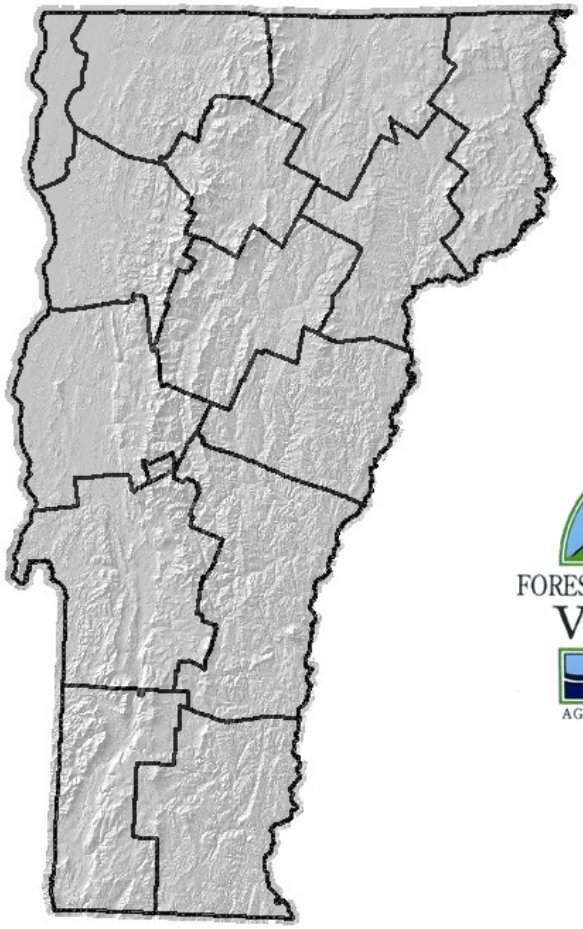
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2019



FORESTS, PARKS & RECREATION
VERMONT
AGENCY OF NATURAL RESOURCES

AGENCY OF NATURAL RESOURCES
DEPARTMENT OF FORESTS, PARKS & RECREATION
MONTPELIER - VERMONT 05620-3801

STATE OF VERMONT

PHIL SCOTT, GOVERNOR

AGENCY OF NATURAL RESOURCES

JULIE MOORE, SECRETARY

PETER WALKE, DEPUTY SECRETARY

DEPARTMENT OF FORESTS, PARKS & RECREATION

Michael C. Snyder, Commissioner

Sam Lincoln, Deputy Commissioner

Danielle Fitzko, Director of Forests

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 2019

PREPARED BY:

Barbara Schultz, Joshua Halman, and Elizabeth Spinney

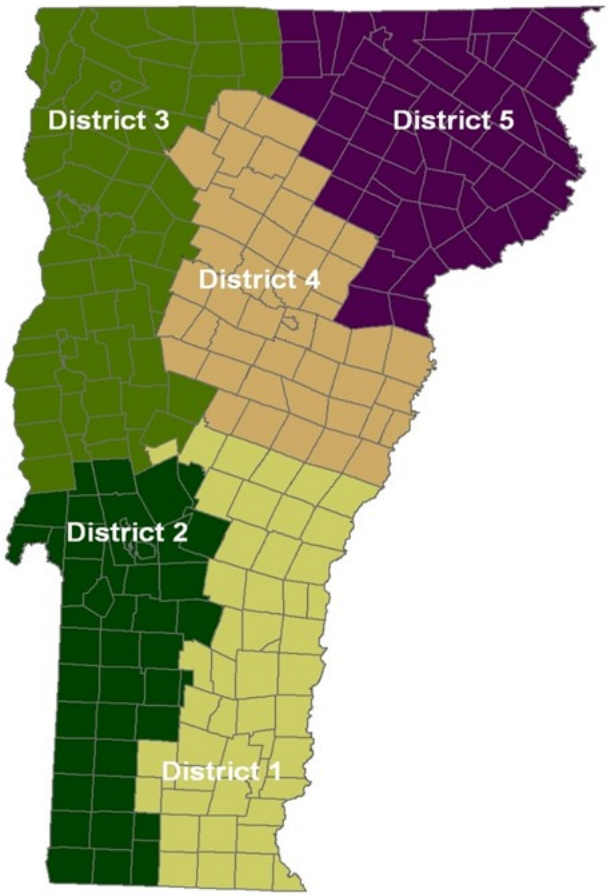
AGENCY OF NATURAL RESOURCES

DEPARTMENT OF FORESTS, PARKS & RECREATION

STATE OF VERMONT – DEPARTMENT OF FORESTS, PARKS & RECREATION
FOREST RESOURCE PROTECTION PERSONNEL

Barbara Schultz Forest Health Program Manager Dept. of Forests, Parks & Recreation 100 Mineral Street, Suite 304 Springfield, VT 05156-3168 Cell Phone: 802-777-2082 barbara.schultz@vermont.gov	**Joshua Halman** Forest Health Specialist Dept. of Forests, Parks & Recreation 111 West St. Essex Junction, VT 05452 Work Phone: 802-279-9999 joshua.halman@vermont.gov	**Elizabeth Spinney** Invasive Plant Coordinator Dept. of Forests, Parks & Recreation 111 West Street Essex Junction, VT 05452-4695 Work Phone: 802-477-2134 elizabeth.spinney@vermont.gov
Savannah Ferreira Forest Health Specialist Dept of Forests, Parks & Recreation VT Agricultural and Environmental Laboratory – Room B26A 163 Admin Drive Randolph Center, VT 05061 Work Phone: 802-565-1585 savannah.ferreira@vermont.gov	**Mary Burnham** Environmental Scientist II Dept. of Forests, Parks & Recreation VT Agricultural and Environmental Laboratory – Room B26A 163 Admin Drive Randolph Center, VT 05061 Work Phone: 802-565-1585 mary.burnham@vermont.gov	

DISTRICT PROTECTION FORESTERS



District 1: Jim Esden
100 Mineral St., Suite 304
Springfield, VT 05156
802-777-1591 (cell)
jim.esden@vermont.gov

District 2: Lars Lund
271 North Main Street, Suite 215
Rutland, VT 05701
802-777-4188 (cell)
lars.lund@vermont.gov

District 3: Dan Dillner
111 West St.
Essex Junction, VT 05452
802-777-3079 (cell)
dan.dillner@vermont.gov

District 4: Jon Cherico
5 Perry St., Suite 20
Barre, VT 05641-4265
802-522-2054 (cell)
jonathan.cherico@vermont.gov

District 5: Emily Meacham
374 Emerson Falls Road, Suite 4
St. Johnsbury, VT 05819
802-595-0169 (cell)
emily.meacham@vermont.gov

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.

Results are summarized from aerial surveys to detect forest damage. Flights covered the entire state to map general forest conditions, and were flown between July 18th—August 27 (7/18, 7/26, 8/1, 8/9, 8/14, 8/20, 8/26, 8/27). This marks a return to the normal target towards the end of the growing season, and is somewhat later than the dates flown in 2016-2018. As a consequence, changes in acres mapped from those years are sometimes due to the survey timing rather than a change in damage incidence.

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

The **Forest Pest First Detector Program** is in its seventh year. In 2019, 20 new volunteers attended Vermont's Forest Pest First Detector Program training, bringing the statewide total of trained volunteers to 154. We thank the many continuing First Detectors, and welcome new volunteers: Bill Baron, John Skutel, Guy Maguire, David Capen, Anne Rodenrys, Julia Lynam, and Nancy Knox.

In response to the arrival of emerald ash borer, we also started training Forest Pest First Detectors to photograph trees suspected of harboring the borer. Ken Parrot, Craig Gardener, Joanne Wood, Mel McKnight, Tom Norton, Jeffrey Cueto, Mark Lembke, Steve Justis, Paul Cate, Sally Thodal, Jock Harvey, Bill Menning, Robert Brandt, Don Dewees, Bob Little Tree, and Michael Quinn, from West Windsor, Bethel, Plainfield, Thetford, E. Montpelier, Chelsea, Middlebury, Londonderry, Huntington, Ludlow, Ferrisburgh, Hartland and Windsor, respectively, were trained to visit and photograph trees in their towns and surrounding areas that are suspected of having emerald ash borer.

Volunteers assisted with deploying and monitoring purple panel traps as part of our **emerald ash borer detection** efforts. Thank you to Tex Aiken, John Azielaszek, Bill Baron, Doug and Mary Burnham, Chris Collier, Nate Cornwell, Bethany Creaser, Al Crist, Mark Dillenbeck, Tim Duclos, Craig Dusablon, Anne Fayen, Bill Foery, Kate Forrer, Michael Gray, Jock Harvey, Jock Irons, Rick LaDue, Bob Little Tree, Sue Lovering, Guy Maguire, Declan McCabe, Mel McKnight, Neil Monteith, Andrew Morrison, Lydia Nuhfer , Roland Payne, Shelby Perry, Susan Sawyer, Dan Steinbauer, Sally Thodal, Jack Travelstead, Allison Turner, Melissa West, Jim White, Brendan Whittaker, and Robert Zimmerman who participated in this project.

Many thanks to all the groups, towns, and organizations who took part in **invasive plant management and outreach** across the state. Huge thanks to AOT VTrans, VT Coverts: Woodlands for Wildlife, Winooski Valley Park District, Master Gardeners, Forest Hero! volunteers, Conservation Commissions, other municipal and private organizations across VT, and many many others who helped to spread the word, not the plant.

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 Chris Chun. Noah Diedrich assisted with outreach at the Southern Vermont Wildlife Festival.

Support in many program areas was provided by 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

Trish Hanson and Neil Monteith, two long-serving staff-members of the Forestry Division, retired from the Forest Resource Protection program in 2019. We are grateful for their contributions to our Forest Health efforts.

Trish started with FPR in 1990, and spent her career serving as head of the Forest Biology Lab. She established the lab as a go-to source of information on insects and tree health in Vermont, fielding many hundreds of inquiries a year. Trish's passion for entomology is contagious, and she was known for going the extra mile when assisting the public, volunteers, and co-workers. Trish produced the popular monthly Insect and Disease Observations and edited this annual report. She also developed the lab's resources, including a comprehensive library and its collection of thousands of invertebrate specimens. After Tropical Storm Irene, recovering the lab's capacity and restoring the collection became a priority, culminating in its recent relocation to the Vermont Agricultural and Environmental Laboratory in Randolph.

Neil retired in late May after working for FPR for over 37 years. Although he assisted with many forest health programs over the years, he officially became a Protection Forester, out of the Barre Office, in 2016. This was in plenty of time to take the lead when emerald ash borer was first detected in Vermont in Orange County. Neil hosted many site visits to "ground zero" and organized initial delineation efforts, bringing his sense of humor to every team he worked with.

TABLE OF CONTENTS

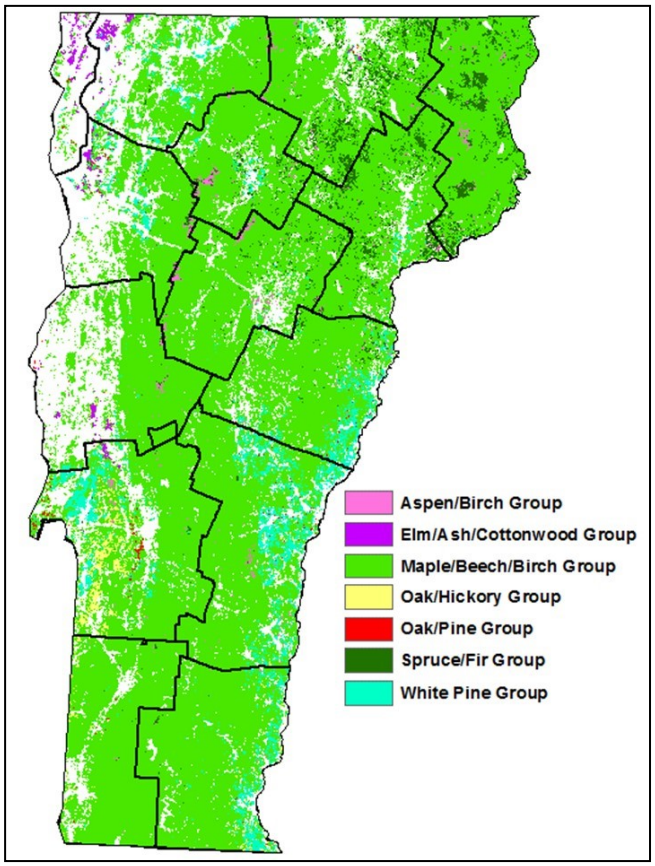
Forest Health VERMONT *highlights* 2019

2019 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 which are not known to occur in the state, 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.



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: http://www.fia.fs.fed.us/tools-data/

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.

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 Agency of Agriculture, Food and Markets (AAFM) collaborate with USDA agencies to survey and manage **non-native forest pests**, and with University of Vermont (UVM) Extension on education and outreach.

In 2019, 76,896 acres of forest damage were sketchmapped during statewide **aerial detection surveys**. This represents less than 2% of Vermont's forest land, and a decrease from the 128,872 acres mapped in 2018. Hardwood discoloration, due to maple leaf cutter and/or anthracnose, and white pine needle damage accounted for 37% and 31%, respectively, of the area mapped.

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. Currently seventeen waivers are in effect for firewood from adjacent counties in New Hampshire, New York, or Massachusetts. Waivers for wood from counties known to have EAB do not allow the importation of untreated ash firewood.

The **Vermont Forest Pest Outreach Program**, implemented by UVM, reached 318 people at workshops, presentations and trainings and an estimated 400,000 people through exhibits, newsletters, radio, newspapers or social media. Efforts included:

- Posting a challenge on the Young Writers website to write about the impact of emerald ash borer (EAB) on Vermont's trees. The three winning pieces were presented at Vermont Arbor Day and made available through Vermont Public Radio, VtDigger, and local newspapers.
- Creating interpretive signs about EAB for museums and nature centers. The signs have visited the Vermont Institute of Natural Science, the Montshire Museum of Science, North Branch Nature Center, the Birds of Vermont Museum and the Southern Vermont Natural History Museum.
- Partnering with the Vermont Department of Libraries to distribute an educational poster about the signs and symptoms of EAB to over 180 libraries.
- Creating an "Online EAB Awareness Toolkit" with DIY activities for Forest Pest First Detectors and other concerned community members to educate homeowners and others about EAB.

Volunteer Forest Pest First Detectors continued to conduct outreach at the Vermont Farm Show and other events.

Loren Young, 12-year old winner of the Young Writers Challenge, read his piece at the Vermont Arbor Day Conference.

EAB interpretive signs were displayed at several locations including the Montshire Museum.

Photos: G. Nickerson

The Forest Biology Lab's insect collection has been restored and moved to the new VAEL in Randolph. Photo: T. Hanson

The **Forest Biology Lab** was relocated to the new Vermont Agricultural and Environmental Laboratory (VAEL) on the campus of Vermont Technical College in Randolph. This new facility reunites multi-agency functions that were dispersed following Tropical Storm Irene in 2011. Concurrently, the restoration of the Forest Biology Lab insect collection reached new milestones. This collection contains at least 1,884 different species of Vermont invertebrates. By moving the collection to 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 and pest management recommendations, and supports education and outreach. In 2019, our inquiries came from all 14 Vermont counties, with highest numbers from Addison, Chittenden and Washington Counties. Three percent of our inquiries were from out-of-state.

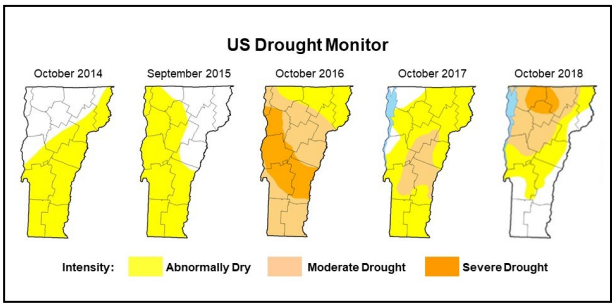
The **Forest Ecosystem Monitoring Cooperative** completed its 29th year of monitoring forest ecosystem health, originally as the Vermont Monitoring Cooperative. Tree condition was evaluated on 48 permanent plots, with crown ratings similar to the long-term average. Other results are available at the FEMC website.

2019 Weather Influences on Forest Health

Winter of 2018-2019 was generally colder and snowier than normal, especially in northern Vermont. With winter snowmelt, and rainfall through the spring and early summer, Vermont was free of abnormal dryness and drought conditions that had been common in recent years. The periodically wet conditions did contribute to windthrow in saturated soils and led to foliage diseases that developed throughout the growing season. Cool conditions prolonged spring development.

Scattered summer storms resulted in tree damage, including late July straight line winds in northwestern Vermont and an August tornado in the town of Windham.

Dry conditions started to develop by mid-August. By the end of September most of the state was rated as abnormally dry and had experienced some frost. With the moderately dry conditions, sunny fall days, and just enough cold, trees with the capacity to turn red displayed brilliant fall colors.



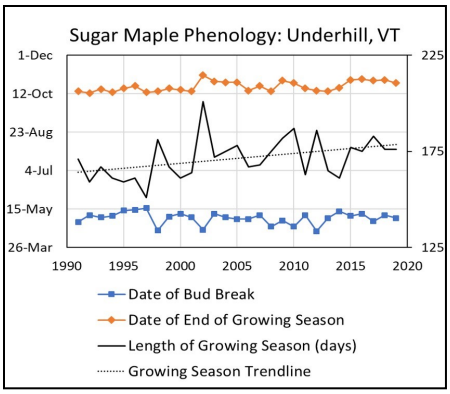
Periodic dry conditions since 2014 continue to impact tree health. Map: NOAA/USDA/NDMC http://droughtmonitor.unl.edu/

Although growing conditions in 2019 were generally good, trees did not "forget" the drought of 2016, the late-season dry conditions in 2017, and the prolonged period of warm, dry weather in 2018. This period of stressful growing conditions continued to be a major driver of tree health and ability to recover from other stressors.

This was a good year for spring flowering species. With an off-year for fruiting in 2018, trees were ready for a seed year, and prolonged cool weather helped flower retention. The result was a **heavy seed crop** on many species, including red, silver, and sugar maple, yellow birch, red oak, beech, hophornbeam and white cedar. White ash was notably absent from the list of 2019 heavy seed producers.

Copious flower production and heavy seed were present on a variety of trees, including sugar maple. Photo: L. Lund

Moderately dry conditions and sunny days brought out the fall reds in red maple and other species. Photo: B. Schultz



We continue to monitor **phenology** for the timing of budbreak, leaf out, fall color and leaf drop. Sugar maple bud expansion matched the long-term average in 2019, with budbreak occurring on May 3. Full leaf-out stalled, however, and occurred 6 days later than average. The timing of peak fall color was close to average for most species. Color development was initially slow. Partially due to multiple high-wind events, full leaf drop occurred rapidly following peak. Based on sugar maple phenology, the total growing season was five days longer than the long-term average.

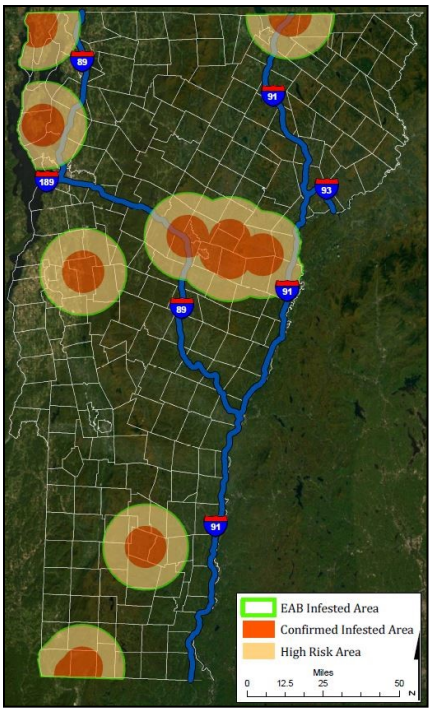
Sugar maple phenology monitoring indicates that 2019 continued the trend of longer growing seasons.

Hardwood Insects and Diseases

New detections of emerald ash borer (EAB) continued in 2019. As a result, EAB has now been confirmed in ten Vermont towns in eight counties. The sudden eruption of EAB detections in Vermont may be related to the recent dry growing seasons. Although EAB infests healthy ash trees, it is especially successful in stressed trees.

Suspects were reported in Bristol, Derby, and Londonderry by individuals with professional connections to plant health. Because each represented a new county for EAB, insect identification was confirmed by a USDA APHIS identifier. EAB beetles were collected from two different purple traps in Alburgh, making it the second confirmed town in Grand Isle County. These were among the 78 traps deployed by volunteers in 30 towns throughout the state. EAB was not collected from any of the other traps.

The EAB detections in Alburgh were found by volunteers using purple prism traps, similar to this one maintained by Forest Pest First Detector Bob Little Tree in Hartford. Photo: G. Nickerson



Maps indicating known EAB infested areas in Vermont are available 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. We know that 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 85 towns in thirteen counties. The infested areas are also available for download on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/.

Applying Slow the Spread Recommendations to the mapped Infested Area reduces the risk of spreading EAB and provides time to conduct management activities. While high risk areas include many towns, visibly infested trees still remain rare in Vermont and there's a lot of spread to slow. One change to these recommendations in 2019 was to redefine the EAB flight season as June 1st – September 30th. After looking at weather records from locations throughout the state, and considering growing degree day models, it was determined that EAB beetle emergence will not actually begin until June in Vermont.

The mapped EAB Infested Area extends ten miles from known EAB locations. There is a high risk of spreading EAB when moving ash from these locations unless Slow the Spread Recommendations are followed.

EAB is difficult to find when it first infests a new location because it is under the bark and often high in the trees. Photo: J. Nunery

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. The following resources are available to assist in slowing the spread of EAB and managing threatened resources.

Recommendations to Slow the Spread of EAB:

Moving Ash from the Infested Area: How and when it is safe to move ash forest products originating from the infested area.

Ash Processing Options: Treatments and processing measures that make ash wood material safe to move at any time of year.

For Forest Landowners: How landowners can avoid spreading EAB when conducting management activities.

For Tree Care and Clearing: How to safely handle ash material resulting from tree care, land clearing, ROW maintenance, and similar activities.

Transporting Ash Wood Products into Vermont Safely and Legally: How and when it is safe to move ash forest products originating from outside Vermont.

Information for Homeowners and Municipalities

Homeowner's Guide to Emerald Ash Borer: Information to help decide what to do about ash trees at risk.

Options for Protecting Ash Trees from EAB with Insecticide Treatments: When to consider insecticide and guidelines for having trees treated.

Community Planning: Goes to VT Urban & Community Forestry's EAB Management website.

Information for Forest Landowners and Managers

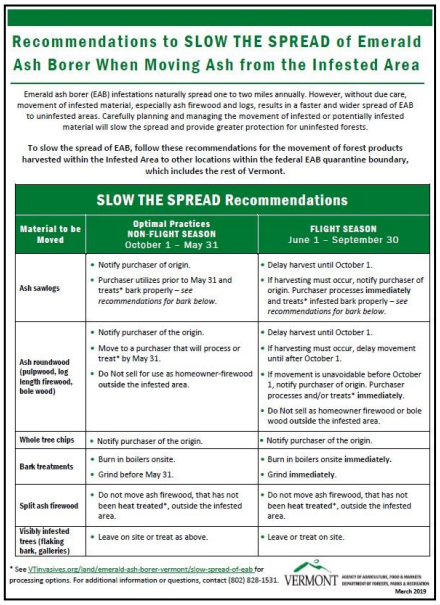
Emerald Ash Borer: Information for Forest Landowners

Ash Management Guidance for Forest Managers

UVA Policy on Forest Management Plans and Amendments

Trap Tree Protocol for Forest Landowners: How to implement the most effective technique for early detection of EAB on a property.

Recommendations for preventing unintended movement of EAB and information about ash management are available at https://vtinvasives.org/land/emerald-ash-borer-vermont.



Recommendations to SLOW THE SPREAD of Emerald Ash Borer When Moving Ash from the Infested Area

Emerald ash borer (EAB) infestations naturally spread one to two miles annually. However, without due care, movement of infested material, especially ash firewood and logs, results in a faster and wider spread of EAB to uninfested areas. Carefully planning and managing the movement of infested or potentially infested material will slow the spread and provide greater protection for uninfested forests.

To slow the spread of EAB, follow these recommendations for the movement of forest products harvested within the Infested Area to other locations within the federal EAB quarantine boundary, which includes the rest of Vermont.

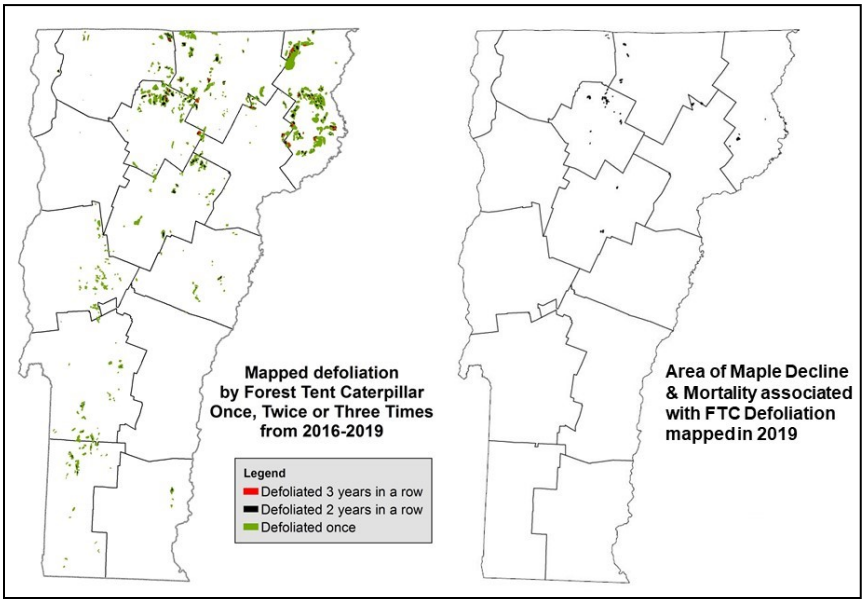
SLOW THE SPREAD Recommendations

Material to be Moved	Optimal Practices NON-FLIGHT SEASON October 1 – May 31	FLIGHT SEASON June 1 – September 30
Ash sawlogs	• Notify purchaser of origin. • Purchaser utilizes prior to May 31 and treats* bark properly – *see recommendations for bark below.*	• Delay harvest until October 1. • If harvesting must occur, notify purchaser of origin. Purchaser processes immediately and treats* infested bark properly – *see recommendations for bark below.*
Ash roundwood (pulpwood, log length firewood, bole wood)	• Notify purchaser of the origin. • Move to a purchaser that will process or treat* by May 31. • Do Not sell for use as homeowner-firewood outside the infested area.	• Delay harvest until October 1. • If harvesting must occur, delay movement until after October 1. • If movement is unavoidable before October 1, notify purchaser of origin. Purchaser processes and/or treats* immediately. • Do Not sell as homeowner firewood or bole wood outside the infested area.
Whole tree chips	• Notify purchaser of the origin.	• Notify purchaser of the origin.
Bark treatments	• Burn in boilers onsite. • Grind before May 31.	• Burn in boilers onsite immediately. • Grind immediately.
Split ash firewood	• Do not move ash firewood, that has not been heat treated*, outside the infested area.	• Do not move ash firewood, that has not been heat treated*, outside the infested area.
Visibly infested trees (flaking bark, galleries)	• Leave on site or treat as above.	• Leave or treat on site.

* See VTinvasives.org/land/emerald-ash-borer-vermont/slow-spread-of-eab for processing options. For additional information or questions, contact (802) 828-1531. VERMONT

March 2019

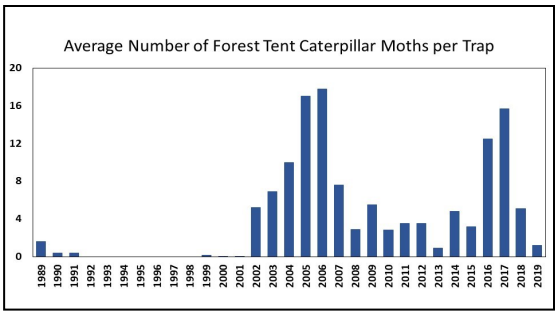
Forest Tent Caterpillar (FTC) defoliation plummeted, with only 537 acres of defoliation mapped in 2019, compared to 71,315 acres in 2018. In all, 156,718 acres were defoliated at least once since 2016. Defoliation data are available on the ANR Natural Resources Atlas. In late 2018 and early 2019, egg mass surveys were conducted in 16 sugarbushes. Only one was identified as at risk of defoliation. No landowners chose to have their properties treated.



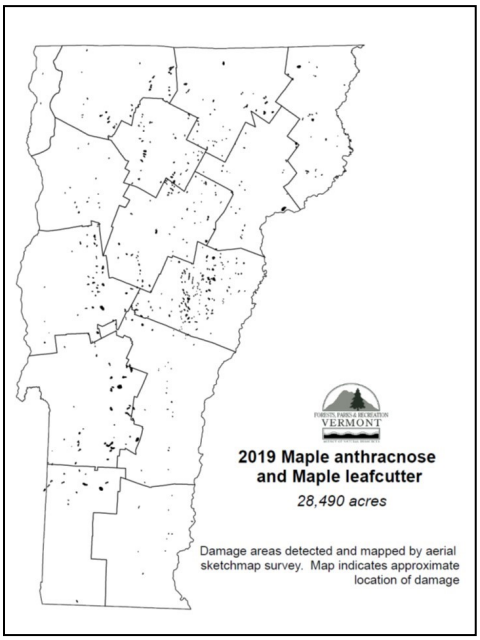
Despite the drop in acres defoliated, the impacts of this outbreak persist. In 2019, we mapped 3,438 acres with dieback or mortality attributed to FTC, in addition to the 4,500 acres mapped in 2018. This is likely the result of repeated years of defoliation, dry growing conditions, and minimal refoliation. Ground evaluations were conducted at four of these sites. More than 69% of sugar maples had at least 50% crown damage. Sugar maple mortality averaged 37%.

Since 2016, 156,718 acres were defoliated at least once by forest tent caterpillar. Maple decline and mortality have been detected in some locations which had been defoliated.

Pheromone traps for FTC were deployed statewide in mid-summer. The number of moths per trap averaged 1.2, a drop from 15.7 at the height of this outbreak. Coupled with the decrease in acres defoliated, this suggests that the outbreak has come to a close.



The recent forest tent caterpillar outbreak appears to be over based on 2019 moth counts as well as on the drop in acres defoliated.



