to unify Vermont's approach to NNIPM. The Coordinator also fielded over 412 inquiries about invasive plants. FPR staff continued to provide outreach and information about invasive plants to the public and resource professionals and to work with landowners and consulting foresters on addressing NNIP on private lands. ANR continued to identify and manage NNIP on **State Lands**. Varied NNIPM strategies were conducted within local communities and by many other organizations, some of which are summarized under **Other Activities**.

Early Detection Species
Patches of Japanese Stiltgrass (*Microstegium vimineum*) that had been reported in 2018 and 2019 had their identification photographically confirmed by the Vermont Natural Heritage Program. This includes an isolated patch on private land in Sandgate (Bennington County), along a roadside in Brattleboro (Windham County), and Poultney (Rutland County). Vouchers were collected for the Windham County population.

Education, Outreach and Capacity Building

Mapping for Healthy Forests, Vermont: This project remains active online, utilizing the iNaturalist website to connect Vermonters with information about the location of invasive plants in the state. Observations made by volunteers are linked to location, photos, information on seed production, and level of infestation of the specific observation. This information is stored on the iNaturalist website and is accessible to anyone. As of November 16th, the project had 4,636 observations provided by 155 observers.

Forest Hero! Volunteer Network: Work continues this year on a project funded by a US Forest Service grant, though at a limited capacity due to a hiring freeze and restrictions on in-person gatherings. One of the focal projects of the grant, a "train the trainer" opportunity for members of the public called Forest Hero! Network, continued full steam ahead, with the Invasive Plant Coordinator supporting network volunteers as they worked to complete their community service projects. In collaboration with partners like Vermont Coverts: Woodlands for Wildlife, four trainings have taken place since October 2018. Thirty people have participated in learning how to effectively communicate information to their communities on invasive plants. As part of the day, participants agree to take what they learned back to their communities and are expected to complete at least one outreach event within a 12-month period. Continuing education is offered through quarterly newsletters.

Tool Loan Pilot Program Continues Even During Pandemic: In an effort to increase access to NNIPM tools, the District 3 (Northwest) office started a pilot program in 2017, loaning out weed wrenches to local organizations, municipalities, and private landowners. FPR's Invasive Plant Coordinator communicates with participants and organizes pick-up and return dates. The loan program was expanded to include tools available through a library at the District 2 (Southwest) office in 2019. The expanded loan program was used 22 times as of November 2020, with a long-term check-out for the winter '20-'21 with a local school looking to create an outdoor classroom space. The Coordinator shared information about the program at speaking engagements throughout the year, and the tools are stored and available for pick up at FPR's Essex Junction and Rutland office.

VTinvasives.org website: The VTinvasives.org website continues to offer content including infor-

mation on terrestrial and aquatic invasive plants and continues to provide information to a variety of user groups from landowners to professional foresters to municipalities, including educational resources and Best Management Practices.

Outreach on Aquatic Invasive Plants: Despite the challenges presented by the pandemic in 2020, the training of state park staff to educate park visitors on aquatic invasive plant control continued, beginning in June. Trainings took place for 16 state parks by the end of the season. In addition to park trainings, educational outreach kits developed for schools were evaluated and updated with digital resources to better serve educators and students. Finally, work was begun on developing a novel "boater self-assessment tool" to educate and instruct boaters on how to clean-drain-dry their vessels to avoid spreading invasive species, even in the absence of a greeter. Support for this work was provided in part by the Vermont Department of Environmental Conservation.

Non-native Invasive Plant Management on State Lands

District 1 (southeast): There were multiple projects to manage NNIP conducted in District 1 in 2020, with several of the larger projects highlighted below.

Initial treatments for honeysuckle and buckthorn completed in 2019 at Dorand State Forest have been successful, with monitoring sites having 90+% mortality rates. This summer, secondary treatment was conducted on the previously treated 17 acres. Initial treatment for honeysuckle and buckthorn was conducted on 15 acres additionally identified for restoration, following a similar protocol and timeline.

NNIPM work at Little Ascutney WMA included a follow-up treatment on 30 acres of timber stand improvement, treating honeysuckle, buckthorn, and phragmites.

This year, the McClary Lot project at Mt. Ascutney State Park was reinvigorated after a 5-10 year hiatus. This initial treatment had seen good success, making the area treated in 2020 substantially smaller than anticipated.

Mechanical removal of invasive plants was conducted at Roaring Brook WMA to provide a travel corridor for the black racer snake, an endangered snake species in Vermont. This project is in cooperation with VT AOT and VT F&W — AOT mows the open areas adjacent to the I-91 weigh station on the WMA each year after the snakes stop traveling, and VT F&W treats the buckthorn that inevitably prospers as a result of the permanent habitat opening.

