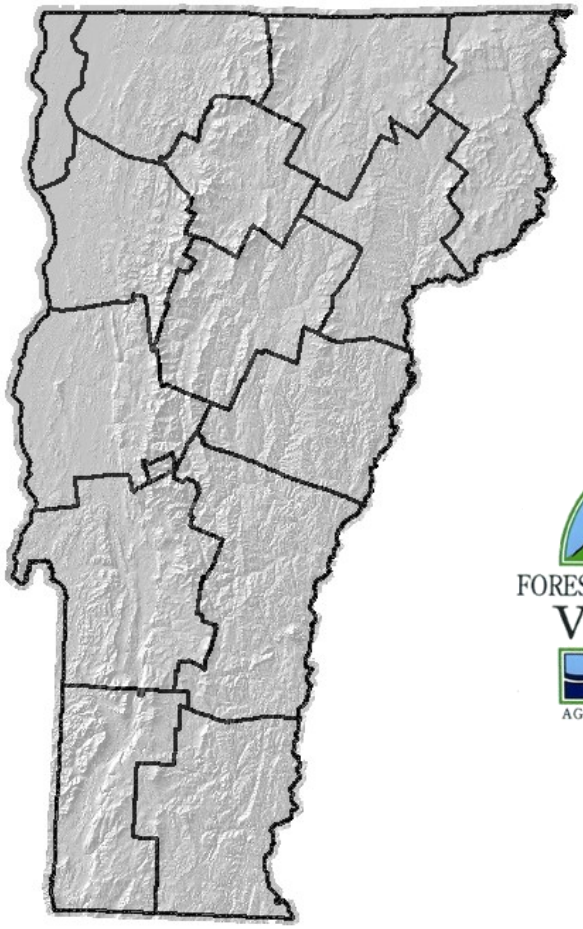
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2018



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http://www.vtfpr.org/

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

FOREST INSECT AND DISEASE CONDITIONS IN VERMONT

CALENDAR YEAR 2018

PREPARED BY:

Barbara Schultz, Trish Hanson,
Joshua Halman, Elizabeth Spinney, Michael Parisio

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DEPARTMENT OF FORESTS, PARKS & RECREATION

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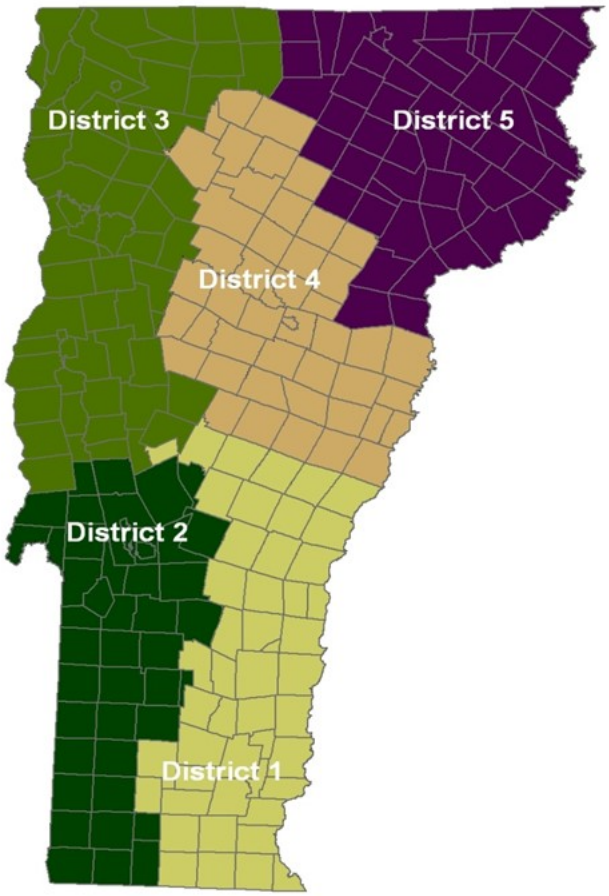

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INTRODUCTION

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

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

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

Results are summarized from aerial surveys to detect forest damage. On June 19, the US Forest Service conducted an aerial survey over the Green Mountain National Forest. An FPR survey covering the rest of the state, to map forest tent caterpillar defoliation and general forest conditions, was flown between July 9—30 (7/9, 7/11, 7/13, 7/16, 7/20, 7/24, 7/30). The range of dates flown in 2016-2018 is about a month earlier than the survey has been flown in other recent years. As a consequence, changes in acres mapped from previous 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 http://fpr.vermont.gov/forest/forest_health/current_health, or in hard-copy 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 sixth year. In 2018, 33 new volunteers attended Vermont's Forest Pest First Detector Program training, bringing the statewide total of trained volunteers to 199. We thank the many continuing First Detectors, and welcome new volunteers: Becky Atchinson, Russ Barrett, Marge Christie, Jeffrey Cueto, Apple Faulkner, Julie Hackbarth, Matthew Holland, Wayne and Dorothy Knott, Melvin McKnight, Lynn McNamara, Anne Miller, and Paul Otenti.

Many thanks to all the **invasive plant survey** participants who helped continue the Mapping for Healthy Forests citizen science project on iNaturalist.org, and helped the project reach over 3,000 observations. Many groups, towns, and organizations took part in **invasive plant management and outreach** across the state. Huge thanks to VT Coverts, Winooski Valley Park District, Master Gardeners, Birds of Vermont Museum, Green Works Vermont Nursery & Landscape Association, Intervale Center, AOT Local Roads program, 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 Don Chandler, Rod Crawford, Kevin Dodds, Charley Eiseman, Aaron Ellison, Nick Gotelli, Alan Graham, Ann Hazelrigg, Rick Hoebeke, Ron Kelley, Warren Kiel, Gabriella Maya, Kent McFarland, Isabel Munck, Bryan Pfeiffer, Judy Rosovsky, JoAnne Russo, Michael Sabourin, Scott Schneider, Nate Siegert, and Dave Wagner. A fervent group of assistants, including Roy Karros, Kent McFarland, Judy Rosovsky, JoAnne Russo, Michael Sabourin, Nathaniel Sharp, Tom Simmons, Alex Wells, and Sandy Wilmot, assisted with archiving and databasing parts of our insect collection.

The **hemlock woolly adelgid program** received survey assistance from Jennifer Weinert and Ed Schmeckpeper. Forest Pest First Detector Katie Kull arranged for a workshop on HWA monitoring and led attendees in a survey at the Marsh Billings Rockefeller National Historic Park. Another First Detector, Wendelyn Bolles, organized and conducted surveys with friends in Central Vermont.

We thank Jason Gagne, Luke Hardt and Beth Daut for providing us with weekly information on the **development of forest tent caterpillars** (FTC) and sugar maple budbreak in the spring of 2018. Their efforts ensured that treatments for FTC occurred at the proper time and place for maximum control of the insect.

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

Sandy Wilmot and Tess Greaves, two fixtures in Forest Resource Protection, retired in 2018, with a combined total of over 50 years of service with state government. We are grateful for their many contributions to our Forest Health Program.

Sandy, who retired in February, was first hired by the Vermont Department of Forests, Parks and Recreation in 1988 as "Thrips Coordinator", and took a permanent position leading the state's Forest Health Monitoring programs in 1990. She was instrumental in the start-up and success of the Vermont Monitoring Cooperative (now FEMC), leading the publication of the first program reports in 1991, and receiving the formal title of VMC Monitoring Director in 1992, which she maintained through 2004. Sandy saw the organization through a period of growth, change and sustained engagement on very important issues, as well as expanding co-located monitoring and research programs on both Mt. Mansfield and Lye Brook. She helped the organization transition through leadership changes, organizational restructuring and physical moves to different locations. After stepping down as the Monitoring Director, Sandy joined the Advisory Committee and continued on that body until her retirement, providing guidance and making connections to a range of initiatives and people across the state and region. Sandy led Vermont's participation in National Forest Health Monitoring and the North American Maple Project, and was a go-to person and spokesperson regarding pollution and forests, most notably regarding climate change.

Tess, a November retiree, began her career with the Department of Forests, Parks and Recreation in 1996, working as an administrative assistant while pursuing and earning her degree. She developed expertise in forest health issues, including insect monitoring and fire weather behavior. Many of you know Tess best through her daily fire weather forecasts during Vermont's fire season. Tess was a regional leader in the National Fire Danger Rating System and has attended Train-the-Trainer sessions to bring her expertise back to Vermont and the northeastern states. She and Joe Mints, Maine Forest Ranger, developed a Fire Danger Operating Plan that will be implemented by Northeast Forest Fire Protection Commission (NFFPC aka the Northeast Fire Compact). For many years, Tess was the point person for scheduled maintenance and replacement for components in the five Remote Automated Weather Stations (RAWS) in Vermont. In addition to her critical role in insect survey efforts in District 5, Tess spearheaded the re-write of the Town Forest Fire Warden Handbook. Tess was a founding member of the Fire Science Working Team for NFFPC and received an Outstanding Service Award for her work and dedication in fire danger and weather services for NFFPC region.

TABLE OF CONTENTS

Forest Health VERMONT *highlights* 2018

2018 Vermont Forest Health Highlights

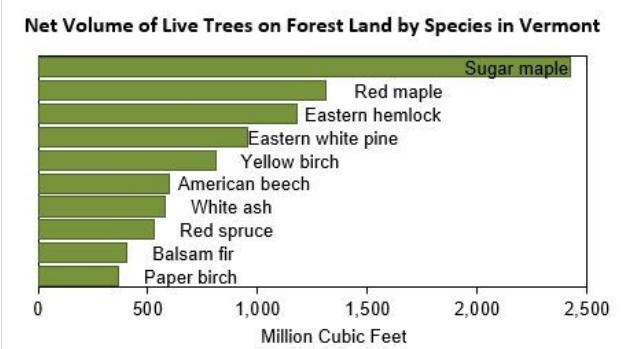
These Forest Health Highlights summarize information from the annual report on Forest Insect and Disease Conditions in Vermont. This summary provides an overview of the forest resource in Vermont, forest health program highlights, a weather summary, sections on hardwood and softwood insects and diseases 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 on-line at http://fpr.vermont.gov/forest/forest_health, or you can contact us:

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

Forest Resource Summary

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



Net volume of live trees, by species, on forest land in Vermont. Source: Morin, Randall S. 2018. Forests of Vermont, 2017. Resource Update FS-164. U.S. Forest Service, https://doi.org/10.2737/FS-RU-164.

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 2018, 128,872 acres of forest damage were sketchmapped during statewide **aerial detection surveys**. This represents just under 3% of Vermont's forestland, and an increase from the 98,555 acres mapped in 2017. Defoliation by forest tent caterpillar and white pine needle damage accounted for 55% and 32%, respectively, of the area mapped.

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.

The **Forest Pest Outreach Program** implemented by UVM resulted in 851 people receiving direct education at workshops and presentations and an estimated 190,023 people exposed to educational material through exhibits, newsletters, and social media messaging. A whiteboard-style video was developed to spread the message that buying firewood locally can limit the spread of invasive forest insects and diseases, and was shared on social media and provided to private campgrounds in Vermont to display on their websites. The website vtinvasives.org continues to offer information on terrestrial plants, forest pests, and aquatics, and serves as a clearinghouse for multi-agency information about emerald ash borer. Two Forest Pest First Detector trainings were held in central Vermont, with arborists, tree wardens, and concerned citizens attending. Volunteers assisted in pest detection surveys and community outreach.

The Forest Pest Outreach Program provided information to students at the Bend Career and Technical Center in Bradford. A whiteboard-style video was developed to spread the message that buying firewood locally can limit the spread of invasive forest pests. https://www.facebook.com/vtinvasives/videos/1992705404285380/. Photo: M. Whitney.

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

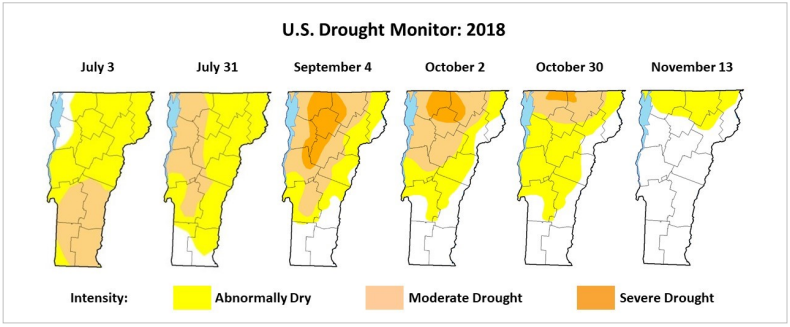
The **Forest Biology Lab** continues to provide invertebrate identifications, tree disease diagnoses and pest management recommendations, and support environmental education and outreach. In 2018, 37% of our inquiries came directly from the public; 25% came from state or federal agencies; questions from researchers and other professionals outside of state and federal government made up 16%; 13% of our inquiries came from other labs; and 9% involved outreach and education. Forest health inquiries came from all 14 Vermont counties, with highest numbers (about 18% each) from Addison, Chittenden and Washington Counties. Four percent of our inquiries were from out-of-state. Relocation of the Forest Biology Lab as part of the new Vermont Agriculture and Environmental Laboratory in Randolph is scheduled for February 2019.

The **Forest Ecosystem Monitoring Cooperative** (formerly Vermont Monitoring Cooperative) completed its 28th year of monitoring ecosystem health. Survey and monitoring results are available at the FEMC website.

2018 Weather Influences on Forest Health

Temperatures for meteorological winter, December 2017 to February 2018, averaged near normal despite some wild swings. Snowpack dropped off in February, then was above normal by mid-March, when over 50 inches of snow had fallen in parts of the state. March and April averaged below normal temperatures and with limited sunshine, winter-like weather continued through the end of April. Green-up was generally delayed. Ash, oak and red maple leaves were still not fully expanded at higher elevations by the end of May.

Below normal precipitation continued from May through early July statewide. The end of June marked the beginning of a heat wave, with temperatures remaining above average through the rest of the growing season. The U.S. Drought Monitor listed most of Vermont as abnormally dry starting on June 19. Moderate drought started in the southern counties on June 26 and shifted through the month of July as rainfall patterns started to diverge between northern and southern parts of the state. By early September, parts of northern Vermont were in severe drought, which persisted through the end of October near the Canadian border. During July aerial surveys, 2,107 acres of drought damage were mapped. Since this was well before the peak of drought conditions, the actual acres of damage to hardwood foliage was significantly larger.



Moderate drought started in the southern counties, but by early September, parts of northern Vermont were in severe drought. Map Author: David Simeral, Western Regional Climate Center, https://droughtmonitor.unl.edu/.

Early fall color started in August but, with the warm temperatures, was slow to progress. Widespread color change arrived about two weeks late. Brilliant early and mid-season color gave way to a muted late-season due to a cloudy October. With the late start, limited frost, and lack of stormy weather, leaves persisted on oaks, beech, and other late-turning species well into November.

Severe tree-damaging storms punctuated the growing season. A partial list includes strong winds and hail on May 4th, the remnants of Hurricane Bud including microburst storms on June 18th, severe storms in southern Vermont on July 27th and 28th, and on August 29th and September 4th in the northeast. In late November, Winter Storm Bruce dumped wet snow statewide, leaving over a foot at higher elevations. Tree breakage was widespread, resulting in approximately 90,000 power outages.

We continue to monitor **phenology** for the timing of budbreak, leaf out, and fall leaf color and drop. Sugar maple budbreak on May 7th was 4 days later than the long-term average, but the timing of full leaf-out was nearly indistinguishable from the long-term average. In fall, the timing of peak color for most species was similar to the long-term average in 2018. Although color development was initially slow, full leaf drop was just one day later than in 2017. Growing season length was 5 days longer than the long-term average.

While seed crops on most species were minimal, especially compared to the heavy seed year in 2017, ash seed production remained heavy. Squirrel populations, which erupted following the abundance of 2017, had a greatly reduced food supply in 2018, and increased squirrel damage to tree buds and bark is expected.

Following the drought of 2016, the late-season dry conditions in 2017, and the prolonged period of warm, dry weather in 2018, water availability continued to be a major driver of tree health and will interfere with tree recovery from defoliation and other stressors.

Hardwood Insects and Diseases

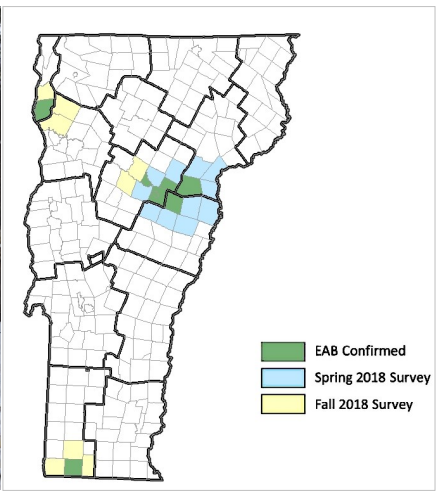
In late February, trees in the town of Orange suspected of being infested with **emerald ash borer (EAB)** were observed by a consulting forester and reported through the vtinvasives.org Report It webpage. The identification was confirmed by the USDA Animal & Plant Health and Inspection Service (APHIS). The source of the infestation is unknown.

Vermont became the 32nd state known to be infested. Elsewhere in the region, Rhode Island, Maine, New Brunswick and Nova Scotia also had their first detections in 2018, and EAB was found in two new counties in New Hampshire.

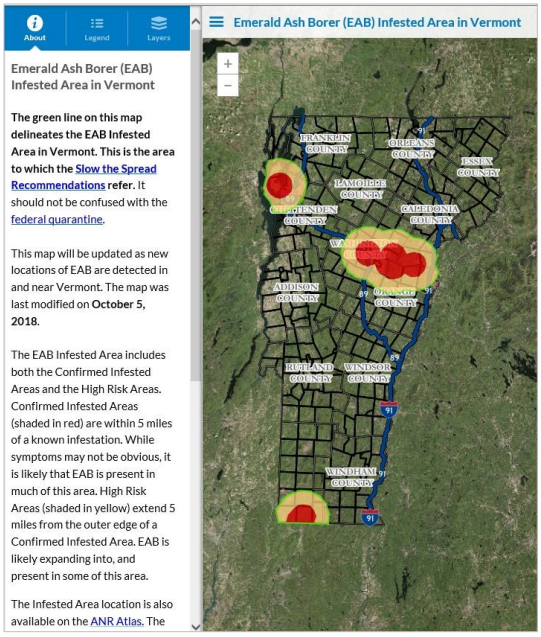
The Vermont detection initiated a multi-agency response by the Dept. of Forests, Parks, and Recreation, the Agency of Agriculture, Food and Markets (AAFM), APHIS, the US Forest Service and UVM Extension, as outlined in in the Vermont Forest Pest Advisory Committee's Emerald Ash Borer Action Plan. A delineation survey was conducted in March and April to determine if the detection represented part of a wider infestation. This was a visual survey, covering all towns adjacent to towns where EAB had been detected and confirmed. In all, fourteen towns were surveyed. EAB-infested trees were found in Groton, Plainfield and Barre.

Additional detections followed. In May, EAB-infested trees were next detected in Montpelier, as a result of an incidental observation. The USDA had 609 purple traps deployed throughout Vermont in 2018, and beetles were caught at two sites in Stamford and a second site in Groton. In late September, an off-duty forester reported symptomatic ash trees in South Hero. Additional delineation surveys are in progress in the eight towns adjacent to South Hero, Stamford, and Montpelier using the same methods as the spring survey. No EAB have been detected in these towns.

Maps indicating known EAB infested areas in Vermont have been made available at vtinvasives.org. These are regularly updated following new EAB detections. EAB is difficult to find when it first attacks a tree, so the mapped Infested Area extends well beyond where the insect has been observed. 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 47 towns in eight counties. The infested area is also available for download on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/.



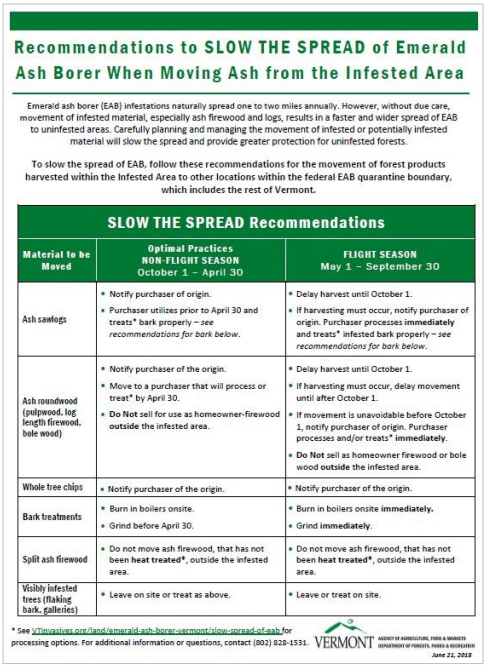
After EAB was detected in February, a delineation survey was conducted in neighboring towns. Similar surveys were conducted in the Fall following separate detections. As of November, EAB is known to occur in Orange, Plainfield, Groton, Montpelier, Stamford, and South Hero. Photo: B. Schultz



Due to the federal EAB quarantine, the State of Vermont needed to choose whether to have a state quarantine covering the three known infested counties or to include the entire state within the federal quarantine boundary. The Vermont Pest Advisory Committee determined that an intrastate quarantine would unnecessarily divert resources to areas that do not pose a risk, since the required quarantine boundaries would not align with the infestation in Vermont. By foregoing an intrastate quarantine, all of Vermont became part of the USDA quarantine.

Resources were focused on developing slow-the-spread recommendations for preventing unintended movement of EAB and information about ash management. Slowing the spread of EAB to uninfested areas slows mortality and financial impacts, and allows time to implement management and to develop better tools for protecting ash.

The Infested Area Map includes the area within 10 miles of any location where the insect has been observed.



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 – April 30	FLIGHT SEASON May 1 – September 30
Ash sawlogs	• Notify purchaser of origin. • Purchaser utilizes prior to April 30 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 April 30. • **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 April 30.	• 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

June 21, 2018

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

Following are some of the resources available through vtinvasives.org:

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 forest landowners can avoid spreading EAB when conducting forest 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 Forest Landowners and Managers

Ash Management Guidance for Forest Managers

UVA Policy on Forest Management Plans and Amendments

Webinar: Silvicultural Considerations for Vermont's Ash within the Context of EAB Presented by Tony D'Amato, UVM.

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

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 treatments and guidelines for having trees treated.

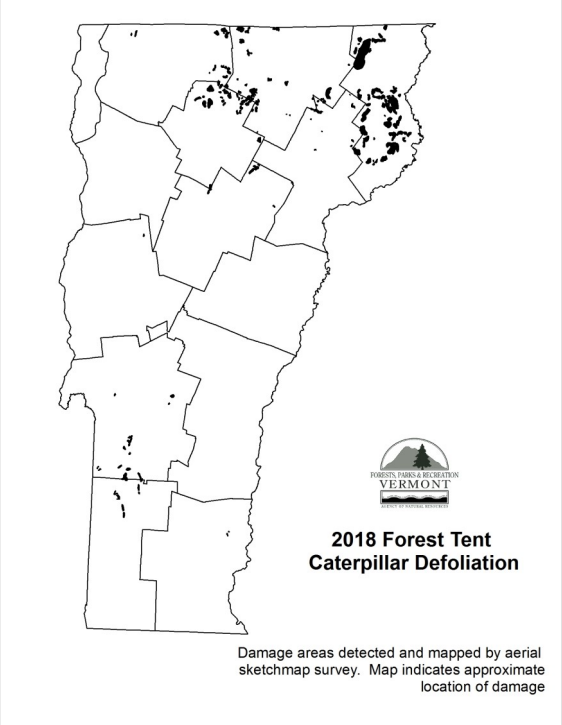
Community Planning: Goes VT Urban & Community Forestry's EAB Management website.

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: K. Freeman

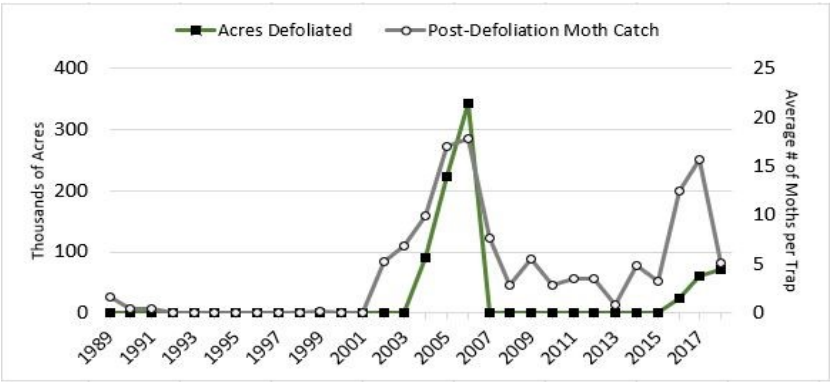
Forest tent caterpillar (FTC) populations increased again in 2018, with 71,315 acres of defoliation mapped during statewide aerial surveys compared to 60,584 acres mapped in 2017. This accounts for roughly 2% of the northern hardwood forest in Vermont. The area defoliated decreased in southern and central Vermont, but more than tripled in Essex County. Defoliation data are available on the ANR Natural Resources Atlas.

At four sites in northern Vermont monitored for spring FTC activity, hatching was first observed in mid-May, roughly 2 weeks later than in 2017. Caterpillar development progressed rapidly, and by the last week of May defoliation had begun.

In late 2017 and early 2018, FPR staff assisted landowners with FTC egg mass surveys to determine the likelihood of defoliation on their property. Of the 84 sugarbushes surveyed, 30 locations were identified as at risk of defoliation. Landowners made arrangements with an aerial applicator to have thirteen properties treated with Foray48, a *Btk* product that is registered for use in certified organic production. In total, these accounted for 4,129 acres. Several additional forest landowners also had their forestland treated. A sample of treated and untreated sites was evaluated once FTC feeding was complete. Among sites predicted to be defoliated based on egg mass surveys, untreated stands averaged 25% foliage loss compared to 15% for treated stands. Stands not predicted to be defoliated experienced only 5% foliage loss on average.



Forest tent caterpillar defoliation was mapped on 71,315 acres, with over half the acres mapped in Essex County.



FTC moth capture decreased dramatically from 2017. In the previous outbreak, this signaled a collapse of the population, with no defoliation mapped the following year.

FTC parasitoids known as friendly flies were reported throughout the defoliated areas, and there was some early caterpillar mortality likely due to viral and/or fungal infection. Pheromone traps for FTC were again deployed throughout the state in 2018, and moth capture decreased dramatically from 2017 levels. If results from the previous outbreak (2004-2007) are any indication, we may see a reduction in defoliation in 2019. While this is a hopeful sign, we will have a better prediction for defoliation in 2019 after winter egg mass surveys have been completed.

This year was also the first year in the current outbreak where tree mortality associated with FTC was visible. Most trees recover from FTC damage, but defoliation can incite tree decline if other stresses are present. In 2018, 4,550 acres of sugar maple dieback and mortality were mapped in locations which had been recently defoliated by forest tent caterpillar in previous years.

The presence of tree mortality following defoliation is likely related to refoliation failures that occurred in all years of the current outbreak (2016-2018). There were abnormally dry and drought conditions in all three years. Other contributing factors may have been the heavy seed on sugar maple in 2017, a late start of feeding in 2018 due to wet weather, and infection by leaf fungi.

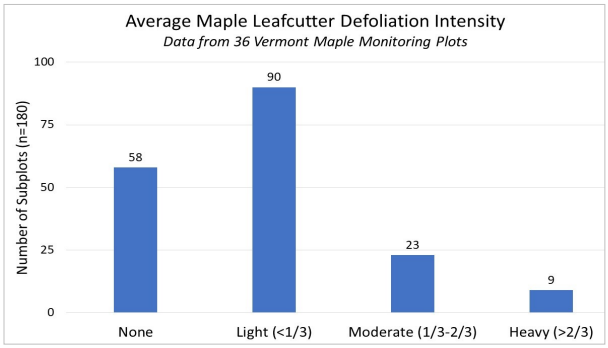
For more details on FTC biology and management, refer to the most recent Forest Tent Caterpillar Update.

Tree mortality following FTC defoliation was mapped on 4,550 acres. Abnormally dry to drought conditions, and subsequent refoliation failures in all three years of the outbreak, have worsened the impact of defoliation. Photo: T. Greaves

Defoliation of entire stands by maple leaf cutter was unusually heavy by early September. Photo: J. Halman

Maple leaf cutter (MLC) damage to lower foliage was noticeable statewide in July, but became unusually heavy by early September, when browning and defoliation of entire stands was obvious in many locations. Starting life as a leafminer, then becoming a casebearer in later instars, the MLC completes its life cycle in its movable dwelling, eventually crawling or fluttering to the ground where it overwinters in a cocoon within the leaf discs.

MLC defoliation was evaluated in late September in 36 maple monitoring plot locations. Heavy defoliation was only reported from plots in southeastern and northeastern Vermont, but moderate defoliation was observed throughout the state. Due to the late timing of defoliation, significant impacts to tree health are not expected.



Maple leaf cutter caterpillars feed within a case made of leaf discs. After feeding is complete, the insect moves to the ground in its movable dwelling. Photos: D. Dillner

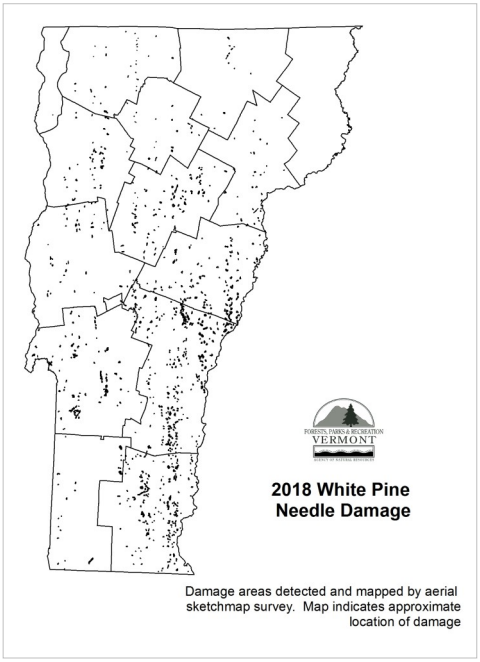
Damage was often confined to lower crowns, and over 80% of the subplots evaluated statewide had no, or only light, defoliation by the end of September.

Softwood Insects and Diseases

White pine needle damage (WPND) was widespread again this year with 40,745 acres mapped, more than doubling the 16,413 acres mapped in 2017. This may underestimate the area affected since damage is mapped from above, while much of the damage is in lower crowns. This damage has been attributed to a complex of fungal pathogens. Since symptoms appear the year following infection, the increase is likely due to the cooler and wetter weather in late spring 2017.

Symptoms showed up, later than normal, in early June. Bright yellow one-year-old needles were widely observed. Due to windy conditions, yellow needles also dropped quickly on many of the affected trees, leaving a carpet of newly cast needles in pine stands.

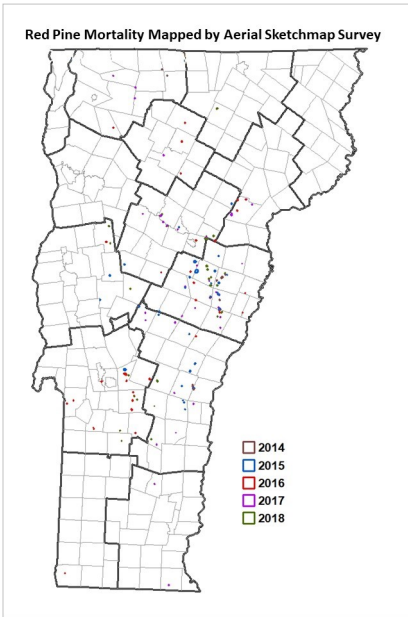
White pine needle damage was mapped on 40,745 acres. The increase in damage is likely related to cool, wet weather in late spring of 2017. Symptoms showed up later than normal in early June. Due to windy weather, needles dropped quickly leaving a carpet of newly cast needles. Photos: B. Schultz



The damage has been widespread since 2010, and the current epidemic has been building at least since 2005. Needle damage generally affects the same trees each year, and some are now exceedingly thin. Decline and mortality of white pine have been occasionally observed where other stress factors are also present.

This year marked the start of a multi-state project to evaluate site factors influencing WPND. In Vermont, crown health and stand characteristics were assessed at twenty sites. Needles were collected for lab evaluation to determine which needle diseases are present. The brown spot needle blight fungus, *Lecanosticta acicola,* was the most common pathogen on white pine needles from Vermont, while a newly described species, *Septorioides strobi*, was the second most abundant species. More information about the study can be found at https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Forest_Health/Library/2018_VT%20FPR_White%20pine%20health%20monitoring%20leaflet.pdf

Twenty sites were assessed as part of a multi-state project to evaluate WPND. Photo: J. Halman

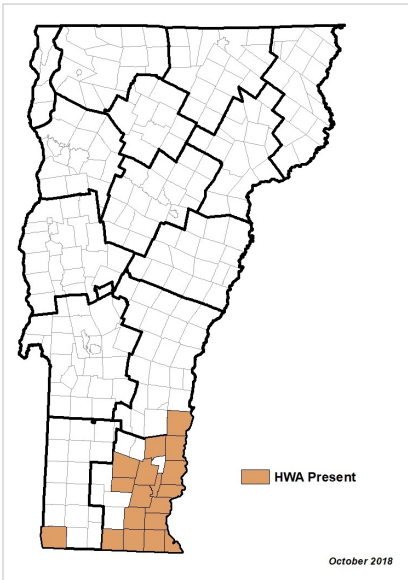


Reports of **red pine mortality** continued in 2018, with 765 acres mapped, scattered in six counties. The exotic insect, red pine scale, collected in 2015 in Rutland and Orange Counties, has not been detected since that time in declining red pine stands. While the expanding pattern of the mortality is consistent with a non-native organism, the cause remains unknown.

Recent red pine mortality was mapped in six counties in 2018. While the expanding pattern of the mortality is consistent with a non-native organism, the cause remains unknown. Photos: J. Halman

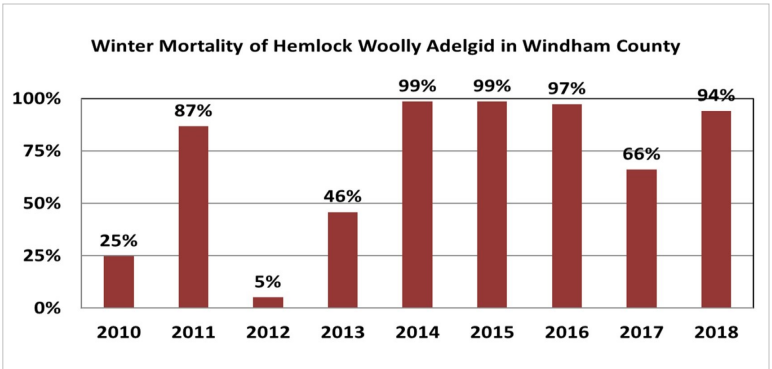
Vermont's **hemlock woolly adelgid** (HWA) infestation remains centered primarily in Windham County, with small spots in Springfield and Pownal. In winter 2017-18, the average winter mortality was 94%, which is considered adequate to restrict expansion of the infestation.

The emphasis of FPR's delineation survey program was shifted to focus on counties adjoining infested counties. Twenty sites were surveyed prior to summer 2018, targeting Rutland, Orange, and northern Windsor Counties. No expansion of the infestation was detected.



Laricobius nigrinus, the predatory beetle, was not recovered during fall sampling of the three sites where they had been released in 2009, 2012 and/or 2017, so the status of this introduction remains unknown.

Vermont's HWA infestation remains centered in Windham County, with no expansion to new towns detected in 2018.