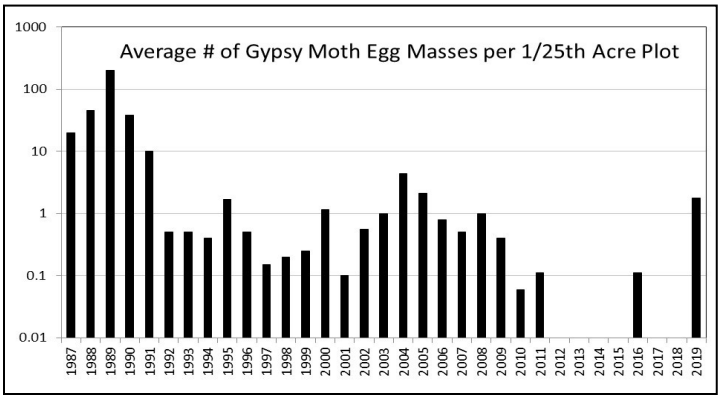
Hardwood foliage symptoms mapped late in the season were caused by a variety of factors, mostly affecting sugar maple. Photo: L. Lund

Thin hardwood crowns and foliage browning were mapped on 28,490 acres in mid-late summer, with a variety of factors responsible. **Maple leaf cutter** populations were very high again this year and led to brown patches of sugar maple at mid-elevations. Maple leaf cutter feeding was also noticeable on yellow birch and beech. Some hardwood browning was due to **anthracnose** and other fungi that infected leaves emerging during wet periods in the spring. The **heavy seed** crop also contributed to the observed symptoms, resulting in unusually small upper-crown leaves which dropped prematurely.

Top: Maple leaf cutter damage led to brown hillsides at mid-elevations. Photos: J. Halman, E. Meacham

Bottom: Anthracnose and heavy seed also contributed to hardwood browning. Photos: J. Esden, B. Schultz

While there were only a few reports of **gypsy moth** caterpillar feeding, egg masses were much more noticeable than normal and counts increased in monitoring plots. While populations are collapsing in southern New England, it's possible they will increase next year in Vermont.



Gypsy moth populations may be increasing, based on egg masses sightings and counts in monitoring plots. Photo: A. Wild

Several other hardwood defoliators also attracted attention. **Fall webworm** defoliation was locally very heavy on cherries and ash along road edges and open areas. The unique feeding pattern of **oak shothole leafminer** was observed throughout the range of red oaks.

By early summer, red oak injury by oak shothole leafminer was widely observed. Later in the season, fall webworm nests were more conspicuous than usual. Photos: R. Skinner, R. Kelley

Light feeding by **saddled prominent** caterpillars was reported mostly in southern Vermont. Our outbreaks have a history of following forest tent caterpillar outbreaks, so it would not be a surprise if this insect is on the rise. Outbreaks often develop suddenly and disappear just as quickly.

To determine if saddled prominent is of concern in 2020, look for caterpillars starting in July. Photo: R. Kelley

Early leaf drop of white ash is attributed to late season dry conditions. Photo: B. Schultz

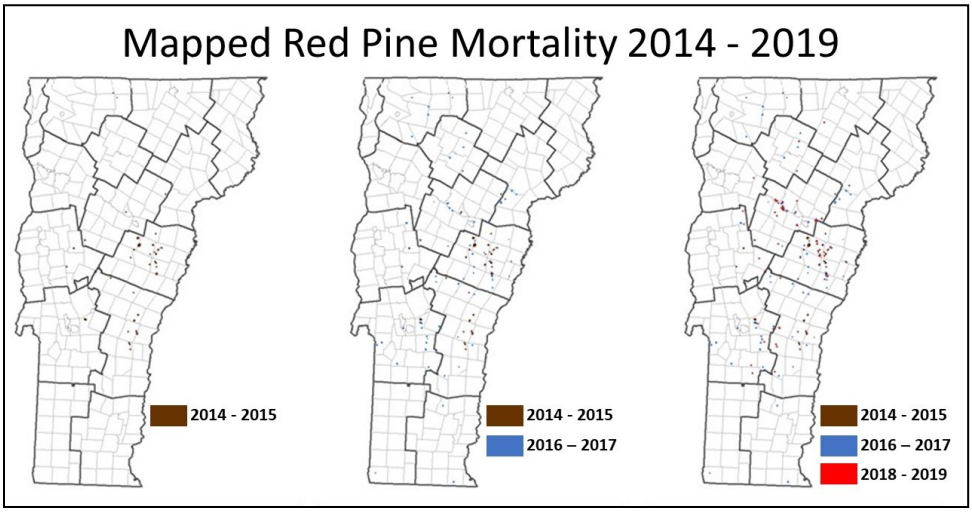
We received multiple reports of **thin black cherry crowns** during the summer. Intact leaf drop had been observed by early July. The cause is unknown. Late-summer **leaf drop of white ash** was even more widespread. Dry conditions that began in August are a likely explanation.

Beech bark disease symptoms were mapped on 15,073 acres. Casual observations indicate that beech scale is more prevalent, possibly due to recent winters without prolonged cold snaps. Dry late summer and fall weather also benefited scale survival and dry bark is more susceptible to canker fungi.

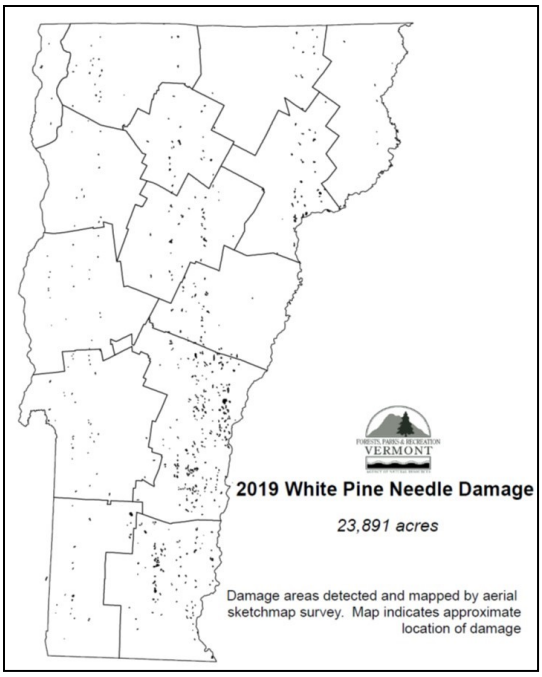
Dry late-summer and fall weather favors beech scale crawler survival. Photo: R. Kelley

Softwood Insects and Diseases

Reports of **red pine mortality** continued in 2019, with 556 acres mapped, scattered in seven counties. While the expanding pattern of the mortality is consistent with a non-native organism, the cause remains unknown. Repeated examinations of symptomatic branches have only found widely established insects and diseases, such as Diplodia and Sirococcus shoot blights and pine gall weevil damage. The exotic insect, red pine scale, has not been detected in Vermont since 2015, when it was only found in two locations. We are beginning to establish monitoring plots to track crown changes in affected stands.

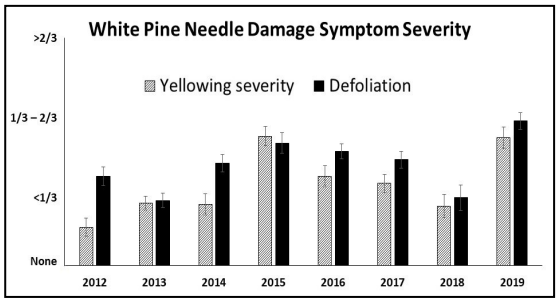


The cause of red pine mortality remains unknown, although the expanding pattern is consistent with a non-native organism. Photo: B. Schultz

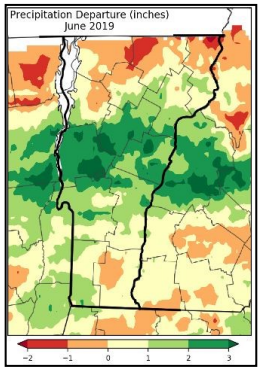


White pine needle damage (WPND) was widespread with 23,891 acres mapped during aerial surveys. WPND has been a regional problem since 2010, attributed to a complex of fungal pathogens.

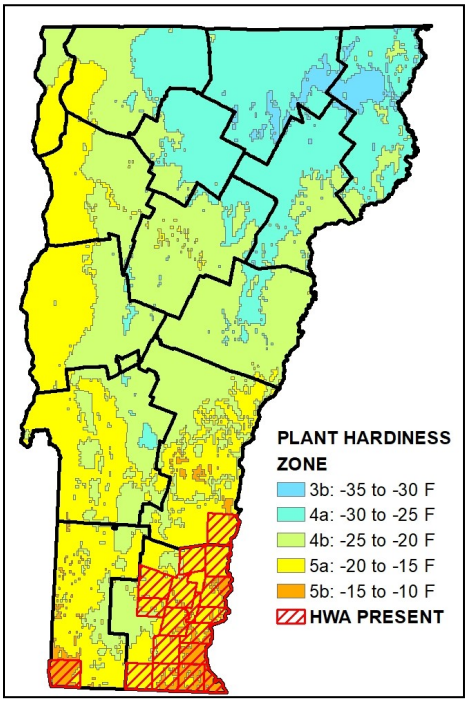
In 2019, symptoms were not noticeable until mid-June, which is later than other years. Regionally, WPND severity in monitoring plots was higher than in any year since 2012; Vermont data follow this trend. Needle damage generally affects the same trees each year, and some are now exceedingly thin. Decline and mortality of white pine have been observed in stands which have had multiple years of WPND and where other stress factors are present.



WPND severity is linked to the amount of humidity when spores were produced the previous year. This is between May and August, generally peaking during shoot elongation in June. As a result of this year's weather, we expect WPND again in 2020.

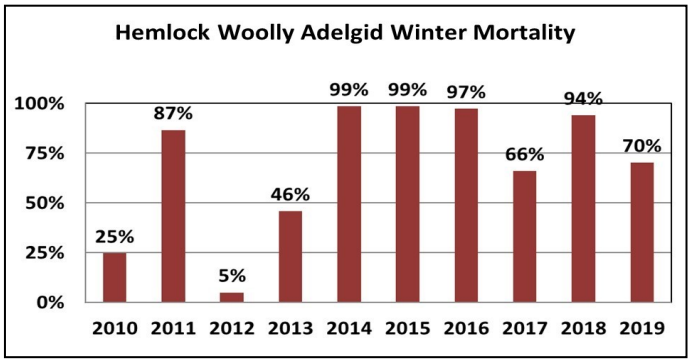


White pine needle damage was mapped on 23,891 acres. Symptoms in Vermont plots were the most severe since monitoring began in 2012. In these plots, some trees are consistently more symptomatic every year than other trees. Because infection peaks during shoot elongation in June, which was wetter than normal this year, we expect WPND to continue in 2020. Photo: B. Schultz. Precipitation map: NE Regional Climate Center



Vermont's **hemlock woolly adelgid** (HWA) infestation remains primarily in Windham County, with small spots in Springfield and Pownal. Traditionally infested sites are still infested, but no spread was documented in 2019. Insect populations were sparse all year despite a lower winter 2018-19 mortality rate of only 70%. The impact of several heat waves through the summer may be part of the explanation.

The leaflet Hemlock Woolly Adelgid in Vermont: Recommendations for Landowner Response was updated due to changes in Vermont's neonicotinoid pesticide rules and our developing understanding of the insect.

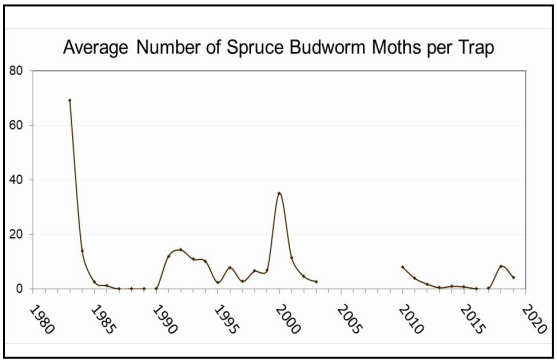


To augment biocontrol efforts that began in 2009, 510 *Laricobius nigrinus* predatory beetles were released in November at a site in Brattleboro. Beetles have also been released in Guilford and Pownal.

Vermont's HWA infestation remains centered in Windham County, with no expansion to new towns detected in 2019. This was in spite of a lower HWA mortality rate in winter 2018-19, which dropped to 70%.

Compounding the risk to hemlock, the incidence of **elongate hemlock scale** seems to be on the rise in southern Windham County due to natural spread. In addition, it has been occasionally been found on nursery-grown trees over the past 20 years. In 2019, an infested balsam fir planting in Charlotte was treated in an effort towards eradicating that introduction.

Elongate hemlock scale is increasingly noticeable in Windham County. It has been occasionally found elsewhere on planted fir and other hosts. Photo: B. Guenther



We're continuing to see fir mortality due to **balsam woolly adelgid** (BWA) in natural stands and ornamental trees, although the mapped acreage is declining. Mild winters have allowed this insect to build up. Signs of BWA are often absent by the time tree mortality occurs.

While **spruce budworm** continues to cause widespread defoliation in eastern Canada, the number of moths captured in Vermont pheromone traps this summer remained low.

Spruce budworm moth trap catches remain low.

Exotic Forest Pests Threatening Vermont

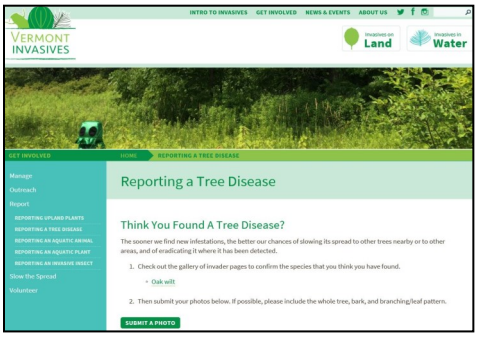
The **common pine shoot beetle** has been found in many Vermont counties since it was detected in the state in 1999. By federal quarantine, pine material is free to move within Vermont and through most of the region. The USDA has recently proposed lifting this quarantine. See Pine Shoot Beetle Quarantine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

We do not currently suspect **oak wilt** anywhere in Vermont. However, Vermont is participating in a regional oak wilt survey because new locations are being detected in New York state. If you have seen a tree with symptoms that match oak wilt, please visit vtinvasive.org's Report it so we can follow up on your observation. For more information: https://www.vtinvasives.org/invasive/oak-wilt.

Beech leaf disease is also of increasing concern with recent detections in Connecticut and southeastern New York. For more information on identifying the disease, see this Forest Health Pest Alert.

Asian longhorned beetle 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, spotted lanternfly, and the agents that cause thousand cankers disease.



Vermont is participating in a multi-state effort to detect oak wilt, which has been confirmed in multiple locations in New York. Symptoms are sudden. The entire crown is affected within weeks or months, and red oaks will be dead by the following spring. Please report suspect trees through vtinvasives.org. Photo: B. Schultz

Middle school student-volunteers learned how to use a weed wrench from FPR staff in Richmond. Since 2018, 1,110 students from more than 20 schools have participated in a hands-on program to learn about non-native invasive plants. Photo: E. Spinney

Non-Native Invasive Plant Programs

Non-native invasive plant (NNIP) management efforts continued in 2019, with progress on control, outreach and education made possible through several grant funded opportunities. FPR's Invasive Plant Coordinator and Habitat Restoration Crew led 47 workshops and the Coordinator fielded over 300 inquiries about invasive plants. Since 2014, 3,810 volunteers have assisted with direct management of NNIP in Vermont.

A program for middle and high school groups continued this year. Since 2018, 1,110 students from over 20 different schools learned about invasive plant identification and ecosystem impacts and participated in a hands-on experience removing them.

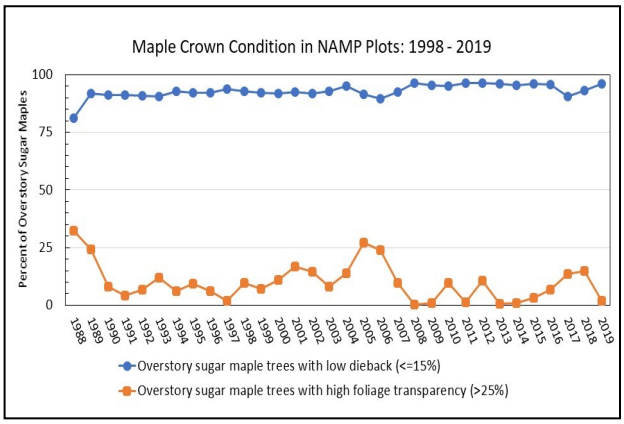
The Forest Hero! Network was established in late 2018 to provide training and support for local leaders working to motivate citizens in their communities to engage in non-native invasive plant management. The network is a collaboration between Vermont Coverts, FPR and VTinvasives.org. Thirty people completed the training, with four sessions conducted between October 2018 and October 2019.

Forest Hero! Network volunteers learn about how to teach plant identification. Photo: L. Thornton

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, 96% of overstory sugar maples were rated as healthy (less than 15% dieback), which is slightly higher than in 2018 (93%). There was a decrease in trees with thin foliage (2%) attributed to the end of the forest tent caterpillar outbreak and more available water during the growing season. The decrease in dieback coupled with less transparent foliage suggests improved sugar maple health statewide.

UrbanFIA work continued for the fourth year in Vermont. 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 UrbanFIA program, targeting urban areas statewide rather than focusing on a single metropolitan area. In 2019, all plots were completed by the end of June through the combined efforts of the US Forest Service, FPR, and the Forest Ecosystem Monitoring Cooperative. Data are collected on a seven year cycle, after which a statewide report will be published.



Sugar maple crown condition improved in maple health monitoring plots. Trees are recovering from successive dry years and forest tent caterpillar defoliation.

FORESTS, PARKS & RECREATION VERMONT
AGENCY OF NATURAL RESOURCES

For more information, contact the Forest Biology Laboratory at 802-565-1585 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.

2019-11

FIGURES AND TABLES

Figures

FIGURES AND TABLES

Tables

2019 PUBLICATIONS & OUTREACH

Hanson T, Bohne M. 2019. Vermont Buprestidae Survey. v1.5. Vermont Center for Ecostudies. Dataset/Occurrence. http://ipt.vtecostudies.org/ipt-2.3.5/resource?r=buprestidae&v=1.5

Michael J. Bohne, Claire E. Rutledge, Trish Hanson, Nichole C. Carrier, Colleen Teerling, et. al. 2019. Utilizing Prey Captures by Cerceris Fumipennis Say (Hymenoptera: Crabronidae) for a Survey of Buprestidae (Coleoptera) in New England, USA. The Coleopterists Bulletin, 73(2) : 369-379. https://doi.org/10.1649/0010-065X-73.2.369

Spinney, E. 2019. Vermont Native Plant vs. Invasive Plant Look-a-likes: Invasive honeysuckles vs. native honeysuckles. Membership Newsletter: Vermont Woodlands Association and Vermont Tree Farm. vermontwoodlands.org. pp 7-8. March 2019.

Spinney, E. Vermont Native Plants vs. Invasive Plant Look-a-likes: Invasive Porcelainberry vs. native grapes. Membership Newsletter: Vermont Woodlands Association and Vermont Tree Farm. vermontwoodlands.org. pp 6-7. June 2019.

Spinney, E. Vermont Native Plants vs. Invasive Plant Look-a-likes: Invasive Lesser celandine vs. native marsh marigold. Membership Newsletter: Vermont Woodlands Association and Vermont Tree Farm. vermontwoodlands.org. September 2019.

Spinney, E. Vermont Native Plants vs. Invasive Plant Look-a-likes: Native Phragmites vs. Invasive Phragmites. Membership Newsletter: Vermont Woodlands Association and Vermont Tree Farm. vermontwoodlands.org. December 2019.

Trish Hanson, Mary R. Burnham, Michael J. Bohne, and E. Richard Hoebeke. 2019. New State Records of Non-Target Buprestidae (Coleoptera) Detected in Emerald Ash Borer Traps in Vermont, USA. The Coleopterists Bulletin, 73(3) : 757-760. https://doi.org/10.1649/0010-065X-73.3.757

Vermont Department of Forests, Parks & Recreation. 2019. 2019 Vermont Forest Health Highlights. Vermont Forest Health Leaflet 2019-11. 10pp. Available at vtforest.com. December 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Ash Management Guidance for Forest Managers. Vermont Forest Health Leaflet 2019-02. 5pp. Available at vtforest.com. March 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Emerald Ash Borer: Information for Vermont Landowners. Vermont Forest Health Leaflet 2019-01. 4pp. Available at vtforest.com. March 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Hemlock Woolly Adelgid in Vermont: Recommendations for Landowner Response. Vermont Forest Health Leaflet 2019-7. 4pp. Available at vtforest.com. October 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations -April 2019. Vermont Forest Health Leaflet 2019-03. 6pp. Available at vtforest.com. April 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations -May 2019. Vermont Forest Health Leaflet 2019-04. 8pp. Available at vtforest.com. May 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations -June 2019. Vermont Forest Health Leaflet 2019-05. 10pp. Available at vtforest.com. June 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations -July 2019. Vermont Forest Health Leaflet 2019-06. 10pp. Available at vtforest.com. July 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations -August 2019. Vermont Forest Health Leaflet 2019-8. 9pp. Available at vtforest.com. August 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Insect and Disease Observations - September 2019. Vermont Forest Health Leaflet 2019-9. 8pp. Available at vtforest.com. September 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Invasive Honeysuckle vs. Native Honeysuckles. Vermont Invasives e-newsletter. vtinvasives.org. March 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Season Highlights: Invasive Plant Management in VT. Vermont Invasives e-newsletter. vtinvasives.org. January 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Spotlight: Japanese Barberry. Vermont Invasives e-newsletter. vtinvasives.org. July 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Spotlight: Amur Maple. Vermont Invasives e-newsletter. vtinvasives.org. September 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Spotlight: Common Buckthorn. Vermont Invasives e-newsletter. vtinvasives.org. November 2019

Vermont Department of Forests, Parks & Recreation. 2019. Tree Condition in Maple Sugaring Sites on State Lands: Results for 2019. Vermont Forest Health Leaflet 2019-10. ?pp. Available at vtforest.com. October 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Tree Condition in Maple Sugaring Sites on State Lands: Results for 2019. Vermont Forest Health Leaflet 2019-11. 10pp. Available at vtforest.com. December 2019.

Vermont Department of Forests, Parks & Recreation. 2019. Watch List Species Highlight: Multiflora Rose. Vermont Invasives e-newsletter. vtinvasives.org. May 2019.

WEATHER

2019 Weather Summary

Winter 2018 – 2019

Temperatures for meteorological winter (December to February) were generally average throughout Vermont. Total precipitation was above normal in western Vermont, and below normal in northeastern Vermont. Starting in January, there was adequate snow cover to protect roots, and there were no extended periods of extreme cold. According to the U.S. Drought Monitor, parts of the state were abnormally dry going into the winter, but by mid-January, the state was free of abnormal dryness.

After a cold and snowy November 2018, which led to some some dieback of sensitive shrubs in northern Vermont, December was unusually warm and also wet. Cold temperatures returned in January, which were mostly average or slightly below in most of the state. January also brought above average snowfall statewide, especially in northern Vermont, with a storm on January 19-21 breaking some local records. February temperatures were generally average, while March was colder than normal.

Spring 2019

Spring conditions were generally good for tree growth. There were no premature warm temperatures or significant late frosts. April was wetter than normal. Although rainfall was less uniform in May and June, most of the state, except a few areas mostly in the northeast and southeast, ended the season with above-average precipitation.

The saturated April soils along with windy days resulted in noticeable windthrow in some areas. May included cool, wet episodes, including a mid-May nor'easter that brought four inches of snow to parts of the state. June was also colder and wetter than normal. These conditions while leaves were developing allowed foliage diseases to develop. They also slowed spring development, with red oak foliage retaining a reddish tinge well into June.

Spring brought prolific flowering of many species. Although this was partly predetermined in 2018, the lack of extreme winter temperatures helped by preventing bud kill. In addition, the prolonged cool temperatures in spring allowed trees to retain a full complement of blossoms for a longer period of time.

Summer 2019

On top of ample spring rainfall, the summer of 2019 provided a reprieve from recent years of abnormal dryness and drought. No part of the state reached drought conditions. However, July was drier and hotter than average; although August and September returned to average temperatures, abnormal dryness began to appear in parts of the state in mid-August and was widespread by late September.

There were tree-damaging storms over the summer, including severe thunderstorms with straight-line winds on July 30 and 31 impacting Chittenden, Addison, Franklin and Grand Isle counties and August 17 thunderstorms in Rutland and Windsor counties. On August 21, a tornado in the town of Windham covered a swath of nearly 100 acres.

Fall 2019

By the end of September, most of the state had experienced a frost. With sunny days and colder nights into early October, the weather set the stage for excellent red colors. The colored leaves did not persist for long, since windstorms and rain in mid-October led to sudden leaf drop. There had been a lot of earlier leaf drop on ash, which is particularly sensitive to dry conditions.

Generally, precipitation and temperature in October were above average. As in 2018, full-on winter started in November, with below average temperatures (including some record-breakers) and snow cover ear-

ly in the month. The trend did not continue into December, which had mostly normal temperatures. The largest snow event in December was restricted to Bennington and Windham counties. While there was snow covering most of the state by the end of the year, depths were sometimes minimal.

Birch, white cedar, and red, silver and sugar maples had heavy seed years. Acorn production was more uneven but was very heavy in some areas.

Figures 1-9 *and* ***Tables 1-3*** *provide details on 2019 precipitation and phenological observations.*

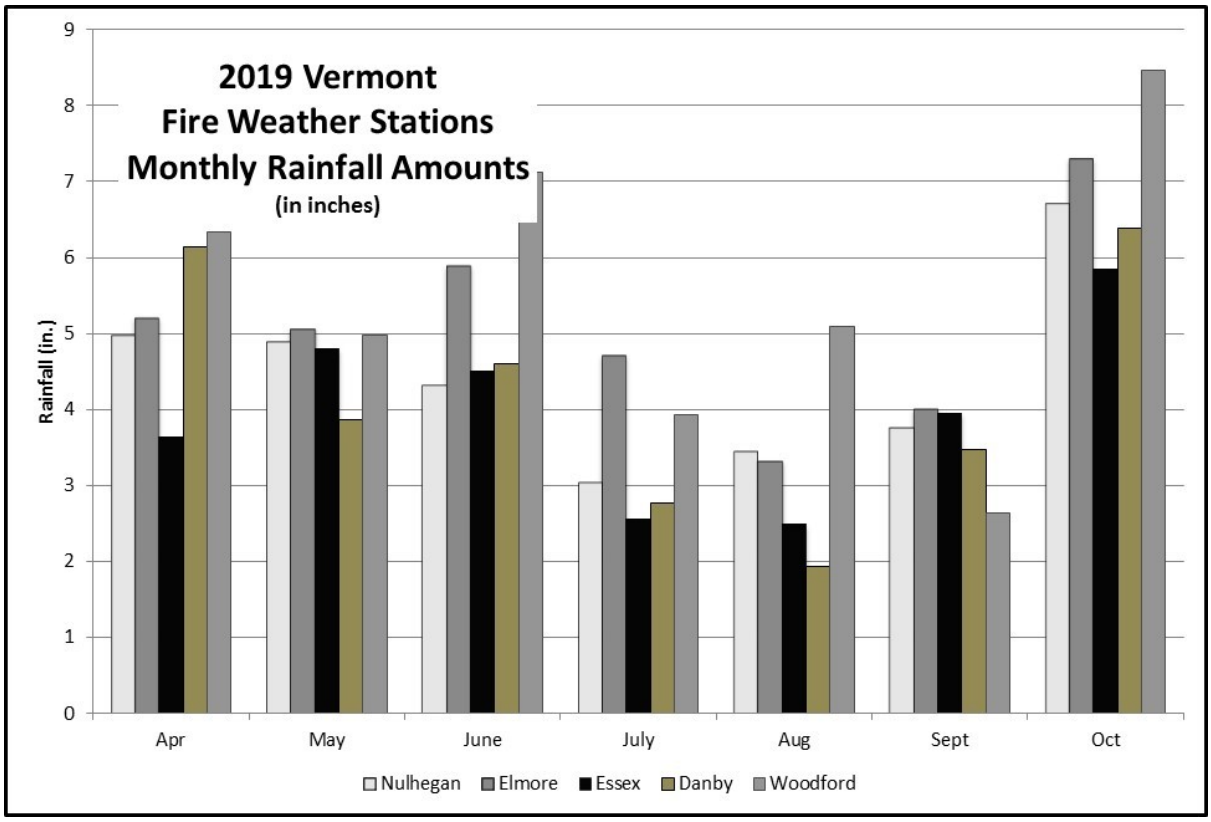


Figure 1. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, April-October, 2019.

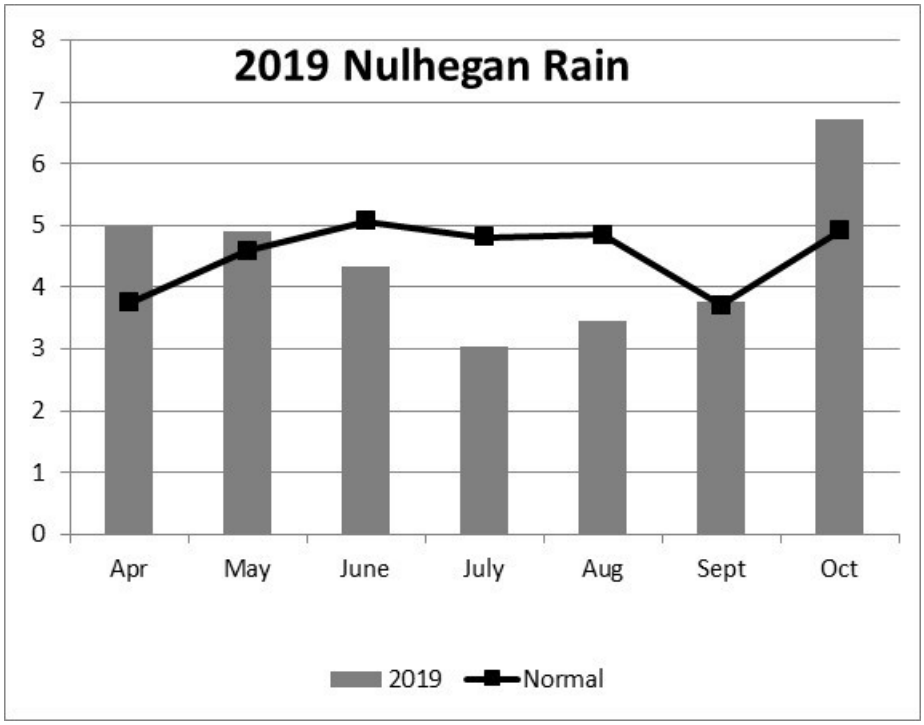


Figure 2. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, VT compared to normal during the fire season, April-October, 2019. Normal is based on 17 years of data.

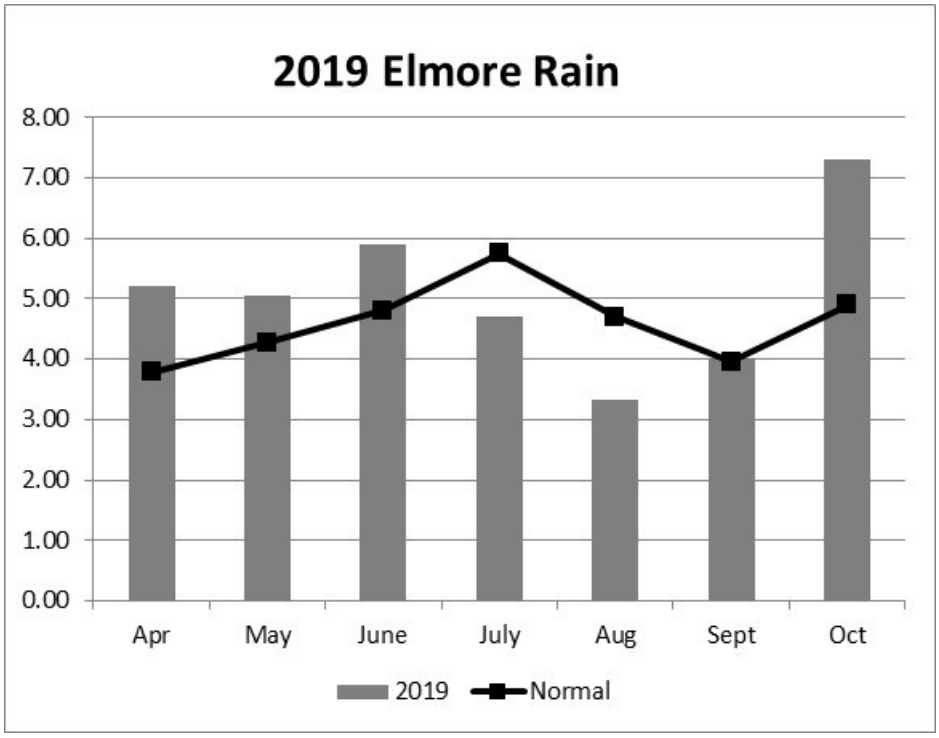


Figure 3. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, VT compared to normal during the fire season, April-October, 2019. Normal is based on 25 years of data.