District 2 (southwest): Due to COVID-19 restrictions, no NNIPM was implemented this year. Since 2013, using an internally developed "strike team" model, the Habitat Restoration Crew has conducted NNIPM in State Forests and State Parks throughout District 2, often with the aid of volunteers. The hope is to pick up this work again in 2021.

District 3 (northwest): District 3 (northwest): Several small-scale projects were tackled in District 3 this year, including annual monitoring of previous treatment sites. In Mill River State Park, knotweed was mechanically treated as a follow-up to the previous year's management, with plans to return for additional treatment in 2021. The Dowsville Block in Camel's Humps State Park had a patch of knotweed treated using the cut and paint (or "clip and drip") method, with a goal of removing the patch that had grown up from fill brought in previous years. This site will need retreatment in 2021 most likely. In Alburgh Dunes State Park, a small patch of wild parsnip was identified and mechanically treated, and will be revisited in 2021. There were follow-up site visits for Phragmites patches throughout the district that were treated in 2018-2019. These visits provided evidence that treatments were highly effective. Across all sites, Phragmites populations were reduced and native species were observed starting to re-occupy most sites. In locations where scattered Phragmites stems persist, follow-up treatments are planned for 2021.

District 4 (central): Long-term projects were the focus this year for District 4. Control efforts contin-

ued on a 0.5 acre patch of knotweed in Long Trail State Forest, with treatments including an early summer mechanical treatment, followed by an early fall foliar spray treatment with Triclopyr and Glyphosate. A new project was started, focusing on the long-term control of small scattered patches of knotweed, common barberry, and shrub honeysuckles in the Woodward Hill Block of Mt. Mansfield State Forest. The patch of knotweed was considered a high priority for treatment because it is located in an otherwise intact mature forest and is likely to spread along an adjacent hiking trail and intermittent stream. In the fall, the scattered patches were treated with a foliar spray of Triclopyr and Glyphosate. Both projects will have follow-up treatments in 2021. There were additional sites of barberry and euonymus observed around parking areas in Thetford Hill State Park. A single barberry plant was mechanically removed, however in a follow-up site visit, more barberry and buckthorn were found. The goal is to assess the property to figure out if population levels permit a plan focused on eradication or containment.

District 5 (northeast): In Willoughby State Forest, District 5 staff the second round of mechanical treatment of 40+ acres of patchy Japanese barberry was conducted, and foliar treatment was applied after resprouting. Follow-up treatments include a similar timeline for the next growing season. In Victory State Forest, a single, shrub honeysuckle was found on a future log landing near Bog Brook. The plant was mechanically removed and a survey of the surrounding area was conducted, to ensure that disturbances from creating a landing would not lead to an abundance of honeysuckle. No other invasive plants were found, so no treatment or follow-up is planned for 2021.

Other Activities

The growing season for 2020 saw many NNIPM projects, led by others, across the state. Below are highlights reported by project leaders.

Cooperative Invasive Species Management Areas
CISMAs, CWMAs, PRISMS, whatever name they're given, their goals are the same: to pool resources amongst local organizations with a vested interest in maintaining the ecological health of a particular area through invasive species outreach, prevention, and management. Currently, in Vermont, there is the Upper Connecticut CISMA, the Batten Kill Watershed CISMA, the Upper White River CISMA, the Southeast VT CISMA, and newly forming is the Orleans County CISMA. While not a CISMA, the Black River Action Team deserves mention for their great work at early detection and rapid response of invasive plants.

The Southeast Vermont Cooperative Invasive Species Management Association (SEVT CISMA) is a partnership of invasive species experts, land managers, and interested members of the public. This past fall, SEVT CISMA has offered a series of hour-long invasive species-focused webinars catering to southeast Vermont landowners. Topics have included chemical and non-chemical management techniques, common woodlot invasives, and common urban invasives. Attendance has been high and the SEVT CISMA is looking forward to providing more online learning opportunities and hopefully in-person resources in the coming year. Recorded webinars can be found at https://windhamcountynrcd.org/recordings-of-cisma-webinars/.

Hinesburg, VT
There are a variety of partners involved with various elements of the project that Chittenden County Forester, Ethan Tapper, is working with the Hinesburg Town Forest Committee to complete. It is a comprehensive invasive species control and restoration project at the LaPlatte Headwaters Town Forest. The project involves the control of woody invasive plants, floodplain restoration, and reed canary grass remediation. The Nature Conservancy Vermont is helping to revegetate historic floodplains of the LaPlatte River through their American Elm Project by plantings, herbivore exclosures, and site inventories (in collaboration with UVM). VT Fish & Wildlife are modeling innovative approaches to floodplain restoration by restoring reed canary grass-infested areas to native floodplain and wetland vegetation

through mowing, plowing, herbicide application, and direct seeding of floodplain tree species. And in 2019 and 2020, a portion of the proceeds from a demonstration timber harvest was used to hire a local invasive control contractor to chemically treat woody invasive plants in wooded areas of the Town Forest (~170 acres).