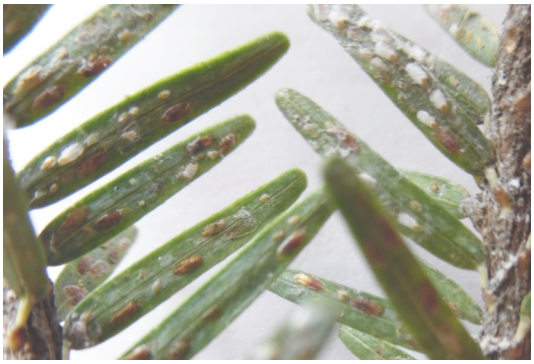


Overwintering mortality averaged 94%, which is considered adequate to restrict spread.

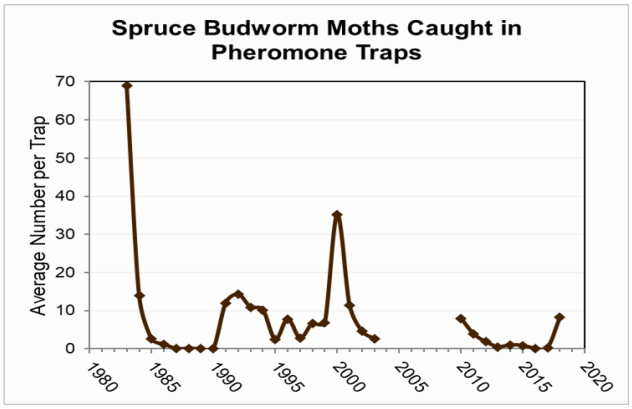
Compounding the risk to hemlock, **elongate hemlock scale** (EHS) is increasingly noticeable in Windham County. It was first detected in the towns of Brattleboro and Guilford in 2014. In addition, EHS has been occasionally been found on nursery-grown trees over the past 20 years. In 2018, an infested balsam fir planting was reported in Charlotte. No additional EHS suspects were found when wild hemlocks nearby were inspected. Fir and spruce are at least as susceptible to EHS as hemlock hosts.

Fir mortality caused by **balsam woolly adelgid** is continuing with 3,434 acres mapped compared to 1,641 acres in 2017. Active populations are rarely observed.

Spruce budworm continues to cause widespread defoliation in eastern Canada. The number of moths captured in our Vermont pheromone traps this summer increased from recent years but remains low.



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



Spruce budworm moth trap catches remain low.

Non-Native Invasive Plant Programs

Non-native invasive plant (NNIP) management efforts continued in 2018, with progress on mapping, control, outreach and education made possible through several grant funded opportunities. FPR's Invasive Plant Coordinator led 28 workshops and fielded over 250 inquiries about invasive plants. Since 2014, 2,279 volunteers have assisted with direct management of NNIP in southwestern Vermont.

This year a new program was launched for middle and high school groups. In 2018, 488 students from 11 different schools participated in the program, learned about invasive plant identification and ecosystem impacts, and got hands-on experience removing them.

In 2018, 488 students from 11 schools participated in a hands-on program to learn about non-native invasive plants. Photo: H. Ewing

Also new this year is a "train the trainer" opportunity for members of the public called the Forest Hero! Network. Ten participants attended the first training, co-hosted by Vermont Coverts. Participants agreed to conduct an outreach event for their communities.

The Mapping for Healthy Forests project continued to provide a resource for tracking NNIP across the landscape, with a focus on private and municipal lands. This citizen science project trains volunteers to assess NNIPs and prioritize treatment areas. All the information from this project is stored on the iNaturalist website and is accessible through this link: https://www.inaturalist.org/projects/mapping-for-healthy-forests-vermont.

Exotic Forest Pests Threatening Vermont

AAFM and USDA APHIS continue efforts to trap non-native forest insects. **Sirex woodwasp** has been trapped in twelve Vermont counties since 2007. In 2018, it was trapped in Caledonia, Orleans, and Windsor Counties. No new observations of Sirex infested trees were reported, with the only known location in Jericho.

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

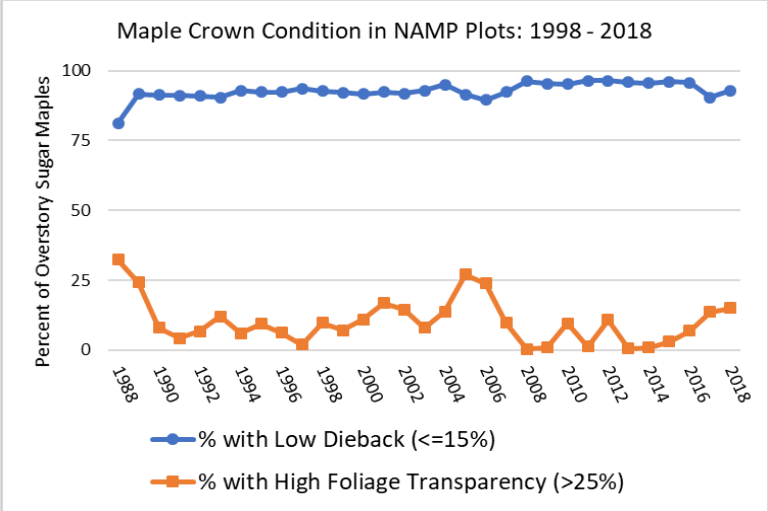
Asian longhorned beetle (ALB), is not known to occur in Vermont and no forest management changes are recommended in anticipation of the insect. Nonetheless, education and outreach that can promote early detection remains a priority. Elsewhere in the region, 2018 is the first year with no ALB detected during surveys around Worcester, MA.

Other **non-native insects and diseases that have not been observed in Vermont** include winter moth, spotted lanternfly, and the agents that cause oak wilt and thousand cankers disease.

Monitoring Forest Health

In Vermont, we have continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these **North American Maple Project** (NAMP) plots, 93% of sugar maples were rated as having low dieback (less than 15%), nearly the same as in 2017 (90%).

Thin foliage due to forest tent caterpillar (FTC) defoliation was not noted in any of the 36 monitoring plots, which is notable since 2017 saw 25% of plots affected. Despite the reduction in defoliation from FTC, the number of trees with thin crowns continued to increase in 2018. Statewide, there was an increase in trees with thin foliage from 7% in 2016, to 14% in 2017, to 15% in 2018. Foliage transparency is sensitive to current stress factors. Other spikes in transparency were due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007, 2016), and pear thrips (1988-1989).



Sugar maple crown condition was similar to 2017 in maple health monitoring plots. Thin foliage and dieback have been higher than average due to successive years of dry weather and forest tent caterpillar defoliation.

In addition, 48 forest health monitoring plots were sampled across Vermont in 2018 as part of the **Forest Ecosystem Monitoring Cooperative** (FEMC). Statewide, dieback and foliar transparency both increased compared to 2017, but were comparable to 2016 levels. However, dieback (12%) was higher than the long-term average (8%), while transparency was indistinguishable from the long-term average (21%).

UrbanFIA work continued for the third 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 2018, all plots were completed by the end of June through the combined efforts of the USDA Forest Service, Vermont Department of Forests, Parks and Recreation, and the Forest Ecosystem Monitoring Cooperative. Data are collected on a seven year cycle, after which a statewide report will be published.

FORESTS, PARKS & RECREATION VERMONT
AGENCY OF NATURAL RESOURCES

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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 U.S. Department of Agriculture policy, this institution is prohibited from discrimination on the basis of race, color, national origin, sex, age, or disability.

FIGURES AND TABLES

FIGURES

TABLES

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WEATHER

2018 Weather Summary

Winter 2017-2018

Temperatures for meteorological winter, December 2017 to February 2018, averaged near normal despite some wild swings. Bone chilling -30 on January 2 was observed at the Nulhegan fire weather station in Brunswick. Less than two weeks later, 56 degrees was recorded. Back to the deep freeze on February 3 with -12 degrees, then the temperature soared to 74 degrees on February 21. Similar variations occurred throughout the state during January and February.

The February 70 degree warmth did not return until April 24. March and April averaged below normal by 4 to 6 degrees. Not only were "Spring" temperatures chilly, but periods of rain and snow showers were common, keeping the winter in spring through the end of April.

January's snowfall was normal but took a hit during the February warm up. March brought the snowpack back with a series of nor'easters early in the month. By March 15th, over 50 inches of snow had fallen in parts of the state including the top of Mt. Mansfield and in Woodford in southern Vermont.

Spring 2018

The delayed spring warm up during April helped to melt the snow slowly, limiting the amount of spring flooding. The flood potential was above normal due to the deep snowpack.

A late season storm on April 30 left a trace to 7 inches of snow across much of the state. The highest amounts were in the Caledonia and western Washington Counties.

The first week of May (April 29— May 5) saw some wild weather with snow on April 30; two days later, there were record-breaking high temperatures and the week finished with violent storms. Despite the wacky beginning, May averaged warmer and drier than normal.

On May 2, a short-lived temperature spike brought high readings from the low and mid 80's up to 88° in North Springfield and Burlington, breaking the old record set in 2001. Lincoln, Montpelier and Rochester recorded high temperatures of 86°. Temperatures reached 85° near Danville accelerating the ice melt on Joe's Pond. The ice was officially declared out on May 4 at 11:27 a.m. This was the latest date since 1994 and the 4th latest date since the ice out contest began in 1988.

Severe storms on May 4 produced strong winds with gusts ranging from 30 to 65 mph, hail, flash flooding, and even the possibility of tornados. None were recorded but winds did bring down plenty of trees and powerlines. Some hard-hit locations included Shelburne, Brookfield, Pittsford, Ascutney, Thetford, Manchester, Danby, Lincoln, Waterbury and Colchester but the storms affected all of Vermont. Two inches of rain caused flash flooding along the Winooski River and into the Northeast Kingdom. Route 5A in Westmore was blocked when a landslide came down the mountain surrounding Willoughby Lake.

Green up was delayed due to a wintry April, extending spring fire season. Light fire activity continued through the month. Just enough green was mixed with dead vegetation to keep fire danger at moderate for most of May. However, fire danger did reach high on May 11. A special weather statement was issued by the National Weather Service that day for low relative humidity and strong winds, combined with extremely dry dead grass, leaf and brush fuels.

Windy days were common through May and increased the potential of spread for fires that did get started. Such was the case of the largest fire reported this fire season. On May 14, fire escaped from a brush pile at a residence in Plymouth. Winds spread the flames up the steep slope near the Hawk Mountain Re-

sort development. Firefighters from eight surrounding towns battled the blaze, which burned 60 acres.

By the end of the month, warm temperatures boosted leaf development finally greening up most of the landscape. However, leaves at higher elevations, and ash, oak and red maple, especially in northeastern Vermont, had still not reached full expansion .

June saw some temperature swings. Day one was hot, but cool and unsettled weather followed during the first week. Chilly lows with patchy frost in the usual cold pockets were recorded on June 11 and 22. Warm and comfortable temperatures turned hot and humid with hit-or-miss severe storms resulting. One of these severe storms hit Vermont during the afternoon hours of June 18, when scattered strong-to -locally-severe storms tracked across the region. According to the National Weather Service, "A warm, moist tropical air mass (from the remnants of Hurricane Bud) was in place over New England and New York ahead of a cold front sagging south from Canada. Due to the moist characteristics of the air mass, storms that did develop produced very heavy rainfall, along with several damaging wet microbursts. These severe storms caused up to 16,000 people in Vermont to lose power. The strongest microburst produced significant property damage and downed 3 to 4 dozen trees in the vicinity of Waitsfield, VT. East Topsham and Newbury were also hard hit.

The storm also brought some much-needed rain to the state. Rainfall amounts varied but some of the heaviest rain totals included 2.29" in Burlington, 1.83" in Plainfield, 1.81" in Middlesex, 1.44" in Jericho and 1.51" in Worcester. Despite the intensity in some locations, the rain was welcome. June was drier than normal for the month. On June 19, most of the state was abnormally dry.

Summer 2018

By the beginning of summer, the southern four counties were classified with moderate drought. Even after heavy rain storms and scattered showers on June 13 and 18 and from June 27 to 29, the July 3 U.S. Drought Monitor remained unchanged from the week before.

The end of June marked the beginning of a heat wave, which extended into the early part of July. A significant record fell on July 2nd, when the temperature in Burlington, VT never fell below 80 degrees Fahrenheit. This established a new all-time record "high-minimum" temperature for any calendar day. The old record was 78F set several times previously.

From the National Weather Service in Burlington on August 1, 2018: "July 2018 was the warmest month ALL-TIME in the Champlain Valley (comparable to a typical July in Philadelphia, PA) and amongst the warmest Top 10 elsewhere across Vermont and Northern New York. It all began with a dangerous heatwave that impacted the North Country during the first week of July and although 'not as hot', warmer than normal temperatures continued for the entire month."

Multiple July highest maximum and highest minimum temperature records were broken or tied elsewhere around the state including in Newport, Rochester, South Lincoln, St. Johnsbury, Rutland, Woodstock, Barre-Montpelier and on top of Mt. Mansfield. July was hot worldwide. Heat waves and record high temperatures were recorded across the Northern Hemisphere, including temperatures in the 90's north of the Arctic Circle.

In addition to the high temperatures, high humidity played a role as well, especially during the heatwave at the beginning of the month. The NWS in Burlington issued their first ever Excessive Heat Warning for the Champlain Valley and Excessive Heat Watch for the rest of the state on June 30. The excessive heat warning lasted for 2 days followed by several days of heat advisories covering the whole state. Temperatures reached 90 or above in many locations across Vermont from June 30 to July 5 and periodically throughout the month. The highest temperature reported in the state during the heatwave was in Charlotte on July 2 with 99 degrees. Four heat-related deaths occurred in the state during the heat wave.

Not only was it hot, most of July was dry as well. Abundant sunshine, lack of rain and plenty of heat

accelerated the drying. Crops were stunted, rivers and streams ran well below normal, and soils dried deep in many locations keeping the KBDI (Keetch-Byram Drought Index) above normal and fire danger moderate for much of the month.

The U.S. Drought Monitor listed most of Vermont as abnormally dry starting on June 19. Moderate drought started in the southern four counties on June 26 and shifted through the month of July. Scattered showers and thundershowers mid-month brought some relief to those locations that were lucky enough to receive rain. Most of the state received some light rain here and there but the hit-or-miss nature of the storms left significant rain in southern Vermont and much less in the Champlain Valley. Elsewhere in the state, rainfall was just above normal but conditions remained abnormally dry.

On July 27, a strong thundershower hit Springfield causing flash flooding and downed trees. On July 28, another violent storm in southern Vermont with torrential rain and damaging winds estimated at 80 mph brought down thousands of trees, blocked roads and one landed on a moving car near the Putney town line. Westminster was hardest hit.

The summer heat continued through August with temperatures for the month 2° to 6° above normal. Highest maximum and highest minimum temperature records were broken in Vermont and across the Eastern US. August had the warmest mean temperature in Burlington with 74.5° and the second warmest in Montpelier with 68.3°. Meteorological summer (June/July/August) tied the warmest mean temperature in Burlington with 72.2°, previously set in 1949 despite June being below normal.

Not only were temperatures hot, high humidity added to the discomfort. Heat advisories for the Champlain and central/southern Connecticut River Valleys were issued early in the month (August 5-7) and again late in the month (August 27). Heat indexes in the warning areas were observed in the 90's to 100°, elsewhere in the upper 80's and low 90's.

The oppressive dewpoint temperatures in the 60° to 70° range kept the air muggy for much of the month. The Iowa Environmental Mesonet graphed hours with dewpoint temperatures at or above 70° for many locations across the Eastern U.S. including Burlington and Montpelier. The Northeast Regional Climate Center website has a link to a database that finds the best match to weather happening at a particular place and the part of the country where such conditions are normally most common. For the month of August, Burlington felt more like Baltimore.

Typically, hot and humid weather generates severe storms. Despite the relentless humidity, severe weather was hit or miss. On August 3-4, thunderstorms brought 0.13" of rain to St. Albans and 2.04" in Manchester where a flash flood watch was issued. Elsewhere, rainfall amounts varied from 0.5 to more than 1.5".

Strong storms with heavy downpours left over an inch of rain in northwestern Vermont (1.2" in Swanton and 1.28" in Alburgh) on August 8. That would be the last significant rainfall there all month. Swanton's month-to-date total was 1.71" and Alburgh's, 1.51".

On August 17, there was heavy thunderstorm activity in southeastern Vermont, and widespread beneficial rain was recorded on August 18. Fast moving storms on August 29 brought a quick shot of torrential rain up to 0.5" total and strong winds that downed trees in a path from Newport to Canaan.

The hit-or-miss nature of rain events left several areas of the state drier than others. Overall, August was drier than normal for northern Vermont with the southern counties wetter. Moderate drought expanded from the end of July to include all northwestern and north central Vermont. Effects of drought showed up in the landscape.

Summerlike weather continued into September but fall arrived before the month's end. September was the 2nd warmest on record at the National Weather Service in Burlington following a trend of warmest Septembers for the last four years.

The first half of the month was well above average setting multiple highest maximum and minimum temperature records. On September 3 and 5, maximum temperatures reached the upper 80's and low 90's across the state. Burlington reached 93° on the 3rd setting a new record. On September 5, a heat advisory for heat indices in the mid 90's to lower 100's was issued for the Champlain Valley and southern Connecticut River valley. Burlington set a new record that day with 93° and Woodstock tied the record with 91°.

A first round of fall-like temperatures arrived during the weekend of September 7 & 8. High dewpoints from earlier in the week finally broke, bringing down the humidity and delivering more comfortable, though chilly temperatures. A frost advisory, the first of the season, was issued on September 8. Some of the colder spots in northern Vermont, especially in Essex County, dropped below freezing as did Morrisville with 31°. Temperatures warmed up again following this first scattered frost with highs in the low to mid 80's and lows in the 60's until mid-month when more normal September temperatures were observed.

Drought continued but conditions improved through the month for much of Vermont. Reports of springs and wells drying up were common and kept well drilling companies exceptionally busy. North central Vermont missed out on several rain events that helped to alleviate drought conditions in other parts of the state. On September 4, scattered storms with damaging winds brought down numerous trees in Irasburg and other locations in the area. This same storm brought isolated spots of torrential rain. Gilman received 2.35 inches, a new one-day highest precipitation record, and Lyndonville received 1.67 inches. Statewide rain events occurred on September 11 and 27.

Fall 2018

Scattered frost occurred on the first day of Autumn, September 22. No widespread killing frost occurred in September. Early fall color reports started in August but the annual show was late to progress. Widespread color change arrived about two weeks late. Peak in the northeast and higher elevations wasn't until Columbus Day weekend. Although late, and despite leaf loss from drought and other causes, areas of heavy maple leaf cutter defoliation and other miscellaneous leaf ailments, Vermonters and out-of-state visitors were not disappointed.

October and early November were generally average in terms of temperature and precipitation. On October 10th, temperatures reached the 80s in much of the state, but the following weeks were, for the most part, seasonable, sometimes dipping to freezing temperatures, with daily highs often in the 40s and 50s. Sunny days were rare, and late fall colors were muted. Due to the late start, limited frost, and lack of stormy weather, leaves persisted on oaks, beech, and other late-turning species well into November.

Then suddenly in mid-November winter conditions arrived throughout the state, and persisted through late fall, with cold weather and snow accumulation. Temperatures dipped to single digits on November 14th. In late November, Winter Storm Bruce dumped wet snow statewide, leaving over a foot at higher elevations. Tree breakage was widespread, resulting in approximately 90,000 power outages.

As it turned out, November was the snowiest on record, with 32.9 inches over the 30 day period. Vermont's next highest snowfall level in November was 24 inches in 1900. The average snowfall in November is 6.1 inches.

In December, near record warmth and heavy rains melted the snow cover from November, creating widespread flooding across Vermont. Numerous roads were blocked by high water. On December 21, Winter Solstice, 0.83 inches of rain fell in Burlington, and the following day, the high temperature was 56 degrees. Normal snowfall in Burlington for the month of December is 17.9 inches. Just 8.6 inches fell in 2018.

Figures 1-14 *and* ***Tables 1-3*** *provide details on 2018 temperatures, precipitation and phenological observations.*

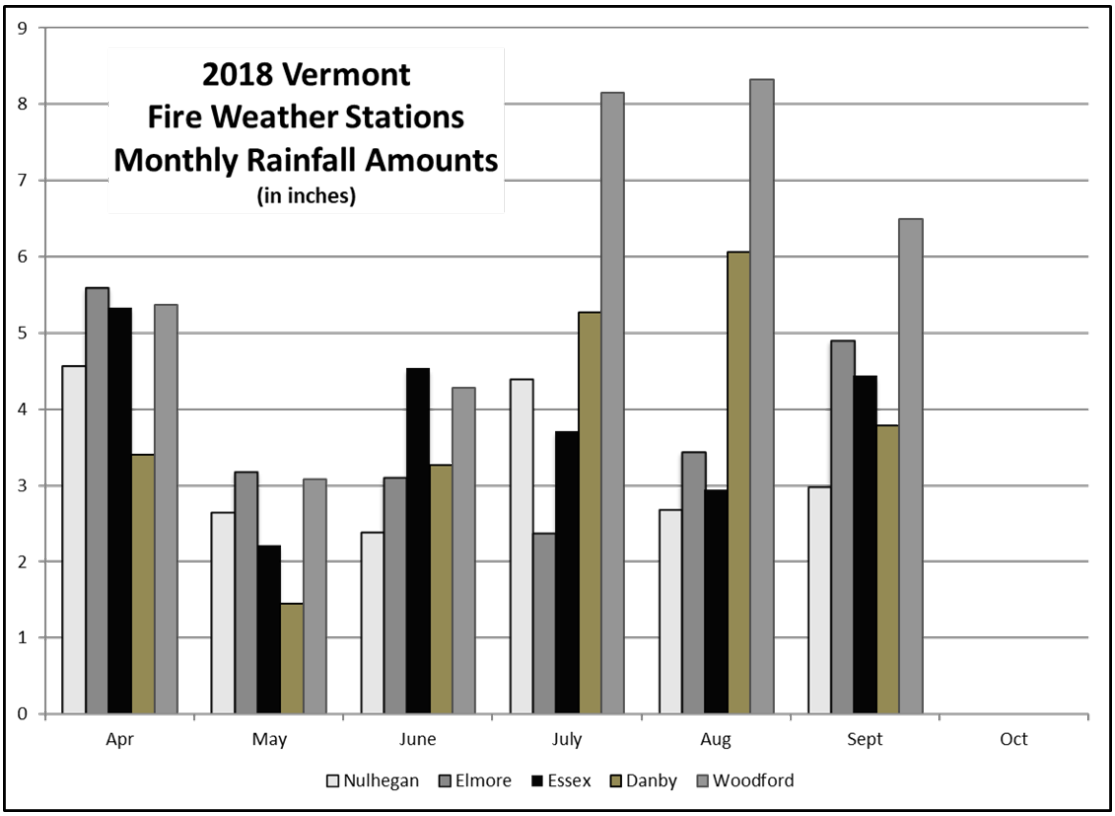


Figure 1. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, March-October, 2018.

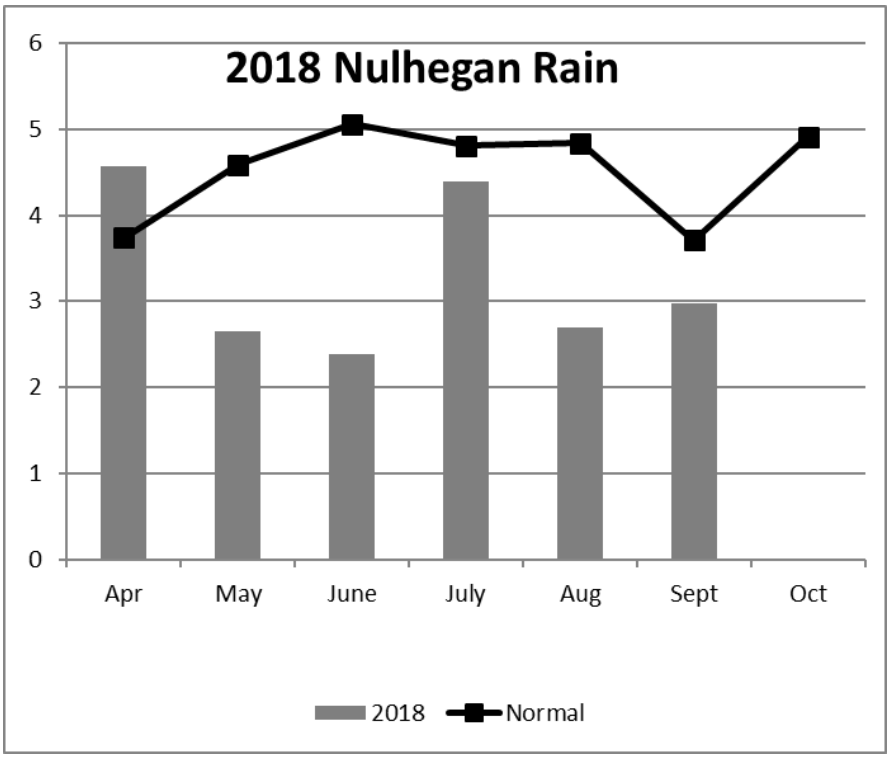


Figure 2. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, Vermont compared to normal through fire season, April-October, 2018. Normal is based on 16 years of data.

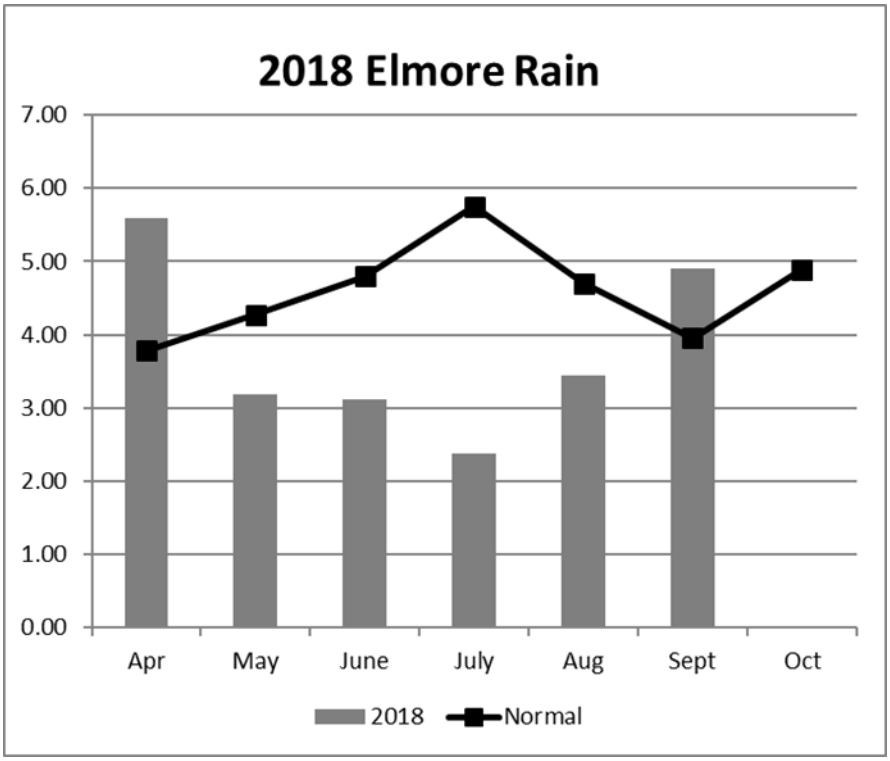


Figure 3. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, Vermont compared to normal through fire season, April-October, 2018. Normal is based on 24 years of data.

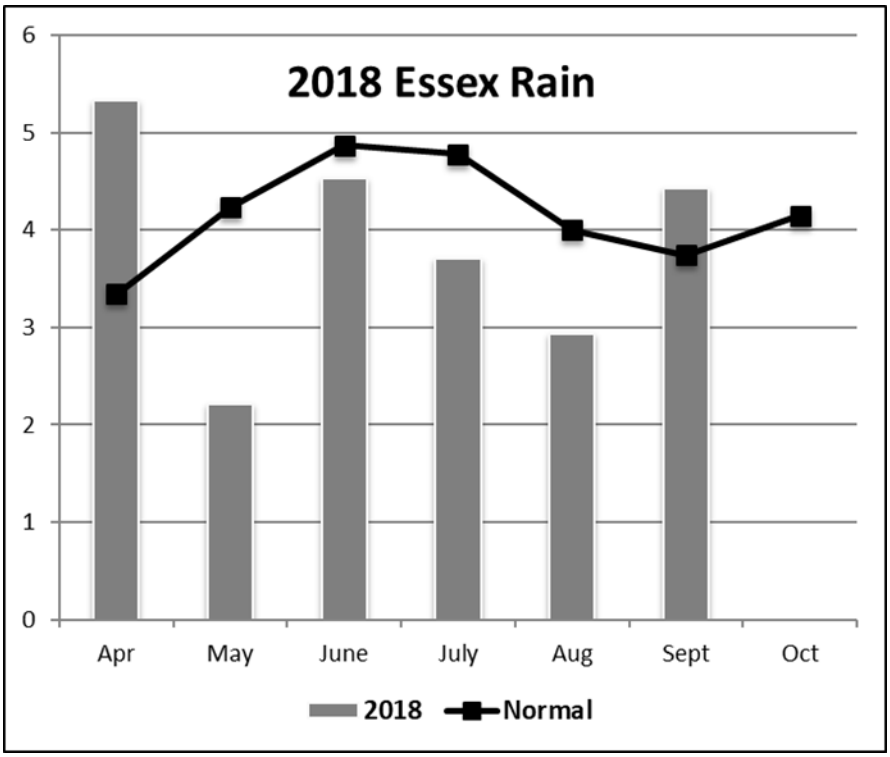


Figure 4. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, Vermont compared to normal through fire season, April-October, 2018. Normal is based on 25 years of data.

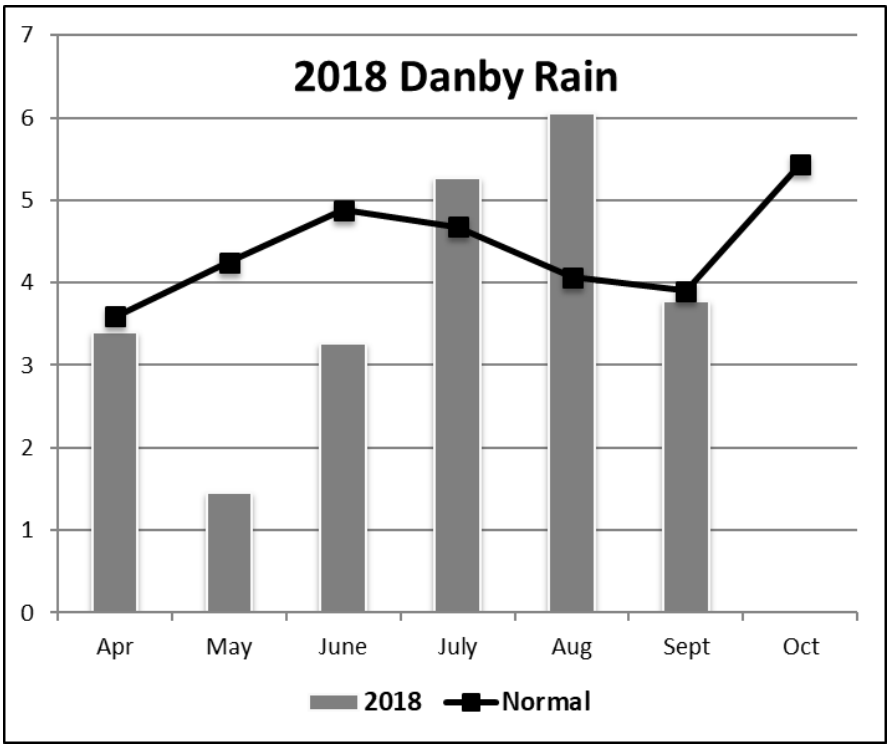


Figure 5. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal through fire season, April-October, 2018. Normal is based on 18 years of data.

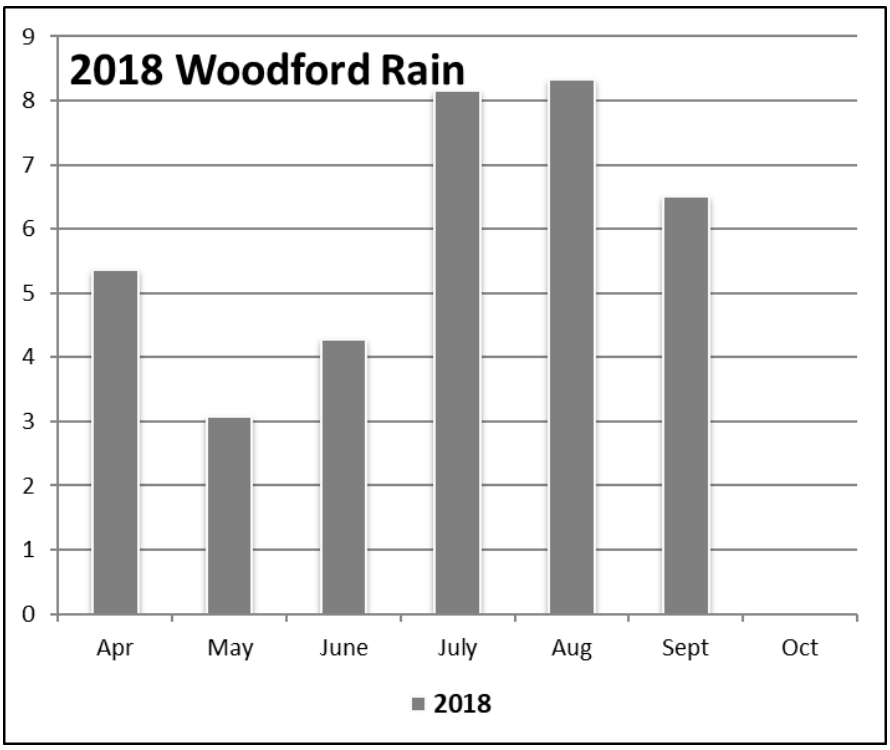


Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont through fire season, April-October, 2018. The Woodford weather station was initially installed in 2013. Normal for this site is not yet established.

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 leaf bud expansion was later than normal in 2018. Budbreak on May 7 was four days later than the long-term average, and nearly a week later than in 2017. Full leaf-out was nearly indistinguishable from the long-term average (Figure 1) but was two days earlier than in 2016.