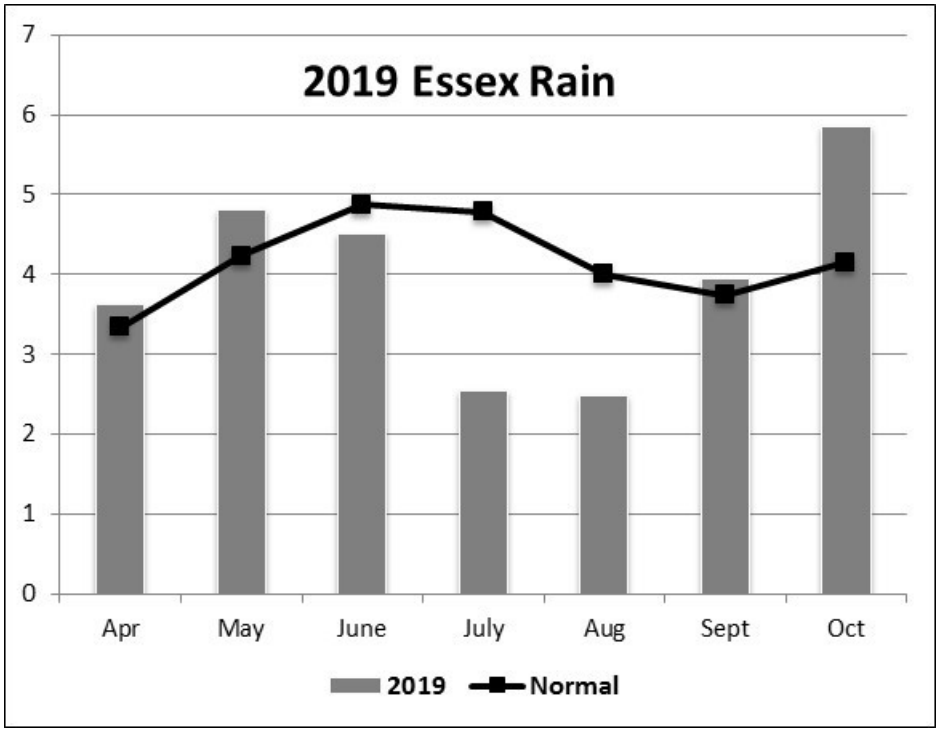


Figure 4. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, VT compared to normal during the fire season, April-October, 2019. Normal is based on 26 years of data.

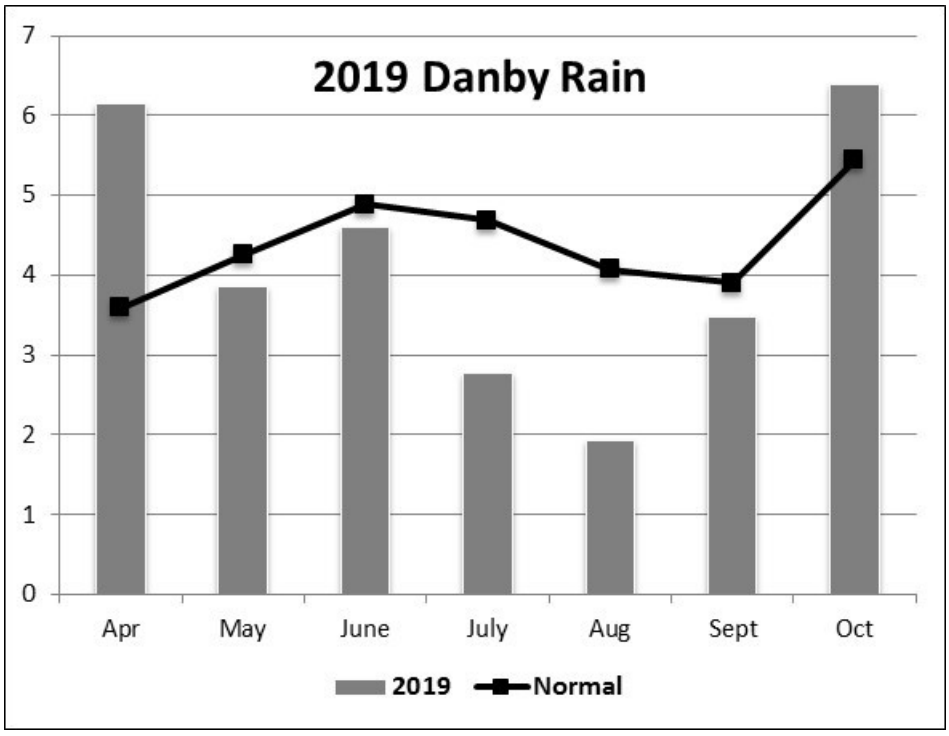


Figure 5. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal during the fire season, April-October, 2019. Normal is based on 19 years of data.

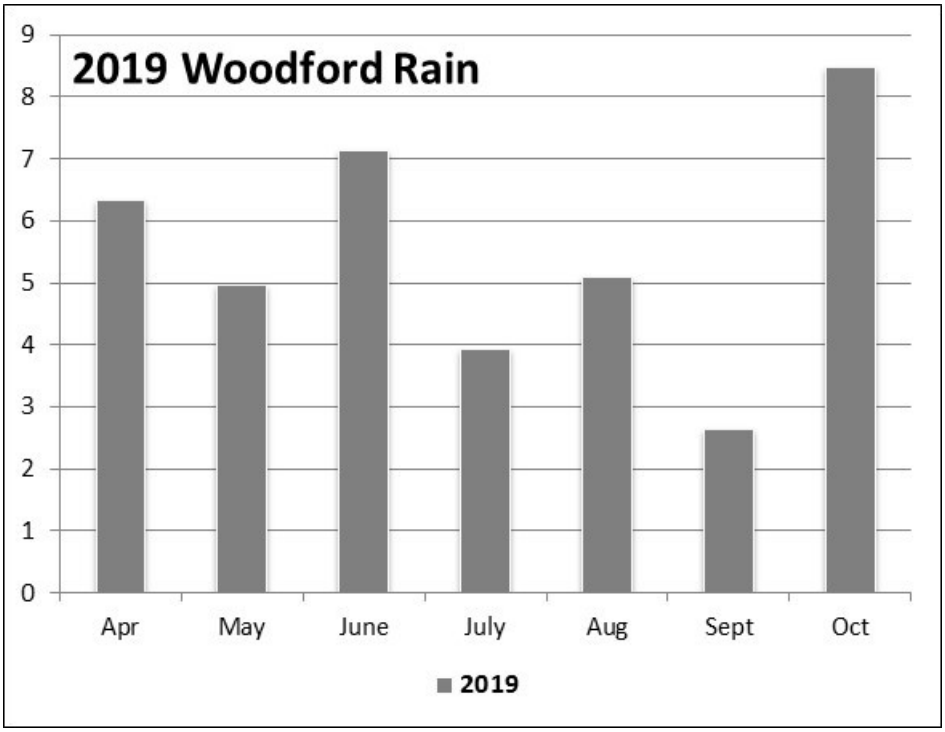


Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont during the fire season, April-October, 2019. The Woodford weather station was initially installed in 2013. Normal for this site is not yet established.

PHENOLOGY

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. Sugar maple bud expansion was right on track with the long-term average in 2019, with budbreak occurring on May 3. Full leaf-out stalled, however, and occurred 6 days later than the long-term average (Figure 7). This was a heavy flowering year for sugar maples as well.

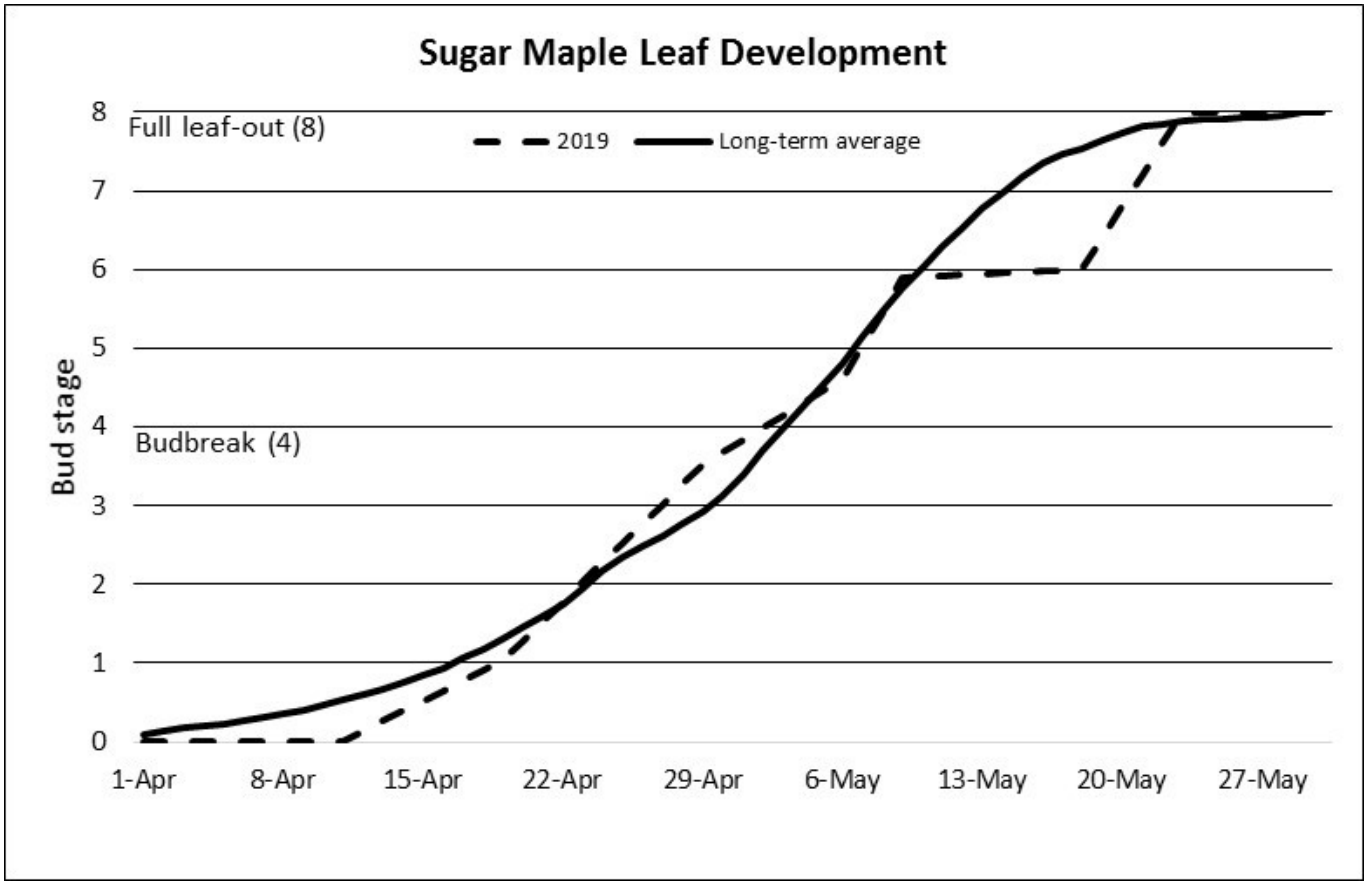


Figure 7. Sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

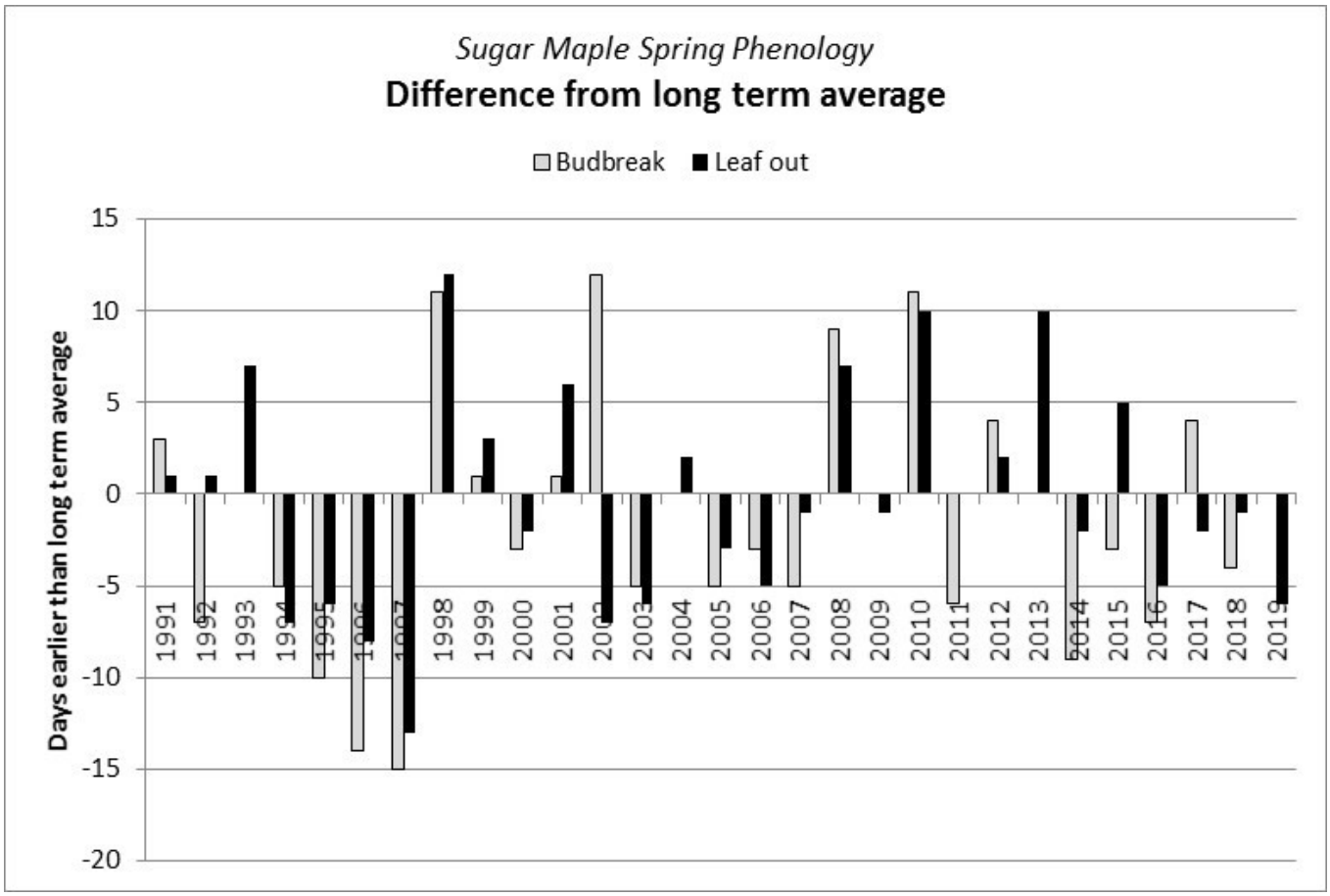


Figure 8. Difference from long-term average of sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

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 percent of trees 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 was similar to the long-term average in 2019. Color development was initially slow, but full leaf drop occurred rapidly following peak, in part due to multiple high-wind events. Growing season length was five days longer than the long-term average (Table 1).

Figure 9. Timing of fall color (Figures 9a-9f) and leaf drop was monitored at three elevations on Mount Mansfield in 2019: 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.

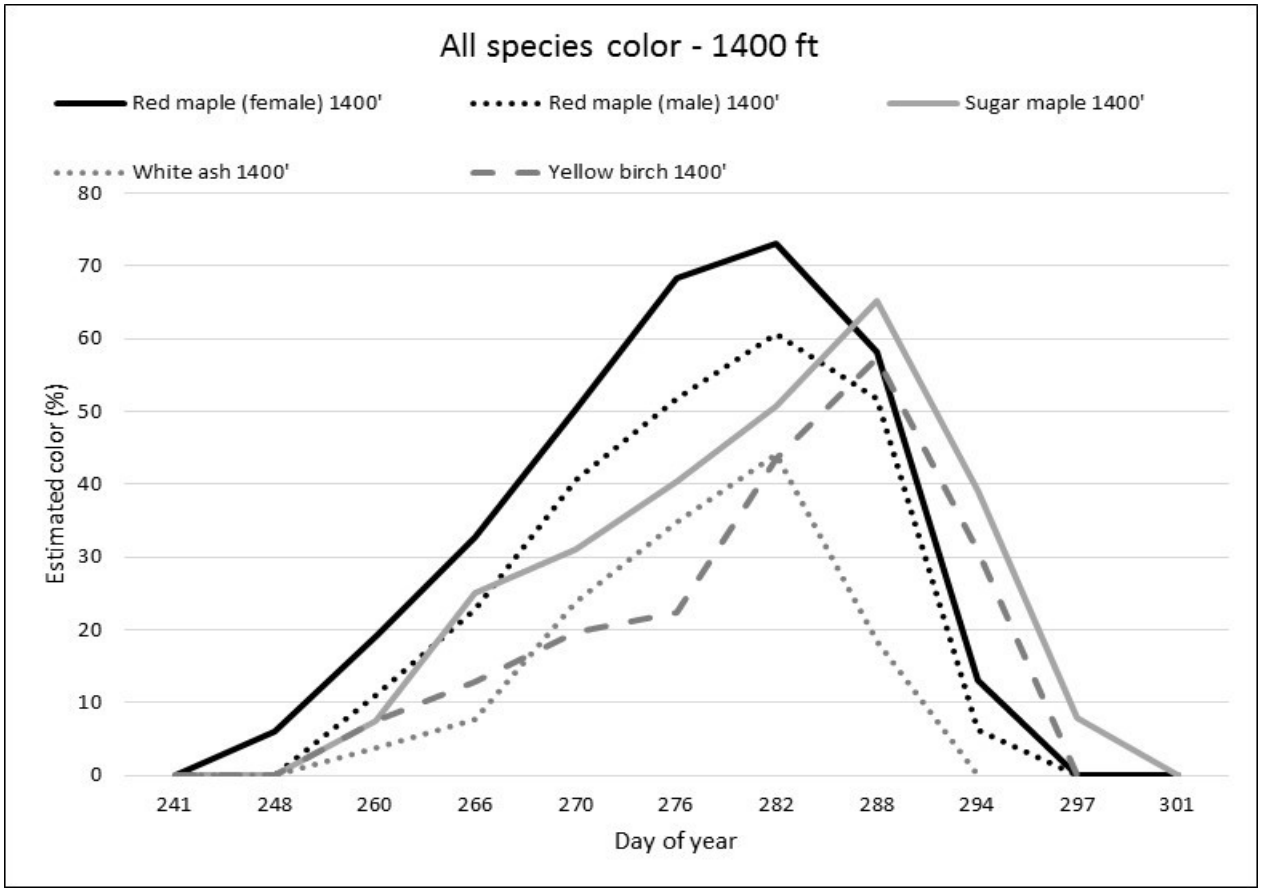


Figure 9a.

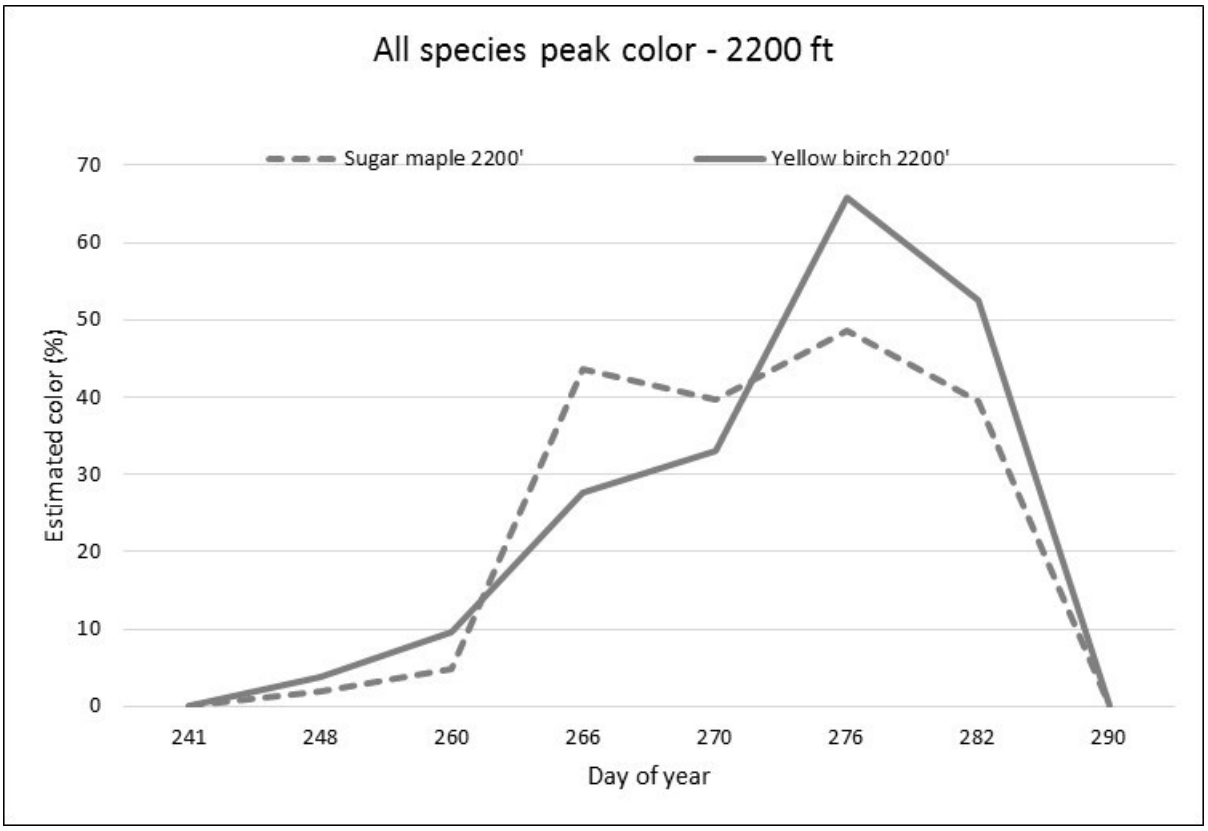


Figure 9b.

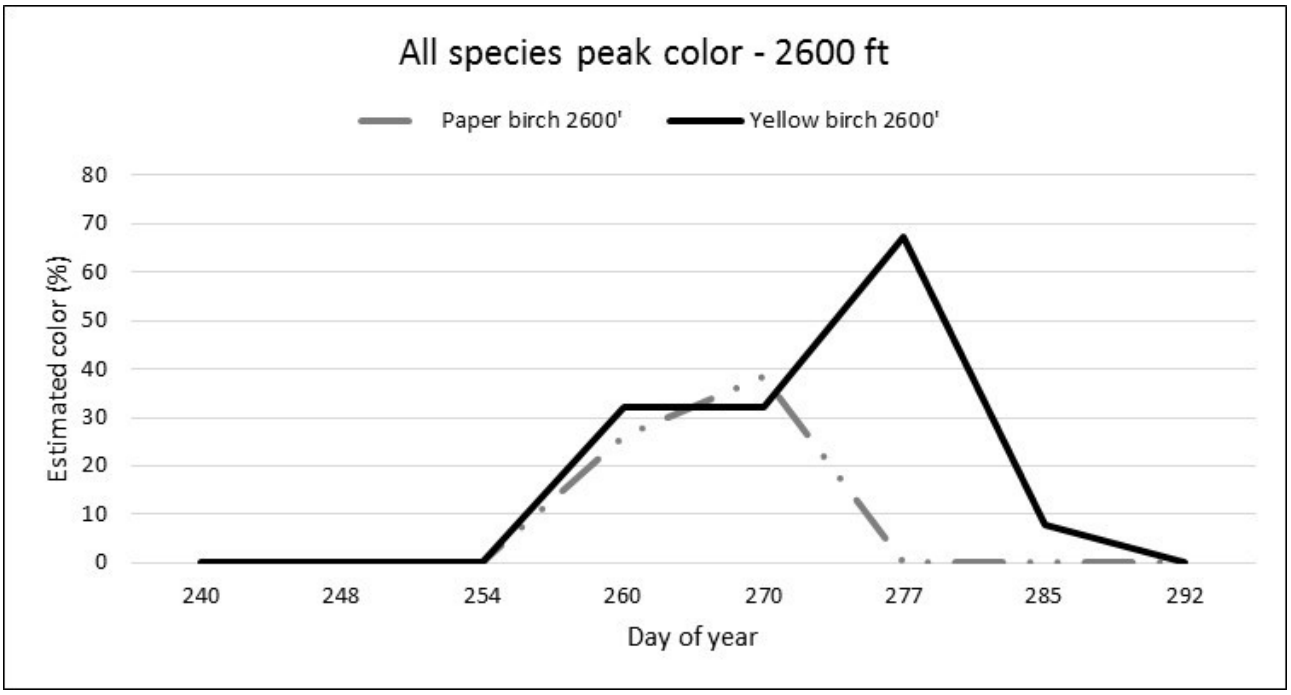


Figure 9c.

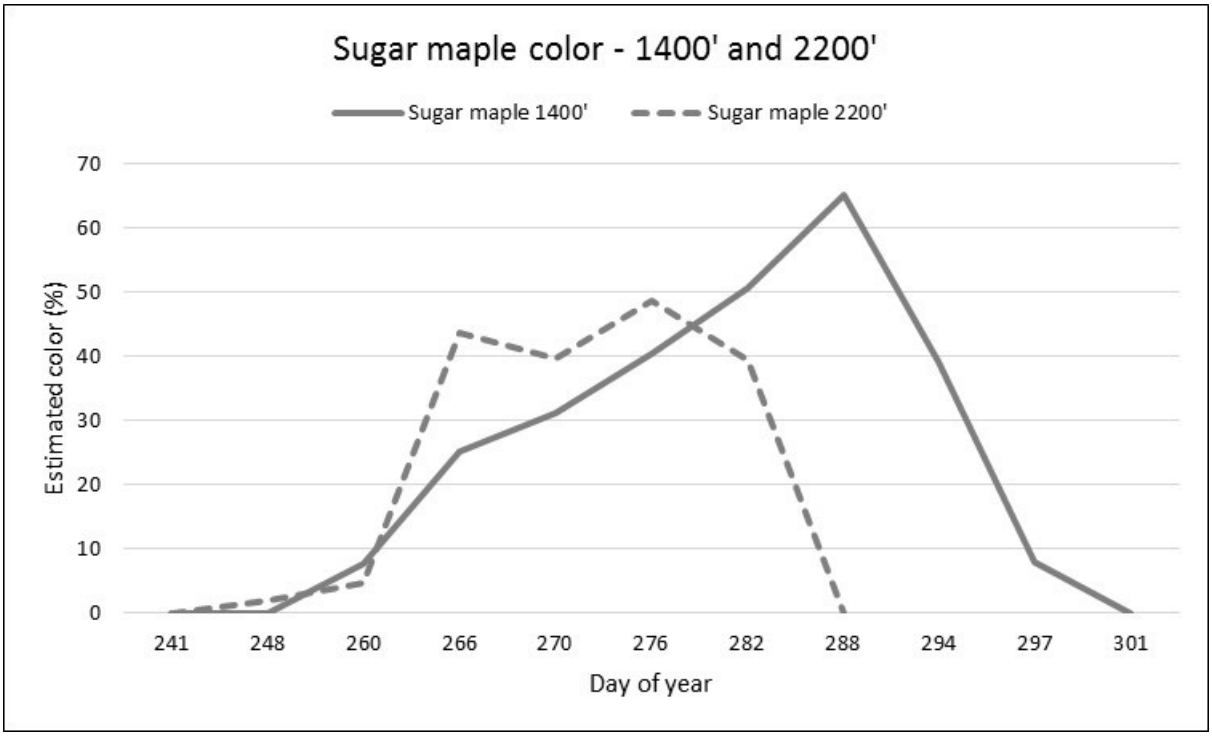


Figure 9d.

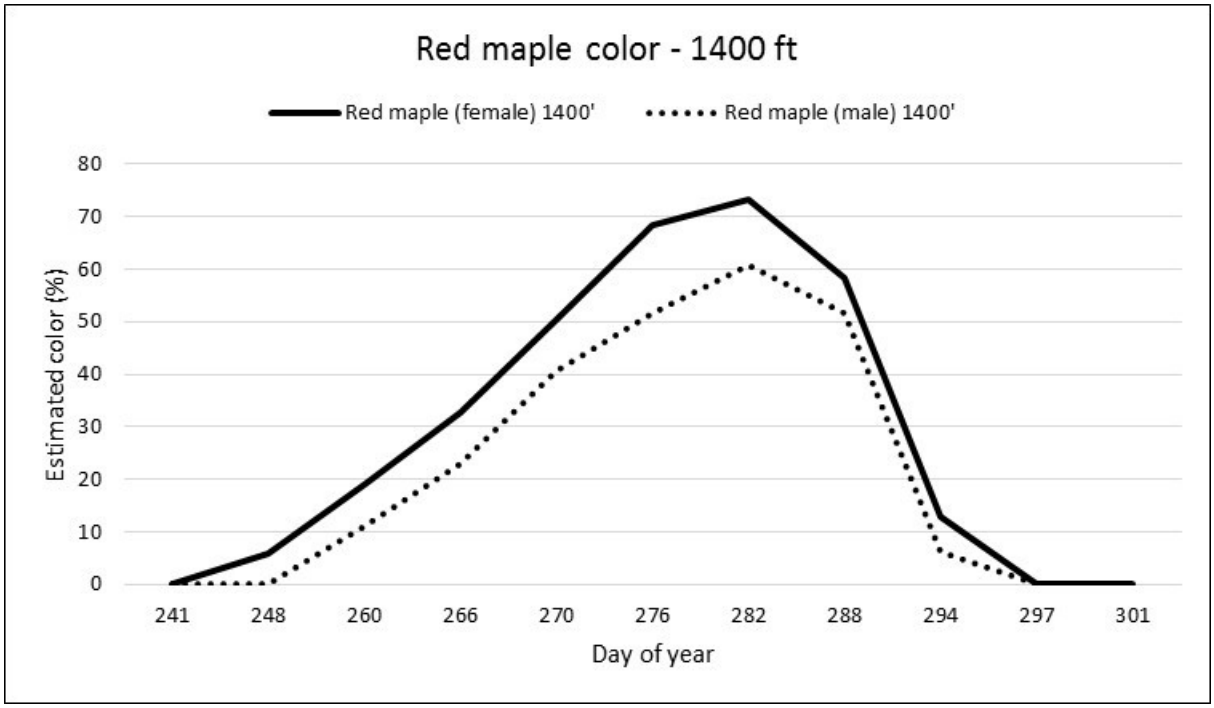


Figure 9e.

