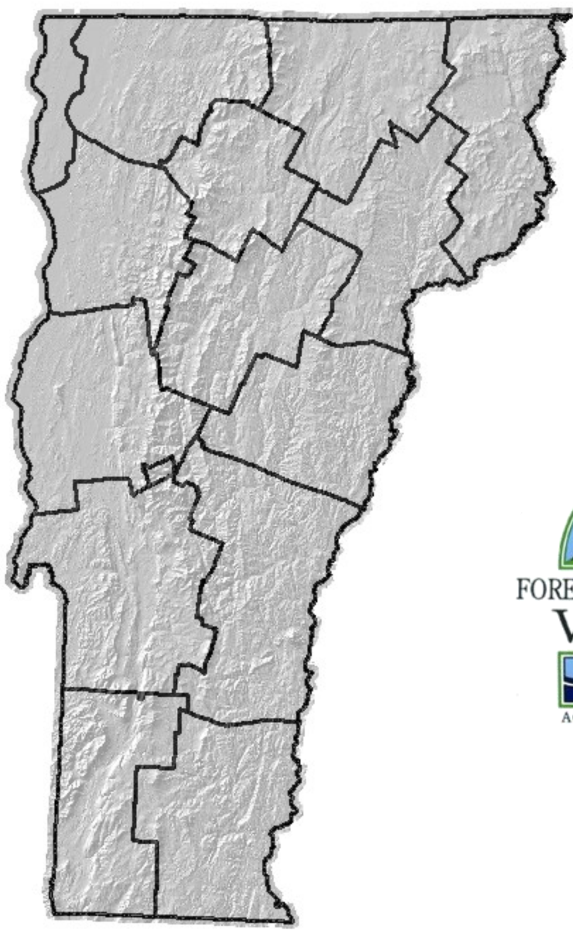
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2016



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DEPARTMENT OF FORESTS, PARKS & RECREATION

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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 2016

PREPARED BY:

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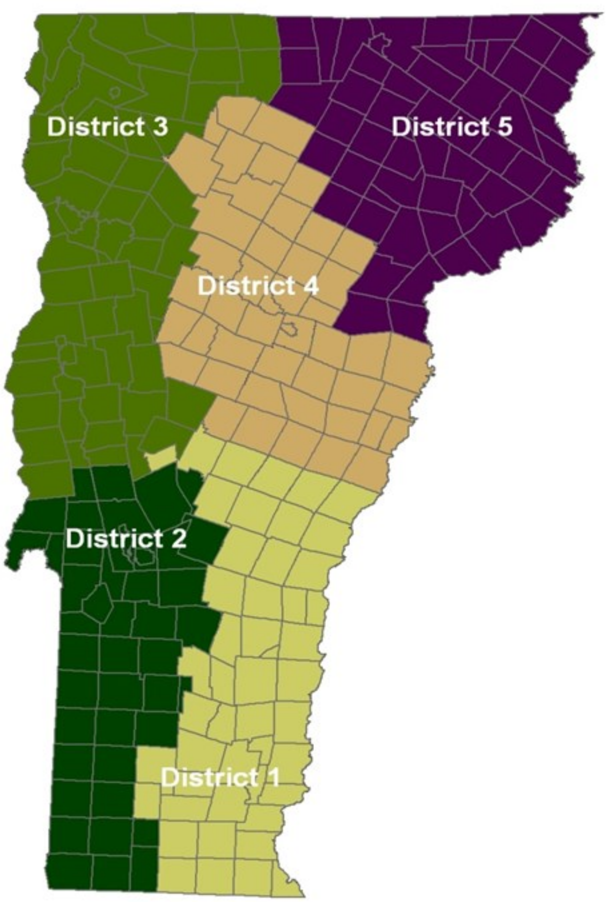

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INTRODUCTION

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

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 23rd, 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 June 21st and August 23rd (6/21, 7/11, 7/12, 7/27, 8/3, 8/4, 8/19, and 8/23). This range of dates is about a month earlier than the survey has been flown in recent years. As a consequence, changes in acres mapped from 2015 and other recent 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 Vermont 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 hardcopy format. For additional information, including defoliation maps, management recommendations, and other literature, assistance in identifying pests, diagnosing forest health problems, on-site evaluations, and insect population sampling, or to participate in invasive pest citizen monitoring, contact Forest Resource Protection Personnel or your County Forester.

ACKNOWLEDGEMENTS

The **Forest Pest First Detector Program** is in its fourth year. In 2016, 38 new volunteers attended Vermont's Forest Pest First Detector Program training, bringing the statewide total of trained volunteers to 166. We thank the many continuing First Detectors, and welcome new volunteers: Clint Anderson, Tommy Benson, Jim Betteridge, Henry Carr, Curtis Comfort, Jason Eaton, Liam Farley, Bill Foery, Jason Gaudreau, Dan Gibson, Jordan Harris, David Hayner, Bruce Hoar, Karl Honsaker, Chris Howe, Sarah Janson, Leonard Jenkins, Joe Karl, Gary and Carolyn Katz, Gabe Kellman, Andrew King, Jeremy Kingsbury, John Kulhowvick, Jordan McGee, Paula Murakami, Bill Murphy, Andrew Noonan, Bonnie Pease, Theron Peck, John Pennucci, Jake Sidey, Elizabeth Spinney, Kelly Stettner, Jim and Peggy Tucker, Amanda Whiting, and Chris Zeoli.

We are thankful to those who assisted us this year with **Cerceris wasp surveys for emerald ash borer (EAB):** Alma Beals, Doug Burnham, Joan, Lena, and Luke Curtis, Grace, Noah and Scott Diedrich, Debbie Duvall, Debbie Foote, John Foster, Laura Gaudette, Annette Goyne, Kathleen Hacker, Chris Harlow, Mary Holland, Wally Jenkins, Bruce Jenson, Chris Johnstone, Tory Jones Bonenfant, Lorens and Priscilla Lindberg, Bob Little Tree, Mary Lynch, Kent McFarland, Bob McNamara, Grace Mitchum, Elizabeth Odom, Tom Prunier and grandchildren Nathan and River, Martha Rabinowitz, Pieter van Loon, Joan Waltermire, Mary Lou Webster, Ben Williams, and Amber Wolf. We also appreciate the help we received with **Asian longhorned beetle and EAB pheromone trap surveys and EAB trap trees:** Holly Betit, Trevor Evans, Jen Loyd-Pain, Annette Preiss, Jim White and Ames True Temper and One World Conservation Center for hosting sites.

Welcomed assistance with **hemlock woolly adelgid surveys** came from Ellen Allman, Alma Beals, Ben Hacker, Kathleen Hacker, Helen Hamman, Frankie Knibb, Lynn Morgan, Kerry Simonson, Kathie Stone, Robert and James Twitchell, and students and staff of the Mt. Campus, Burr and Burton Academy.

Many thanks to **invasive plant survey** volunteers who helped continue the Mapping for Healthy Forests citizen science project on iNaturalist.org: ECO Americorps 2016 members and staff, Kim Kendall and her CCV Montpelier class, Winooski Valley Park District, Centerpoint School, Jen Loyd-Pain and her CCV Bennington Class, and the Birds of Vermont Museum. Many groups, towns, and organizations took part in **invasive plant management and outreach** across the state. Huge thanks to VT Coverts, Ellen Gawarkiewicz and her students, Winooski Summer Teen Employment Program, Logger Education to Advance Professionalism (LEAP), Vermont Envirothon, Vermont State-Wide Environmental Education Programs (SWEEP), Vermont Women Owning Woodlands, Vermont Woodlands Association, Conservation Commissions across VT, and many others.

Many individuals supported the **Forest Biology Lab**. Each year since Tropical Storm Irene destroyed much of our insect reference collection, Warren Kiel has contributed carefully collected and meticulously prepared Lepidoptera specimens, as well as historical data from his collection. Thanks to Warren, we have been able to rebuild our collection and to add new species records. Whitney Burgess regularly contributed her time to working with specimens and helping with data entry. Taxonomic and other assistance came from Don Chandler, Rod Crawford, Kevin Dodds, Charley Eiseman, Aaron Ellison, Jeff Freeman, Nick Gotelli, Scott Griggs, Ann Hazelrigg, Rick Hoebeke, Ron Kelley, Jim Kellogg, Warren Kiel, Bob Rabaglia, Leif Richardson, Michael Sabourin, Scott Schneider, Nate Siegert, and Dave Wagner.

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 VT State Parks, as well as many others in the VT Agency of Natural Resources.

SPECIAL ACKNOWLEDGEMENT

Jay Lackey Retires

In August of 2016, after 42 years of service, Jay Lackey retired from Forest Resource Protection for the Vermont Department of Forests, Parks and Recreation. Longevity in the insect world means that Jay has seen cycles of forest tent caterpillar, spruce budworm, gypsy moth, Bruce spanworm, pear thrips, and saddled prominent, but not Asian long-horned beetle or emerald ash borer! (He's leaving that to his successor.)

Jay has been a steady force with the Central Vermont fire wardens and used his talents as a trainer to help design the 9-hour fire course. He was always ready to lend advice or help acquire equipment for local fire fighters. Within the regional forest health monitoring programs, he was recognized as the go-to trainer for standardized rating of crown health and assisted in improving field manuals. Recently, local campgrounds benefitted from his diligence in educating campers and park staff about firewood that could carry insects or diseases.

A graduate of Paul Smith's, Jay was named in "Who's Who Among American College and University Students."

To commemorate Jay's career, long-time co-worker Barbara Schultz wrote these lyrics to the tune of "Wild Rover." (Jay is a dedicated fan of the group known as Woods Tea Company, and this is one of their signature songs.)

We all miss Jay's quiet demeanor and gentle wit.

NO, JAY, NEVER, NO MORE

Jay's been with the state now for many a year;
As he says "so long" we applaud his career
And go over a list of achievements galore.
He'll never balloon spray block corners no more.

And it's no, Jay, never. No, Jay, never, no more
Will you set out the spray cards. No never, no more.

An assessor of ozone and stereo pairs.
He's also a stalwart at meetings and fairs
Getting the word out all over the place
About non-native pests or defensible space.

And it's no, Jay, never. No, Jay, never, no more
Will you scout parks for hazards. No never, no more.

State government's got to have transparency;
Jay's an expert on that and down woody debris.
And on when to assign a sick tree "vigor four".
He won't travel the east training field crews no more.

And it's no, Jay, never. No, Jay, never, no more
Will you tie flags on test trees. No never, no more.

Jay can sleuth wildfires to determine the cause,
And has mastered explaining air quality laws.
He was key in creating the nine-hour course
Now he won't have to host warden meetings no more.

And it's no, Jay, never. No, Jay, never, no more
Will you add up per diem. No never, no more.

Jay's thoughtful questions will make you think twice.
His quips make you smile, he gives good advice.
If CAVE people shrug, that's their loss, for sure.
Staff meetings are gonna be more of a snore.

And it's no, Jay, never. No, Jay, never, no more
Will he weigh in on workplans. No never, no more.

Jay's a far-sighted guy who can see the next step:
He's the one who proposed that communities prep
For the passing of ash, and's the one who suggested
That we focus on firewood so we don't get infested.

And it's no, Jay, never. No, Jay, never, no more
Will you bag wood for burning. No never, no more.

He leaves a cadre of wardens and trained volunteers
A network of plots that he's followed for years
He's turned in his vest and cleaned his desk drawers
He won't have to click codes on his time sheet no more.

And it's yo, Jay, if ever you find retirement's a bore.
We'll be anticipating your knock on the door.

TABLE OF CONTENTS

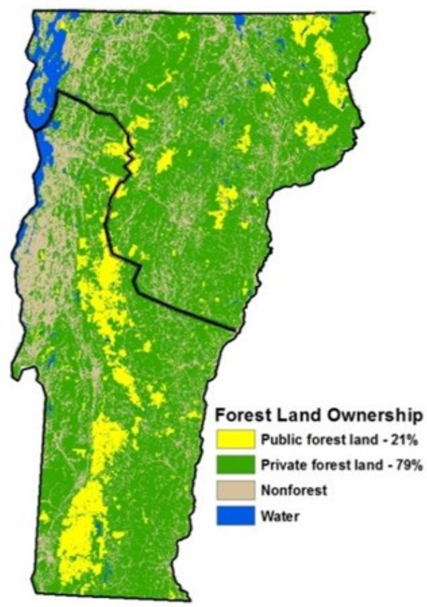
Forest Health highlights

VERMONT

2016

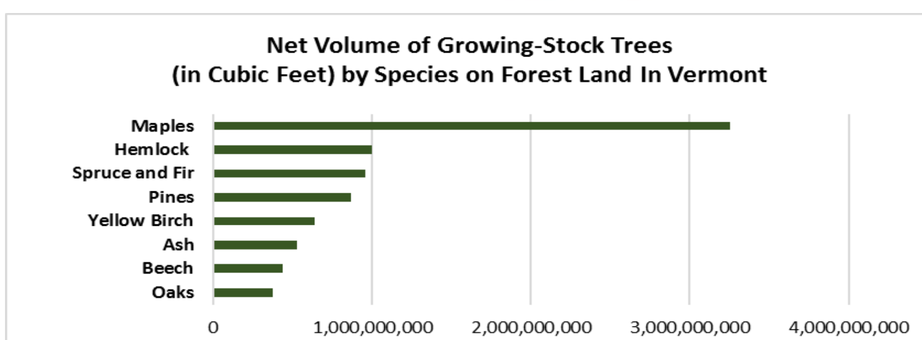
These highlights summarize information from the annual report on Forest Insect and Disease Conditions in Vermont. In addition to an overview of the forest resource in Vermont, this summary provides forest health program highlights, separate sections on hardwood and softwood insects and diseases which are native or well-established in the state, a section on exotic forest pests which are not known to occur in the state or which are recent invaders, a summary of activities related to non-native invasive plants, and our results from monitoring forest health.

The complete annual report, as well as other Vermont forest health information, is posted on-line at http://fpr.vermont.gov/forest/forest_health. To receive a copy by mail, for assistance in identifying pests or diagnosing forest health problems, to request on-site evaluations or insect population sampling, to obtain defoliation maps, management recommendations, and other literature, or to participate in invasive pest citizen monitoring, contact us.

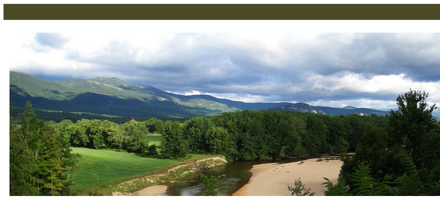


Forest Resource Summary

Forests cover 73% of Vermont. Seventy-nine percent of the State's forest land is privately owned with 10% under Federal management in the Green Mountain National Forest and 8% managed by the State of Vermont. Sugar and red maple, eastern hemlock, and white pine are the most common species by volume. More information on Vermont's forest inventory is at http://fpr.vermont.gov/forest/forest_business/forest_statistics/fia



Forest Land Area by Ownership: Morin, R.S.; Widmann R.H. 2016. Forests of Vermont, 2015**.** Resource Update FS-80. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p.
Net Volume of Growing Stock Trees data presented are from Forest Inventory and Analysis (FIA) plots established by USDA – Forest Service. Estimates for Vermont totals were calculated using EVALIDator (v. 1.6.0.03) software (http://apps.fs.fed.us/Evalidator/evalidator.jsp), December 2016.



Forest Health Programs in the Northeast

Vermont Department of Forests, Parks and Recreation (FPR) works in partnership with the US Forest Service to monitor forest conditions and trends in Vermont and respond to pest outbreaks to protect the forest resource.

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.

The website **vtinvasives.org** is getting a new look. The new site design will offer information on terrestrial plants, forest pests, and aquatics. Navigation will be easier, resources will be stored in a searchable hub, and news articles added weekly. You can also follow vtinvasives on Twitter and Facebook.

An updated version of vtinvasives.org is coming soon.

In 2016, 38 new volunteers, including tree wardens, conservation commission members, arborists and concerned citizens, attended Vermont's **Forest Pest First Detector** program training and received a new pocket-sized field guide to invasive pests developed by UVM Extension. Volunteers assisted in survey and outreach. In Lamoille County, volunteers formed a Regional Invasive Insect Preparedness Team (RIIPIT) and spent over 500 hours creating education PSAs, newspaper ads, and ash tree inventories.

The Forest Pest First Detector program gained 38 new volunteers (Photo: G. Kozlowski), and a new pocket-sized field guide was developed.

The PSAs developed by Lamoille County volunteers are worth watching… and sharing.

Vermont's firewood rule went into effect in May 2016.

Vermont's **Firewood Rule** went into effect on May 1, 2016. Basic elements are:

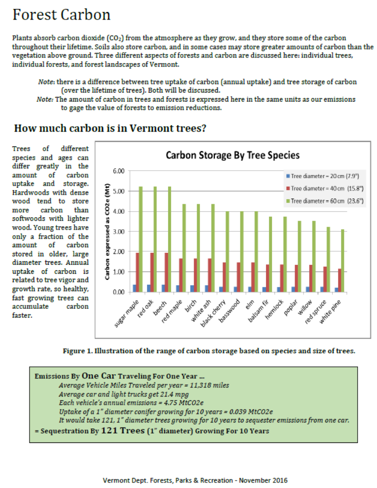
- Firewood is defined as wood processed for burning and less than 48 inches in length. It does not include wood chips, pellets, pulpwood, or wood for manufacturing purposes.
- Untreated firewood cannot be brought into Vermont.
- Treated firewood must be treated to the highest USDA standard (160° F/71.1° C for at least 75 minutes), which kills Asian longhorned beetle among other pests.
- Treated firewood must be accompanied by certification of treatment, such as a phytosanitary certificate, invoice, bill of lading, or label stating that the firewood has been heat treated to the 160° F/75 minute standard.
- By written request, FPR can grant a waiver allowing untreated firewood to be moved into Vermont, but only if there is minimal threat to forest health, and not restricted by existing state or federal pest quarantines. Currently, waivers are being granted to import firewood from counties adjacent to Vermont, as long as the material complies with other quarantines, including EAB quarantine restrictions.
- Enforcement is through the Agency of Natural Resource's Enforcement Division. Firewood imported in violation of the rule may be confiscated or destroyed.

Don't Move Firewood outreach efforts are conducted in collaboration with the US Forest Service, USDA PPQ, the Vermont Agency of Agriculture Food and Markets, and UVM Extension. Letters were sent to private campgrounds and firewood producers, and posters were distributed to each of the 17 welcome centers and to 700 convenience stores.

A new leaflet, **Earthworms in Forests**, was produced jointly with the University of Vermont, and provides information on non-native worm identification and impacts.

Climate Change remained a focus in 2016. Two new online resources are VT ANR's Climate Change Dashboard, and a fact sheet on Forest Carbon, including estimates of the amount of carbon stored in Vermont's forestland.

A fact sheet on Forest Carbon estimates the amount stored in Vermont's forestland.



Forest Carbon

Plants absorb carbon dioxide (CO_2) from the atmosphere as they grow, and they store some of the carbon throughout their lifetime. Soils also store carbon, and in some cases may store greater amounts of carbon than the vegetation above ground. Three different aspects of forests and carbon are discussed here: individual trees, individual forests, and forest landscapes of Vermont.

Note: there is a difference between tree uptake of carbon (annual uptake) and tree storage of carbon (over the lifetime of trees). Both will be discussed.

Note: The amount of carbon in trees and forests is expressed here in the same units as our emissions to gage the value of forests to emission reductions.

How much carbon is in Vermont trees?

Trees of different species and ages can differ greatly in the amount of carbon uptake and storage. Hardwoods with dense wood tend to store more carbon than softwoods with lighter wood. Young trees have only a fraction of the amount of carbon stored in older, large diameter trees. Annual uptake of carbon is related to tree vigor and growth rate, so healthy, fast growing trees can accumulate carbon faster.

Figure 1. Illustration of the range of carbon storage based on species and size of trees.

Emissions By One Car Traveling For One Year ...
Average Vehicle Miles Traveled per year = 11,318 miles
Average car and light trucks get 21.4 mpg
Each vehicle's annual emissions = 4.75 MtCO2e
Uptake of a 1" diameter conifer growing for 10 years = 0.039 MtCO2e
It would take 121, 1" diameter trees growing for 10 years to sequester emissions from one car.
= Sequestration By 121 Trees (1" diameter) Growing For 10 Years

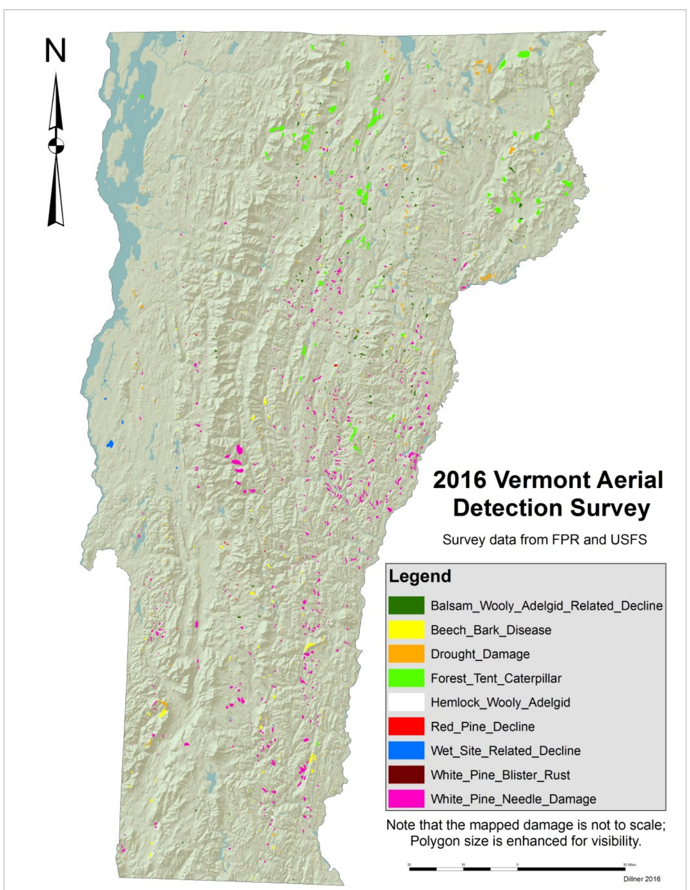
Vermont Dept. Forests, Parks & Recreation - November 2016

At the **Forest Biology Laboratory**, we continue to provide invertebrate identifications, tree disease diagnoses and pest management recommendations, and support environmental education and outreach. The lab retains a rich source of records on forest insect and disease incidence and distribution. Some of this information is shared through our yearly Conditions Reports, Forest Health Updates and website postings.

We are also striving to make our records more widely accessible to improve documentation of Vermont species. Over the past year, we have shared data on Vermont sphinx moths with NatureServe's pollinating hawk moth project, on metallic wood borers with a regional project through the US Forest Service, and on bees, butterflies, beetles and flies with Vermont's Pollinator Protection Committee and the Vermont Atlas of Life through the Vermont Center for Ecostudies.

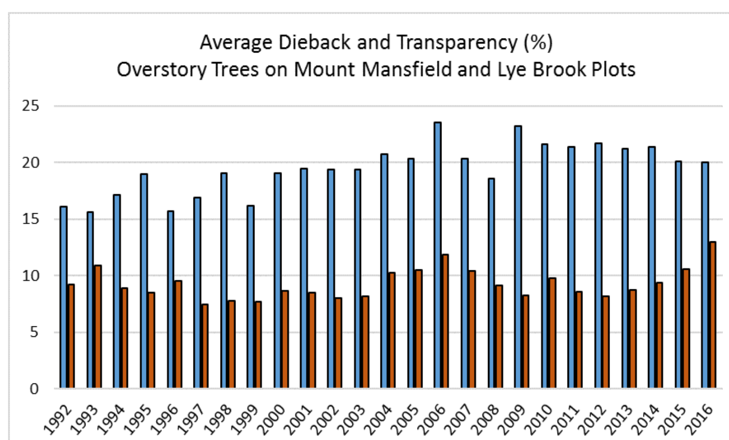
Planning efforts continue for eventual relocation of the Vermont Agriculture and Environmental Laboratory to a new facility in Randolph.

In 2016, 80,233 acres of forest damage were sketchmapped during statewide **Aerial Detection Surveys**. This represents less than 2% of Vermont's forestland, and a decrease from 2015, when 128,391 acres were mapped. White pine needle damage and hardwood defoliation by forest tent caterpillar accounted for 34% and 32%, respectively, of the area mapped.



The most common damages mapped in 2016 were forest tent caterpillar defoliation and white pine needle damage.

The **Vermont Monitoring Cooperative** (VMC) completed its 26th year of monitoring forest ecosystem health. In 2016, 42 forest health monitoring plots were sampled across Vermont as a collaborative effort between the State, UVM and the US Forest Service. Additional monitoring of air, streams, wildlife, soils and flora by a variety of partners added to the archived database maintained at the UVM. Results are maintained on the VMC website as Long-Term Monitoring Updates.



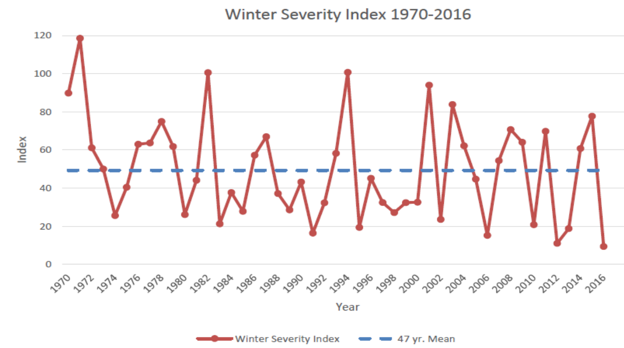
Data have been collected on VMC forest health monitoring plots since 1992.

2016 Weather Influences on Forest Health

Following multiple years during which tree health was shaped by wet springs and stormy summers, the primary influences in 2016 were the abnormally mild winter interrupted by a cold snap in mid-February, and dry weather starting in mid-May and continuing through the end of the growing season.

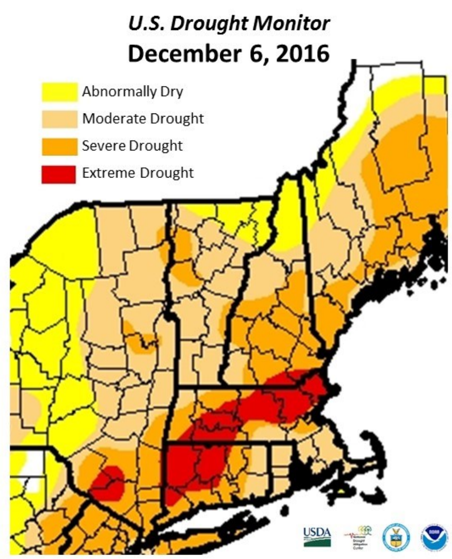
The cold snap in late February increased **winter injury to conifers**. It was so warm early in the month, that needles were beginning the process of de-acclimation, exchanging their cold-hardiness for a chance to get a jump on spring. Then the cold weather came and killed those no-longer-cold-hardy tissues. The fact that parts of Vermont were dry towards the end of 2015 may have played a role.


In the spring, winter injury was common on ornamental conifers and Christmas trees (Photo right: J. Horst).

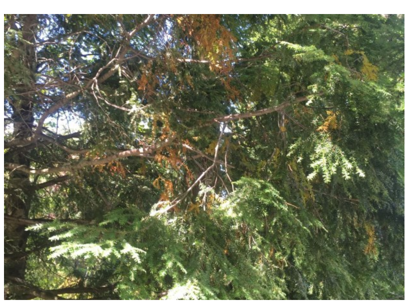


2016 started with an abnormally mild winter, the mildest recorded since the inception of the Winter Severity Index in 1970. (Data analysis and graph: Tim Appleton)

By mid-summer, symptoms of **drought** became noticeable. These included early color on sugar and red maple, early symptom development on trees affected by beech bark disease, and poor refoliation of defoliated trees. Later in the summer, brown margins developed on a variety of hardwoods, especially on shallow sites. There was also an increase in interior needle drop of conifers and premature leaf drop of ash and other hardwoods. Mid-season browning or off-color foliage on hardwoods, attributed to drought, was mapped on 7,924 acres.



Dry conditions resulted in early color on maples and interior needle drop of conifers. By late fall, the entire state was abnormally dry or in drought. (Map Author: Anthony Artusa, NOAA/NWS/NCEP/CPC http://droughtmonitor.unl.edu/)

By late fall, the entire state was abnormally dry or worse, although conditions were more severe in southern New England. Dry fall conditions led to a number of difficult-to-extinguish ground fires. Despite (or perhaps because of) drought conditions (see August Update), fall foliage was particularly stunning in some areas, with red maples and red oaks demonstrating how they got their names.

Hardwood Insects and Diseases

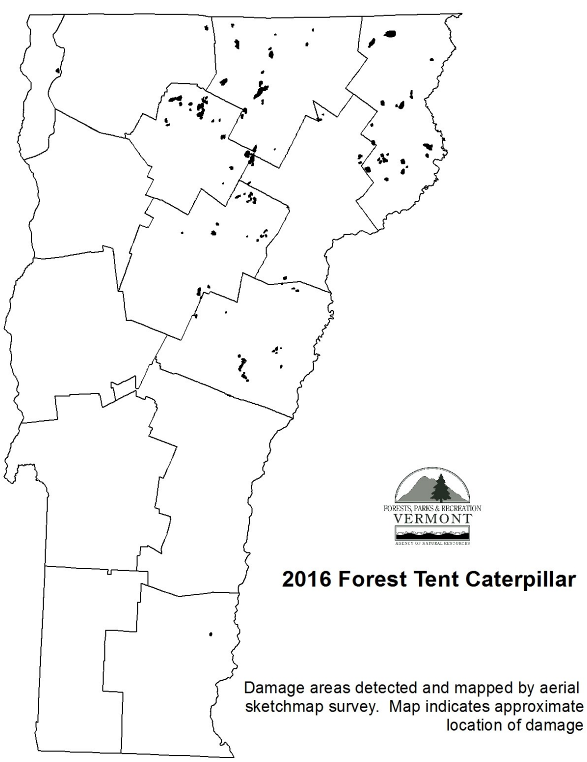
Populations of the native **forest tent caterpillar** (FTC) exploded, especially in north-central and northeastern Vermont; 24,278 acres of defoliation were mapped. The mapped area covers less than 1% of Vermont's northern hardwood forest type. By contrast, in 2006 at the peak of the most recent outbreak, about 10% of the northern hardwood forest type was defoliated. These defoliated areas mapped during 2016 aerial surveys are available on the ANR Natural Resources Atlas. (The "Forest Tent Caterpillar (2016)" layer is available under the "Forests, Parks and Recreation" theme.) The VT FPR Forest Tent Caterpillar Update describes the current status of forest tent caterpillar, and provides management information for sugar makers, forest land managers, and others concerned about protecting tree health.

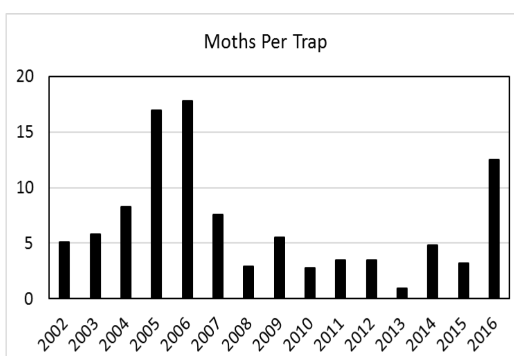
The defoliated area is likely to increase in 2017. Moth catches in all but one of our pheromone trap locations increased from 2015, with the statewide average trap catch in double digits for the first time since 2006. Overwintering egg mass surveys provide some indication of the risk of FTC defoliation for the following year. We are available to conduct these fall and winter surveys for maple sugar makers, by request. Sugar makers who may be interested in participating in a state-coordinated spray program, should contact the Vermont Department of Forests, Parks, and Recreation as soon as possible. The deadline to sign up is February 15th.

Forest tent caterpillar populations exploded in 2016. (Photo: R. Kelley)

Most trees can survive several years of defoliation. However, dry conditions last summer will be an important factor. While trees typically respond to early-season defoliation by sending out a new flush of leaves, this year, foliage remained thin because lack of water reduced refoliation success. Refoliated leaves were small, and sometimes, leaves were scorched or dropped to the ground, tender refoliated shoots wilted, and trees attempted a third flush of leaves. Even where refoliation was successful, dry conditions in 2016 have limited the new leaves' ability to replenish lost food. This will almost certainly affect wood production, and the amount of foliage and shoot growth next year. Prevent avoidable stress in defoliated stands by delaying thinning 1-3 years, using conservative tapping rates,

Forest tent caterpillar defoliation was widespread in north-central and northeastern Vermont, but was observed in scattered locations statewide. Dry conditions reduced refoliation success (Photo right: M. Isselhardt)





The number of moths trapped in 2016 increased from 2015, indicating that defoliation will be more widespread next year.

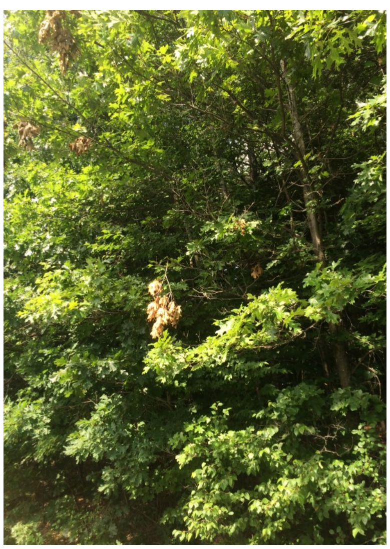
Maple webworm became surprisingly ubiquitous in some locations. Webworm moths lay their eggs in leaves rolled or tied by other insects like FTC that feed earlier in the season. Increased numbers of maple webworm have coincided in past years with FTC outbreaks, and the insect was linked to an episode of "maple blight" in the 1950s. Maple webworm larvae can be found on trees from early July to October. At first, they feed where the eggs were laid, but later web leaves together and feed on surrounding leaves.

Maple webworm is common during forest tent caterpillar outbreaks. (Photo right: R. Kelly)

Other hardwood insects observed in 2016 included several that feed on sugar maple foliage. There were significant populations of maple leafcutter in some locations and lesser levels of injury by maple trumpet skeletonizer and pear thrips.