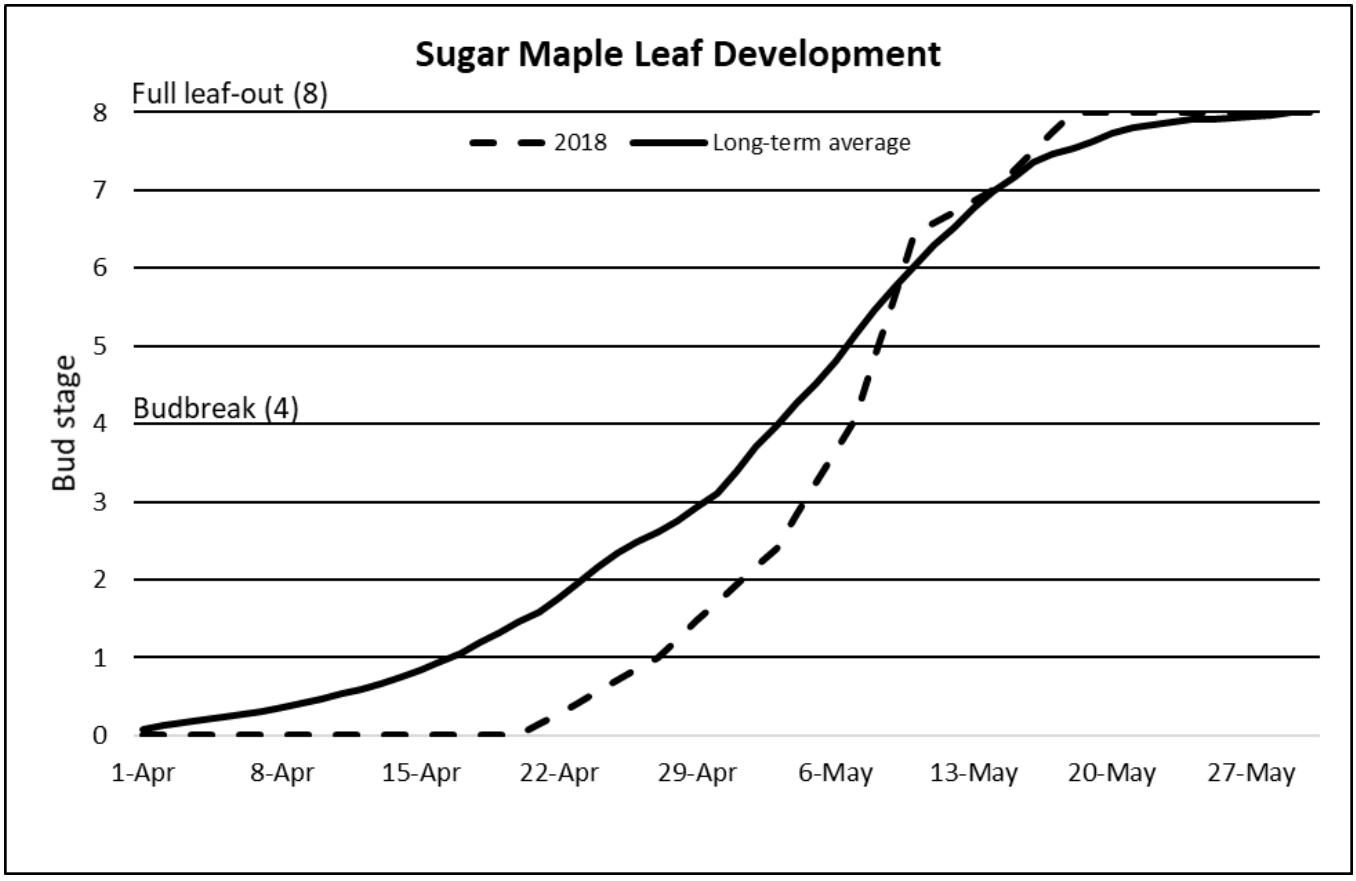


Figure 7. Sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

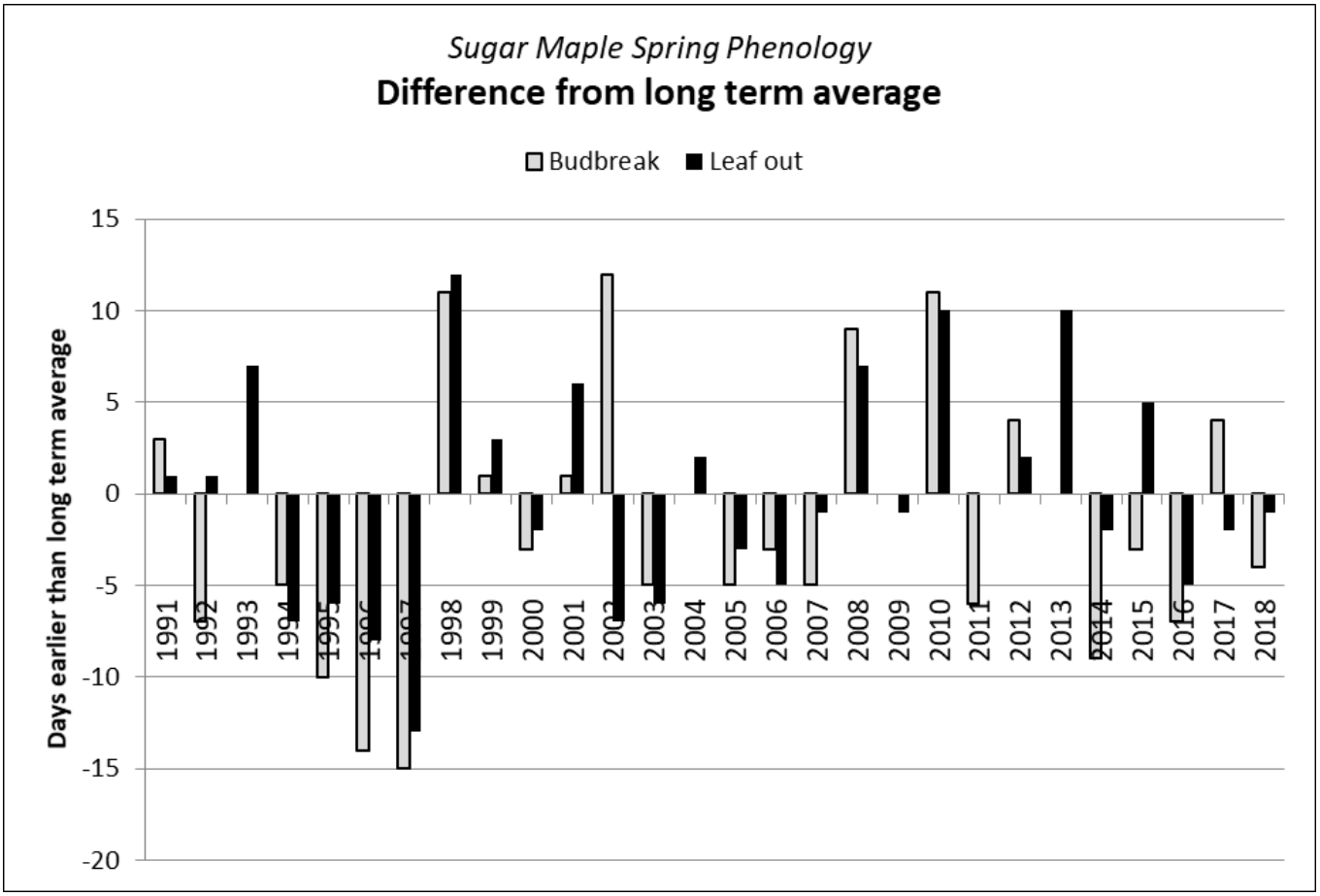


Figure 8. Difference from long-term average of sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

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 (Figure 9). Field data recorded included percent of tree expressing fall color, as well as portion of 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 2018. Although color development was initially slow, full leaf drop was just one day later than in 2017. Growing season length was 5 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 2018: 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.

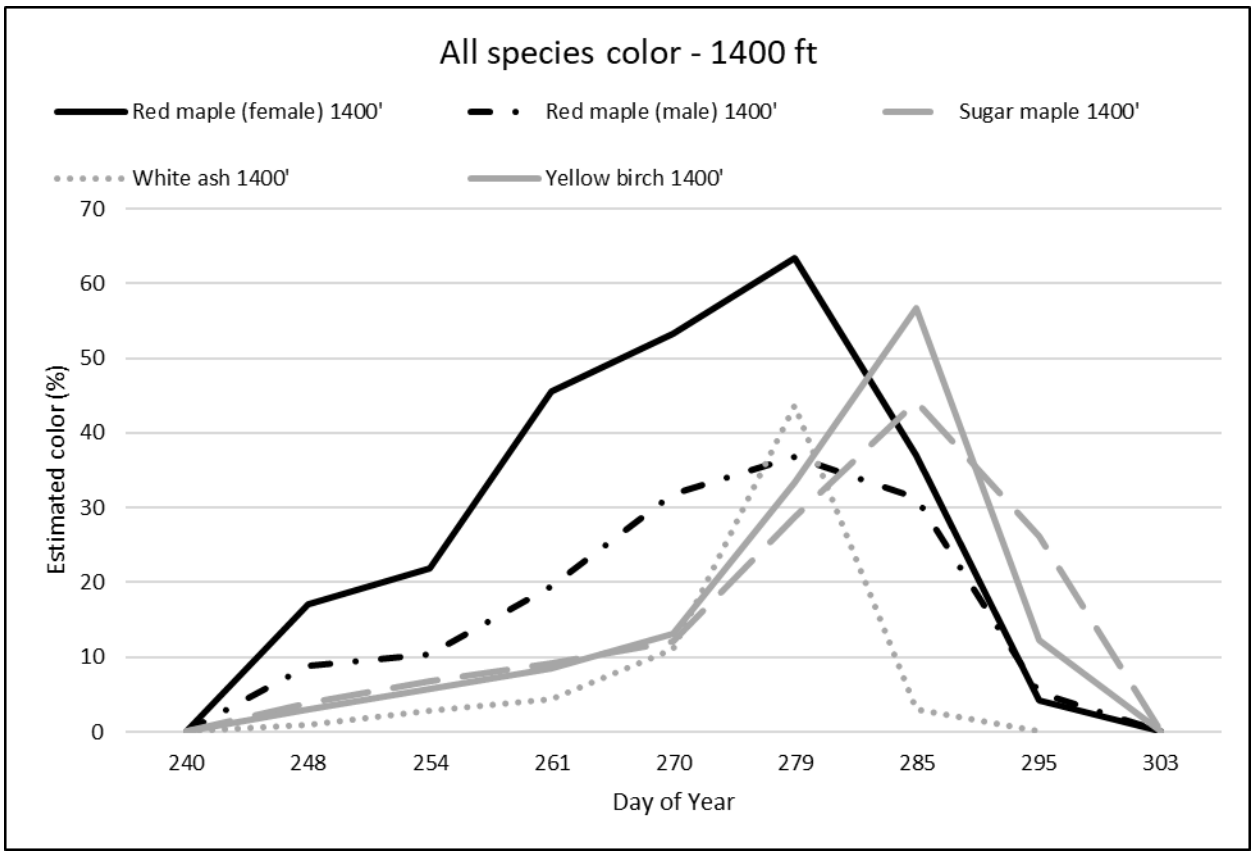


Figure 9a.

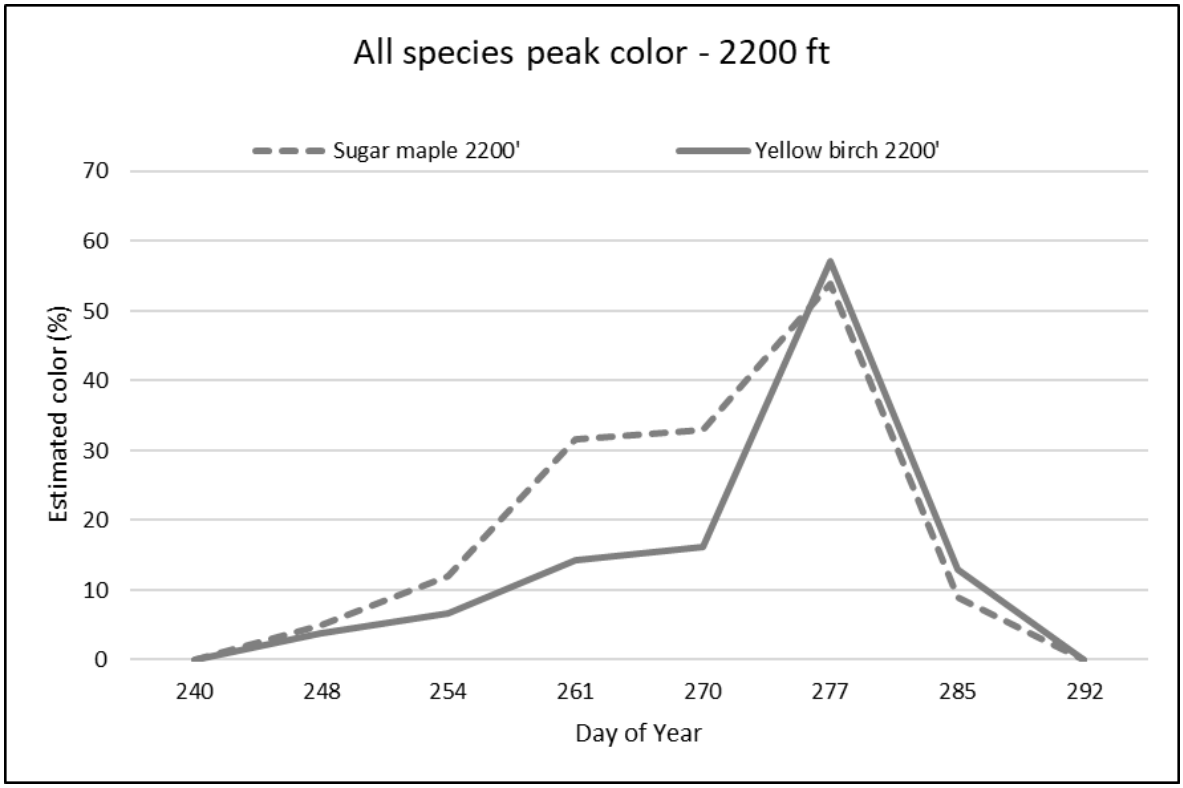


Figure 9b.

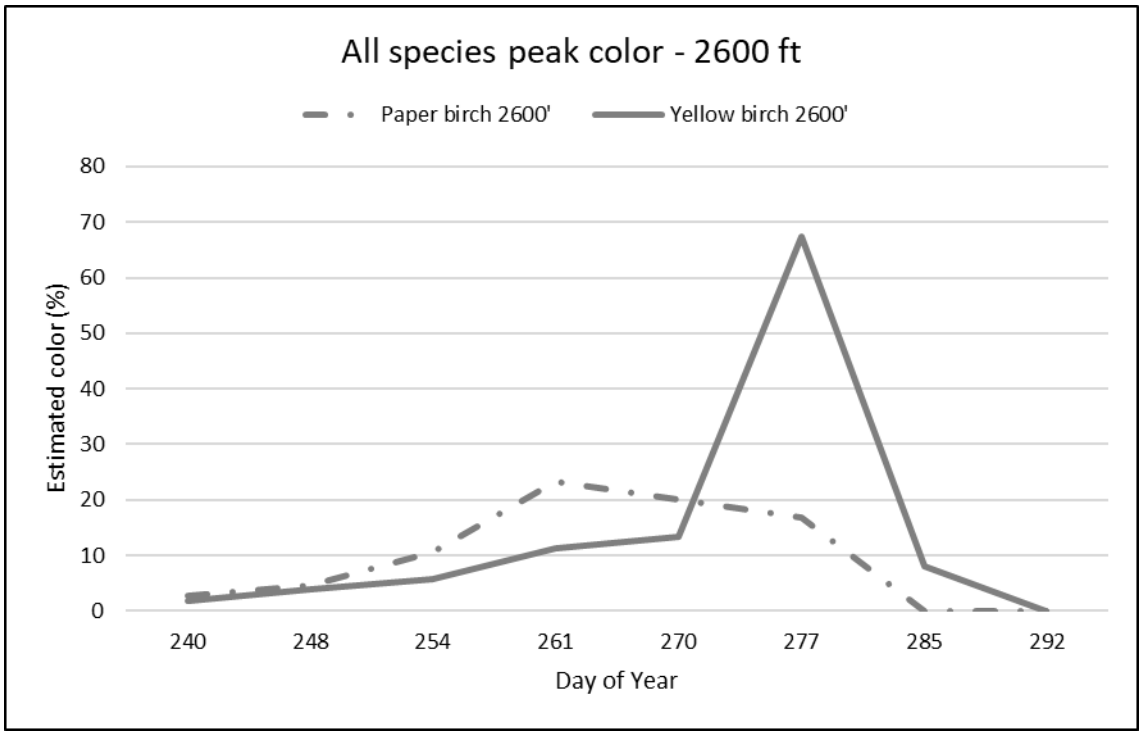


Figure 9c.

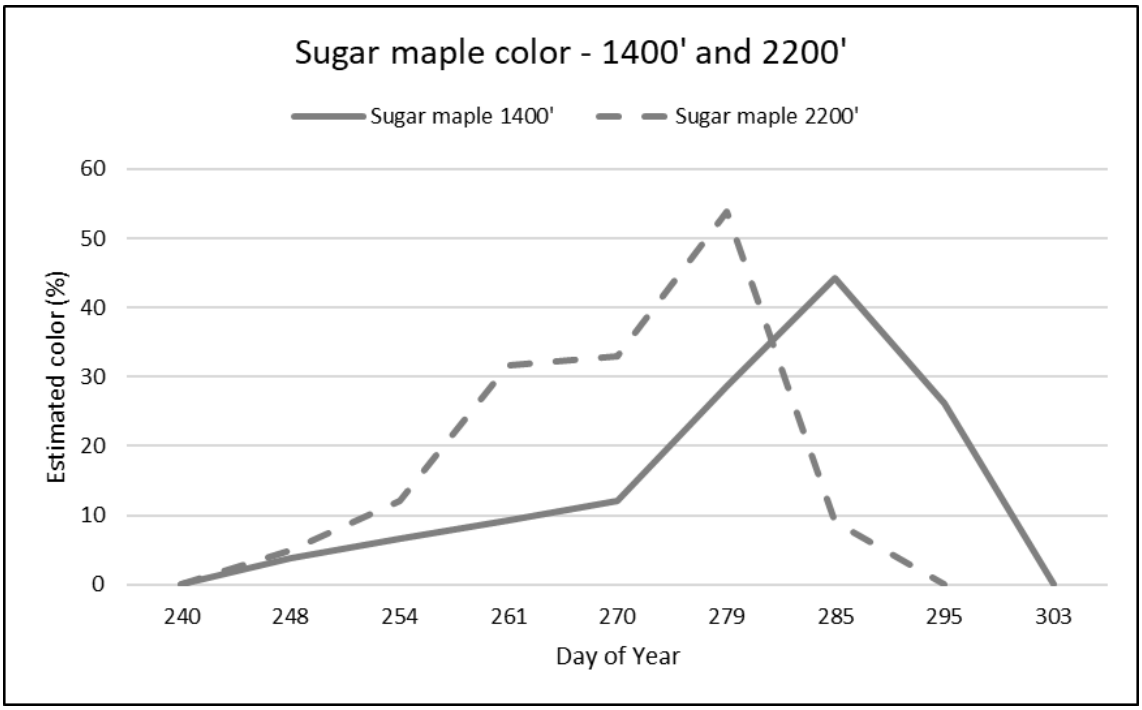


Figure 9d.

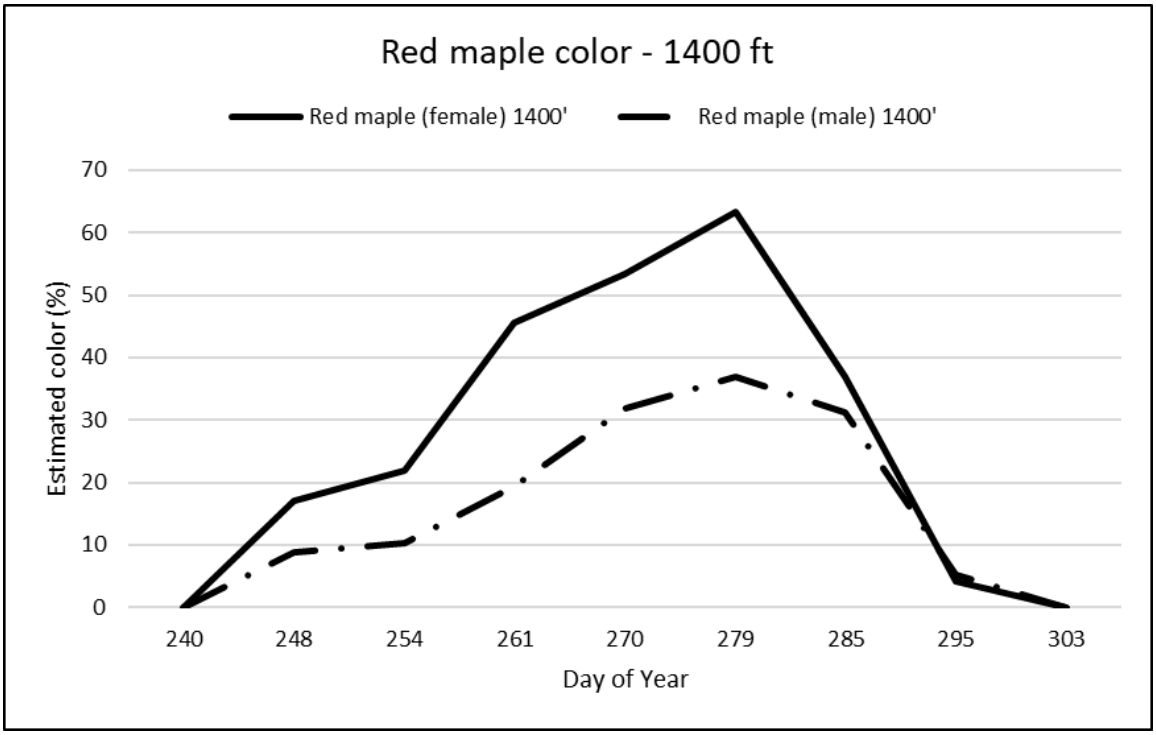


Figure 9e.

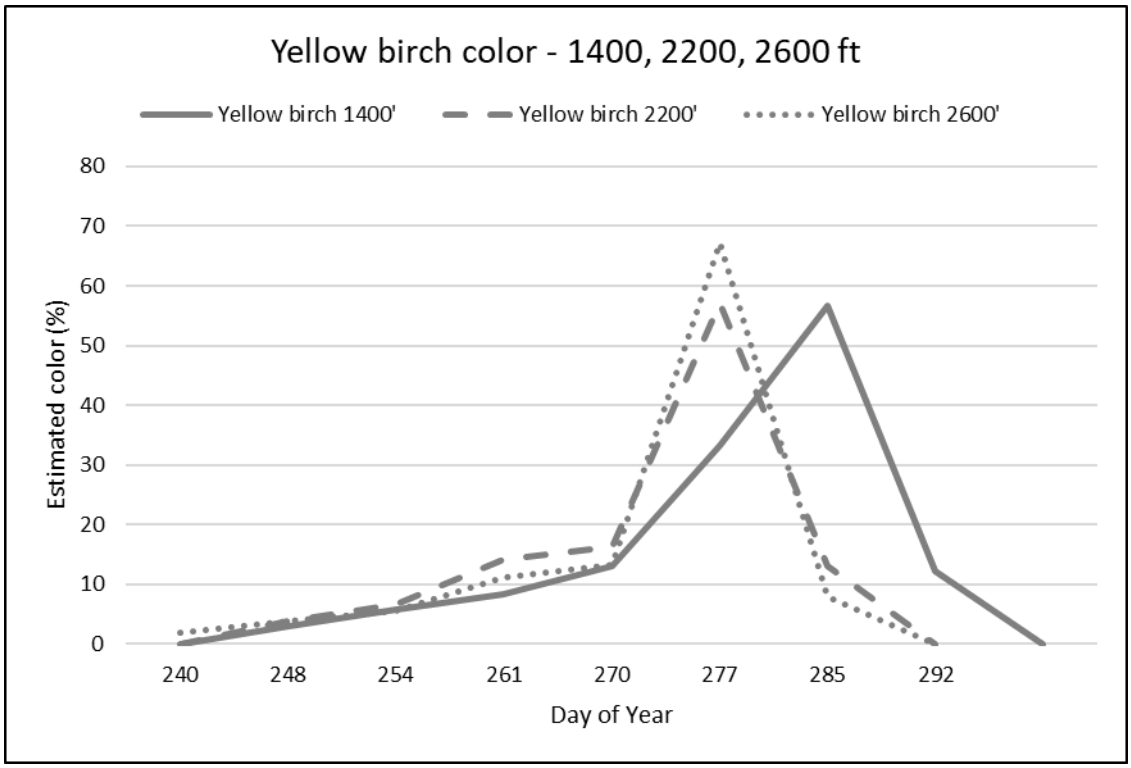


Figure 9f.

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 20-year record, red maple and white ash a 24-year record, sugar maple at 1400 ft a 28-year record, and all other trees a 27-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)	2018 Data (Day of year)
Elevation 1400'		
Red maple (Female)	280	279
Red maple (Male)	284	279
Sugar maple	287	285
Yellow birch	285	285
White ash	279	279
Elevation 2200'		
Sugar maple	277	277
Yellow birch	276	277
Elevation 2600'		
Yellow birch	276	277
Paper birch	269	261

Table 2. Progression of leaf drop for trees at 3 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)	2018 Data (Day of year)	Long-term Average (Day of year)	2018 Data (Day of year)
Elevation 1400'				
Red maple (Female)	289	284	299	295
Red maple (Male)	290	282	300	296
Sugar maple	291	291	303	302
Yellow birch	288	289	298	301
White ash	285	280	297	285
Elevation 2200'				
Sugar maple	282	280	295	294
Yellow birch	280	282	292	292
Elevation 2600'				
Yellow birch	279	281	289	288
Paper birch	272	268	286	283

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
Long term Average (1991-2018)	**5/4**	**10/21**	**171**

HARDWOOD DEFOLIATORS

Forest Tent Caterpillar (FTC), *Malacosoma disstria*, defoliation increased again in 2018, with 71,314 acres of defoliation mapped during statewide aerial surveys (Table 4; Figure 10). This accounts for roughly 2% of the northern hardwood forest in Vermont. Defoliation increased by more than 10,000 acres this year compared to 2017, when 60,588 acres were defoliated. Defoliation data are available on the ANR Natural Resources Atlas. This was also the first year in the current outbreak where tree mortality associated with FTC was visible in our aerial survey. Approximately 4,550 acres of dieback and mortality were mapped throughout the state in 2018 (Table 5; Figure 11a).

In late 2017 and early 2018, FPR staff assisted landowners with FTC egg mass surveys to determine the likelihood of defoliation on their property (Figure 11b). Survey methods included quantifying the number of new egg masses on limbs in upper canopies of co-dominant sugar maples. Based on these numbers, stands were predicted to be 1) at risk of defoliation, 2) at no risk of defoliation, or 3) borderline - possibly defoliated, but not enough egg masses to guarantee defoliation. Of the 84 sugarbushes surveyed in 2018, 30 locations were identified as at risk of defoliation. In 2017, 64 sugarbushes were surveyed with 32 locations identified as at risk of defoliation (Figure 12).

In the spring, FPR and cooperators monitored leaf development, caterpillar hatch, and defoliation at four sites in northern Vermont (Figure 12a). Leaf development was rated on a 4-point scale - dormant buds, budbreak, small leaves, or full leaves. Caterpillar hatch was categorized into either dormant, < 1/2 hatched, or > 1/2 hatched, and defoliation of crowns was measured in 5% increments. Data from these sites were posted on the FPR website regularly. Hatching was first observed in mid-May – roughly 2 weeks later than in 2017 (Table 5a). Caterpillar development progressed rapidly, and by the last week of May defoliation had begun.

During aerial surveys, locations where egg mass surveys had been done over the winter were observed to determine if defoliation was easily visible. Based on these rapid aerial evaluations, there was no significant defoliation in 86% of the sugarbushes where defoliation was not expected based on egg mass surveys. Defoliation was observed in, or close to, 59% of the unsprayed sugarbushes where defoliation was predicted. These numbers are very similar to the 87% and 62%, respectively from 2017.

Landowners made arrangements with an aerial applicator to have thirteen properties treated with Foray48, a *Btk* product that is registered for use in certified organic production. In total, these accounted for 4,869 acres**.** Treatments were conducted on May 21, 25, and 30, as well as June 3 and 10. Several additional private landowners, primarily located in the northeast portion of the state, also had their forestland treated; 5,200 acres were permitted, not all were treated. Two aerial applicators were employed to do this work.

We assessed defoliation at sites predicted to be defoliated, according to egg mass surveys, that were either treated (4 sites) or untreated (3 sites), as well as 2 sites where defoliation was not predicted, in order to track treatment effectiveness (Figure 12c). Percent defoliation was evaluated between May 29 – June 13, at the time of treatment, and between August 1 – August 13, after FTC feeding was complete. Sites predicted to be defoliated had the same amount of initial feeding whether or not they were treated (8.8% foliage loss), but untreated stands experienced greater defoliation throughout the growing season and averaged 25.4% foliage loss (compared to 15.4% for treated stands) by the end of the feeding window. Stands not predicted to be defoliated experienced only 5.5% foliage loss on average by the end of the season (Figure 13).

FTC parasitoids known as friendly flies (*Sarcophaga aldrichi)* were reported throughout the state and in areas that had experienced FTC defoliation last year. Pheromone traps for FTC were again deployed throughout the state in 2018, and moth capture decreased dramatically from 2017 levels (Table 6 and

Figure 14). If results from the previous outbreak (2004-2007) are any indication, we may see a reduction in defoliation in 2019 (Figure 15).

Trees typically respond to the relatively early-season feeding by FTC by sending out a new flush of leaves. However, in all years of the current outbreak (2016-2018), some defoliated areas remained noticeable all summer because of a lack of refoliation. The exact mechanism by which trees did not refoliate is unclear, but factors that may have contributed to this include dry mid-summer conditions, the lingering effects of drought in 2016 and 2017, and heavy seed on sugar maple in 2017. Infection by leaf fungi may also have played a role, especially in 2017. The presence and extent of tree mortality associated with FTC (Figure 17) is likely due to some of the same factors that prevented refoliation of trees. It will be important to continue to monitor areas affected by FTC for dieback and mortality in 2019 as well.

For more details on FTC biology and management, refer to the most recent Forest Tent Caterpillar Update.

Table 4. Mapped acres of forest tent caterpillar defoliation in 2018.

County	Acres
ADDISON	76
BENNINGTON	1494
CALEDONIA	1770
CHITTENDEN	0
ESSEX	41642
FRANKLIN	3621
GRAND ISLE	0
LAMOILLE	8435
ORANGE	0
ORLEANS	9724
RUTLAND	2973
WASHINGTON	1522
WINDHAM	58
WINDSOR	0
Total	71314

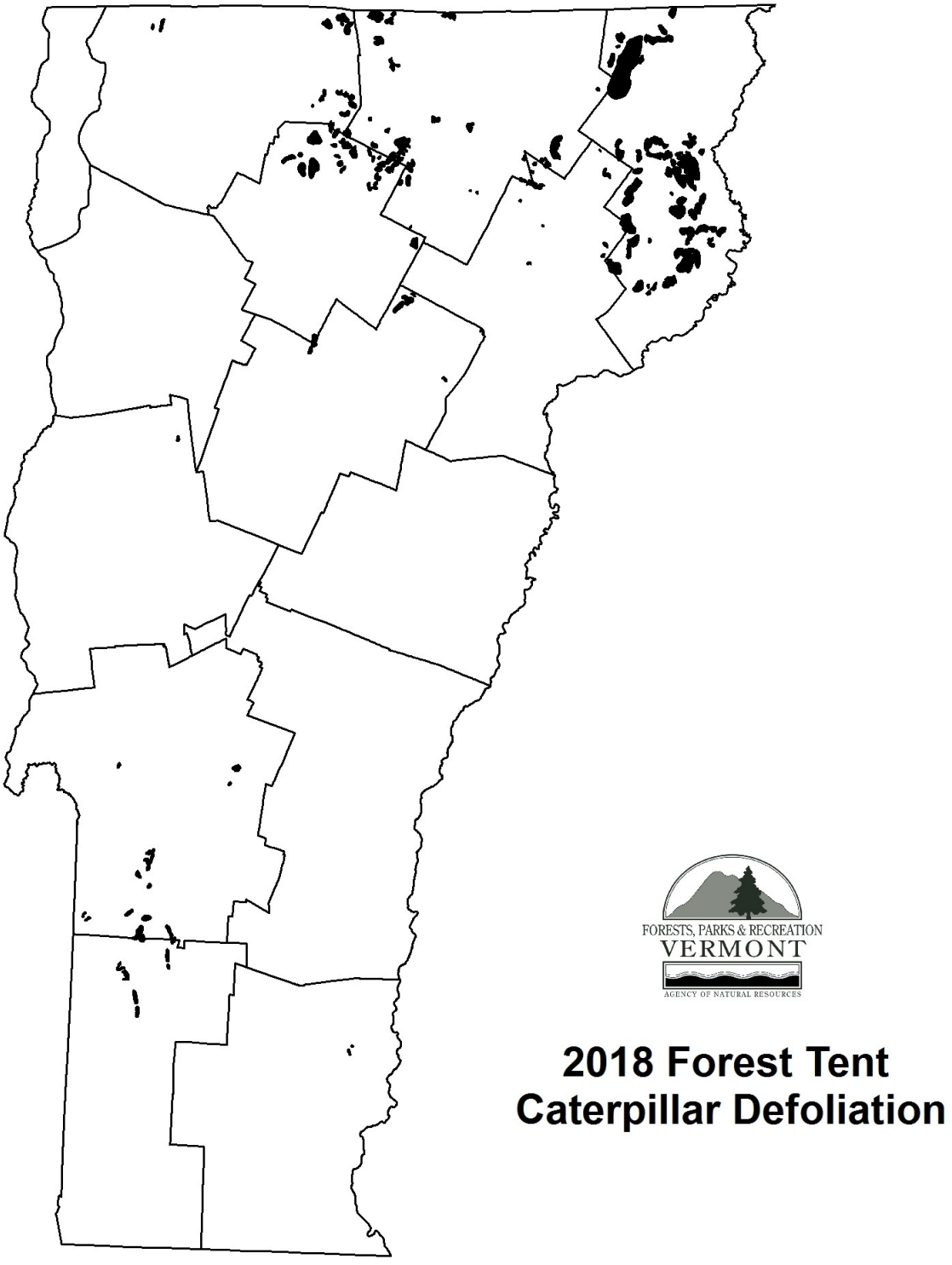


Figure 10. Forest tent caterpillar defoliation mapped in 2018. Mapped area includes 71,314 acres.

Table 5. Area of tree dieback and mortality, mapped in 2018, resulting from forest tent caterpillar defoliation.