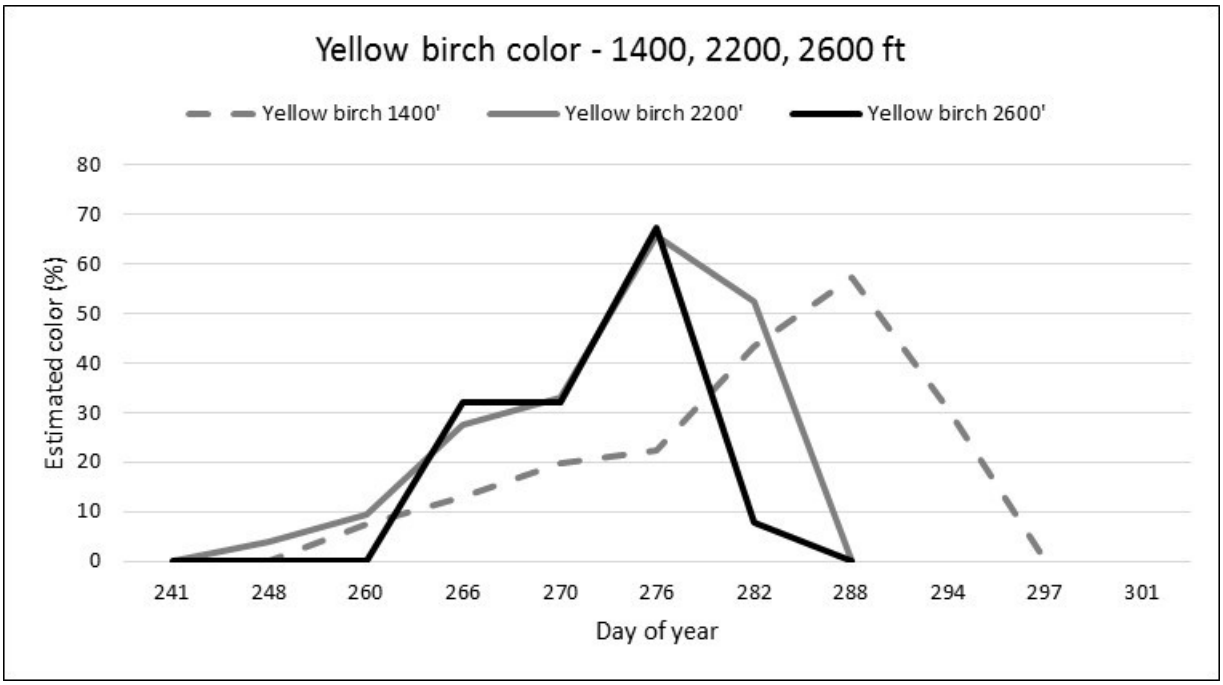


Figure 9f.

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 21-year record, red maple and white ash a 25-year record, sugar maple at 1400 ft a 29-year record, and all other trees a 28-year record. Color was considered "peak" when the highest integrated value of color and leaf presence occurred.

Peak color		
	Long-term Average (Day of year)	2019 Data (Day of year)
Elevation 1400'		
Red maple (Female)	280	282
Red maple (Male)	284	282
Sugar maple	287	288
Yellow birch	285	288
White ash	279	282
Elevation 2200'		
Sugar maple	277	276
Yellow birch	276	276
Elevation 2600'		
Yellow birch	276	277
Paper birch	269	270

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)	2019 Data (Day of year)	Long-term Average (Day of year)	2019 Data (Day of year)
Elevation 1400'				
Red maple (Female)	289	290	300	298
Red maple (Male)	290	290	300	295
Sugar maple	290	293	303	299
Yellow birch	288	295	298	297
White ash	285	287	296	294
Elevation 2200'				
Sugar maple	282	282	295	290
Yellow birch	279	284	292	290
Elevation 2600'				
Yellow birch	279	280	289	288
Paper birch	272	275	286	284

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

Year	Date of Bud break	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
Long term Average (1991-2019)	**5/3**	**10/21**	**171**

HARDWOOD DEFOLIATORS

Forest Tent Caterpillar (FTC), *Malacosoma disstria*, defoliation decreased dramatically in 2019. There were only 537 acres mapped compared to 71,315 acres in 2018 (Table 4).

In all, 156,718 acres have been mapped as defoliated by FTC between 2016-2019, with 132,164 acres defoliated just once, 22,134 acres defoliated twice and 2,420 acres three times. (Figure 10-12). Defoliation data are available on the ANR Natural Resources Atlas.

Table 4. Mapped acres of forest tent caterpillar defoliation in 2019.

County	Acres
ADDISON	0
BENNINGTON	0
CALEDONIA	305
CHITTENDEN	0
ESSEX	102
FRANKLIN	0
GRAND ISLE	0
LAMOILLE	0
ORANGE	0
ORLEANS	130
RUTLAND	0
WASHINGTON	0
WINDHAM	0
WINDSOR	0
Total	**537**

In late 2018 and early 2019, FPR staff assisted landowners with FTC egg mass surveys to determine the likelihood of defoliation on their properties. Of the 16 sugarbushes surveyed, only one location was identified as at risk of defoliation ("borderline"). As a result of these predictions, no landowners chose to have their properties treated with the insecticide Foray 48B in 2019. Similarly, FPR staff did not need to monitor FTC phenological development this year in order to better time insecticide application, as had been done in 2017 and 2018.

Pheromone traps for FTC moths were again deployed throughout the state in 2019. The number of survey sites was increased to better cover the state and increase our predictive capability for future defoliation events. Moth capture decreased from 2018 levels (avg = 5.1 moths per trap) to an average of 1.2 moths per trap (Table 5, Figure 13). For context, at the height of this outbreak, average capture per trap was 15.7 moths. This, coupled with the decrease in acres defoliated, suggests that this most recent outbreak has come to a close..

Figure 10. Total acres mapped as defoliated by forest tent caterpillar by year, 2016-2019.

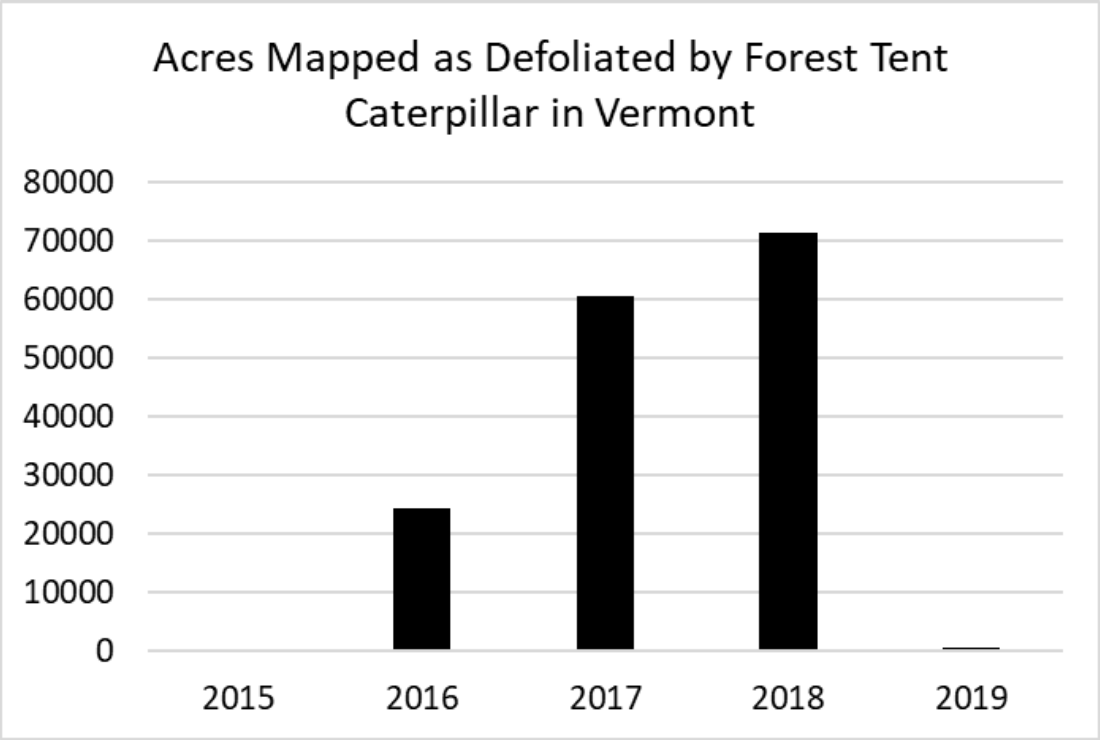
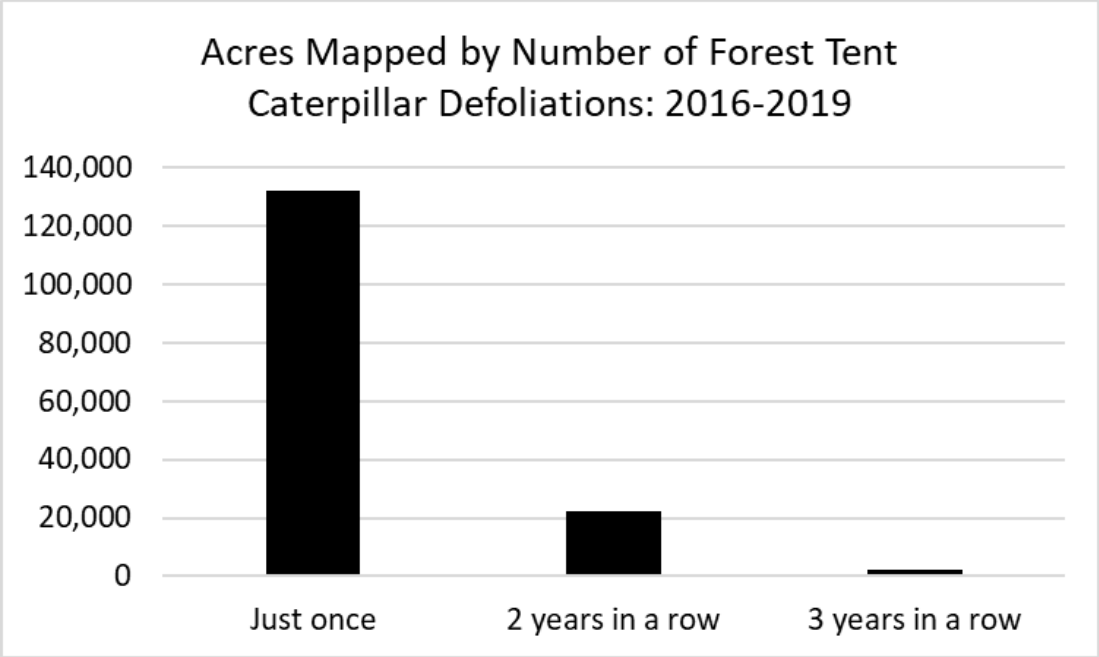


Figure 11. Total acres mapped as defoliated by forest tent caterpillar classified by frequency of defoliation, 2016-2019.



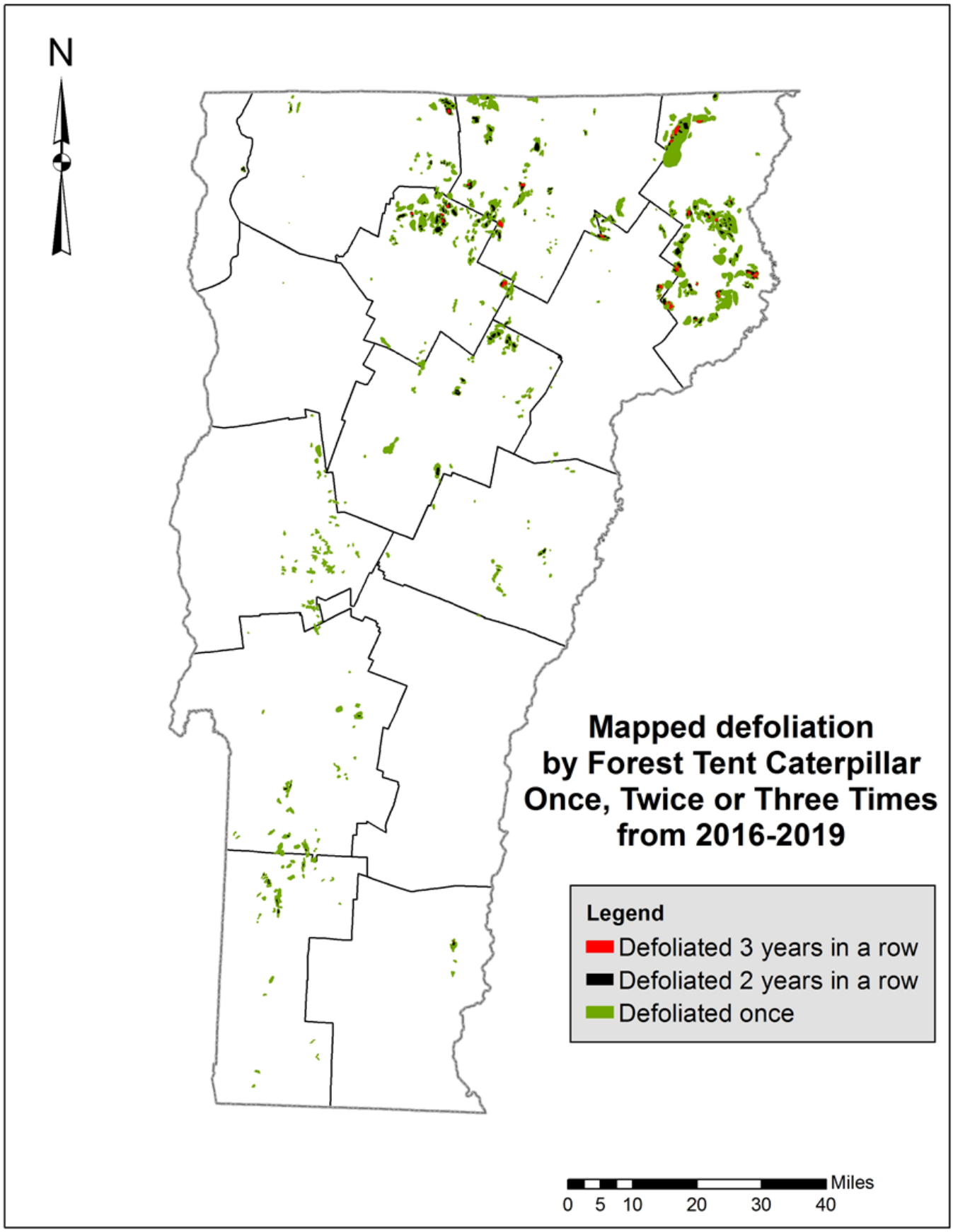


Figure 12. Forest tent caterpillar defoliation mapped in 2016-2019. Mapped area includes 156,718 acres.

Table 5. Average number of forest tent caterpillar moths caught in pheromone traps, 2002-2019. Three multi-pher traps baited with PheroTech lures were deployed at each survey location in 2019.

County	Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Addison	Lincoln (NAMP 34)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Bennington	Manchester	----	----	----	----	----	----	0	5.7	3	1	0.7	0.3	1.3	10.3	12	19.3	3.7	0.7
Bennington	Rupert (Merck Forest)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.3
Chittenden	Huntington (NAMP 27)	9.2	6.7	10	15.7	16	6.3	4.3	4.3	2.7	6.3	6	1.7	2.7	0	10.3	11	6	0.7
Chittenden	Underhill (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	6.7	1.7
Chittenden	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
Chittenden	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	3	0.3
Essex	Norton	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	8.3
Essex	Victory	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Franklin	Fairfield (NAMP 29)	----	1.3	1.7	----	4.3	4.7	4	10.3	2	6	4	1.7	3.3	1.3	1.3	8	2	0
Franklin	Montgomery Dillner Farm	----	----	----	----	----	----	----	----	----	----	----	----	----	1	4.3	18	4.3	0
Lamoille	Waterville (Codding Hollow/Locke)	0	2	1.3	17.7	24.7	2.7	2.3	1.3	3	4.3	3	1	12.5	3.3	13.3	28.3	13.3	2.7
Orange	Vershire (NAMP 37)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.7
Orleans	Albany (NAMP 3)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Orleans	Glover (NAMP 1)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Rutland	Castleton	----	----	----	17	17.3	8	1	4.7	1	1.7	0.3	2.3	1.7	1.7	14	13.3	8.7	0.7
Rutland	Killington/Sherburne (Gifford Woods)	6.9	9.7	20	15.3	21	17.3	7.3	8	2.7	0	1	0.7	6	5.3	8.3	18.7	6.7	0.3
Washington	Roxbury (Roxbury SF)	16	14.7	13.3	7.3	22	22.7	8	2.7	7	2	1.5	1.7	6.3	5.7	29	15	3.3	0.3
Washington	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
Windham	Westminster (NAMP 21)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.7
Windham	Wilmington (NAMP 25)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2.7
Windsor	Rochester (Rochester Mountain)	5	4.7	9	4.7	29	10.3	0.7	----	0.3	0	0	0	3.5	2.3	9	7.3	2	0
Windsor	Woodstock (NAMP 24)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Average		5.1	5.8	8.3	17	18	7.6	2.9	5.5	2.8	3.5	3.5	0.9	4.8	3.2	13	16	5.1	1.2

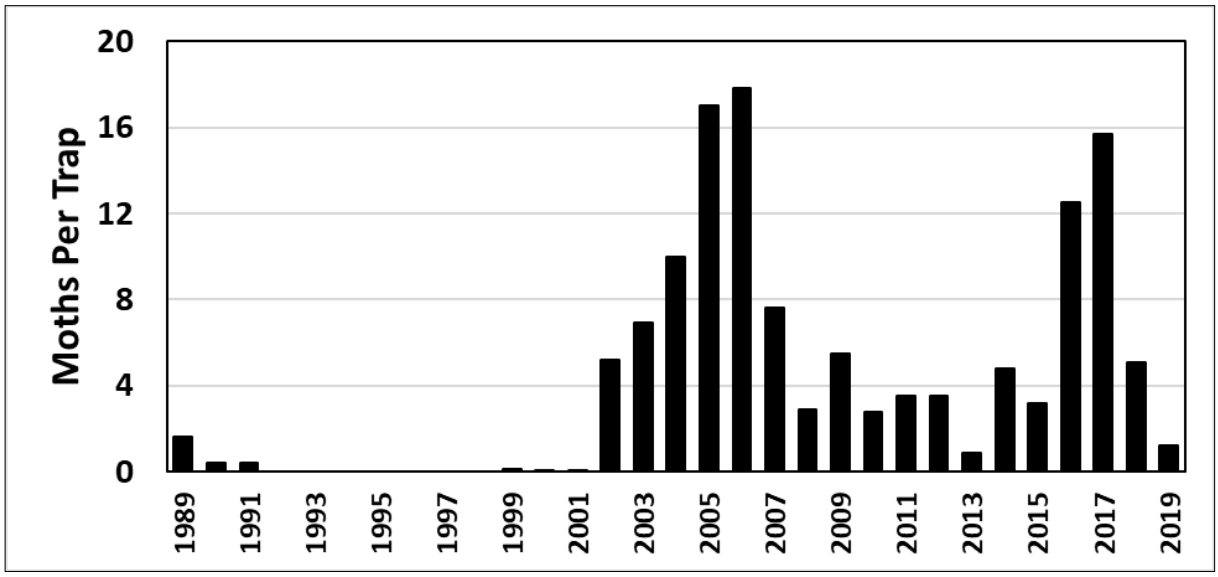


Figure 13. Average number of forest tent caterpillar moths caught in pheromone traps 1989-2019. Three multi-pher pheromone traps per site, with PheroTech lures, were used in 2019.

Despite the reduction in defoliation, the impacts of this outbreak persist. In 2018, over 4,500 acres of dieback or mortality associated with multiple years of FTC defoliation were mapped via aerial detection surveys. In 2019, we mapped an additional 3,438 acres of dieback or mortality related to previous years of FTC defoliation (Table 6, Figure 14). It is likely that the combination of repeated years of defoliation, periods of dry growing conditions over the course of the outbreak, and minimal refoliation of affected trees resulted in the dieback and mortality observed.

For comparison, we mapped about 660,000 acres of defoliation during both the 1977-1982 and 2004-2006 FTC outbreaks. Between 2004-2006, there was ample precipitation, and we only mapped 1,300 acres of decline in defoliated areas. After 1982, following a period that was dry and included one extremely cold, open winter, we mapped 30,000 acres of decline.

Table 6. Area of tree dieback and mortality, mapped in 2019, resulting from forest tent caterpillar defoliation.

County	Acres
ADDISON	0
BENNINGTON	0
CALEDONIA	237
CHITTENDEN	0
ESSEX	488
FRANKLIN	67
GRAND ISLE	0
LAMOILLE	1482
ORANGE	0
ORLEANS	820
RUTLAND	0
WASHINGTON	344
WINDHAM	0
WINDSOR	0
Total	**3438**

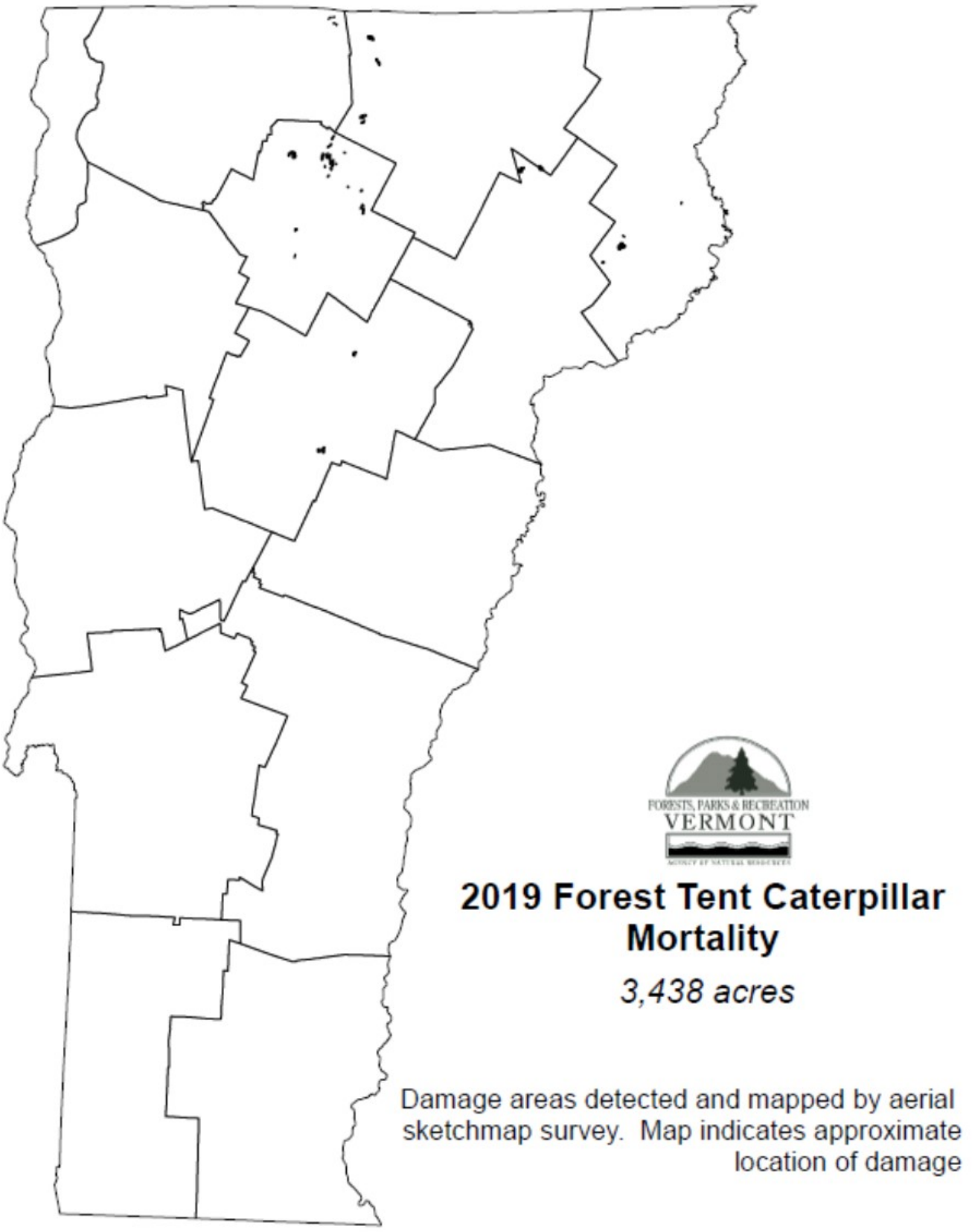


Figure 14. Tree dieback and mortality mapped in 2019 resulting from multiple years of repeated forest tent caterpillar defoliation. Mapped area includes 3,438 acres.

To evaluate the severity of dieback and mortality on stands affected by FTC, we visited four sites that were mapped as having FTC-related mortality during our 2018 and 2019 aerial surveys and assessed tree vigor, dieback, and incidence or mortality (among other standard forest health metrics). Sites were sugar-maple dominant, with the species accounting for 70% of stems on average. More than 69% of all codominant and dominant sugar maple crowns had more than 50% of their crown damaged in some way, and average dieback was 38.4% for codominant and dominant sugar maples (n = 136 trees). In total, 36.8% of codominant and dominant sugar maples died during the course of the recent outbreak, likely due to the combination of repeated FTC defoliation and other environmental stressors.

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 in focal area monitoring plots (Figure 15 and Table 7).

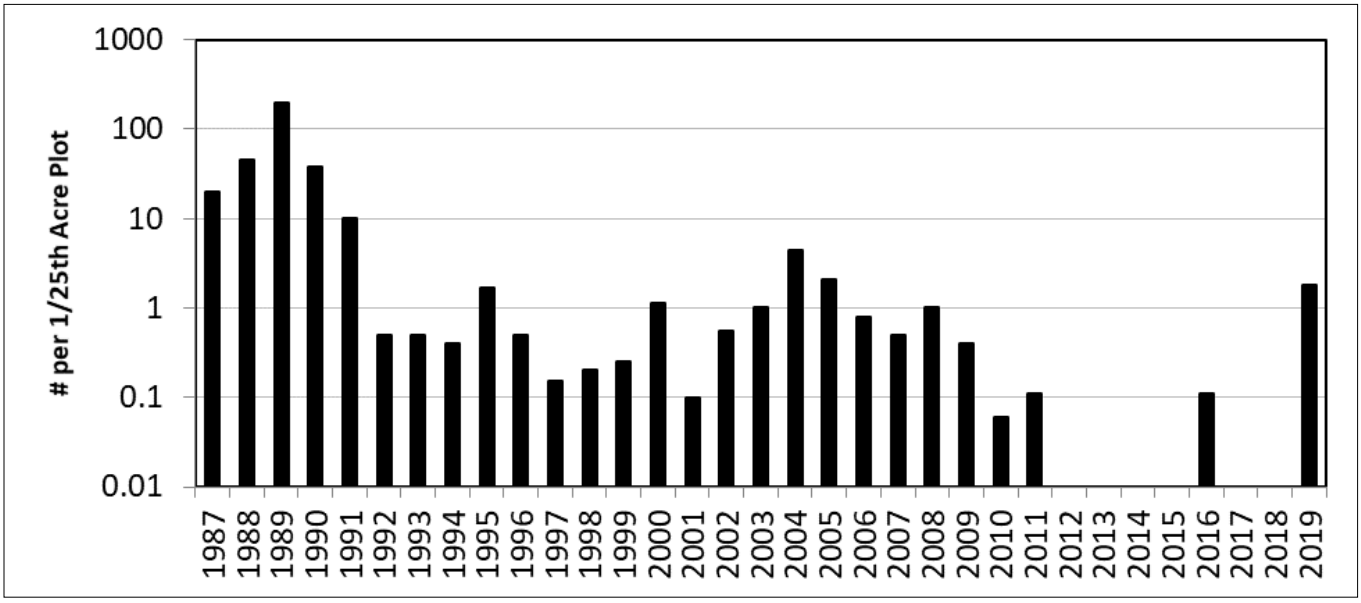


Figure 15. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 1987-2019. Data reflect the average egg mass counts from ten locations, with two 15-meter diameter plots per location containing burlap-banded trees.

Table 7. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 2003-2019. 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
Arrowhead	Milton	1.5	2.5	0	0	0	2.5	0	0	0.5	0	0	0	0	0	0	0	0.5
Brigham Hill	Essex	2.5	2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5
Ft. Dummer	Guilford	0	——	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0
Minard's Pond	Rockingham	0.5	2	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	2.5
Mount Anthony	Bennington	1.5	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
Rocky Pond	Rutland	0	0	0.5	3	3	0.5	0	0	0	0	0	0	0	0	0	0	0
Sandbar	Colchester	3	1.5	0	0	0	2.5	0.5	0	0	0	0	0	0	0	0	0	0.5
Tate Hill	Sandgate	0	30	18	3	0	1.5	0.5	0	0	0	0	0	0	1	0	0	6
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

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Birch Leafmining Sawflies	*Messa nana, Fenusa pusilla,* and others.	Birch	Northeastern Vermont	Injury observed by July.
Beech Leaftier	*Psilocorsis* sp.	Beech	Statewide	Noticeable, causing light damage.
Birch Skeletonizer	*Bucculatrix canadensisella*	Birch	Underhill	Only light damage.
Browntail Moth	*Euproctis chrysorrhoea*	Hardwoods		Not observed or known to occur in Vermont.
Cherry Scallop Shell Moth	*Hydria prunivorata*	Cherry	Statewide	Occasional nests observed.
Dusky Birch Sawfly	*Croesus latitarsus*	Birch	Springfield	Non-native ornamental host species.
Eastern Tent Caterpillar	*Malacosoma americanum*	Cherry and Apple	Widely scattered	Populations remain low.
Elm Spanworm	*Ennomos subsignaria*	Hardwoods	Cambridge	Adult observed in a sugar maple stand.
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*			See narrative.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Green-striped Mapleworm	*Dryocampa rubicunda*	Sugar Maple	Widely scattered	Larvae occasionally observed, often in association with saddled prominent.
Gypsy Moth	*Lymantria dispar*			See narrative.
Hickory Tussock Moth	*Lophocampa caryae*	Hardwoods	Statewide	Larvae frequently observed in late summer, with reports of dozens at a time. No defoliation reported.
Japanese Beetle	*Popillia japonica*	Many	Widespread	Observed in gardens, but tree injury not reported in 2019.
Locust Leafminer	*Odontata dorsalis*	Black Locust	Statewide	Locally heavy defoliation, but decrease from 2018.
Maple Leaf Cutter	*Paraclemensia acerifoliella*	Sugar Maple, occasional Yellow Birch and Beech	Widespread	Populations high, but less than 2018. Up to 50 mines per leaf observed in Hyde Park. Widespread heavy damage to lower crowns and scattered brown patches of maple at mid-elevations beginning in late August. See Anthracnose.
Maple Trumpet Skeletonizer	*Catastega aceriella*	Sugar maple	Statewide	Occasionally observed, but negligible damage.
Mountain Ash Sawfly	*Pristiphora geniculata*	Mountain Ash	Springfield	Heavy defoliation of ornamentals.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Oak Shothole Leafminer	*Japanagromyza viridula*	Red Oak	Statewide	Characteristic feeding damage widely observed in June. Appeared to "show up all at once" in Vermont and nearby states.
Oak Skeletonizer	*Bucculatrix ainsliella*	Red Oak	Southern Vermont	Only light feeding, but overwintering pupae noticeable.
Red-humped Caterpillar	*Schizura concinna*	Apple	Widely scattered	Observed in several locations.
Rose Chafer	*Macrodactylus subspinosa*	Many	Widespread	Observed in gardens, but tree injury not reported in 2019.
Saddled Prominent	*Heterocampa guttivata*	Sugar maple	Widely scattered; Especially southeastern Vermont	Increase from 2018. Caterpillars widely observed, with occasional frass "raining" but only light "window feeding" observed.
Spotted Tussock	*Lophocampa maculata*	Hardwoods	Statewide	Larvae widely observed, but no defoliation reported.
Sycamore Tussock	*Halysidota harrisii*	Sycamore	Southeastern Vermont	Heavy defoliation in Dummerston by late summer.
Uglynest Caterpillar	*Archips cerasivorana*	Cherry and other Hardwoods	Dummerston	Nest observed in a meadow.
Viburnum Leaf Beetle	*Pyrrhalta viburni*	Viburnum	Barre	Heavy defoliation of ornamental viburnum.