Non-native satin moth caterpillars caused scattered heavy defoliation on poplar and willow. Light damage by the beech leaftier was observed statewide, with noticeable browning of lower foliage tied together by the feeding larva. Damage by oak twig pruner was also common. Its larvae burrow in twigs, leaving dead shoots hanging in the crown.

Beech leaftiers were noticeable on lower foliage throughout the state. (Photo: L. French)



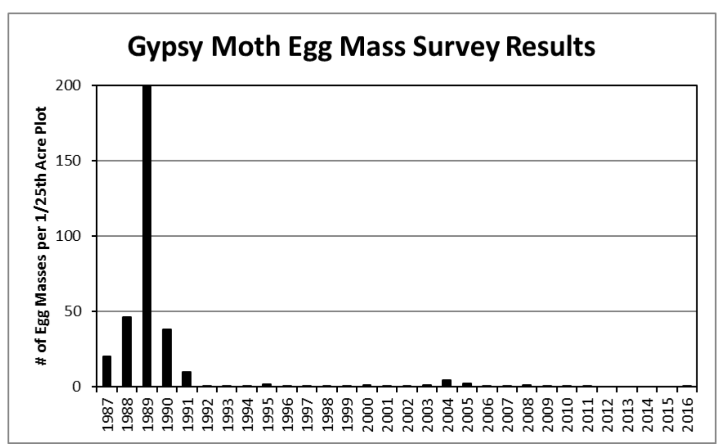
The oak twig pruner burrows in twigs, and leaves dead shoots hanging in the crown.

Gypsy moth defoliation was not observed in Vermont this year, although it was extensive elsewhere in New England. Egg mass monitoring plots indicate our populations will remain low in 2017.

The **browntail moth**, currently a serious pest in Maine, is not known to occur in Vermont. This non-native defoliator was here 100 years ago, with the last serious infestation in Vermont reported in 1917.

Thanks to dry conditions in spring 2016, there was very little anthracnose or other foliage diseases of hardwoods. An exception was **poplar leaf blight** on balsam poplar in riparian areas.

Beech bark disease remains a chronic cause of dieback and mortality, with damage mapped on 7,278 acres.

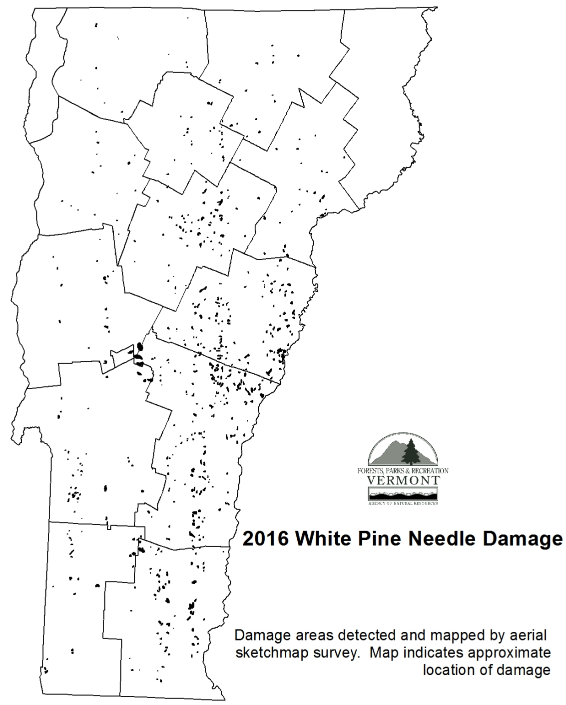


Egg mass monitoring plots indicate gypsy moth populations will remain low in 2017.

Softwood Insects and Diseases

White pine needle damage continued, with the condition even more widespread and severe than it has been in recent years. Although damage peaks in the spring, so was less noticeable during mid-summer aerial surveys, 30,666 acres were mapped. As summarized in a publication about dramatic needle browning and canopy dieback of eastern white pine produced by UMass, the cause is not fully understood.

Similar symptoms have been observed throughout New England and in New York. The large footprint suggests that weather is an important factor. Several fungi have been associated with the disease. One of them, the brown spot needle blight, is more likely to spread when weather in June is wet, so that disease, at least, may be less severe in 2017. This recent episode of damage was first reported in 2005, with widespread symptoms occurring annually since 2010. Research is continuing at UNH and by the US Forest Service. Since 2009, there has been a 10 – 60% decline in annual wood growth on affected pines.



White pine needle damage has been wide-spread since 2010. Damage was particu-larly severe in 2016. Although damage was less visible by mid-summer, when aerial surveys were completed, 30,666 acres were mapped.

Browning and dieback on hard pines, particularly Scots pine, remained common, and 554 acres of damage were mapped. **Brown spot needle blight** has caused repeated defoliation of Scots pine wherever that species has been planted. Shoot blight diseases and other pests have also been associated with these symptoms.

Fir mortality caused by **balsam woolly adelgid** is continuing with acres mapped increasing to 5,616 compared to 2,263 acres in 2015. Currently active heavy populations are very widely scattered, and the infestation has already collapsed in many mortality areas. However, where fir mortality is occurring, especially on upland sites and where large-crowned trees are dying first, consider this insect could be the cause, even if it is inconspicuous. A Vermont Forest Health leaflet on this insect describes its symptoms, impact, and management considerations.

Six sites where the balsam woolly adelgid predator, *Laricobius erichsonii*, was released in the early 1960s were visited in late spring to see if that beetle could be recovered, but no evidence of the predator was found.

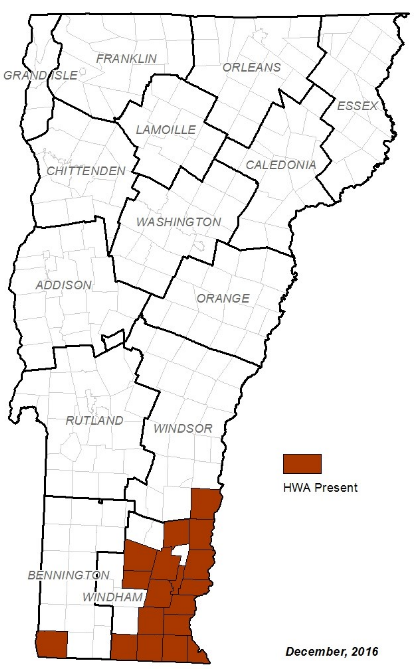
The white wool of balsam woolly adelgid (left) may be hard to find even where the insect has caused mortality (right). Balsam woolly adelgid is vulnerable to cold winters and doesn't survive on dead trees.

Reports of **red pine mortality** continued in 2016, with 743 acres mapped, scattered in eight counties. A research project, led by a doctoral student at the University of New Hampshire with funding from the US Forest Service, continues work to identify whether a primary pest or pathogen is responsible. The exotic insect, red pine scale, detected by this project in 2015 in Rutland and Orange Counties, continues to be a suspect.

Although it remains premature to say that red pine scale is the sole "cause" of this mortality, best practices would be to take precautions to reduce possible spread. Harvest declining red pine in winter when the insect is not capable of moving on its own, chip tops so twigs and branches dry out more quickly, and ensure equipment is free of plant material before leaving the site.

Research is underway to determine the cause of red pine mortality, which has been mapped in eight Vermont counties. (Photo: K. Beland)

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



Drought effects were likely to have been the "last straw" leading to occasional mortality of blue spruce repeatedly defoliated by **Rhizosphaera needlecast**. The cause of thin crowns and occasional mortality in northeastern Vermont white spruce stands may be related to this disease, but as of now, the cause is undetermined.

Exotic Forest Pests

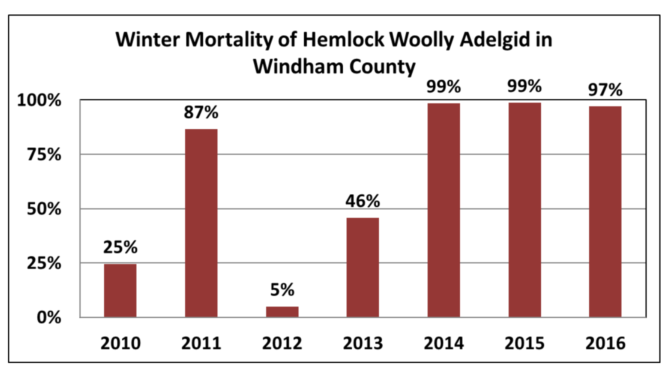
Vermont's **hemlock woolly adelgid** infestation remains centered primarily in Windham County, with small spots in Springfield and Pownal. We continue to conduct intensive surveys to delineate this infestation, and hemlock woolly adelgid was detected in Westminster for the first time in 2016. Fifty-five sites were surveyed, with volunteers completing nearly half of the survey work.

The limited spread is due in large part to an unexpectedly high winter mortality rate, which averaged 97% in our monitoring sites. High mortality throughout the northeast is attributed to the cold snap in late February. Earlier warm weather had prompted the insects to become less cold-hardy, making them vulnerable to the sudden cold.

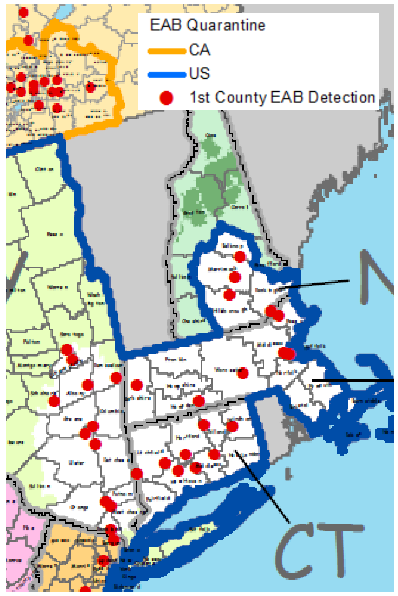
No predatory beetles, *Laricobius nigrinus,* were recovered during fall sampling of the three sites where they had been released, so the status of this introduction remains unknown.

While recent adelgid mortality rates have been high enough to slow its spread, trees are still threatened. Some stands of hemlock are in noticeable decline, with 322 acres mapped during aerial surveys, compared to 83 acres in 2015. Compounding the situation are the spread of **elongate hemlock scale** into southeastern Windham County, and the dry summer leaving the hemlock woolly adelgid infested area in drought conditions for a substantial period.

Hemlock woolly adelgid spread has been limited, with the only new town detection in Westminster. High overwintering mortality of the insect is attributed to the February cold snap following warm weather earlier in the winter. Some infested stands of hemlock are in noticeable decline (arrow).



Emerald ash borer (EAB) is not known to occur in Vermont and was not detected by survey. However, new counties were found to be infested in Massachusetts and Connecticut in 2016, and the insect is now reported from thirty states. Anyone using ash products from infested states should be aware of current regulations. Information is available by contacting USDA APHIS, AAFM, or an FPR office below.



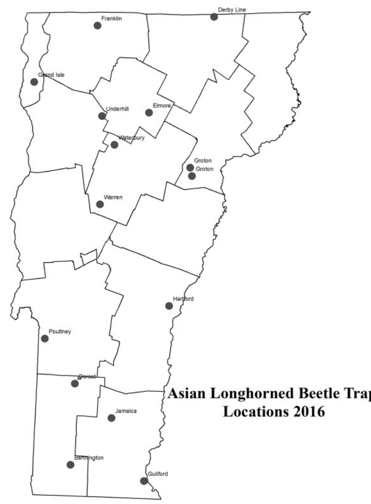
As of December 2016, four counties in New Hampshire, and all of New York, Connecticut and Massachusetts are included in the emerald ash borer quarantine area.

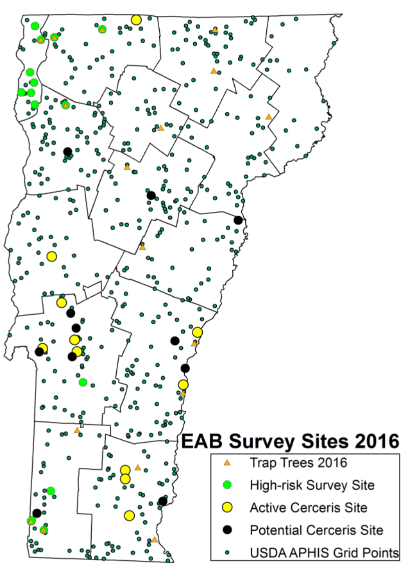
Map data from USDA APHIS, 12/20/16. For current information visit: www.aphis.usda.gov/plant_health/plant_pest_info/

An aggressive emerald ash borer detection effort continues in Vermont. Building on the 2015 intensive trapping survey, with the assistance of volunteers we continued with 5 high risk sites in southwestern Vermont, and 10 new sites in the northwestern corner of the state. USDA APHIS continued its statewide survey by deploying an additional 515 purple traps throughout Vermont.

In 2016, wasp watchers made a total of 136 visits to 42 known and potential Cerceris nest sites. Twenty of the sites were active enough to warrant routine monitoring, but no emerald ash borers were found amongst 719 beetles that were collected. We are also using girdled trap trees as a detection tool. In 2016, 16 trap trees in high risk areas in ten counties were girdled in the spring, then harvested in November and peeled to look for signs of EAB.

Asian longhorned beetle is not known to occur in Vermont, and was not found in any of the 15 traps deployed in 2016.





Emerald ash borer has not been detected in Vermont in spite of intensive surveys. In 2016, 15 high risk sites in SW and NW Vermont were monitored with green and purple traps. USDA APHIS led the deployment of 515 additional traps statewide. Volunteers assisted with visiting 42 Cerceris sites (photo) and with peeling 16 trap trees.

Asian longhorned beetle (ALB), is not known to occur in Vermont and no forest management changes are recommended in anticipation of the insect. The natural spread of ALB is relatively slow when compared to some other invasive species such as the emerald ash borer. Nonetheless, education and outreach, that can promote early detection, remain a priority. Early detection is particularly important with Asian longhorned beetle, since small, newly-discovered populations can be successfully eradicated. For the fourth year, we deployed panel traps in locations with a high risk that out-of-state firewood might have been in the area. Fifteen traps were checked bi-weekly between early July and late September, and no ALB were collected during the survey.

AAFM and USDA APHIS continue efforts to trap non-native forest insects.

Sirex woodwasp has been trapped in six Vermont counties since 2007. In 2016, it was trapped again in Addison, Rutland, and Windham Counties. No new observations of Sirex infesting trees were reported.

The **common pine shoot beetle,** which has been found in many Vermont counties since it was detected in 1999, was trapped this year in Chittenden County. 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.

The **brown marmorated stinkbug** was also trapped in Chittenden County.

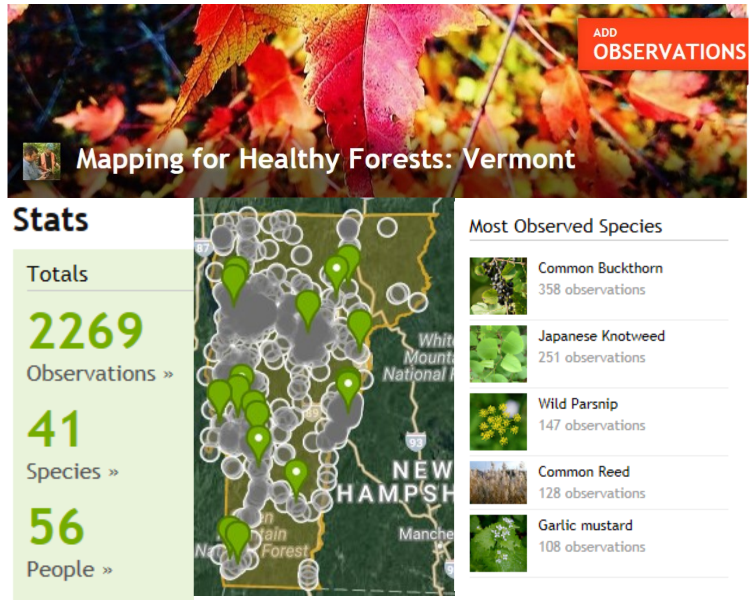
Dry conditions seem to have accelerated the symptoms of **Dutch Elm Disease**, with widespread observations of brown, curled leaves on flagging branches. Researchers at the US Forest Service Northern Research Station are working to identify American elms that are resistant and are requesting samples of diseased elms from which they can isolate fungi. To participate contact Jessie Glaeser.

Other **Non-Native Insects and Diseases that Have Not Been Observed** in Vermont include winter moth, and the agents that cause oak wilt, thousand cankers disease, and sudden oak death.

Non-Native Invasive Plants

Non-native invasive plant management (NNIPM) efforts grew in 2016, with progress on mapping, control, outreach and education made possible through several grant funded opportunities, and varied strategies within local communities. The statewide invasive plant coordinator within FPR led over 28 workshops for a variety of stakeholders, and worked with multiple state departments and agencies to unify Vermont's approach to NNIPM. Department staff continued to provide outreach and information about invasive plants to the public and professionals, building the capacity to continue to manage invasive terrestrial plants on state lands across Vermont.

In 2016, over 20 state-owned properties were managed to remove NNIP. Some sites involved large-scale treatments while others required more localized means. Volunteer hours helped bolster these efforts in many cases – nearly 600 volunteers and over 2,000 volunteer hours were logged for either education or direct management of NNIP.



The Mapping for Healthy Forests website helps assess treatment areas for non-native invasive plant management on town and private lands.

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

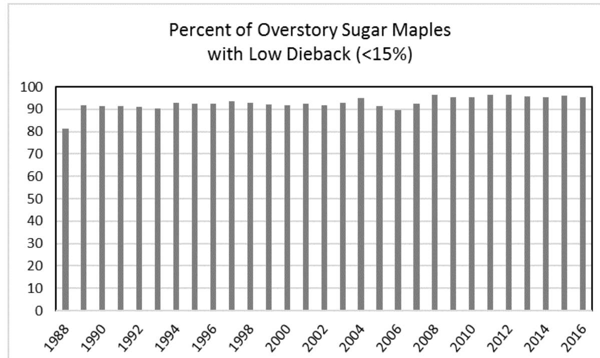
In 2016, invasive plant removal activities were conducted on 20 state-owned properties. Nearly 600 volunteers were involved with invasive plant management or education. (Photo: H. Ewing)

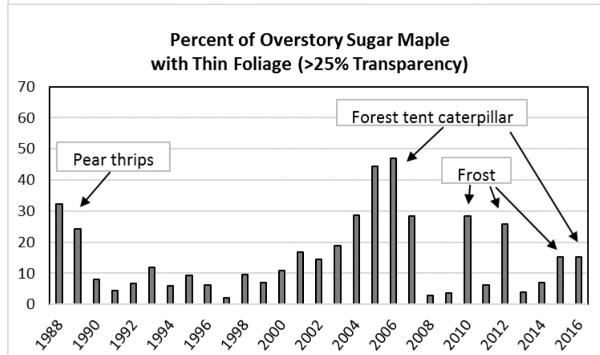
Monitoring Forest Health

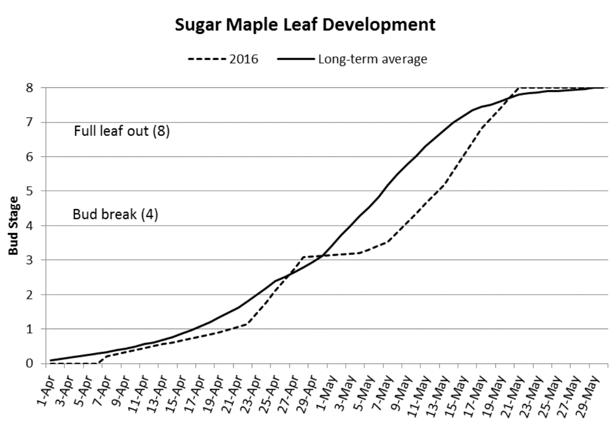
Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 95% of trees were rated as having low dieback (less than 15%). Of the 36 plots, 8 had moderate-heavy defoliation (22%) due to forest tent caterpillar and 20 had light defoliation (55%). The frequency of thin foliage was similar to last year when frost injury affected foliage density. Foliage transparency is sensitive to current stress factors. Other spikes in transparency have been due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007), and pear thrips (1988-1989).

In addition, 42 forest health monitoring plots were sampled across Vermont as part of the Vermont Monitoring Cooperative. Dieback increased in the original 23 sites on Mount Mansfield and Lye Brook Wilderness Area. Foliage transparency remained steady. Unusual lack of snow cover the previous winter, combined with dry summer conditions were contributing factors to increased dieback.

As part of ongoing phenology monitoring, sugar maple trees were monitored for the timing of budbreak and leaf out in the spring. Leaf bud expansion was later than normal; budbreak on May 9th was nearly 6 days later than the long-term average following a cool spell in early May. However, full leaf-out was nearly indistinguishable from the long-term average.







Over 95% of sugar maples were rated as having low dieback (<15%) in North American Maple Project plots (above). Thin foliage was mostly due to forest tent caterpillar defoliation.

In spring phenology monitoring plots, the timing of sugar maple budbreak was normal (left).

For more information, contact the Forest Biology Laboratory at 802-879-5687.	Windsor & Windham Counties..........................	Springfield (802) 885-8845
	Bennington & Rutland Counties.......................	Rutland (802) 786-0060
To contact Forest Resource Protection or County Foresters:	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 Protection
US Forest Service
Northeastern Area State and Private Forestry
271 Mast Rd.
Durham, NH 03824
603–868–7708
http://www.na.fs.fed.us

Vermont Department of Forests, Parks and Recreation
1 National Life Drive, Davis 2
Montpelier, VT 05620-3801
802-828-1531
http://fpr.vermont.gov/

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.

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FIGURES AND TABLES

FIGURES

TABLES

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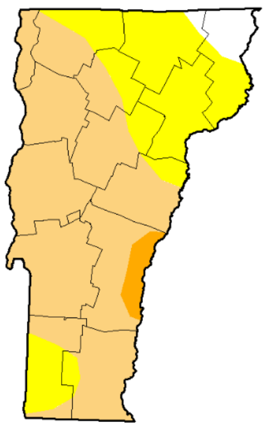


Figure 1. Yearend level of drought. December 27, 2016.

2016 Weather Summary

2016 is over and the final temperature and precipitation numbers have been tallied. As expected, 2016 was a warm and dry year.

Vermont ended the year with the 2nd warmest temperature on record based on readings at the National Weather Service office in Burlington, Vermont. Mt. Mansfield and North Springfield also recorded the 2nd warmest temps and numerous locations around the state recorded one of the top 5 warmest years.

The shortfall in snowfall last winter was just the beginning of a continuing precipitation deficit through much of 2016 covering most of Vermont and the northeastern United States. However, abnormally dry conditions first showed up in Vermont in Bennington and Windham counties in early August of 2015. Since then, drought spread and intensified throughout 2016. On December 27, 2016, some level of drought remained in place for all of Vermont except northern Essex county (Figure 1).

Winter 2015-2016

From December 2015 through March 2016, temperatures were 2° to 10° above normal. In January and February, above normal departures in double digits were common at locations all over the state. Temps more than 20° above normal were reported periodically over this period. On January 10, a strong thunderstorm with heavy rain, hail and lightning occurred. Strong winds accompanied the storm especially on the western slopes of the Green Mountains with nearly 70 mph gusts. Downed trees in the Underhill and Cambridge area were reported. While severe weather is not all that common in January, when it's 53° anything's possible.

In February, a cold snap from the 11th to the 15th saw the first extended period of below normal weather. This four-day single digit/sub-zero chill was followed on the 16th with temps more than 10° warmer than normal.

During this period, Burlington set several records. On January 31st, the warmest November to January period with an average mean temperature of 35.7° was recorded. The previous record was 34.1° set in 2002. On February 1, the high temperature reached 53° at 6:45 a.m. The old record high was 50° set in 1988. Again, on February 3, a 50° high broke the old record of 49° back in 1991. And, to top it off, on February 29th a 50° high tied the old record set in 1896!

Not only were temps warm but snow was lacking as well… a bad thing for the ski areas and others who depend on winter snow but a good thing for road budgets and heating bills. From October to April, snowfall was 30 to 60 inches below normal statewide.

Precipitation (snow, rain, sleet, ice, etc.) in general was below normal for most of the state all year although February and early March were wetter. During the winter with the frozen ground in place, much of this moisture was not absorbed into the soil. A heavy rain on February 24 was a good example. Instead of snow, between an 1-2+" of rain fell across the state melting any snow that had stuck around. Ice jams and flooding were reported in several locations including along the Lamoille and Missisquoi rivers. As a result, a sharp rise in Lake Champlain occurred. The lake level jumped from 96 to 97.24 feet in just over 2 days. Normal for the end of February is 95.6 feet.

Spring, 2016

North central/northeast Vermont (not including upper elevations) had 2 to 16 inches of snow on the ground in early March. Recording breaking temperatures on March 9, however, brought that meager total down to 0 to 8 inches.

Records fell all over the northeastern U.S. when temps soared into the upper 60's and 70's on the 9th. In Burlington, a reading of 68° broke the previous record of 66° set in 2002. Before the day was over, Burlington reached 70°, the earliest 70° reading ever! Montpelier recorded 66°, breaking their previous record of 61° set in 2000 as did St. Johnsbury with 65°, previous record of 61° was also set in 2000.

Snow was gone two days later except for the high elevations and northern Orleans and Essex counties (Figure 2).

Figure 2. No snow at Brandon Gap, 2,710 feet elevation on March 12, 2016. Photo: T.Greaves

By the end of March, spring fire season heated up. With little to no snow cover all winter, the potential for an early start was anticipated but most of the fire activity was minimal through mid-April. It is interesting to note, however, that there were as many fires in the Northeastern part of the state as in the Champlain valley and southern Vermont due to lack of winter snow. Normally, fire activity starts in the valleys and works north and into the higher elevations.

Winter arrived in April. By April 9th, three snow events had dusted the ground with snow and temperatures were 10° to 18° below normal, values more typical of early March than April. Cold temps nipped early buds that had gotten a jump start due to warm March temps. Fire activity stalled as well.

By mid-month, a stretch of pleasant spring weather returned with dry, cool days. Temps remained below normal for the most part, although there were warm days here and there. In fact, Burlington reached 75° on April 21st and similar temps were reported all over the state. Along with the sun came low humidity and gusty winds...the formula for high fire danger. From April 13 to 25, Vermont fire wardens reported 70 grass and brush fires burning 185 acres. The largest fire during this time period was a 47-acre fire in a remote location in Chelsea that started from an undetermined cause. Fire season was not over, but this would be the most active period all year.

Chilly, snowy weather returned near the end of the month again slowing the greening process that had surged during mid-month. Between 2 to 5 inches of snow fell across the state on April 26 with the highest amounts in central Vermont. Burlington's 2.1 inches was more snow than the city received all of March!

Even though much of May had below normal temperatures, when it ended, the statewide average for the month was above normal by about 2 degrees. Average precipitation was 2 inches below normal. As of May 31, Franklin, Orleans, Windsor and Windham counties were classified as abnormally dry.

On May 9, there were snow flurries, and on May 10th, early morning temps were in the 20's and 30's with reports of frost damage. On the morning of May 16, snow covered the ground, with a trace in Burlington, 4 inches in Hyde Park and amounts in between across northern Vermont and the southern mountains. By afternoon it was gone.

Burlington hit a record for the month of May of 9 consecutive days with 80+ temps, including 2 days with 90 or above. A record high of 91°was set in Burlington on May 27. On May 29, the Vermont City Marathon was cut short when multiple medical problems resulted from the high heat and humidity. Before the day was done, a severe thunderstorm in the St. Albans/Swanton/Sheldon area brought heavy rain and hail. Strong winds accompanied the storm bringing down trees and power lines in Franklin county.

Summer, 2016

Summer temperatures averaged above normal with June nearly normal, July above normal and August warmer still. Burlington reached 90° or greater 12 times in 2016 when 5 times a year is normal! Much of the rest of the state felt the heat as well. Dry conditions continued through the summer even after a wetter than normal August. Despite the August rain, all of Vermont remained abnormally dry by the end of the month except for Caledonia county. Throughout the summer, Chittenden county and other areas of the Champlain valley missed out on several scattered rain events while Caledonia county managed to catch most of them.

June 5th was an exception when heavy rain in Burlington set a daily maximum rainfall record of 1.45 inches breaking the old record of 1.17 inches set in 2002. Also on June 5th, Montpelier set a daily maximum rainfall record with 1.36 inches. This broke the old record of 1.08 inches set in 2006.

A blast of cold Canadian air on June 9 left high temperatures in Vermont struggling to get out of the 40's in the Northeast Kingdom (NEK) and 50's across the rest of northern Vermont. Temps moderated somewhat the next couple of days, but dipped again on June 12 accompanied by showers and gusty winds. Snow flurries were observed on Mt. Mansfield.

A severe storm on June 29, brought rain to scattered locations. Eden Mills topped the 24-hour precipitation chart with 5.30 inches of rain, almost 3 inches falling in just over an hour and nearly 5 inches in 3 hours! Just 10 miles away in Eden Falls, less than a quarter inch fell. Strong winds caused some tree damage in parts of Swanton and a lightning strike sparked a South Hero house fire.

By July, impacts of drought were beginning to show. Stream flow on all major rivers was below normal resulting in a below normal lake level for Lake Champlain. Moderate drought was in place in southeastern Vermont where lawns were beginning to brown and crops were struggling to grow. Maples defoliated by forest tent caterpillar failed to re-foliate in some of the heavier defoliated sugarbushes in Orleans and Essex counties. The aerial survey observed areas of early color on sugar and red maple throughout the state.

July 4 was dry for the first time in 5 years but stormy weather followed soon after. From July 13-18, heat and humidity triggered bouts of scattered severe thunderstorms and heavy rains in some locations. Damaging winds, hail, downed trees, and power outages were reported. On Saturday, July 23, strong storms and damaging winds blew through much of New England and the Northeast, leaving thousands without power. Sadly, a man from Hubbardton was killed by a falling tree. Boaters were caught out on Lake Champlain and Lake Bomoseen swamping the Coast Guard and other public safety agencies with distress calls.

August was hot. Temperatures were from 2° to 6° warmer than normal for the month across the state. Burlington's 73.7° average temperature was the highest on record, the old record from 1947 was 73.1°. By the end of August, Burlington's meteorological summer (June 1 to August 31) was the 2nd hottest on record. Elsewhere in the state, on August 11, Montpelier/Barre airport was 90° breaking the old record of 88° set in 1988. Mount Mansfield also broke a record that day with a temperature of 76°. The old record was 74° set in 2002. Normally, summer heat is accompanied by high humidity. That was not the case though for early August as many of those hot days saw low humidity, a rare dry heat.

Fall, 2016

In the August edition of the Vermont Forest Health Insect & Disease Observations, we did a story on drought's affect on fall foliage. As noted, "some of our best foliage years follow dry summers because, most often, dry weather brings out the reds, thanks to some details of plant physiology." As it turned out, the foliage season of 2016 did not disappoint! Old timers claimed it was the BEST foliage season they had ever seen! It was spectacular…

The drought deepened during the fall. By the end of September, a band of moderate drought stretched along Lake Champlain in Chittenden, Addison and Rutland counties across the state to Windsor and Windham counties. Trees already stressed, such as elms by Dutch elm disease, blue spruce repeatedly defoliated by Rhizosphaera needlecast, and shallow-rooted landscape trees, succumbed to drought. Fire danger indicators were at all time highs in the Champlain valley. A few small fires were reported.

Fall temperatures were above normal. The first frost of the season was on September 16 in the NEK but by the 18th temps rebounded into the 80's around the state. On Sept. 22 the first day of fall, Burlington's high was 84°, the 85th day of 80° temps in 2016. With the warm up, the growing season in the NEK was not declared over until September 26.

By early October, severe drought was noted for the first time all year in southern Grand Isle and parts of Chittenden county. Drought worsened through October and by mid month, severe drought spread from Chittenden and Addison to Rutland and Windsor counties. The rest of the state was in moderate drought except for the NEK and eastern Franklin county which remained abnormally dry. Towns with spring fed water and shallow wells began water conservation. In mid October through mid November, several small wildfires were ignited from various causes and were difficult to extinguish due to dry surface and soil fuels.

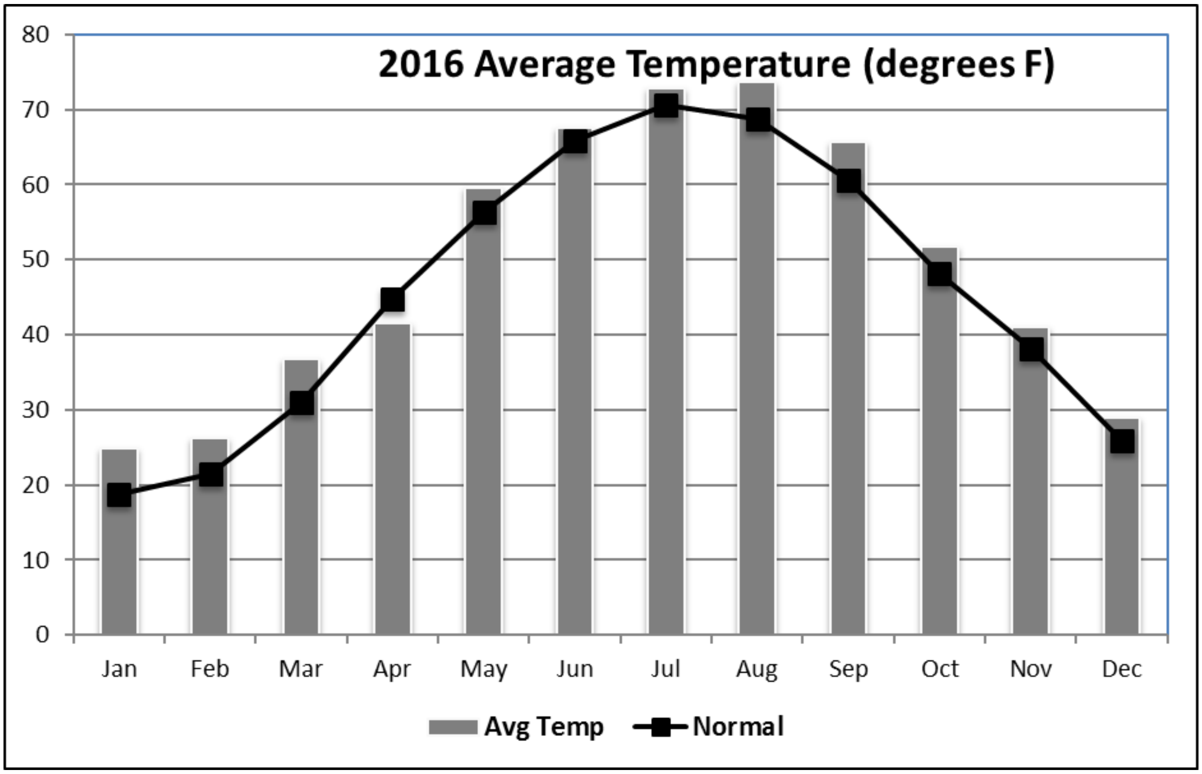
The first snows of the season arrived on October 23 and again on October 28 concentrating mainly on mid to upper elevations. Ski areas got a early shot of natural snow to start their season. Meanwhile, foliage lingered on...