Huntington, VT
Audubon Vermont staff at the Green Mountain Audubon Center held a volunteer work party this fall and focused efforts on trail cleaning and removal of invasive plants. Volunteers were offered free training by FPR's Invasive Plant Coordinator on plant identification and removal techniques before the event. Twenty bags of knotweed and a truck bed of shrub honeysuckle were removed as part of the effort along the River Trail and around the Center. Mechanically removing the plants will help slow their spread to other parts of the property and trails.

Charlotte, VT
ECO Americorps members provided assistance to the Clemmons Family Farm (a non-profit and a landmark site along VT's African American Heritage Trail) in Charlotte in recovering 2 acres from invasive plants to be used for an outdoor classroom. This work moving forward will also include the creation of signage discussing the restoration work completed. Tools were borrowed from the FPR Tool Loan Program.

Milton, VT
The Milton Conservation Commission is active in their invasive plant management of various properties around town, including one parcel that adjoins the Milton Town Forest. This work includes assessments, learning to discern invasive plants from their native plant look-a-likes, the physical removal of species like bush honeysuckle and buckthorn, and outreach to hikers and recreators. Many of these efforts are spearheaded by Committee member, Bonnie Pease.

South Burlington, VT
City staff continued efforts for stewardship of various parcels despite the challenges of 2020 and took away a lesson that we need to be resilient in the face of adversity, whether facing the challenges of a pandemic, or land management. Working with a consultant, they changed tactics and focused on one-on-one work with experienced and trained volunteers and the consultant, and utilizing an early detection rapid response model, to accomplish the restorations planned. This allowed good progress to happen towards improving wildlife habitat and native plant diversity at Red Rocks, Wheeler, Underwood, and City Center Parks. There is visible evidence of the positive impact these cumulative efforts are having, allowing successful transition from invasive plants to native plants in several critical locations at each park.

TRENDS

Sugar Maple Health in 2020

Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 94% of overstory sugar maples were rated as having low dieback (less than 15%), which is slightly higher than in 2018 (93%) (Figure 23).

Statewide, there was an increase in trees with thin foliage (8%) which is higher than 2019 (2%). This was likely due to light defoliation from saddled prominent and/or maple leafcutter. Foliage transparency is sensitive to current stress factors. Other spikes in transparency have been due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007, 2016-2018), and pear thrips (1988-1989).