OTHER HARDWOOD DEFOLIATORS

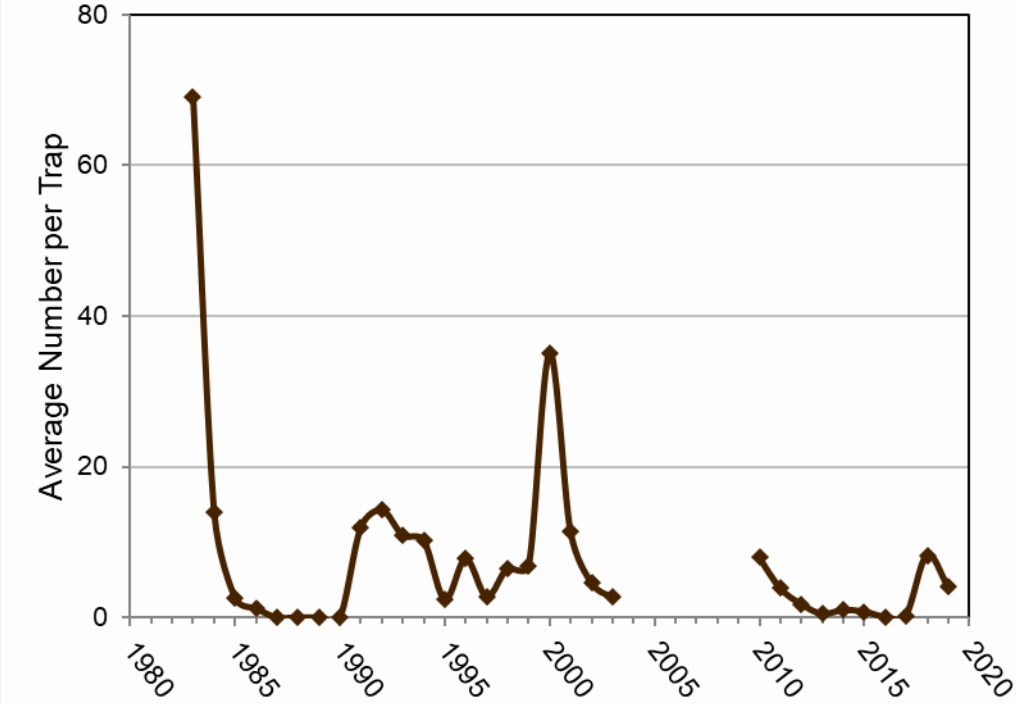
INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Willow Weevil Leafminer	*Isochnus sequensi*	Willows	Northwestern Vermont	Feeding on riparian willows.
Winter Moth	*Operophtera brumata*	Hardwoods		Not observed or known to occur in Vermont.
Yellow-necked Caterpillar	*Datana ministra*	Hardwoods	Widely scattered	Larva observed feeding on birch and apple.

Hardwood defoliators not reported in 2019 include Alder leaf Beetle, *Altica ambiens* ; America Dagger Moth, *Acronicta americana* ; Birch Leaf Folder, *Ancylis discigerana* ; Bruce Spanworm, *Operophtera bruceata* ; Dogwood Sawfly, *Macremphytus tarsatus* ; Euonymus Caterpillar, *Yponomeuta cagnagella* ; Imported Willow Flea Beetle, *Plagiodera versicolora* ; Large Aspen Tortrix, *Choristoneura conflictana* ; Maple Webworm, *Pococera asperatella* ; Orange-humped Mapleworm, *Symmerista leucitys* ; Red-humped Oakworm, *Symmerista canicosta* ; Satin Moth, *Leucoma salicis* ; White-marked Tussock Moth, *Orgyia leucostigma.*

SOFTWOOD DEFOLIATORS

Spruce Budworm, *Choristoneura fumiferana*, moth trap catches in Vermont declined to an average of 4.1 compared to 8.3 in 2018, which was the highest in the past decade. Traps were deployed in Caledonia, Chittenden, Essex, and Orleans Counties in 2010-2019. Catches decreased at all locations, including the Underhill site, which continued to have higher moth numbers than other sites (Figure 16, Tables 8-9). We do not anticipate defoliation by the spruce budworm in 2020.

Figure 16. Average number of spruce budworm moths caught in pheromone traps 1983-2019. Trapping was discontinued, 2004-2009. Average of six locations in 2019.



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 8. Locations of spruce budworm pheromone traps in 2019. Note: the trap site in Willoughby State Forest is in the town of Sutton rather than Burke, as designated in some earlier reports.

Table 9. Average number of spruce budworm moths caught in pheromone traps, 1991-2019. Trapping had been discontinued 2004-2009. There were three traps per location, one location per town, in 2019.

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
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
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	0.3	9.0	1.0
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	4.0	3.3
Essex Lewis	2.0	2.7	0.7	2	0	0.7	0	8	4.3	14	6.7	1.3	1.7	5.7	0.3	0	0	0	0.0	0	0	2.6	0.3
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	1	26.3	18.3
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	2.0	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	4.1

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Eastern Spruce Budworm	*Choristoneura fumiferana*	Balsam Fir and Spruce	Statewide	See narrative.
Pine False Webworm	*Acantholyda erythrocephala*	White Pine	Bristol	Christmas tree plantation.
Web-spinning Sawfly	*Pamphiliidae*	Blue Spruce	Burlington	Ornamental.

Softwood defoliators not reported in 2019 included Arborvitae Leafminer, *Argyresthia thuiella* ; Balsam Fir Sawfly, *Neodiprion abietus* ; European Pine Sawfly, *Neodiprion sertifer;* Fall Hemlock Looper, *Lambdina fiscellaria* ; Introduced Pine Sawfly, *Diprion similis;* Rusty Tussock Moth, *Orygia antigua;* Yellow-headed Spruce Sawfly*, Pikonema alaskensis;* Spruce Needleminer, *Taniva albolineana* ; White Pine Sawfly*, Neodiprion pinetum.*

SAPSUCKING INSECTS, MIDGES, AND MITES

Balsam Woolly Adelgid (BWA), *Adelges piceae***,** populations remain mostly low. However, we continue to see new tree mortality in areas where BWA-initiated mortality was reported in previous years, especially in central and northeastern Vermont, and occasional dying landscape trees with characteristic symptoms such as gouting and topkill. 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 10).

Table 10. Mapped acres of balsam woolly adelgid-related decline 2016-2019.

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. EHS may co-occur with hemlock woolly adelgid, and symptoms of stress have been observed on trees infested with both insects.

In 2018, EHS was reported in Charlotte on balsam fir purchased and planted in 2013. Because there are wild hemlocks nearby, providing an opportunity to spread, these trees were treated with a basal bark spray of Safari 20 SG on June 11th. In all, eight trees totaling twenty diameter inches were treated. By the end of the season (9/19), EHS populations were dramatically reduced, although two trees had dense scale populations on a few branches.

Hemlock Woolly Adelgid (HWA), *Adelges tsugae*, continues to threaten hemlock trees in southern Vermont, especially in the Connecticut and West River valleys. Traditionally infested sites are still infested, but no spread of the infestation was documented in 2019 and population numbers were down despite a low 2018-19 winter mortality rate. The impact of several heat waves through the summer may be part of the explanation. New research is suggesting that temperatures in excess of 86° F can be lethal to HWA. Excessive heat also forces the insect into an earlier aestivation, which reduces the amount of feeding damage to the tree.

Fifteen acres of hemlock decline related to HWA were mapped during aerial surveys. Generally, however, drought appeared to be the primary cause of symptoms on unhealthy hemlock trees brought to our attention through diagnostic requests.

In 2018, the primary emphasis of the survey program was shifted to counties that adjoin the known infested counties: Windham, Windsor and Bennington. Target counties are Rutland and Orange. 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 southern-most edge. Twenty sites were surveyed, with one positive find in Ft. Dummer State Park, a site previously known to be infested (Table 11). The shift to county by county surveying resulted in coarser "resolution" and may account for the fact that no expansion of the infestation was observed.

Table 11. Sites inspected for the presence of hemlock woolly adelgid (HWA) by visual survey, winter 2018-2019.

County	Town	Number of Sites	Positive for HWA
Windsor	Springfield	5	0
	Weathersfield	1	0
Rutland	Danby	1	0
	Fair Haven	1	0
	Hubbardton	1	0
	Mendon	1	0
	Poultney	1	0
	Wallingford	1	0
Orange	Fairlee	1	0
	Thetford	3	0
	Strafford	2	0
Windham	Guilford	1	1
	Londonderry	1	0
Total		20	1

Overwintering mortality was assessed at four sites which have been monitored since 2010. The average winter mortality was 70%, this is below the threshold of 91 or 92% that restricts expansion of the infestation (Table 12, Figure 17).

Table 12. Assessment of hemlock woolly adelgid winter mortality over the 2018-2019 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	3/20/2019	88	26	62	70%
Jamaica	3/20/2019	271	131	140	52%
Townshend	3/20/2019	387	56	331	86%
Vernon	3/20/2019	278	76	202	73%

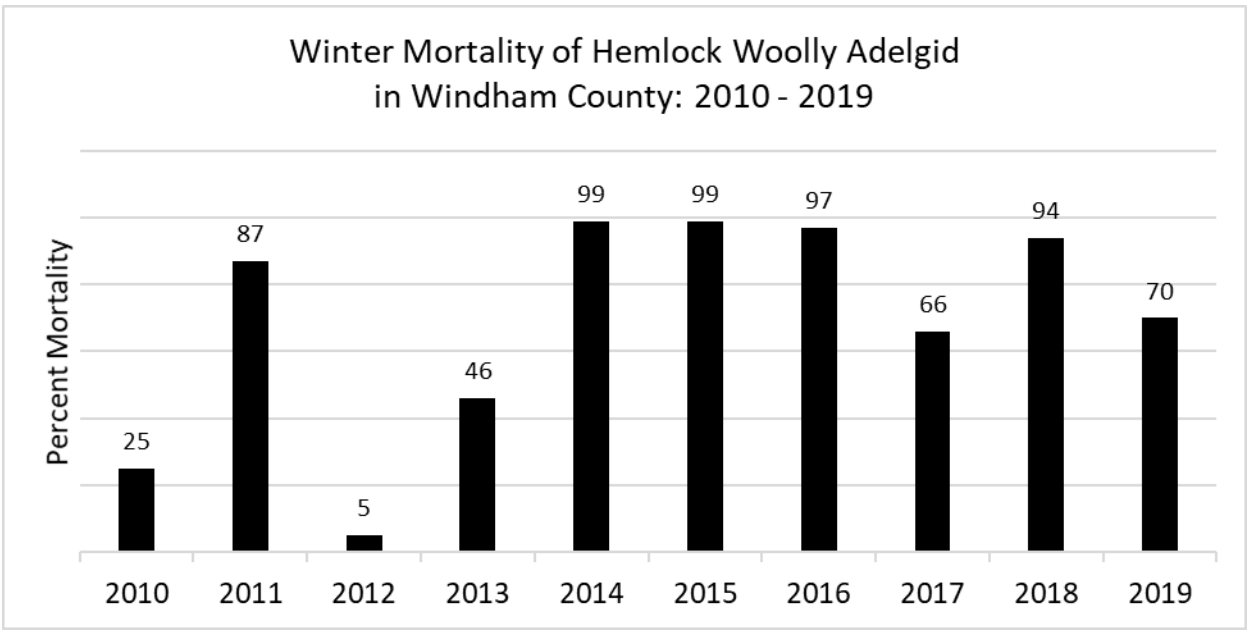


Figure 17. Average overwintering mortality of hemlock woolly adelgid at four sites in Windham County, 2010-2019.

We continue to maintain five HWA impact monitoring plots. In 2019, assessments were done at the Black Mountain Natural Area in Dummerston, and the Roaring Brook Wildlife Management Area and the I-91 Visitor's Center, both in Guilford. Diameters were re-measured, and crowns 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.

We also continued biological control efforts. On November 14th, 500+ adults of the predatory beetle *Laricobius nigrinus*, obtained from the rearing laboratory at Virginia Tech, were released at a previous release site in Brattleboro. On November 26th, 500+ were released at a new site located within Jamaica State Park. We also have two additional previous release sites in Vernon and Pownal. All three sites where *L. nigrinus* had been released prior to this year were surveyed for the beetle in 2019, but none were recovered.

Pear Thrips, *Taeniothrips inconsequens*, numbers in our long-term monitoring plot at the Proctor Maple Research Center in Underhill were down compared to 2018. Sticky trap counts totaled 312, compared to 455 in 2018. Emergence began the week of April 11, with the highest numbers present from April 29 through May 9 (Table 13, Figure 18). No damage was reported.

Table 13. Pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, VT in 2019. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.

Sample Dates	Counts
4/3-4/11	0
4/11-4/19	6
4/19-4/29	64
4/29-5/9	83
5/9-5/18	67
5/18-5/23	50
5/23-5/31	30
5/31-6/12	8
6/12-6/24	4
Total	312

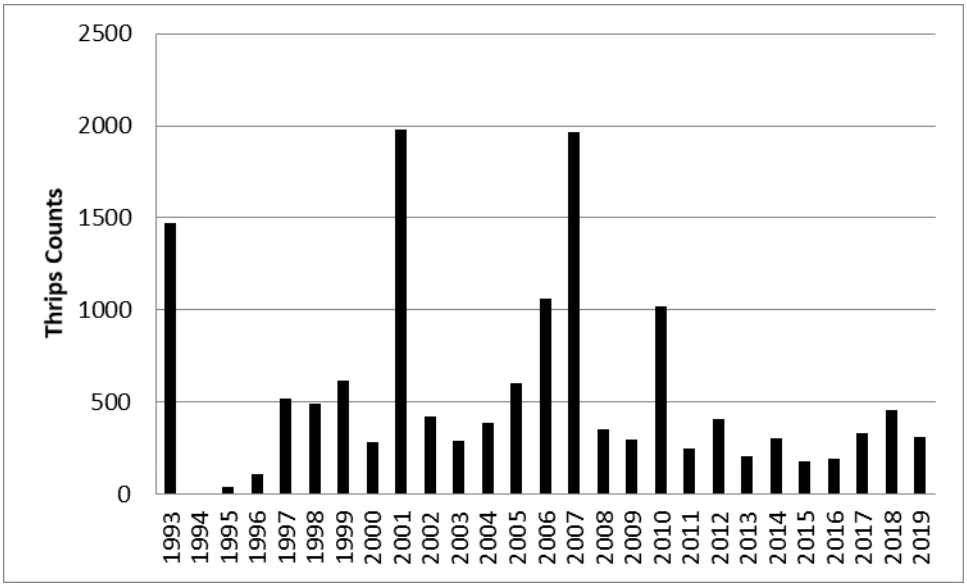


Figure 18. Total number of thrips collected at Proctor Maple Research Center in Underhill, VT on sets of four sticky traps, 1993-2019.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Balsam Gall Midge	*Paradiplosis tumifex*	Balsam Fir	Hyde Park	Increase in damage to Christmas trees from 2018.
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		See narrative.
Beech Scale	*Cryptococcus fagisuga*	Beech		See Beech Bark Disease narrative.
Black Treehopper	*Acutalis tartaria*	Black Locust	Unknown	Single report.
Boxelder Bug	*Boisea trivittatus*	Boxelder	Northwestern Vermont	Adults observed.
Brown Marmorated Stink Bug	*Halyomorpha halys*	Many	Shelburne	Found inside a house.
Eastern Spruce Gall Adelgid	*Adelges abietis*	Spruce	Southern Green Mountains	Observed on regeneration.
Elm Cockscomb Aphid	*Colopha compressa*	Elm	Northfield	Ornamental.
Elongate Hemlock Scale	*Fiorinia externa*	Hemlock and Balsam Fir		See narrative.
Hemlock Scale	*Hemiberlesia ithacae*	Hemlock	Charlotte	Confirmed by USDA-ARS.
Hemlock Woolly Adelgid	*Adelges tsugae*	Hemlock		See narrative.
Lacebugs	*Tingidae*	Hardwoods	Widely scatttered	Damage occasionally observed, but none reported to the diagnostic lab.
Leafhoppers	*Cicadellidae*	Hardwoods	Widely scatttered	Injury in 2019 exacerbated by hot and dry conditions.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Oak Leaf Blister Mite	*Aceria triplacis*	Red Oak	Ferrisburgh	Planted trees on clay soil.
Oystershell Scale	*Lepidosaphes ulmi*	Apple	Widely scatttered	Occasionally observed. Populations generally low.
Pear Thrips	*Taeniothrips inconsequens*	Hardwoods		See narrative.
Pine Bark Adelgid	*Pineus strobi*	White Pine	Londonderry	Light population.
Pine Leaf Adelgid	*Pineus pinifoliae*	White Pine	Londonderry	Light population.
Pine Needle Scale	*Chionapsis pinifoliae*	Hemlock and Red Pine	Charlotte Peacham	Light populations.
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.
Sumac Gall Aphid	*Melaphis rhois*	Sumac	Unknown	Single report.
Spider Mite	*Tetranychidae*	Conifers	Widely scatttered	Occasionally observed. Populations generally low.

Sapsucking Insects, Midges and Mites that were not reported in 2019 include Ash Flowergall Mite, *Aceria fraxiniflora* ; Beech Blight Aphid, *Grylloprociphilus imbricator* ; Cinara Aphids, *Cinara* sp.; Conifer Root Aphid, *Prociphilus americanus* ; Pine Spittlebug, *Aphrophora parallela* ; Woolly Alder Aphid, *Paraprociphilus tessellatus.*

BUD AND SHOOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Common Pine Shoot Beetle	*Tomicus piniperda*	Pines	No new counties	Since first detected in 1999, has been found in many counties. Under federal quarantine, pine is free to move through most of the northeast.
Pine Gall Weevil	*Podapion gallicola*	Red Pine	Peacham, Mendon	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 2019 included Balsam Shootboring Sawfly, *Pleroneura brunneicornis,* Oak Twig Pruner*, Anelaphus parallelus.*

ROOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Asiatic Garden Beetle	*Maladera castanea*	Many	Vershire	Larvae numerous in a lawn.
Japanese Beetle	*Popillia japonica*	Many		See Hardwood Defoliators.
Oriental Beetle	*Exomala orientalis*	Many	Hinesburg	Adult.

Root Insects not reported in 2019 included Broadnecked Root Borer, *Prionus laticollis* ; Conifer Root Aphid, *Prociphilus americanus* ; Conifer Swift Moth, *Korsheltellus gracillis,* June Beetle*, Phyllophaga spp.*

BARK AND WOOD INSECTS

Emerald Ash Borer (EAB), *Agrilus planipennis*, was first discovered in Vermont in February 2018, and new detections continued in 2019. As a result, EAB has now been confirmed in ten towns in eight counties. 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.

In late May, a private forester reported EAB on a street tree in Bristol, the first detection in Addison County. Multiple life stages were observed on the tree. In late June, an infested tree in Derby Line, with branches hanging over the international border, was reported by a plant health specialist. This was the first known EAB in Orleans County. In early October, an adult beetle from Londonderry was determined to be a suspect by an arborist and reported by the homeowner. The USDA confirmation made this the first in Windham County.

The sudden eruption of EAB detections in Vermont may be related to the recent dry growing seasons. Based on tree symptoms, EAB had already spread to the new counties before it was first detected in Vermont.

Ash dieback and mortality from EAB were also mapped during aerial surveys for the first time, with a total of 139 acres mapped at the site of the original detection in Orange and Washington Counties.

Maps indicating known EAB infested areas in Vermont (Figure 19) 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. We know that 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 85 towns in thirteen counties. The infested areas are also available for download on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/.

EAB surveys continued in Vermont. To monitor significant spread of known infestations, a visual road-based survey was conducted after leaf-off. A crew of at least two people spent one day driving through towns within each of the mapped infested areas. When unhealthy ash were encountered, the observers stopped to inspect the tree with binoculars. In all, 563 miles were covered and 25 symptomatic trees were inspected. (Table 14, Figure 20). No new EAB locations were detected.

Table 14. Road miles covered during visual EAB detection surveys in each mapped infested area, Fall 2019.

Town(s) at Core of Infested Area	Miles Covered
Bristol	48
Derby	77
Londonderry	52
Orange/Plainfield/Groton/Barre/Montpelier	214
South Hero/Alburgh	154
Stamford	18
Total	**563**

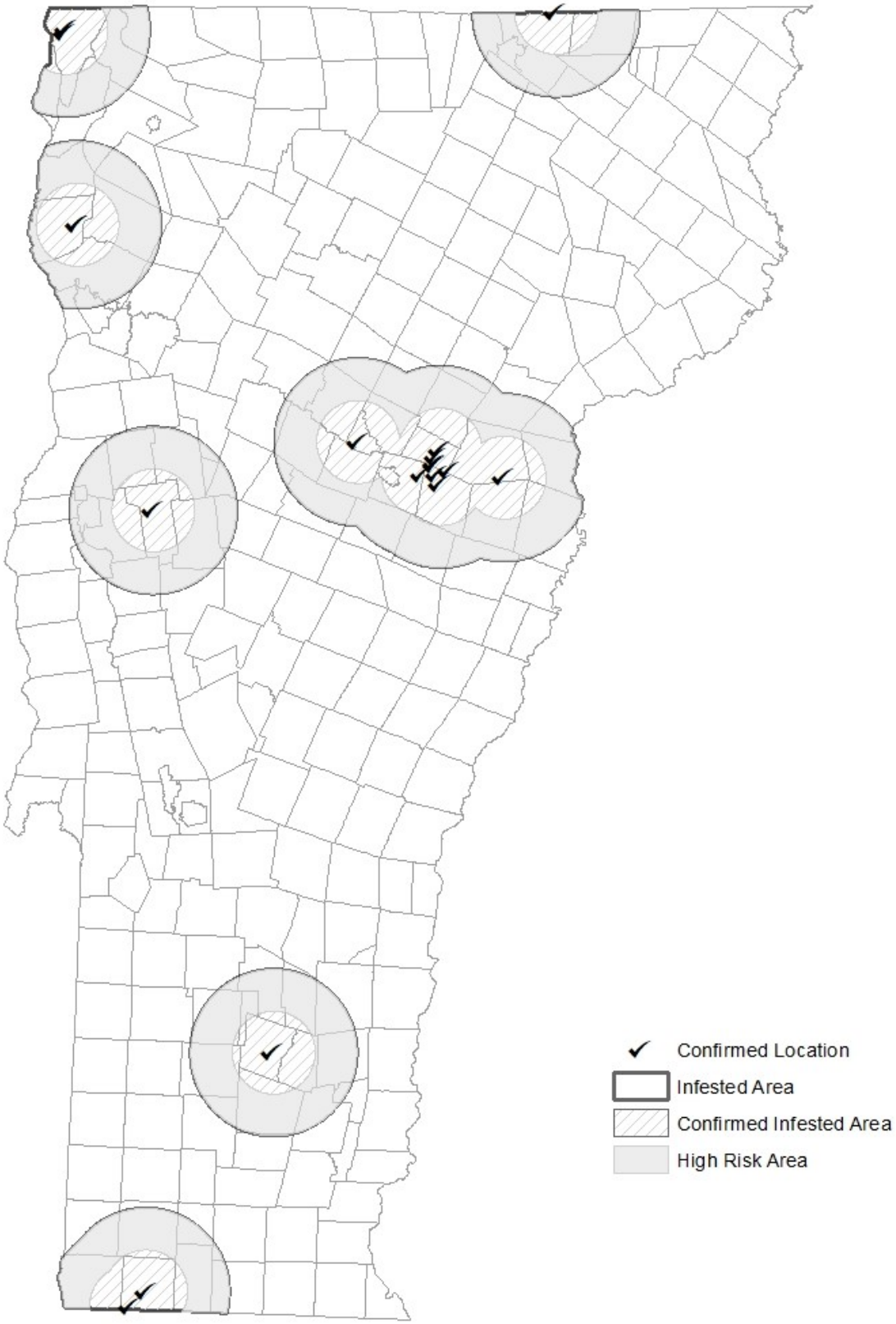


Figure 19. The mapped emerald ash borer infested area in December, 2019. Locations where the presence of the insect has been confirmed are indicated with a check mark. The "confirmed infested areas" are within five miles of these locations. High risk areas extend five miles from the outside of the confirmed infested areas; EAB is likely expanding into and present in some of this area. The mapped infested area now includes 85 towns in thirteen counties.

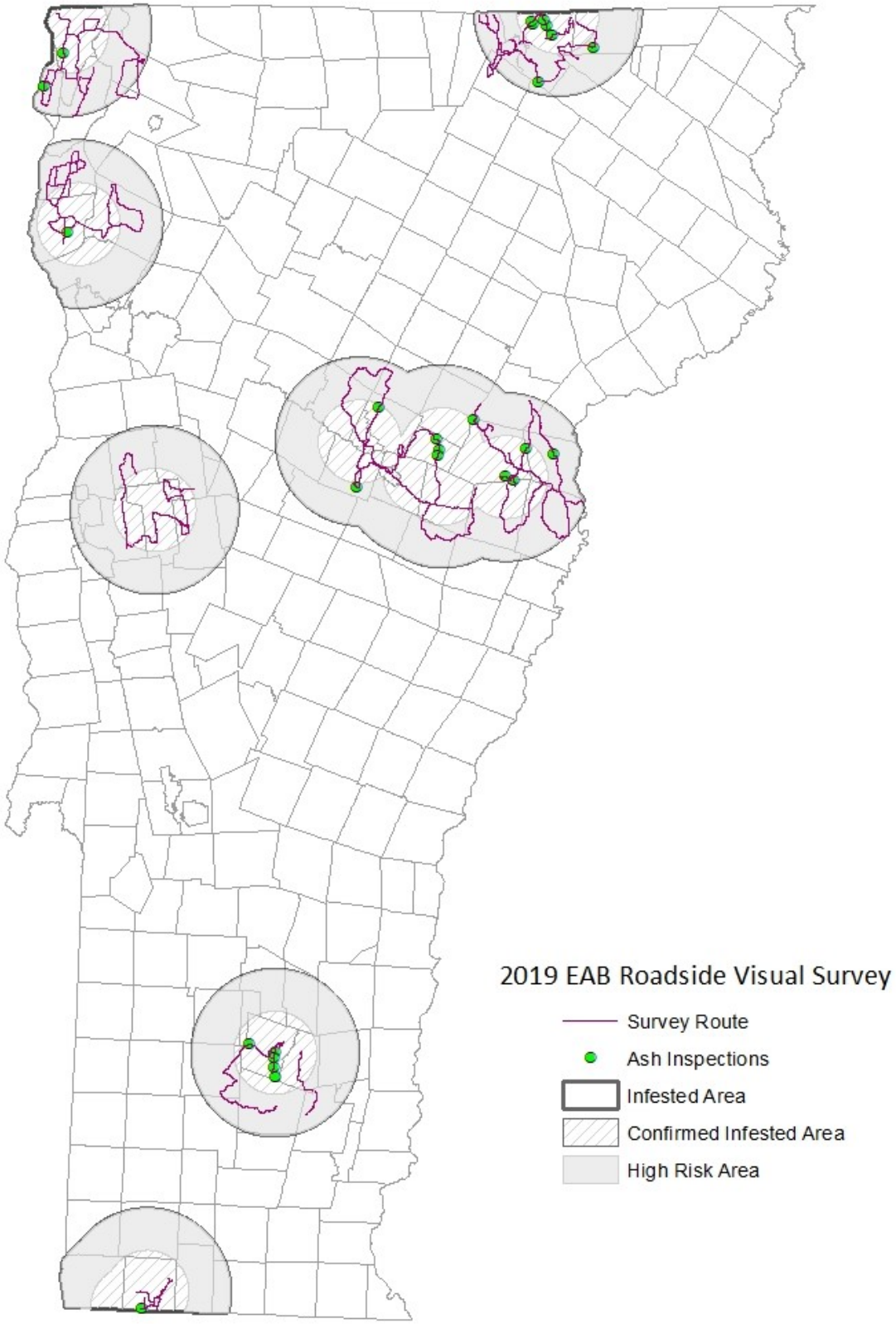


Figure 20. 2019 Visual surveys for emerald ash borer in 2019. After leaf-off, a survey crew spent one day driving through each of the mapped infested areas. When unhealthy ash were encountered, observers stopped to inspect the tree.

Because the entire state is within the federal quarantine, USDA APHIS discontinued its EAB trapping program in Vermont. However, through the multi-agency Forest Pest Survey and Outreach Program, thirty volunteers were trained to hang and monitor purple prism traps. As a result, at least 78 traps were deployed in 30 towns throughout the state (Figure 21). EAB adults were caught at two locations in Alburgh, which was not previously known to be infested. No additional EAB were trapped.

Girdled trap tree surveys are the most sensitive technique currently used for early detection of EAB. Between April 22 and June 14, trap trees were girdled at 36 locations, mostly on State Land in or near known infested areas (Table 15, Figure 22). The trees were felled and peeled between October 16 and December 3. No EAB were found.

Over the course of the year we responded to many observations of possible EAB. Sixteen of these resulted in a follow-up site visit to inspect ash trees (Figure 23) .

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. One change to these recommendations in 2019 was to redefine the EAB flight season as June 1st – September 30th. After looking at weather records from locations throughout the state, and considering growing degree day models, it was determined that EAB beetle emergence will not actually begin until June in Vermont.

We have begun visiting potential biocontrol release areas with a plan to begin releases in 2020.

The following resources are available through vtinvasives.org.