It was early October before foliage peaked in northern Vermont. Warm days, chilly nights and no wind storms kept the leaves on the trees through October and even into November in southern Vermont and the Champlain valley. Social media erupted with photos and videos. This awesome season was well documented including drone's eye views like this one, https://www.youtube.com/watch?v=nvt3G0Th8SM.

Drought conditions did improve somewhat in November and December. A heavy snow on November 20-21 caused power failures and tree damage statewide but hardest hit was southern Vermont. Woodford reported 26 inches of snow. Strong winds brought down more trees and powerlines on December 1 and on December 16, winds and cold temps combined to bring wind chills down to -60° on Mt. Mansfield, -43° in Ludlow and -37° in Walden. These cold temps started ice forming on lakes and rivers. On December 21, the National Weather Service in Burlington posted a satellite image of Lake Champlain showing where ice had formed. They noted "we'd show a shot from 2015, but it was 68F on Christmas Eve, so kind of hard to find ice."

We did have a white Christmas in 2016 with much more seasonal temps. On December 29, more snow arrived with 1-2 inches reported in western Vermont, 4-8 in the northeast and southwestern parts of the state and 6-9 inches in south central and eastern Vermont. More was expected, snow lovers were disappointed but winter is far from over. Meanwhile the drought lingers into 2017.

Figures 3-12 and Tables 1-4 *provide details on 2016 temperatures, precipitation and phenological observations.*



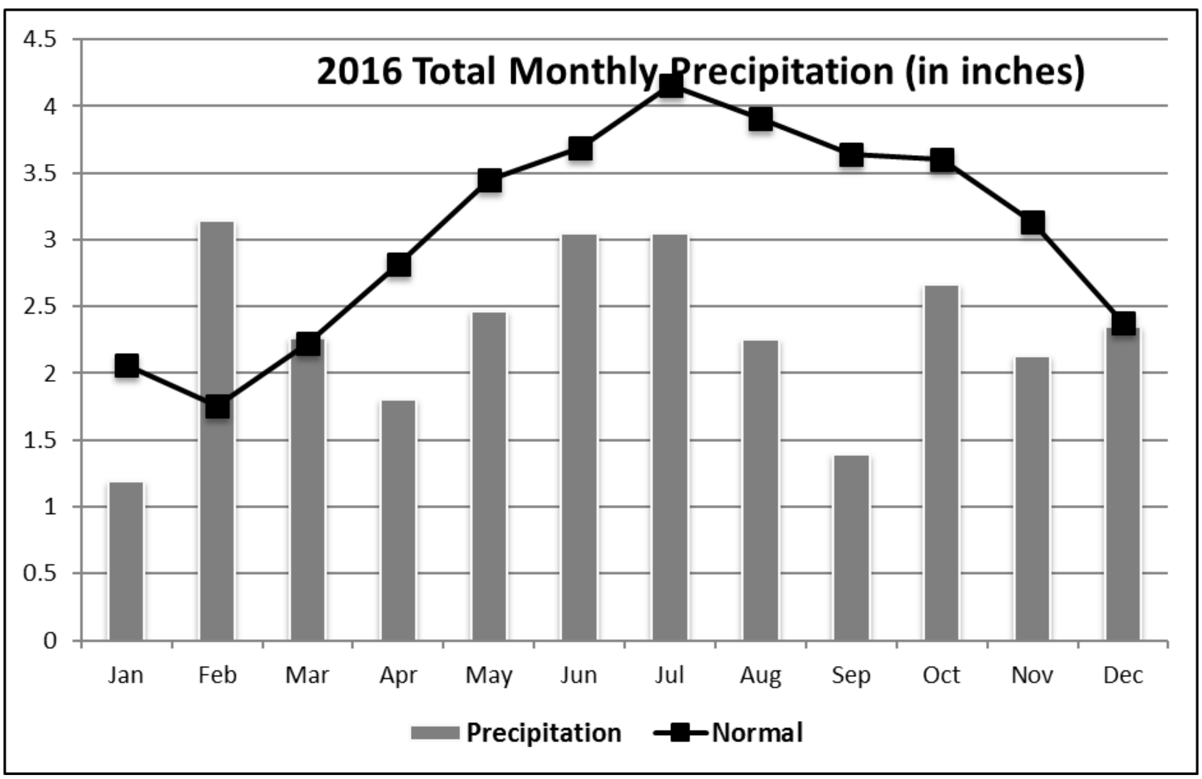


Figure 3. Monthly average temperature and total monthly precipitation in 2016, compared to normal for Burlington, Vermont. (Normals are for years 1981-2010.) *Source: National Weather Service, Burlington.*

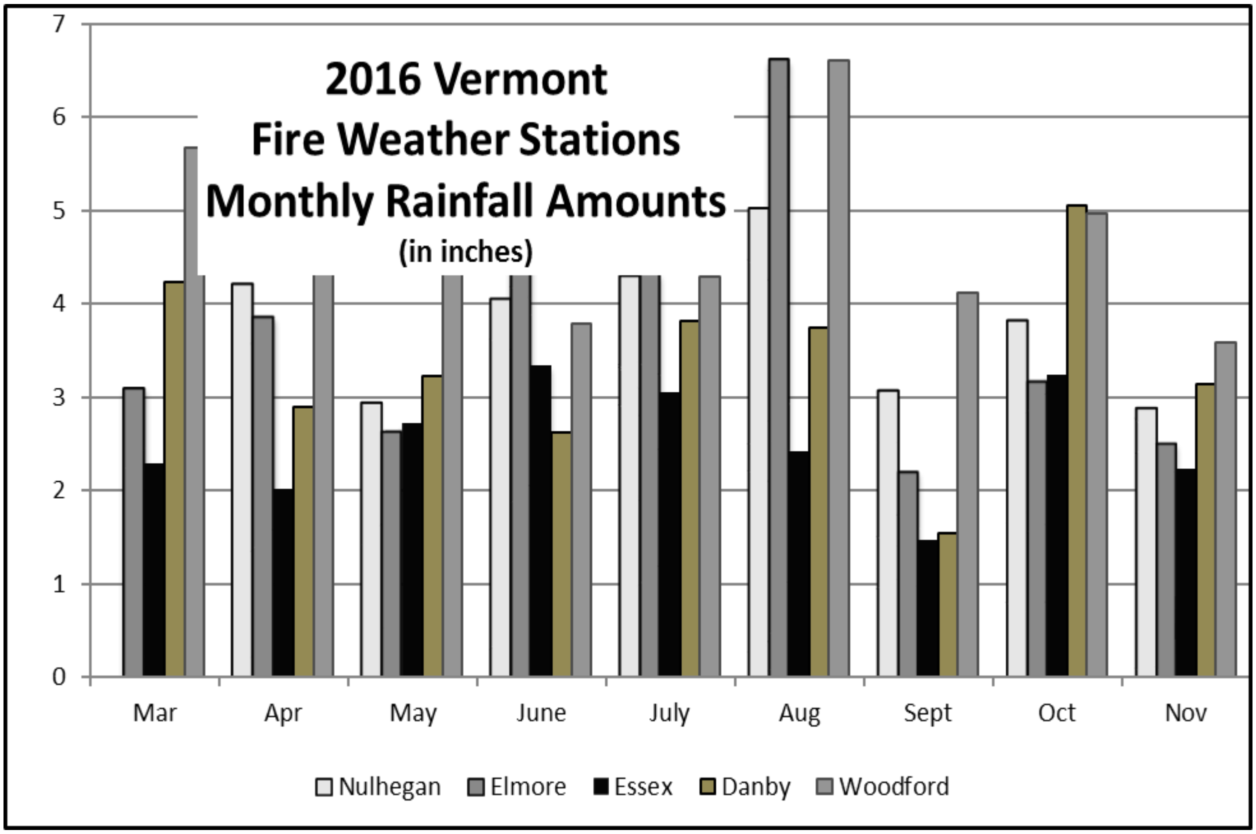


Figure 4. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, March-November, 2016.

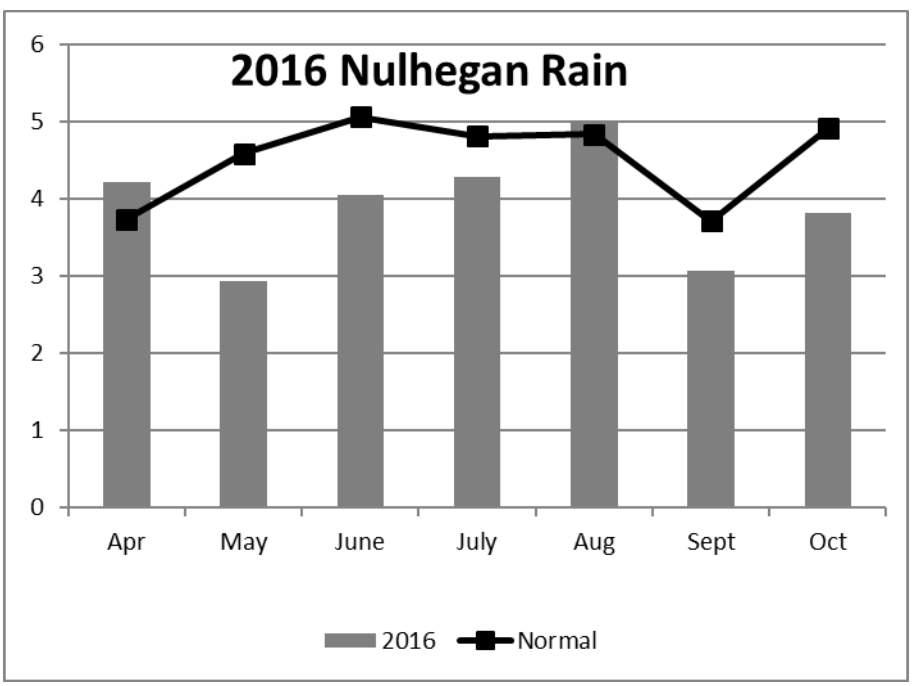


Figure 5. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, Vermont compared to normal through fire season, April-October, 2016. Normal is based on 14 years of data.

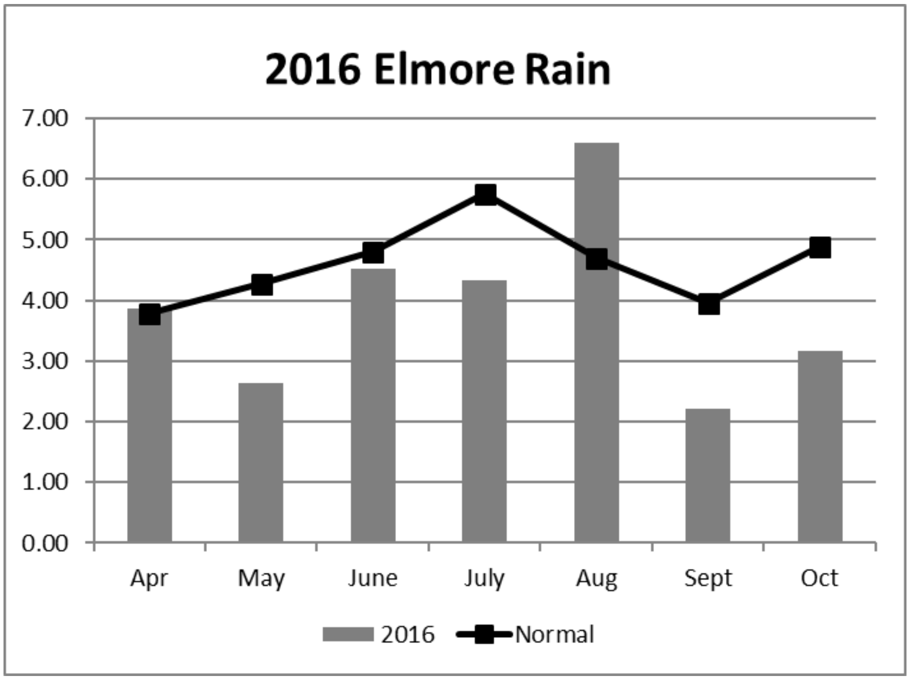


Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, Vermont compared to normal through fire season, April-October, 2016. Normal is based on 22 years of data.

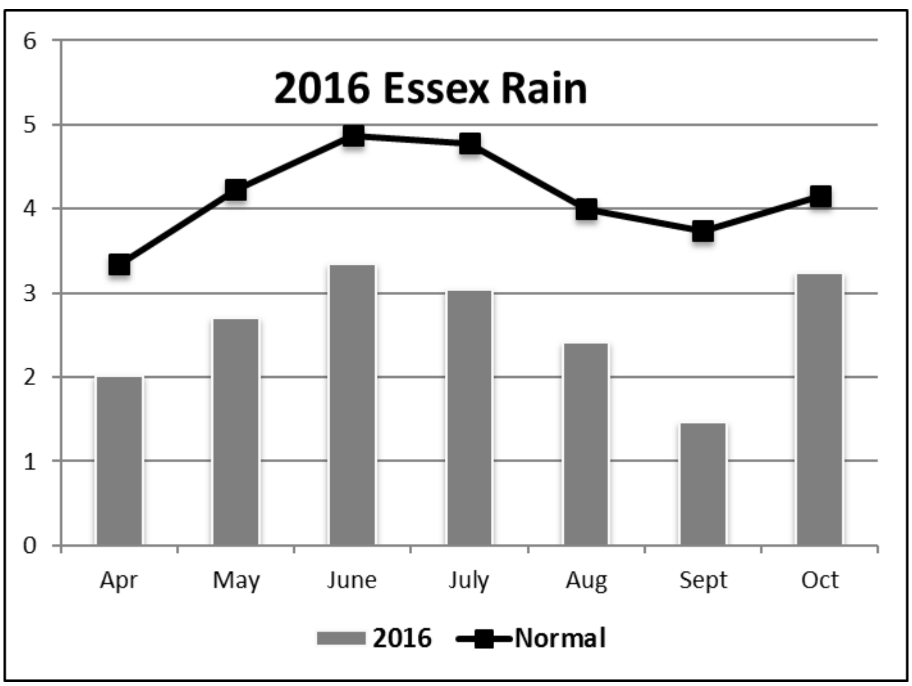


Figure 7. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, Vermont compared to normal through fire season, April-October, 2016. Normal is based on 23 years of data.

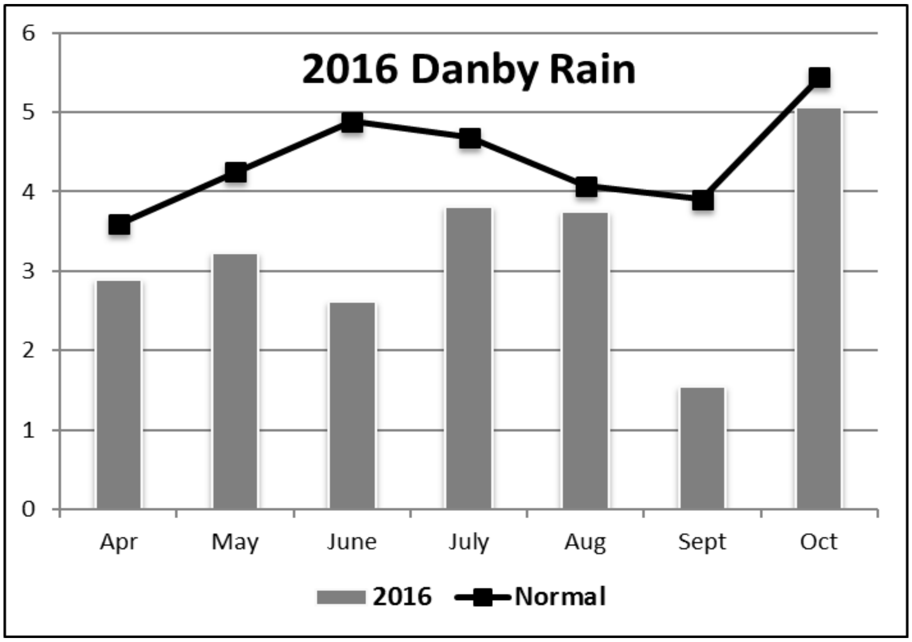


Figure 8. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal through fire season, April-October, 2016. Normal is based on 16 years of data.

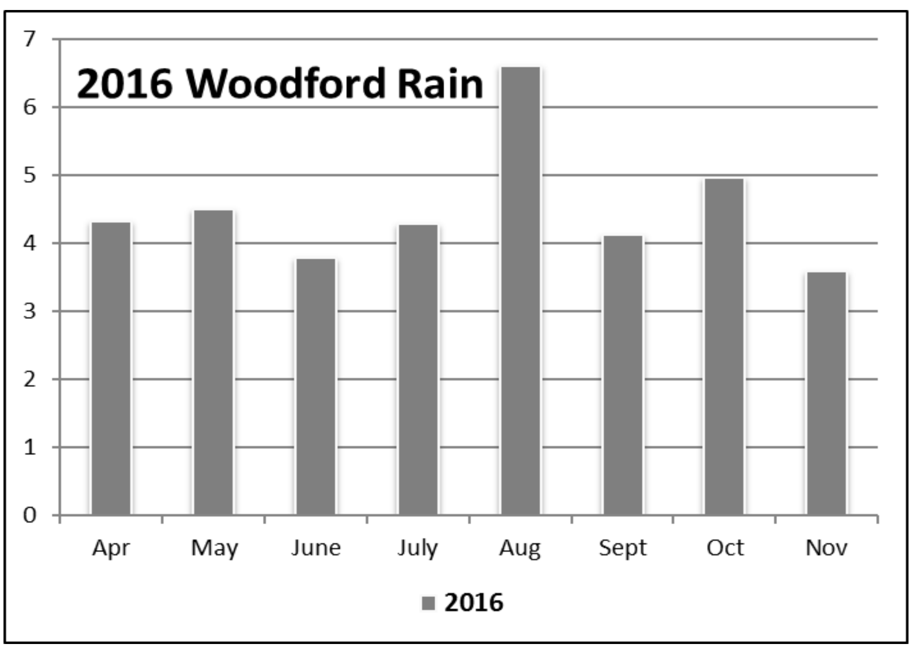


Figure 9. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont through fire season, April-November, 2016.

Spring Bud Break and Leaf Out at Mount Mansfield and throughout Vermont

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 work with the Vermont Monitoring Cooperative. Sugar maple leaf bud expansion was later than normal in 2016. Budbreak on May 9th was nearly 6 days later than the long-term average following a cool spell in early May. Full leaf-out was nearly indistinguishable from the long-term average (Figures 10 and 11), but was two days later than in 2015.

A broader selection of species was monitored for vegetative bud development throughout the spring in Vermont (Table 1). Trees that were monitored will be incorporated into annual phenology measures in order to evaluate the influence of climate on sensitive and valuable species in the state.

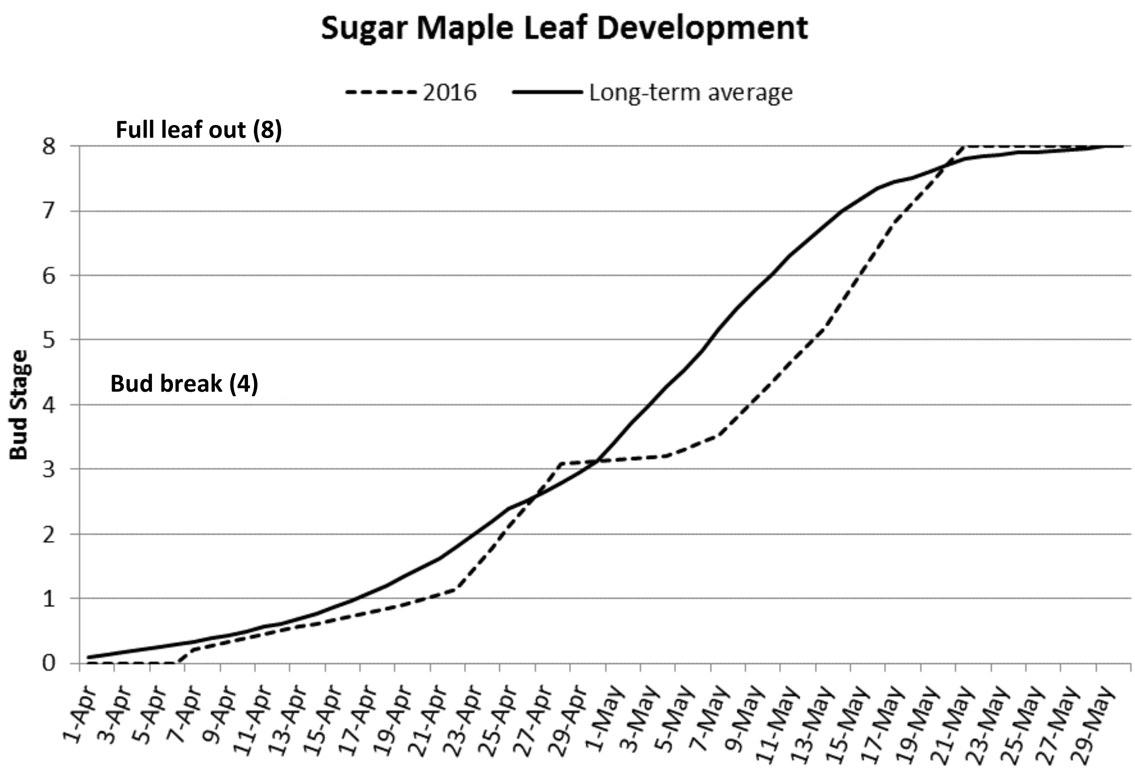


Figure 10. Sugar maple bud break and leaf-out at Proctor Maple Research Center, Underhill, Vermont. Note: bud stage 4 = bud break, bud stage 8 = full leaf-out.

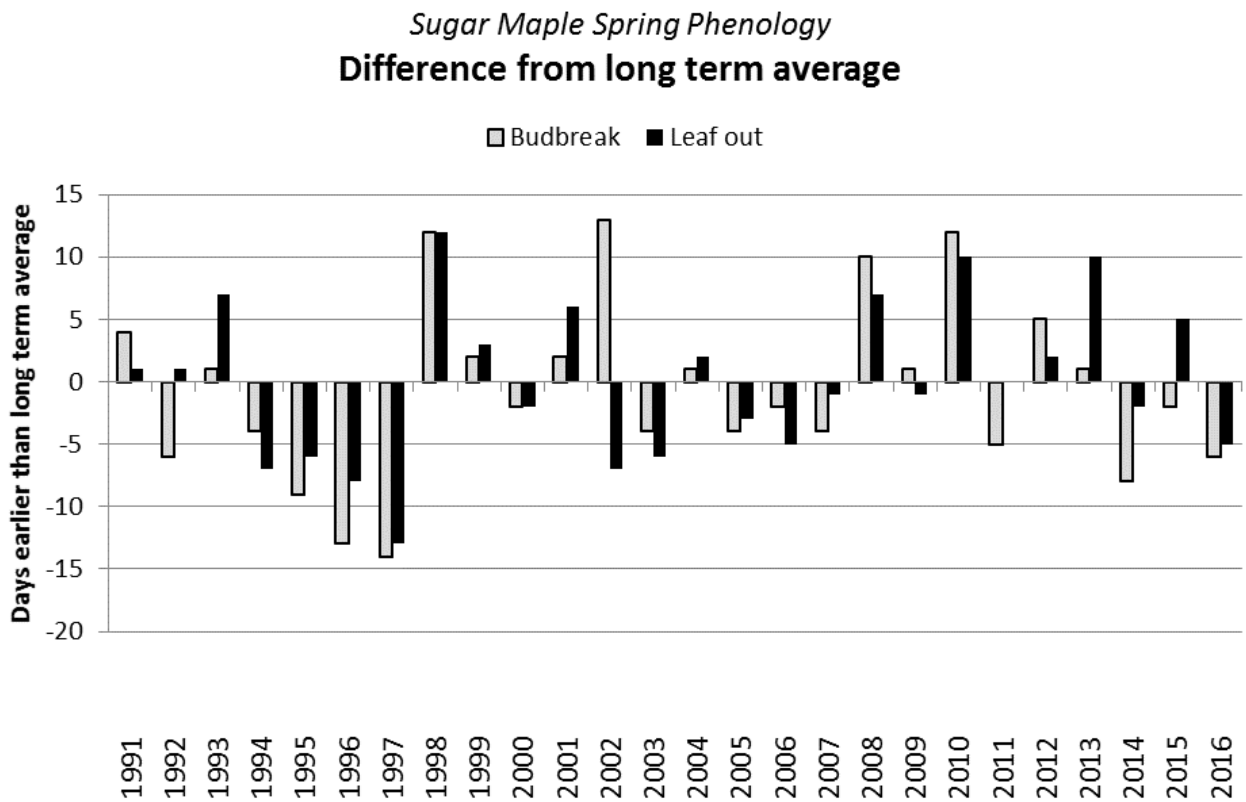


Figure 11. The timing of sugar maple bud break and leaf-out compared to the long-term (25 year) average of trees monitored at the Proctor Maple Research Center, Underhill, Vermont.

Table 1. Dates of vegetative bud development for species at five locations throughout Vermont.

Species	Location	Bud swell	Bud break	Leaf-out
Sugar maple	Underhill	4/21	5/9	5/21
Red maple	Underhill	4/18	5/9	5/25
White ash	Underhill	5/3	5/11	6/1
Yellow birch	Underhill	4/26	5/9	5/25
Balsam fir	Lincoln	5/13	5/22	5/30
Red spruce	Lincoln	5/22	6/4	6/20
Eastern hemlock	Springfield	5/15	5/20	5/26

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 12). 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. Sugar maple trees at the Proctor Maple Research Center (1400 feet) were later than the long-term average (1991-2016) for both timing of color and progression of leaf drop (Tables 2 and 3). In addition, all species experienced later peak color than the long-term average (Table 4).

Figure 12. Timing of fall color (Figure 12 a-f) and leaf drop were monitored at three elevations on Mount Mansfield in 2016: 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.

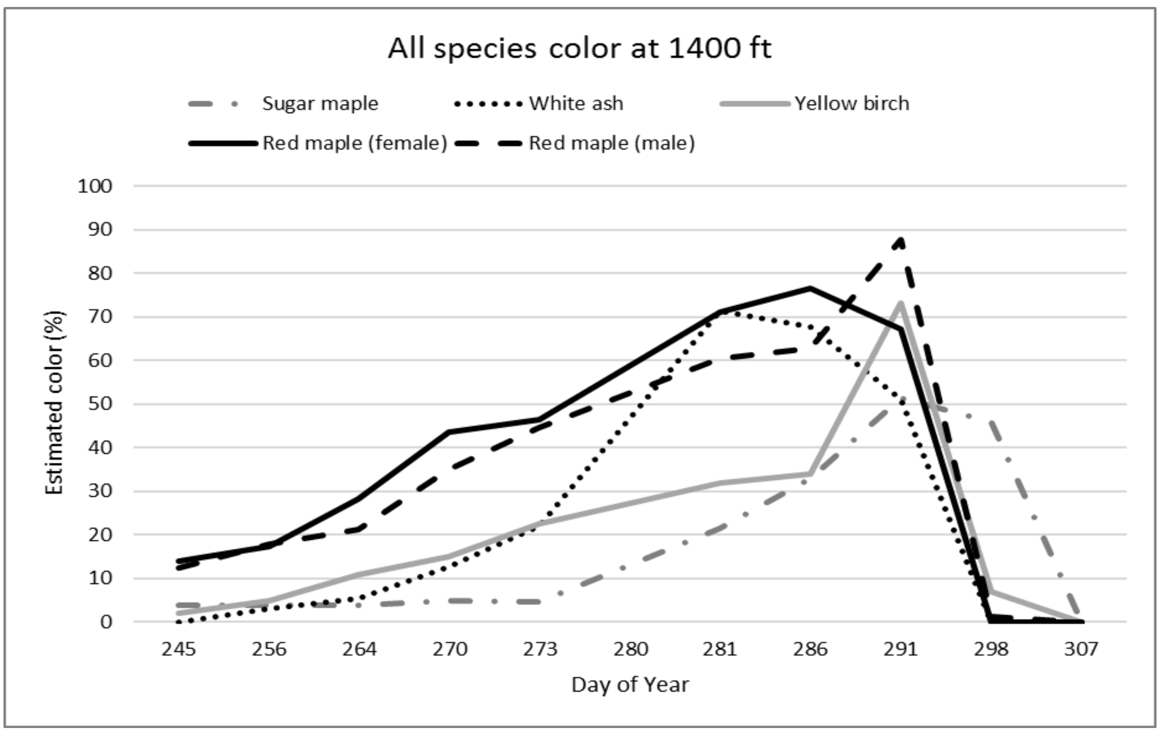


Figure 12a.

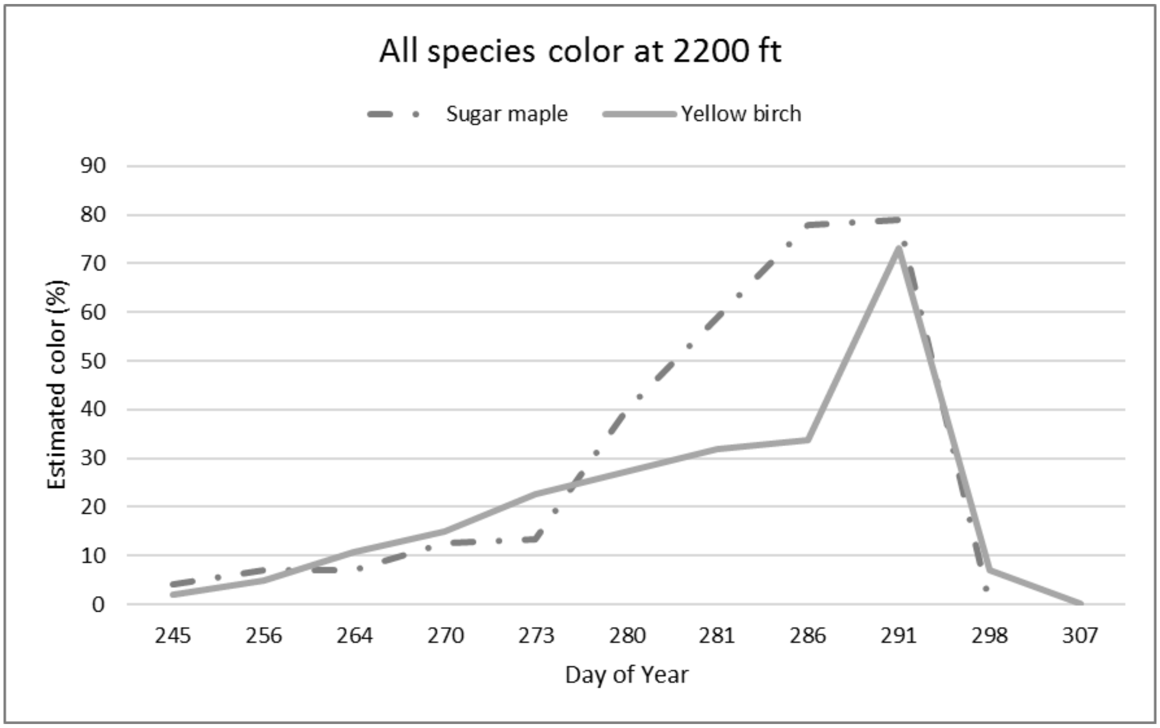


Figure 12b.

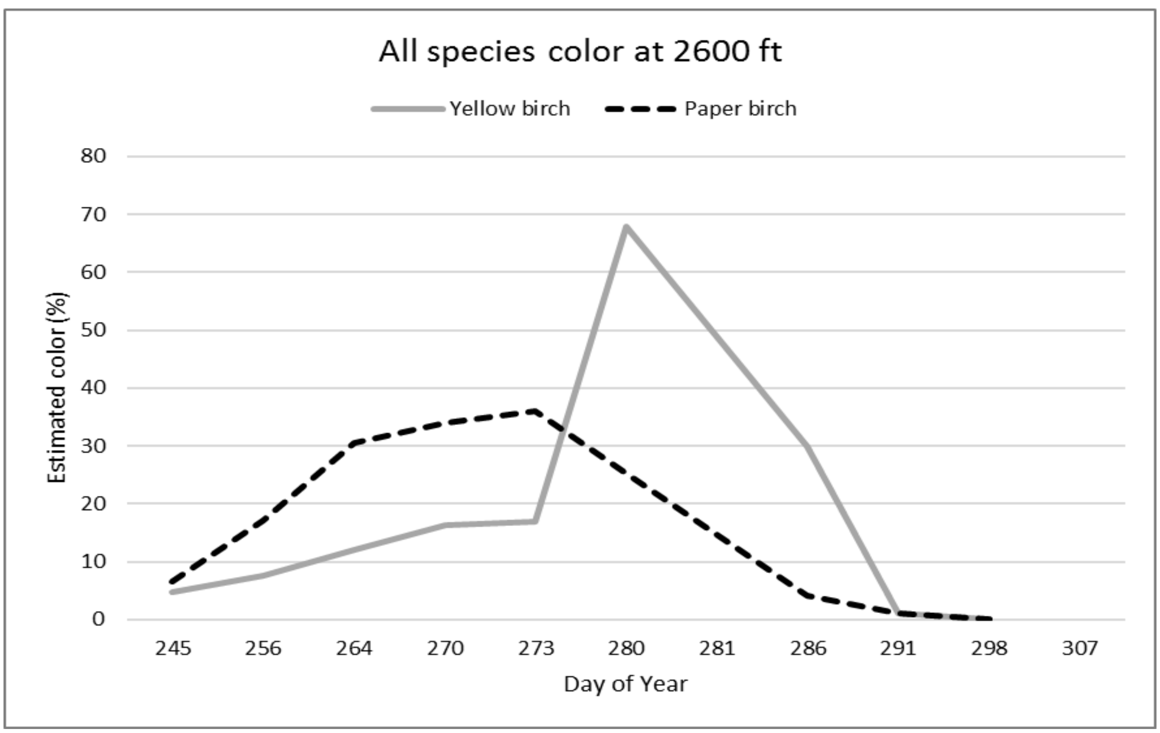


Figure 12c.