County	Acres affected
ADDISON	0
BENNINGTON	24
CALEDONIA	179
CHITTENDEN	0
ESSEX	2269
FRANKLIN	74
GRAND ISLE	0
LAMOILLE	1216
ORANGE	18
ORLEANS	398
RUTLAND	77
WASHINGTON	296
WINDHAM	0
WINDSOR	0
Total	4550

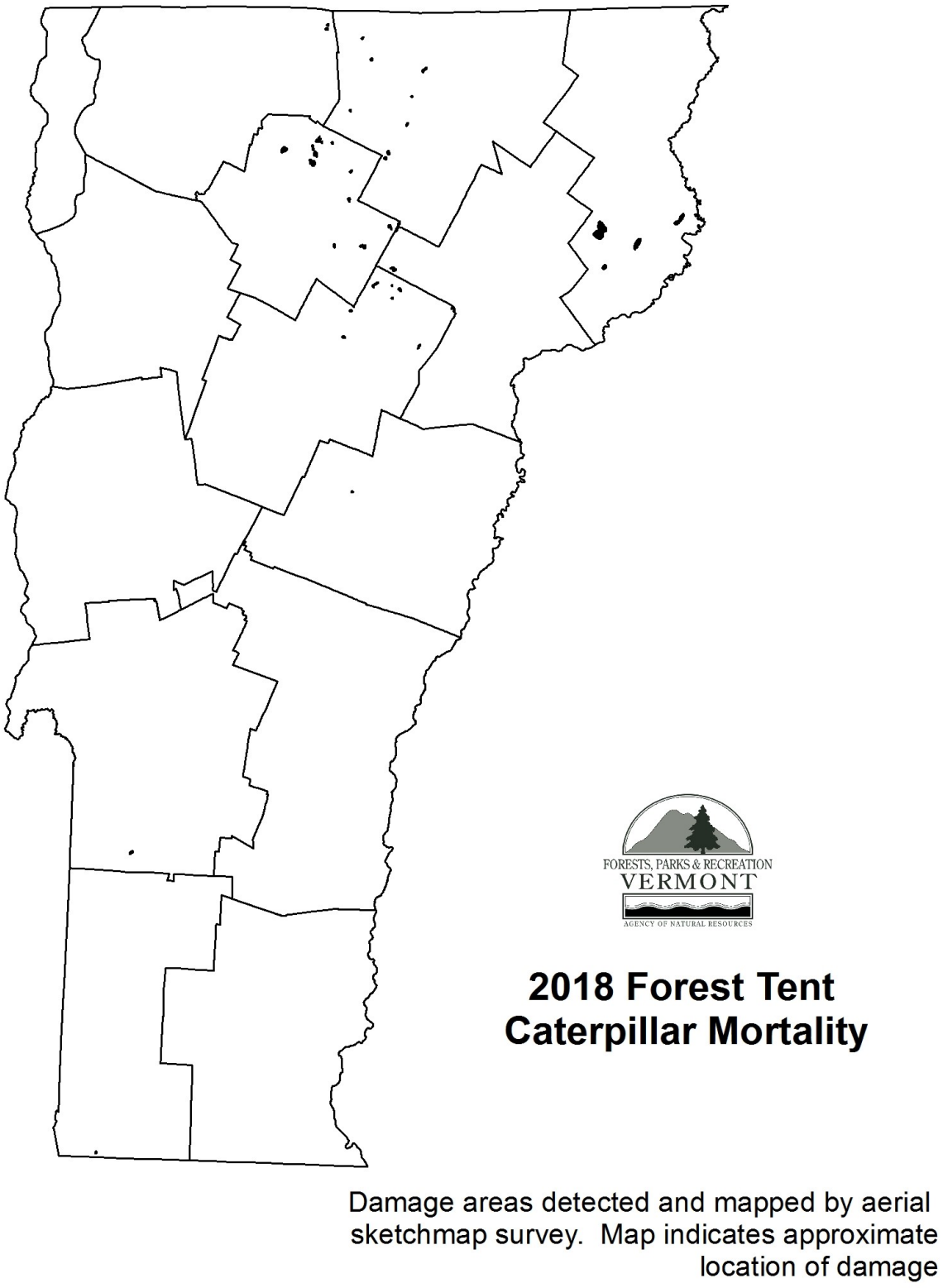


Figure 11a. Tree dieback and mortality mapped in 2018 resulting from multiple years of repeated forest tent caterpillar defoliation. Mapped area includes approximately 4,550 acres.

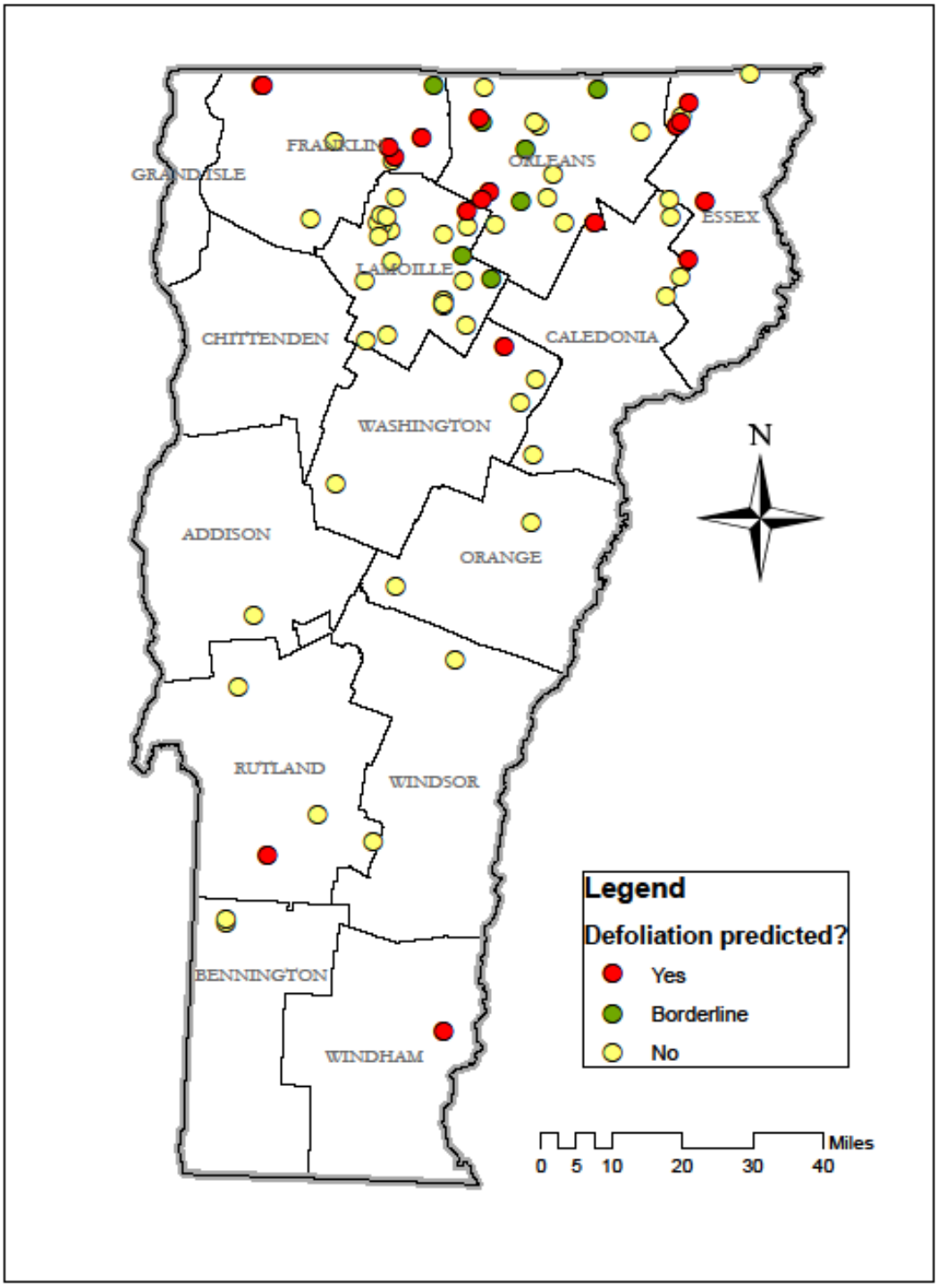


Figure 11b. Locations and defoliation predictions of FTC egg mass surveys. Eighty-four sugarbushes were surveyed in winter 2017-18.

Table 5a. Results from forest tent caterpillar egg mass surveys by county, winter 2017-2018.

County	Total Number of Surveys	Predicted Defoliation (# of surveys)	Predicted Borderline (# of surveys)	Predicted No Defoliation (# of surveys)
Addison	1	0	0	1
Bennington	2	0	0	2
Caledonia	5	0	0	5
Chittenden	0	0	0	0
Essex	7	5	0	2
Franklin	9	5	1	3
Grand Isle	0	0	0	0
Lamoille	27	3	3	21
Orange	3	0	0	3
Orleans	17	4	4	9
Rutland	6	2	1	3
Washington	4	1	0	3
Windham	1	1	0	0
Windsor	2	0	0	2
Total	**84**	**21**	**9**	**54**

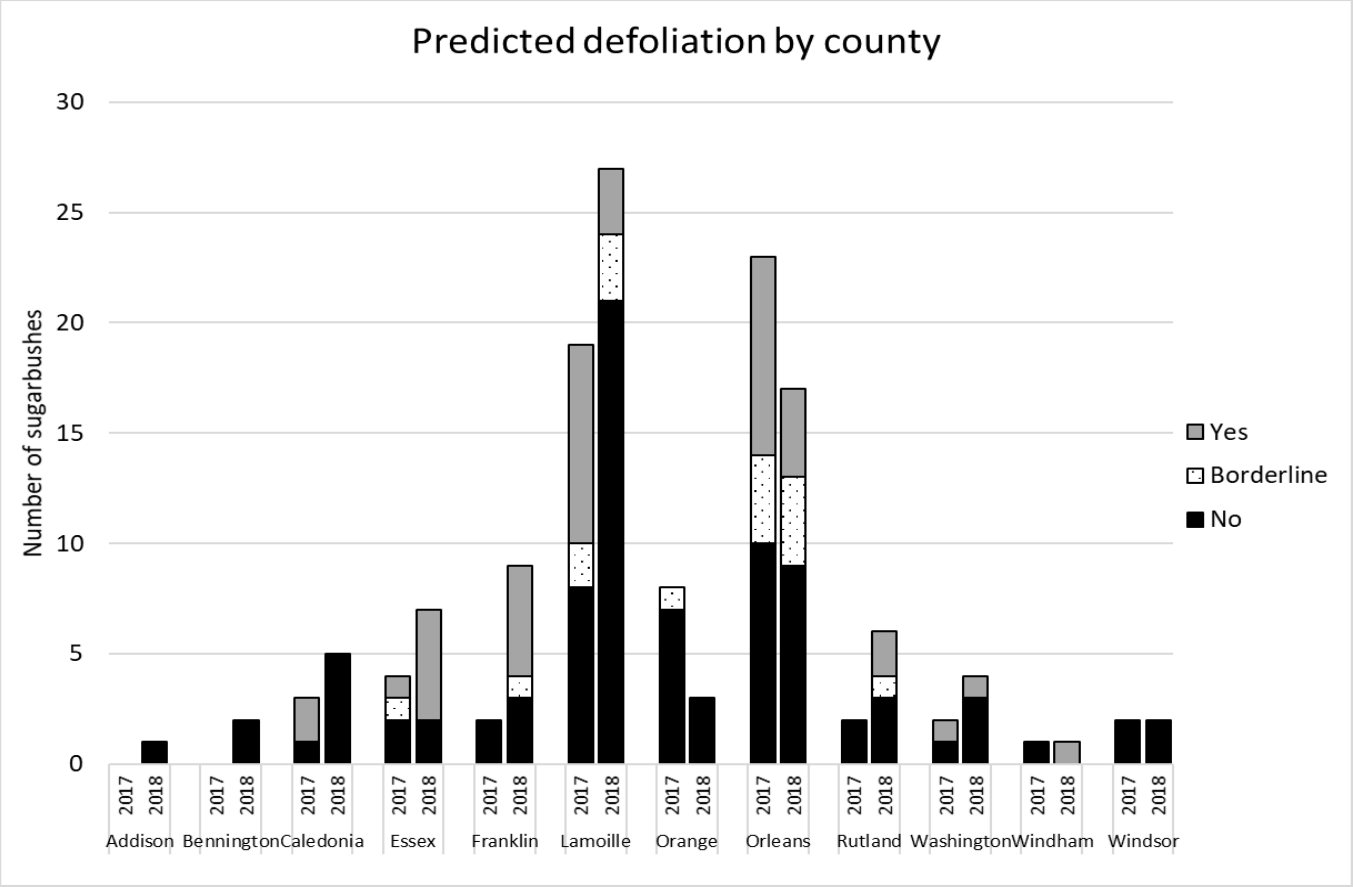


Figure 12. Summary of forest tent caterpillar egg mass surveys by county for the past two winters. In 2017, 64 sugarbushes were surveyed with 32 locations identified as at risk of defoliation. Of the 84 sugarbushes surveyed in 2018, 30 locations were identified as at risk of defoliation.

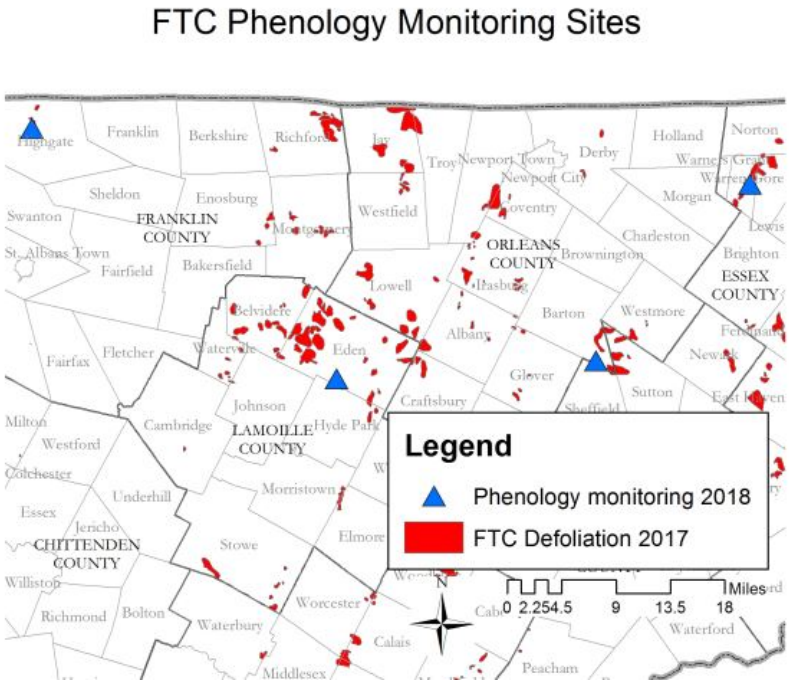


Figure 12a. Locations of FTC phenology monitoring locations with areas defoliated in 2017 shown. The Highgate, Barton and Warren's Gore sites were monitored by consulting foresters or landowners. The Eden site was monitored by FPR staff.

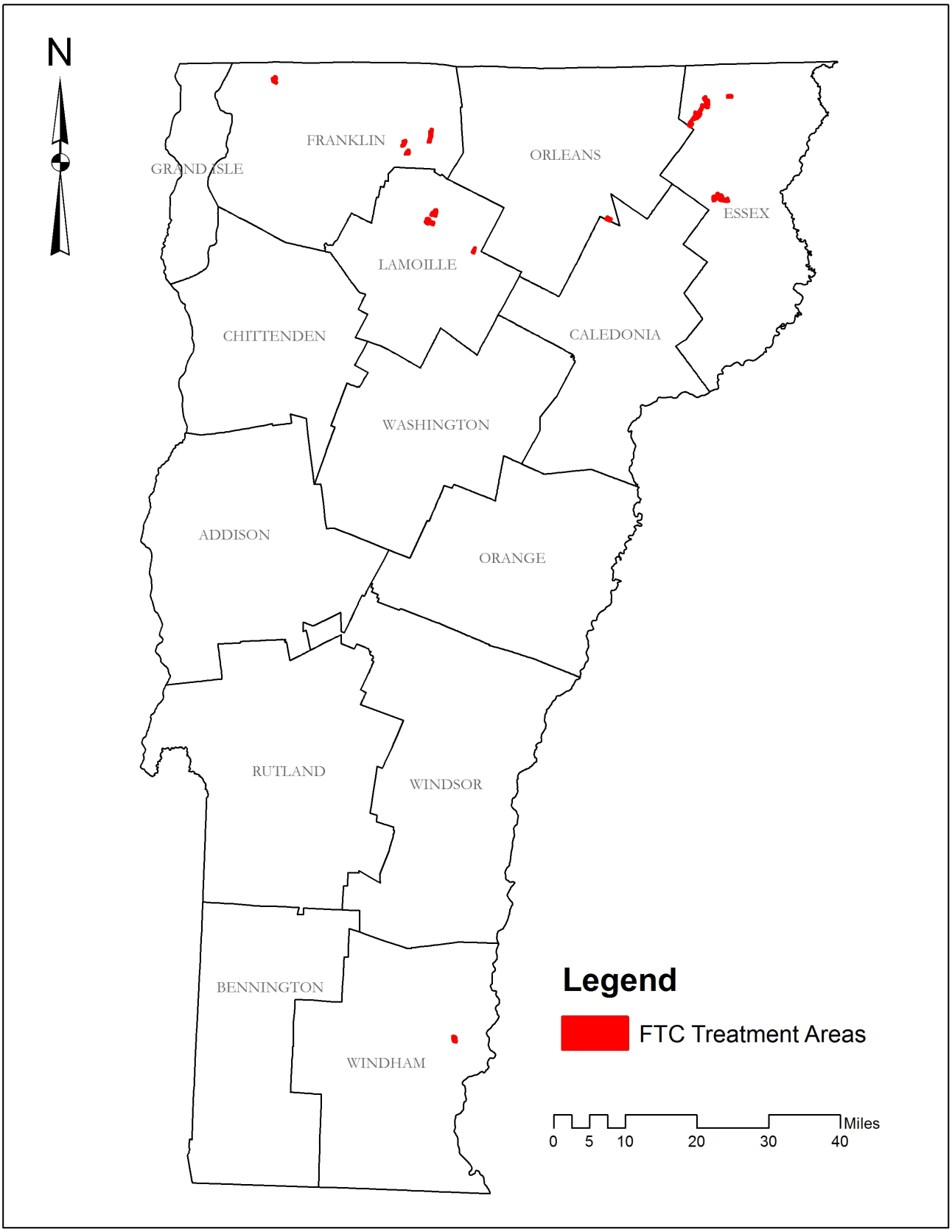


Figure 12b. Locations of FTC treatment areas in 2018. Treatment areas were treated with Foray 48B between May 21—June 10.

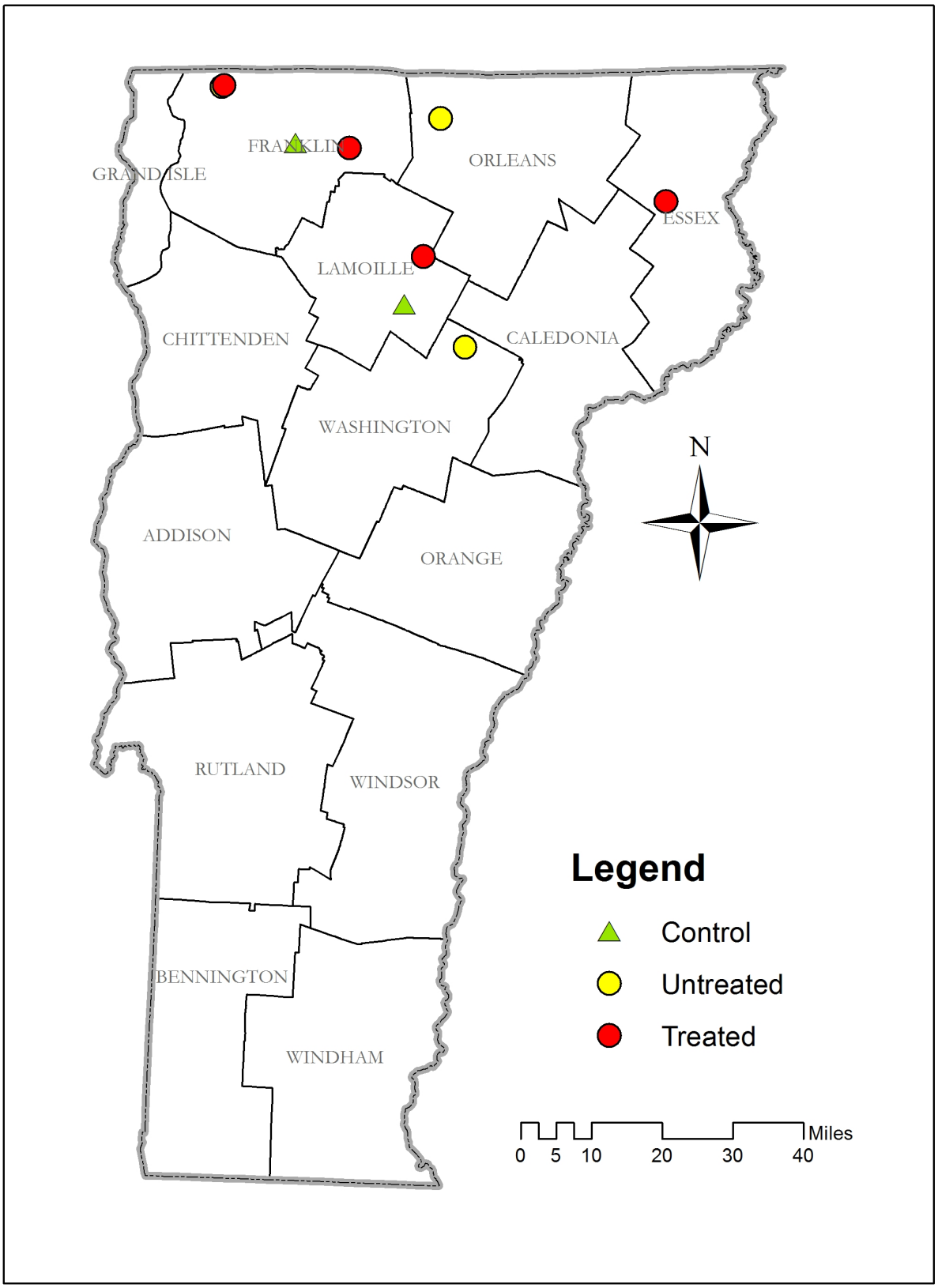


Figure 12c. Locations of defoliation assessments following aerial treatment for FTC. Control sites were not predicted to be defoliated, whereas both Untreated and Treated sites were expected to be defoliated in 2018.

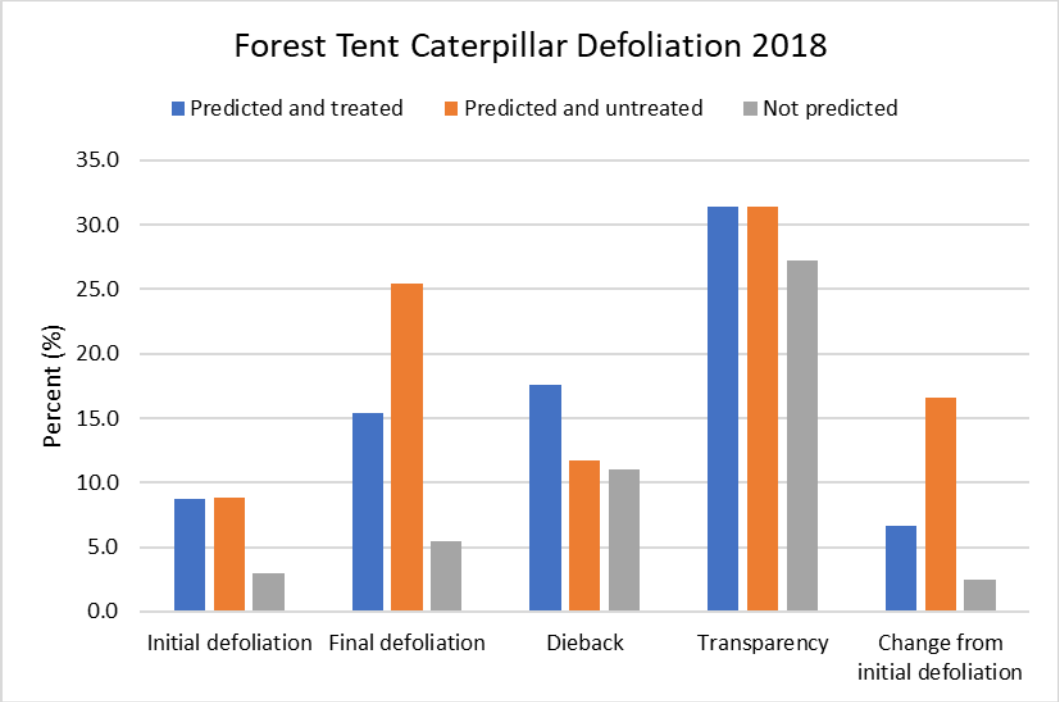


Figure 13. Forest tent caterpillar defoliation assessments in 2018 showing percent of sites predicted to be defoliated that were either treated (4 sites) or untreated (3 sites) as well as 2 sites where defoliation was not predicted. Initial defoliation was evaluated at the time of treatments. Final defoliation was evaluated when feeding was complete for the season.

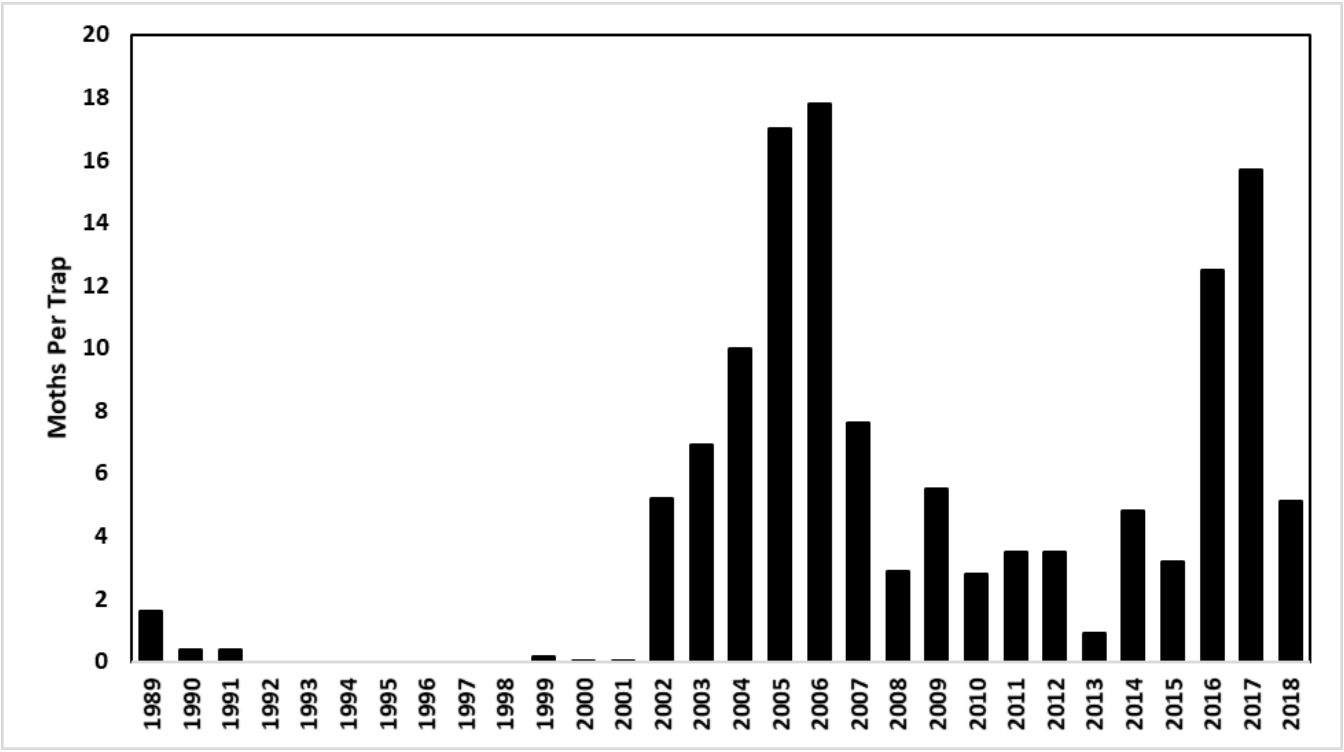


Figure 14. Average number of forest tent caterpillar moths caught in pheromone traps 1989-2018. Three multi-pher pheromone traps per site, with PheroTech forest tent caterpillar lures, were used in 2018.

Table 6. Average number of forest tent caterpillar moths caught in pheromone traps, 2002-2018. Three multi-pher pheromone traps baited with PheroTech forest tent caterpillar lures were deployed at each survey location in 2018.

Site	Year																
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Castleton	----	----	----	17	17.3	8	1	4.7	1	1.7	0.3	2.3	1.7	1.7	14.0	13.3	8.7
Fairfield (NAMP 29)	----	1.3	1.7	----	4.3	4.7	4	10.3	2.0	6	4	1.7	3.3	1.3	1.3	8.0	2.0
Huntington (NAMP 027)	9.2	6.7	10	15.7	16	6.3	4.3	4.3	2.7	6.3	6	1.7	2.7	0.0	10.3	11.0	6.0
Killington/Sherburne (Gifford Woods)	6.9	9.7	20	15.3	21	17.3	7.3	8	2.7	0	1.0	0.7	6.0	5.3	8.3	18.7	6.7
Manchester	----	----	----	----	----	----	0	5.7	3	1	0.7	0.3	1.3	10.3	12.0	19.3	3.7
Rochester (Rochester Mountain)	5.0	4.7	9	4.7	29	10.3	0.7	----	0.3	0	0	0	3.5	2.3	9.0	7.3	2.0
Roxbury (Roxbury SF)	16	14.7	13.3	7.3	22	22.7	8.0	2.7	7.0	2	1.5	1.7	6.3	5.7	29.0	15.0	3.3
SB 2200 (Stevensville Brook)	3.8	11.7	18.3	23.3	35.3	6.3	5.7	10	2.7	6.3	8	0.3	5.3	2.7	7.3	29.0	6.7
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
Underhill (VMC 2200)	3	7	6.3	11.7	6.3	4.7	1.3	4.3	2	2.7	4.7	0.3	2.5	1.3	3.7	9.0	3.0
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
Waterville (Codding Hollow/Locke)	0	2	1.3	17.7	24.7	2.7	2.3	1.3	3.0	4.3	3	1	12.5	3.3	13.3	28.3	13.3
Dillner Farm Montgomery	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	4.3	18.0	4.3
Average	**5.1**	**5.8**	**8.3**	**17**	**17.8**	**7.6**	**2.9**	**5.5**	**2.8**	**3.5**	**3.5**	**0.9**	**4.8**	**3.2**	**12.5**	**15.7**	**5.1**

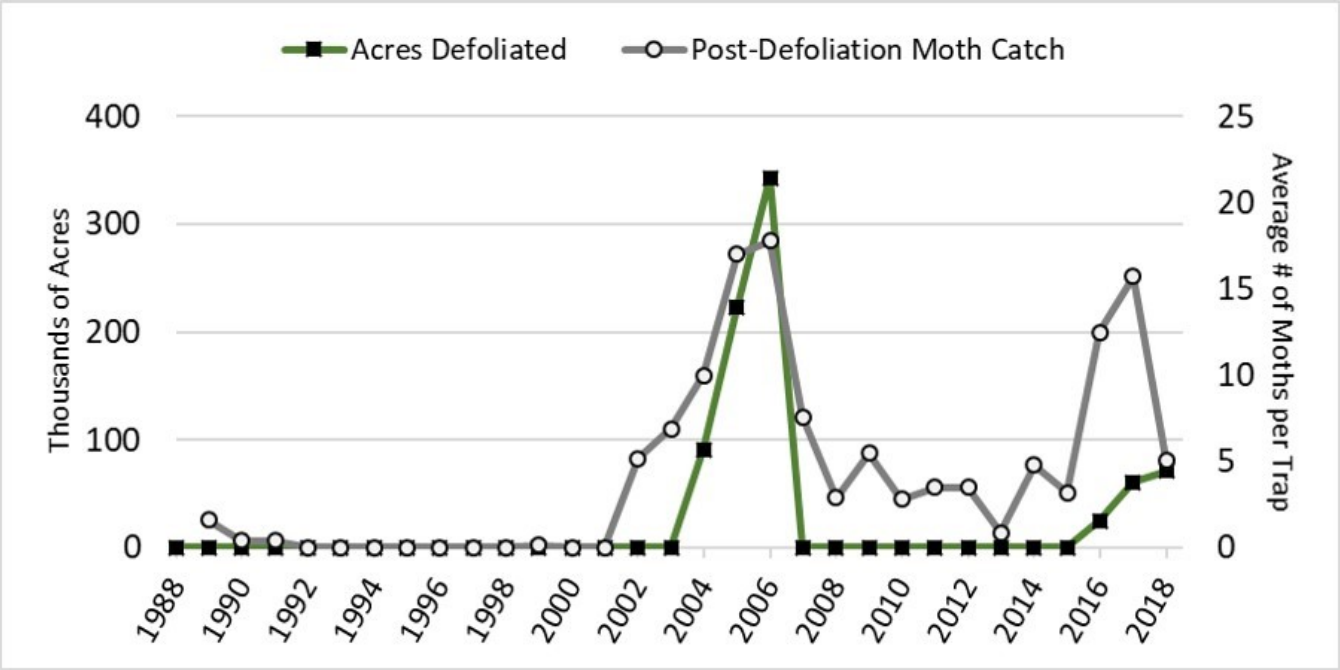


Figure 15. Pheromone trap catches (average number per trap) and acres defoliated by forest tent caterpillar, 1988-2018.

Gypsy Moth, *Lymantria dispar*, caterpillars were not reported in 2018. Our only report of gypsy moth activity was of numerous male moths circling a former FPR employee in Hyde Park. No over-wintering egg masses were found in focal area monitoring plots (Figure 18 and Table 7).

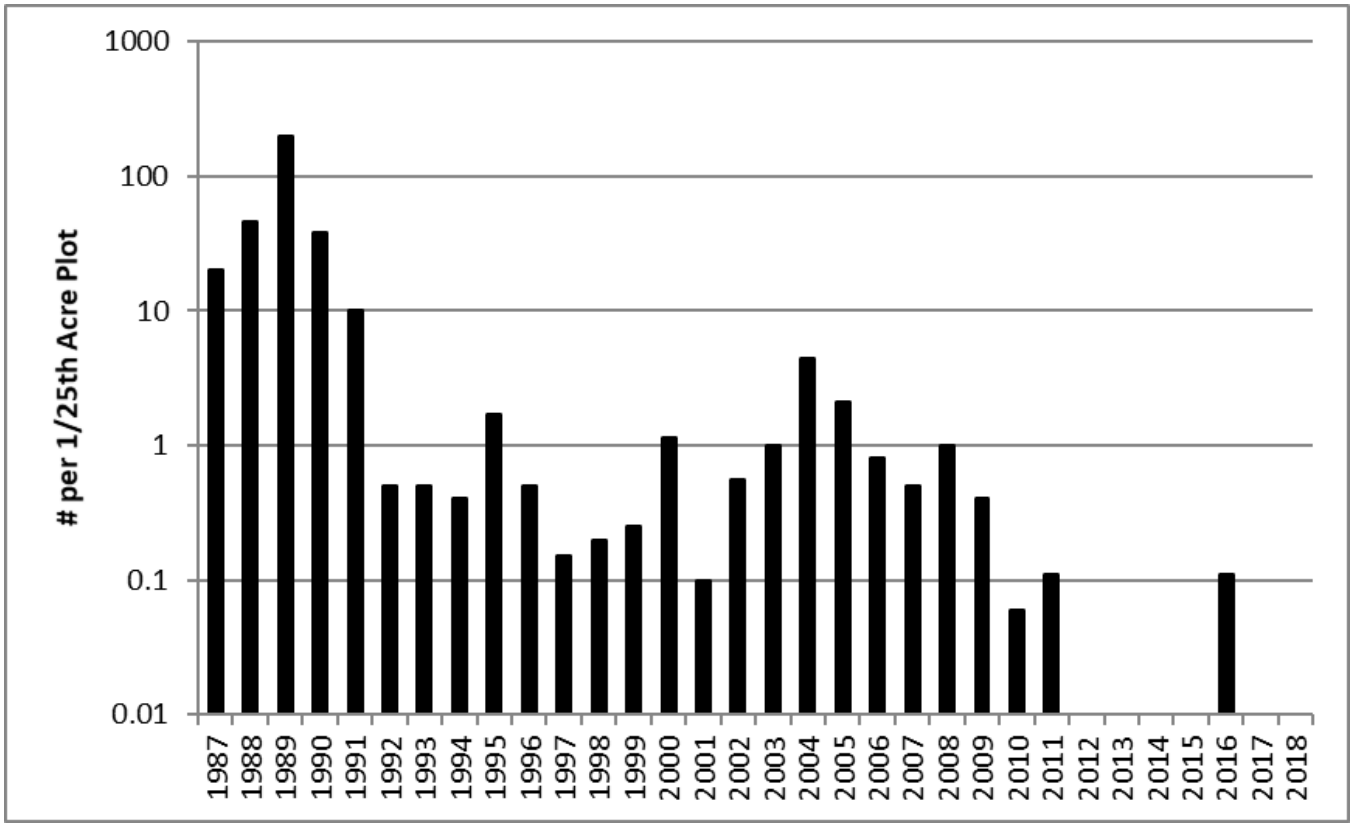


Figure 16. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 1987-2018. Data reflect the average egg mass counts from ten locations, with two 15-meter diameter plots per location containing burlap-banded trees. No egg masses were found in 2018.