Slow the Spread Recommendations for moving material originating within the EAB infested area:
- Moving Ash from the Infested Area, regarding the movement of forest products
- Ash Processing Options regarding the treatment or processing of ash material
- Tree Care and Clearing regarding treatment of ash and moving material (wood, branches, stumps, debris, etc.) in tree maintenance and removal
- Guidance for Solid Waste Facilities
- Transporting Ash Wood Products into Vermont Safely and Legally

Homeowner and Municipal Tree Resources
- Homeowner's Guide to Emerald Ash Borer
- Options for Protecting Ash Trees from Emerald Ash Borer with Insecticide Treatments
- Ash Tree Protection Services Contact List
- FAQs on the Potential Side Effects of EAB Insecticides
- My ash tree is dead… now what do I do?
- Planting New Trees
- Emerald Ash Borer Management Worksheet for Vermont Municipalities
- Managing Emerald Ash Borer in Your Municipality: Frequently Asked Questions
- Rapid Roadside Ash Inventory Planning Worksheet

Forest Landowners and Managers
- Emerald Ash Borer: Information for Forest Landowners
- Ash Management Guidance for Forest Managers
- Use Value Appraisal Standards for Forest Management Related to Emerald Ash Borer Infestations
- Trap Tree Protocol for Forest Landowners

Outreach
- EAB PowerPoint and Presentation Notes

The **Vermont Forest Pest Outreach Program** continued as a cooperative interagency effort implemented by UVM Extension with participation, oversight, and/or funding by FPR, the Agency of Agriculture, Food and Markets, the US Forest Service, and USDA APHIS. In 2019, the program conducted targeted forest pest outreach resulting in 318 people receiving direct education at workshops, presentations and trainings about the threats posed by specific invasive forest pests. An estimated 400,192 people were also exposed to forest pest educational information through outreach exhibits at high profile events, newsletters, social media messaging, and information on the radio or newspapers. Special projects included:

Posting a challenge on the Young Writers website (4,500 active users) to write about the impact of emerald ash borer on Vermont's trees. The three winners presented their pieces at Vermont Arbor Day, and were published as a recorded reading on Vermont Public Radio; articles in VtDigger.net; and local newspapers with a combined subscriber/listener/viewership of over 543,000 people.

Creating **four visually engaging interpretive signs** about ash trees and EAB for use on trails at museums and nature centers. The signs are moveable and have visited the Vermont Institute of Natural Science, the Montshire Museum of Science, North Branch Nature Center, the Birds of Vermont Museum and the Southern Vermont Natural History Museum. Signs are available for towns to borrow.

As part of **Emerald Ash Borer Awareness week** (May 18 – 25th) the program partnered with the Vermont Department of Libraries to distribute an educational poster about signs and symptoms of EAB to over 180 libraries. An "On-line EAB Awareness Toolkit" was created and promoted with DIY activities for Forest Pest First Detectors and other concerned community members to educate homeowners and others about EAB.

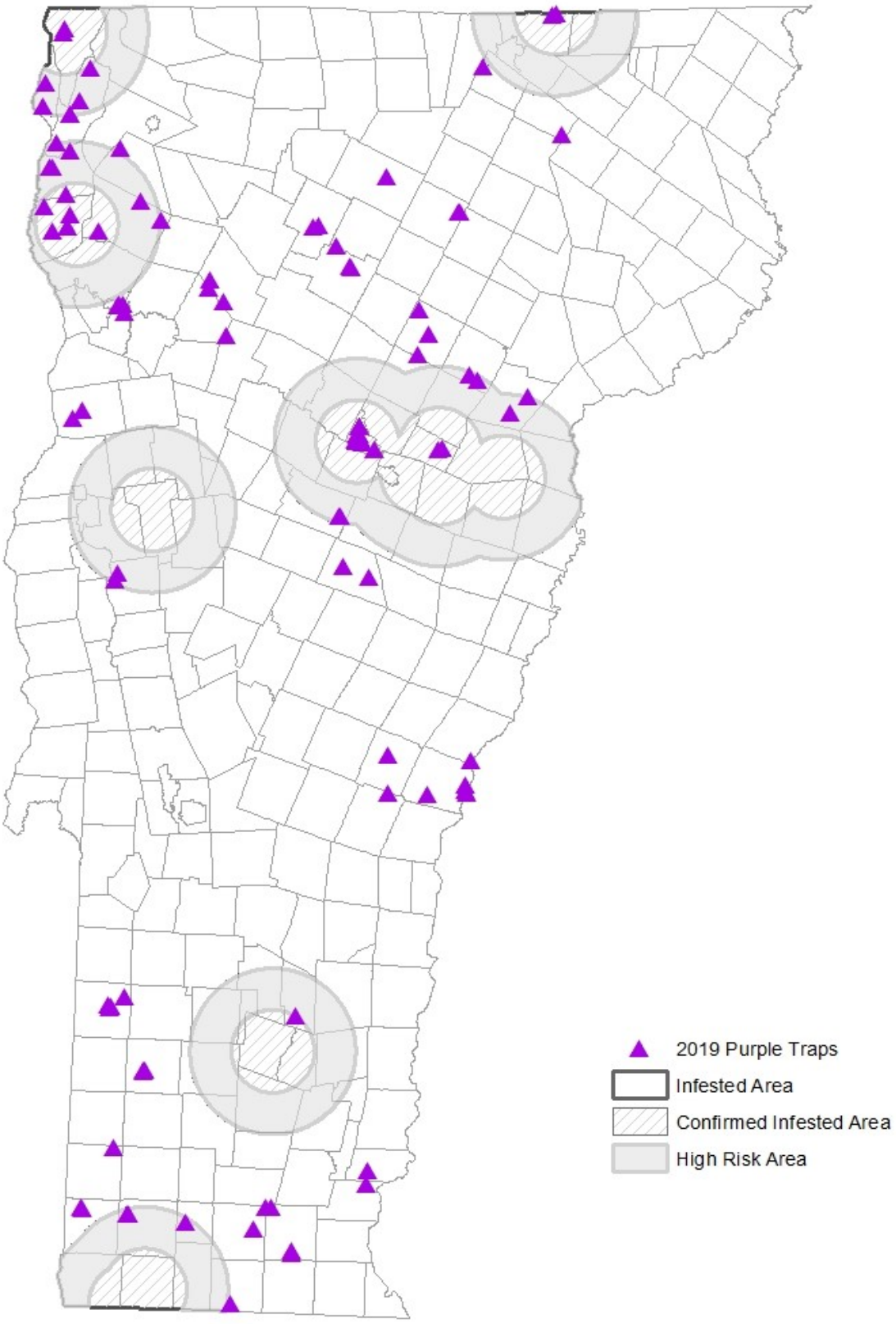


Figure 21. Approximate locations of purple pheromone traps for emerald ash borer, deployed by volunteers, in 2019. At least 78 traps were deployed. In early August, adult EAB were collected on traps in two locations in Alburgh.

Table 15. Location of girdled trap trees on state and private lands in Vermont in 2019.

Site Name	Latitude	Longitude
Allen Point Fishing Access	44.60945	-73.3112
Allis State Park	44.04394	-72.63724
Atherton Meadows WMA	42.76722	-72.91125
Bennington College 1	42.918	-73.23387
Bennington College 2	42.91602	-73.23071
Bennington Fish Culture Station	42.85252	-73.16642
Boyer State Forest	44.21125	-72.60661
Camel's Hump State Park	44.20491	-72.95777
CC Putnam State Forest Waterbury Trailhead	44.40236	-72.67441
CC Putnam State Forest Worcester Trailhead	44.42171	-72.57385
Coolidge State Park	43.5474	-72.69545
Eagle Point WMA	45.004095	-72.20578
Grand Isle State Park	44.68756	-73.29145
Groton Route 232 Overlook	44.27266	-72.27956
Groton State Forest Butterfield Block	44.47506	-72.30145
Kettle Pond State Park	44.29417	-72.30846
Knight Point State Park	44.77152	-73.29579
Little River State Park	44.39112	-72.76796
LR Jones State Forest	44.22619	-72.37655
Molly Stark State Park	42.85054	-72.81499
Molly’s Falls State Park	44.36347	-72.30265
New Discovery State Park	44.31952	-72.28623
Niquette Bay State Park	44.58795	-73.19109
Owls Head Access Road	44.30135	-72.29589
Pine Mountain WMA	44.19591	-72.20704
Ricker State Park	44.24567	-72.25223
Round Pond State Park	44.62616	-73.28366
Roy Marsh WMA	44.64173	-73.3156
Sandbar State Park	44.62764	-73.24305
Sandbar WMA	44.62207	-73.20041
Seyon State Park	44.22717	-72.30247
South Stream WMA	42.81136	-73.17685
Stillwater State Park	44.27992	-72.27131
Washington State Forest	44.04838	-72.37913
Whipstock Hill WMA	42.89147	-73.25883
Woodford Harbour Road	42.90693	-73.1254

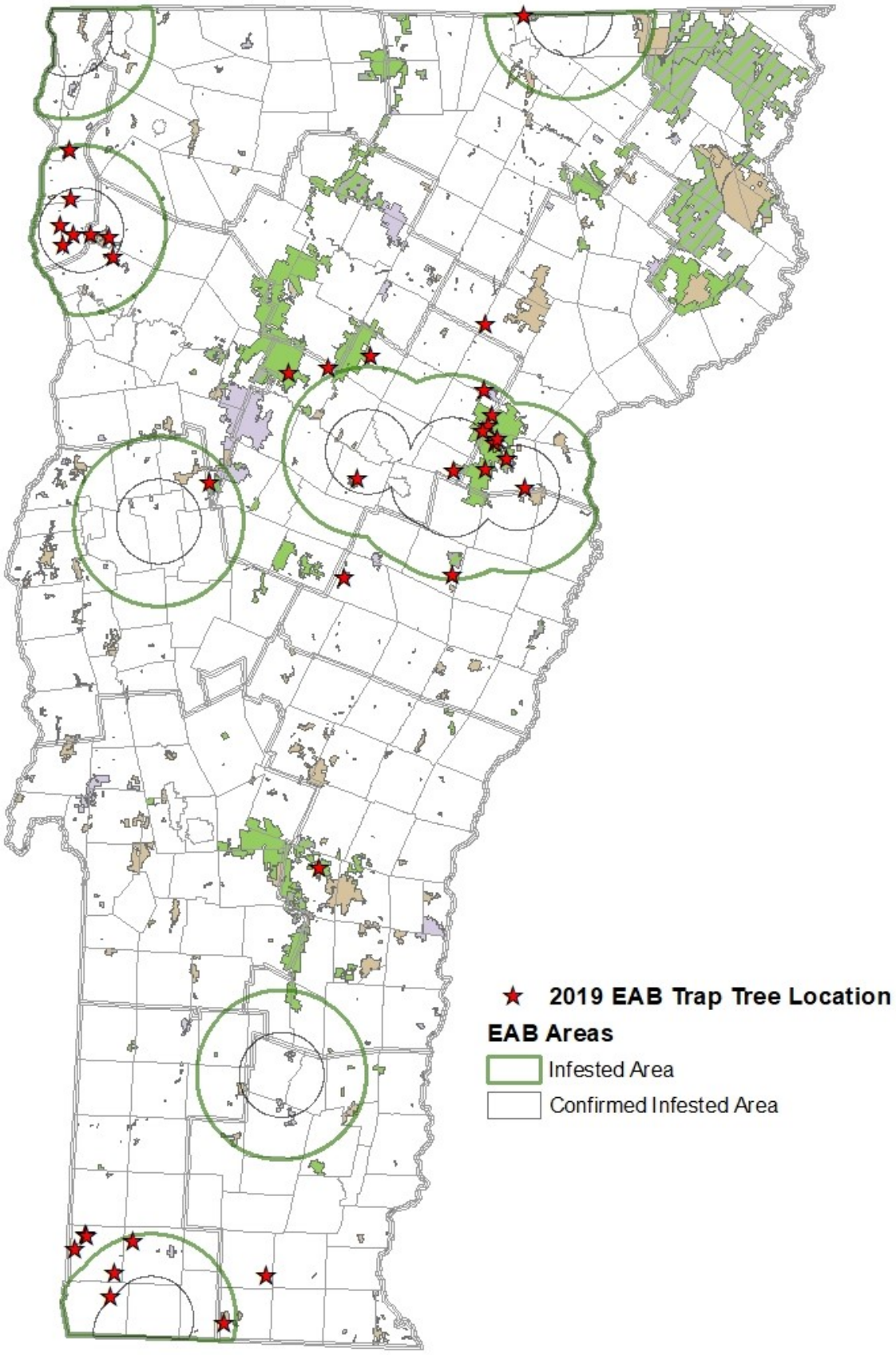


Figure 22. Location of girdled trap trees on state and private lands in Vermont in 2019. A single ash was girdled, and later peeled, at each location. No EAB were found.

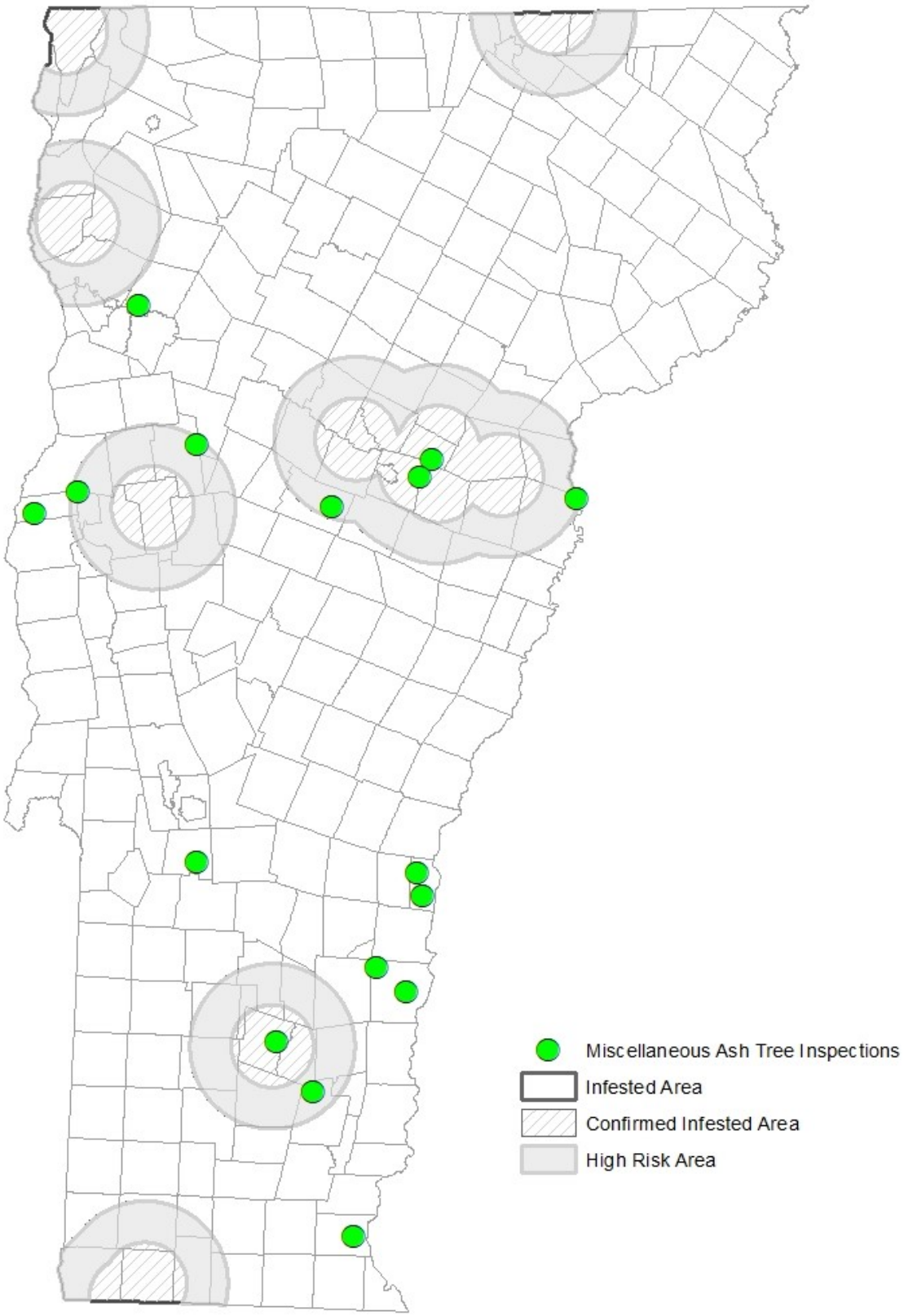


Figure 23. Locations where additional ash tree inspections were made in 2019 as a result of reports from the public or through incidental observations.

A **Firewood Quarantine**, the Rule Governing the Importation of Untreated Firewood into the State of Vermont, has been in effect since May 2016. In 2019, twenty-one waivers were granted, allowing importation of untreated firewood from adjacent counties in New Hampshire, New York, or Massachusetts. Waivers for wood from counties known to have EAB do not allow the importation of untreated ash firewood.

The **State Parks Firewood Exchange Project** continued for the 11th year. As in recent years, Vermont State Parks exchanged firewood with campers who brought firewood in from out of state. This year a total of ten firewood bundles were collected statewide. This was is the lowest since the firewood exchange began (Table 16).

State Parks that collected firewood this year included (with the number of bundles are in parentheses) Lake Carmi (2) and Little River (8). Forest Protection staff opened and examined the bags that were collected. No evidence of invasive pests were found.

Table 16. Numbers of bundles of firewood brought into Vermont State Parks during the 2009-2019 camping season. From 2009-2012, firewood from over 50 miles away was exchanged. Since 2013, wood has been exchanged if it was brought in from out of state.

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

Sirex Woodwasp, *Sirex noctilio*, was not recovered by any traps deployed as part of the AAFM and USDA APHIS trapping effort for non-native wood boring insects. This insect has been trapped in twelve Vermont counties since 2007 (Table 17). No new observations of *Sirex*-infested trees were reported, with the only known location in Jericho.

Table 17. 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

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Ambrosia Beetle	*Heteroborips seriatus*	Many	Pittsfield	First detection in Vermont. Recovered by AAFM/ USDA exotic wood boring insect trap. Identified by Carnegie Museum of Natural History identifier.
Ant-like Longhorn	*Cyrtophorus verrucosus*	Hardwoods, Pine	Ferrisburgh	Adult.
Asian Longhorned Beetle	*Anoplophora glabripennis*	Various hardwoods		Not observed or known to occur in Vermont.
Native Ash Borers	*Neoclytus acuminatus 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.
Bronze Birch Borer	*Argrilus anxius*	Birch	Scattered throughout	Sometimes observed on stressed ornamentals.
Brown Prionid	*Orthosoma brunneum*	Decaying wood	Irasburg	Adult
Brown Spruce Longhorned Beetle	*Tetropium fuscum*	Spruce, Pine and Fir		Not observed or known to occur in Vermont.
Cerambycid	*Stenocorus schaumii*	Ash, Maple and other Hardwoods	Danville	Adult.
Eastern Ash Bark Beetle	*Hylesinus aculeatus*	Ash	Scattered statewide	Mulitple inquiries initiated by galleries from people concerned about emerald ash borer.
Eastern Larch Bark Beetle	*Dendroctonus simplex*	Larch	Montgomery, Stowe	Associated with declining larch.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Emerald Ash Borer	*Agrilus planipennis*	Ash		See narrative.
European Woodwasp	*Sirex noctilio*	Red and Scots Pine		See narrative.
Hemlock Borer	*Phaenops fulvoguttata*	Hemlock	Widely scattered	Several reports of infested trees completely debarked by woodpeckers.
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.
Pigeon Tremex	*Tremex columba*	Sugar Maple	Springfield	Adults.
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.
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 2019 included Carpenterworm, *Prionoxystus robiniae* ; Elm Bark Beetles, *Hylurgopinus rufipes* and *Scolytus multistriatus* ; Locust Borer, *Megacyllene robiniae* ; Round-headed Apple Tree Borer*, Saperda candida;* Spruce Beetle, *Dendroctonus rufipennis.*

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Acorn Plum Gall Wasp	*Amphibolips prunus*	Red Oak	Hartland	Galls observed on the ground.
Pip Gall Wasp	*Callirhytis operator*	Red Oak	Springfield, Woodstock	In several locations with heavy acorn production.
Western Conifer Seed Bug	*Leptoglossus occidentalis*	Conifers	Statewide	A common household invader. Damage to Vermont conifers has not been recorded.

Fruit, Nut and Flower Insects not reported in 2019 included Asiatic Garden Beetle, *Autoserica castanea* ; Butternut Curculio, *Conotrachelus juglandis;* Fir Coneworm*, Dioryctria abietivorella;* Pine Coneworm, *Dioryctria reniculelloides;* Plum Curculio, *Conotrachelus nenuphar.*

STEM DISEASES

Dieback from **Beech Bark Disease,** caused by *Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*, was mapped on 15,073 acres, an increase from the 5,443 acres mapped in 2018 (Table 18 and Figure 24).

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 2018-19 winter had no prolonged cold snaps, and deep snow in some locations protected scales at the base of trees.

The increased acreage also reflects the later timing of the aerial survey following several years of earlier flights during the 2016–2018 forest tent caterpillar outbreak. The bright yellow crowns of symptomatic beech develop over the growing season, and are less noticeable in mid-summer than in late summer.

Table 18. Mapped acres of beech bark disease in 2019.

County	Acres
Addison	106
Bennington	1091
Caledonia	498
Chittenden	1153
Essex	2364
Franklin	507
Lamoille	367
Orange	2194
Orleans	683
Rutland	953
Washington	1717
Windham	1854
Windsor	1586
Total	**15073**

Oak Wilt, caused by *Bretziella fagacearum*, is not known to occur in Vermont. Because of recent detections in New York State, Vermont and nearby states are participating in a regional effort to look for oak wilt. In Vermont, the primary detection method is outreach, with an estimated 3,300 contacts through newsletters and social media and 420 contacts through workshops in 2019. As a result of this effort, three suspects were reported, but symptoms did not match oak wilt and no samples were taken.

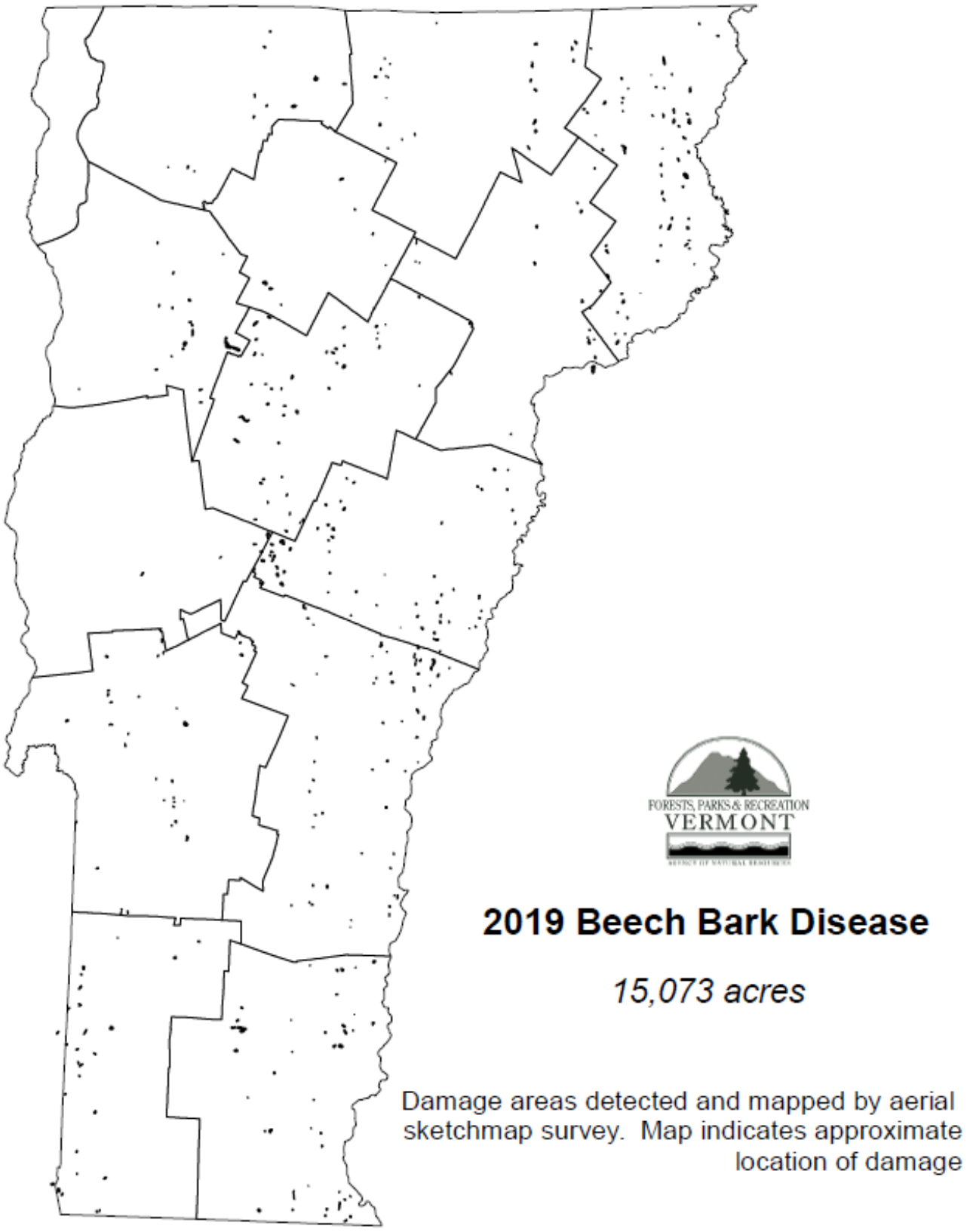


Figure 24. Beech bark disease related decline and mortality mapped in 2019. Mapped area includes 15,073 acres.

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*			See narrative.
Black Knot	*Dibotryon morbosum*	Cherry	Scattered throughout	Remains common at normal levels, especially on off-site black cherry.
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*	White Pine	Rockingham	Associated with heavy mortality of small poles under an oak canopy.
Crown Gall Rust	*Puccinia corronata*	Common Buckthorn	Guilford, Milton, South Burlington	Causing galls as well as leaf spots.
Decay Fungi	*Polyporus squammosus*	Hardwoods	Widespread	Basidiophores particularly noticeable in the spring.
Dutch Elm Disease	*Ophiostoma novo-ulmi*	Elm	Throughout	Similar to other years. Dead trees commonly observed along roadsides.
Nectria Canker	*Nectria galligena*	Hardwoods	Scattered throughout	
Oak Wilt	*Bretziella fagacearum*			See narrative.
Red Pine Shoot Blight	*Diplodia sapinea, Sirococcus conigenus,* and *Pestalotiopsis spp.*	Red Pine	Peacham	Identified by the US Forest Service on dying shoots. See Red Pine Decline and Mortality.
Red Ring Rot	*Phellinus pini*	White Pine	Scattered throughout	Common in stressed or overstocked stands.

OTHER STEM DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Thousand Cankers Disease	*Geosmithia morbida* and *Pityophthorus juglandis*	Walnut		Not observed or known to occur in Vermont.
White Pine Blister Rust	*Cronartium ribicola*	White Pine	Scattered throughout	Generally a decrease from a recent spike in occurrence that began in 2009. 386 acres of scattered mortality were mapped during aerial surveys.
Yellow Witches Broom Rust	*Melampsorella caryophyllacearum*	Balsam Fir	Widely scattered	Continues to be very noticeable, especially in northern Vermont.

Other Stem Diseases not reported in 2019 included Chestnut Blight, *Cryphonectria parasitica* ; Cytospora Canker, *Leucostoma kunzei* ; Eastern Dwarf Mistletoe, *Arceuthobium pusillum* ; Fireblight, *Erwinia amylovora* ; Hypoxylon Canker, *Hypoxylon pruinatum;* Phomposis Twig Blight, *Phomposis spp.;* Sapstreak, *Ceratocystis coerulescens* ; Scleroderris Canker, *Ascocalyx abietina;* Verticillium Wilt, *Verticillium albo-atrum;* Woodgate Gall Rust, *Endocronartium harknessii.*

FOLIAGE DISEASES

The wet weather early in the 2019 growing season left multiple hardwood species vulnerable to infection by **Anthracnose** fungi.

Sycamore Anthracnose was particularly heavy. Many trees were bare in late spring after dropping infected foliage or due to infections at budbreak that prevented foliage expansion. By mid-season, the crowns of defoliated trees had recovered. Sycamores have indeterminate shoot growth, and continued to produce foliage after the wet spring infection period had passed.

Sugar Maple Anthracnose infection occurred for the same reason, but symptoms were slow to develop. By mid-July, brown foliage in the canopy was visible during aerial detection surveys. A total of 28,490 acres of damage were mapped (Table 19, Figure 25). It should be noted, however, that over the course of our aerial surveys, two additional factors contributed to the "browning" observed. Heavy seed production led to thin foliage and crowns tinged with brown as seeds matured. Maple leafcutter caused widespread late-season browning in lower crowns, leading to noticeable brown patches of maple at mid-elevations beginning in late August (see *Hardwood Defoliators*). Ground checks indicated that all three factors were widespread, and often co-mingled, but varied in importance between mapped areas.

Table 19. Mapped acres of brown hardwood foliage due to maple anthracnose, maple leafcutter and heavy seed in 2019.

County	Acres
Addison	3188
Bennington	1567
Caledonia	1283
Chittenden	504
Essex	1103
Franklin	2174
Grand Isle	47
Lamoille	2453
Orange	5209
Orleans	1920
Rutland	4839
Washington	2922
Windham	264
Windsor	1017
Total	**28,490**

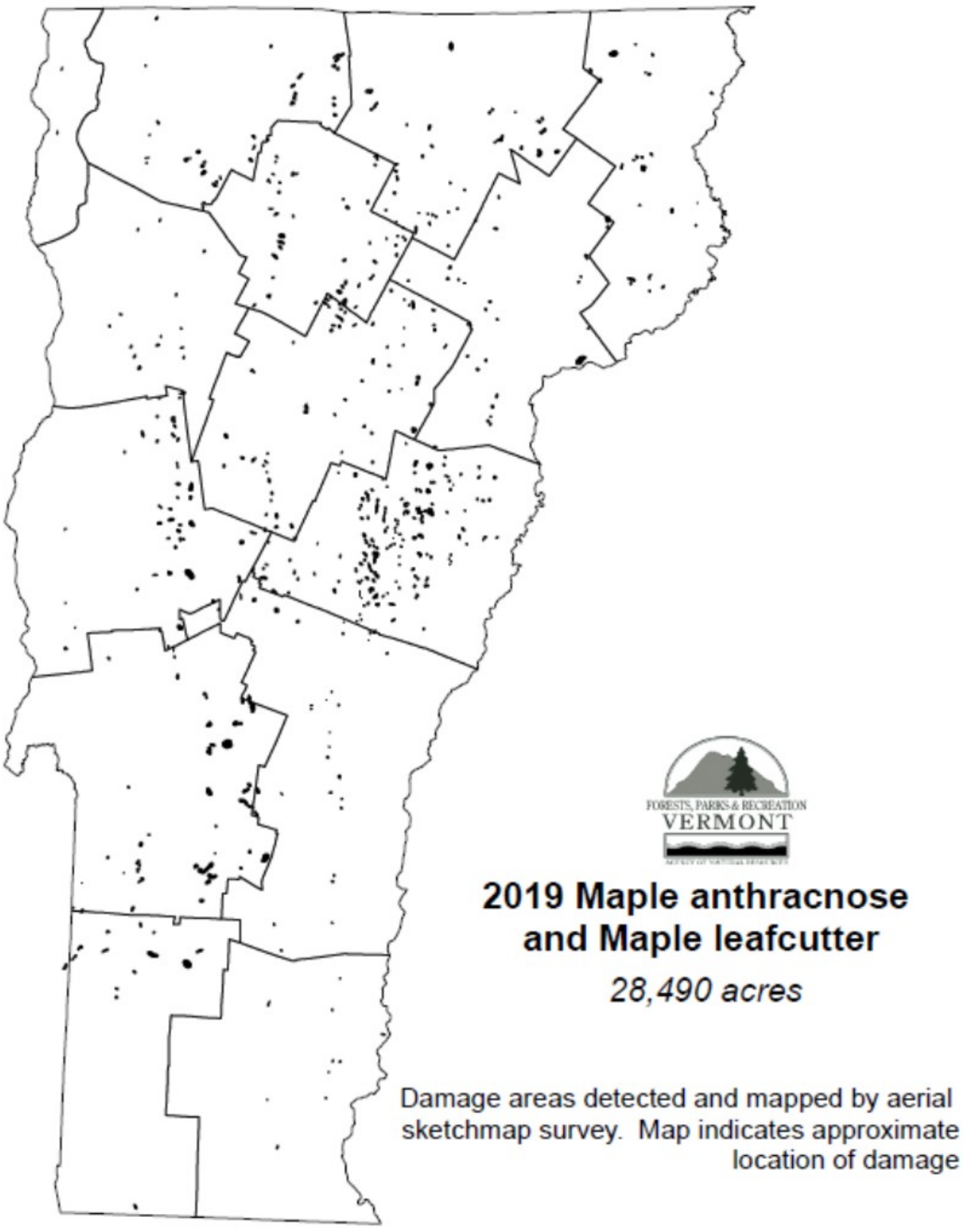


Figure 25. Maple anthracnose and maple leafcutter damage in 2019. A total of 28,490 acres were mapped where sugar maples experienced browning foliage over the course of the growing season. The damage agents were comingled, along with heavy seed, and were combined in estimates of the area affected.