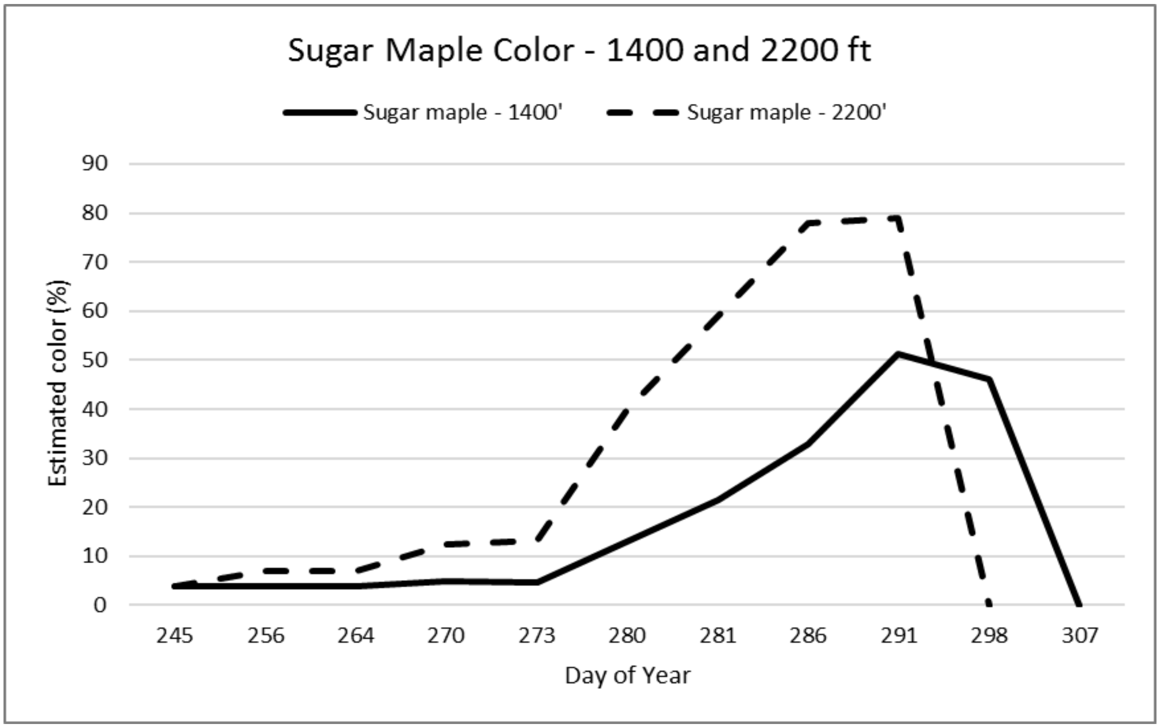


Figure 12d.

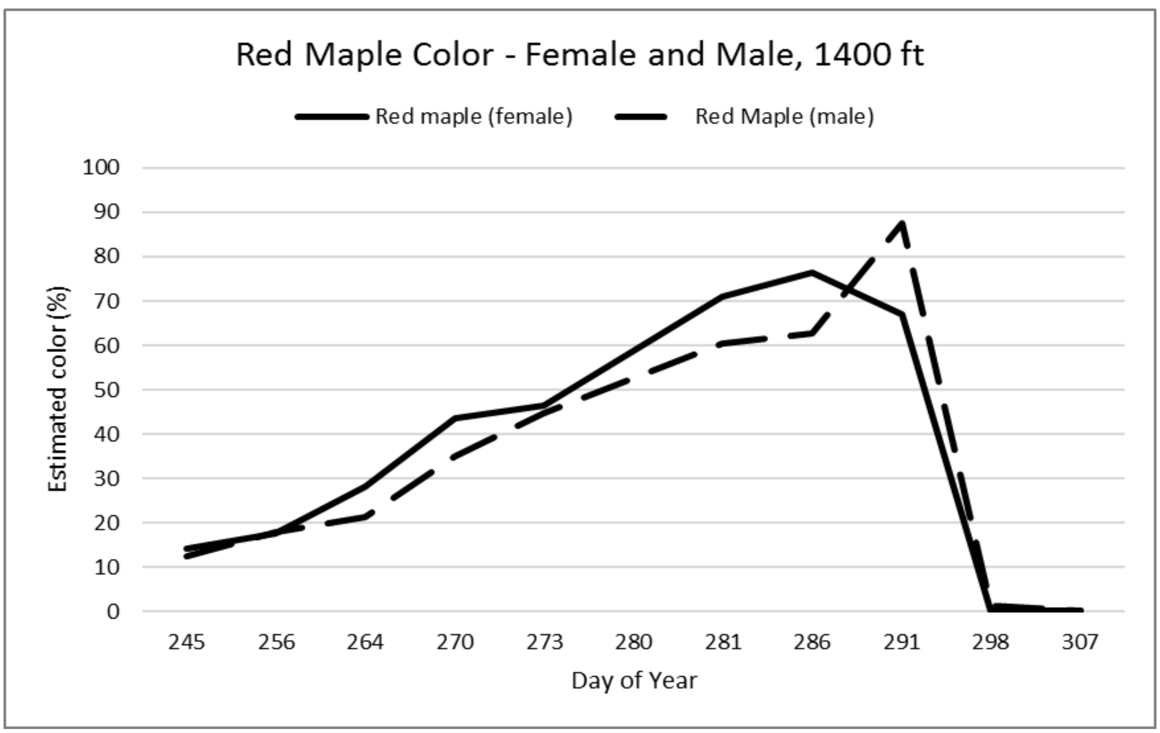


Figure 12e.

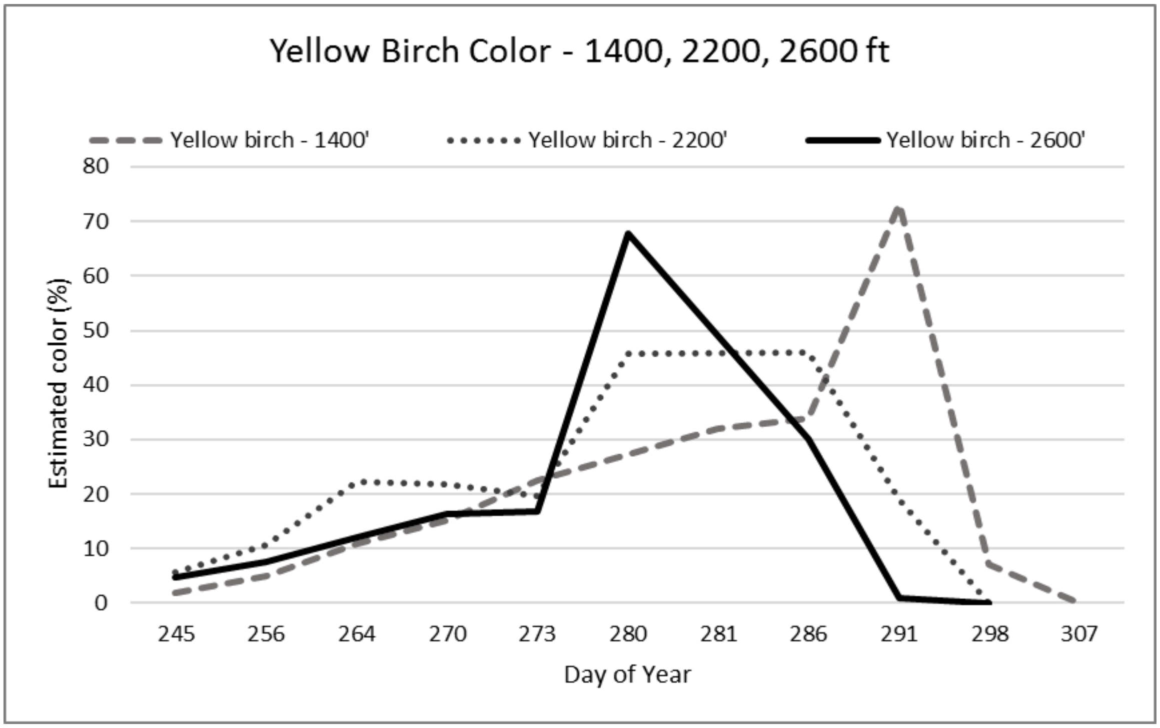


Figure 12f.

Table 2. Estimates of peak color based on percent color and percent of foliage present on Mount Mansfield. Length of long-term averages differs by species, with trees at 2600 feet having a 18-year record, red maple and white ash a 22-year record, sugar maple at 1400 feet a 27-year record, and all other trees a 26-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)	**2016 data (Day of year)**
Elevation 1400'		
Red maple (Female)	281	286
Red maple (Male)	284	291
Sugar maple	287	291
Yellow birch	285	291
White ash	279	281
Elevation 2200'		
Sugar maple	277	291
Yellow birch	276	286
Elevation 2600'		
Yellow birch	275	280
Paper birch	269	273

Table 3. Progression of leaf drop for trees at three elevations on Mt. Mansfield. Day of year when either 50% of foliage had dropped or more than 95% of foliage had dropped are included for both this year, and the long-term average. In general, all species began losing leaves later in 2016 than the average, as can be seen in the “50% leaf drop” data (in particular, mid-elevation species). However, full leaf drop was relatively similar to the average.

Leaf Drop					
	50% leaf drop			**> 95% leaf drop**	
	Long-term average (Day of year)	**2016 data (Day of year)**		**Long-term average (Day of year)**	**2016 data (Day of year)**
Elevation 1400'					
Red maple (Female)	288	293		299	298
Red maple (Male)	290	295		300	298
Sugar maple	290	298		302	305
Yellow birch	288	294		298	300
White ash	284	292		296	297
Elevation 2200'					
Sugar maple	281	294		294	298
Yellow birch	279	287		291	296
Elevation 2600'					
Yellow birch	278	285		289	291
Paper birch	272	274		286	286

Table 4. Average dates of sugar maple bud break, end of growing season (leaf drop) and length of the growing season 1991-2016 at the Proctor Maple Research Center in Underhill.

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
Long-term Average (1991-2016)	**5/3**	**10/20**	**171**

FOREST INSECTS

HARDWOOD DEFOLIATORS

Very little **Birch Defoliation** was observed in 2016, with only 59 acres attributed to birch leafmining sawflies (e.g., *Fenusa pusilla*, *Messa nana*, and others), and 172 acres to birch leaf fungus (*Septoria*) during aerial survey (Table 5). This acreage is in strict contrast to 2015, when a total of 25,468 acres were affected. Light populations of birch skeletonizer (*Bucculatrix canadensisella*) were observed in sites in Caledonia and Chittenden Counties, including Underhill State Park and Proctor Maple Research Center. (Also see Foliar Diseases.)

Table 5. Mapped acres of birch defoliation in 2016.

County	Acres
Bennington	86
Lamoille	29
Washington	57
Windsor	59
Total	231

Forest Tent Caterpillar (FTC), *Malacosoma disstria*, populations increased dramatically in 2016 with 24,278 acres of defoliation mapped during statewide aerial surveys. Most defoliation was in Essex, Lamoille, Orange, Orleans, and Washington Counties (Table 6 and Figure 13).

Surveys made in July in North American Maple Project (NAMP) and leased sugarbush plots showed that 8 of the 36 monitoring plots had trees with moderate defoliation (22%) and 20 of the 36 monitoring plots had trees with light defoliation (55%). Outbreaks tend to be cyclical, and our last outbreak of this native insect occurred 2004 - 2006 (Table 7). In 2006, at the peak of the outbreak, about 10% of the northern hardwood forest type was defoliated. The mapped area in 2016 covers less than 1% of Vermont's northern hardwood forest type, but is likely to increase in 2017. Moth catch increased four-fold in traps from 2015 with the statewide average trap catch in double digits for the first time since 2006 (Figure 14 and Table 8).

Dry summer conditions will be an important factor determining the impact of the 2016 defoliation. Trees typically respond to the relatively early-season feeding by FTC by sending out a new flush of leaves. This year, defoliated areas remained noticeable all summer because lack of water reduced the success of refoliation. On some sites, the only visible refoliation was on ash. On sugar maple, refoliated leaves were small. Sometimes, leaves were scorched or dropped to the ground, tender refoliated shoots wilted, and trees attempted a third flush of leaves. Even where refoliation was successful, dry conditions in 2016 have limited the new leaves' ability to replenish lost food. This will almost certainly affect wood production, and the amount of foliage and shoot growth next year.

FTC parasitoids known as friendly flies (*Sarcophaga aldrichi)* were reported from Cabot and Hyde Park, areas that had experienced FTC defoliation last year.

Table 6. Mapped acres of forest tent caterpillar defoliation in 2016.

County	Acres
Caledonia	1,727
Essex	7,327
Franklin	201
Grand Isle	243
Lamoille	4,983
Orange	2,000
Orleans	5,185
Washington	2,422
Windham	139
Windsor	51
Total	**24,278**

Table 7. Year by year defoliation caused by forest tent caterpillar from 1953 to present.

Year	Acres
1953	200,000
1954-1970	0
1971	600
1972-1975	0
1976	4,500
1977	31,120
1978	74,200
1979	43,464
1980	62,996
1981	117,000
1982	322,605
1983	180
1984-2002	0
2003	371
2004	90,556
2005	229,702
2006	342,802
2007-2015	0
2016	24,278

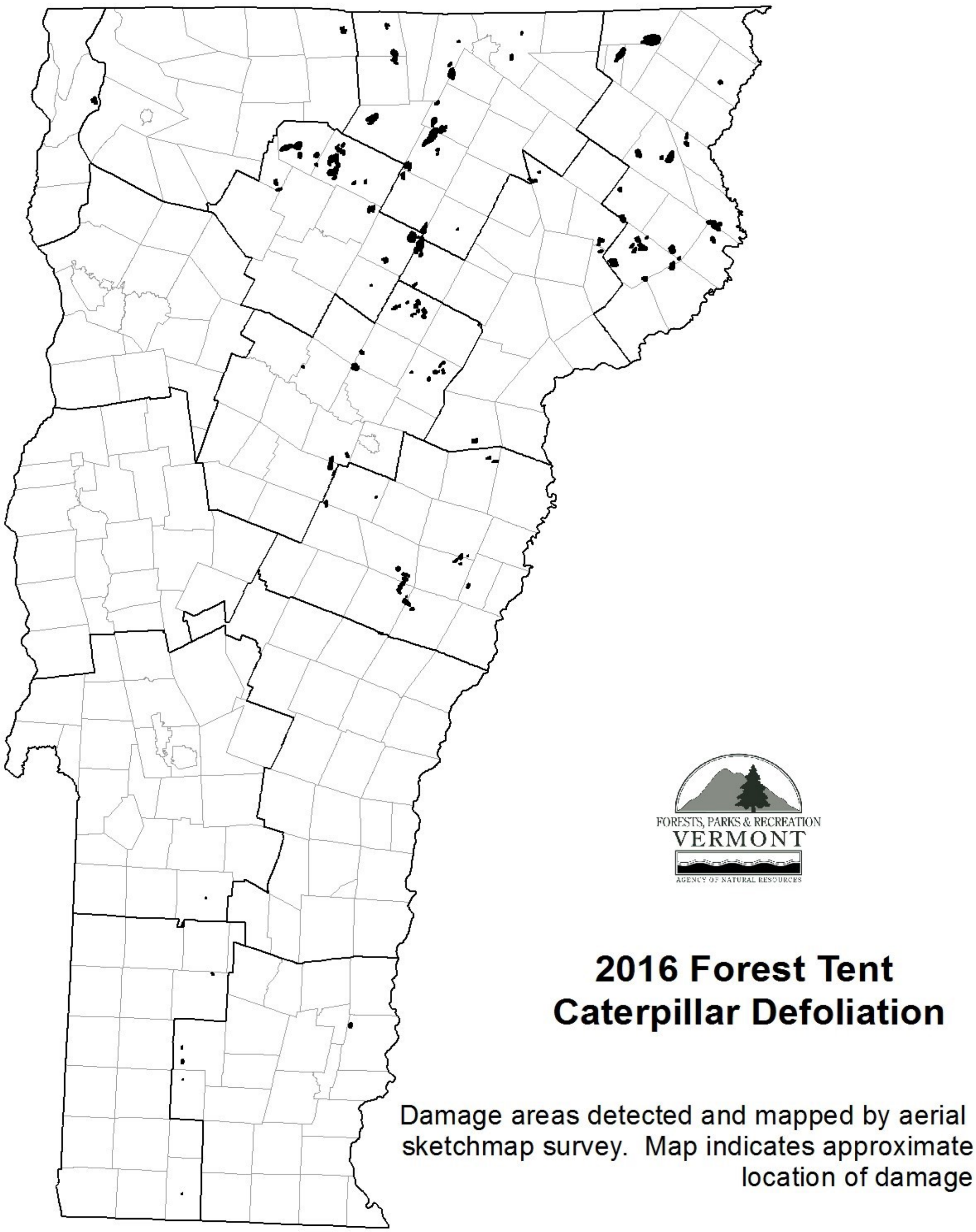


Figure 13. Forest tent caterpillar defoliation mapped in 2016. Mapped area includes 24,278 acres.

Table 8. Average number of forest tent caterpillar moths caught in pheromone traps, 2002-2016. Three multi-pher pheromone traps baited with PheroTech forest tent caterpillar lures were deployed at each survey location in 2016.

Site	Year														
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Castleton	----	----	----	17	17.3	8	1	4.7	1	1.7	0.3	2.3	1.7	1.7	14.0
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
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
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
Manchester	----	----	----	----	----	----	0	5.7	3	1	0.7	0.3	1.3	10.3	12.0
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
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
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
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
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
Stowe (VMC 3800)	1	2.7	10.3	26	5.7	5	1.3	1.7	0.7	2	2	1.3	1.7	----	----
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
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
Dillner Farm Montgomery	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	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**

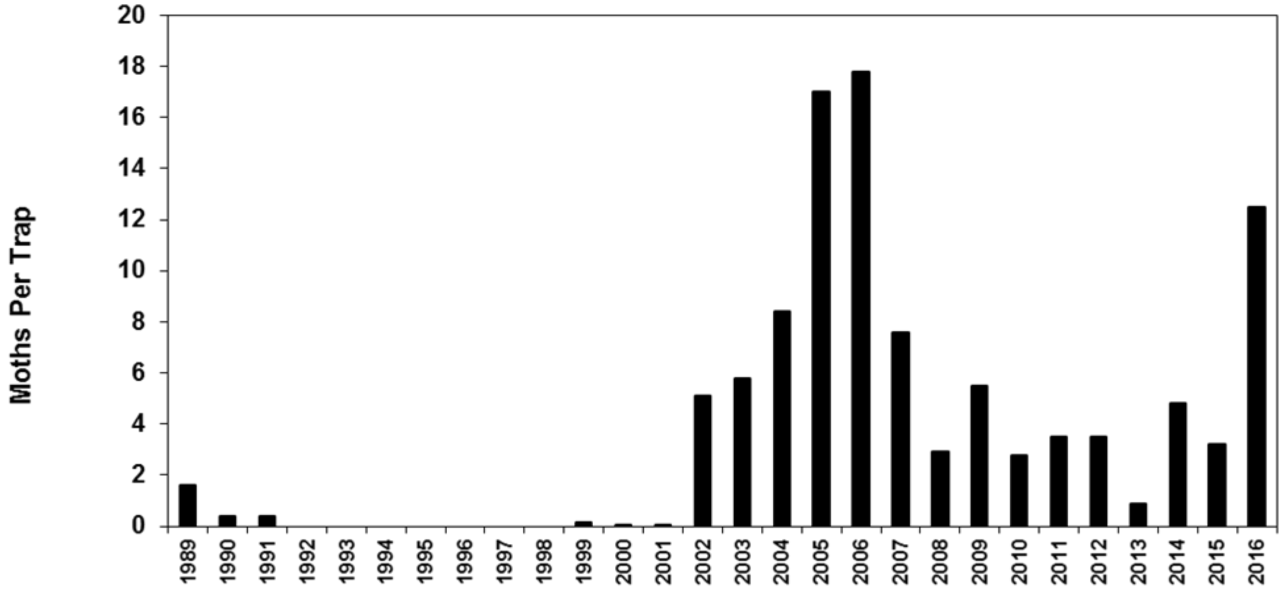


Figure 14. Average number of forest tent caterpillar moths caught in pheromone traps 1989-2016. Three multi-pher pheromone traps per site, with PheroTech forest tent caterpillar lures, were used in 2016.

Gypsy Moth, *Lymantria dispar*, was rarely observed in 2016, with one exception. On July 2, at the rest area southbound on I-89 in Williston, a line of rose bushes next to the road was "being hammered" by gypsy moth caterpillars. Some of the bushes were totally stripped of leaves, and the larvae were very large. An individual larva was observed in a North American Maple Project (NAMP) plot in Braintree. Overwintering egg masses are few. From 2012 through 2015, no egg masses were found in focal area monitoring plots. This year, two masses were observed at Tate Hill in Sandgate. No egg masses were found at the other focal area monitoring plots (Figure 15 and Table 9).

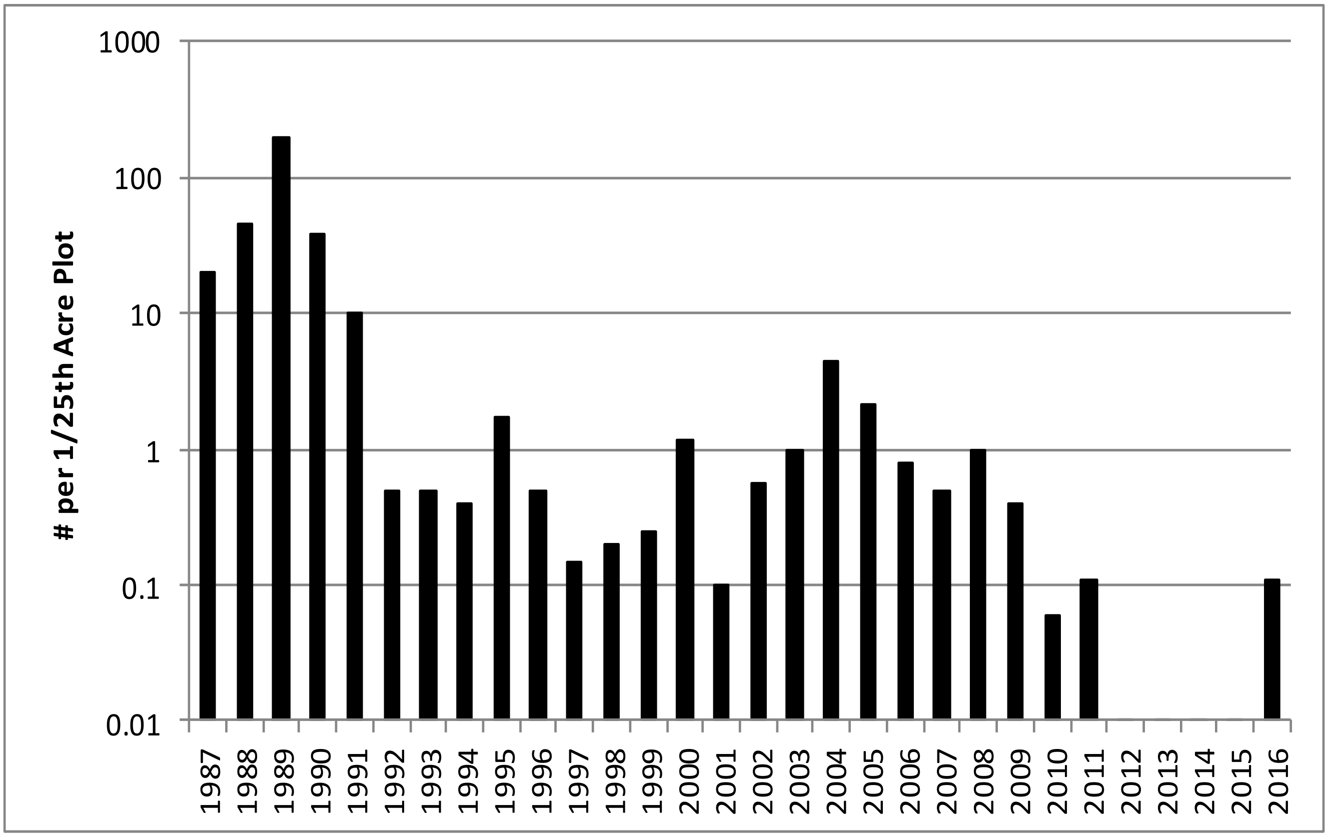


Figure 15. Number of gypsy moth egg masses per 1/25th acre from focal area monitoring plots, 1987 -2016. 2016 data reflect the average egg mass counts from ten locations, with two 15-meter diameter burlap-banded plots per location. A total of 2 egg masses were found in 2016.

Table 9. Number of gypsy moth egg masses per 1/25th acre from focal area monitoring plots, 2003-2016. Average of two 15-meter burlap-banded plots per location in 2016.

Site	Town	Year													
		2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Arrowhead	Milton	1.5	2.5	0	0	0	2.5	0	0	0.5	0	0	0	0	0
Brigham Hill	Essex	2.5	2	1.5	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
Minard's Pond	Rockingham	0.5	2	0	0	0	0	0.5	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
Perch Pond	Benson	0	0	0.5	1	0	0.5	0	0.5	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
Sandbar	Colchester	3	1.5	0	0	0	2.5	0.5	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
Average		**1**	**4.4**	**2.3**	**0.8**	**0.3**	**0.8**	**0.2**	**0.06**	**0.11**	**0**	**0**	**0**	**0**	**0.11**

Saddled prominent, *Heterocampa guttivitta*, surveys continued in 2016, but with fewer traps deployed than in 2014 and 2015. Through combined efforts with the USFS those years, 54 traps were set in 2014 and 60 in 2015. In 2016, a total of 36 traps (3 traps/site at 12 locations) were used. Average catch per trap was 1.2 in both 2015 and 2016 compared to 13.4 moths per trap in 2014 (Table 10 and Figure 16).

No moths were collected at six of the 12 sites surveyed in 2016. The two locations with the highest trap catches included Sheldon (total of 16 moths in three traps) and Sharon (total of 13 moths overall). The map below shows locations of trap sites, and the table provides details of traps that were deployed in 2016.

Table 10. Sites, listed by county, where saddled prominent pheromone traps were deployed in 2016. Data include location, town, county, coordinates, and average number of moths per site for 2014-2016. (NT – not trapped).

Location	Town	County	Lat	Long	Ave # SP moths/ trap 2014	Ave # SP moths/ trap 2015	Ave # SP moths/ trap 2016
Gale/Orvis (USFS)	Lincoln	Addison	44.15115	-72.95627	4.3	1	0
Hagelberg (NAMP 40)	Arlington	Bennington	43.06350	-73.17630	21.3	0.7	NT
Sprague (USFS)	Searsburg	Bennington	42.87463	-72.91520	12	0	0
Willoughby S.F.	Sutton	Caledonia	44.71037	-72.03990	10.3	0.3	0
Groton S.F.	Peacham	Caledonia	44.31163	-72.28880	3.3	0	NT
Honey Hollow	Bolton	Chittenden	44.34702	-72.91	31	1.7	NT
VMC 1400-PMRC	Underhill	Chittenden	44.52405	-72.86510	10	1.3	0
Reed (NAMP 8)	Sheldon	Franklin	44.86471	-72.87340	NT	6	5.3
Smith (NAMP 37)	Vershire	Orange	43.96919	-72.34424	13	1	0
Butterfield (NAMP 39)	Topsham	Orange	44.17331	-72.29451	11.7	1.7	NT
Ward	Vershire	Orange	43.98590	-72.37471	NT	1.7	0
Bartley (NAMP 6)	Derby	Orleans	44.96356	-72.17170	6	NT	NT
Shelton (NAMP 9)	Glover	Orleans	44.70073	-72.20980	26	0.3	NT
Spring Lake Ranch (NAMP 16)	Shrewsbury	Rutland	43.48305	-72.90990	20	2	0.7
Smokey House (NAMP 17)	Danby	Rutland	43.35054	-73.06020	47.3	1.3	NT
Griffith (USFS)	Mt. Tabor	Rutland	43.34283	-72.97840	4.7	1.7	0.7
Ascutney	Weathersfield	Windsor	43.42785	-72.46550	1.3	0	NT
Camp Plymouth SP	Ludlow	Windsor	43.47553	-72.69430	5.7	0.3	NT
Begin (USFS)	Stockbridge	Windsor	43.78549	-72.78468	6.7	1	1.1
Harrington (USFS)	Pomfret	Windsor	43.70859	-72.44882	6.7	2	2.7
Downer SF	Sharon	Windsor	43.78901	-72.38104	NT	0.3	4.3
Average					13.4	1.2	1.2

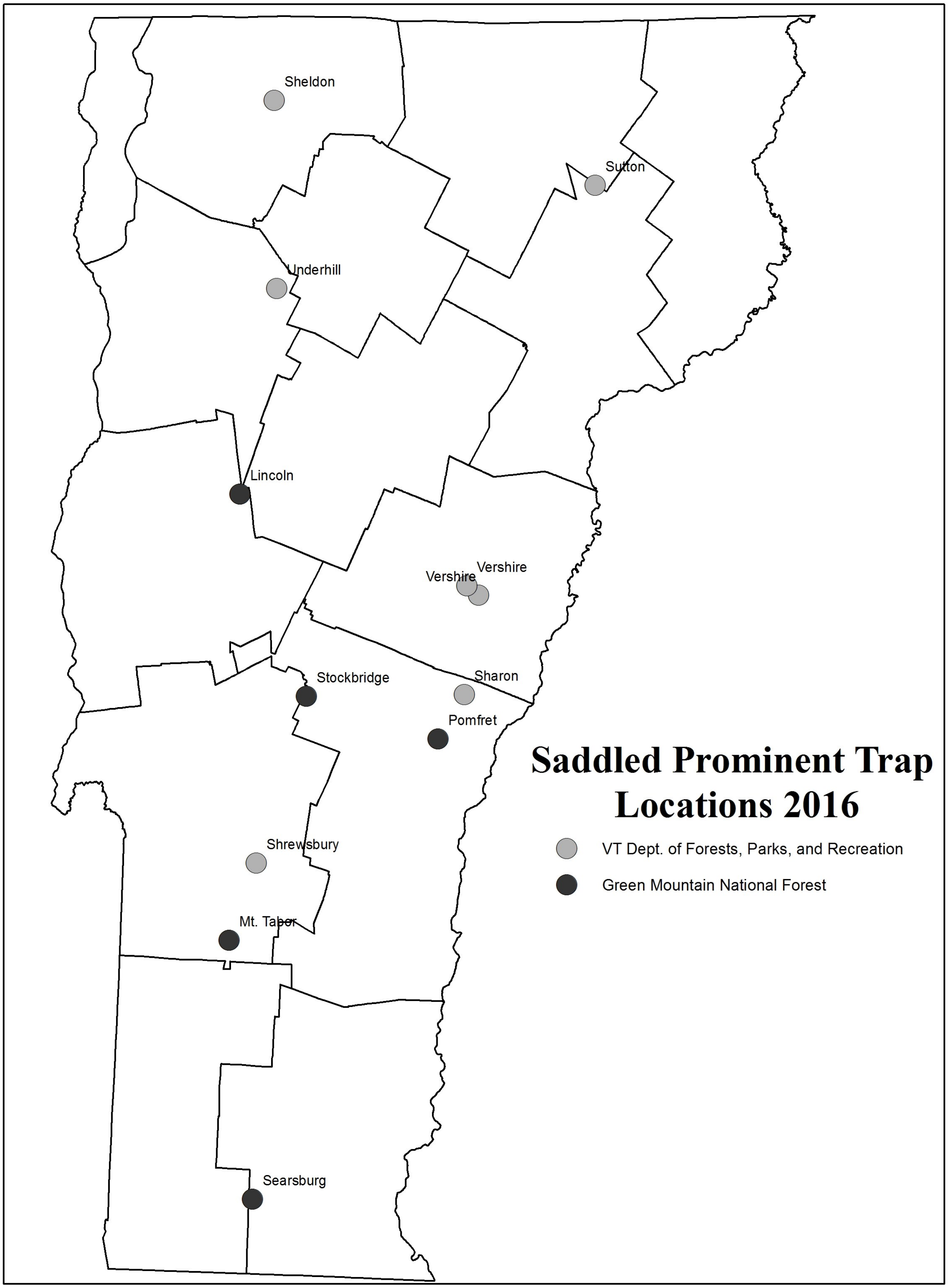


Figure 16. Location of saddled prominent pheromone traps set in Vermont in 2016 by VT FPR and the US Forest Service.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Beech Leaftier	*Psilocorsis* sp.	Beech	Statewide	Noticeable light late season browning of lower foliage very common.
Birch Skeletonizer	*Bucculatrix canadensisella*	Birch	Caledonia and Chittenden Counties	Light populations reported in scattered locations. Also see narrative under Birch Defoliation.
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	Bakersfield, Colchester	Light feeding noted; few moths observed.
Cherry Scallop Shell Moth	*Hydria prunivorata*	Black cherry	Springfield, Norton	Very light. Occasional nests.
Dogwood Sawfly	*Macremphytus tarsatus*	Red osier dowood	Underhill	Observed on 15 foot ornamentals.
Eastern Tent Caterpillar	*Malacosoma americanum*	Cherry and apple	Franklin, Orange, Orleans, Windham and Windsor Counties	More than usual numbers of egg masses observed in parts of the state over the 2015-2016 winter. Nests common, but scattered, in the spring.
Euonymus Caterpillar	*Yponomeuta cagnagella*	Euonymus	Burlington, Thetford	High numbers of larvae on ornamentals.
Fall Webworm	*Hyphantria cunea*	Hardwoods	Statewide	Fewer nests observed than normal in southern Vermont. Normal levels in northern Vermont. Only light damage.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Forest Tent Caterpillar	*Malacosoma disstria*			See narrative.
Gypsy Moth	*Lymantria dispar*			See narrative.
Imported Willow Leaf Beetle	*Plagiodera versicolora*	Willow	Bennington County	Although 45 acres of heavy defoliation was observed from the air, generally less common than 2015.
Japanese Beetle	*Popillia japonica*	Many	Statewide	Widely scattered. Heavy damage observed on ornamentals in northeastern VT.
Hickory Tussock Moth	*Lophocampa caryae*	Various hardwoods	Champlain Valley, Windsor County	No damage, but larvae occasionally observed. One report of a rash from holding the caterpillar.
Locust Digitate Leafminer	*Parectopa robiniella*	Black locust	Springfield	Noticeable in late summer.
Maple Leaf Cutter	*Paraclemensia acerifoliella*	Sugar maple	Statewide	In northern and central Vermont, moderate to heavy defoliation observed in scattered locations. Elsewhere, common and noticeable, but only light damage to lower foliage.
Maple Trumpet Skeletonizer	*Epinotia aceriella*	Sugar maple	Statewide	Variable, ranging from light to heavy populations (e.g. Smugglers Notch in Cambridge).