Table 7. Number of gypsy moth egg masses per 1/25th acre in focal area monitoring plots, 2003-2018. Counts are the average of two 15 meter plots per location containing burlap-banded trees.

Site	Town	Year															
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Arrowhead	Milton	1.5	2.5	0	0	0	2.5	0	0	0.5	0	0	0	0	0	0	0
Brigham Hill	Essex	2.5	2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Ft. Dummer	Guilford	0	——	0	0	0	0	0	0	0.5	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
Mount Anthony	Bennington	1.5	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
Rocky Pond	Rutland	0	0	0.5	3	3	0.5	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
Tate Hill	Sandgate	0	30	18	3	0	1.5	0.5	0	0	0	0	0	0	1	0	0
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**

Maple Leaf Cutter (MLC), *Paraclemensia acerifoliella,* damage to lower foliage was noticeable statewide in July, but became unusually heavy by early September, when browning and defoliation of entire stands was obvious in many locations. Maple was the most common host, but MLC was also observed on birch and beech. Damage was not observed from the air because aerial surveys had already been completed by the time MLC defoliation and browning became significant.

MLC defoliation was evaluated in late September in 36 maple monitoring plot locations. Heavy defoliation was only reported from plots in southeastern and northeastern Vermont, but moderate defoliation was observed throughout the state (Figure 17).

Due to the late timing of defoliation, significant impacts to tree health are not expected.

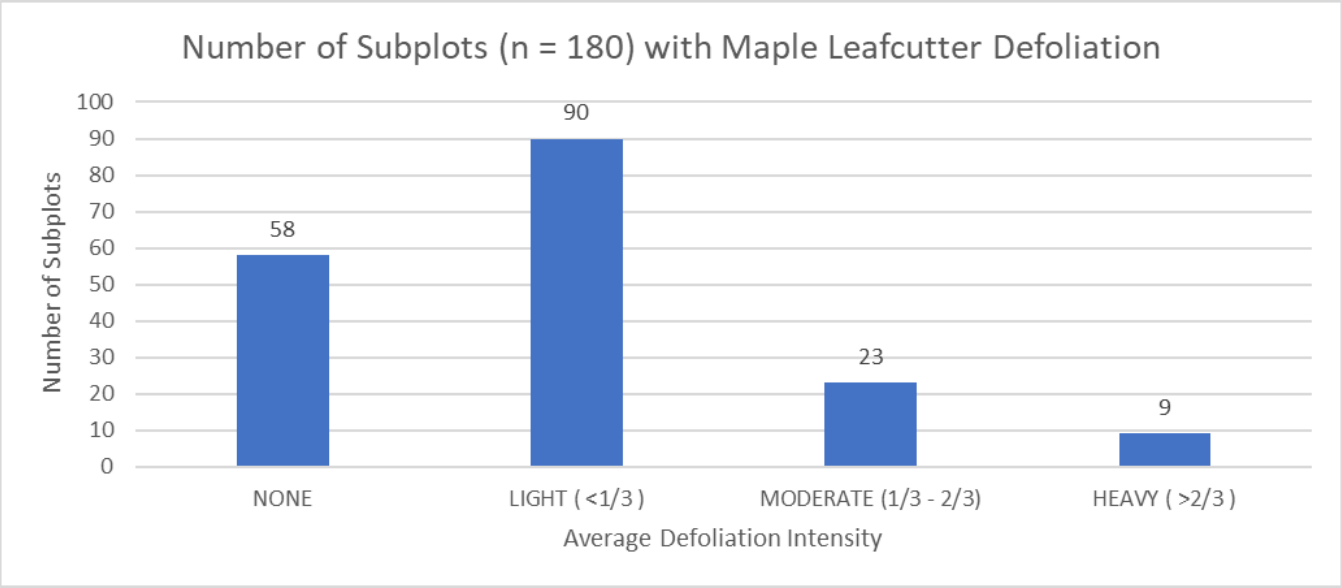


Figure 17. Results of late-season surveys of 180 NAMP subplots to evaluate maple leafcutter damage in 2018.

Saddled prominent, *Heterocampa guttivitta*, surveys continued in 2018 at seven locations. Average catch in 2018 was 2.3 moths per trap compared to 0.3 moths per trap at the same locations in 2017 (Table 8). In 2017, the US Forest Service deployed traps in 5 additional Vermont sites, but USFS monitoring was discontinued in 2018.

Table 8. Average number of saddled prominent moths caught in pheromone traps in 2017 and 2018. Data include location, town, county, coordinates and average number of moths per site.

Location	Town County	Lat	Long	Avg. # SP moths/trap 2017	Avg. # SP moths/trap 2018
Willoughby S.F.	Sutton Caledonia	44.71037	-72.03990	0	0
VMC 1400-PMRC	Underhill Chittenden	44.52405	-72.86510	0	2.3
Reed (NAMP 8)	Sheldon Franklin	44.86471	-72.87340	0.7	4.7
Smith (NAMP 37)	Vershire Orange	43.96919	-72.34424	0.3	3.0
Ward	Vershire Orange	43.98590	-72.37471	0	4.0
Spring Lake Ranch (NAMP 16)	Shrewsbury Rutland	43.48305	-72.90990	0.7	1.3
Downer SF	Sharon Windsor	43.78901	-72.38104	0.7	0.7
Average				**0.3**	**2.3**

Winter Moth, *Operophtera brumata,* has not been found in Vermont. Local entomologist, JoAnne Russo, in cooperation with the University of Massachusetts, conducted a pheromone trap survey for winter moth in Vermont, November 18 through December 30, 2018. Ten traps, baited with PB-WM Winter Moth Lure, were hung from oaks and maples along Route 9 from Brattleboro to Bennington, and along Route 5 in Putney and Brattleboro (Table 8).

Operophtera were collected in 7 out of 10 traps. Most were caught in traps close to the Connecticut River and at other lower elevations where the November snows had melted. All 29 moths were *Operophtera bruceata*, the native Bruce spanworm.

Table 9. Location of the 10 traps deployed for winter moth, *Operophtera brumata*, in Vermont November 18— December 30, 2018. No winter moths were collected, but traps attracted 29 Bruce spanworm, *O. bruceata*.

ID #	Town	Location	Total Number of Bruce Spanworm Moths Trapped
trap1	Dummerston	Route 5	12
trap2	Brattleboro	Cotton Mill Hill/Route 142	7
trap3	Brattleboro	Hamilton Road/Route 9	6
trap4	Marlboro	Church Hollow Road/Route 9	1
trap5	Wilmington	Sun & Ski Road/Route 9	1
trap6	Wilmington	123 W. Main Street	1
trap7	Searsburg	Somerset Road/Route 9	0
trap8	Woodford	Pine Valley Road/Route 9	0
trap9	Woodford	Long Trail/Route 9	1
trap10	Rockingham	Between Hitchcock Rd/Minards Rd	0

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Alder leaf Beetle	*Altica ambiens*	Alder	Hyde Park	Heavy on roadsides.
America Dagger Moth	*Acronicta americana*	Hardwoods	Statewide	One of several tussock moth caterpillars commonly observed in 2018.
Beech Leaftier	*Psilocorsis* sp.	Beech	Statewide	Common, but continues to be less noticeable than 2016.
Birch-Aspen Leafroller	*Epinotia solandriana*	Quaking Aspen	Montpelier	Light population observed.
Birch Leaf Folder	*Ancylis discigerana*	Yellow Birch	Statewide	More noticeable in some sites in 2018 (e.g., Underhill State Park), but no significant defoliation observed.
Birch Skeletonizer	*Bucculatrix canadensisella*	Birch	Underhill	Light population reported.
Browntail Moth	*Euproctis chrysorrhoea*	Hardwoods		Not observed or known to occur in Vermont. Last serious infestation in Vermont was reported in 1917.
Bruce Spanworm	*Operophtera bruceata*	Sugar maple, aspen, beech and other hardwoods	Statewide	No feeding reported and few moths observed; 29 specimens were collected in traps deployed for winter moth. (See narrative on Winter Moth.)
Definite-marked Tussock	*Orgyia definita*	Blueberries	Lincoln	Observed stripping blueberry bushes of their foliage.
Cherry Scallop Shell Moth	*Hydria prunivorata*	Cherry	Brandon, Brighton and NAMP plot in Whitingham	Individual nests observed in widely scattered locations.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Dogwood Sawfly	*Macremphytus tarsatus*	Dogwood	Weathersfield, Windsor	Wilgus State Park had heavy defoliation on the clump of trees that was infested.
Eastern Tent Caterpillar	*Malacosoma americanum*	Cherry and apple	Statewide	Scattered observations along roadsides; no noteworthy damage.
Euonymus Caterpillar	*Yponomeuta cagnagella*	Euonymus	Hinesburg, Mendon, Randolph	Reported on ornamentals.
European Snout Beetle	*Phyllobius oblongus*	Sugar Maple	Bridgewater, Hartland	Light feeding.
Fall Webworm	*Hyphantria cunea*	Hardwoods	Statewide	Observed statewide, but unusually variable. In southern Vermont populations remained light. In some locations in northern Vermont, observations and phone calls were numerous, and some trees were completely defoliated. One observor described the situation as "the most seen in years".
Forest Tent Caterpillar	*Malacosoma disstria*			See narrative.
Gypsy Moth	*Lymantria dispar*			See narrative.
Hickory Tussock Moth	*Lophocampa caryae*	Hardwoods	Statewide	One of several tussock moth caterpillars observed in 2018. Though commonly seen, damage was negligible.
Japanese Beetle	*Popillia japonica*	Many	Statewide	Widely scattered, decribed as locally common, locally heavy in southern Vermont.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Locust Leafminer	*Odontata dorsalis*	Black Locust	Statewide	Scattered, with locally moderate damage along the interstate in locations in District 1.
Maple Leaf Cutter	*Paraclemensia acerifoliella*	Sugar Maple	Statewide	See narrative.
Maple Trumpet Skeletonizer	*Catastega aceriella*	Sugar maple	Statewide	Common, but negligible damage.
Mountain Ash Sawfly	*Pristiphora geniculata*	Mountain Ash	Calais, Springfield	Feeding gregariously on ornamental trees.
Northern Walkingstick	*Diapheromera femorata*	At large	Springfield	Though known to occur in Vermont, people rarely get a chance to see these highly camouflaged insects.
Oak Skeletonizer	*Bucculatrix ainsliella*	Red Oak	Brookfield, Orange	Observed on ornamentals.
Red-headed Flea Beetle	*Systena frontalis*	Ornamentals	Colchester	Numerous on ornamentals.
Red-humped Oakworm	*Symmerista canicosta*	Oak	Springfield	Individual larvae.
Saddled Prominent	*Heterocampa guttivata*	Sugar maple		See narrative.
Satin Moth	*Leucoma salicis*	Poplar	Statewide	Heavy in a few isolated locations.
Spotted Tussock	*Lophocampa maculata*	Hardwoods		Like other tussock caterpillars, prevalent in 2018.
Trumpet Leaf-mining Moth	*Coptotriche* poss. *citrinipennella*	Red Oak	Orange	On ornamental, causing curled edges on leaf margins.

OTHER HARDWOOD DEFOLIATORS

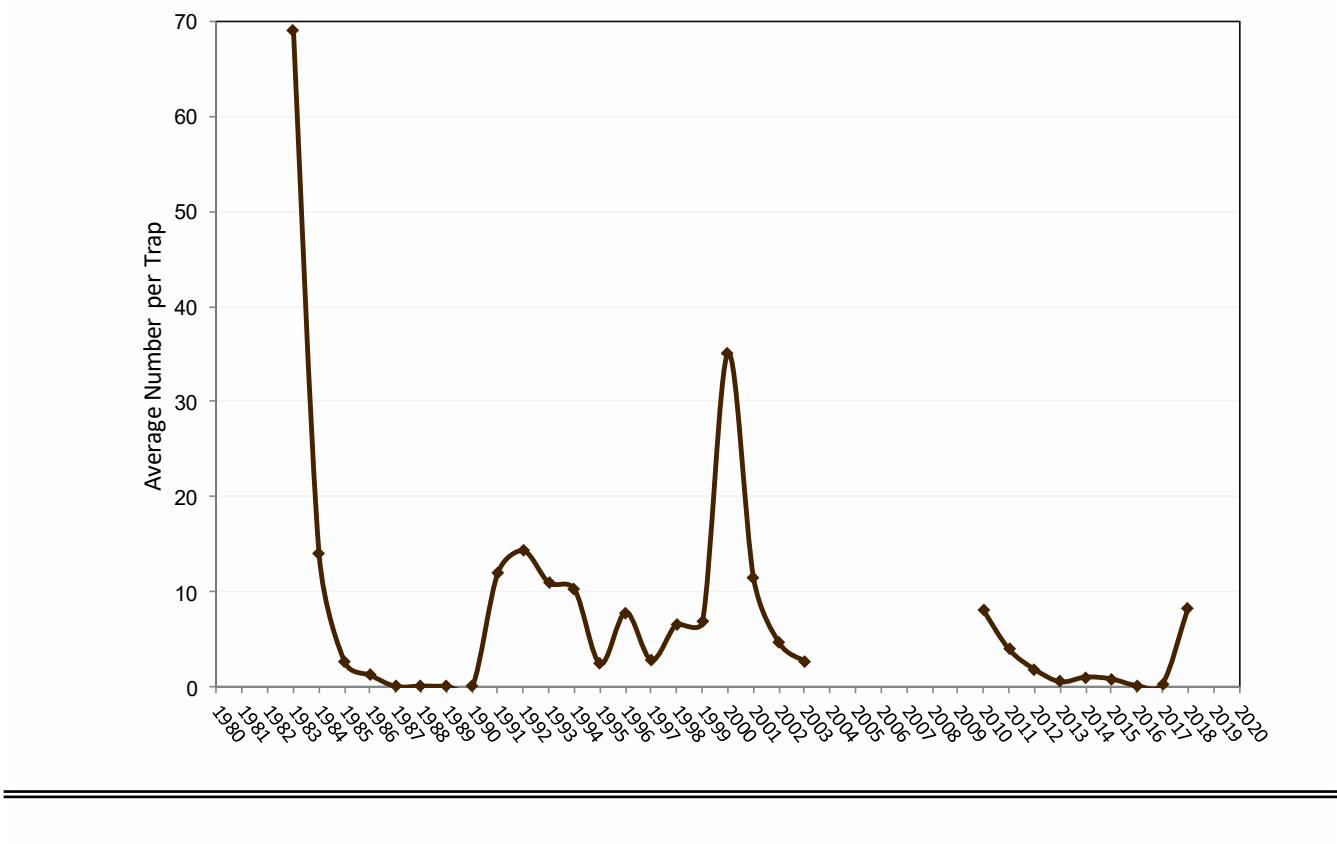
INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
White-marked Tussock Moth	*Orgyia leucostigma*	Various	Scattered	As above, one of the species of tussock moths that were commonly observed in 2018.
Winter Moth	*Operophtera brumata*	Hardwoods		Not known to occur in Vermont and not collected in pheromone trap survey. See narrative.
Yellow-necked Caterpillar	*Datana ministra*	Red Oak	Cambridge	On ornamentals.

Hardwood defoliators not reported in 2018 include Apple and Thorn Skeletonizer, *Choreutis pariana;* Elm Sawfly, *Cimbex americana* ; Green-striped Mapleworm, *Dryocampa rubicunda* ; Imported Willow Flea Beetle, *Plagiodera versicolora* ; Large Aspen Tortrix, *Choristoneura conflictana* ; Maple Webworm, *Pococera asperatella* ; Mimosa Webworm, *Homadaula anisocentra* ; Oak Shothole Leafminer, *Japanagromyza viridula* ; Oak Slug Sawfly, *Caliroa quercuscoccineae* ; Orange-humped Mapleworm, *Symmerista leucitys* ; Red-headed Flea Beetle, *Systena frontalis* ; Red-humped Caterpillar, *Schizura concinna* ; Rose Chafer, *Macrodactylus subspinosa* ; Spiny Oak Sawfly, *Periclista* sp.; Uglynest Caterpillar, *Archips cerasivorana*, Viburnum Leaf Beetle, *Pyrrhalta viburni.*

SOFTWOOD DEFOLIATORS

Spruce Budworm, *Choristoneura fumiferana*, moth trap catch averages in Vermont were the highest since 2010 when we resumed trapping after a hiatus between 2004 and 2009. Traps were deployed in Caledonia, Chittenden, Essex, and Orleans Counties in 2010-2018. The Underhill site averaged 26.3 moths per trap, which was considerably higher than moth numbers captured at other sites (Figures 18, Tables 10-11). We do not anticipate defoliation by the spruce budworm in 2019.

Figure 18. Average number of spruce budworm moths caught in pheromone traps 1983-2018. Trapping was discontinued, 2004-2009. Average of six locations in 2018. Average of six locations in 2018.



Trap #	Trap Location	Town	Latitude	Longitude
SBW-18	Steam Mill Brook WMA	Walden	44.48385	-72.25364
SBW-22	Willoughby S.F.	Sutton	44.69555	-72.03616
SBW-23	Tin Shack/Silvio Conte	Lewis	44.85915	-71.74222
SBW-24	Black Turn Brook S. F.	Norton	44.99521	-71.81300
SBW-25	Holland Pond WMA	Holland	44.97610	-71.93103
SBW-27	VMC 1400	Underhill	44.52570	-72.86477

Table 10. Locations of spruce budworm pheromone traps in 2018. A correction from previous years' reports is that that trap site in Willoughby State Forest is in the town of Sutton rather than Burke, as designated earlier.

Table 11. Average number of spruce budworm moths caught in pheromone traps, 1991-2018. Trapping had been discontinued 2004-2009. There were 3 traps per location, one location per town in 2018.

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
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
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
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
Essex Lewis	2.0	2.7	0.67	2	0	0.67	0	8	4.3	14	6.7	1.3	1.7	5.7	0.3	0	0	0	0.0	0	0	2.6
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
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
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

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Eastern Spruce Budworm	*Choristoneura fumiferana*	Balsam fir and spruce	Statewide	See narrative.
Fall Hemlock Looper	*Lambdina fiscellaria*	Hemlock	Scattered	Few moths observed this fall.
Rusty Tussock Moth	*Orygia antigua*	Conifers	Scattered	Occasional observations of larvae.
Yellow-headed Spruce Sawfly	*Pikonema alaskensis*	Blue Spruce	Grand Isle	Single infested tree also had Rhizosphaera.

Softwood defoliators not reported in 2018 included Arborvitae Leafminer, *Argyresthia thuiella* ; Balsam Fir Sawfly, *Neodiprion abietus* ; European Pine Sawfly, *Neodiprion sertifer;* Larch Casebearer, *Coleophora laricella;* Introduced Pine Sawfly, *Diprion similis;* Spruce Needleminer, *Taniva albolineana* ; White Pine Sawfly, *Neodiprion pinetum.*

SAPSUCKING INSECTS, MIDGES, AND MITES

Balsam Woolly Adelgid (BWA), *Adelges piceae***,** infestations have dwindled, with only light populations observed in scattered locations. The aftermath of BWA infestations includes declining trees with some pockets of heavy mortality. Reports from various locations in Elmore and Worcester described individual trees dying and turning brown from top to bottom.

During 2018 aerial surveys, 3,434 acres of fir dieback and mortality attributed to BWA were mapped as compared to 1,641 in 2017 and 5,615 in 2016 (Table 12 and Figure 19).

For more information, a leaflet entitled "Balsam Woolly Adelgid" can be found on the Vermont Forest Health website.

Table 12. Mapped acres of balsam woolly adelgid-related decline in 2018.

County	Acres mapped		
	2016	2017	2018
ADDISON	107	0	0
BENNINGTON	69	0	0
CALEDONIA	1,096	412	807
CHITTENDEN	51	0	0
ESSEX	736	20	1,082
FRANKLIN	59	0	5
GRAND ISLE	0	0	
LAMOILLE	683	13	188
ORANGE	1,101	320	322
ORLEANS	518	399	316
RUTLAND	240	122	88
WASHINGTON	895	279	561
WINDHAM	57	4	9
WINDSOR	4	72	56
Total	5,616	1,641	3,434

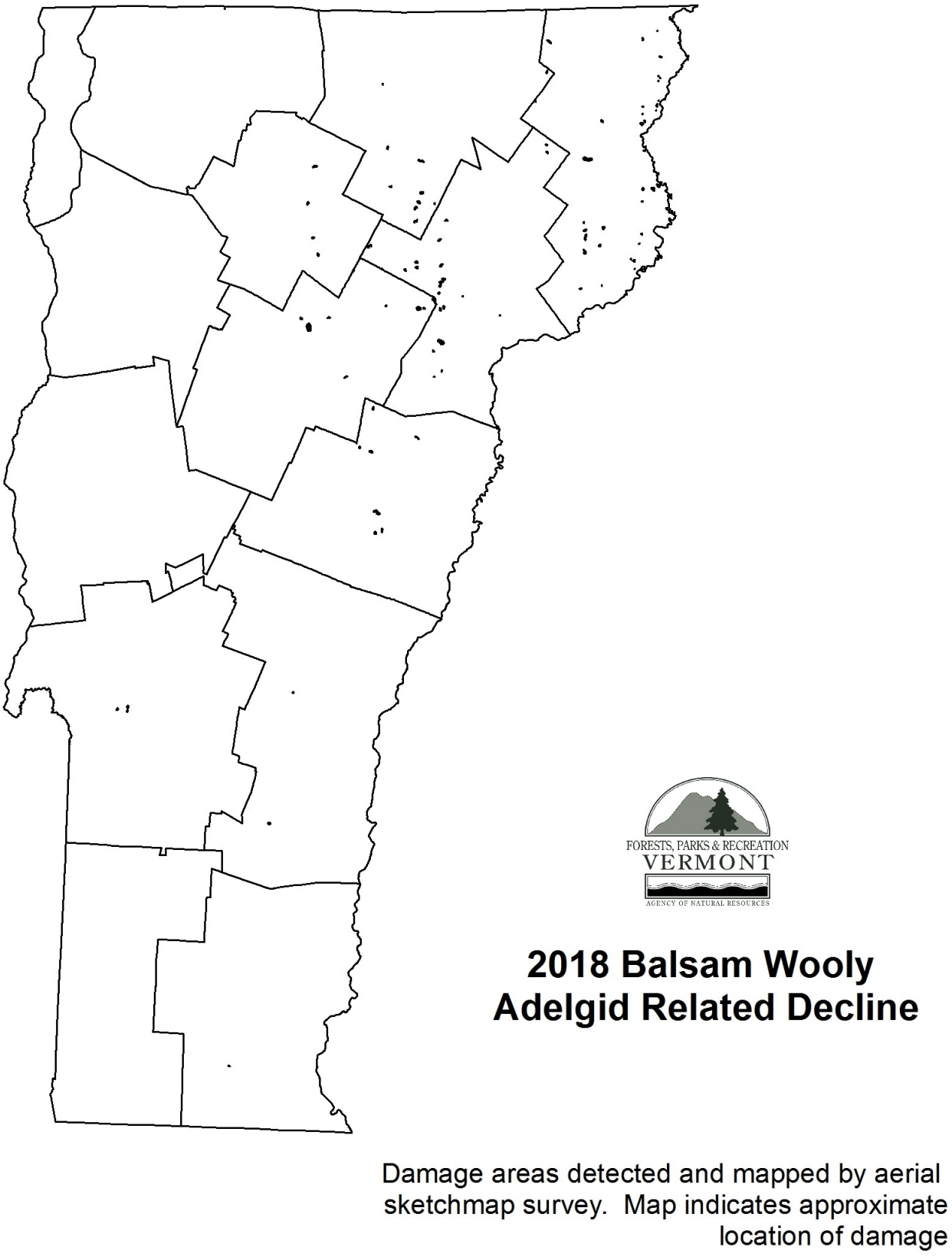


Figure 19. Balsam wooly adelgid related decline mapped in 2018. Mapped area includes 3,434 acres.

Elongate Hemlock Scale (EHS), *Fiorinia externa*, has become more noticeable in Windham County. It was first detected in the towns of Brattleboro and Guilford in 2014. EHS has also occasionally been found on nursery-grown trees over the past 20 years. In 2018, an infested balsam fir planting was reported in Charlotte. No additional EHS suspects were found when wild hemlocks nearby were inspected. Fir and spruce are at least as susceptible to EHS as hemlock hosts.

EHS can develop and reproduce on 43 species, including various fir species. In fact, despite the name, fir and spruce tend to be more susceptible than hemlock. EHS also has a reputation of teaming up with hemlock woolly adelgid to cause more severe damage to hemlocks.

EHS has had a spotty history in Vermont. Our first records date back to August 1999, when now-retired county forester Bill Guenther found suspect EHS on balsam fir in Westminster. Jon Turmel, former state entomologist with the Agency of Agriculture, confirmed the identification. The following year, EHS was found on hemlock at box store nurseries in Rutland and Williston. Trees from those sites were destroyed, but there was no way to track any infested trees that might have been sold prior to the discovery of the scale.

Fast forward to 2013, when an astute groundskeeper found vigorous populations of EHS on several conifers on properties in Charlotte and Bristol. An eradication plan was quickly developed. In 2014, elongate hemlock scale was found by an arborist at two sites in Brattleboro, and species confirmation was made by the UMass plant diagnostic lab. Follow-up surveys by FPR staff confirmed that EHS was established in southeastern Windham County.

This year, when a second EHS infestation popped up in Charlotte on balsam fir in an ornamental planting, a delineation survey of ¼ mile concentric circles was conducted. No additional EHS suspects were found. However, a visit to the initial 2013 site in Charlotte, about 5 miles away, seemed prudent, and active EHS populations were found on a Korean fir and on an eastern hemlock. Management approaches are being discussed.

Hemlock Woolly Adelgid (HWA), *Adelges tsugae*, continues to threaten hemlock trees in southern Vermont. However, little spread of HWA was documented during the 2017-2018 overwintering surveys, even the previous winter had an HWA mortality rate of only 65%, which is below the threshold expected to restrict HWA expansion. Twenty sites were surveyed and two locations found positive for HWA in 2018 (Table 13). Both were in Windsor County in the town of Springfield, a county and town already known to be infested.

This year, the emphasis of the survey program was shifted to counties adjoining infested counties. Known infested counties were Windham, Windsor and Bennington. Target counties were Rutland and Orange. Windsor County is only known to be infested at its southernmost edge, leaving a large gap to Orange County, so sites in high risk areas in northern Windsor County were surveyed. Plant hardiness zones 5a and 5b are considered areas of risk. The shift to county by county surveying resulted in coarser "resolution" and may account for the fact that no expansion of the infestation was noted. Twelve volunteers contributed a total of 14 hours of work to the surveys.

The average winter mortality for 2017-2018 was 94%, which is well above the threshold to restrict expansion of the infestation (Table 14, Figure 20).

Table 13. Sites inspected for the presence of hemlock woolly adelgid (HWA) by visual survey, winter 2017-2018.

County	Town	Number of sites inspected	Positive for HWA
Windsor	Springfield	2	2
	Woodstock	1	
	Royalton	1	
	Hartland	2	
	W. Windsor	1	
Rutland	W. Rutland	1	
	Poultney	2	
	Wallingford	1	
	Fairhaven	1	
Orange	Thetford	3	
	Strafford	2	
Washington	Berlin	2	
Windham	Whitingham	1	
Total		20	2

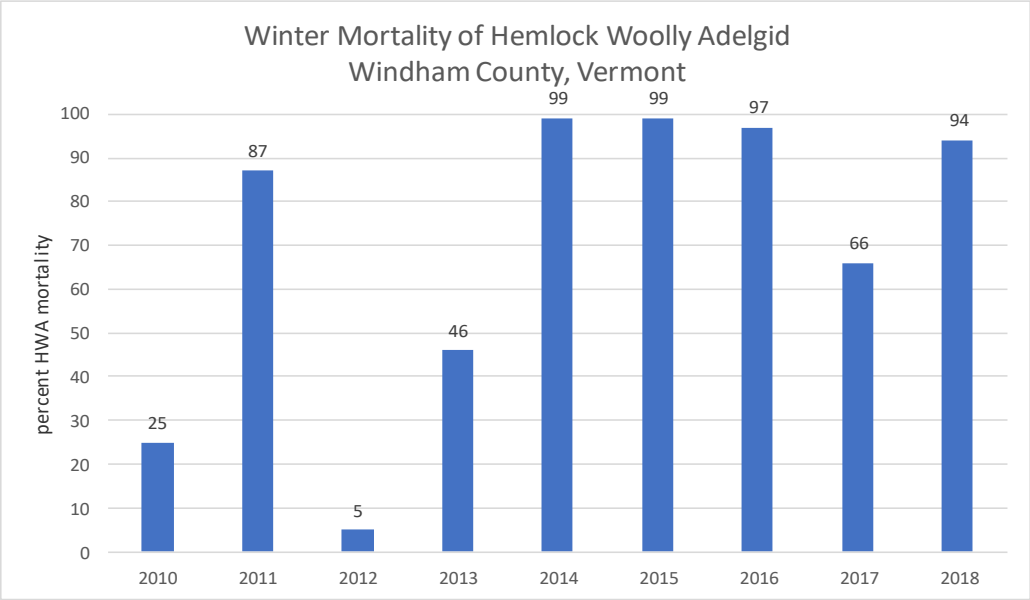


Figure 20. Average overwintering mortality of hemlock woolly adelgid at four sites in Windham County, 2010-2018.

Table 14. Assessment of hemlock woolly adelgid winter mortality over the 2017-2018 winter. Data from four assessment sites include location, date, HWA specimens collected, number of dead and live adelgids, and percent mortality.

Site	Date	Number of Live HWA	Number of Dead HWA	% Mortality
Vernon	4/9/2018	0	424	100
Townshend	4/9/2018	23	475	95
Brattleboro	4/9/2018	2	518	99
Jamaica	4/9/2018	73	331	82

Shade tree calls for sick hemlock trees often seemed to be primarily due to drought response. The compound effects of apparently increasing populations of elongate hemlock scale in Windham County are also of concern.

Monitoring of HWA impact plots is done every other year and staggered. This year, Atherton Meadows Wildlife Management Area and Townshend State Park were scheduled for monitoring. HWA has not yet been observed at Atherton Meadows, but Townshend SP is known to be infested. Diameters were re-measured, and crowns assessed for live crown ratio, crown density, crown transparency, and crown position. In general, the crowns at Townshend seemed to be smaller and thinner than in the previous monitoring.

The predatory beetle *Laricobius nigrinus* has been previously released as a biocontrol agent in sites in Vernon, Brattleboro and Pownal. All three sites were monitored for *Laricobius* in 2018. There were no beetles found.

A new predator, the western strain of a silver fly (*Leucopis* sp.), is being evaluated by researchers at the University of Vermont for use against hemlock woolly adelgid. FPR has assisted by finding field sites for experimental, bagged releases.

FPR continues to be involved with outreach in the form of articles, engaging school classes, and meeting with concerned groups of citizens.

Pear Thrips, *Taeniothrips inconsequens*, numbers in our long-term monitoring plot at the Proctor maple Research Center in Underhill are up compared to the last 3 years. Populations and damage generally remain light, though we had some reports of noticeable early season defoliation in northern Vermont.

Sticky trap counts totaled 455 in 2018. Pear thrips emergence began the week of April 11 and the highest numbers were present from April 27 through May 11. Emergence was complete by June 1 (Table 15 and Figure 21).

Table 15. Pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, VT in 2018. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.

Sample dates	Counts
4/4-4/11	0
4/11-4/20	3
4/20-4/27	25
4/27-5/3	121
5/3-5/11	131
5/11-5/18	82
5/18-5/25	71
5/25-6/1	22
6/1-6/11	0
Total	455

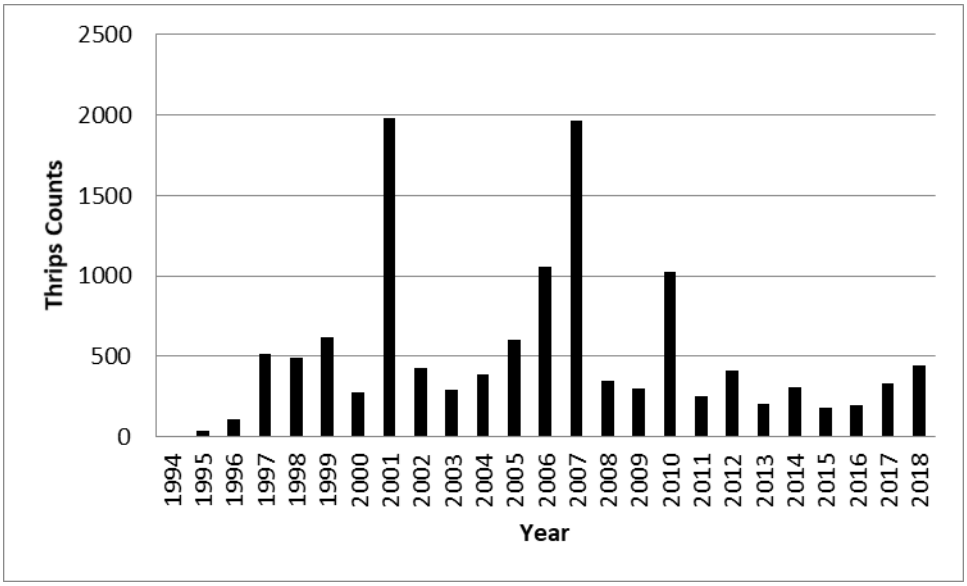


Figure 21. Total number of thrips collected at Proctor Maple Research Center in Underhill, VT on sets of four sticky traps, 1994-2018.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Balsam Twig Aphid	*Mindarus abietinus*	Balsam fir and Fraser fir	Brookfield, Williamstown	Observed on trees planted in yard to screen I- 89. Scattered damage to several trees.
Balsam Woolly Adelgid	*Adelges piceae*	Balsam fir and Fraser fir	Statewide	See narrative.
Beech Blight Aphid	*Grylloprociphilus imbricator*	Beech	Grafton, Killington	More interesting than worrisome.
Beech Scale	*Cryptococcus fagisuga*	Beech	Statewide	See Beech Bark Disease narrative.
Black Pineleaf Scale	*Dynaspidiotus californica*	Hemlock	Norwich	No damage reported.
Boxelder Bug	*Boisea trivittatus*	Boxelder	Scattered	Usual number of reports of "nuisance" bugs in and around homes; no damage to trees reported.
Brown Marmorated Stink Bug	*Halyomorpha halys*	Wide variety of hosts, including apples	Burlington, Plainfield, Waterbury	No damage observed. Records from past years include Bennington, Chittenden, Lamoille, Washington, Windham and Windsor Counties.
Eastern Spruce Gall Adelgid	*Adelges abietis*	Spruce	Scattered	Light populations.
Elongate Hemlock Scale	*Fiorinia externa*	Hemlock, Balsam fir	Windham County; Charlotte	See narrative.
Erineum Gall	*Aceria elongatus*	Ash	Brookfield, Orange	Minor damage to ash regeneration.
Hemlock Woolly Adelgid	*Adelges tsugae*	Hemlock	Windham, Bennington and Windsor Counties	See narrative.
Lacebugs	Family Tingidae	White Ash	Springfield	

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Oystershell Scale	*Lepidosaphes ulmi*	Apple	Hardwick, Washington	Wild apple trees looking unthrifty with leaf loss and general decline
Pear Thrips	*Taeniothrips inconsequens*	Hardwoods		See narrative.
Pine Bark Adelgid	*Pineus strobi*	White pine	Barnard	On ornamental.
Red Pine Scale	*Matsucoccus resinosae*	Red pine		Not observed in 2018. Also see Red Pine Decline.
Spider Mite	Family Tetranychidae	Hemlock and other conifers	Scattered statewide	Only negligible symptoms observed.
White-margined Burrowing Bug	*Sehirus cinctus*	*Lamium sp.*	Hardwick	Red and black immatures found in large aggregations.
Woolly Alder Aphid	*Paraprociphilus tessellatus*	Alder	Killington	Damage negligible.