Needle Diseases of White Pines 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*. During aerial surveys, 23,891 acres of white pine needle damage were mapped, which is a decrease from 2018 (Table 20, Figure 26). However, aerial detection surveys were conducted later in the growing season this year, ostensibly after affected needles had fallen, which may in part explain the decrease in area. Furthermore, this likely underestimates the area affected since damage is mapped from above the trees, while much of the damage is observed within and in lower portions of tree crowns.

Regionally (New England and New York), the severity of white pine needle damage was higher in 2019 than in any year on record since 2012, and Vermont's data follow this trend. Trees indicated as "healthy" at the beginning of the study have experienced lower levels of chlorosis and defoliation than those deemed initially "unhealthy". Decline and mortality of white pine have been observed in stands which 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.

Table 20. Mapped acres of white pine needle damage in 2019.

County	Acres
Addison	295
Bennington	912
Caledonia	848
Chittenden	2,208
Essex	278
Franklin	670
Grand Isle	145
Lamoille	1,060
Orange	1,409
Orleans	448
Rutland	867
Washington	1,538
Windham	4,063
Windsor	9,737
Total	**23,891**

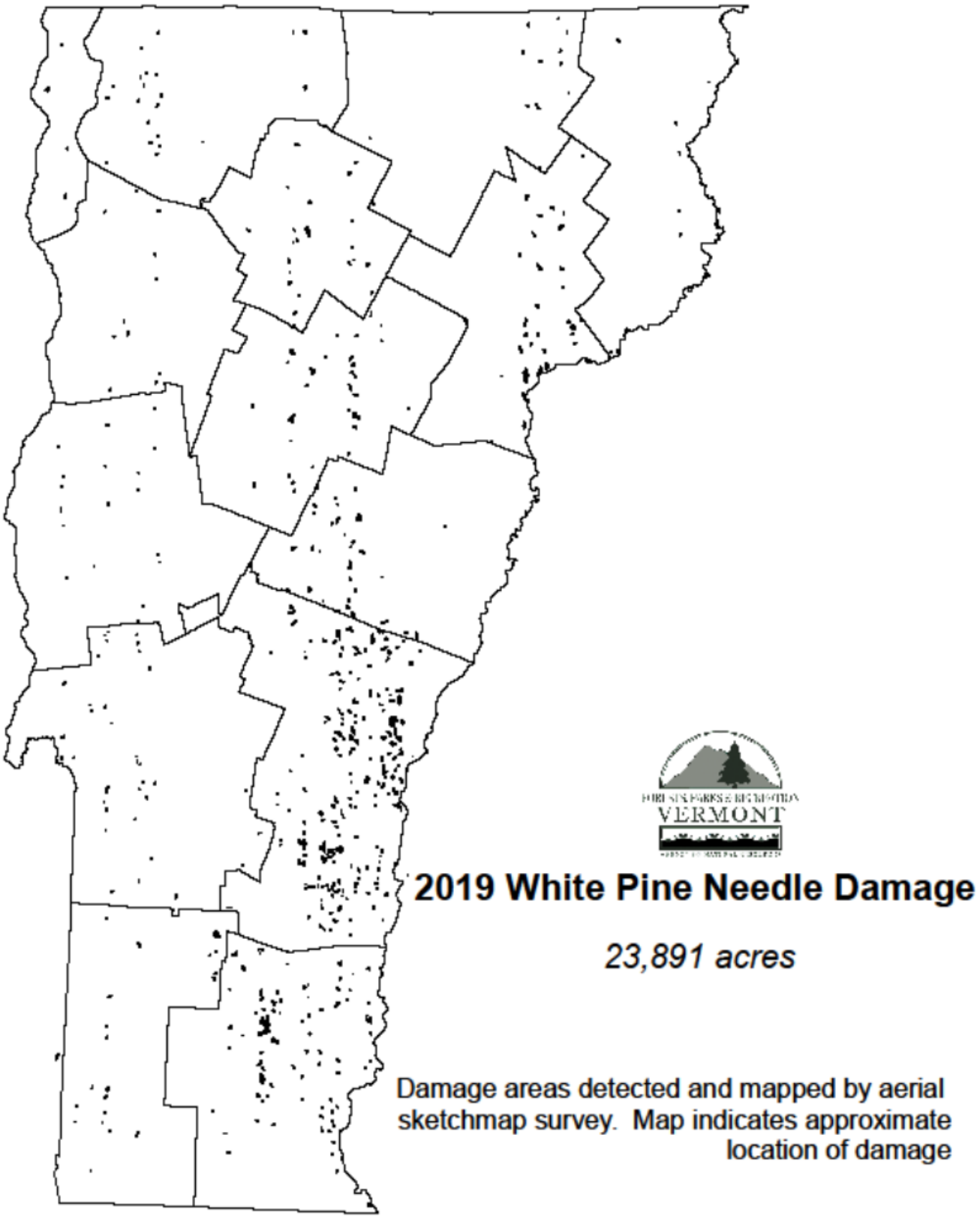


Figure 26. White pine needle damage mapped in 2019. Mapped area includes 23,891 acres.

The US Forest Service, in cooperation with 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 27-29). 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.

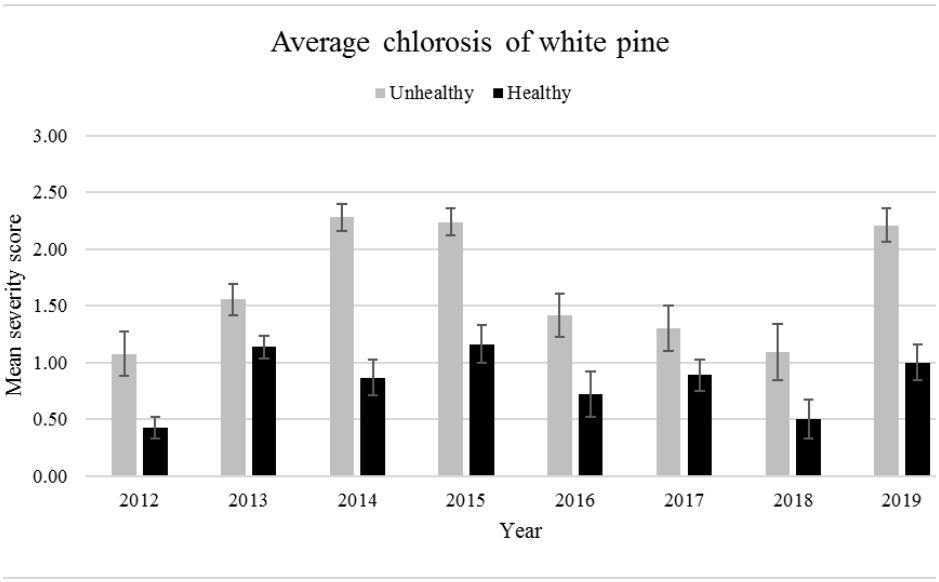


Figure 27. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed between 2012-2019 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

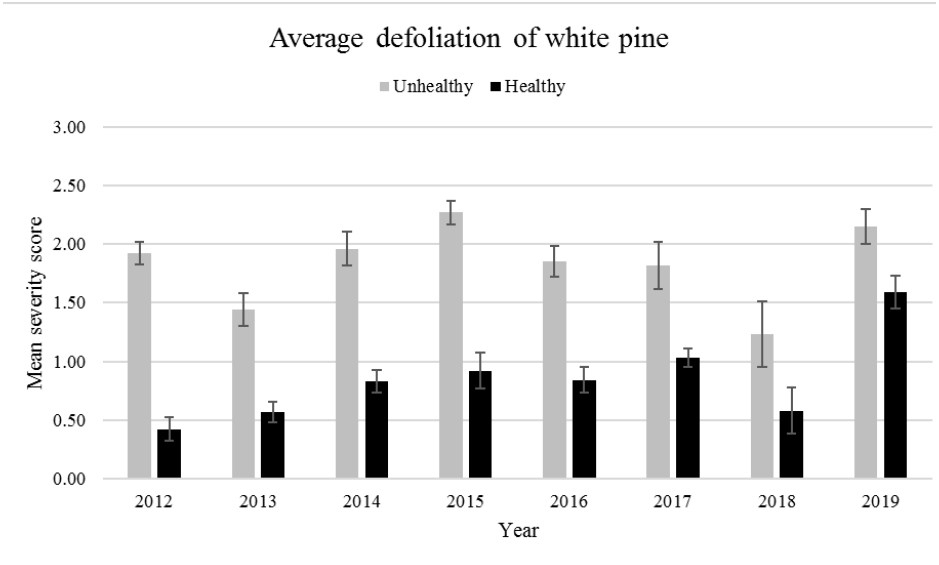


Figure 28. Defoliation severity of unhealthy and healthy white pines surveyed between 2012-2019 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

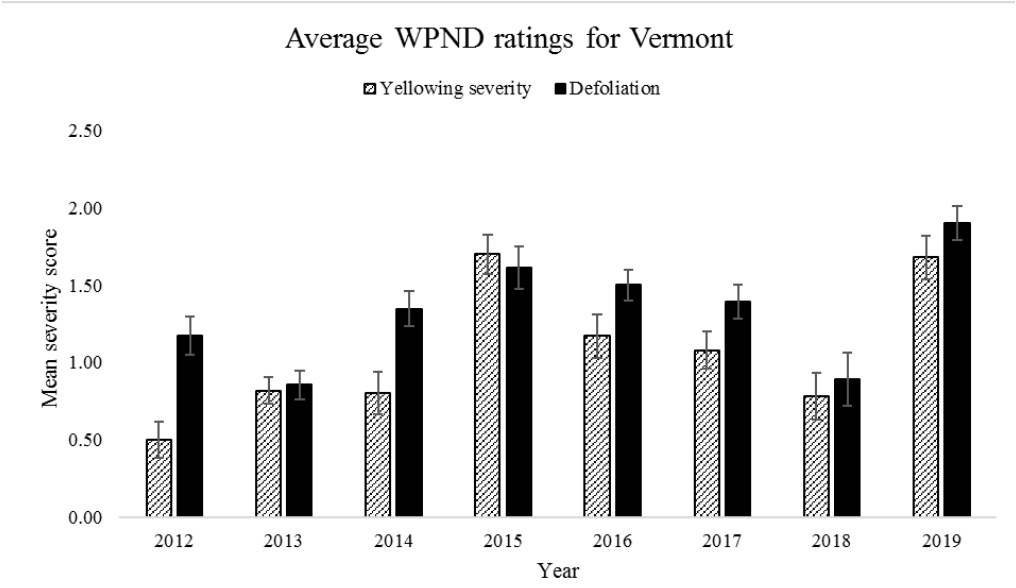


Figure 29. Average trends in yellowing severity and defoliation for all trees sampled at four sites in Vermont between 2012-2019. Data presented are mean severity scores (0 = no chlorosis/defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Apple Scab	*Venturia inaequalis*	Apple	Statewide	Heavy late season defoliation of wild apples.
Brown Spot Needle Blight	*Lecanosticta acicola*	Pines	Statewide	Thin crowns, some decline. Heavy early needle drop. See Needle Diseases of White Pine.
Crown Rust	*Puccinia coronata*	Buckthorn	Northern VT	Increase from recent years. See Stem Diseases.
Fir-Fern Rust	*Uredinopsis mirabilis*	Balsam Fir	Northwest VT	Incidental observation.
Giant Tar Spot	*Phytisma acerinum*	Norway Maple	Statewide	Increase from 2018 levels, but still mostly light damage.
Poplar Leaf Blight	*Marssonina spp.*	Poplar	Northwest VT	Noticeable late in growing season.
Rhizosphaera Needlecast	*Rhizosphaera kalkhoffi*	Spruce	Statewide	Mortality of ornamental blue and white spruce continues due to heavy defoliation in the past.
Septoria Leafspot	*Septoria aceris*	Sugar Maple	Southern VT	Continues to be present in the Rutland area.

Foliage Diseases not reported in 2019 included Birch Leaf Fungus, *Septoria betulae* ; Cedar-Apple Rust, *Gymnosporangium juniperi-virginianae* ; Dogwood Anthracnose, *Discula destructiva* ; Dothistroma needle blight, *Dothistroma pini* ; Phyllosticta leafspot, *Phyllosticta sp* .; Powdery Mildew, *Eryiphaceae;* Sirococcus tip blight, *Sirococus tsugae* ; Tubakia leafspot, *Tubakia dryina* .

ROOT DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Armillaria Root Rot	*Armillaria spp.*	Many	Statewide	Sporophores uncommon in 2019.
Heterobasidion Root Disease (formerly Annosus Root Rot)	*Heterobasidion annosum*			Previously confirmed in 9 counties. No reports in 2019.

DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

Red Pine Decline and Mortality was mapped on 556 acres scattered in seven counties, compared to 765 acres mapped in 2018 (Table 21, Figure 30). We continue to investigate the cause of the mortality, but a clear causal agent has not been identified. Although red pine scale remains a possible suspect, research and observations to date have not been able to confirm this hypothesis.

Table 21. Mapped acres of red pine decline and mortality in 2019.

County	Acres
Addison	0
Bennington	0
Caledonia	5
Chittenden	12
Essex	0
Franklin	0
Grand Isle	0
Lamoille	15
Orange	36
Orleans	0
Rutland	36
Washington	386
Windham	0
Windsor	65
Total	556

Investigations in 2019 focused on a fifty-acre 100-year-old red pine plantation in Groton State Forest (Peacham), where a harvest was conducted in late winter 2019. Symptoms were first observed in 2011. During a visit on March 15, canopies of recently felled trees looked thin, but foliage was healthy and the wood was sound. There was evidence of *Diplodia* spp. on some discolored shoots. Pine gall weevil (*Podapion gallicola*) was common, but branches heavy with galls had healthy foliage and the tissue on the surface of the galls was green.

A four-acre reserve area was left uncut for monitoring. During a visit on July 9, the most common symptom was old dead shoots, without needles, throughout the crown. Healthier trees had tufted foliage and many needle-free dead shoots (indicating the shoots been dead for some time), but very few recently dead shoots. They had no resin on the mainstem, and no evidence of bark beetles or root rot. It appeared they were on a "recovery" period from the primary stressor. More unthrifty trees often had foliage with brown tips, and bark beetles were common. These appeared to be trees that were not going to recover from the primary stressor and were now succumbing to secondary pests.

Two trees were felled so branches could be submitted to the US Forest Service Forest Health Protection for analysis. No evidence of red pine scale was found. *Diplodia sapinea, Sirococcus conigenus,* and *Pestaliopsis* spp. shoot blight(s) were identified on stunted shoots and cone scales. Both trees had spider mites and pine gall weevil. The findings do not explain the stand-level decline and mortality.

Four 34-ft radius monitoring plots were established and crown condition was rated. Shoot dieback averaged 75% (Table 22). Plots will be remeasured annually.

Table 22. Crown condition of red pine trees in Peacham monitoring plots, July 2019.

Subplot #	% Dead Shoots	Live Crown Ratio	Crown Transparency	Crown Density
1	78	22	57	25
2	73	32	25	35
3	80	30	40	33
4	68	34	26	31
Average	**75**	**30**	**37**	**31**

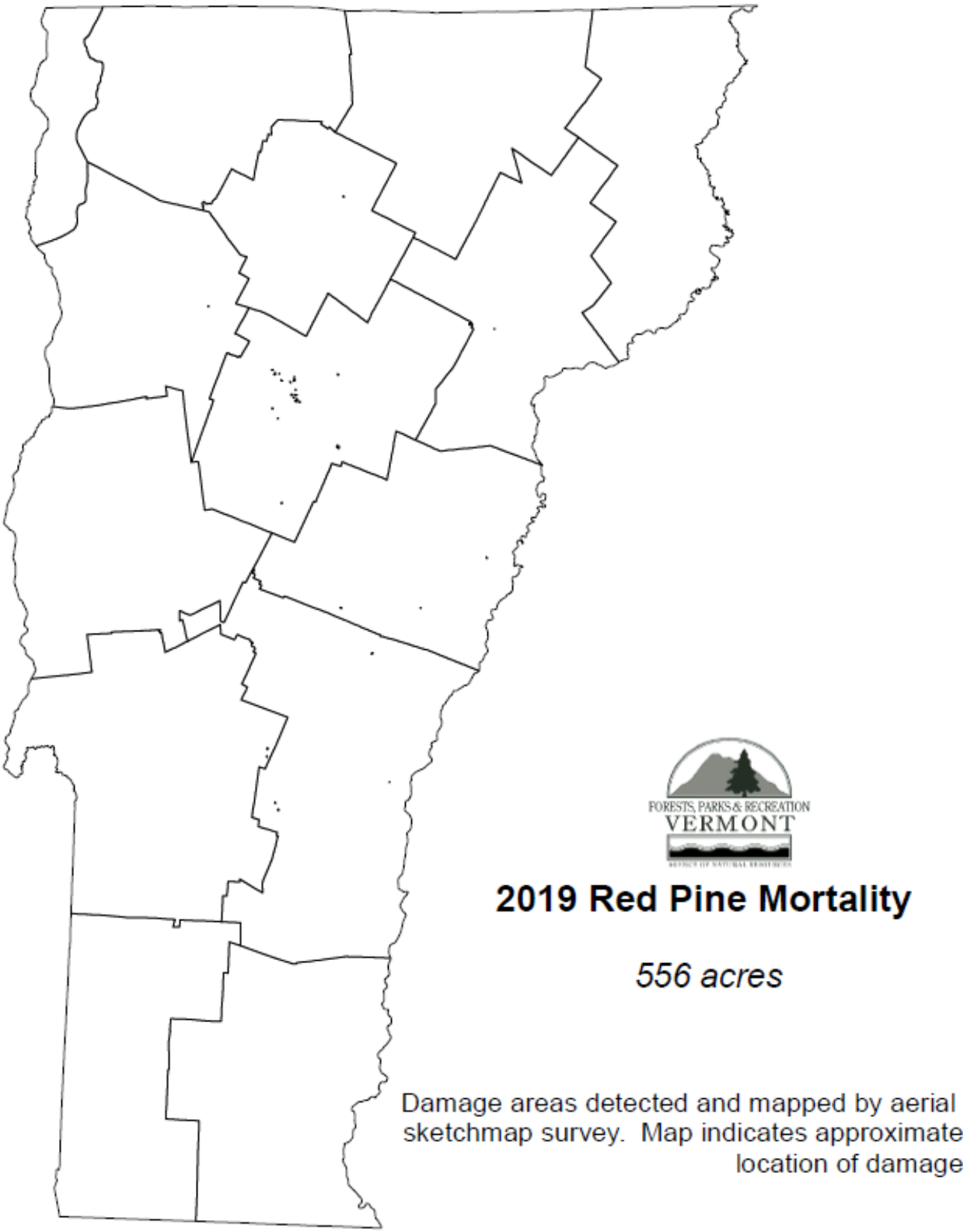


Figure 30. Red pine decline and mortality mapped in 2019. Mapped area includes 556 acres.

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	Bennington County	31 acres of mortality mapped.
Hardwood Decline and Mortality			See Forest Tent Caterpillar.
Heavy Seed	Sugar and Red Maple	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	White Pine	Widespread	While not unusually severe, foliar browning was common in late winter.
Red Pine Mortality			See narrative.
Wet Site Related Decline	Many	Statewide	Only 248 acres of new symptoms were mapped.
White Pine Needle Damage			See Foliage Diseases.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Wind Damage	Many	Scattered Statewide	20 acres mapped. Wet spring soils led to windthrow. An additional 100 acres with scattered damage resulted from a tornado in the town of Windham. See 2019 Weather Summary.
Winter Injury	Fir	Bennington County	Recently planted Christmas trees.

Other Diebacks, Declines, and Environmental Diseases not reported in 2019 included air pollution injury, birch decline, chlorosis due to rainfall, frost damage, hail damage, ice and snow breakage, spruce decline.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Squirrel	Maples, Oaks	Statewide	Populations were still high in 2019, with branch clipping noted in multiple locations.
Woodpecker	Wood products; Balsam fir, Mountain ash	Statewide	Scattered throughout the state.

INVASIVE PLANTS

Non-native invasive plant management (NNIPM) efforts continued in 2019, with progress on **Education, Outreach, and Capacity Building** made possible through several grant funded opportunities. The statewide Invasive Plant Coordinator within FPR presented 35 workshops for a variety of stakeholders and worked with multiple state departments and agencies to unify Vermont's approach to NNIPM. The Coordinator also fielded over 350 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

A few new locations of **Giant Hogweed** were confirmed in Plymouth and Woodstock.

An isolated patch of what was suspected to be **Japanese Stiltgrass** was reported in Sandgate in late 2018. There has not been botanical confirmation of the presence of this plant, because the site was treated as part of a private land management project. A potential site for this plant was reported in October 2019 in Brattleboro, but there has not yet been botanical confirmation of the presence of this plant.

A known location of **Tree-of-Heaven** was re-reported in Colchester this year. To date, confirmed locations also include Woodford and Brattleboro.

***Petasites* spp.** are known in Burlington, Warren, Barton, Plainfield, Sharon, Pomfret, Woodbury and Readsboro. This season the species was confirmed in Chelsea, Woodstock, and Bridgewater. Potential other sites yet to be botanically confirmed include: Springfield, East Montpelier, Quechee, Worcester, Weathersfield. Many of these new sites were identified through photographs sent to F&W Natural Heritage staff and FPR staff. Volunteers from the Black River Action Team worked with them to start management of those sites.

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 through this link: https://www.inaturalist.org/projects/mapping-for-healthy-forests-vermont. As of October 21st, the project had 4,289 observations provided by 125 observers.

Habitat Hero! Student Volunteers: Work continues this year on a project funded by a US Forest Service grant, where the Habitat Restoration Crew (seasonal staff based out of the Rutland office) and the Invasive Plant Coordinator focus outreach efforts on middle and high school groups. Students who participate in the program learn about the negative impacts invasive plants have on Vermont's ecosystems, learn how to identify common invasive plants, and get hands-on experience removing invasive plants. In 2019, the crew worked with 633 student volunteers from 17 schools across Vermont. Between 2014-2019, the crew has worked with over 2,500 volunteers (11,558 volunteer hours). Additionally, this year the crew worked on mapping, curriculum development for programs with schools, and installing interpretive panels about NNIPM demonstration sites in state parks.

Forest Hero! Volunteer Network: Another part of the Forest Service grant is an outreach "train the trainer" opportunity for members of the public called the Forest Hero! Network. 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. A follow up workshop was offered this spring, with another planned for spring 2020, to enhance the volunteers' knowledge of field identification and control.

Tool Loan Pilot Program Continues with Plans for Growth: 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 this year. The loan program was used 16 times as of September 2019, with more check-outs planned for the rest of the fall. 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 information 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.

Non-native Invasive Plant Management on State Lands

District 1 (southeast): Numerous NNIPM projects were continued across the district, and preparations for a large-scale project at Mt. Ascutney State Park on the McClary Lot are being coordinated. That project will see the treatment of 20 acres of honeysuckle and barberry.

District 2 (southwest): Using a "strike team" model, the Habitat Restoration Crew conducted NNIPM in State Forests and State Parks throughout District 2. An example of a NNIPM project conducted by the crew is ongoing management of a population of *Pastinaca sativa* in Coolidge State Forest in a meadow on Tin Shanty Road, and along Town Highway 20. A small satellite population was found two seasons ago, and the crew has been working to keep the population along the road from progressing into a nearby meadow and wetland. This work has been in collaboration with the town Conservation Commission, and members of the commission have taken their learned skills and applied that to management of the species on other parcels of town land. Another example is the continued management of an isolated patch of *Alliaria petiolate* on the Rich Woods Trail in Emerald Lake State Park. Originally discovered in 2015, the crew takes a few hours each season to hand pull the plants that come up from the seed bank. A few hours of crew work each season is protecting rough 20 acres of a unique natural community.

District 3 (northwest): At Alburgh Dunes State Park, Long View Forests LLC completed year two of herbicide treatment to control the *Phragmites* infestations that threaten the integrity of the wetland, and several RTE plant species. The 2018 treatment was highly effective with a kill rate of greater than 90%. District 3 hopes that the 2019 treatment will reduce the infestation to a point that in future years the *Phragmites* and other emerging invasive plant threats can be treated in-house.

In Sandbar WMA, there are multiple stands of *Phragmites* (0.24 acres). Along Route 2, the stand has been treated in previous years, and appears to be weakened. This year only produced few small resprouts after treatment. Near Round Pond, the stand is larger, and this year managed only a handful of shoots.

The Intervale WMA has three stands of *Phragmites* (~0.1 acres). The berm stand is very vigorous (12-15 feet tall), but compact and relatively small. Another stand is near the end of the berm, and is difficult to get to, but small. Finally, there is a stand within the VTrans ROW for Route 127. This is a large patch not on the WMA but probably good to pay attention to or it will spread onto the WMA. The smaller stands were much reduced after initial treatment, sending up only a few shoots this year.

At Dead Creek WMA, there is purple loosestrife in a ditch and pond (~1.6 acres). The density of seed-

lings in the ditch made initial treatments ineffective, and the overall scattered nature of the population made it hard to systematically treat. Only the pond was effectively treated this year. There is also a stand of *Phragmites* near the Farrell access, and is partially shaded out. It has been previously treated and was treated again this season. Treatment was very effective, however more was found this year. Along Gage Road is another stand of *Phragmites*, also mostly shaded out was treated this year.

At Avery's Gore WMA, there is a dense stand of Japanese knotweed along the creek (~0.13 acres) (Figure 38) It is limited to one side of the creek by a steep bank. The creek is heavily infested upstream and downstream of the site, so permanent eradication is impossible. A collapsed beaver dam altered the course of the creek this year, drowning much of the alder and knotweed, but also exposing a very large rhizome.

Mallett's Creek WMA has two patches of wild parsnip (0.9 acres), abutting a road, that were assessed and treated in 2018. Treatment occurred again in 2019 however it seems the infestation is beyond control with a backpack sprayer.

At Mud Creek WMA, a stand of *Phragmites* (0.28 acres) received follow up treatment. Assessment indicates it has been reduced. Rhizomes were observed growing towards the adjacent forested wetland. This stand managed only a few shoots this year, however yellow iris seems to have opportunistically filled in the space. This was treated as well. Two new patches were added to the roster this year, one very small and shaded, the other is quite large in contiguous with a very big patch on private land, so eradication may not be possible.

In Rock River WMA, a stand of *Phragmites* is located in two patches on either side of the rail trail (0.14 acres). Neither are large, and the western patch is contained by dense cattails. This site was devastated by the 2018 treatments. A small infestation was found on the other side of St Armand Rd and was also treated.

District 4 (central): District 4 began work at Mt. Mansfield State Forest, French Hill Block in Johnson, controlling a one-acre patch of Japanese knotweed. This patch is considered a high priority for treatment because it is located in an otherwise intact mature forest, and, although it's isolated geographically, it's likely to spread along an adjacent hiking trail and intermittent stream. The treatment timeline for this year was to mechanically treat (brushsaw cutting of all stems) in July, and the follow up in September with a foliar spray treatment. Follow up treatments include a similar timeline for the next growing season.

District 5 (northeast): VT Dept. of Fish & Wildlife and FPR Forest Protection staff conducted a second year of treatments to approximately 30 Japanese knotweed patches early in establishment along the Moose River in Victory Basin. Previous cut and drip treatments seem to have been largely effective and were continued, though the presence of knotweed upstream on private land will need to be dealt with to manage the problem in the long term.

Efforts have also been initiated to control the barberry at Willoughby State Forest. The first step was to mechanically treat the larger stems/patches with a plan of follow up herbicide treatment after plants resprout.

A large Japanese knotweed management project in Jay State Forest was started in July, in collaboration with VTrans, Jay Peak Resort, and FPR staff. Fourteen staff from FPR and VTrans spent two days in the first phase of the project, cutting back the patches to prepare for follow up treatment in the fall. Several staff returned for a third day of cutting satellite patches. The resort allowed FPR to store the cut material while it decomposed enough to then be safely transported to a composting facility in Newport.

Figure 31. FPR and VTrans staff collaborated on a Japanese knotweed management project in Jay State Forest.

Other Activities

The growing season for 2019 saw many NNIPM projects, led by others, across the state. Below are highlights reported by some of these project leaders.

Burlington, VT:
The Winooski Valley Park District (WVPD) has been working to manage invasive species at their parks by engaging the public through service learning projects. In 2019, WVPD continued an ongoing partnership with CP Smith Elementary School, Essex Middle School, and Williston Central School to remove invasive plant species and plant native trees and shrubs at the Ethan Allen Homestead in Burlington. In addition, WVPD's Sustainable Outdoor Leadership Education (S.O.L.E.) Camp also worked to remove invasive plants and promote native species in Burlington's Intervale. Thanks to the dedicated hard work of these volunteers, thousands of invasive plants were removed and hundreds of native species were planted to support a healthier and more diverse ecosystem. WVPD hopes to expand its service learning partnerships in 2020.

Essex Junction, VT:
The Center for Technology, Essex's Natural Resources Program manages the wood lot at the Essex Tree Farm Soccer Complex. The property is about 100 acres and 46 acres are forested. In 2019, students and staff from the Natural Resources program spent 20 hours scouting and pulling buckthorn, bittersweet, barberry, multiflora rose, and Norway maple and plan to double that number in 2020. The preferred management technique is cutting (stressing) plants three times in two growing seasons, but treatments also include pulling, cutting, and girdling invasive plants. A work day is being planned on the property for the spring of 2020. All stakeholders, including the cross country teams, VAST users, soccer teams, Essex High School & Center for Technology, Essex students and teachers, will be rallied for a major removal effort.