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Maple Webworm	*Tetralopha asperatella*	Sugar maple	Statewide	Mostly light feeding, but sometimes very noticeable, with more than 2/3 of outer crown affected in one sugarbush. Increase in maple webworm has coincided in past years with FTC outbreaks.
Mimosa Webworm	*Homadaula anisocentra*	Honeylocust	Windsor	Light damage in a single location.
Oak Shothole Leafminer	*Japanagromyza viridula*	Bur oak	Cabot	Holes present from feeding of adult fly along with shriveled brown patches that were likely larval mines of the species.
Oak Skeletonizer	*Bucculatrix ainsliella*	Red oak	Southern Vermont	Only light damage, but increase from 2015.
Oak Slug Sawfly	*Caliroa quercuscoccineae*	Red oak	Rutland	Light feeding in upper to mid canopy of small ornamental.
Rose Chafer	*Macodactylus subspinosa*	Various	Craftsbury	Heavy on some ornamentals.
Saddled Prominent	*Heterocampa guttivata*	Sugar maple		See narrative.
Satin Moth	*Leucoma salicis*	Poplar	Northeastern and central Vermont	Heavy defoliation in Randolph location that was also heavily hit in 2015. FTC may have contributed to the damage in 2016.
White-marked Tussock Moth	*Orgyia leucostigma*	Various	Greensboro	Feeding on hardwoods and conifers.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Winter Moth	*Operophtera brumata*	Hardwoods		Not known to occur in Vermont.

Hardwood defoliators not reported in 2016 include Apple and Thorn Skeletonizer, *Choreutis pariana;* Birch Leaf Folder, *Ancylis discigerana* ; Elm Sawfly, *Cimbex americana* ; European Snout Beetle, *Phyllobius oblongus* ; Green-striped Mapleworm, *Dryocampa rubicunda* ; Large Aspen Tortrix, *Choristoneura conflictana;* Mountain Ash Sawfly, *Pristiphora geniculata* ; Oak Trumpet Skeletonizer, *Catastega timidella* ; Red-headed Flea Beetle, *Systena frontalis* ; Red-humped Caterpillar, *Schizura concinna* ; Spiny Oak Sawfly, *Periclista* sp.; Uglynest Caterpillar, *Archips cerasivorana,* Viburnum Leaf Beetle, *Pyrrhalta vibruni;* White-marked Tussock Moth, *Orgyia leucostigma* .

SOFTWOOD DEFOLIATORS

Spruce Budworm, *Choristoneura fumiferana*, moth trap catches in Vermont remain low. Traps were deployed in Caledonia, Chittenden, Essex and Orleans Counties in 2010 - 2016. Only one moth was collected in 2016, in a trap in the town of Norton in Essex County (Figures 17 and 18, Table 11). We do not anticipate defoliation by the spruce budworm in 2017.

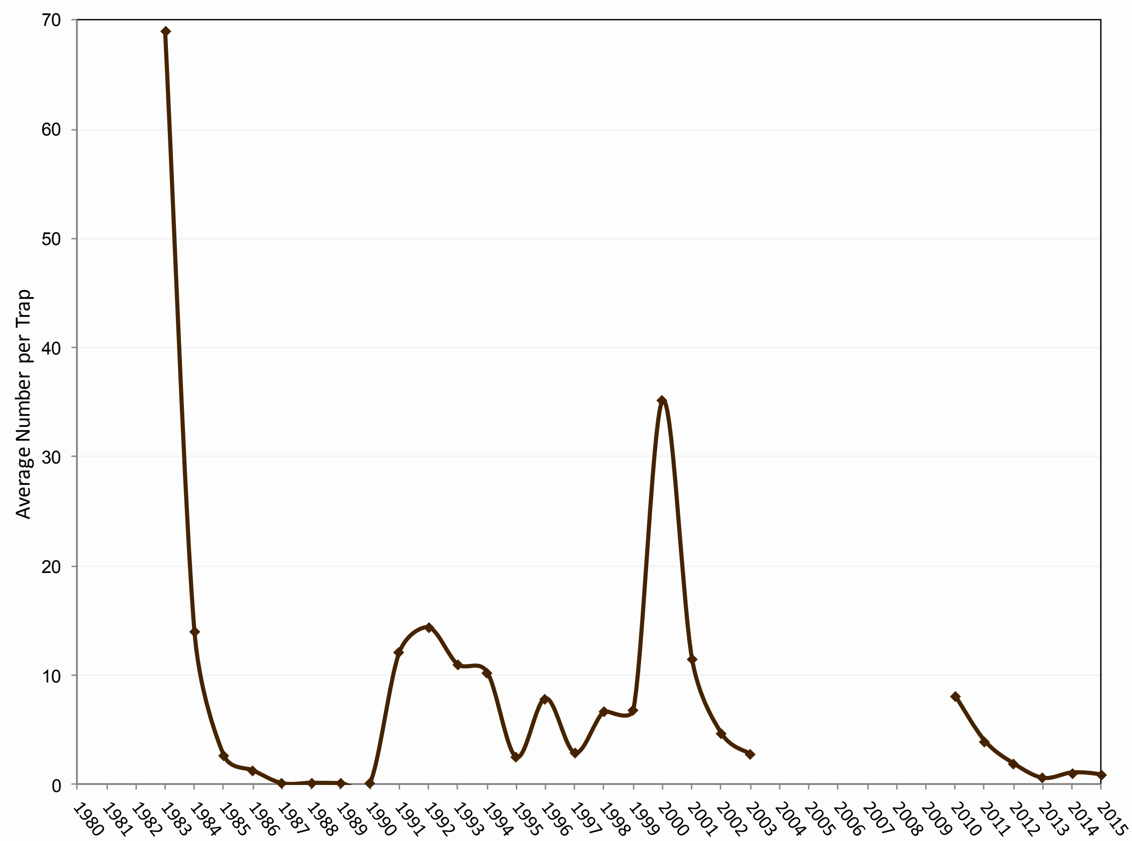
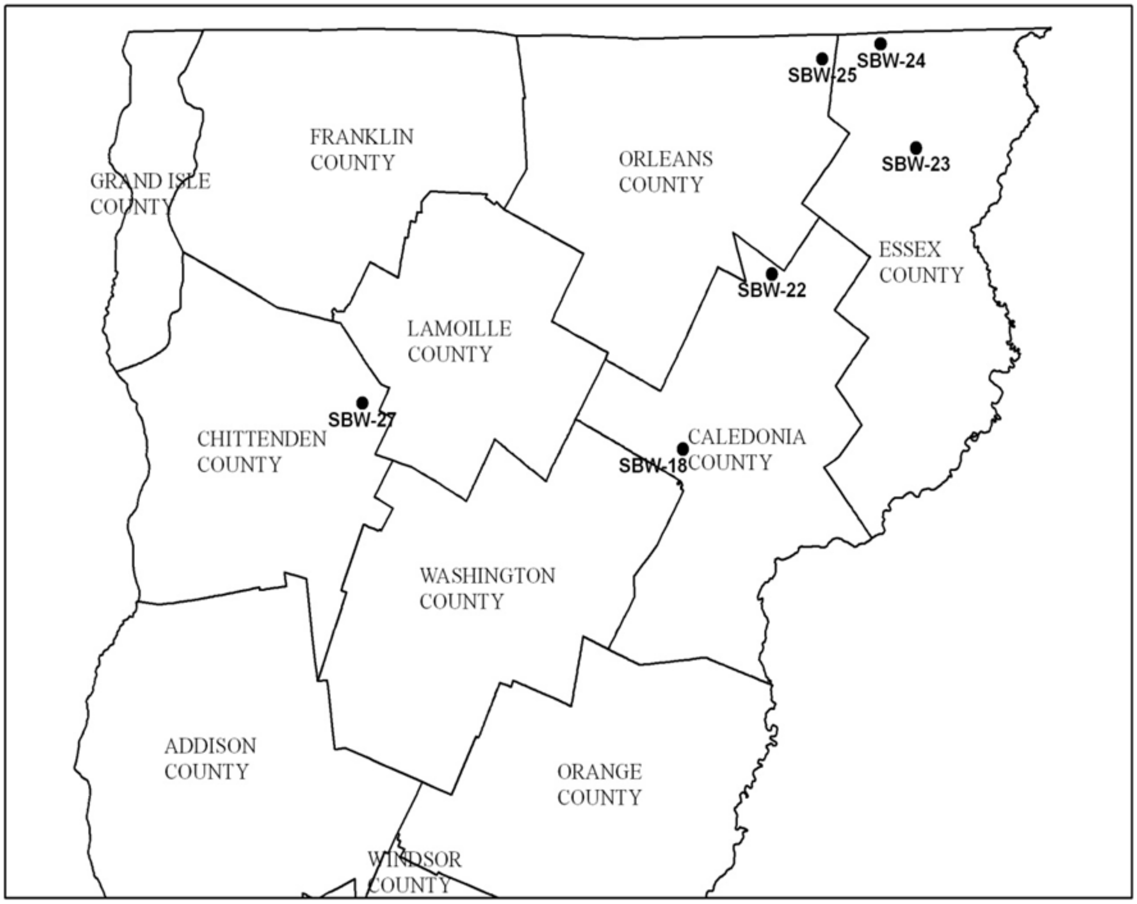


Figure 17. Average number of spruce budworm moths caught in pheromone traps 1983-2016. Trapping was discontinued, 2004-2009. Average of six locations in 2016.

Table 11. Average number of spruce budworm moths caught in pheromone traps, 1991-2016. Trapping had been discontinued 2004-2009. There were 3 traps per location, one location per town in 2016.

County and Town	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2010	2011	2012	2013	2014	2015	2016
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
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
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
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
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
Caledonia - Burke	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
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

Spruce Budworm Trap Locations



Trap #	Trap Location	Town	Latitude	Longitude
SBW-18	Steam Mill Brook WMA	Walden	44.48385	-72.25364
SBW-22	Willoughby S.F.	Burke	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

Figure 18. Locations of spruce budworm pheromone traps in 2016. Coordinates are NAD83.

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Arborvitae Leafminer	*Argyresthia thuiella*	Arborvitae	Rutland County	Scattered browning.
Balsam Fir Sawfly	*Neodiprion abietus*	Balsam fir	Peacham	Individual observed.
Eastern Spruce Budworm	*Choristoneura fumiferana*	Balsam fir and spruce	Statewide	See narrative.
Fall Hemlock Looper	*Lambdina fiscellaria*	Hemlock	Woodstock	Individual observed.
Yellow-headed Spruce Sawfly	*Pikonema alaskensis*	Blue Spruce	Middlesex, Cabot	Quickly defoliated ornamental spruce.

Softwood defoliators not reported in 2016 included 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***,** has become more obvious in scattered locations throughout the state. Heavy active populations are widely scattered, and there are small pockets of heavy fir mortality (Table 12 and Figure 19). During 2016 aerial surveys, 5,615 acres of fir dieback and mortality attributed to BWA were mapped.

BWA, a pest introduced from Europe, has been a chronic and episodic issue in Vermont since the early 1930s. More than 25 species of predators have been released into North America. In 1955, two releases of the beetle *Laricobius erichsonii* (in the family Derodontidae, the tooth-necked fungus beetles) were made in the US, including one in Searsburg, VT (489 beetles). Additional introductions of *L. erichsonii* were made at eight sites in Vermont in 1961. The following year, beetles were recovered in five of these sites. An additional release was made in 1963.

Given the recent outbreak of BWA in Vermont we wondered if we could recover these introduced predators. In late May and early June, we revisited six sites where BWA had been historically found and where *Laricobius* releases had taken place. These included Peacham, Cabot, Williamstown, Northfield, Rutland, and Ripton (Table 13). Our goals were to (1) determine if historical infested sites still contained balsam fir, (2) look for BWA in areas where balsam fir persisted, and (3) search for *Laricobius erichsonii.* Although BWA was present at some of the sites, no *Laricobius* life stages were observed. (Table 13).

A leaflet about Balsam Woolly adelgid can be found at http://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Forest_Health/Library/VTFPR%20Forest%20Health%20Leaflet_Balsam%20Woolly%20Adelgid_2016.pdf.

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

County	Acres
Addison	107
Bennington	69
Caledonia	1,096
Chittenden	51
Essex	736
Franklin	59
Grand Isle	0
Lamoille	683
Orange	1,101
Orleans	518
Rutland	240
Washington	895
Windham	57
Windsor	4
Total	5,616

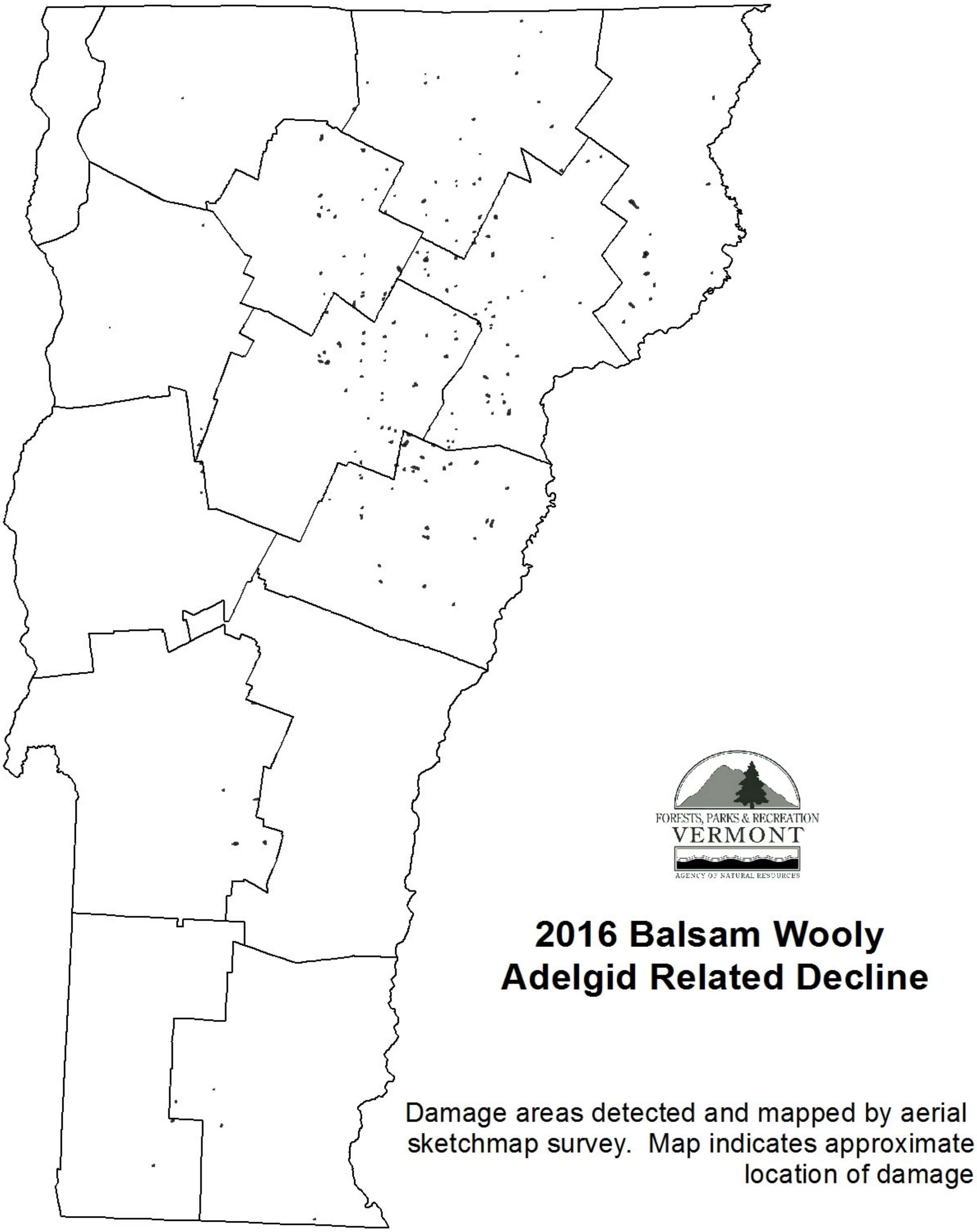


Figure 19. Balsam wooly adelgid related decline mapped in 2016. Mapped area includes 5,616 acres.

Table 13. *Laricobius erichsonii* release sites that were revisited in 2016. Data include county, town, site, location, year of *Laricobius* release, number released, recovery of *Laricobius* the year after release, elevation and 2016 observations. *Laricobius* release in Addison took place in 1963 and no recovery records were available.

County	Town	Site	Location	Year Re-leased	Number Released	Recovery in 1962	Elevation	2016 Observations
Caledonia	Peacham	Groton State Forest	Peacham Bog	1961	400	Good	1800	Some standing dead balsam fir. None to few BWA observed though a couple of trees had heavy populations. No *Laricobius* found.
Washington	Cabot	Private	Joe's Pond	1961	500	None	1800	Balsam trees still in the area. A few trees had heavy BWA populations but most were light to none. Heavily infested trees side-by-side with light to no infestation. No *Laricobius* found.
Washington	Cabot	Goodrich	Molly's Pond	1961	500	Good across brook	1900	Limited balsam left; area now mostly cedar/ spruce swamp with adjacent clearcut. The few scattered balsam on site had very light BWA. No *Laricobius* found.
Washington	Williamstown	Private	Route 64	1961	500	Good	1800	Few balsam fir present, but no concentration of trees. No BWA observed. No *Laricobius* found.
Washington	Northfield	Allis State Park	Northfield Gulf	1961	500	Excellent	1700	Few balsam fir present, but no concentration of trees. No BWA observed. No *Laricobius* found.
Rutland	Mount Tabor	GMNF	Ten Kiln Meadow	1961	1500	None	1900	Very light populations of BWA on the lower boles of the tree. No *Laricobius* found.
Addison	Ripton	GMNF	Middlebury River	1963	1131	NA	1800	Balsam fir present with considerable regeneration; evidence of previous balsam fir decline (large, standing dead trees and some fallen trees). Declining trees, some with fiddle-shaped tops, visible to the east of the area formerly marked as infested. Very few BWA on select trees. No *Laricobius* found.

Elongate Hemlock Scale (EHS), *Fiorinia externa*, which was not known to be established in Vermont prior to 2014, was reported from several new sites in southeastern Windham County. The combination of hemlock woolly adelgid, elongate hemlock scale, and drought has resulted in tree decline in a few locations.

Hemlock Woolly Adelgid (HWA), *Adelges tsugae*, spread has been limited, with the only new town detection, for 2016, in Westminster. The infestation remains centered in Windham County, with a small spot in Springfield, Windsor County and an isolated stand in the town of Pownal in Bennington County (Figure 20).

We did continue efforts to detect spread of this insect during the 2015-2016 period. Sixty-one sites were surveyed for hemlock woolly adelgid, primarily in towns adjacent to infested towns (Table 14). Fifteen volunteers logged 122 hours and did nearly half of the survey work.

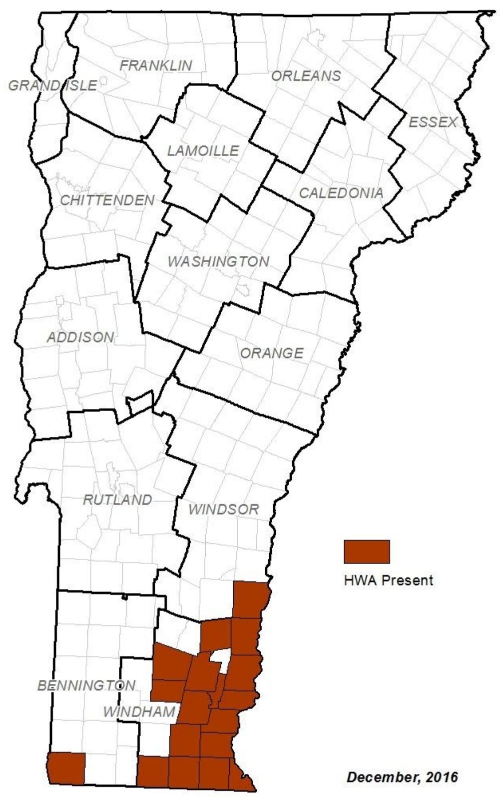


Figure 20. Towns known to have hemlock woolly adelgid-infested trees in 2016.

Table 14. Number of sites inspected for the presence of hemlock woolly adelgid (HWA) by visual survey, winter 2015-2016, including number of sites where HWA was detected. The positive site in Westminster was a first detection in that town.

County	Town	Number of Sites Inspected	Number of Sites where HWA was Detected
Bennington	Bennington	1	0
	Stamford	3	0
	Woodford	2	0
Windham	Dover	2	0
	Grafton	10	0
	Jamaica	1	0
	Londonderry	4	0
	Rockingham	7	2
	Westminster	4	1
	Wilmington	2	0
	Windham	2	0
	Winhall	1	0
Windsor	Chester	5	0
	Hartford	1	0
	Springfield	9	1
	Weathersfield	6	0
	Windsor	1	0
TOTAL		61	4

The slow spread of HWA may be due in large part to an unexpectedly high winter mortality rate. Given the mild winter, expectations were that most of the population would survive, but mortality rates varied from 97.79 to 99.01 percent at our four winter mortality monitoring sites (Table 15 and Figure 21). This is well over the threshold of 91 or 92 percent that seems to limit spread, and was the third winter in a row with negligible spread. Other factors, however, continue to stress the hemlock resource, including another summer of drought and elongate hemlock scale.

In addition to overwintering mortality, progrediens recovery is assessed at the Jamaica monitoring site as part of a multi-state cooperative. During the 2/10 visit, sistens density was evaluated on twenty branches. Progrediens numbers were counted on the same branches on 6/21. Data are available through a database maintained by Virginia Tech.

Table 15. Assessment of hemlock woolly adelgid winter mortality over the winter of 2015-2016. Data from four assessment sites include location, date hemlock wooly adelgid samples were collected, number of dead and live adelgids, and percent mortality.

Site	Date	#HWA alive	#HWA dead	Percent mortality
Vernon	3/21/16	4	401	99.01
Brattleboro	3/21/16	33	502	93.83
Townshend	3/21/16	15	663	97.79
Jamaica	3/21/16	12	697	98.31

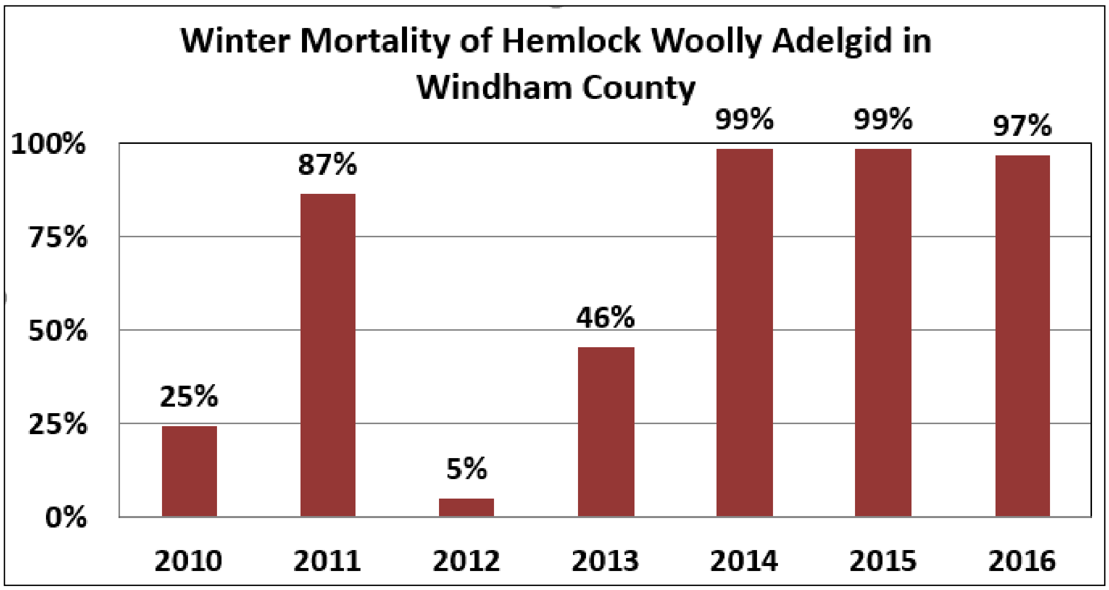


Figure 21. Overwintering mortality of hemlock woolly adelgid in Windham County 2010-2016

The predatory beetle, *Laricobious nigrinus* has been released in three sites in Vermont: Brattleboro (2009 & 2012), Pownal (2012) and Vernon (2009). These sites are visited annually to look for these beetles, and were visited in 2016 on the November 8th or November 10th. None were found again on these visits. The insect has not been recovered in Vermont since 2012, but may be present nonetheless. It is known to be difficult to recover, and can persist in low numbers.

Numerous outreach activities were conducted, many through volunteers and Forest Pest First Detectors, in the form of articles, public presentations, displays at town meeting, parades, county fairs, and other events.

The publication, *Managing Hemlock in Northern New England Forests Threatened by Hemlock Woolly Adelgid and Elongate Hemlock Scale,* produced by the states of Maine, New Hampshire, and Vermont, in cooperation with our colleagues from the US Forest Service is still available at http://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Forest_Health/Library/ManagingHemlockNortherNEForestsSept2015.pdf

In deference to public concerns about neonicotinoids FPR did not initiate any chemical control efforts in 2016, although many states do conduct or support chemical control efforts as part of their hemlock health management strategy.

Pear Thrips, *Taeniothrips inconsequens*, were observed in North American Maple Project (NAMP) and Vermont Monitoring Cooperative (VMC) plots in Underhill, Sheldon, Johnson, Topsham, Stowe, Cambridge, Huntington and Roxbury, but damage, where detected, was light. This year, pear thrips emergence began April 6-17, as indicated on yellow sticky traps at our long-term monitoring site at Proctor Maple Research Center in Underhill. The highest numbers were present May 3-12, averaging just over 20 insects per trap. Emergence was complete by June 1. Thrips counts for the year totaled 193, just 12 thrips more than 2015 counts, which were the lowest on recent record. (Figure 22 and Table 16).

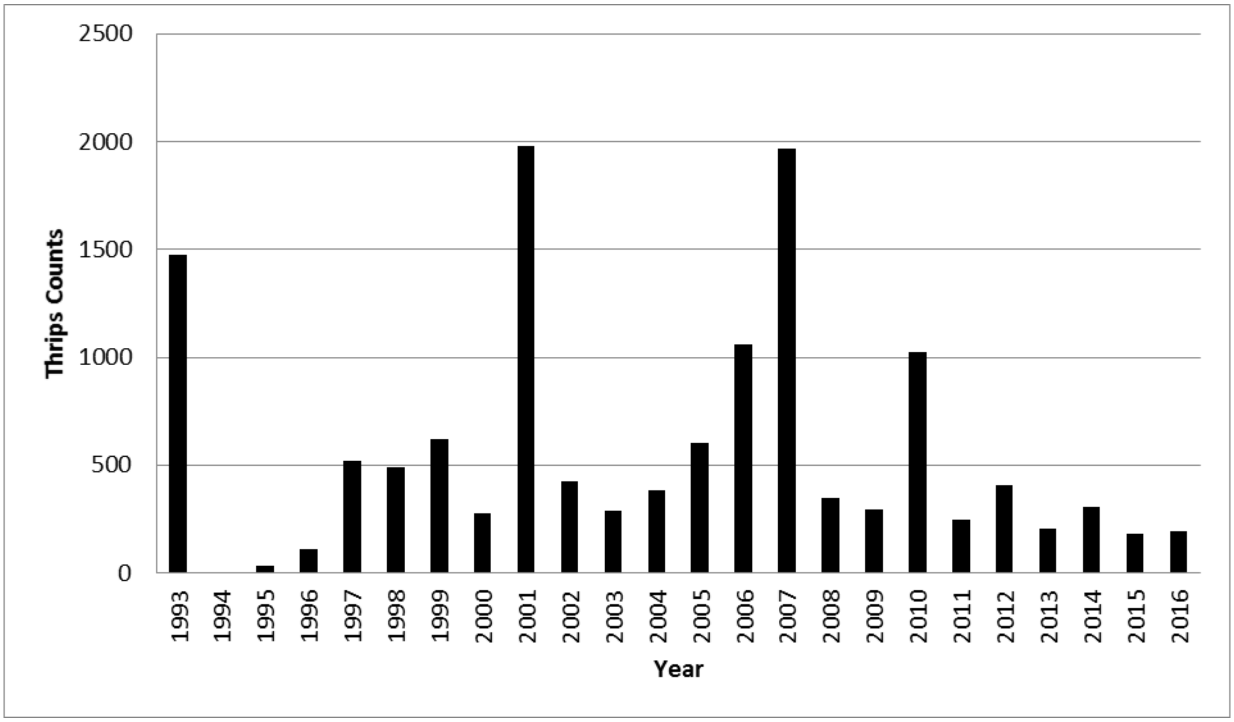


Figure 22. Total number of thrips collected at Proctor Maple Research Center in Underhill, VT on sets of four sticky traps, 1993-2016.

Table 16. Total pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, Vermont, from 2010-2016. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.

2010		2011		2012		2013		2014		2015		2016	
Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips	Sampling Dates	Number of Thrips
				3/19 – 3/26	121								
4/2 – 4/7	408	4/6 – 4/12	0	3/26 – 4/2	6	3/29 - 4/5	0	4/1 – 4/10	0				
4/7 – 4/15	100	4/12 – 4/21	2	4/2 – 4/9	7	4/5 - 4/15	0	4/10 – 4/18	2	4/10-4/16	3	4/6-4/17	4
4/15 – 4/23	102	4/21 – 4/29	191	4/9 – 4/16	84	4/15- 4/22	23	4/18 – 4/25	60	4/16-4/24	5	4/17-4/27	11
4/23 – 5/3	175	4/29 – 5/6	10	4/16 – 4/23	23	4/22 - 4/30	125	4/25 – 5/2	88	4/24-5/4	90	4/27-5/3	20
5/3 – 5/11	151	5/6 – 5/13	9	4/23 – 4/30	8	4/30 - 5/7	18	5/2 – 5/9	38	5/4-5/12	51	5/3-5/12	84
5/11 – 5/18	43	5/13 – 5/20	16	4/30 – 5/7	53	5/7 - 5/13	27	5/9 – 5/16	29	5/12-5/20	18	5/12-5/20	63
5/18 – 5/24	36	5/20 – 5/27	15	5/7 – 5/14	65	5/13 - 5/20	11	5/16 – 5/23	65	5/20-5/26	7	5/20-5/25	6
5/24 – 6/1	4	5/27 – 6/2	5	5/14 – 5/21	25	5/20 - 5/28	1	5/23 – 5/30	16	5/26-6/1	5	5/25-6/1	5
6/1 – 6/7	2			5/21 – 5/30	16	5/28 - 6/3	0	5/30 – 6/6	6	6/1-6/6	2	6/1-6/8	0
				5/30 – 6/4	1					6/6-6/12	0		
	1,021		248		409		205		304		181		193

Red Pine Scale, *Matsucoccus resinosae*, has been confirmed in two locations in Rutland and Orange Counties, where light populations of the exotic insect were first observed in 2015. Reports of red pine mortality continued in 2016, with the 743 acres mapped scattered in eight counties (Table 17 and Figure 23). Though red pine scale remains a suspect, confirmation of whether a primary pest or pathogen is responsible for the mortality is under investigation through a research project led by a doctoral student at the University of New Hampshire with funding from the US Forest Service. Best management practices would be to take precautions to reduce human-caused spread, harvesting declining red pine stands in winter when the insect is not capable of moving on its own, to chip tops so twigs and branches dry out more quickly, and to ensure equipment is free of plant material before leaving the site.

Table 17. Mapped acres of red pine decline in 2016. Though red pine scale is a suspect, the causal agent and/or contributing factors of the mortality remain under investigation.