Sapsucking Insects, Midges and Mites that were not reported in 2018 include Ash Flowergall Mite, *Aceria fraxiniflora* ; Balsam Gall Midge, *Paradiplosis tumifex* ; Cinara Aphids, *Cinara* sp.; Conifer Root Aphid, *Prociphilus americanus* ; Gouty Vein Midge, *Dasineura communis* ; Grape Phylloxera, *Daktulosphaira vitifoliae;* Green Stink Bug, *Chinavia hilaris;* Magnolia Scale, *Neolecanium cornuparvum* ; Pine Leaf Adelgid; *Pineus pinifoliae;* Pine Needle Scale, *Chionapsis pinifoliae* ; Pine Spittlebug, *Aphrophora parallela* ; Woolly Elm Aphid, *Eriosoma americanum.*

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, but pine is free to move through most of the northeast.
European Fire Ant	*Myrmica rubra*	Nursery setting	Elmore	These ants are omnivorous and eat both plant and decaying animal matter. They are included here as they may be encounted as they forage on both herbaceous plants and shrubs and trees.
European Hornet	*Vespa crabo*	Nest on porch	Springfield	Predatory on other insects, which are used to feed young. Also girdle twigs to drink sap. Attracted to light at night.
Oak Twig Pruner	*Anelaphus parallelus*	Red oak	Brookfield, Burlington	Ground under ornamentals littered with pruned twigs.
Pine Gall Weevil	*Podapion gallicola*	Red pine	Groton, Norwich	In areas of red pine shoot dieback.
White Pine Weevil	*Pissodes strobi*	White pine and Colorado blue spruce	Statewide	Scattered disfigurement common in some areas; shoot mortality in July continues at low levels.

Bud and Shoot Insects not reported in 2018 included Balsam Shootboring Sawfly, *Pleroneura brunneicornis.*

ROOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Japanese Beetle	*Popillia japonica*	Many	Scattered throughout	Heavy in scattered locations, but generally fewer reports than in the recent past.
June Beetle	*Phyllophaga* spp.	Many	Scattered	Few reports were received in 2018.

Root Insects not reported in 2018 included Broadnecked Root Borer, *Prionus laticollis* ; Conifer Root Aphid, *Prociphilus americanus* ; Conifer Swift Moth, *Korsheltellus gracillis* .

BARK AND WOOD INSECTS

Emerald Ash Borer (EAB), *Agrilus planipennis*, was discovered in Vermont in 2018. In late February, trees in the town of Orange, suspected of being infested, were observed by a consulting forester and reported through the vtinvasives.org Report It webpage. The identification was confirmed by the USDA Animal & Plant Health and Inspection Service (APHIS). The source of the infestation is unknown.

Vermont became the 32nd state known to be infested. In the northeast, the states of Rhode Island and Maine, and New Brunswick and Nova Scotia in Canada also had their first detections in 2018. In addition, EAB was found in two new counties in New Hampshire.

The Vermont detection initiated a multi-agency response by the Dept. of Forests, Parks and Recreation, the Agency of Agriculture, Food and Markets (AAFM), APHIS, the US Forest Service and UVM Extension, as outlined in the Vermont Forest Pest Advisory Committee's emerald ash borer action plan.

Because the first detection was close to the county line, site visits were conducted to locate infested trees in adjacent towns. In mid-March larval samples were collected in Plainfield (Washington County) and Groton (Caledonia County), and also confirmed to be EAB by USDA taxonomists.

Between March 20th and April 5th, a delineation survey was conducted to determine if the new detections represented part of a wider infestation already established in other towns. This was a visual survey, covering all towns adjacent to towns where EAB was detected and confirmed. A road-based survey, by a three-person crew, was conducted in each town. One-square-mile grids over the town were prioritized for survey based on accessibility, forest cover, and EAB risk. When ash trees were seen from the vehicle, the crew inspected them for symptoms. To ensure coverage of the town, no more than 30 minutes were spent in any one block. Each town was surveyed until all priority blocks were visited, but no longer than one day. Insect specialists made follow-up visits to suspect trees, peeling them if necessary, to determine whether EAB was present. Because of the constraints of visual observations, this survey was limited to detecting infestations that were several years old.

In all, twelve towns were surveyed, with ash trees examined at 376 locations, and follow-up visits at 35 locations. EAB was found in one additional town (Barre) (Figure 23).

On May 22nd, as a result of an incidental observation, EAB-infested trees were next detected on planted green ash trees Montpelier. EAB specimens collected at that time were all in the pre-pupal stage.

The USDA had 609 purple traps deployed throughout Vermont in 2018, which resulted in several additional EAB detections (Figure 24.) On July 19th, a beetle was collected during a mid-season trap check in Stamford (Bennington County). The location was within five miles of a known infestation in the town of North Adams, MA. In August, beetles were collected on traps from a second site in Stamford and a second site in Groton. All specimen IDs were confirmed by USDA.

In late September, an "off-duty" forester found and reported symptomatic ash trees in South Hero (Grand Isle County). Larvae were collected, and their identification was confirmed by USDA. EAB is likely to have travelled to the area via firewood. Also in late September, a call to the national EAB hotline resulted in confirmation of infested trees at a second site in Plainfield.

Between August and December, additional delineation surveys were done in the towns adjacent to South Hero, Stamford, and Montpelier using the same methods as the spring survey (Figure 25). In all, eight towns were surveyed, with ash trees examined at over 50 locations. No EAB infested trees were detected in this survey.

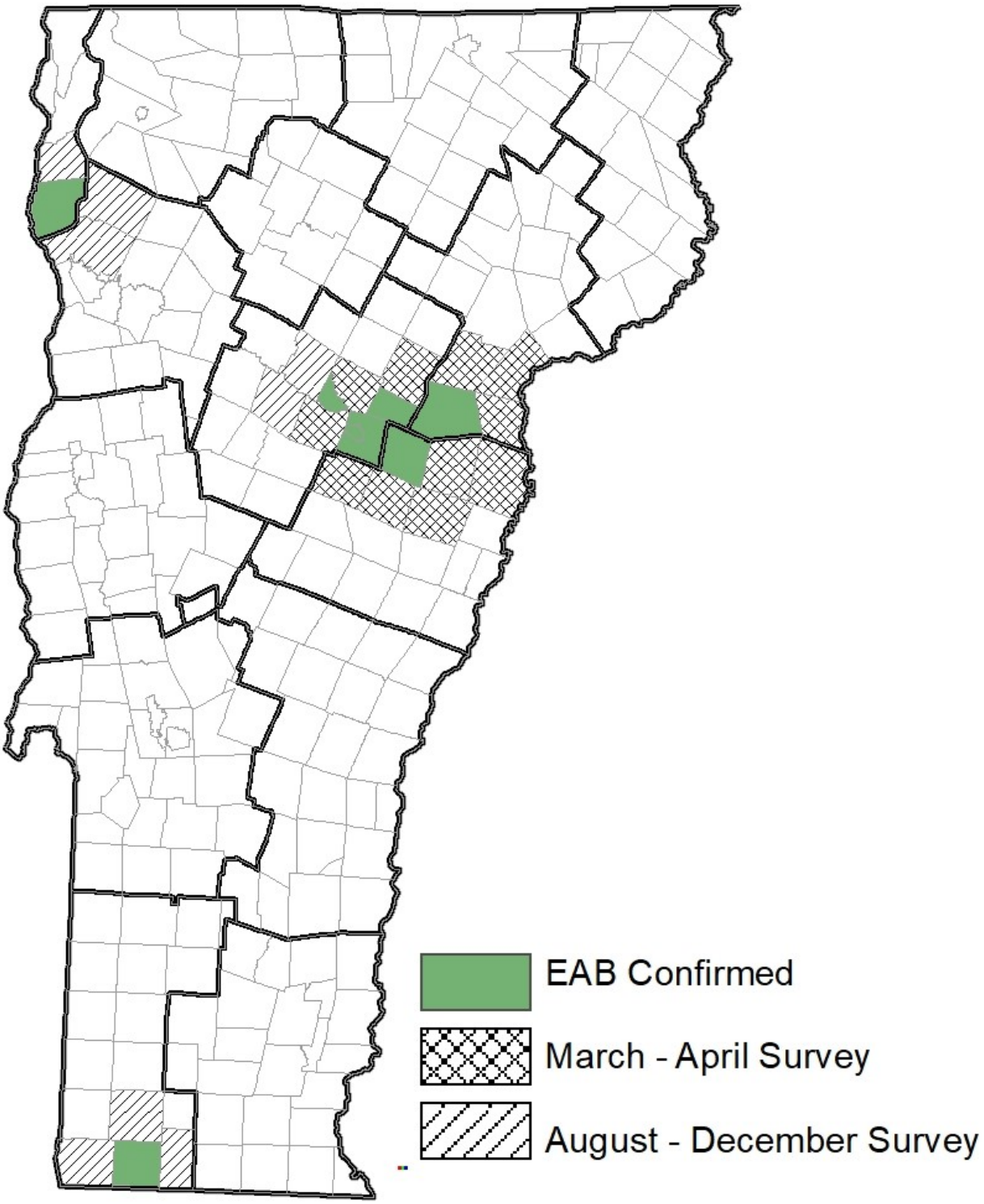


Figure 23. 2018 Delineation surveys for emerald ash borer. After the confirmation of EAB in Orange, Plainfield, and Groton, surveys were conducted in twelve adjacent towns, with ash trees examined at 376 locations. EAB was found in one additional town (Barre). Following detections in Montpelier, Stamford, and South Hero, additional delineation surveys were conducted. Between August and December, eight towns were surveyed, with ash trees examined at over 50 locations. No EAB infested trees were detected.

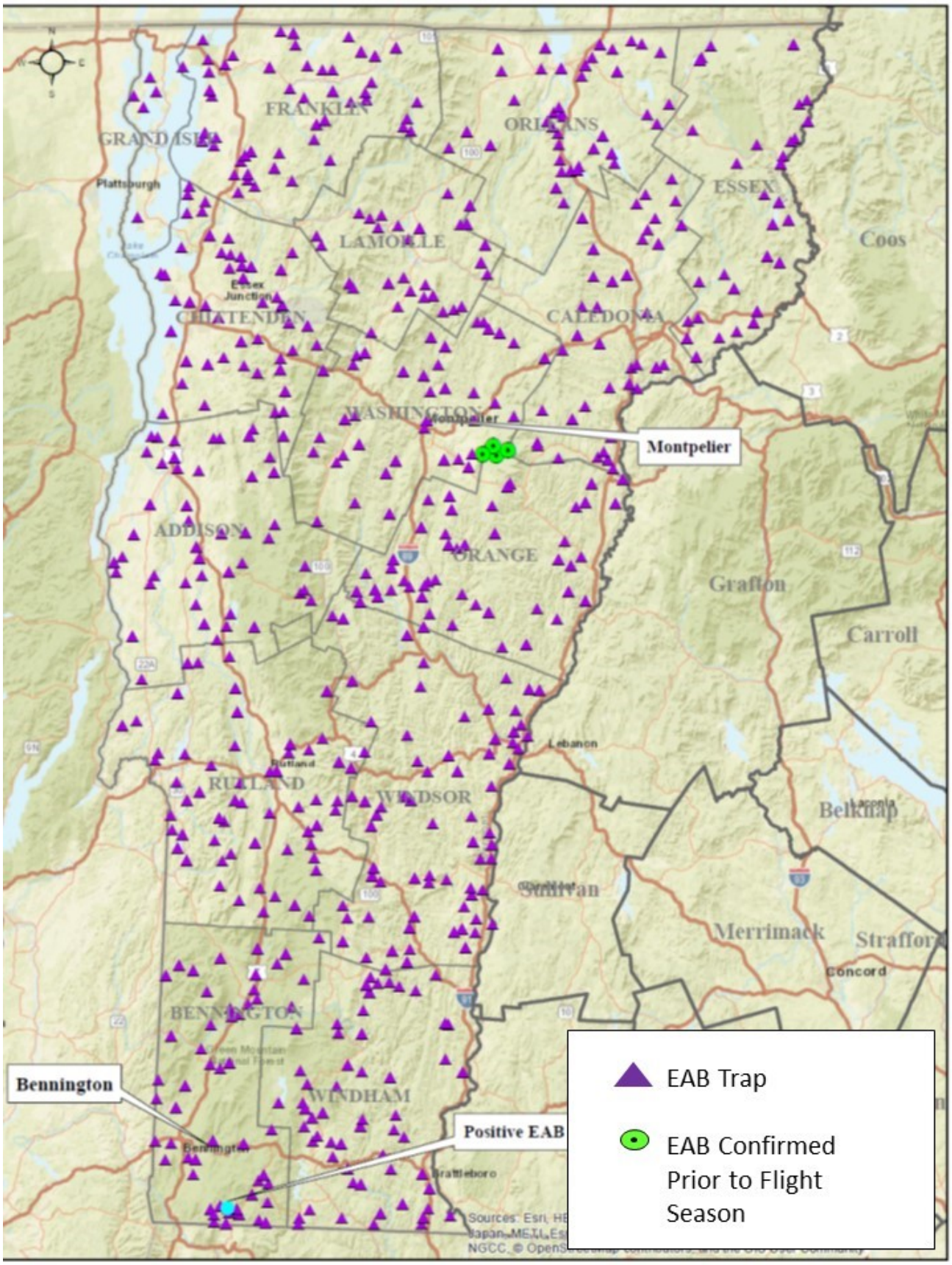
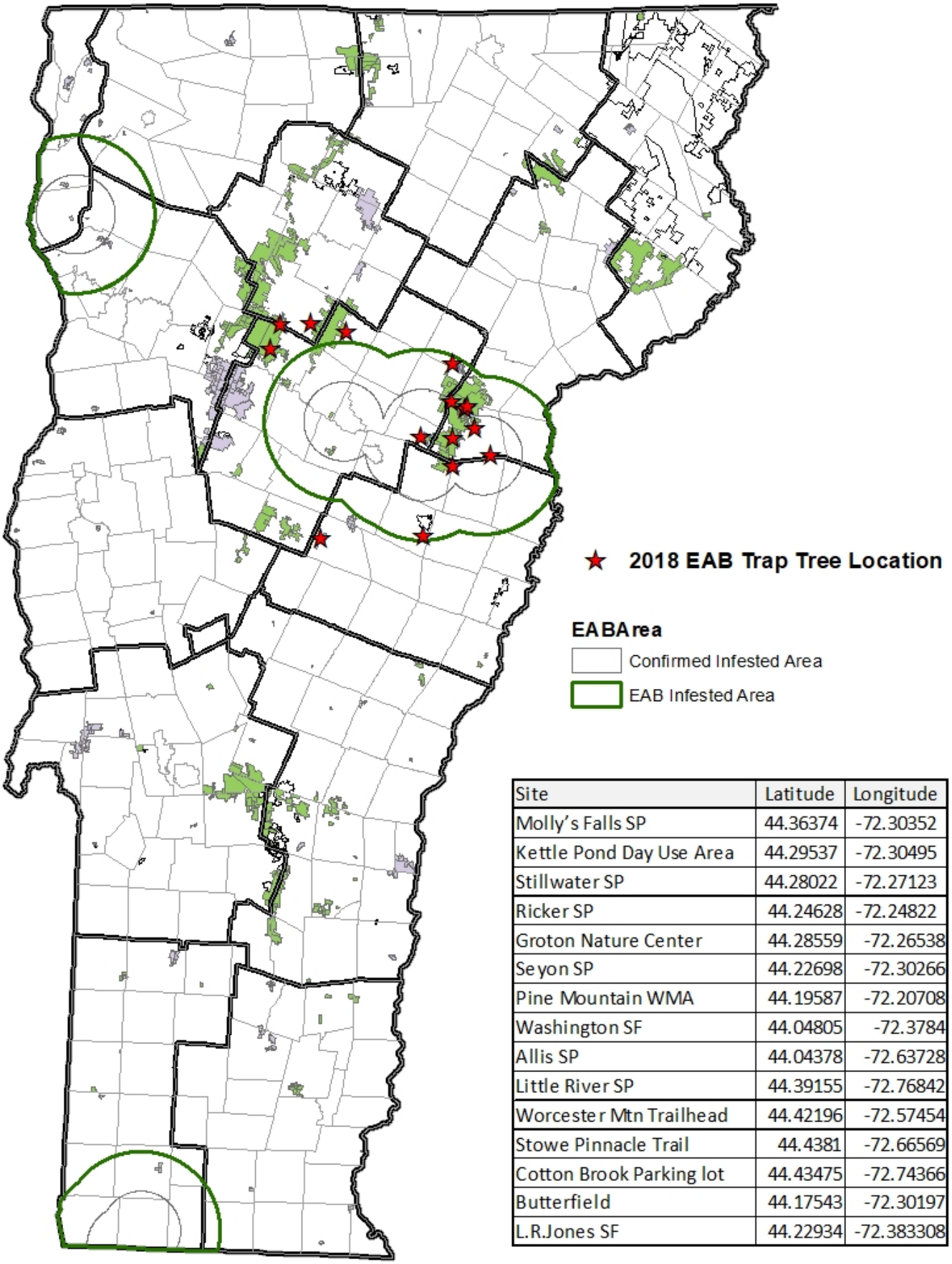


Figure 24. 2018 USDA grid points for purple pheromone traps for Emerald Ash Borer. 609 traps were deployed in Vermont. In July, a beetle was collected during a mid-season trap check in Stamford in Bennington County. In August, beetles were collected on traps from a second site in Stamford and a second site in Groton.



Site	Latitude	Longitude
Molly's Falls SP	44.36374	-72.30352
Kettle Pond Day Use Area	44.29537	-72.30495
Stillwater SP	44.28022	-72.27123
Ricker SP	44.24628	-72.24822
Groton Nature Center	44.28559	-72.26538
Seyon SP	44.22698	-72.30266
Pine Mountain WMA	44.19587	-72.20708
Washington SF	44.04805	-72.3784
Allis SP	44.04378	-72.63728
Little River SP	44.39155	-72.76842
Worcester Mtn Trailhead	44.42196	-72.57454
Stowe Pinnacle Trail	44.4381	-72.66569
Cotton Brook Parking lot	44.43475	-72.74366
Butterfield	44.17543	-72.30197
L.R.Jones SF	44.22934	-72.383308

Figure 25. Location of girdled trap trees on State Lands in Vermont in 2018. A single ash was girdled, and later peeled, at each location. No EAB were found.

Girdled trap tree surveys are the best technique currently used for early detection of EAB in an area. Trap trees were girdled at 14 locations on State Land near the central Vermont infested area between June 5th and June 15th (Figure 25). The purpose was to assist in making management decisions and to locate potential sites for biocontrol. The trees were felled and peeled in November, and no EAB were found.

Over the course of the year, 50 additional sites with suspect ash, located though reports from the public or through incidental observations, were inspected, with no EAB detected at these sites (Table 17 and Figure 26)

Table 17. Location of additional ash tree inspections in 2018 that resulted from reports from the public or through incidental observations.

County	Number of Ash Tree Inspections
Addison	2
Bennington	1
Caledonia	3
Chittenden	9
Franklin	3
Grand Isle	1
Orange	5
Orleans	4
Rutland	8
Washington	2
Windham	6
Windsor	6
Total	50

Maps indicating known EAB infested areas in Vermont have been made available at vtinvasives.org. These are regularly updated following new EAB detections. Because EAB is difficult to find when it first attacks a tree, the map includes the area within ten miles of any location where the insect has been observed within, or outside of, Vermont. The mapped Infested Area now includes 20 entire towns, and parts of 27 additional towns, in eight counties (Figure 27).

The EAB infested area includes both the Confirmed Infested Areas and the High Risk Areas. Confirmed infested Areas are defined as being within five miles of a known infestation point. It is likely that EAB is present in much of this area. 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 infested area location is also available on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/. The "EAB Infested Area" layer is under the Forests Parks and Recreation tab in the Atlas Layers. This mapping function allows viewing of the infested area in conjunction with other layers like parcels or roads. It is also available to download as a pdf document or as a shapefile, KML, or spreadsheet.

Due to the federal EAB quarantine, Vermont needed to choose whether to have a state quarantine covering the three known infested counties or to include the entire state within the federal quarantine boundary. Vermont determined that an intrastate quarantine would unnecessarily divert resources to areas that do not pose a risk, since the required quarantine boundaries would not align with the infestation in Vermont. EAB was only known to occur in parts of four towns, but the minimum size of an intrastate quarantine under USDA rules would be three counties. This would put over 20% of Vermont under quarantine. Within that large area, infested ash could move freely. The potential for multiple sat-

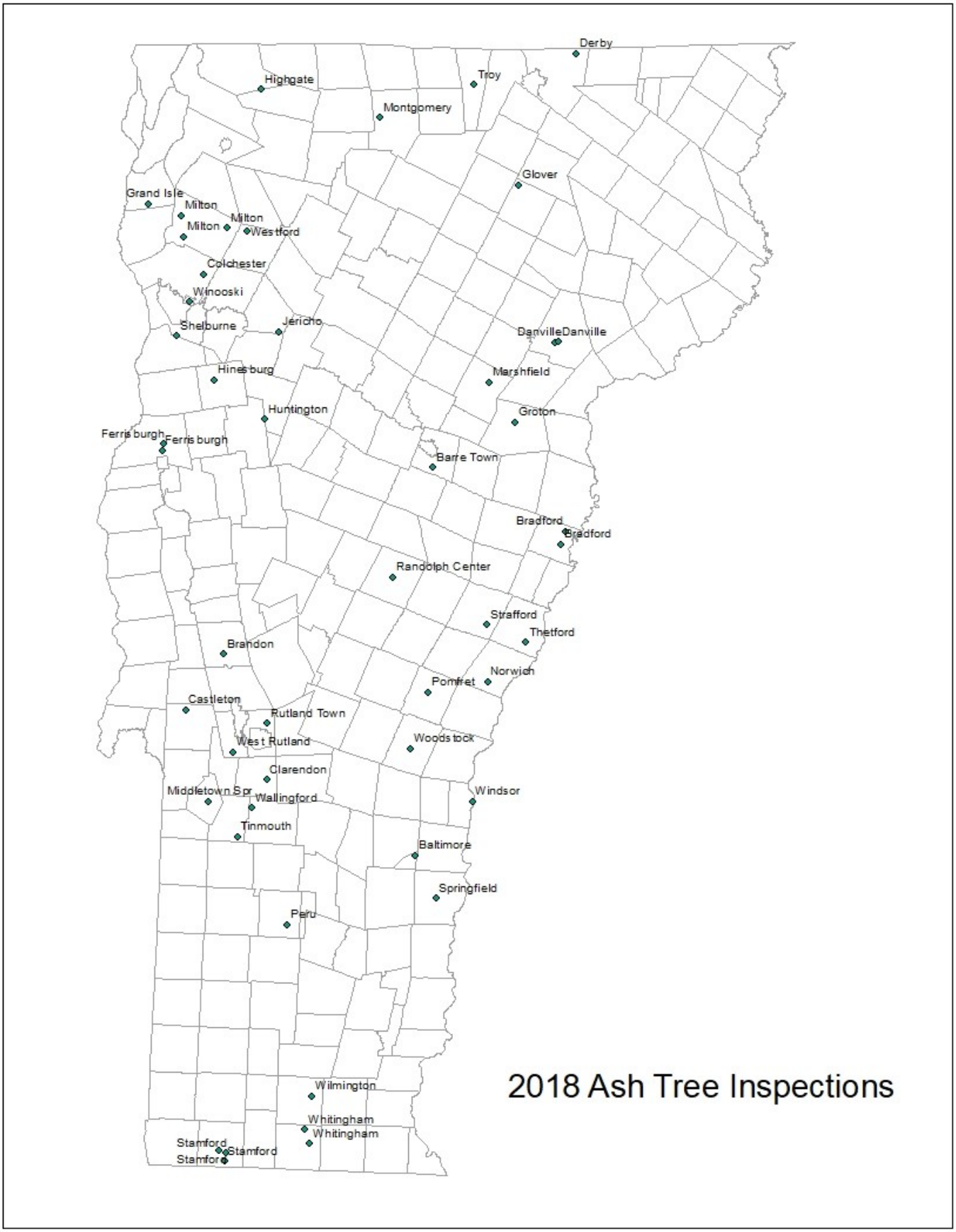


Figure 26. Locations where additional ash tree inspections were made in 2018 as a result of reports from the public or through incidental observations. (Also see Table 17.)

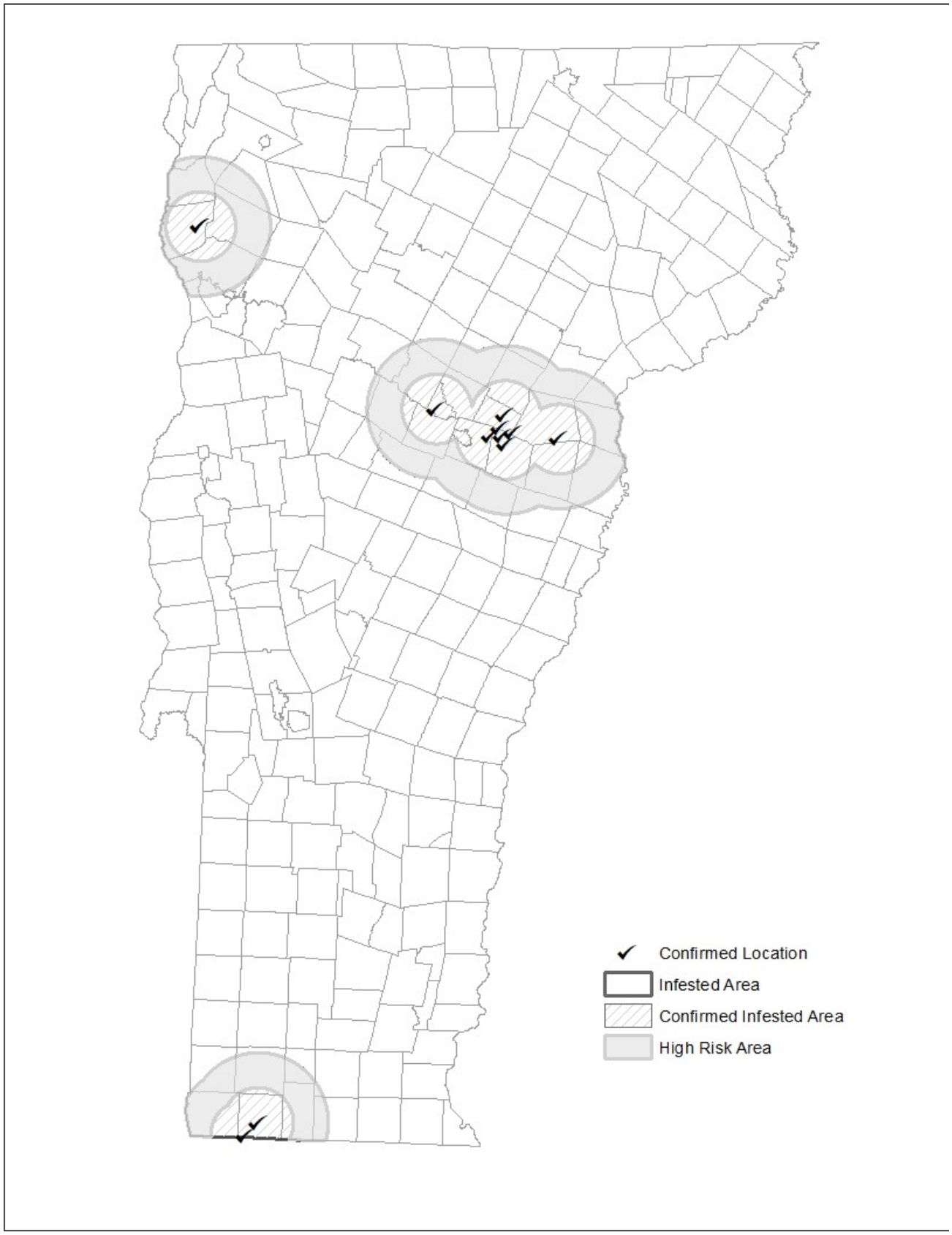


Figure 27. Map showing the emerald ash borer infested area in December, 2018. Known locations are indicated with a check mark. The "confirmed infested areas" are within five miles of known locations. High risk areas extend five miles from the outside of the confirmed infested areas; EAB is likely expanding into and present in some of this area. The mapped infested area now includes 20 entire towns, and parts of 27 additional towns, in eight counties.

ellite infestations within the counties would quickly increase the risk of accidental movement to other locations. By foregoing an intrastate quarantine, all of Vermont became part of the USDA quarantine.

Following the detection of EAB in Vermont, FPR focused resources on developing slow-the-spread recommendations for preventing unintended movement of EAB, and providing information about ash management. Slowing the spread of EAB to non-infested areas slows mortality and financial impacts, and provides time to implement management strategies and to develop better tools for protecting ash. 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
- Transporting Ash Wood Products into Vermont Safely and Legally

Homeowner and Municipal Tree Resources
- Homeowner's Guide to Emerald Ash Borer
- Emerald Ash Borer Management Worksheet for Vermont Municipalities
- Options for Protecting Ash Trees from Emerald Ash Borer with Insecticide Treatments
- Managing Emerald Ash Borer in Your Municipality: Frequently Asked Questions
- Rapid Roadside Ash Inventory Planning Worksheet

Forest Landowners
- Emerald Ash Borer: Information for Forest Landowners
- Use Value Appraisal Standards for Forest Management Related to Emerald Ash Borer Infestations

Outreach
- EAB PowerPoint and Presentation Notes

In other educational and outreach efforts, the **Vermont Forest Pest Outreach Project** (FPRP) successfully conducted targeted forest pest outreach in the state resulting in 851 people receiving direct education at workshops and presentations about the threats posed by specific invasive forest pests. Additionally, an estimated 190,023 people were exposed to forest pest educational material through outreach methods such as exhibits at high profile events, newsletters, and social media messaging.

Firewood Quarantine

The Rule Governing the Importation of Untreated Firewood into the State of Vermont has been in effect since May 2016. Currently, eighteen waivers are in effect allowing importation of untreated firewood from adjacent counties in New Hampshire, New York, and Massachusetts. Waivers for wood from counties known to have EAB do not allow the importation of untreated ash firewood. Letters describing the requirements of Vermont's firewood quarantine were sent to ten facilities in the region that are certified to treat firewood.

Outreach efforts continued in partnership with UVM Extension, along with Vermont Agency of Agriculture, Food, and Markets, Animal Health, Plant Inspection Service (AHIPS), and the national Don't Move Firewood. A whiteboard video PSA was developed for use by local media.

The **State Parks Firewood Exchange Project** continued for the 10th year. As in recent years, Vermont State Parks exchanged firewood with campers who brought firewood in from out of state. This year the total number of firewood bundles collected statewide was 31, which was a slight increase from last year (Table 18).

The State Parks that collected firewood this year included (with the number of bundles are in parentheses): Stillwater (3), Little River (4), Underhill (3), Grand Isle (1), Quechee (7), Molly Stark (6) and Smuggler's Notch (7). Firewood brought into Vermont State Parks this year came from New York, New Hampshire, Massachusetts, Connecticut, and Maine. Vermont has had a law prohibiting the importation of untreated firewood for two years. Many of the states where the firewood came from have similar laws. A few bags were purchased firewood in shrink wrap or netted bags. None of these were labeled as being treated.

Forest Protection staff opened and examined all the bags of firewood collected. No evidence of invasive pests were found.

Table 18. Numbers of bundles of firewood brought into Vermont State Parks during the 2009-2018 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

Sirex Woodwasp, *Sirex noctilio*, was trapped in Caledonia, Orleans, and Windsor Counties in 2018 as part of AAFM and USDA APHIS trapping effort for non-native forest insects. This insect has been trapped in twelve Vermont counties since 2007 (Table 19). No new observations of *Sirex*-infested trees were reported, with the only known location in Jericho.

Table 19. 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
Allegheny Mound Ant	*Formica exsectoides*	Conifers	Waterbury	Large nests observed as curiosity by inquirer.
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.
Bark Beetles	Subfamily Scolytinae	White Pine, Beech, Ash	Royalton, Elmore, Northfield	Bark beetle emergence holes and galleries observed.
Black and Red Horntail	*Urocerus cressoni*	Conifers	Addison	No damage observed.
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 Spruce Longhorned Beetle	*Tetropium fuscum*	Spruce, pine and fir		Not observed or known to occur in Vermont.
Carpenter Ant	*Camponotus* sp.	Wood products	Scattered	Usual number of homeowner inquiries.
Eastern Ash Bark Beetle	*Hylesinus aculeatus*	Ash	Scattered statewide	Observed on upper branches with ash trees showing significant dieback. Mulitple inquiries initiated by galleries from people concerned about emerald ash borer, and from beetles encountered in homes as they emerged from firewood and logs.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Eastern Carpenter Bee	*Xylocopa virginica*	Wood product	Weybridge	Nesting in wood framing of home.
Eastern Larch Bark Beetle	*Dendroctonus simplex*	Larch	Bristol	Declining trees.
Elderberry Borer	*Desmocerus palliatus*	Elderberry	Essex Junction	Showy adult observed.
Emerald Ash Borer	*Agrilus planipennis*	Ash		See narrative.
European Woodwasp	*Sirex noctilio*	Red and Scots pine		See narrative.
Hemlock Borer	*Phaenops fulvoguttata*	Hemlock and occasionally other conifers	Statewide	Observed where on hemlocks had been stressed by drought conditions.
Japanese Cedar Longhorned Beetle	*Callidiellum rufipenne*	Arborvitae, eastern redcedar, juniper and others		Not observed or known to occur in Vermont.
Locust Borer	*Megacyllene robiniae*	Black locust	St. Albans	Adult beetle. No damage observed.
Northeastern Sawyer	*Monochamus notatus*	Conifers	Scattered	Occasional reports during adult flight period.
Pigeon Tremex	*Tremex columba*	Sugar maple	Scattered throughout	Commonly observed in declining trees or turning up while splitting firewood.
Southern Pine Beetle	*Dendroctonus frontalis*	Pine		Not observed or known to occur in Vermont.
Sugar Maple Borer	*Glycobius speciosus*	Sugar maple	Scattered throughout	Stable populations; observed in sugarbushes and new maple planting.
Turpentine Beetles	*Dendroctonus* spp.	White pine	Scattered throughout	Observed in stands stressed by white pine needle diseases.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Whitespotted Sawyer	*Monochamus scutellatus*	White pine and other conifers	Throughout	Adults commonly observed.

Other Bark and Wood Insects not reported in 2018 included Brown Prionid, *Orthosoma brunneum* ; Carpenterworm, *Prionoxystus robiniae* ; Elm Bark Beetles, *Hylurgopinus rufipes* and *Scolytus multistriatus* ; Round-headed Apple Tree Borer, *Saperda candida;* Spruce Beetle, *Dendroctonus rufipennis;* Tanbark Borer, *Phymatodes testaceus.*

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Asiatic Garden Beetle	*Autoserica castanea*		Vershire	Devouring many plants, present in high numbers at this location.
Hermit Flower Beetle	*Osmoderma eremicola*	Rotten logs	Addison	Adults feed on sap and occasionally fruit, and are attracted to lights.
Western Conifer Seed Bug	*Leptoglossus occidentalis*	Conifers	Statewide	A common household invader. Damage to Vermont conifers has not been recorded.
Willow Pine Cone Gall Midge	*Rabdophaga strobiloides*	Willow	Canaan, Weybridge	Forms galls in the apical buds of growing tips on many species of willow.