Waterbury, VT:
Since 2010, NNIP removal efforts have been underway at Little River State Park in Waterbury. Between 2011 and 2017, Brian Aust, Park Interpreter, has led volunteers from Ben & Jerry's, Green Mountain Coffee Roasters, and the VT Housing and Conservation Board's AmeriCorps team in removing close to 90% of the honeysuckle found around the parks campsites and roads. During this time, an interpretive program called *War Of The Weeds!* was developed to teach park visitors about NNIPs, spend some time pulling them and to offer an interesting option for kids to fulfill the park service project in their Junior Ranger booklets. Occasional school groups would opt for a field trip that included a honeysuckle-pull as part of on-site education about tree & plant identification. In all, 626 people have put in more than 1,000 hours of work eradicating honeysuckle from the park since August 2010.

In the past couple of seasons, emphasis has shifted from honeysuckle eradication to the prevention of other NNIPs from becoming established. Since 2014, Japanese knotweed has begun to colonize a handful of sites around the park. In 2019, knotweed was cut using a hand scythe every couple of weeks (seven times total) and not allowed to flower. All cut Japanese knotweed plants were either sealed in contractor bags or stashed off the ground in tree branches away from water. No knotweed has resprouted from chopped plants disposed of this manner since the practice was begun in 2016.

In 2019, wild chervil arrived inside the park for the first time prompting swift action by park staff. A crew ventured out to uproot chervil one rainy day in early June. The plants were sealed in contractor bags and set out to 'cook' in a corner of the park's work pit.

All of this work has produced an outcome both profound and hopeful. In recent seasons Brian noticed a very literal 'buzz' of activity along an approximately 150-meter stretch adjacent to the B-Side Beach. Numerous butterflies and other pollinating insects, an array of dragonflies, and birds (including hummingbirds) were turning up that hadn't been noticed before when the area was dominated by honeysuckle. Brian now refers to this area as the park's habitat restoration area because of the untold diversity of insects and birds that now have a newly established resource to utilize. In 2019, at least 30 species of flowering plants were documented to have colonized this former honeysuckle thicket, along with 13 species of butterflies and a dozen kinds of dragonflies. Certain wildflowers like goldenrods and asters arrived directly in the wake of honeysuckle removal circa 2011, while others such as Allegheny monkeyflower and boneset took a few years to turn up. Still others arrived in 2018 or 2019, including swamp candle and pale St. John's Wort. There now exists a succession of plant species blooming at various times of the spring, summer and fall in areas where previously the only flowers of the entire season were those of honeysuckle for 2 weeks in June. The wildflower succession in turn attracted what to the untrained eye would appear as a healthy aggregation of pollinators and their predators. In a world where alarming declines of insects, birds and biodiversity has been abundantly documented, even small-scale restoration efforts like this can create crucial safe havens ("pollinator hubs") for what remains. The difference between what was and what has become of the B-Side Beach restoration area is so profoundly noticeable that no less than three separate interpretive programs were created in order to showcase this location, including *Here Be Dragonflies, Let It Grow* and *Butterfly Gardening: Wildflower Edition.* Perhaps the interpretation of transformed places and restoration efforts like these can buffer against the forces of extinction, one butterfly and positively influenced park visitor's mind at a time.

Richmond, VT:
Since 2009 the Great Richmond Root-Out! has worked to control invasive plants on 120 acres of state-significant silver maple-ostrich fern floodplain forest—the largest remaining example of this now rare natural community on the upper Winooski River. In addition to its ecological importance, our floodplain forest is also prized by the people of Richmond who use it extensively for hiking, biking, birdwatching, fishing, boating, and nature exploration. Participating lands are owned by the Town of Richmond, the Richmond Land Trust, The Nature Conservancy and private landowners.

Many volunteers have helped the Root-Out! over the years, including community members, middle and high school science classes, UVM students, land trust members and more. This past year both 5th and 7th grade science classes from Camel's Hump Middle School got very connected. They spent class and

field time learning about floodplain ecology and then did a spectacular job finding and removing invasive garlic mustard and knotweed. Thanks to their help and that of all Root-Out! volunteers, knotweed, barberry, honeysuckles and phragmites infestations have all been shrunk by 95-99% since the program's inception.

The Great Richmond Root-Out! expanded its efforts this year to include invasive control on the natural area surrounding the Camels' Hump Middle School (honeysuckle) and the Lake Iroquois Recreation Area (buckthorn, barberry and honeysuckle).

Bennington, VT:
CISMA-BKW, which stands for Cooperative Invasive Species Management Association for the Batten Kill Watershed, is a collaborative partnership between organizations which share an interest in restoring native habitat by managing harmful non-native invasive plants. Some of the plants removed in 2019 include Asiatic bittersweet, common and glossy buckthorn, barberry, burning bush, garlic mustard, bush/shrub honeysuckle, and Japanese knotweed. In 2019, the CISMA monitored, managed, and/or improved habitat quality in over 91 acres of public, and 39 acres of private land. Looking ahead to 2020 and beyond, CISMA-BKW is taking steps toward becoming an official 501c3 nonprofit organization, which will allow it to expand efforts to include other sites within the Batten Kill Watershed, and beyond.

The Nature Conservancy:
TNC completed a variety of NNIPM work across Vermont. Spring work included management at Williams Woods in Charlotte (volunteers spent three days removing garlic mustard and wall lettuce as part of a WHIP project); management at LaPlatte River Natural Area in Shelburne (TNC staff spent one day releasing purple loosestrife beetles); management at Raven Ridge in Monkton (volunteers spent one day pulling garlic mustard and wall lettuce along trails); management at Eshqua Bog (TNC staff spent one day pulling wall lettuce); and management at Butternut Hill in North Hero (TNC staff spent one day pulling garlic mustard).

Summer work included management at White River Ledges in Sharon/Pomfret (TNC staff spent one day completing control work on Japanese knotweed and *Phragmites*); management at the Hubbardton River Clayplain Natural Area in West Haven (TNC staff initiated an experiment to cover a 50' x 80' patch of *Phragmites* with heavy woven road fabric); and management at the Helen W. Buckner Natural Area in West Haven (volunteers spent two half days removing woody NNIP and experimented using a grubbing attachment on the front of a skid steer to pull out large honeysuckle).

Fall work included management work at Williams Woods (volunteers spent two days removing woody NNIP as part of a WHIP project); management at LaPlatte River Natural Area (volunteers spent one day removing woody NNIP along the river); management at Raven Ridge (volunteers spent one day removing woody NNIP along the edge of the old field and near the beaver pond); management at Wilmarth Woods in Addison (volunteers removed woody NNIP for one day); management at Butternut Hill (TNC staff spent one day removing woody NNIP); management at Black Mountain in Dummerston (TNC staff spent one day removing woody NNIP); management at Bond Island in Whiting (volunteers spent one day removing woody NNIP); and management at Shaw Mountain in Benson (TNC staff spent one day doing cut stump treatment on woody NNIP on approximately six acres of lightly infested, high priority forest and ledge habitat).

Black River, VT:
The Black River watershed in Windsor County faces multiple threats and pressures from invasive and problematic plants such as Asiatic bittersweet, Japanese knotweed, black swallow-wort, and Japanese barberry. The Black River Action Team (BRAT) embraces a true grassroots approach, making connections between people and the landscape around them in positive and proactive ways. Embracing the paradigm of "Early Detection, Rapid Response," BRAT Director Kelly Stettner encourages community members of every sort to become citizen scientists. BRAT volunteer Rhonda Benoit recently noticed an unusual plant on a streambank in Woodstock; she snapped a photo to share with Stettner, who reached out to experts for verification - it turned out to be *Petasites japonicus*, or giant coltsfoot (aka Japanese

butterbur), a new species to be on the lookout for. The butterbur discovery has led to several discussions with new potential partners on establishing more comprehensive and collaborative regional vegetation management. BRAT has plans to continue the dialogue into 2020 and beyond, launching at least one non-chemical management project to tackle several problem plants in Springfield.

Lake Champlain Islands, VT:
In August 2019, staff from VHB (a private consulting firm), the Green Mountain National Forest, the Vermont Department of Fish and Wildlife, and the Lake Champlain Land trust came together to begin control of NNIPs on an island in Lake Champlain. During a 2018 survey of the rare plants growing on the island, VHB recognized the need for intervention when they observed woody NNIPs encroaching on the island's five species of rare plants. Despite the challenges of coordinating schedules between several organizations, working in steep terrain with prevalent poison ivy, and working around the weather and plants phenology, staff from the four organizations were able to begin the work of removing target species, including honeysuckle, buckthorn, barberry, bittersweet, and wall lettuce in August of 2019. The group made progress on control using management techniques including flame weeding, cutting, and buckthorn baggies. They hope to return in future years to continue to protect the rare plants and unique island ecosystem from NNIPs.

Sugar Maple Health in 2019

Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 96% of overstory sugar maples were rated as having low dieback (less than 15%), which is slightly higher than in 2018 (93%) (Figure 32).

As in 2018, thin foliage due to forest tent caterpillar (FTC) defoliation was not noted in any of the 36 monitoring plots in 2019. Statewide, there was a decrease in trees with thin foliage (2%) which is down from the previous three years (2016 (7%), 2017 (14%) and 2018 (16%)). 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), and pear thrips (1988-1989). The increase in trees with low dieback, coupled with the decrease in number of trees with high foliar transparency, suggests generally improved sugar maple health statewide.

Of the 1,779 live sugar maple trees (all crown classes) surveyed, 132 (7.4%) had defects from various damage agents in 2019. The most common damage type was bole injury from sugar maple borer (18.9%), followed by Eutypella canker (15.9%) on trees with visible damage. Other damages, from nondescript cankers, conks, and cracks/seams, accounted for 52.3% of tree damages combined.

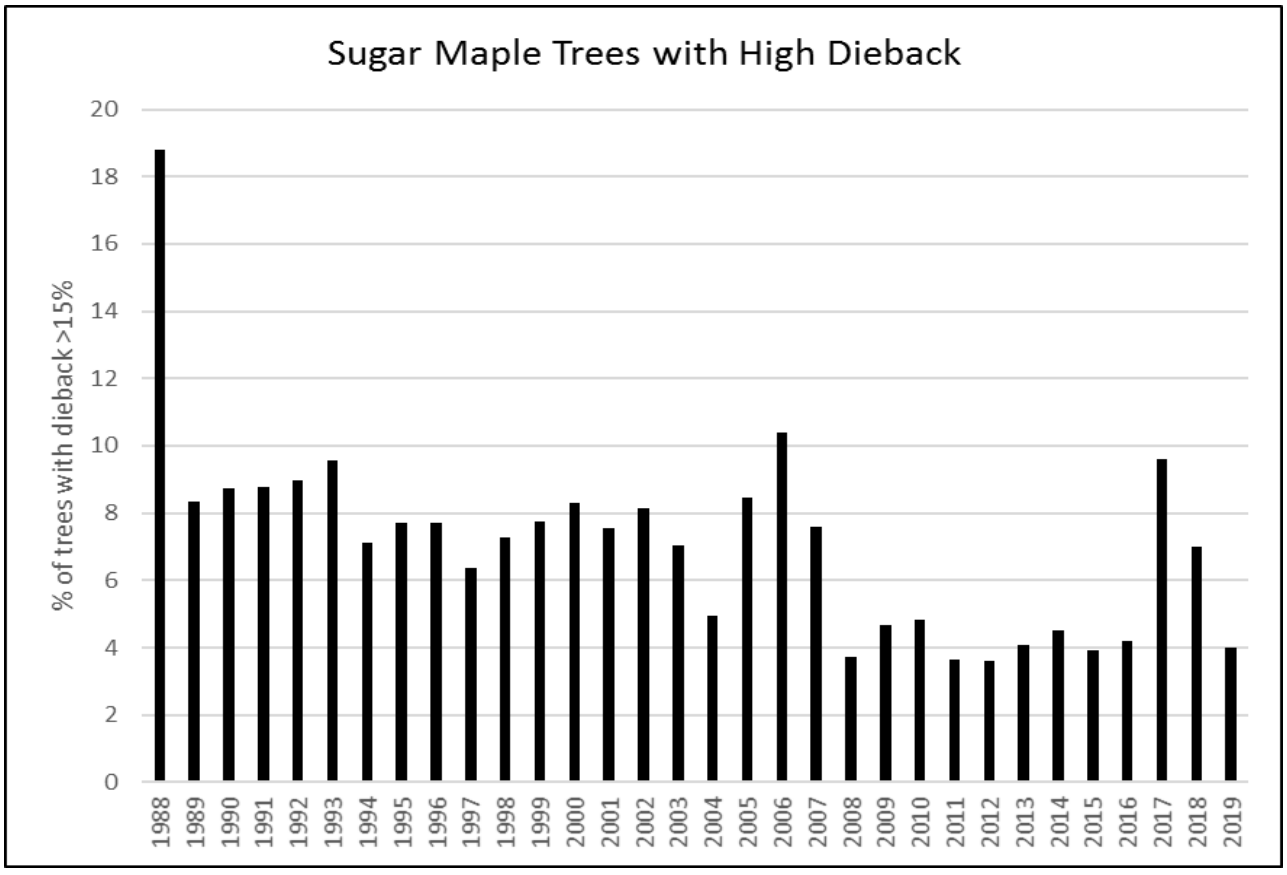


Figure 32. Percent of overstory sugar maple trees on NAMP plots with high dieback (> 15%), 1988-2019. *n* = 1,142 trees at 36 sites.

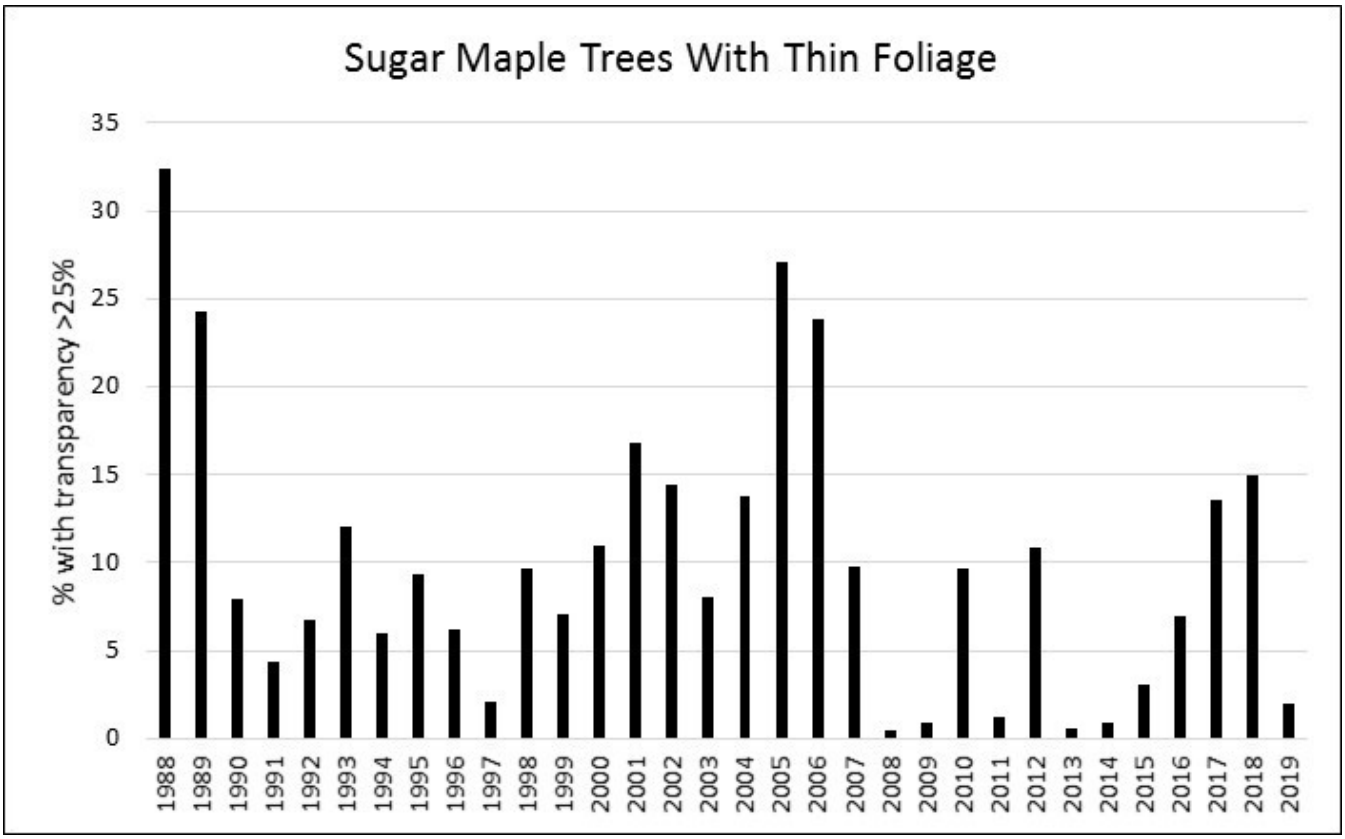


Figure 33. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage (>25% foliage transparency), 1988-2019. *n* = 1,142 trees at 36 sites.

Forest Ecosystem Monitoring Cooperative
Trends in Forest Health throughout Vermont in 2018

Vermont forest health monitoring plots were sampled at 48 sites across the state in 2019 as part of the Forest Ecosystem Monitoring Cooperative (formerly the Vermont Monitoring Cooperative). Results showed an increase in both average dieback and foliage transparency (Figures 33-37), indicators of tree stress. Periods of dry weather and/or drought over the past two growing seasons may be in part to blame for the increase.

Data were collected annually on eight plots in 1992 and 1993, on 12 plots from 1994-1996, and on 19 plots from 1997-2006. Data were collected on a three year cycle between 2007 - 2013, and then resumed annual measurement from 21 plots in 2014, 41 plots in 2015, and from 48 plots between 2016-2018.

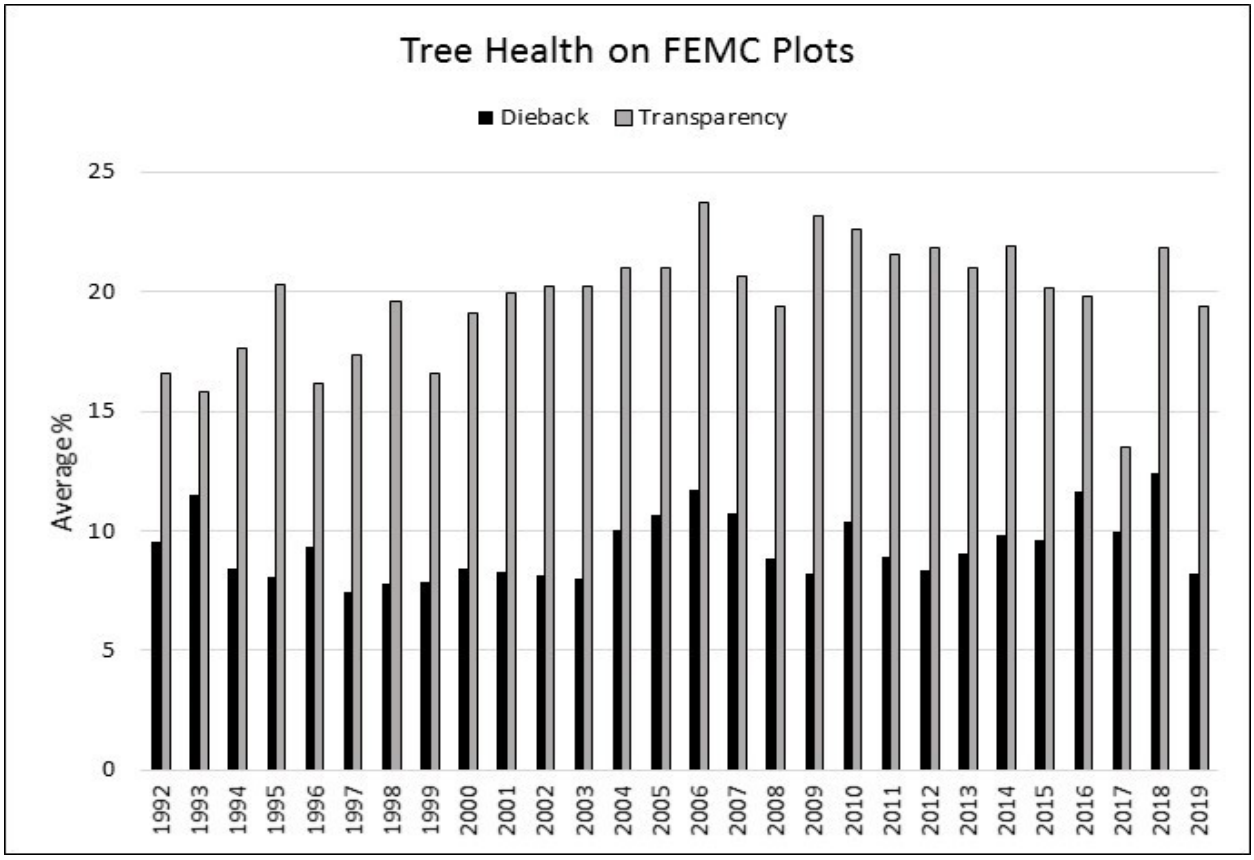


Figure 34. Trend in the average dieback and foliage transparency of overstory trees on Forest Health Monitoring plots in Vermont, 1992-2019.

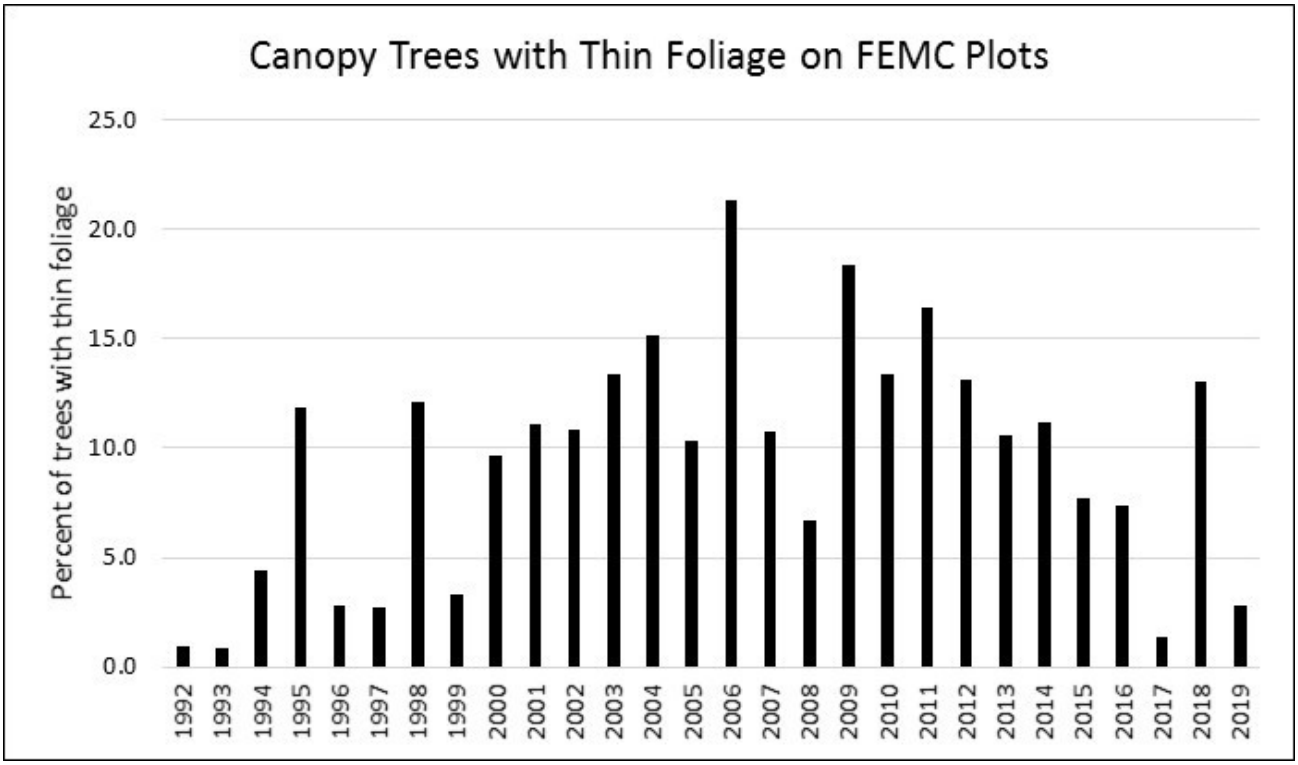


Figure 35. Percentage of overstory trees on Forest Health Monitoring plots in Vermont with thin foliage (> 25% foliage transparency), 1992-2019.

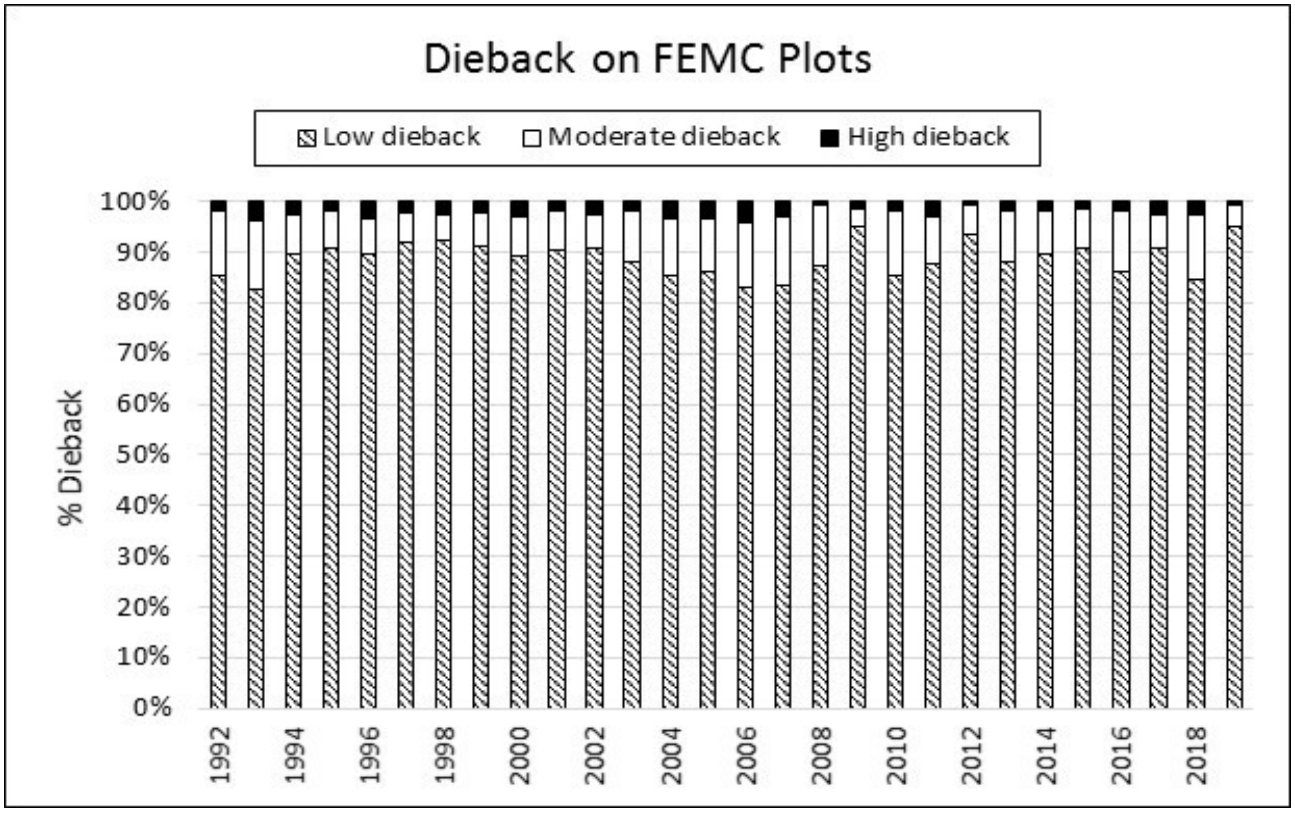


Figure 36. Trend in the percent of overstory trees with low (0-15%), moderate (16-40%) or severe (>40%) dieback on FEMC plots, 1992-2019.

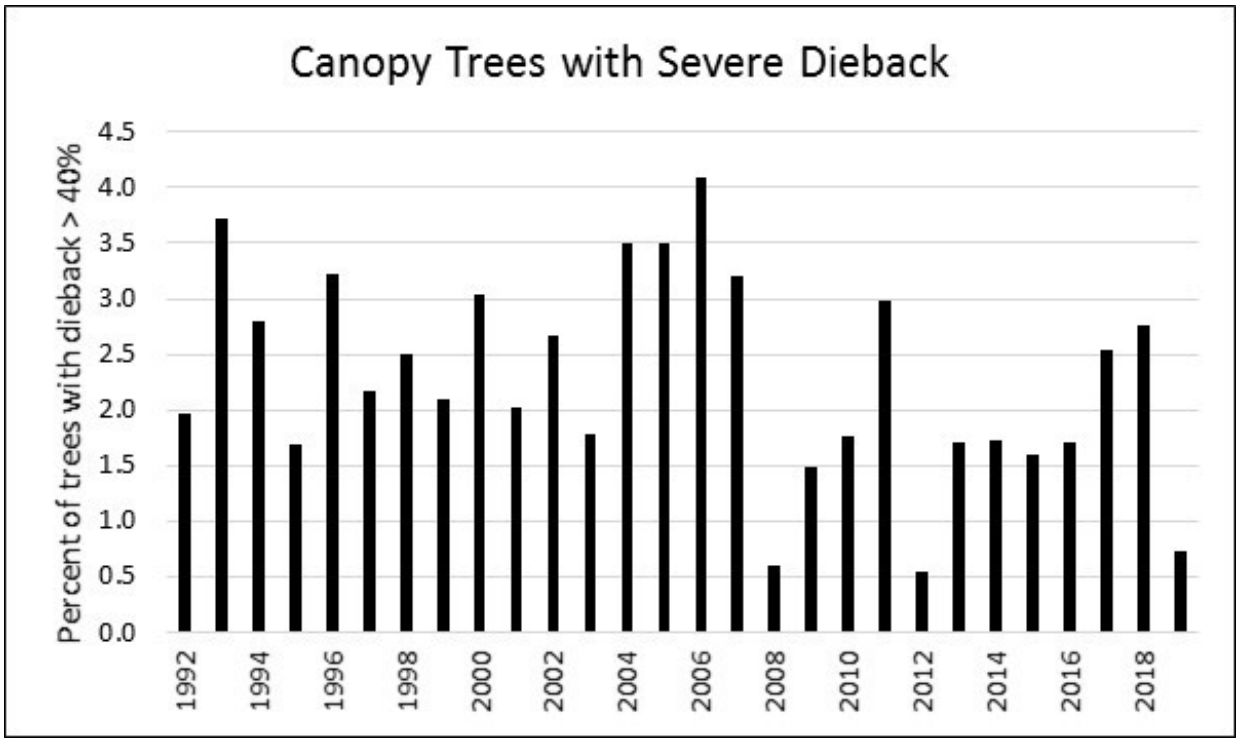


Figure 37. Trend in overstory trees with severe (>40%) dieback on FEMC plots, 1992-2019.