County	Acres
Addison	33
Bennington	4
Caledonia	33
Franklin	6
Lamoille	76
Orange	275
Rutland	246
Washington	58
Windsor	12
Total	743

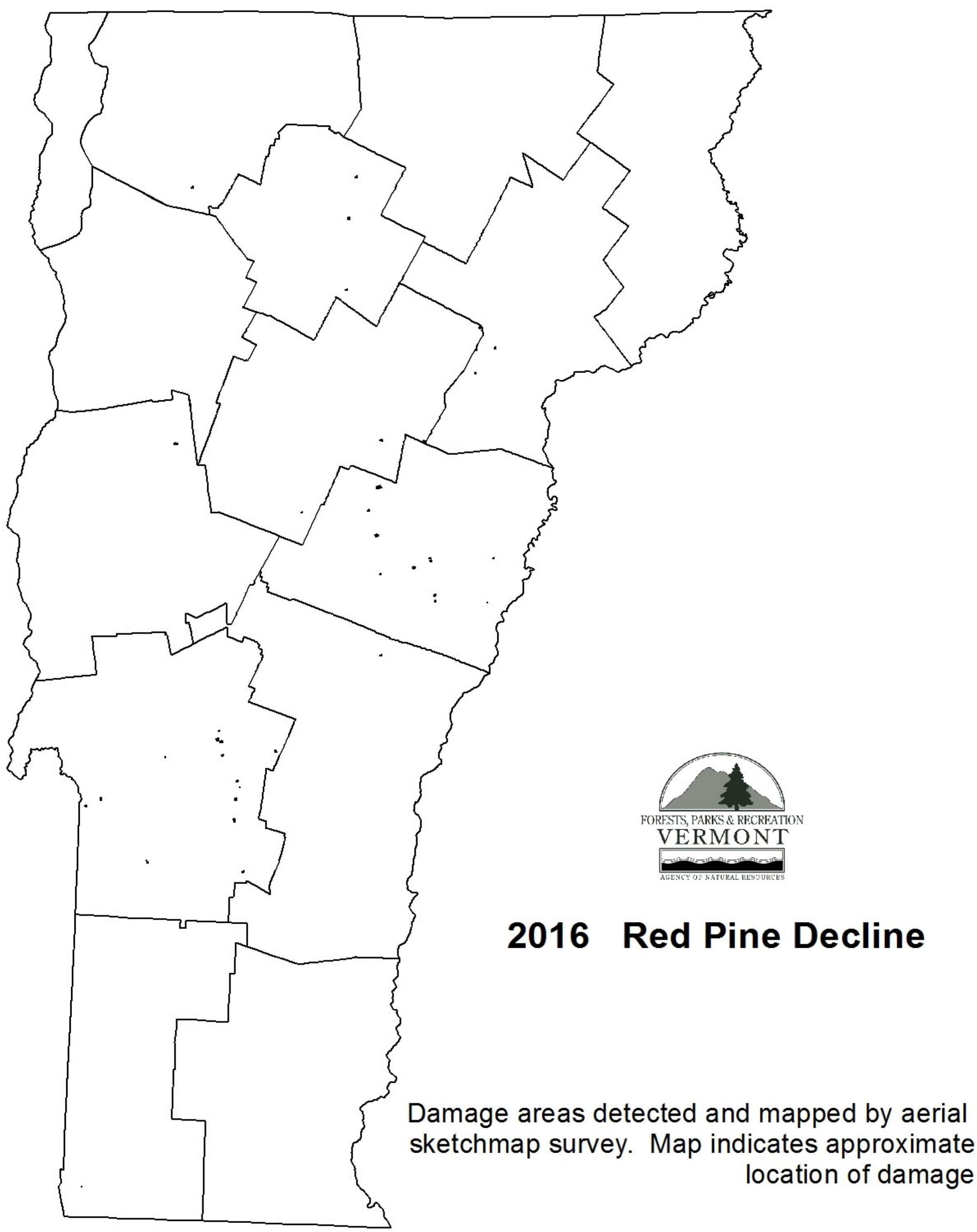


Figure 23. Red pine decline mapped in 2016. Mapped area includes 743 acres.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Ash Flowergall Mite	*Aceria fraxiniflora*	Ash	Vernon, Barnet	Light, scattered damage.
Balsam Twig Aphid	*Mindarus abietinus*	Balsam fir	Statewide	Scattered at low levels.
Balsam Woolly Adelgid	*Adelges piceae*	Balsam fir and Fraser fir	Statewide	See narrative.
Beech Scale	*Cryptococcus fagisuga*	Beech	Statewide	See Beech Bark Disease narrative.
Black Pineleaf Scale	*Dynaspidiotus californicus*	Austrian pine	Quechee, Town of Hartford	Species confirmation by Scott A. Schneider, Systematic Entomology Laboratory, USDA-ARS Beltsville Agricultural Research Center, MD. Previous record from South Burlington on mugho pine in 1984.
Bladdergall Mite	*Vasates quadripedes*	Sugar maple	Waterbury and elsewhere	Common observation on ornamentals.
Boxelder Bug	*Leptocoris 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	Chittenden County	Trapped by VT Agency of Agriculture Food & Markets (VAAFM). No damage observed. Records from past years include Bennington, Chittenden, Lamoille, Washington, Windham and Windsor Counties.
Cinara Aphids	*Cinara* sp.	Balsam fir	Ripton	Active population on a cut, indoor Christmas tree after the holiday season.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Elongate Hemlock Scale	*Fiorinia externa*	Ornamentals	Windham County	See narrative.
Grape Phylloxera	*Daktulosphaira vitifoliae*	Grape	Rutland	Leaf galls unsightly but causing little damage. Infestation of roots can be difficult to control.
Green Stink Bug	*Chinavia hilaris*	Many	Shrewsbury	Generally considered widespread.
Hemlock Woolly Adelgid	*Adelges tsugae*	Hemlock	Windham, Bennington and Windsor Counties	See narrative.
Lacebugs	Family Tingidae	Basswood and other hardwoods	Statewide	Widely observed causing light damage.
Lecanium Scale	*Lecanium* or *Parthenolecanium*	Hophornbeam and maple	Bolton	Scales observed on twigs but no damage was noted.
Magnolia Scale	*Neolecanium cornuparvum*	Magnolia	Brattleboro	Accompanied by sooty mold.
Pear Thrips	*Taeniothrips inconsequens*	Hardwoods	Statewide	See narrative.
Pine Bark Adelgid	*Pineus strobi*	White pine	Bradford, Milton	Light populations.
Pine Leaf Adelgid	*Pineus pinifoliae*	Red spruce White pine	Grafton Springfield	Noticeable galls.
Pine Spittlebug	*Aphrophora parallela*	Hemlock	Salisbury	Observed on the undersides of hemlock twigs.
Spruce Gall Adelgids	*Adelges spp.*	Spruce	Scattered	Stable at low levels.
Spruce Spider Mite	*Oligonychus ununguis*	Yew Arborvitae	Burlington West Rutland	Speckled foliage apparent.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
White-margined Burrowing Bug	*Sehirus cinctus*	Nettle and flax families	Burlington	Aggregations of red and black immatures observed in fields, woodlands, lawns and gardens.
Willow Pinecone Gall Midge	*Rabdophaga strobiloides*	Willow	Montpelier	Conelike galls formed in the apical buds of growing willow twigs.
Woolly Elm Aphid	*Eriosoma americanum*	Elm	Swanton	Infested leaves swollen and curled.

Sapsucking Insects, Midges and Mites that were not reported in 2016 include Balsam Gall Midge, *Paradiplosis tumifex* ; Conifer Root Aphid, *Prociphilus americanus* ; Gouty Vein Midge, *Dasineura communis* ; Oystershell Scale, *Lepidosaphes ulmi* ; Pine Needle Scale, *Chionapsis pinifoliae* ; Woolly Aplder Aphid, *Paraprociphilus tessellatus.*

BUD AND SHOOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Common Pine Shoot Beetle	*Tomicus piniperda*	Pines	Chittenden County (not a new county)	Collected by VAAFM during exotic woodboring beetle survey. Since first detected in 1999, has been found in many Vermont counties. Under federal quarantine, but pine is free to move through most of the northeast.
Oak Twig Pruner	*Anelaphus parallelus*	Red oak	Lamoille, Windham, and Windsor Counties	Dead twigs hanging from trees or accumulating on the ground commonly observed at low levels.
White Pine Weevil	*Pissodes strobi*	White pine and Colorado blue spruce	Statewide	Damage to young conifers remains low.

Bud and Shoot Insects not reported in 2016 included Balsam Shootboring Sawfly, *Pleroneura brunneicornis* ; Pine Gall Weevil, *Podapion gallicola.*

ROOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Japanese Beetle	*Popillia japonica*	Many	Throughout	Populations much reduced in 2016.
June Beetle	*Phyllophaga* spp.	Many	Scattered	Noteworthy that no reports were received in 2016, perhaps due to drought.

Root Insects not reported in 2016 included Conifer Root Aphid, *Prociphilus americanus*; Conifer Swift Moth, *Korsheltellus gracillis*.

BARK AND WOOD INSECTS

Asian Longhorned Beetle (ALB), *Anoplophora glabripennis*, was not observed and is not known to occur in Vermont.

2016 marked our fourth year of deploying flight intercept/pheromone traps for detection of ALB (Table 18, Figure 24). We deployed three traps per district in locations that were potentially high risk based on the chance that infested firewood might have been in the area. Most trap sites were also considered "high profile" in terms of public outreach, providing opportunities to connect with campers and others about ALB and invasive pests. Lures were comprised of six different pheromones and volatiles. Pheromone "B" was replaced at 30 days; at 60 days all of the pheromone components were replaced. Traps were removed at 90 days. No ALB suspects were found.

Education and outreach that can prevent movement of infested wood and promote early detection remain priorities. Early detection is particularly important with Asian longhorned beetle, since small, newly-discovered populations can be successfully eradicated.

Table 18. Location of Asian Longhorned Beetle traps deployed in Vermont in 2016. Data include county, town, location, tree species, coordinates, dates of deployment and number of trap checks.

County	Town	Site	Tree Species	Latitude	Longitude	Date out	Date in	Number of Trap Checks
Chittenden	Underhill	Underhill State Park	Sugar maple	44.529	-72.843	7/6/2016	9/23/2016	6
Grand Isle	Grand Isle	Grand Isle State Park	Sugar maple	44.68682	-73.29166	7/7/2016	9/23/2016	6
Franklin	Franklin	Lake Carmi State Park	Red maple	44.95409	-72.87571	7/6/2016	9/23/2016	5
Windham	Jamaica	Jamaica State Park	Sugar maple	43.10879	-72.77467	6/24/2016	9/10/2016	5
Windsor	Hartford	Quechee State Park	Sugar maple	43.63593	-72.40372	6/24/2016	9/26/2016	6
Windham	Guilford	I-91 Visitor Center	Sugar maple	42.81263	-72.56603	6/24/2016	6/24/2016	6
Bennington	Bennington	Woodford State Park	Sugar maple	42.88771	-73.03626	6/16/2016	9/9/2016	6
Bennington	Dorset	Emerald Lake State Park	Sugar maple	43.26999	-73.01112	6/14/2016	9/9/2016	6
Rutland	Poultney	Lake St Catherine State Park	Sugar maple	43.48074	-73.20694	6/14/2016	9/9/2016	6
Lamoille	Elmore	Elmore State Park	Sugar maple	44.54462	-72.53438	7/1/2016	9/9/2016	5
Washington	Waterbury	Little River State Park	Sugar maple	44.39394	-72.76129	6/30/2016	9/9/2016	5
Washington	Warren	Claudia Watt Residence	Weeping willow	44.11349	-72.85426	7/1/2016	9/9/2016	5
Caledonia	Groton	Groton State Forest Nature Center	Norway maple	44.28580	-72.26496	6/29/2016	9/21/2016	5
Orleans	Derby Line	Derby Line Welcome Center	Sugar maple	44.99443	-72.10335	6/30/2016	9/21/2016	5
Caledonia	Groton	Ricker Pond State Park	Sugar maple	44.24645	-72.25317	6/29/2016	9/21/2016	5

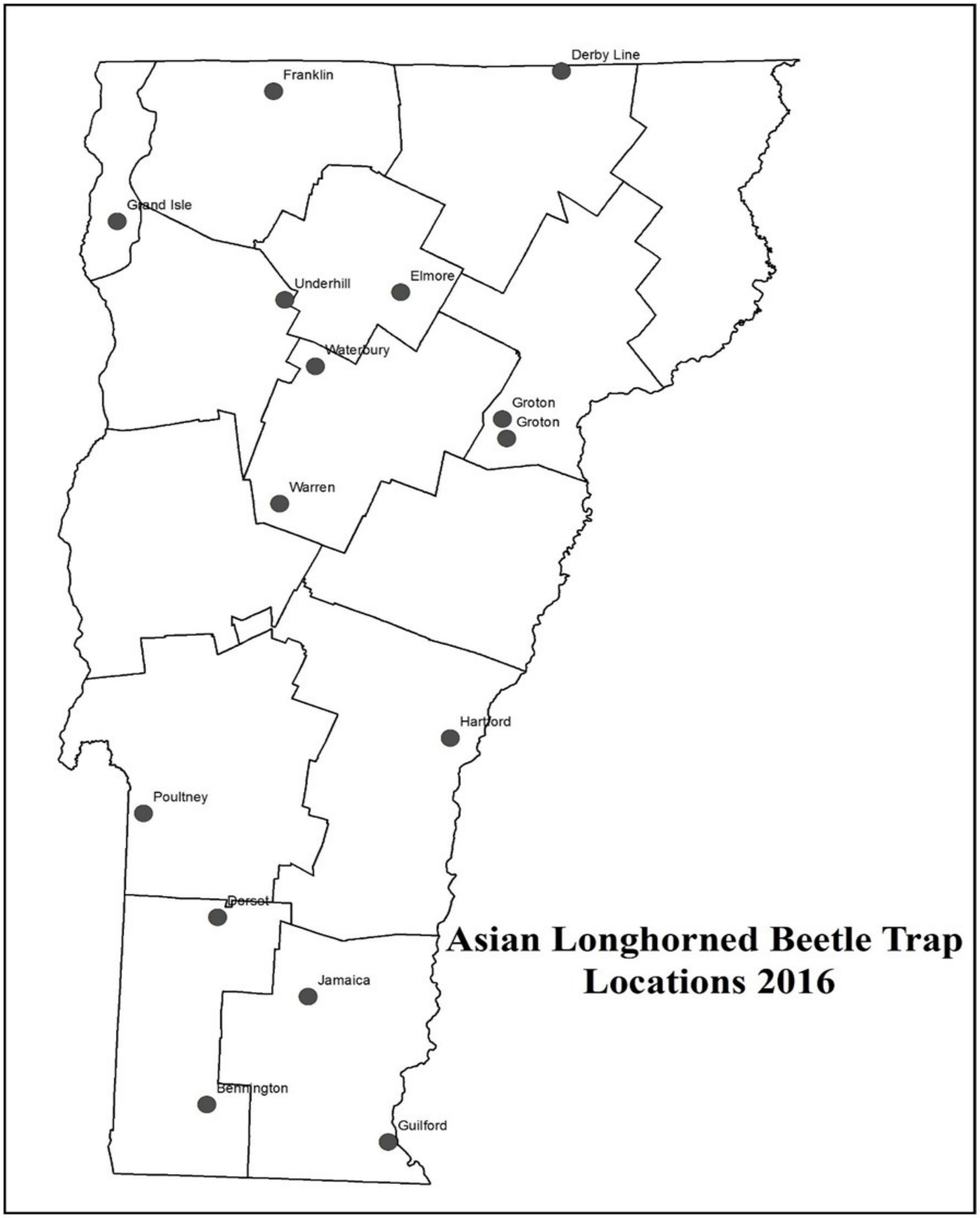


Figure 24. Asian Longhorned Beetle trap locations in 2016. There was a single trap at each location.

Emerald Ash Borer (EAB), *Agrilus planipennis*, is not known to occur in Vermont and was not detected by survey in spite of our most aggressive emerald ash borer detection efforts to date. USDA APHIS continued to lead a statewide survey effort, and established 515 purple pheromone traps throughout Vermont.

To compliment the USDA traps, and build on our 2015 intensive survey in Bennington and Rutland counties, we expanded this effort to the northwest corner of Vermont (Grand Isle and Franklin counties). Working with volunteers and staff, five high risk sites were resurveyed in southwestern Vermont, and 10 new sites were established in the northwestern corner of the state. At each site, a single purple prism trap and green funnel trap were hung, for a total of 30 traps. Girdled trap trees were established at six of the sites. (Figure 25).

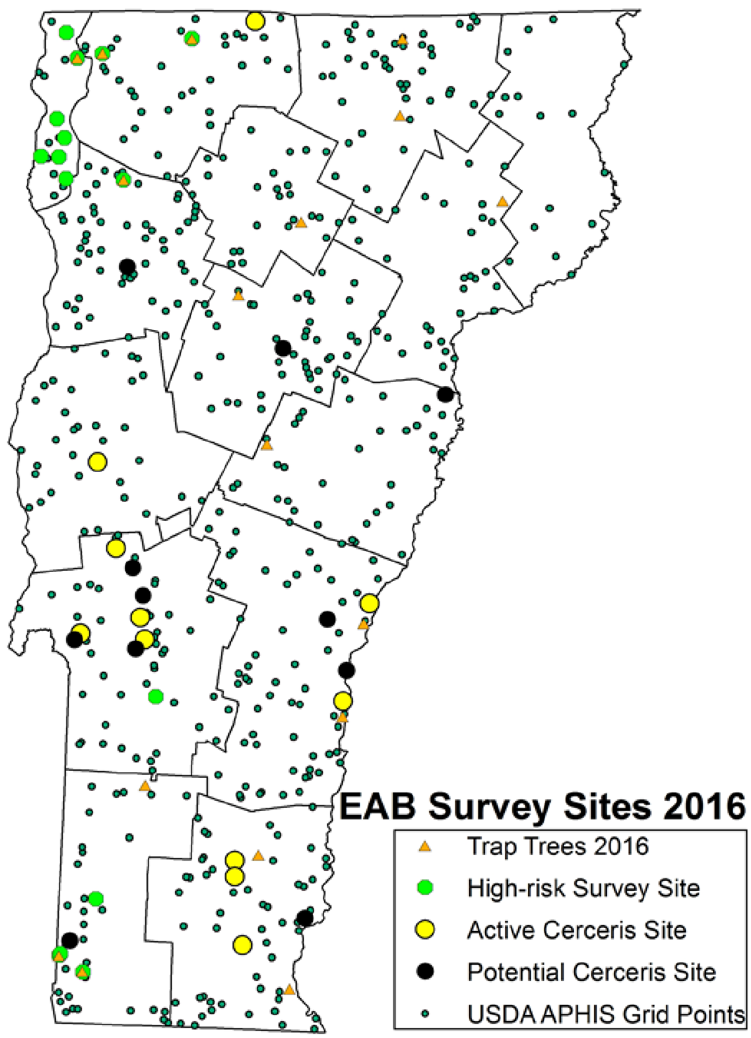


Figure 25. 2016 survey locations for Emerald Ash Borer in Vermont, including trap trees, high-risk intensive survey sites, active and potential *Cerceris fumipennis* nest sites, and USDA grid points for purple pheromone traps.

In addition to trap trees that were part of the intensive EAB survey effort in Bennington, Rutland, Franklin and Grand Isle Counties, we selected ash trees from twelve additional high risk areas for a total of 18 trap trees in 10 counties (Table 19 and Figure 26). Three were green ash and the rest were white ash. As in past years, trees 4-10 inches in diameter were girdled with a pruning saw to make two parallel cuts, 8-12 inches apart. A drawknife was used to remove the bark between these cuts. Girdled trees were cut in early November. FPR staff, with the assistance of VAAFM and First Detectors, peeled bolts from the trees on November 10. No evidence of the emerald ash borer was discovered.

Table 19. Locations of girdled trap trees used to survey for emerald ash borer in 2016. Data include district, site, county, coordinates, observer and tree identification number.

EAB Trap Tree Locations - 2016						
District	**Site**	**County**	**Latitude**	**Longitude**	**Observer**	**Tree Number**
1	I-91 ROW WRJ	Windsor	43.64347	-72.33896	Esden	16-1-1
1	Ascutney SP	Windsor	43.43460	-72.40414	Esden	16-1-2
1	Fort Dummer SP	Windham	42.82376	-72.56665	Esden	16-1-3
2	Whipstop Hill WMA	Bennington	42.89637	-73.26839	Lund	16-2-1
2	Emerald Lake SP	Bennington	42.28033	-73.00795	Lund	16-2-2
2	One World Conservation Ctr.	Bennington	42.86144	-73.19683	Lund	16-2-3
3	Maquam WMA	Franklin	44.92017	-73.15719	Dillner	15-3-1
3	Lake Carmi SP	Franklin	44.95734	-72.87498	Dillner	15-3-2
3	North Hero SP	Grand Isle	44.90853	-73.23652	Dillner	15-3-3
4	Randolph Swamp Plains Forest	Orange	43.92455	-72.66218	Lackey	16-4-1
4	Elmore SP	Lamoille	44.54436	-72.53200	Lackey	16-4-2
4	Waterbury Center Day Use SP	Washington	44.38007	-72.72671	Lackey	16-4-3
4	Allis SF	Orange	44.04552	-72.63733	Lackey	16-4-4
5	Bluffside Farm	Orleans	44.9545	-72.21397	Greaves	16-5-1
5	Lake Region HS	Orleans	44.78243	-72.22193	Greaves	16-5-2
5	Toll Road, Burke Mountain	Caledonia	44.58934	-71.90175	Greaves	16-5-3

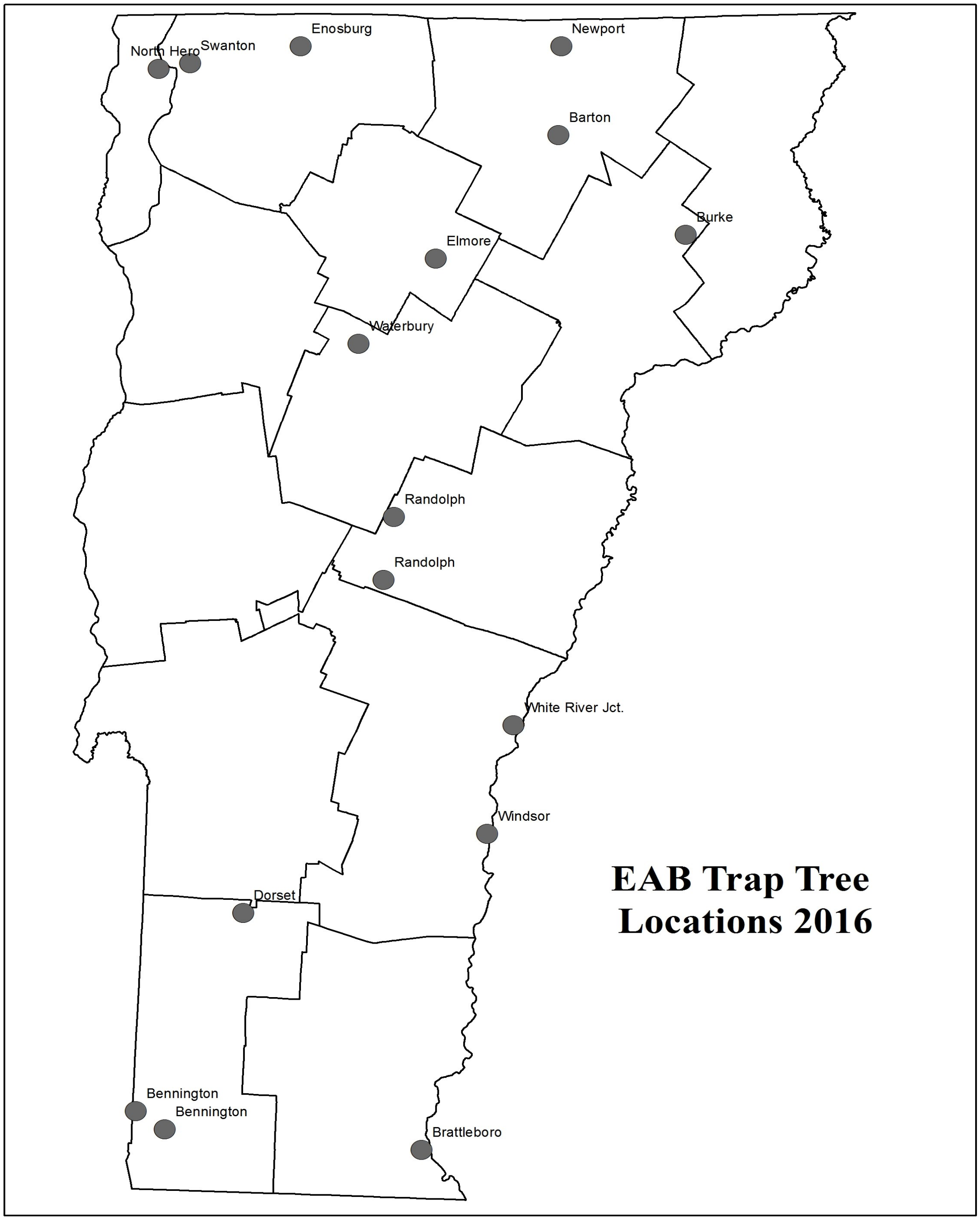


Figure 26. Location of girdled ash trap trees in 2016.

Cerceris fumipennis wasps continue to be an important early detection biosurveillance tool for emerald ash borer. In 2016, a total of 136 visits were made to 42 known and potential nest sites in Vermont. Buprestid beetles (719 specimens, comprised of 210 "steals" and 509 "drops") were collected at 20 nest sites (Table 20 and Figure 27). Though several *Agrilus* species were collected, none were the emerald ash borer, *Agrilus planipennis*. In addition to FPR efforts, 37 volunteers contributed a total of 99 hours to the surveys, and were credited with finding new sites in Bellows Falls, Shelburne and Windsor.

Table 20. Vermont sites where *Cerceris fumipennis* nests were found in 2016. Data include county, town, site, coordinates, and numbers of buprestid beetles collected at each site.

County	Town	Site	Latitude	Longitude	Number of Buprestids
Addison	Middlebury	Middlebury Union HS	44.003689	-73.162169	10
Chittenden	Shelburne	Shelburne Ballfield	44.379082	-73.229597	9
Franklin	Richford	Richford Playground	44.993795	-72.677627	50
Orange	Newbury	Newbury Green	44.078323	-72.059989	1
Rutland	Brandon	Estabrook Field	43.810583	-73.103448	36
Rutland	Castleton	Castleton Hubbardton Elem. School	43.619623	-73.211399	25
Rutland	Hydeville	Hydeville Ball Field	43.604961	-73.229946	2
Rutland	Pittsford	Lothrop School	43.705447	-73.018670	50
Rutland	Poultney	Poultney Elementary	43.313080	-73.141685	2
Rutland	Proctor	Proctor Junior/Senior High School	43.655607	-73.028018	110
Rutland	Rutland Town	Dewey Field	43.607180	-73.013244	53
Washington	Montpelier	Montpelier High School	44.260380	-72.589250	52
Windham	Bellows Falls	Bellows Falls Union High School – Hadley Field Parking Lot	43.111720	-72.438390	37
Windham	Bellows Falls	Bellows Falls Union High School – Lower ballfield	43.118820	-72.447410	17
Windham	Jamaica	Stephen Ballantine Memorial Field	43.076380	-72.733690	67
Windham	Putney	Sand Hill Pit	42.982761	-72.520881	117
Windham	Putney	Sand Hill Road	42.981790	-72.520430	3
Windsor	Norwich	Dothan Brook School	43.688980	-72.321390	30
Windsor	Windsor	Simon Pearce	43.518382	-72.400921	45
Windsor	Windsor	Windsor Town Rec Field	43.469240	-72.403290	3
					719

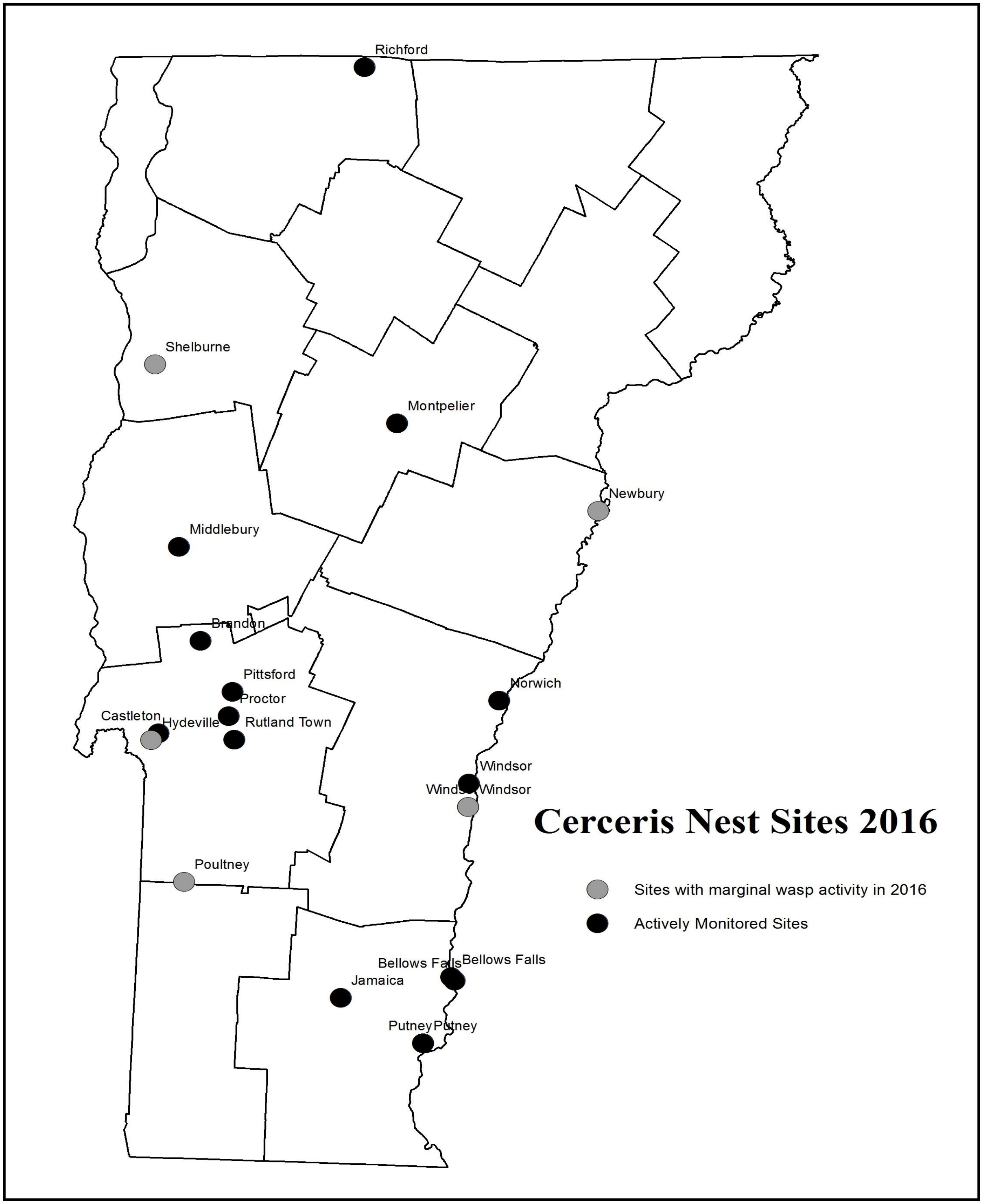


Figure 27. Location of *Cerceris fumipennis* nest sites in 2016.

Because *Cerceris fumipennis* excels at detecting **buprestid diversity**, we have realized a side benefit of this biosurveillance work. We have added 42 records to our state buprestid list since we began "wasp watching" in 2008; 27 species were acquired from incoming foraging wasps (19 "steals" and 8 "drops"), five came from purple traps and 10 from green funnel traps.

E.R. Hoebeke, Associate Curator of the Collection of Arthropods at Georgia Museum of Natural History, University of Georgia, has been identifying Vermont buprestids collected as part of our EAB survey work. In addition to our buprestid records, we have obtained information from the Zadock Thompson Collection at the University of Vermont. Table 21 lists buprestid species in these collections and provides date and location of each record. Identifications of buprestids collected in 2016 are pending.

Table 21. First records of Buprestids from Vermont FPR Forest Biology Lab Collection and UVM Zadock Thompson Collection through 2015.