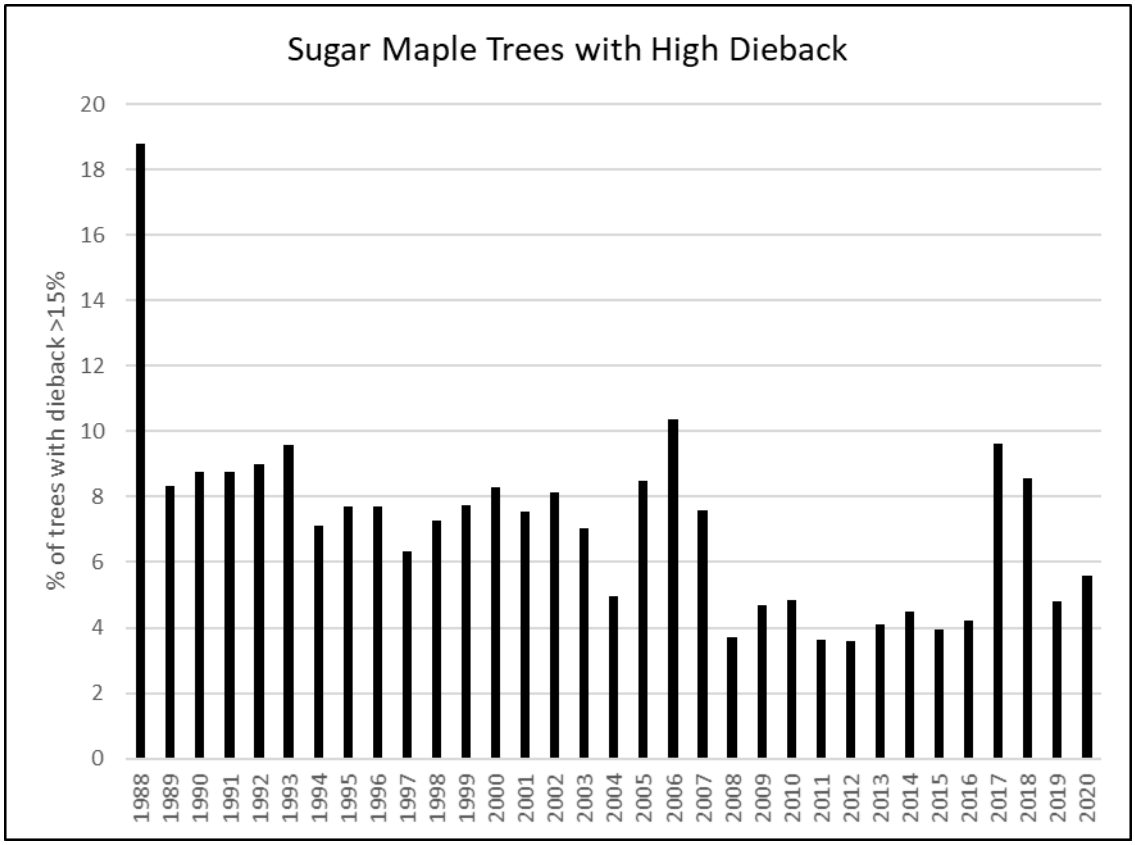


Figure 23. Percent of overstory sugar maple trees on NAMP plots with high dieback (> 15%), 1988-2020. *n* = 1,142 trees at 36 sites.

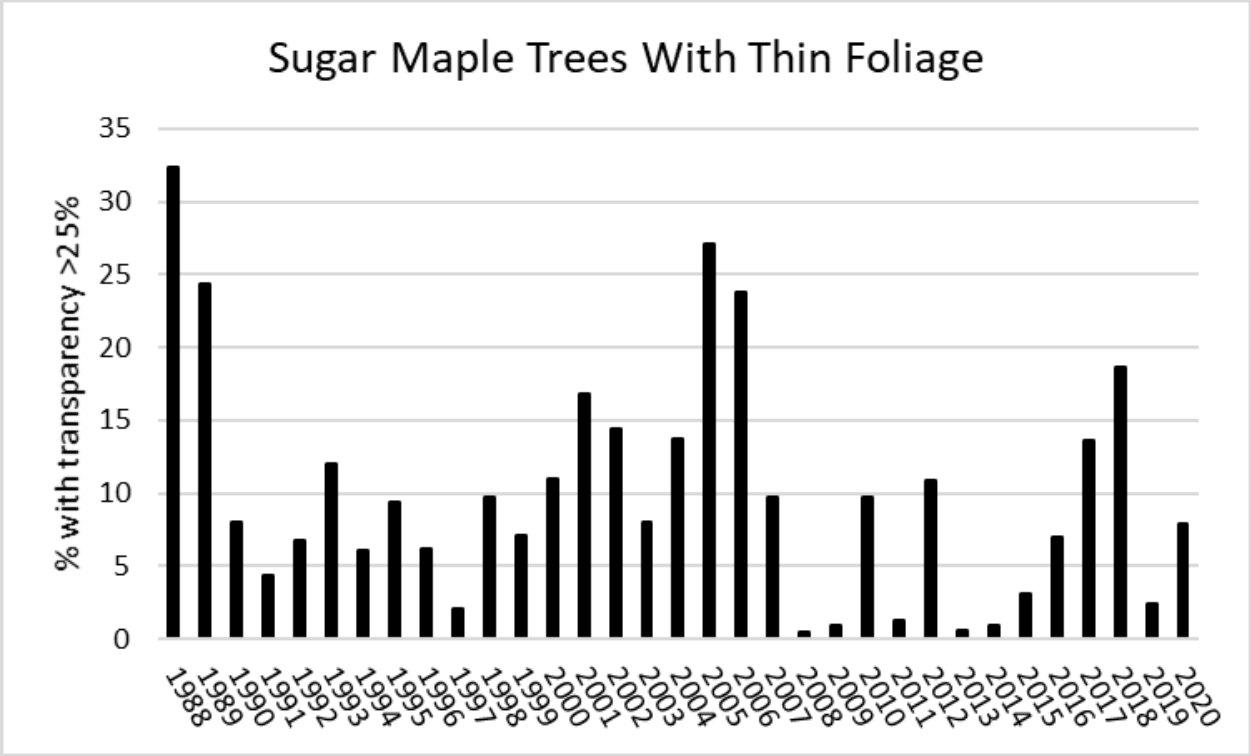


Figure 24. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage (>25% foliage transparency), 1988-2020. *n* = 1,142 trees at 36 sites.

Forest Ecosystem Monitoring Cooperative
Trends in Forest Health throughout Vermont in 2020

Vermont forest health monitoring plots were sampled at 48 sites across the state in 2020 as part of the Forest Ecosystem Monitoring Cooperative (formerly the Vermont Monitoring Cooperative). Measures recorded were comparable to those collected for NAMP plots. Results and analysis from this plot network can be obtained in the annual reports produced by FEMC, found at https://www.uvm.edu/femc/products/reports.