Fruit, Nut and Flower Insects not reported in 2018 included Butternut Curculio, *Conotrachelus juglandis;* Fir Coneworm, *Dioryctria abietivorella;* Pine Coneworm, *Dioryctria reniculelloides;* Plum Curculio, *Conotrachelus nenuphar;* Rose Chafer, *Macrodactylus subspinosus.*

STEM DISEASES

Dieback from **Beech Bark Disease** was mapped on 5,443 acres, an increase from the 2,807 acres mapped in 2017 (Table 20 and Figure 28).

Bark symptoms remain common and crown symptoms are increasingly noticeable in mid-summer. This may be due to dry conditions that allowed greater beech scale crawler survival, more successful bark infection, and more tree vulnerability. Continued mapping of low acreage reflects, in part, the earlier mid-summer timing of the aerial survey in 2016–2018 compared to the late summer surveys in other recent years. The bright yellow crowns of symptomatic trees develop over the growing season, and are less noticeable in mid-summer than in late summer.

Table 20. Mapped acres of beech bark disease in 2018.

County	Acres
ADDISON	0
BENNINGTON	511
CALEDONIA	36
CHITTENDEN	0
ESSEX	1233
FRANKLIN	25
GRAND ISLE	0
LAMOILLE	132
ORANGE	178
ORLEANS	6
RUTLAND	1536
WASHINGTON	444
WINDHAM	701
WINDSOR	642
Total	5443

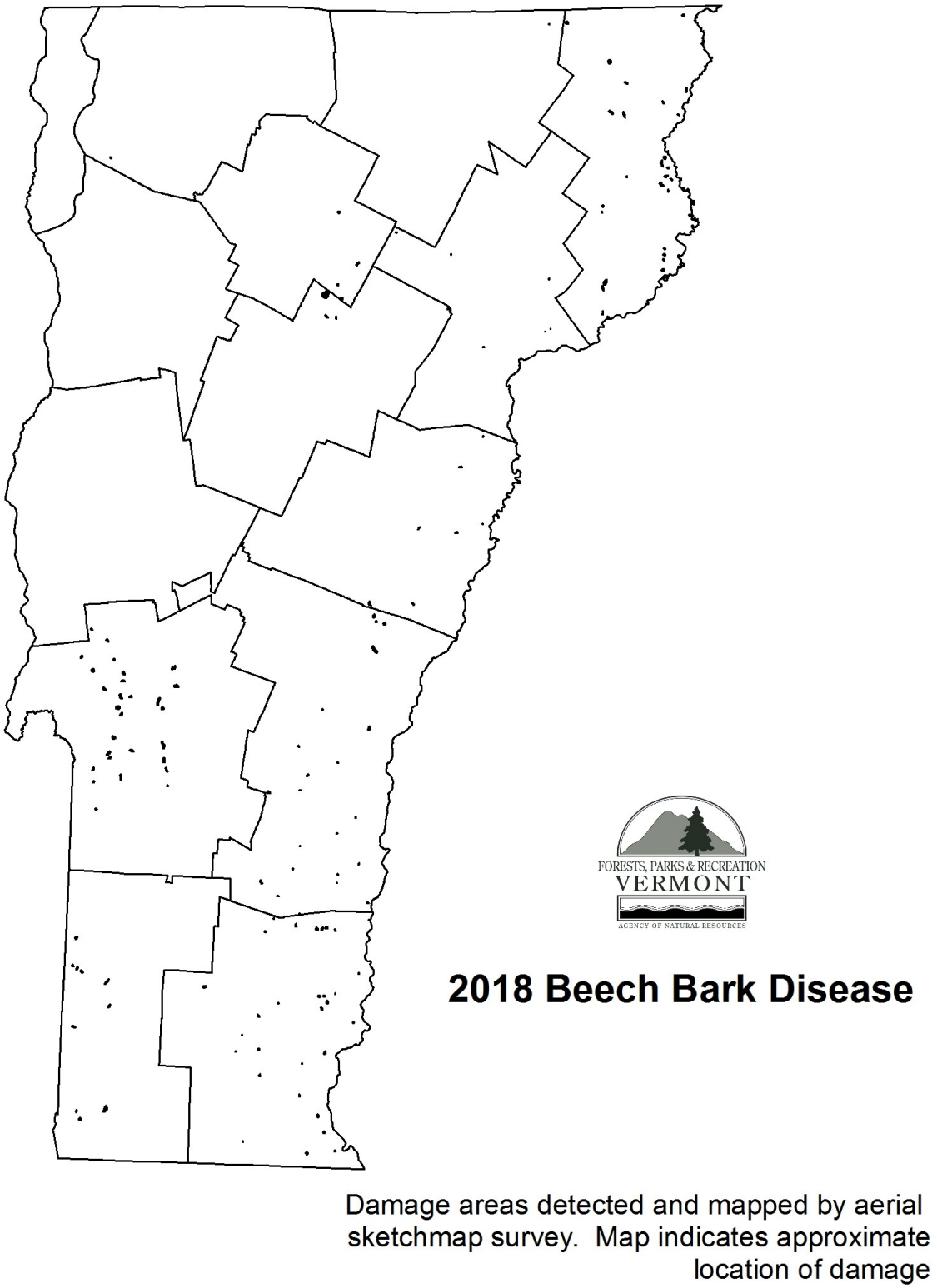


Figure 28. Beech bark disease related decline and mortality mapped in 2018. Mapped area includes 5,443 acres.

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. Most severe where cherry is near edge of range.
Butternut Canker	*Sirococcus clavigignenta-juglandacearum*		Widespread	Remains stable, with most butternuts showing signs of the disease.
Caliciopsis Canker	*Caliciopsis pinea*	White pine	Widely scattered	Associated with decline where trees are stressed by recurrent needle diseases. Noticeable damage on trees with thin crowns in a recently thinned stands in Ryegate.
Chestnut Blight	*Cryphonectria parasitica*	American chestnut	Southeastern Vermont	Observed on sprouts.
Decay Fungi	*Ganoderma lucidum, Polyporus squammosus* *Ganoderma tsugae*	Hardwoods Hemlocks	Widespread	Basidiophores of many species particularly noticeable in the spring.
Dutch Elm Disease	*Ophiostoma novo-ulmi*	Elm	Throughout	Flagging widely observed on young trees in June. Mortality similar to other years.
Hypoxylon Canker	*Hypoxylon pruinatum*	Poplar	Widely scattered	Damage levels low.
Nectria Canker	*Nectria galligena*	Hardwoods	Scattered throughout	
Oak Wilt	*Ceratocystis fagacearum*	Oaks		Not observed or known to occur in Vermont.
Phomopsis Twig Blight	*Phomposis spp.*	Maples	Williston	
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	Occasional cause of topkill or breakage of mature trees. 75 acres of scattered mortality 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 2018 included Cedar Apple Rust, *Gymnosporangium juniperi-virginianae* ; Cytospora Canker, *Leucostoma kunzei* ; Diplodia Shoot Blight, *Sphaeropsis sapinea* ; Eastern Dwarf Mistletoe, *Arceuthobium pusillum* ; Fireblight, *Erwinia amylovora* ; Sapstreak, *Ceratocystis coerulescens* ; Scleroderris Canker, *Ascocalyx abietina;* Verticillium Wilt, *Verticillium albo-atrum;* Woodgate Gall Rust, *Endocronartium harknessii*.

FOLIAGE DISEASES

Needle Diseases of White Pines – White pine needles were affected once again this year by a complex of fungal species including Brown Spot Needle Blight (*Lecanosticta acicola*), and two needlecast fungi (*Lophophacidium dooksii* and *Bifusella linearis*). During aerial surveys, 40,745 acres were mapped, which is an increase from the 16,413 acres mapped in 2017 (Table 21, Figure 29). 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 when viewed from the ground.

These diseases are most severe in the lower crown where fungi have been thriving due to multiple wet springs. The damage has been widespread since 2010, and the current epidemic has been building since at least 2005. 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 21. Mapped acres of white pine needle damage in 2018.

County	Acres
Addison	1,433
Bennington	1,282
Caledonia	848
Chittenden	1752
Essex	0
Franklin	654
Grand Isle	5
Lamoille	647
Orange	5,516
Orleans	393
Rutland	5,133
Washington	3,681
Windham	6,888
Windsor	12,511
Total	**40,745**

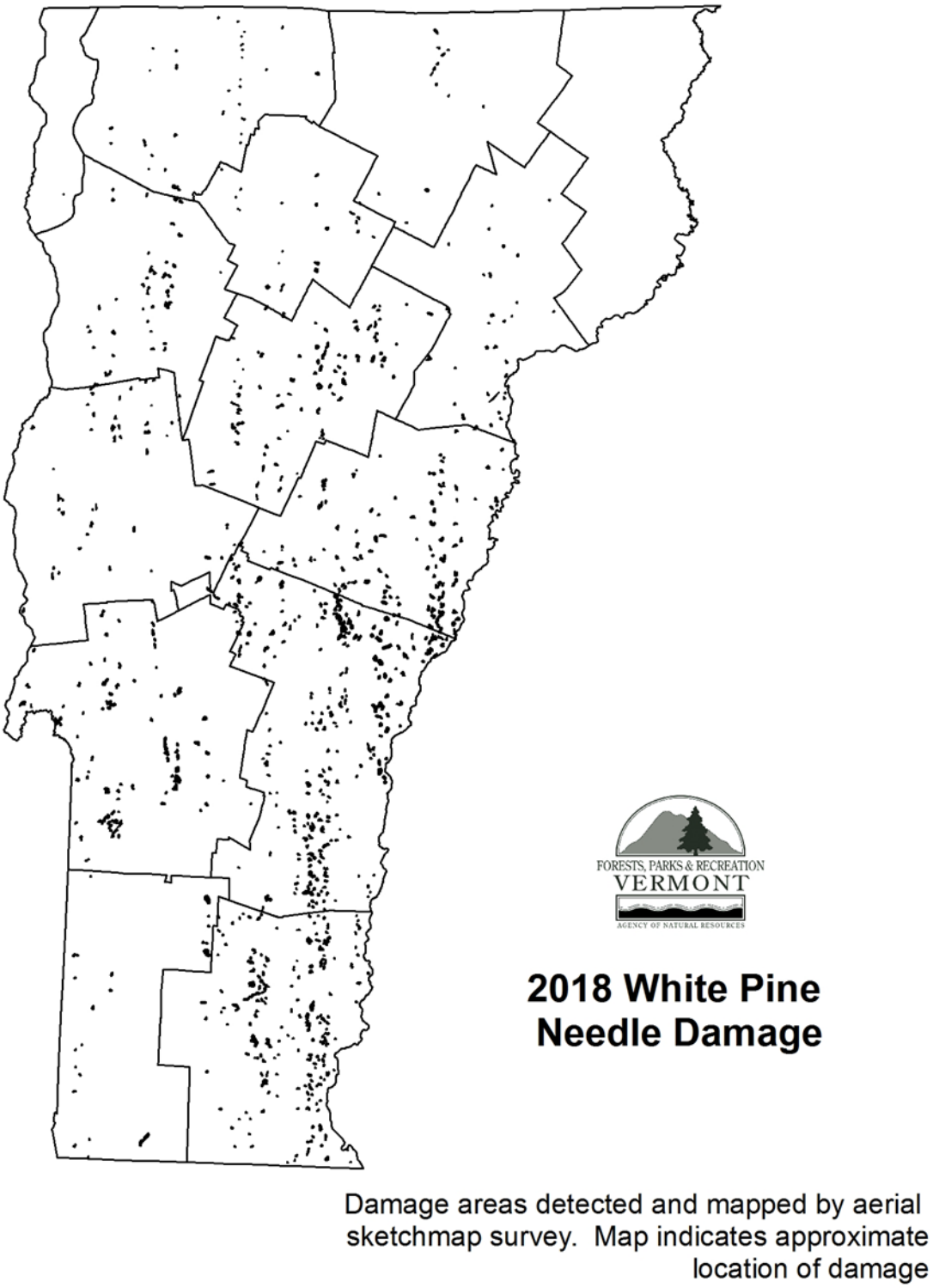


Figure 29. White pine needle damage mapped in 2018. Mapped area includes 40,745 acres.

The U.S. 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 30-32). These data 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. We, along with neighboring states and the USFS, are pursuing efforts to expand our sampling in future years.

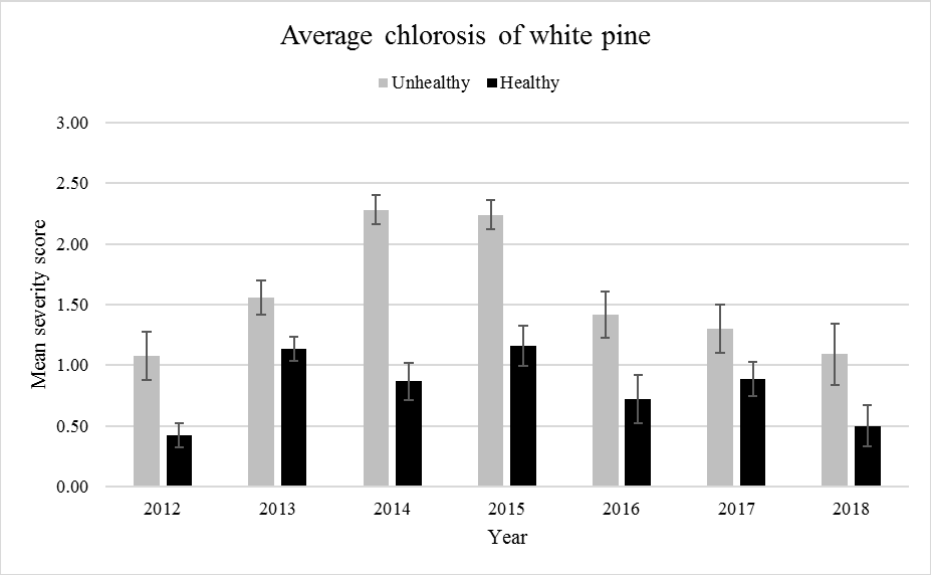


Figure 30. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed between 2012-2018 at four sites in Vermont. Trees were rated unhealthy or healthy in 2012. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

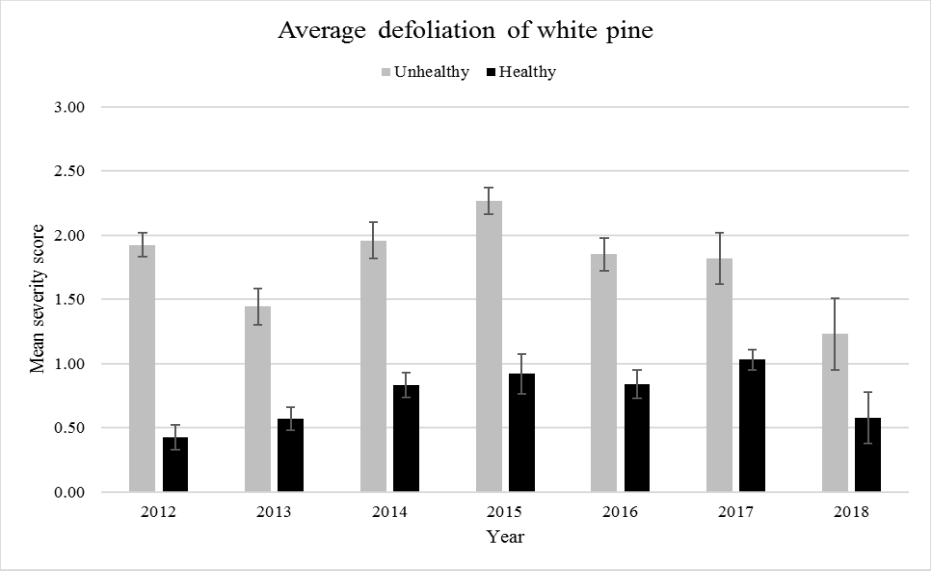


Figure 31. Defoliation severity of unhealthy and healthy white pines surveyed between 2012-2018 at four sites in Vermont. Trees were rated unhealthy or healthy in 2012. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

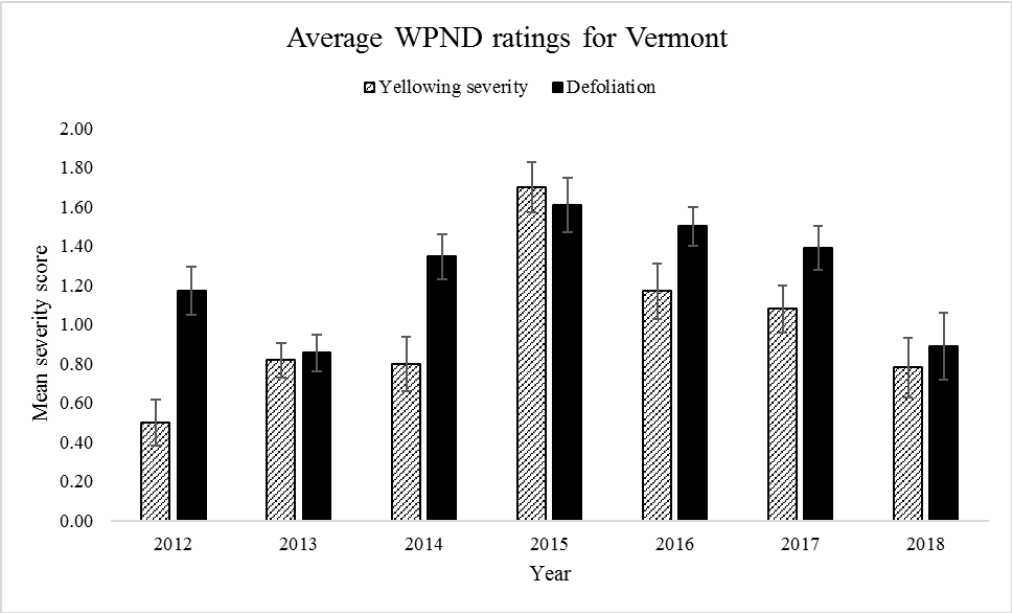


Figure 32. Average trends in yellowing severity and defoliation for all trees sampled at four sites in Vermont between 2012-2018. Data presented are mean severity scores (0 = no chlorosis/defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

Multi-state white pine health survey

This year marked the start of a multi-state project to evaluate site factors influencing white pine needle diseases. In Vermont, 20 sites were established to assess crown health, stand density, and determine which needle diseases are present. These sites were selected based on the presence or absence of white pine needle damage observed during aerial detection surveys. More information about the purpose of the study can be found at https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Forest_Health/Library/2018_VT%20FPR_White%20pine%20health%20monitoring%20leaflet.pdf

A total of 21 needle samples from the 20 sites were submitted for analysis by UMass-Extension. *Lecanosticta acicola* was the most frequently encountered fungal pathogen on white pine needles from Vermont (Figure 33). A newly described species, *Septorioides stobi*, was the second most abundant fungal species found. While *L. acicola* is widely known as a contributor to white pine needle damage, less is known about *S. strobi*. In 2019, data from all states will be compiled and analyzed to determine patterns of infection and tree health across the region.

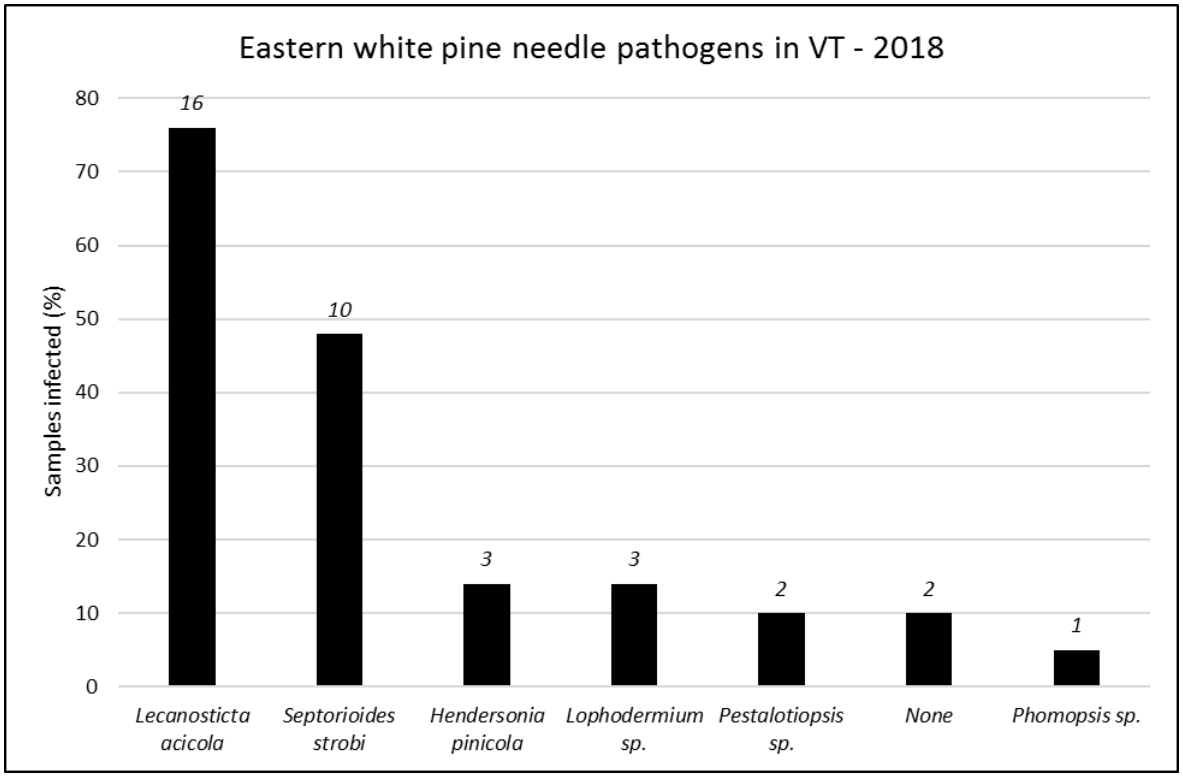


Figure 33. Fungal pathogens identified in eastern white pine foliage from 20 sites in Vermont in 2018 by UMass-Extension. Bars represent the percentage of all samples infected, while numbers on top of bars indicate the number of samples containing each pathogen.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Anthracnose	*Glomerella* spp.*;* *Apiognomonia* spp.	Maples, Oaks, Ash, Sycamore	Statewide	Uncommon. Decrease from significant levels in 2017.
Brown Spot Needle Blight	*Lecanosticta acicola*	Pines	Statewide	Thin crowns, some decline. Symptoms developed later in 2018 than in previous years. Heavy early needle drop. See Needle Diseases of White Pine.
Dothistroma Needle Blight	*Dothistroma pini*	Scots Pine	Swanton	Incidental observation
Fir-Fern Rust	*Uredinopsis mirabilis*	Balsam Fir	Groton	Incidental observation
Giant Tar Spot	*Phytisma acerinum*	Norway Maple	Statewide	Decrease from 2017 levels
Lirula Needlecast	*Lirula macrospora*	Balsam fir	Leicester	
Rhizosphaera Needlecast	*Rhizosphaera kalkhoffi*	Spruce	Statewide	Mortality of ornamental blue spruce continues due to heavy defoliation in the
Sirococcus Tip Blight	*Sirococcus tsugae*	Hemlock	Southeastern Vermont	Especially understory hemlock
Tubakia	*Tubakia dryina*	Pin oak	Morristown	

Foliage Diseases not reported in 2017 included Apple Scab, *Venturia inaequalis* ; Birch Leaf Fungus, *Septoria betulae* ; Cedar-Apple Rust, *Gymnosporangium juniperi-virginianae* ; Dogwood Anthracnose, *Discula destructiva* ; Phyllosticta leafspot, *Phyllosticta sp* .; Poplar Leaf Blight, *Marssonina spp.* ; Powdery Mildew, *Eryiphaceae;* Rhizosphaera Needle Blight, *Rhizosphaera pini;* Septoria Leafspot, *Septoria aceris.*

ROOT DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Armillaria Root Rot	*Armillaria spp.*	Many	Statewide	Sporophores common again in 2018. Drought and defoliation are expected to increase root infection levels.
Heterobasidion Root Disease (formerly Annosus Root Rot)	*Heterobasidion annosum*			Previously confirmed in 9 counties. No reports in 2018.

DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

Drought conditions affected forests in most of the state at some point during the growing season, with severe drought persisting in north central Vermont. During July aerial surveys, 2,107 acres of drought damage were mapped (Table 22, Figure 34). Since this was well before the peak of drought conditions, the actual acres of damage to hardwood foliage was significantly larger. Drought symptoms included browning on leaf edges of many hardwood species, including ash and maple, early leaf drop (including early casting of green sugar maple leaves), and interior needle discoloration and early needle cast of hemlock and fir. Drought conditions are thought to be the cause of higher-than-normal ash decline and mortality, and to have contributed to maple decline following forest tent caterpillar defoliation.

Following the drought of 2016, the late-season dry conditions in 2017, and the prolonged period of warm, dry weather in 2018, water availability will continue to be a major driver of tree health and will interfere with tree recovery from defoliation and other stressors.

Table 22. Mapped acres of drought symptoms in 2018**.** Because surveys were completed by the end of July, and drought symptoms were more visible late in the summer, the total area affected was actually larger.

County	Acres
ADDISON	467
BENNINGTON	64
CALEDONIA	4
CHITTENDEN	151
ESSEX	667
FRANKLIN	10
LAMOILLE	59
ORANGE	164
ORLEANS	56
RUTLAND	115
WASHINGTON	324
WINDSOR	25
Total	2107

Red Pine Decline and Mortality were mapped on 765 acres scattered in six counties, an increase from 516 acres in 2017 (Table 23, Figure 35). In some stands in Washington and Rutland Counties, mortality approaches 100%. 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 23. Mapped acres of red pine decline and mortality in 2018.

County	Acres
ADDISON	59
ORANGE	353
ORLEANS	33
RUTLAND	91
WASHINGTON	148
WINDSOR	81
Total	765

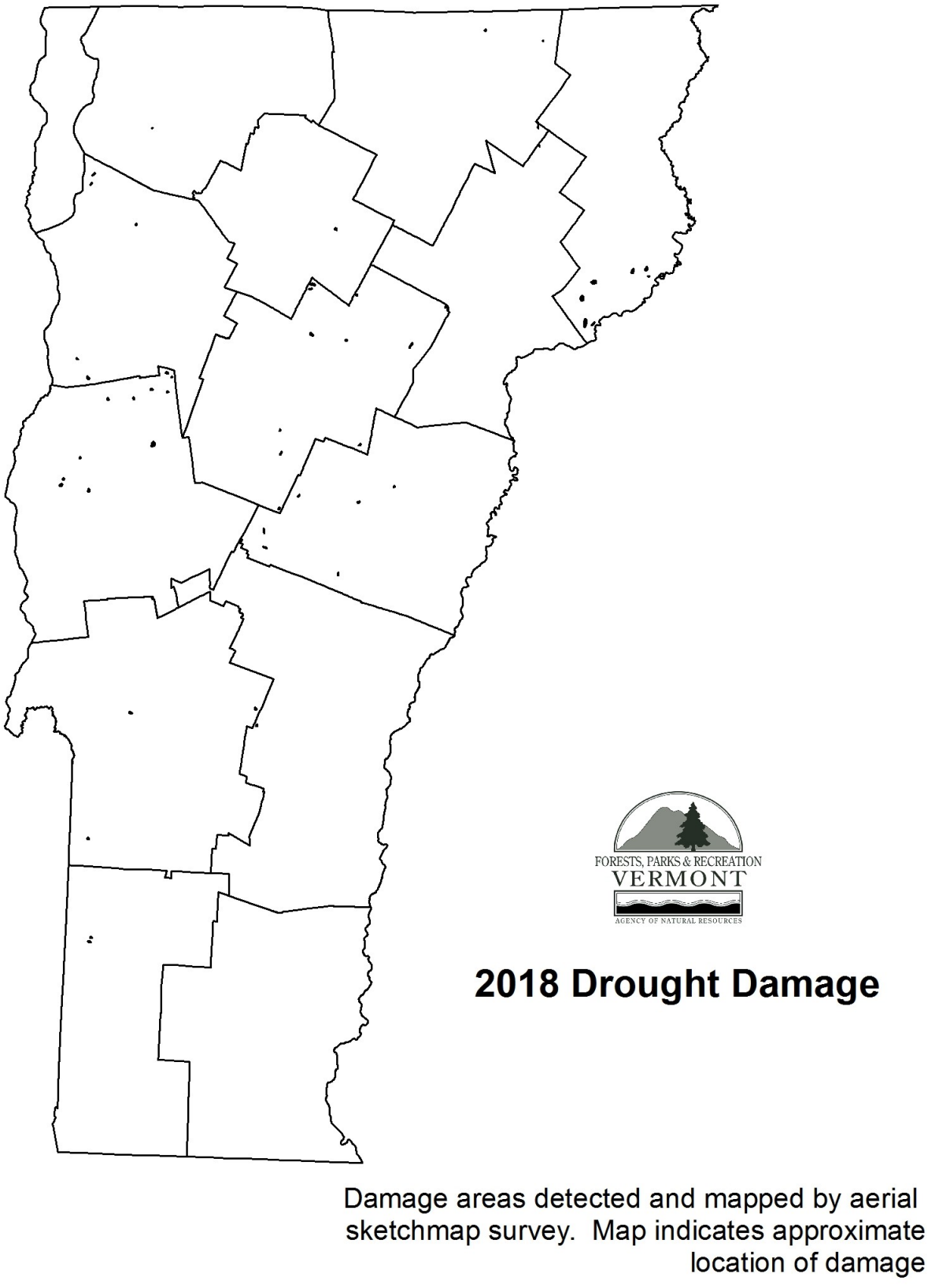


Figure 34. Symptoms of drought damage mapped in 2018. Mapped area includes 2,107 acres.

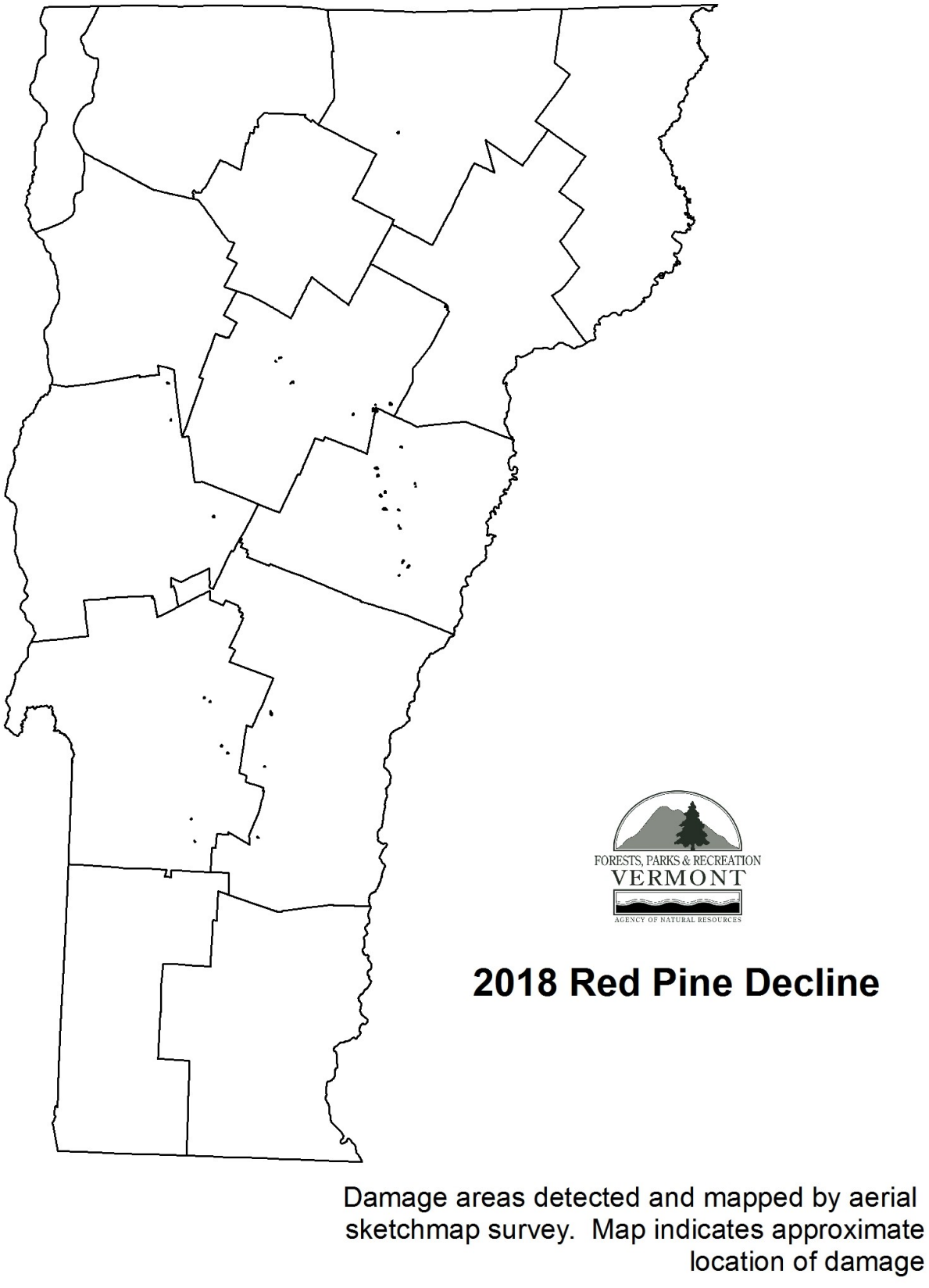


Figure 35. Red pine decline and mortality mapped in 2018. Mapped area includes 765 acres.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Air Pollution Injury			See Ozone Injury.
Ash Dieback	White ash	Scattered Statewide	Remains heavy in scattered locations. Increase attributed to ash susceptibility to drought.
Birch Decline	White birch	Scattered Statewide	Old mortality visible at higher elevations.
Drought Damage			See narrative.
Fire Damage	Many	Rutland County	10 acres of mortality mapped.
Hardwood Decline and Mortality			See Forest Tent Caterpillar.
Heavy Seed	Ash	Statewide	Thin crowns due to heavy seed were common on ash. On maple and other species, heavy seed in 2017 may be contributing to decline.
Ice/Snow Breakage	Many	Widespread, especially higher elevations	Wet snow from a storm beginning on 11/26.
Lightning Damage	Red Maple	Rockingham	Flagging of a young ornamental.
Logging-related Decline	Many	Widely scattered	An occasional cause of tree symptoms. 127 acres mapped.
Ozone Injury			Ozone monitoring plots were discontinued in 2018.
Salt damage	Conifers	Statewide	Damage noticeable in the spring on roadside pines and other conifers. Similar to other years.
Red Pine Decline			See narrative.
Wet Site Related Decline	Many	Statewide	Only 215 acres of new symptoms were mapped.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
White Pine Needle Damage			See Foliage Diseases.
Wind Damage	Many	Scattered Statewide	40 acres mapped. See 2018 Weather Summary for information about storm events.
Winter Injury	Fir	Bennington	Christmas trees

Other Diebacks, Declines, and Environmental Diseases not reported in 2018 included air pollution injury, chlorosis due to rainfall, frost damage, hail damage, larch decline, spruce decline.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Porcupine	Hardwoods and softwoods	Statewide	Usually scattered and negligible
Squirrel	Maples, Oaks	Statewide	Populations erupted following a heavy seed year in 2017 on many tree species. Both red and grey squirrels were observed in abundance, especially in late summer and fall. With minimal seed production on many species in 2018, we expect squirrel feeding on bark and shoots to increase in 2019.
Woodpecker	Wood products; Balsam fir, Mountain ash	Statewide	Scattered throughout the state

INVASIVE PLANTS

Non-native invasive plant management (NNIPM) efforts continued in 2018, with progress on **Education, Outreach, and Capacity Building** made possible through several grant funded opportunities. The statewide Invasive Plant Coordinator within FPR led 31 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 280 inquiries about invasive plants. FPR staff continued to provide outreach and information about invasive plants to the public and resource professionals, to work with land owners and consulting foresters on addressing NNIP on private lands. ANR continues 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 new location of **Giant Hogweed** was confirmed in Windsor County. The Agency of Agriculture, Food & Markets is working with the landowner to determine the best course of action.