Species	Location	How collected	Date
Subfamily Agrilinae			
Agrilus anxius Gory	Ludlow, VT	Emerged from birch	1/23/2007
Agrilus arcuatus (Say)	Windsor, VT	Stolen from Cerceris	7/28/2009
Agrilus bilineatus (Weber)	Ferrisburgh, VT	EAB purple trap	5/18/2010 - 7/6/2010
Agrilus carpini Knull	Bellows Falls, VT	Stolen from Cerceris	7/21/2014
Agrilus corylicola Fisher	Sunderland, VT	Stolen from Cerceris	7/22/2012
Agrilus crinicornis Horn	Pownall, VT	Green funnel trap	5/29/2015-6/15/2015
Agrilus cyanescens Ratzeburg	Bennington & Wallingford VT	Green funnel trap	6/9/2015-6/23/2015
Agrilus egenus Gory	Wallingford, VT	Green funnel trap	6/25/2015-7/10/2015
Agrilus granulatus (Say)	Rutland Town, VT	Stolen from Cerceris	7/16/2011
Agrilus juglandis Knull	Jamaica, VT	Stolen from Cerceris	7/11/2012
Agrilus masculinus Horn	Shaftsbury, VT	Green funnel trap	5/29/2015-6/12/2015
Agrilus obsoletoguttatus Gory	Putney, VT	Stolen from Cerceris	7/17/2012
Agrilus ohioensis Knull	Shaftsbury, VT	Green funnel trap	5/29/2015-6/12/2015
Agrilus osburni Knull	Wallingford, VT	Green funnel trap	6/9/2015-6/25/2015
Agrilus otiosus Say	Shaftsbury, VT	Green funnel trap	5/29/2015-6/12/2015
Agrilus politus (Say)	Georgia, VT	EAB purple trap	8/13/2009
Agrilus putillus Say	Grand Isle, VT	EAB purple trap	7/30/2013
Agrilus ruficollis (F.)	Huntington, VT	Hand collected	7/5/2009
Agrilus sayi Saunders	Grand Isle, VT	EAB purple trap	9/10/2008
Agrilus subcinctus Gory	Bennington, VT	Green funnel trap	5/29/2015-6/24/2015
Eupristocerus cognitans (Weber)	Swanton, VT	Stolen from Cerceris	7/15/2010
Subfamily Buprestinae			
Anthaxia viridifrons Gory	Bennington, VT	Green funnel trap	5/29/2015-6/24/2015
Buprestis consularis Gory	Jamaica, VT	Stolen from Cerceris	7/13/2015
Buprestis fasciata F.	Burlington, VT	Hand collected	7/1/1993
Buprestis maculativentris Say	East Dorset, VT	Hand collected	7/1/1935
Buprestis striata F.	East Dorset, VT	Hand collected	5/1/1953
Dicerca asperata (Laporte & Gory)	Rutland Town, VT	Stolen from Cerceris	7/31/2012

Species	Location	How collected	Date
Subfamily Buprestinae (cont.)			
Dicerca caudata LeConte	East Dorset, VT	Hand collected	8/1/1935
Dicerca divaricata (Say)	East Dorset, VT	Hand collected	9/1/1934
Dicerca dumolini (Laporte & Gory)	Brandon, VT	Dropped by Cerceris	7/20/2012
Dicerca lurida (F.)	Grand Isle, VT	Baited exotic bark beetle funnel trap	6/7/1995
Dicerca pugionata (Germar)	Jamaica, VT	Stolen from Cerceris	7/29/2015
Dicerca punctulata (Schoenherr)	Bellows Falls, VT	Dropped by Cerceris	7/18/2013
Dicerca tenebrica (Kirby)	Mallett's Bay, VT	Hand collected	5/1/1969
Dicerca tenebrosa (Kirby)	Richford, VT	Stolen from Cerceris	8/12/2010
Dicerca tuberculata (Gory & Laporte)	Greensboro, VT	Hand collected	8/7/1984
Phaenops fulvoguttata (Harris)	Burke, VT	Hand collected	6/25/1980
Poecilonata cyanipes (Say)	Bolton, VT	Hand collected	7/1/1972
Spectralia gracilipes (Melsheimer)	Brandon, VT	Stolen from Cerceris	7/20/2011
Subfamily Chalcophorinae			
Chalcophora fortis LeConte	Ferrisburgh, VT	Hand collected	7/11/2014
Subfamily Chrysobothrinae			
Chrysobothris azurea LeConte	Poultney, VT	Stolen from Cerceris	7/14/2011
Chrysobothris chlorocephala Gory	Swanton, VT	Dropped by Cerceris	7/12/2010
Chrysobothris cribraria Mannerheim	Berlin, VT	Hand collected	6/11/1957
Chrysobothris dentipes (Germar)	Putney, VT	Dropped by Cerceris	7/6/2013
Chrysobothris femorata (Olivier)	Lincoln, VT	Hand collected	8/15/1993
Chrysobothris harrisi (Hentz)	Wolcott, VT	Hand collected	6/25/1992
Chrysobothris neopusillus Fisher	Richford, VT	Stolen from Cerceris	7/19/2014
Chrysobothris orono Frost	East Thetford, VT	Stolen from Cerceris	7/20/2014
Chrysobothris rotundicollis Gory & Laporte	Jamaica, VT	Stolen from Cerceris	7/13/2012
Chrysobothris pusilla Gory & Laporte	Bellow Falls, VT	Dropped by Cerceris	7/10/2015
Chrysobothris scabripennis Gory & Laporte	Castleton, VT	Dropped by Cerceris	7/24/2014
Chrysobothris sexsignata (Say)	Moretown, VT	EAB purple trap	6/18/2008
Chrysobothris trinervia Kirby	Wells River, VT	Stolen from Cerceris	8/6/2014

Species	Location	How collected	Date
Subfamily Trachyinae			
Brachys aerosus (Melsheimer)	Sunderland, VT	Stolen from Cerceris	7/22/2012
Brachys sp., poss. *aeruginosus Gory*	Bennington, VT	Green funnel trap	6/19/2016-7/10/2015
Brachys ovatus (Weber)	Brandon, VT	Stolen from Cerceris	7/21/2011

Firewood Program: Invasive insects, like the emerald ash borer and Asian longhorned beetle, can live inside firewood and are unknowingly transported to new locations where they will emerge as adults and start new infestations. The impacts from such infestations are devastating to the environment, economy, and society.

The **State Parks Firewood Exchange Project** continued in 2016, marking the 8th year that our State Parks exchanged firewood with campers who had transported wood over long distances. From 2009-2012, firewood from over 50 miles away was exchanged (Table 22). Since 2013, wood has been exchanged if it was brought in from out of state. This year the total number of firewood bags collected statewide was 64. This is more than what was collected in the past 2 years.

Parks that collected firewood this year included: Stillwater (2 bags), Elmore (8 bags), Little River (17 bags), Emerald Lake (2 bags), Wilgus (15 bags), Silver Lake (9 bags), Coolidge (4 bags), Fort Dummer (2 bags), Ascutney (2 bags), and one bag each from Brighton, Jamaica, and Gifford Woods. Firewood brought into our Parks this year came from: Virginia, Pennsylvania, New York, New Jersey, Massachusetts, Connecticut and New Hampshire. Forest Protection staff opened and examined all of the wood collected. No evidence of invasive pests were found.

Table 22. Numbers of bags of firewood brought into Vermont State Parks during the 2009-2016 camping seasons. 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

On May 1, 2016 a state **Firewood Rule** went into effect. Untreated firewood may not be brought into Vermont unless it is certified as heat-treated. The definition of firewood states that it is wood processed for burning and less than 48 inches in length, but does not include wood chips, pellets, pulpwood, or wood for manufacturing purposes. It allows treated firewood to enter the state if it is treated to the USDA standard of 160° F (71.1° C) for at least 75 minutes at a certified treatment facility and is accompanied by certification of treatment. By written request, the Commissioner may waive this prohibition under conditions which ensure that the firewood poses minimal threat to forest health.

UVM Extension is working in partnership with Vermont Department of Forests, Parks and Recreation, Vermont Agency of Agriculture, Food, and Markets, Animal Health, Plant Inspection Service (APHIS), Green Mountain National Forest, and Don't Move Firewood to spread awareness about the law. The ongoing campaign has three target audiences: firewood dealers, private campground owners, and second home owners. UVM Extension mailed letters to 82 private campgrounds throughout Vermont with information about the law and an opportunity for each campground to request outreach material for their campers. Vermont Department of Forests, Parks and Recreation sent letters to firewood dealers and vendors throughout the state. UVM Extension partnered with the Vermont Lottery to distribute posters to 700 convenience stores throughout the state.

Regional Invasive Insect Preparedness Team: Concerned citizens who have been trained as Forest Pest First Detectors started the Regional Invasive Insect Preparedness Team (RIIPT) in 2013. RIIPT represents a planning effort spanning much of Lamoille County and beyond. This year, with a $5000 Caring for Canopy grant from the Vermont Urban & Community Forestry Program, volunteers created four educational and fun public service announcements that were distributed throughout the state on a variety of different media (YouTube links below). RIIPT also created a full page, four color ad that was placed in the News & Citizen and Stowe Reporter, which reached over 16,000 households. Two ash inventories were completed (Eden and Elmore) and three preparedness plans were written (Morristown, Eden, and Elmore). A total of 490 volunteer hours were recorded by RIIPT members and an additional 168 volunteer hours were logged by student volunteers, and other members outside RIIPT for this project. RIIPT continues to educate and inform people across Lamoille County and beyond about importance of preparing for an invasive species infestation. For https://www.youtube.com/watch?v=qyHTjlXqXbQ&feature=youtu.be

Exotic Wood Borer/Bark Beetle National Survey: In 2016, staff with the USDA APHIS Plant Protection and Quarantine (PPQ) and the Vermont Agency of Agriculture, Food and Markets (VAAFM) deployed traps for exotic woodboring beetles. Trap catches were submitted to the Carnegie Museum for identification. Though complete results are pending, three targeted insects were collected, including the pine shoot beetle (*Tomicus piniperda*), sirex woodwasp (*Sirex noctilio*), and brown marmorated stinkbug (*Halyomorpha halys*) (Table 23).

Table 23. Target insects collected by USDA APHIS and VAAFM in Vermont as part of the Exotic Wood Borer/Bark Beetle National Survey.

Target	County	Collection Date	Trap Type	Lure Combo	Agency
Pine Shoot Beetle	Chittenden	6/24/2016	Lindgren	Alpha-pinene, Ethanol, Monochomol	VAAFM
Sirex noctilio	Addison	8/24/2016	Lindgren	Alpha-pinene, Ethanol, Monochomol	VAAFM
Sirex noctilio	Rutland	8/24/2016	Lindgren	Alpha-pinene, Ethanol UHR	VAAFM
Sirex noctilio	Windham	8/12/2016	Lindgren	Alpha-pinene, Ethanol UHR	USDA-APHIS
Brown Marmorated Stinkbug	Chittenden	9/30/2016	Lindgren	3 component Ips	VAAFM

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Asian Longhorned Beetle	*Anoplophora glabripennis*	Various hardwoods		Not observed or known to occur in Vermont. See narrative.
Banded Ash Borer	*Neoclytus caprea*	Ash	West Windsor	Emerged from dead tree.
Bronze Birch Borer	*Argrilus anxius*	Birch	Scattered throughout	Frequently observed on stressed ornamentals.
Black Spruce Beetle	*Tetropium castaneum*	Spruce, pine, fir and larch		Not observed or known to occur in Vermont.
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	Continue to receive inquiries from homeowners.
Eastern Ash Bark Beetle	*Hylesinus aculeatus*	Ash	Scattered reports	Beetles encountered in homes as they emerged from firewood and logs.
Eastern Carpenter Bee	*Xylocopa virginica*	Wood product	Springfield	Bees had nested in wood framing of home and were defecating on siding.
Eastern Larch Beetle	*Dendroctonus simplex*	Tamarack	Northeastern Vermont	Scattered mortality.
Emerald Ash Borer	*Agrilus planipennis*	Ash		Not observed or known to occur in Vermont. See narrative.
European Woodwasp	*Sirex noctilio*	Red and Scots pine		See narrative in Exotic Wood Borer/Bark Beetle National Survey report.
Hemlock Borer	*Phaenops fulvoguttata*	Hemlock and occasionally other conifers	Statewide	No new mortality reports, but levels expected to increase following dry conditions in 2016.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Japanese Cedar Longhorned Beetle	*Callidiellum rufipenne*	Arborvitae, eastern redcedar, juniper and others		Not observed or known to occur in Vermont.
Locust Borer	*Megacyllene robiniae*	Locust	Winooski	Adults observed on goldenrod.
Northeastern Sawyer	*Monochamus notatus*	Conifers	Scattered	Occasional reports during adult flight period.
Old House Borer	*Hylotrupes bajulus*	Cedar log home	Brownington	Chewing noises heard and adult beetles observed.
Pigeon Tremex	*Tremex columba*	Sugar maple	Scattered throughout	Commonly observed in declining trees or turning up while splitting firewood.
Roundheaded Apple Tree Borer	*Saperda candida*	Apple	Widely scattered	Found in trees already weakened due to some other stress.
Rustic Borer	*Xylotrechus colonus*	Hardwood firewood	Underhill	Adults recovered.
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.
Tanbark Borer	*Phymatodes testaceus*	Oak	Underhill	Adult emerged from firewood.
Whitespotted Sawyer	*Monochamus scutellatus*	White pine and other conifers	Throughout	Adults commonly observed.

Other Bark and Wood Insects not reported in 2016 included Allegheny Mound Ant, *Formica exsectoides;* Brown Prionid, *Orthosoma brunneum;* Carpenterworm, *Prionoxystus robiniae* ; Eastern Larch Beetle, *Dendroctonus simplex;* Elderberry Borer, *Desmocerus palliatus* ; Elm Bark Beetles, *Hylurgopinus rufipes* and *Scolytus multistriatus* ; Red-headed Ash Borer, *Neoclytus acuminatus* ; Red Turpentine Beetle, *Dendroctonus valens;* Spruce Beetle, *Dendroctonus rufipennis.*

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Rose Chafer	*Macrodactylus subspinosus*	Many	Statewide	Few reports in 2016.
Western Conifer Seed Bug	*Leptoglossus occidentalis*	Conifers	Statewide	Fewer reports than previous years. No damage to Vermont conifers has been recorded, but a common household invader.
Xyela sawfly	*Xyela* sp.	Pine	Weathersfield	Tiny white maggots dropped from trees onto car beneath. Larvae feed in staminate flowers or in shoots of pines.

Fruit, Nut and Flower Insects not reported in 2016 included Asiatic Garden Beetle, *Autoserica castanea* ; Butternut Curculio, *Conotrachelus juglandis;* Fir Coneworm, *Dioryctria abietivorella;* Pine Coneworm, *Dioryctria reniculelloides;* Plum Curculio, *Conotrachelus nenuphar*.

STEM DISEASES

Dieback from **Beech Bark Disease** was mapped on 7,278 acres, a decrease from the 35,866 acres mapped in 2015 (Table 24 and Figure 28). The drop in acreage mapped may be due to the timing of the aerial survey in 2016 compared to recent years. The bright yellow crowns of symptomatic trees develop over the growing season, and would be less noticeable in mid-summer than in late summer. From the ground yellow crowns, dieback and mortality are commonly observed.

Weather may also have played a role. The summers of 2011-2013 had a high frequency of storms which may have reduced the survival of beech scale crawlers. An uptick in beech bark disease is expected, since recent summers have had fewer storms, and drought-stressed bark is more susceptible to the Nectria fungus.

Table 24. Mapped acres of beech bark disease in 2016.

County	Acres
Addison	510
Bennington	1,224
Caledonia	197
Chittenden	52
Essex	736
Franklin	177
Grand Isle	0
Lamoille	221
Orange	441
Orleans	275
Rutland	740
Washington	203
Windham	1,178
Windsor	1,324
Total	7,278

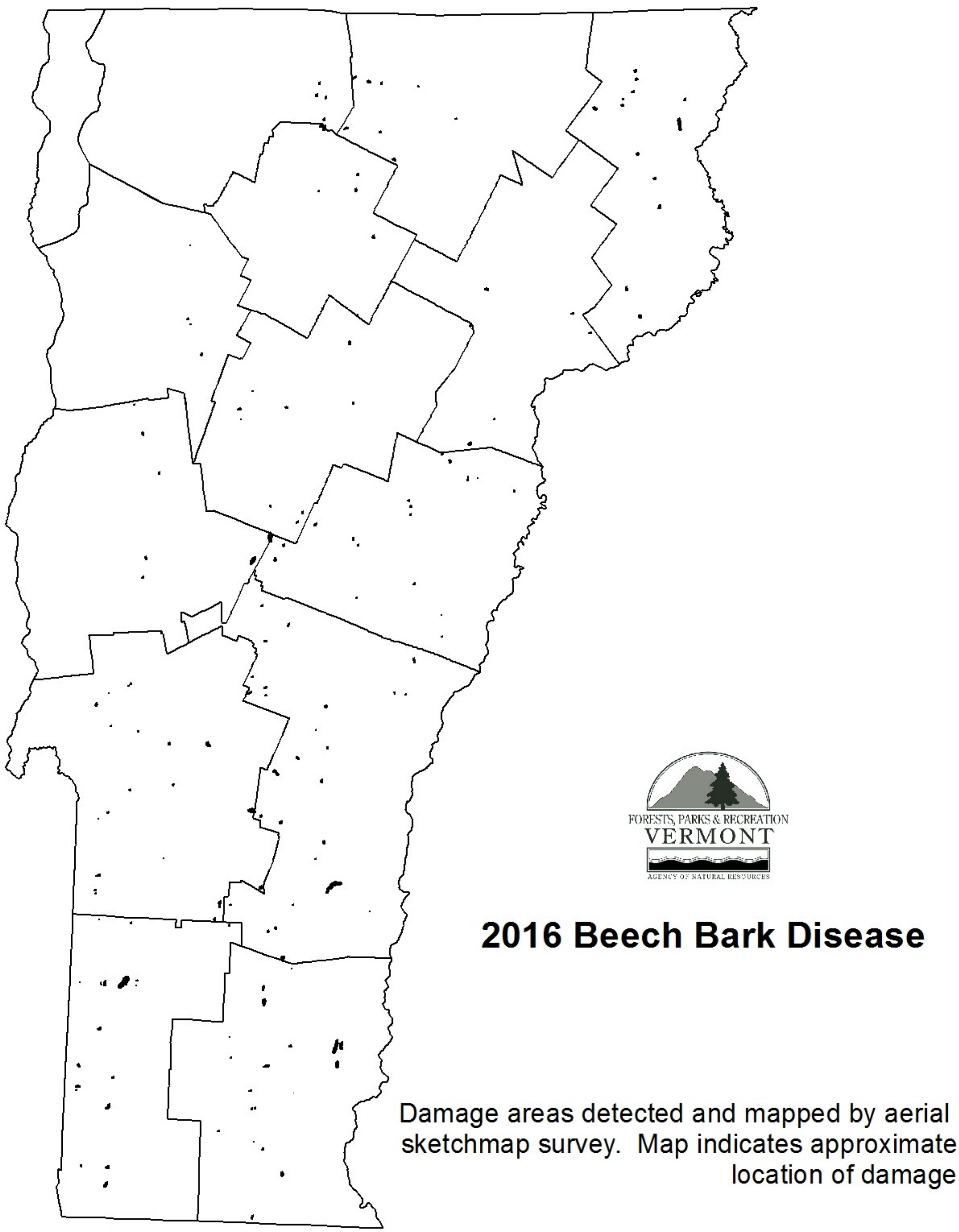


Figure 28. Beech bark disease related decline and mortality mapped in 2016. Mapped area includes 7,278 acres.

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.
Beech Bark Disease	*Cryptococcus fagisuga and Nectria coccinea var. faginata*			See narrative.
Black Knot	*Dibotryon morbosum*	Cherry	Scattered throughout	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.
Chestnut Blight	*Cryphonectria parasitica*	American chestnut	Southern Vermont, Champlain Valley	Observed on sprouts. The American Chestnut Foundation remains active in establishing seed orchards in Vermont.
Cytospora Canker	*Leucostoma kunzei*	Blue spruce	Widely scattered	Damage levels remain low.
Diplodia Shoot Blight	*Sphaeropsis sapinea*	Red pine	Widespread	Role in red pine decline is unclear (see Diebacks, Declines, and Environmental Diseases).
Dutch Elm Disease	*Ophiostoma novo-ulmi*	Elm	Throughout	Flagging and mortality more noticeable than normal by mid-summer.
Hickory Canker Rot	*Poria spiculosa*	Bitternut Hickory	Brandon	Thought to be the cause of canker in woodlot hickory.

OTHER STEM DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Hypoxylon Canker	*Hypoxylon pruinatum*	Poplar	Widely scattered	Damage levels low.
Nectria Canker	*Nectria galligena*	Hardwoods	Scattered throughout	
Oak Wilt	*Ceratocystis fagacearum*			Not observed or known to occur in Vermont.
Red Ring Rot	*Phellinus pini*	White pine	Scattered throughout	Common in unthrifty stands, heavily wounded, or overstocked stands.
Thousand Cankers Disease	*Geosmithia morbida* and *Pityophthorus juglandis*	Walnut		Not observed or known to occur in Vermont.
Verticillium Wilt	*Verticillium albo-atrum*	Sugar maple	Woodstock	Ornamental.
White Pine Blister Rust	*Cronartium ribicola*	White pine	Scattered throughout	Incidence remains higher than normal with 197 acres of scattered mortality mapped during aerial surveys.
Woodgate Gall Rust	*Endocronartium harknessii*	Scots pine	Northern Vermont	Present in pockets of unthrifty roadside Scots pine.
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 2016 included Cedar Apple Rust, *Gymnosporangium juniperi-virginianae* ; Delphinella Tip Blight of Fir, *Delphinella balsamae* ; Eastern Dwarf Mistletoe, *Arceuthobium pusillum* ; Sapstreak, *Ceratocystis coerulescens* ; Scleroderris Canker, *Ascocalyx abietina* .

FOLIAGE DISEASES

White Pine Needle Damage (WPND) – White pine needle damage was widespread once again this year, with a complex of fungal species including Brown Spot Needle Blight (*Mycosphaerella dearnessii*), and two needlecast fungi (*Lophophacidium dooksii* and *Bifusella linearis*) contributing to the damage. Statewide, we observed more white pine needle damage than ever; during aerial surveys, over 30,000 acres were mapped (see Table 25 and Figure 29). The larger acreage mapped reflects both the large area affected and the earlier aerial survey date in 2016. Nonetheless, this still 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, and since damage peaks in the spring becoming less noticeable during mid-summer aerial surveys.

Table 25. Mapped acres of thin crowns due to needle diseases of white pines in 2016.

County	Acres
Addison	1,415
Bennington	1,442
Caledonia	1,145
Chittenden	273
Franklin	219
Lamoille	636
Orange	6,073
Orleans	565
Rutland	2,097
Washington	2,460
Windham	4,585
Windsor	9,756
Total	**30,666**

The damage has been widespread since 2010, and the current epidemic has been building at least since 2005. The same symptoms have been reported as “needle diseases of white pine” (2012-2015), “white pine needlecast (2011), and “white pine needle damage” (2010) in previous reports of Forest Insect and Disease Conditions in Vermont, and were reported for several years prior to 2010 as “brown spot needle blight”.

These diseases are most severe in the lower crown where fungi have been thriving due to multiple wet springs. 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.

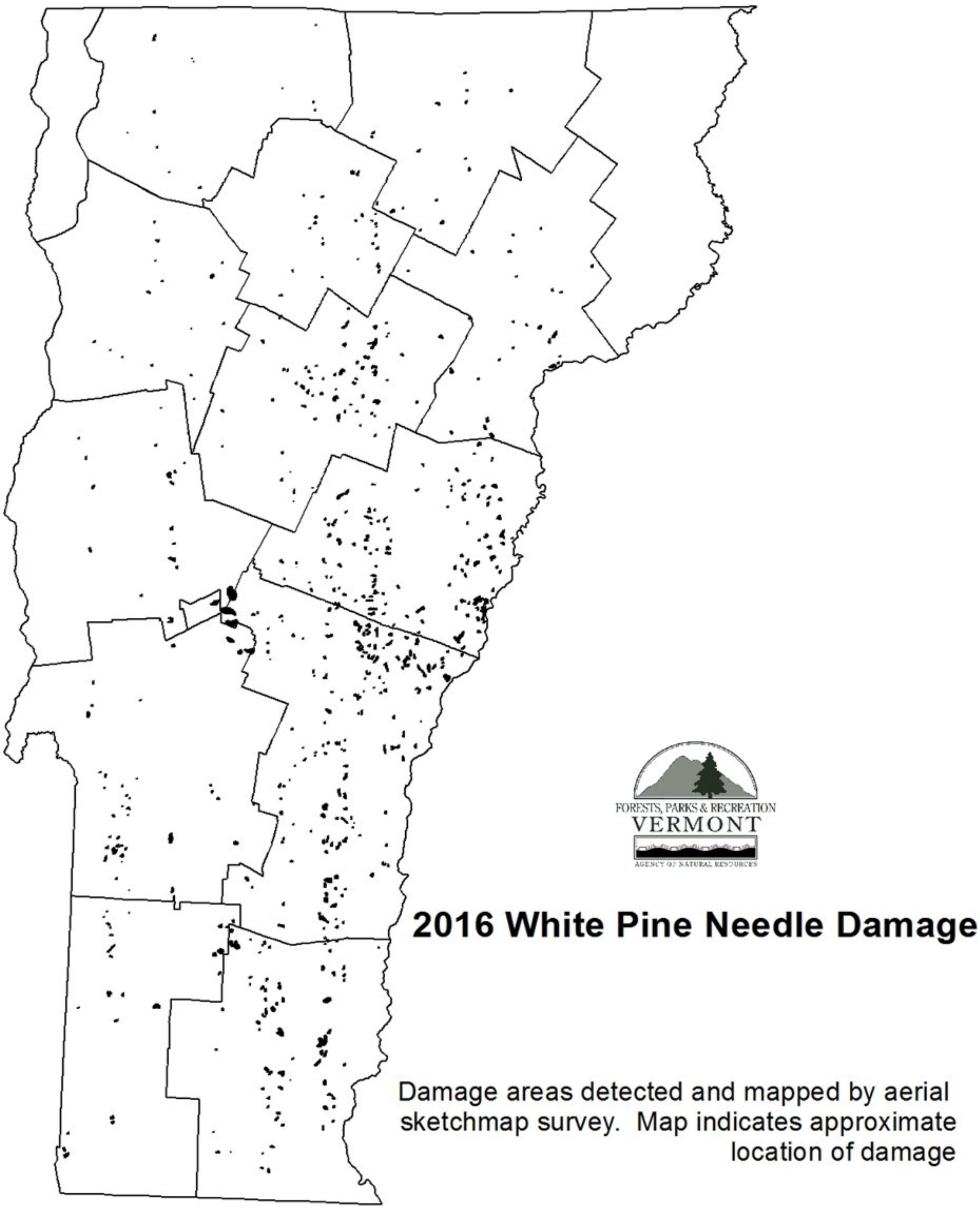


Figure 29. Thin crowns of white pines due to needle diseases mapped in 2016. Mapped area includes 30,666 acres.

The U.S. Forest Service, in cooperation with UNH and 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.

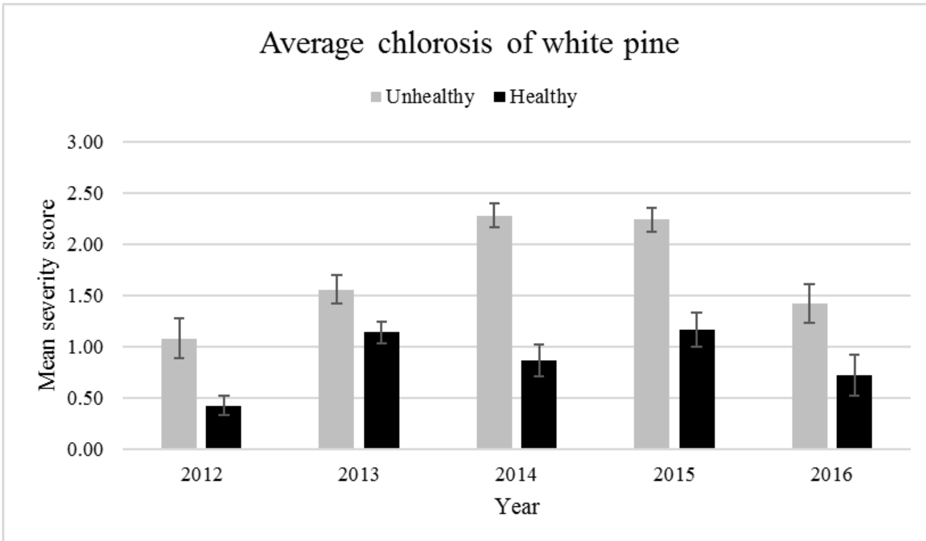


Figure 30. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed at four sites between 2012-2016 in Vermont. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

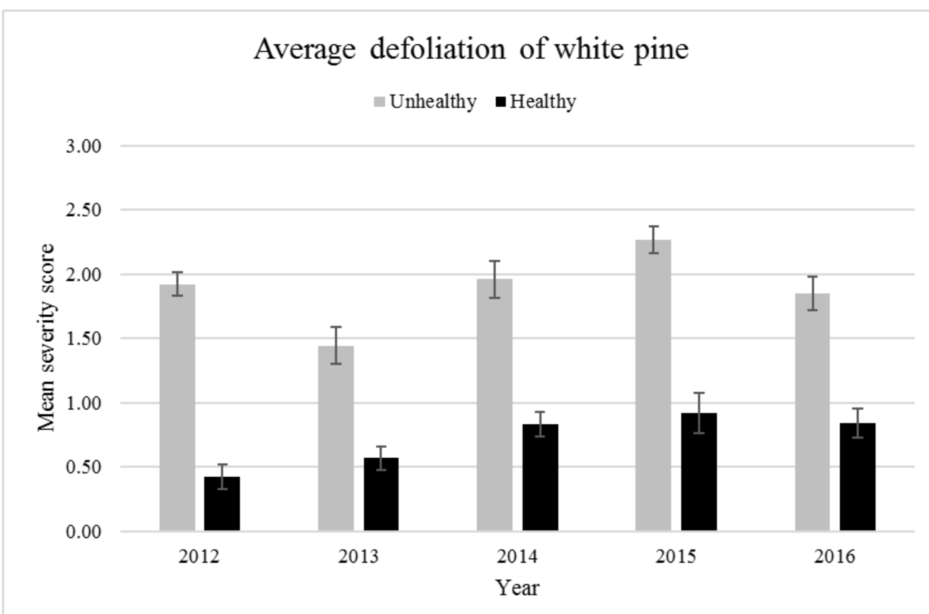


Figure 31. Defoliation severity of unhealthy and healthy white pines surveyed at four sites between 2012 -2016 in Vermont. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

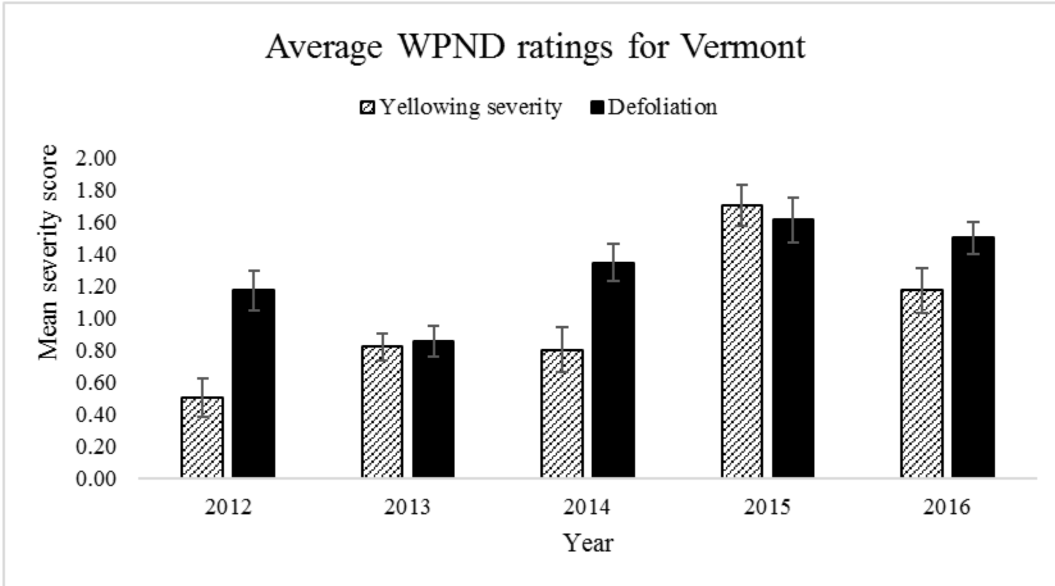


Figure 32. Average trends in yellowing severity and defoliation for all trees sampled at four sites in Vermont between 2012-2016. Data presented are mean severity scores (0 = no chlorosis/defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Anthracnose	*Glomerella spp.; Apiognomonia*	Hardwoods	Statewide	No areas of heavy anthracnose were reported this year, likely due to dry conditions.
Birch Leaf Fungus	*Septoria betulae*	Birch	Statewide	Very little birch defoliation in 2016.
Brown Spot Needle Blight	*Scirrhia acicola*	Pines	Northeastern Vermont	Thin crowns, some decline and mortality.
Cedar-Apple Rust	*Gymnosporangium juniperi-virginianae*	Apple	Northeastern Vermont	Incidental observation.
Fir-Fern Rust	*Uredinopsis mirabilis*	Balsam Fir	Southeastern Vermont	Incidental observation.
Giant Tar Spot	*Rhytisma acerinum*	Norway Maple	Statewide	Less common than previous years, potentially due to dry conditions.
Poplar Leaf Blight	*Marssonina spp.*	Poplar	Statewide	Although notably less than recent years, one of the few hardwood foliage diseases that was widespread in 2016.
Powdery Mildew	Eryiphaceae	Lilac, Pear	Statewide	Minor damage.
Rhizosphaera Needlecast	*Rhizosphaera kalkhoffi*	Spruce	Statewide	Heavy needlecast reported on white spruce christmas trees. May be affecting mature white spruce as well. Mortality of ornamental blue spruce continues due to heavy defoliation in the past.
Septoria Leaf Spot	*Septoria aceris* *Septoria betulae*	Hardwoods	Northeastern Vermont	Light damage. Not as common as in 2015. See Birch Defoliation.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Sirococcus tip blight	*Sirococcus tsugae*	Hemlock	Southeastern Vermont	Sometimes significant - may have been made more noticeable due to drought.

Foliage Diseases not reported in 2016 included Apple Scab, *Venturia inequalis* ; Dogwood Anthracnose, *Discula destructiva* ; Lirula Needlcast, *Lirula sp.* ; Rhizosphaera Needle Blight, *Rhizosphaera pini* .

ROOT DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Annosus Root Rot	*Heterobasidion annosum*	Softwoods		No new infection centers reported.
Armillaria Root Rot	*Armillaria spp.*	Hardwoods	Statewide	Commonly found on declining trees.

DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

Birch Decline decreased from previous years as older decline areas have become less visible (Figure 33). During aerial surveys, 100 acres of birch decline were mapped in 2016, down from 245 acres the previous year. New areas of rapidly dying paper birch were reported from Londonderry and Mount Holly, in Windham and Rutland County, respectively. Birch decline above 2,000 feet in mixed spruce-paper birch stands has been reported. Although no causal agent has been identified, declines may be related to recent heavy snow loads. An analysis of annual rings at the Mount Holly site suggests that growth declines began following dry years, predisposing trees to decline when additional stress occurred.