An isolated patch of **Hardy Kiwi** was confirmed in Windham County.

Education, Outreach and Capacity Building

Mapping for Healthy Forests, Vermont: Efforts continued to encourage volunteers to take part in a citizen science project to assess and prioritize treatment areas for NNIP management (NNIPM) on town or private land. 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 31st, the project had 3,725 observations, provided by 98 observers.

Habitat Hero! Student Volunteers: This year, funded by a new US Forest Service grant, the Habitat Restoration Crew (seasonal staff hired in the Rutland office) and Invasive Plant Coordinator launched a new program for 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. The crew worked with 600 student volunteers in 2018, from 13 schools across Vermont. Between 2014-2017, the crew has worked with 2,279 volunteers (9,266 volunteer hours). Additionally, this year the crew worked on mapping, curriculum development for programs with schools, and installing interpretive panels about demonstration sites for NNIPM for state parks.

Forest Hero! Volunteer Network: Also, part of the new 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, the first training took place on October 23rd. The ten participants learned how to effectively communicate information to their communities on invasive plants. As part of the day, participants agreed to take what they learned back to their communities and are expected to complete at least one outreach event before October 2019. A follow up workshop is planned for spring 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 used 12 times throughout 2018. 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 office. The plan is to create a similar arrangement in the Rutland office in order to provide this service to a broader audience.

VTinvasives.org website: The VTinvasives.org website continues to offer content including information on terrestrial and aquatic invasive plants and continues to provide that wide range of 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 completed across the district. Follow up treatments for populations of Butterbur at Amity Pond and Sweet Pond, where staff are seeing significant reductions after several years of treatment. At Prison Farm and Little Ascutney, the treatment continues to be both follow-ups on previous years' work and in new areas. Specifically, at Prison Farm, the mowing schedule frequency has been increased to try to significantly reduce populations of wild Parsnip. At Patchen's Point, management work will treat buckthorn in hopes of keeping the spread contained to infested parts of the property.

Figure 36. *Phragmites australis* demonstration site on CCC Rd in Coolidge State Forest; 2014, 2015, 2018.

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 *Phragmites australis* on the CCC road in Coolidge State Forest (Figure 36). In 2013, all the Phragmites stems in the approximately 2,000 sq. ft. area were cut back to the ground and the area was covered in thick black plastic. In 2014, many stems had poked through the plastic, so with the help of volunteers, the stems were cut, and another layer of plastic was added. In 2015 and 2016, only a handful of stems managed to poke through the plastic, and these stems were treated with a drip application of herbicide. In 2017, no new stems were detected, so the crew took up the plastic and replanted the area with native shrubs and trees. As of 2018 native vegetation is reclaiming the area. A few Phragmites stems emerged and were treated with a drip application of herbicide. This early detection of an invasive population allowed the crew to try an experimental mechanical treatment which proved to be very effective. The economics of this restoration project from 2013-2018 included 86 person-hours of work including volunteer time, and $736 in costs (plastic, sand bags, disposal of plastic, trees for revegetating).

District 3 (northwest): In Camel's Hump State Park, staff continued follow-up herbicide treatments to several heavy infestations of honeysuckle and multiflora rose, mainly around Honey Hollow and Bombardier Roads in Bolton. Infestations of multiflora rose have required several follow-ups due to multiple layers of dense foliage. Other smaller infestations of honeysuckle, multiflora rose, and Japanese knotweed were also treated using either herbicide or hand-pulling along forest highways in North Duxbury and the Dowsville Headwaters Block.

In Ferrisburgh, at both Little Otter Creek WMA and Lower Otter Creek WMA, staff have continued monitoring and spot treatments of areas treated with herbicide in 2016 and 2017. The goal in each case is to control and reduce invasive species prior to commercial harvests scheduled for the upcoming win-

ter.

At Alburgh Dunes State Park, Long View Forests LLC completed year one of herbicide treatment to control the phragmites infestations that threaten the integrity of the wetland and several RTE plant species. This infestation has been on the radar for years and staff are hopeful that a second year of commercial treatment should reduce the phragmites to a level that can be treated by staff in subsequent years.

At East Creek WMA, a stand of Phragmites was identified near one of the channels within the WMA. It is not on state land, but staff plan to reach out to the landowners to see if they are amenable to the idea of staff treating this patch.

On Snake Mountain, there is a large, dense, vigorous patch of Phragmites (0.02 acres) in a remote site that is hard to access with equipment (Figure 37). Initial treatments were attempted this season, but this site will require more attention.

At Lemon Fair WMA, there is a heavy infestation of wild parsnip in a drainage swale (~7 acres). Initial assessment suggests that it will require a large investment to eradicate, as neighboring fields have abundant parsnip (continued monitoring will be required), and treatments this season took significant person time to treat only half the population.

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 has been treated several times this season, though there are spots that will need follow up.

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 reduced after initial treatment, but the more vigorous stand will require follow up treatments.

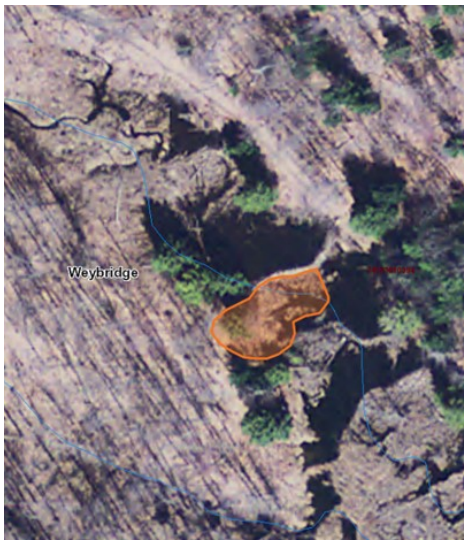


Figure 37. A Phragmites stand at Snake Mountain WMA, in Addison/ Weybridge.

At Dead Creek WMA, there is purple loosestrife in a ditch and pond (~1.6 acres). The density of seedlings in the ditch made initial treatments ineffective, and the overall scattered nature of the population made it hard to systematically treat. The pond was dry, so treatment was easier. 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. Along Gage Road is another stand of Phragmites, difficult to access, but there are plans to treat it in the future.

In Fairfield Swamp WMA, a stand of Phragmites (~0.24 acres) is confined to the roadside by deep water along the road and thick cattails which are competing well. It has also been weakened by previous treatments. Access is difficult for the southern and northern sections of the stand. Upon returning for the second treatment, to be completed this season, there were very few standing live stems to treat along the highway due to mowing.

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, and spans property boundaries, so effective treatment will require collaborating with the neighboring landowner. Initial treatments reduced

the more vigorous growth, but thick alder growth had covered an extension of the stand that didn't get treated.

Mallett's Creek WMA has two patches of wild parsnip (0.9 acres), abutting a road, that were assessed and treated in 2018.

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.

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 did not seem impacted by the 2018 treatments, and assessment will occur in 2019.

Figure 38. The stands of Japanese knotweed at Avery's Gore WMA in Montgomery, VT.

District 4 (central): A variety of NNIPM control projects were continued this year.

District 5 (northeast): Much of the NNIPM occurred on a variety of WMAs, by F&W staff with assistance by FPR staff. F&W has treated honeysuckle, Phragmites, and Japanese knotweed at numerous sites on 6 WMAs. Many sites are now under control thanks to previous treatments, though there remain more plants and infested sites than district staff can treat on their own. FPR staff also treated ~0.5 acre stand of Phragmites, and plan to follow up in 2019. At Willoughby State Forest, FPR staff are planning to control a large (10+ acre) patch of barberry. So far, staff have created a management plan and will conduct first phase of the project in spring 2019.

Other Activities

The growing season for 2018 saw many NNIPM projects, led by others, across the state. Below are highlights of some of these local efforts.

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, this area is also prized by the people of Richmond who use it extensively for hiking, biking, bird-watching, 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 with Root-Out! over the years, including community members, middle and high school science classes, UVM, land trust members and more. This past year both 5th and 7th grade science classes from Camel's Hump Middle School got very involved (Figure 39). They spent class and field time learning about floodplain ecology and they helped remove invasive plants. Thanks to their help and that of all Root-Out! volunteers, knotweed, barberry, honeysuckle and Phragmites infestations have all been shrunk by 95-99% since the program's inception. In 2018, FPR's Invasive Plant Control Program assisted by teaching Root-Out! how to work more effectively with large groups of volunteers.

Burlington, VT: The Winooski Valley Park District (WVPD) works with and relies on local schools, youth groups and other volunteer groups to manage NNIP across their parklands. This year WVPD continued their management efforts across their parks with both staff and volunteer time.

Figure 39. Middle school volunteers learning how to use a weed wrench from FPR staff in Richmond, VT.

South Burlington, VT: The City of South Burlington continued invasive plant management projects with a focus on two parks: Red Rocks Park and Wheeler Nature Park. At Red Rocks Park the city worked to remove eight infestations of Asiatic bittersweet, two early detection sites of garlic mustard, and removed 900 glossy buckthorn shrubs. In Wheeler Nature Park, 209 wild parsnip plants were removed, an early detection site of garlic mustard was removed, a patch of Phragmites was cut back, and buckthorn shrubs were cut back.

Bradford, VT: The River Bend Career and Technical Center Diversified Agriculture and Natural Resources program in Bradford is taking an active role in managing the spread of invasive plant species on their school owned property and adjacent town property. The students learn how to identify the different species and the steps to mechanically control them. They learn the reasons why this is important while gaining a deeper understanding of our local woodland natural biodiversity. Students worked with FPR's Invasive Plant Program last spring and have purchased a mechanical puller tool. They will continue to maintain an area that is relatively free of invasives while pushing NNIP back in other areas that are bordering it.

Bennington, VT: The Cooperative Invasive Species Management Area for the Batten Kill Watershed (CISMA-BKW) had a successful season. In the past year, the CISMA-BKW habitat steward managed approximately 9.75 acres of the Equinox Preservation Trust, seven acres of the adjacent Nature Conservancy Rocking Stone property, and about one acre of Japanese knotweed along Bourne Brook. In addition, the habitat steward monitored 71.8 acres of private land and 18.7 acres of public land for invasive species. Finally, the habitat steward also managed invasives at a property owned by the Green Mountain National Forest in Manchester and at the Arlington Recreation Park. Both efforts were undertaken with the help of VYCC service members. In the fall, the new habitat steward helped to plant 170 seedlings to create a riparian buffer on private land.

Upper Valley, VT: The Upper Connecticut River Cooperative Invasive Species Management Area (UCCISMA) hired a new part-time conservation coordinator this summer, spent 64.5 hours this field season on identification and treatment of Japanese knotweed and other priority species throughout the watershed. While much of the activity in 2018 focused on the NH side of the Connecticut River watershed, the CISMA is currently reaching out to the Vermont towns of Canaan and Bloomfield to try and gain their support for invasive species removal treatments. Next year the CISMA hopes to continue treatments on current sites and to begin treatments on new sites, and to increase participation in our Vermont communities.

The Nature Conservancy: TNC completed a variety of NNIPM work across Vermont. Spring work included management at Williams Woods in Charlotte (volunteers spent 4 days removing garlic mustard and wall lettuce as part of a WHIP project); management at Raven Ridge in Monkton (volunteers spent 1 day pulling garlic mustard and wall lettuce along trails); management at Chickering Bog (volunteers spent three days pulling wall lettuce); and management at Eshqua Bog (TNC staff spent one day pulling wall lettuce). Summer work included management at White River Ledges in Sharon/ Pomfret (TNC staff spent one day completing control work on Japanese knotweed and Phragmites). Fall work included management work at Williams Woods (volunteers spent three days removing woody NNIP as part of a WHIP project); management at LaPlatte River Nature Area (volunteers spent 1 day removing NNIP along the river, and TNC contracted with Redstart Forestry to complete follow-up work on an herbicide treatment on 50 acres on the east side of the natural area); management at Raven Ridge (volunteers spent 1 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 two days); management at Butternut Hill in North Hero (TNC staff spent one day removing woody NNIP); management at Black Mountain in Dummerston (TNC staff spent one day removing woody NNIP); management at White River Ledges (TNC staff removing woody NNIP); and for the Helen W. Buckner Natural Area in West Haven, TNC hired contractors Land Stewardship, Inc. to treat woody NNIP on 23 acres.

Sugar Maple Health in 2018

Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 93% of trees were rated as having low dieback (less than 15%) (Figure 40).

Thin foliage due to forest tent caterpillar (FTC) defoliation was not noted in any of the 36 monitoring plots, which is notable since 2017 saw 25% of plots affected. Despite the reduction in defoliation from FTC, the number of trees with thin crowns continued to increase in 2018 (Figure 41). Statewide, there was an increase in trees with thin foliage from 7% in 2016, to 14% in 2017, to 16% in 2018. Foliage transparency is sensitive to current stress factors. Other spikes in transparency were due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007, 2016), and pear thrips (1988-1989).

Of the 1,823 live sugar maple trees (all crown classes) surveyed, 125 (6.9%) had defects from various damage agents in 2018. The most common damage type was bole injury from sugar maple borer (27.2%), followed by Eutypella canker (13.6%) on trees with visible damage. Other damages from non-descript cankers, conks, and cracks/seams accounted for 46.4% of tree damages combined.

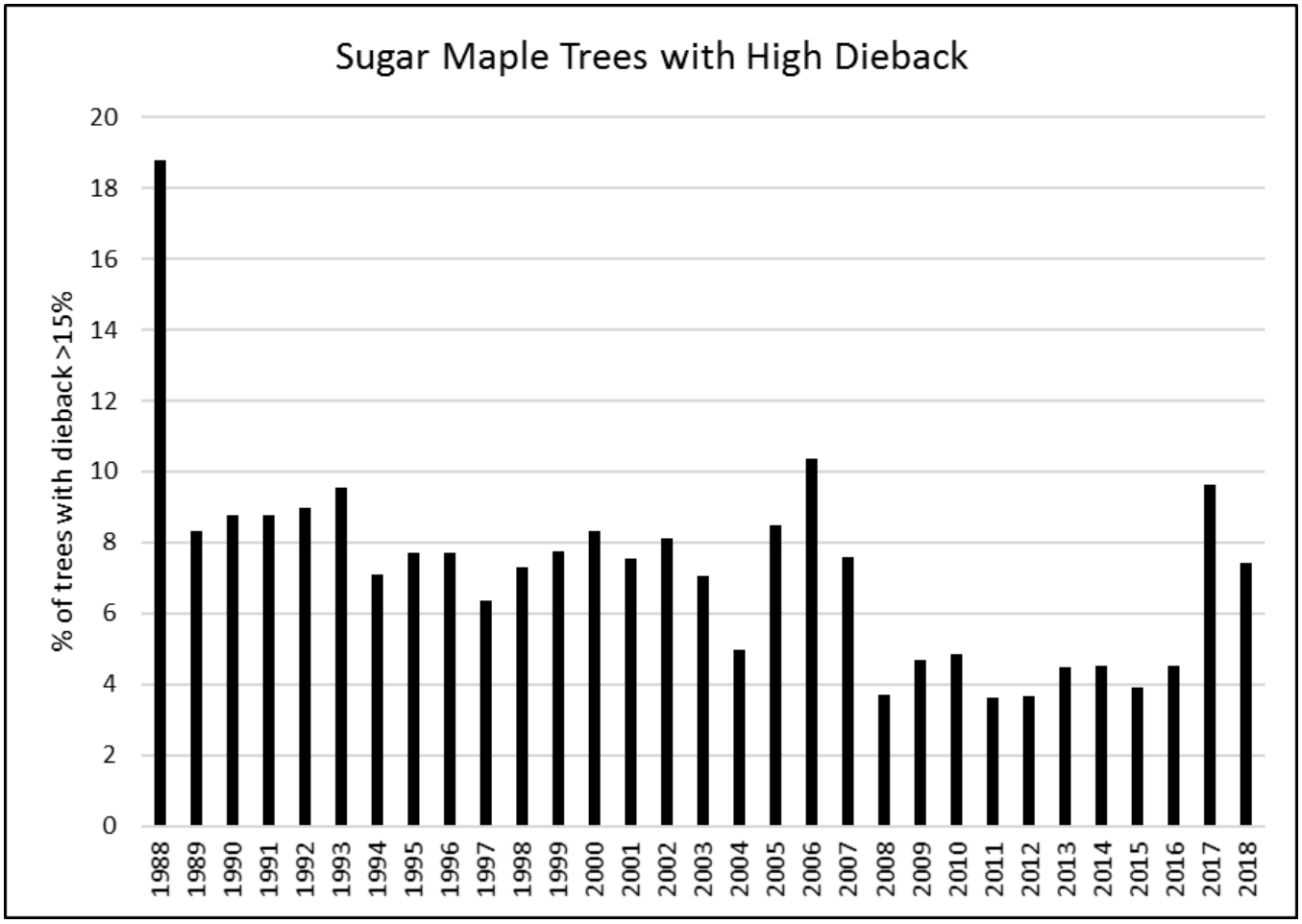


Figure 40. Percent of overstory sugar maple trees on NAMP plots with high dieback (> 15%). *n* = 1,142 trees at 36 sites.

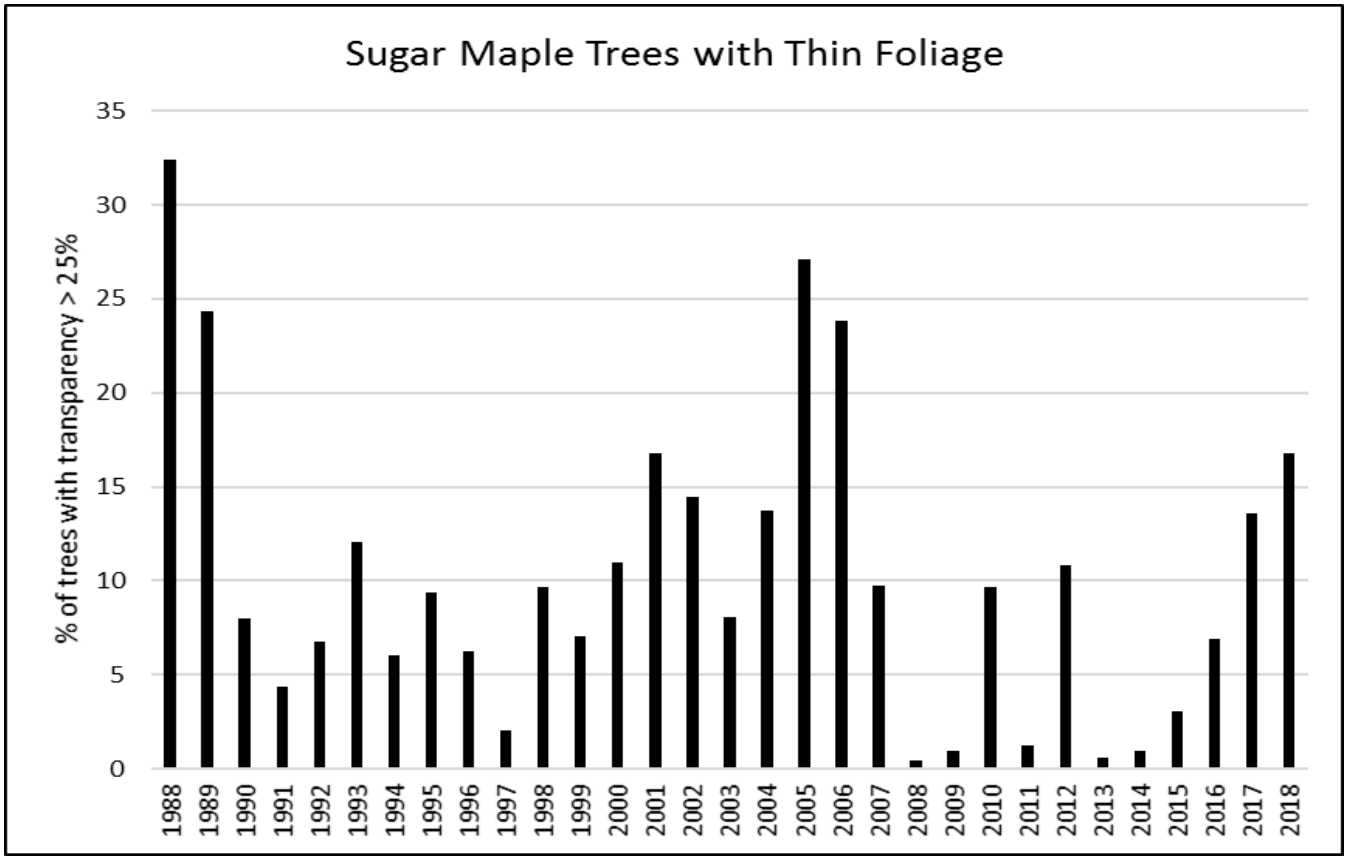


Figure 41. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage (>25% foliage transparency). *n* = 1,142 trees at 36 sites.

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 2018 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 42-45), indicators of tree stress. Periods of dry weather and/or drought over the past 2 growing seasons may be in part to blame for the increase.

Data were collected annually on 8 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 on 21 plots in 2014, 41 plots in 2015, and from 48 plots between 2016-2018.

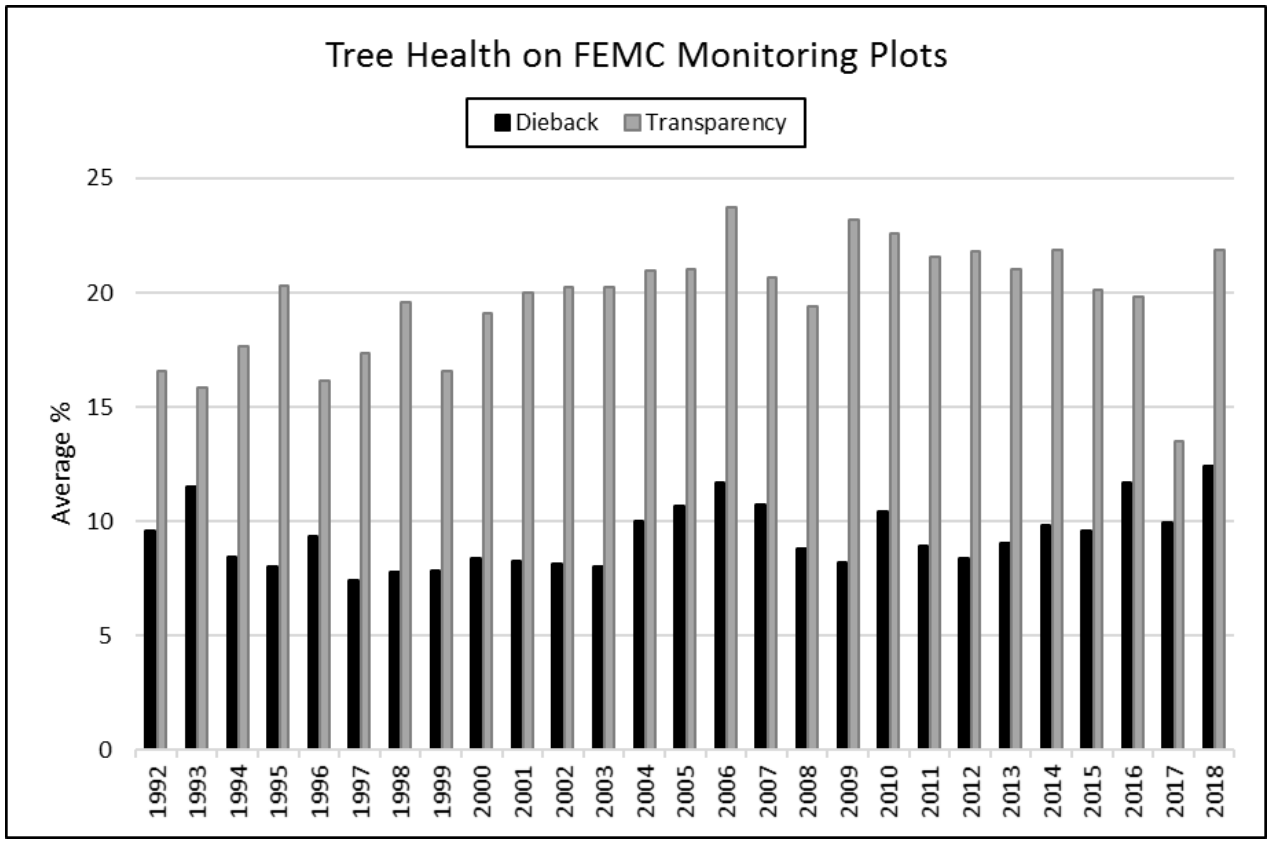


Figure 42. Trend in the average dieback and foliage transparency of overstory trees on Forest Health Monitoring plots in Vermont.

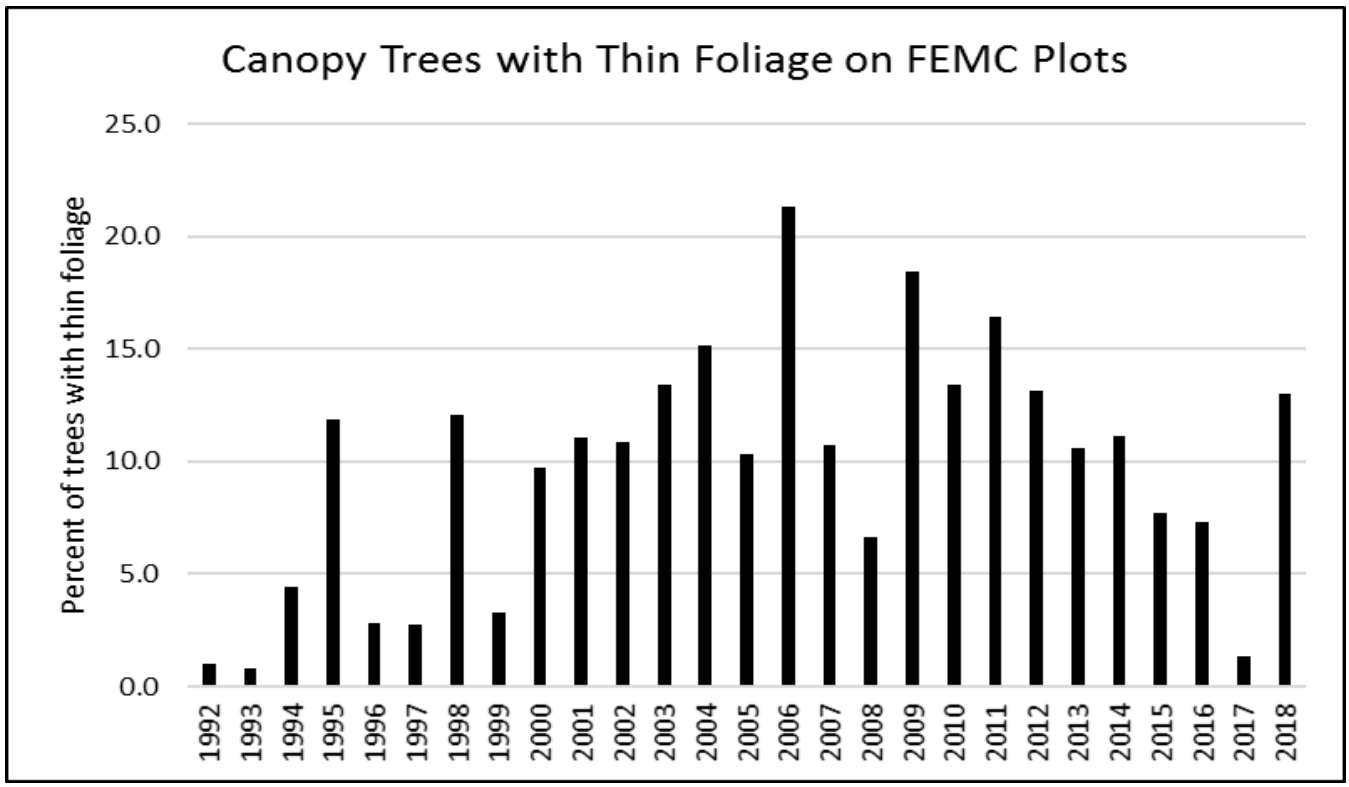


Figure 43. Percentage of overstory trees on Forest Health Monitoring plots in Vermont with thin foliage (> 25% foliage transparency)

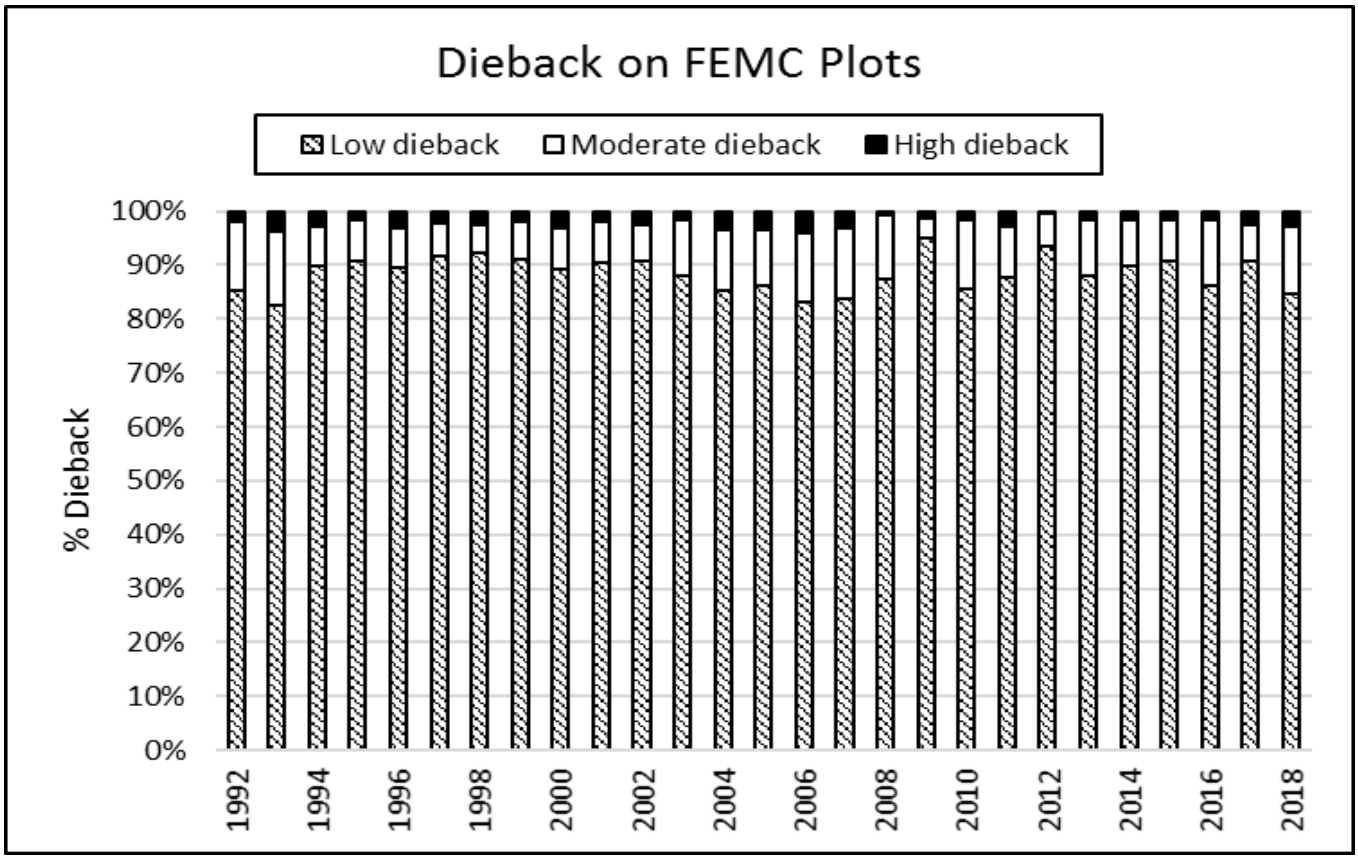


Figure 44. Trend in the percent of overstory trees with low (0-15%), moderate (16-40%) or severe (>40%) dieback on FEMC plots.

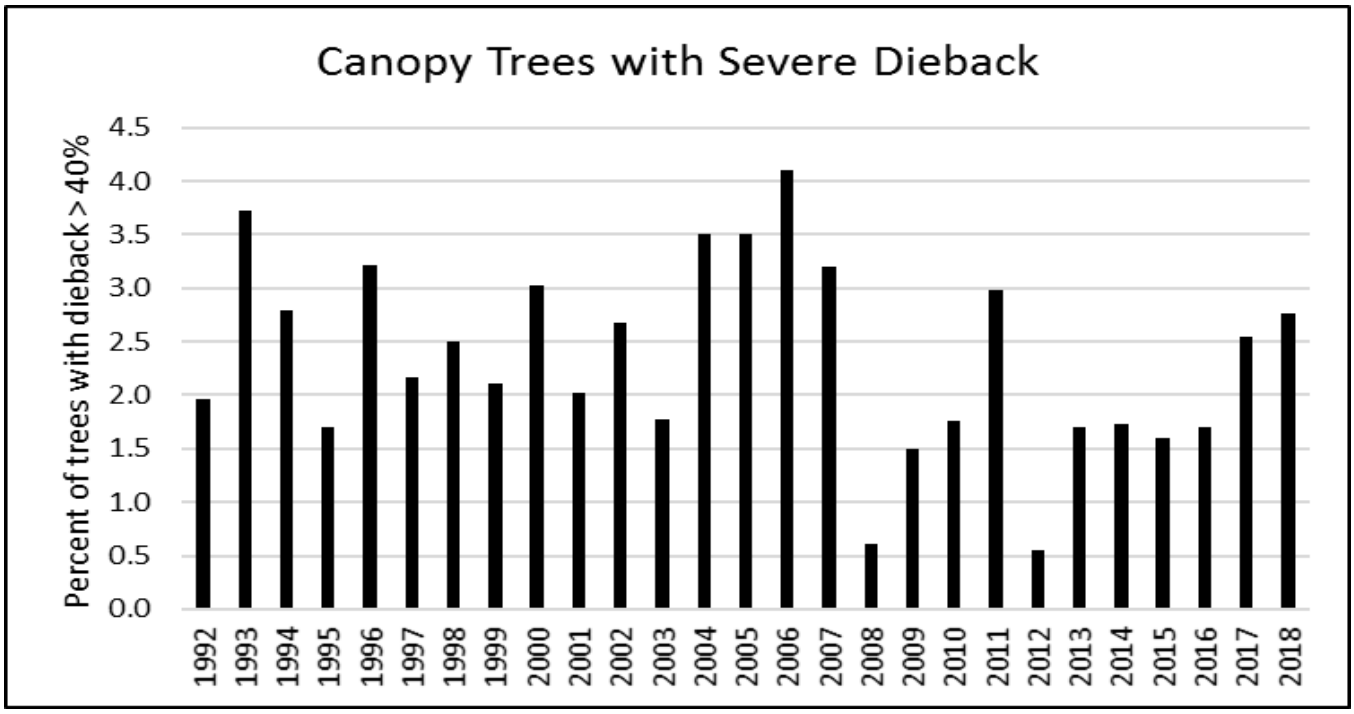


Figure 45. Trend in overstory trees with severe (>40%) dieback on FEMC plots.