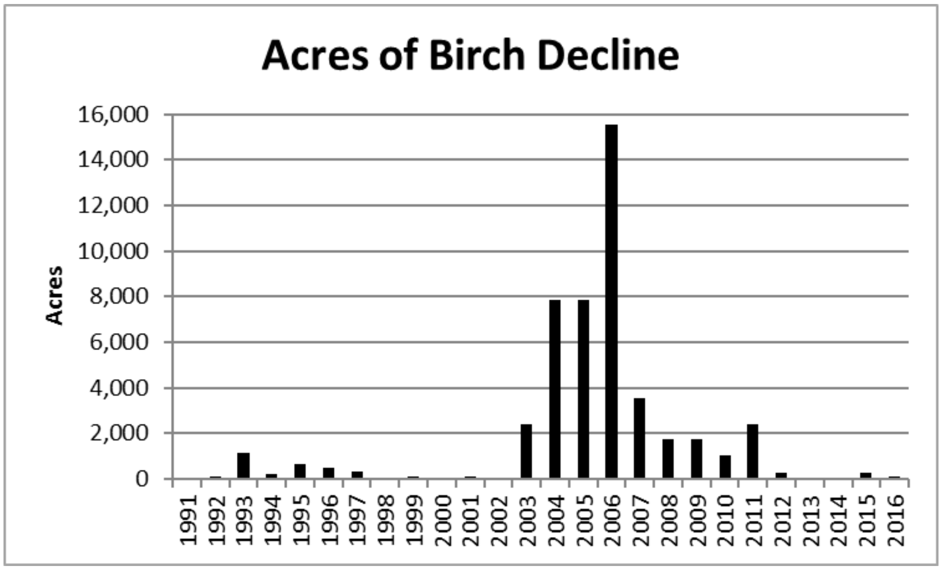


Figure 33. Trend in acres of birch decline mapped during aerial surveys. In 2016, only 100 acres were mapped, a decrease from 245 in 2015, and a significant decrease from the high in 2006 of nearly 16,000 acres.

Drought conditions began during the winter with little to no snow cover most of the season (See Weather section for more details). The lack of snow pack combined with very warm temperatures accelerated drying. May had 9 consecutive days over 80°, and there was a seasonal total of 12 days over 90° in Burlington. By July most of the state was abnormally dry and southeastern towns were in a moderate drought. Dry conditions extended into the fall and symptoms were observed in nearly every county (Table 26). Symptoms attributed to drought damage were mapped from aerial surveys affecting 7,924 acres (Figure 34).

Symptoms included mid-season off-color on hardwoods, late season interior needle drop on conifers, exacerbated decline of stressed trees such as those affected by balsam woolly adelgid, early leaf drop on ash, and browning leaves especially on shallow sites. Recovery of trees defoliated by forest tent caterpillar may have been compromised by dry conditions as was evident with the lack of significant refoliation in affected areas.

Table 26. Mapped acres of drought symptoms in 2016**.** Drought symptoms were more visible late in the summer, so some areas mapped early in the summer may not be well-represented in these data.

County	Acres
Addison	230
Bennington	555
Caledonia	1,838
Chittenden	435
Essex	1,074
Franklin	0
Grand Isle	0
Lamoille	0
Orange	600
Orleans	1,509
Rutland	330
Washington	293
Windham	519
Windsor	541
Total	7,924

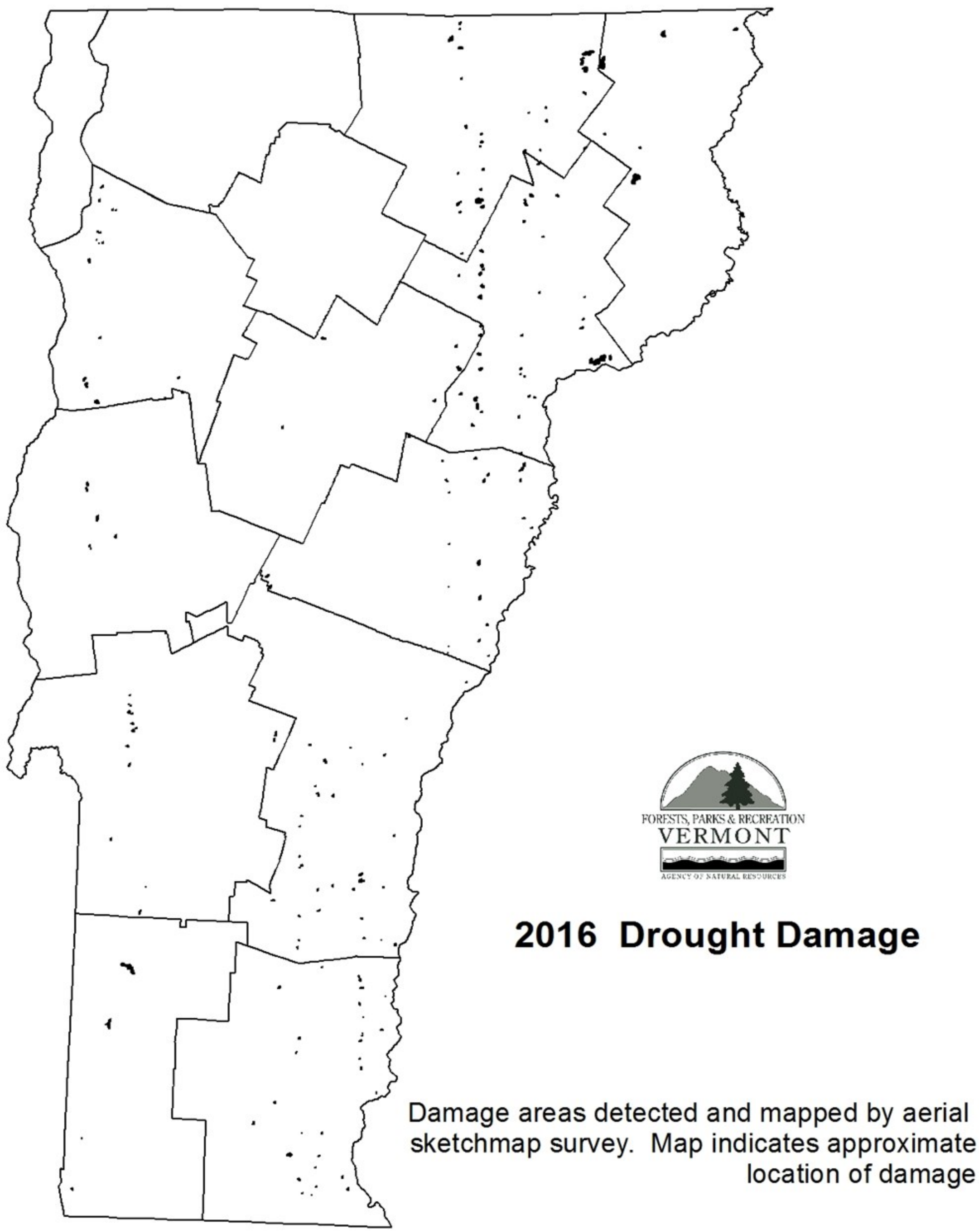


Figure 34. Symptoms of drought damage mapped in 2016. Mapped area includes 7,924 acres.

Frost Damage resulting from stalled leaf development in the spring followed by a cold snap affected scattered locations in Lamoille, Rutland and Washington Counties (Table 27). In most cases trees were able to fully refoliate so that no long-term effects are expected. Acres affected was much less than in 2015 when frost damage affected over 24,000 acres (Figure 35).

Table 27. Mapped acres of frost damage in 2016**.**

County	Acres
Lamoille	59
Rutland	47
Washington	7
Total	**113**

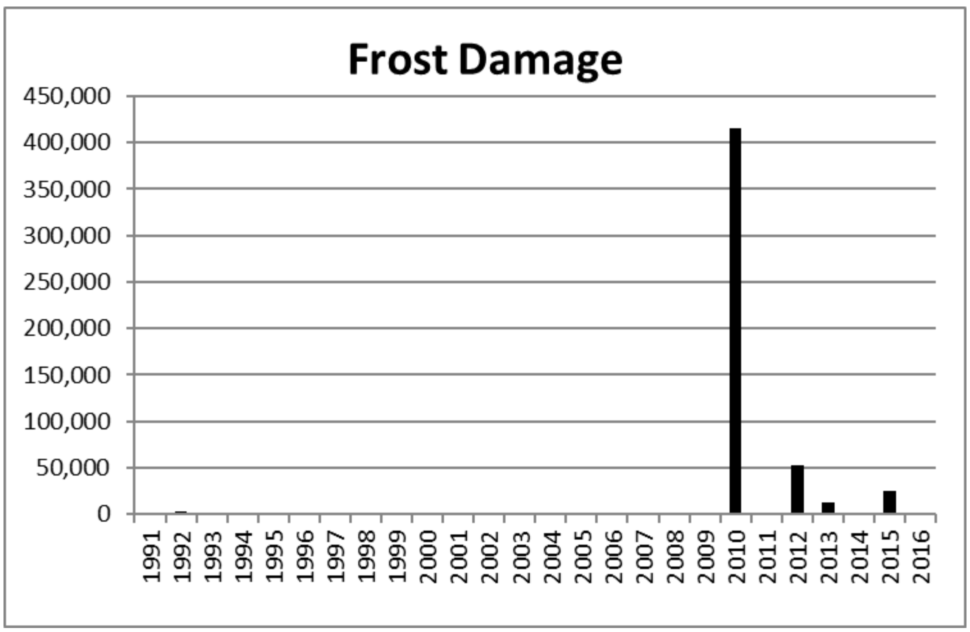


Figure 35. Trend in frost damage mapped during aerial surveys. In 2016, 113 acres were mapped.

Hardwood Decline was mapped on 135 acres in 2016. Dieback and mortality was observed in Essex, Orange and Windsor Counties (Table 28). This is the first time since 2012 when hardwood declines have been mapped during aerial survey, but previous decades had thousands of acres affected (Figure 36).

Hardwood decline was also more commonly observed in the landscape. Sudden loss of leaves on ornamental sugar maples was attributed to pre-existing problems exacerbated by drought.

Table 28. Mapped acres of hardwood decline in 2016**.**

County	Acres
Essex	40
Orange	12
Windsor	83
Total	**135**

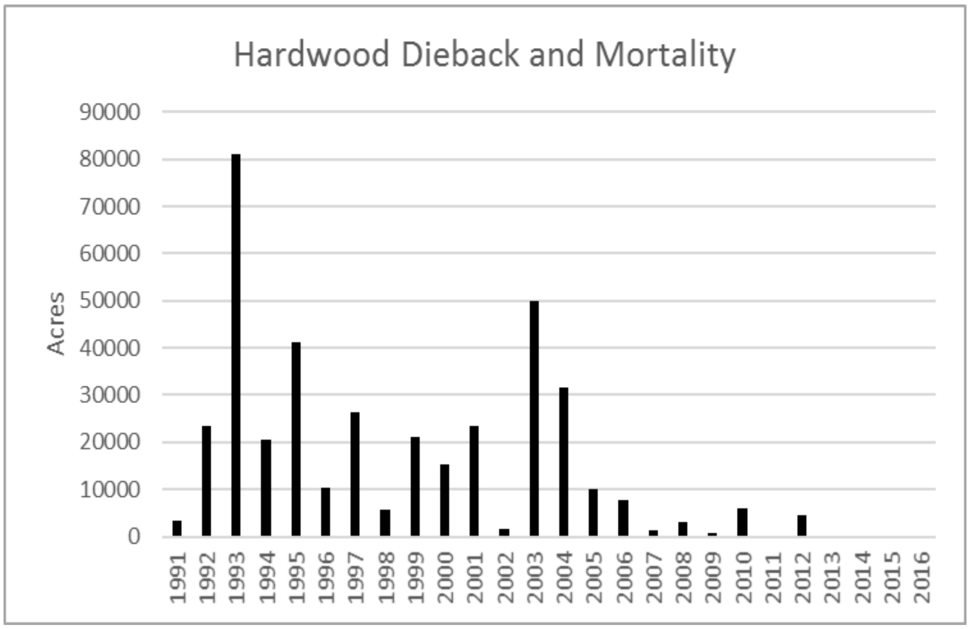


Figure 36. Trend in acres of hardwood dieback and mortality mapped during aerial survey. In 2016, 135 acres were mapped.

Larch Decline may be a result of heavy larch casebearer and eastern larch beetle populations that were on the rise a few years ago. Orange, Orleans and Washington Counties had damage mapped during aerial survey (Table 29 and Figure 37). Dry conditions on stressed trees, especially shallow rooted trees, may have contributed to these declines and are likely to lead to increased larch decline in 2017.

Table 29. Mapped acres of larch decline in 2016**.**

County	Acres
Orange	115
Orleans	40
Washington	9
Total	**164**

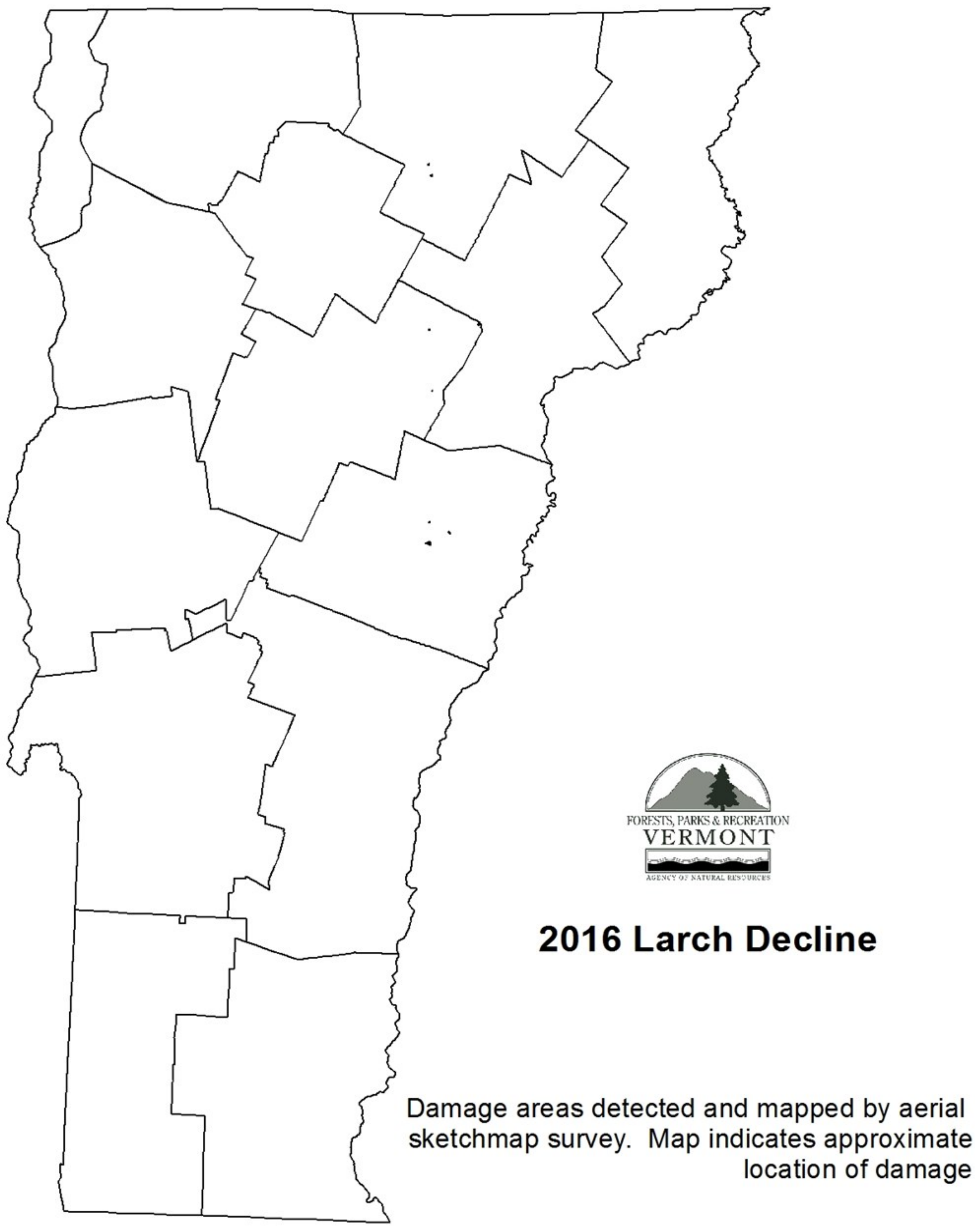


Figure 37. Larch decline mapped in 2016. Mapped area includes 164 acres.

Ozone injury on sensitive plants was evaluated at 7 monitoring locations in August (Table 30). Of the 770 plants examined, symptoms of ozone injury (stippling on upper leaf surface) were recorded at 4 of the locations. Where symptoms were present, very few plants were affected. No ozone damaged forests were mapped during aerial survey.

Table 30. Ozone bioindicator sites visited in 2016 and observed ozone injury.

Town	Ozone injury
Clarendon	Present
Dover	None
Groton	Present
Orange	None
Rupert	Present
Sudbury	None
Woodstock	Present

Damage from Unknown Causes
There were 520 acres of forest damage mapped during aerial surveys in 2016 that could not be associated with any specific cause (Table 31). This included a variety of species and locations, especially in southern counties.

Table 31. Mapped acres of damage from unknown causes in 2016.

County	Acres
Caledonia	10
Orange	53
Orleans	5
Rutland	115
Windham	166
Windsor	171
Total	**520**

Extreme weather events consist of storms or abnormal weather patterns that result in impacts to tree health. Aerial survey mapping of weather-related damages totaled 9,320 acres in 2016. These estimates of weather-related damage likely underrepresent actual impacts since some of the damages are not visible during aerial survey. In 2016, drought was the most significant and extensive weather damage (Table 32). Other weather-related tree damage mapped during aerial survey was caused by late spring frost, inundated sites, and from wind events.

Table 32. Trend in acres of forest damage from weather events and major factors involved mapped during aerial surveys.

Year	Total Acres from Weather Damage	Extensive Damage Factors	Other Damage Factors
1991	64,529	Drought	
1992	17,790		Flooded sites, drought, frost
1993	54,067	Spruce winter injury	Flooded sites
1994	10,780		Flooded sites
1995	17,365		Flooded sites, drought
1996	19,324		Spruce winter injury, wet sites
1997	10,557		Flooded sites
1998	1,031,716	Ice storm, flooded sites	
1999	122,024	Drought	Ice, flooded sites, wind
2000	10,634		Flooded sites
2001	180,494	Drought	Flooded sites
2002	210,534	Drought	Flooded sites
2003	106,238	Spruce winter injury, flooded sites	Wind, drought
2004	19,877		Flooded sites
2005	11,078		Flooded sites
2006	6,786		Flooded sites
2007	21,656		Drought, flooded sites, wind
2008	2,401		Flooded sites
2009	15,315		Winter injury, flooded sites
2010	417,180	Frost	
2011	10,029		Flooded sites
2012	55,872	Frost	Flooded sites
2013	15,332*	Frost, ice*	Flooded sites, wind
2014	4,848		Flooded sites, wind, ice storm, hail damage
2015	35,898	Frost, drought	Flooded sites, wind, ice/snow breakage
2016	9,320	Drought	Flooded sites, frost, wind

*A December 2013 ice storm was not mapped during aerial survey but affected large areas in northern Vermont.

Wet or Flooded Site Declines were mapped on 1,183 acres in 2016, a decrease from 1,869 acres recorded in 2015 (Table 33 and Figures 38 and 39). Some of these sites may have been a result of past year's flooding.

Table 33. Mapped acres of forest decline associated with flooded or otherwise wet sites.

County	Acres
Addison	923
Bennington	5
Essex	38
Franklin	86
Orange	23
Orleans	39
Rutland	22
Windham	35
Windsor	12
Total	**1,183**

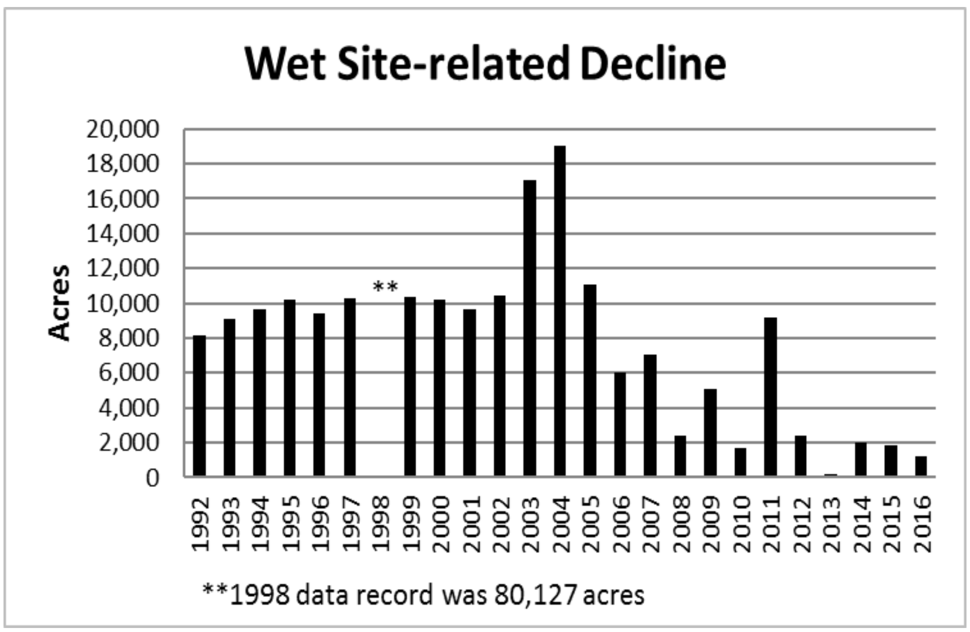


Figure 38. Trend in acres of forest decline related to wet or flooded sites mapped during aerial surveys. In 2016, the mapped area included 1,183 acres, a decrease from 1,869 in 2015.

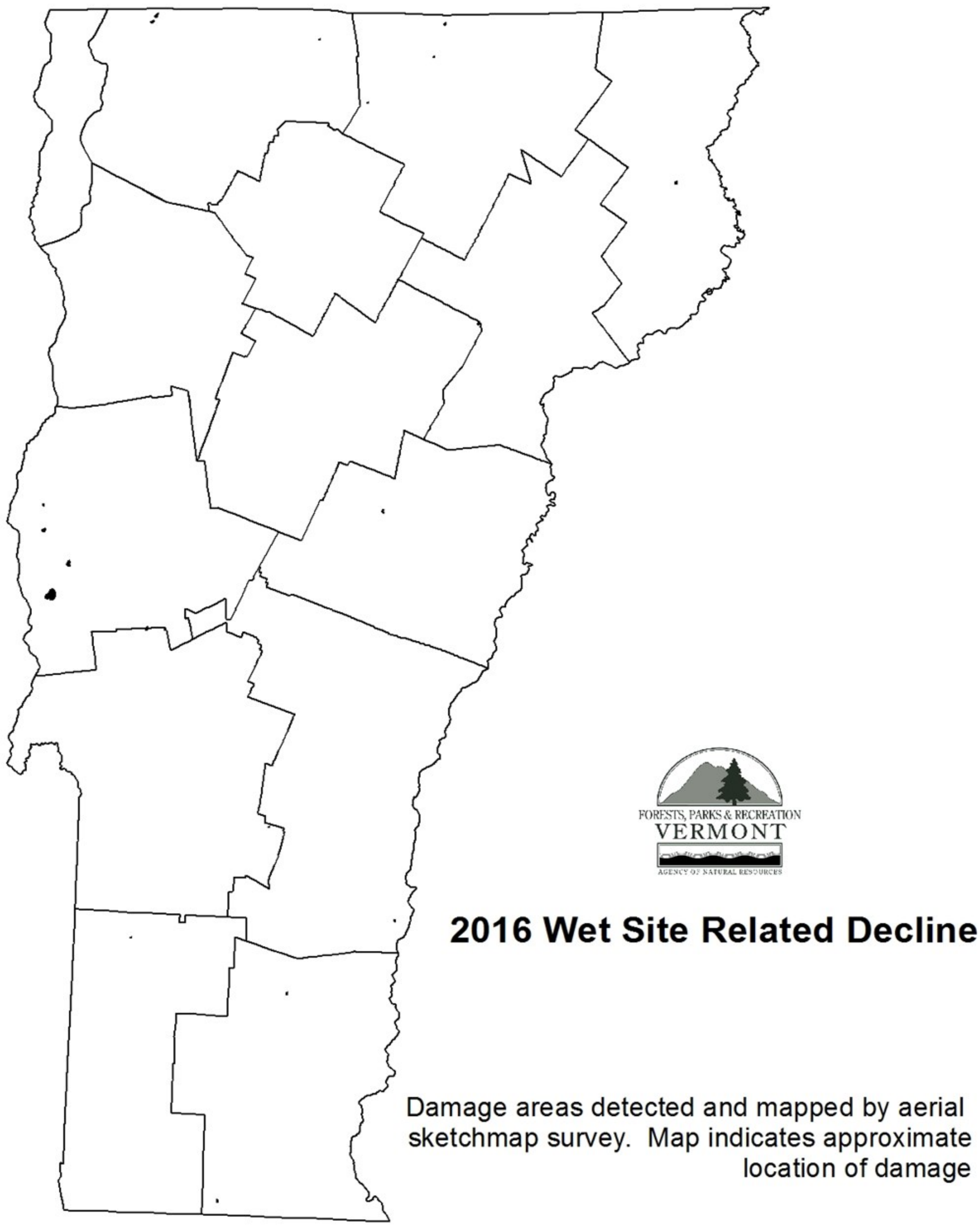


Figure 39. Wet or flooded site related decline mapped in 2016. Mapped area includes 1,183 acres.

White Spruce Decline was observed in several counties and mapped during aerial survey on 77 acres (Table 34). The cause of thin crowns and occasional mortality in northeastern Vermont stands may be related to Rhizosphaera needlecast, but is still under investigation.

Table 34. Mapped acres of white spruce decline in 2016.

County	Acres
Caledonia	28
Orange	49
Total	**77**

Wind Damage from a variety of storms affected forests in Lamoille, Orange and Windsor Counties (Table 35). A total of 100 acres were mapped statewide in 2016, a decrease from 764 acres mapped in 2015 (Figure 40).

Table 35. Mapped acres of wind damage in 2016.

County	Acres
Lamoille	3
Orange	34
Windsor	63
Total	**100**

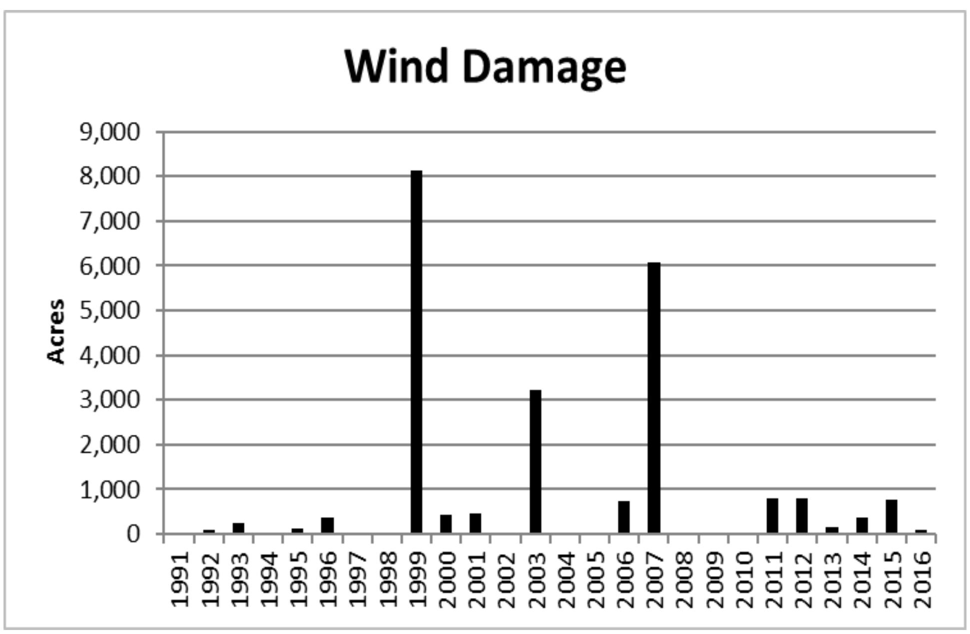


Figure 40. Trend in wind and storm damage mapped during aerial surveys. Mapped area includes 100 acres in 2016.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Air Pollution Injury	Various		See narrative for ozone injury.
Ash Dieback	White Ash	Statewide	Occasional heavy mortality; especially prevalent where soil is wet, disturbed or compacted; often reported as emerald ash borer suspected damage, but no evidence of EAB has been observed.
Birch Decline	White birch		See narrative.
Delayed Chlorophyll Development – chlorosis	Hardwoods	Scattered statewide	Attributed to dry conditions.
Drought Damage			See narrative.
Fire Damage	Various	Widely scattered	Late summer persistent ground fires due to dry conditions. Mapped on 6 acres during aerial survey.
Frost Damage	Hardwoods		See narrative.
Hardwood Decline and Mortality	Hardwoods		See narrative.
Hail	Hardwoods	Ripton	Light damage to foliage.
Interior Needle Drop	Conifers	Scattered statewide	Increase over last year, attributed to drought.
Larch Decline	Larch		See narrative.
Lightning	Pines	Widely scattered	

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Logging-related Decline			See narrative.
Red Pine Decline	Red pine		See Red Pine Scale.
Spruce/Fir Dieback and Mortality	Red spruce, Balsam fir	Widely scattered statewide	See also Balsam Woolly Adelgid.
Wet Site	Various		See narrative.
White Pine Needle Damage	White pine	Statewide	See narrative.
White Spruce Decline	White spruce		See narrative.
Wind Damage	Various		See narrative.
Winter Injury	Arborvitae; Balsam fir Christmas trees	Southwestern Vermont	Locally heavy. Early warm temperatures in February may have triggered deacclimation, and was followed by cold weather in late February. Fraser fir unaffected.

Not reported in 2016: heavy seed affecting foliage density, ice damage, salt damage, snow damage.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Porcupine	Many	Hardwoods	Increase in reported damage from 2015.
Squirrel	Many	Hardwoods	Very high populations present during summer. Damage seen on maples and oaks in spring and fall, respectively.

INVASIVE PLANTS

2016 saw the continued growth of non-native invasive plant (NNIP) early detection and management efforts statewide. Progress with mapping, control, outreach and education have been made possible through several grant-funded opportunities, and varied strategies within local communities. The statewide invasive plant coordinator within FPR led over 28 workshops for a variety of stakeholders (state parks, conservation commissions, non-profits, community groups, others), focusing on NNIP information, management and prioritization. Department staff continue to provide outreach and information about NNIP to the public and professionals, and are building the capacity to continue to identify and manage NNIP on state lands across Vermont.

Early Detection Species

Populations of an early detection species, **Amur corktree (*Phellodendron amurense*)**, have been identified in southwestern Vermont. The population at Lake St. Catherine State Park was discovered in the fall of 2015, escaping into woods around the park. The escaped individuals, from planted ornamentals, were producing large numbers of berries. The 10 ornamental plantings were removed, and in 2016, volunteers helped treat the escaped populations. This effort took 15+ hours.

Several other early detection species were identified throughout the state in 2016 including:

- Tree of Heaven (*Ailanthus altissima*) in Brattleboro
- Himalayan touch-me not (*Impatiens glandulifera*) in Northfield (originally identified in 2013)
- *Petasites hybridus/japonicas* (hard to distinguish without flower or fruit) in Warren
- *Cardamine impatiens* in Woodstock

These are not the full ranges nor initial introductions of these species within the state, rather new observations collected in 2016.

The Vermont Invasive Exotic Plant Committee updated the unofficial watch list of NNIP. The complete list can be found at: http://fpr.vermont.gov/forest/forest_health/invasive_plants

Regional Grant-Funded Activities

Education, Outreach, Capacity Building & Treatment in Vermont's Forest Priority Areas: Efforts continued to train 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 spatial 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.

Invasive Plant Mitigation on State Land in Vermont: Education Volunteer Outreach & Capacity Building: Three seasonal staff were hired onto the Habitat Restoration Crew in District 2 (southwest), running volunteer days and conducting NNIPM in state forests and state parks throughout the district. The Crew worked with 594 volunteers in 2016, with 2,155 volunteer hours. This program has worked with 1,455 volunteers (6,111 volunteer hours) from 2014-2016. The crew worked with the Castleton Village School for a third year, integrating invasive ecology and restoration into their school-wide curriculum and taking an entire day to get all the students and staff outside completing NNIPM and native plant restoration at Lake Bomoseen State Park.

This is also the third year of working with the Northlands Job Corps Urban Forestry Program. Nine students put in 150 volunteer hours in 2016. There were continued collaborations with Keurig Green Mountain, Orvis, and Vermont Country Store.

Invasive Terrestrial Plant Treatment on Working Forests and Conserved Natural Areas in Vermont's Forest Priority Areas: The Nature Conservancy (TNC) completed a variety of NNIPM work across VT. Volunteers removed garlic mustard and wall lettuce in the spring at Williams Woods in Charlotte, and removed woody NNIP in the fall. This work was follow-up on a long-term control project funded through WHIP. Volunteers removed NNIP along the LaPlatte River in Shelburne as part of the follow-up from a USFS grant. Garlic mustard was controlled on the Raven Ridge property in Monkton in the spring, and woody NNIP were removed along the edge of the old field and around the beaver pond in the fall. Butternut Hill in North Hero saw control efforts for barberry and buckthorn. Knotweed was managed in the summer at White River Ledges in Pomfret, with efforts continuing in the fall to control woody NNIP. Volunteers spent a day fall of 2016 controlling woody NNIP at Wilmarth Woods in Addison.

Other Activities

The growing season for 2016 saw many projects across the state on NNIPM. Below are highlights of some of these local efforts.

Castleton, VT - For a fourth year, an AmeriCorps member has been serving as the Native Plants Land Manager at Green Mountain College in Poultney. In 2016, they hosted volunteer days in nearby natural areas to the GMC campus to remove NNIP, focusing on honeysuckle, buckthorn, and garlic mustard. This position will continue with a newly appointed Native Plants Land Manager.

Reading, VT - Reading Elementary School, led by Beth Drinker and her students, participated in the 3rd annual New England Garlic Mustard Challenge, competing against teams across the region on who can pull the most garlic mustard. This crew created and performed a play called "Garlic Mustard Wars" to sixty 2nd graders from Woodstock, Pomfret, Bridgewater, and Killington as part of the Super Junior Rangers program. These students also made garlic mustard pesto and served it at the Trek to Taste event at Marsh Billings Rockefeller National Historic Park, reaching an audience of varied ages and interests. Reading Elementary School intends to make this a schoolwide effort next spring.

Bennington, VT - The Batten Kill Watershed Comprehensive Invasive Species Management Association (BKW CISMA), a project of the Bennington County Conservation District, started in 2015, made great progress in 2016 to prevent the spread of invasive species within the Batten Kill Watershed.

BKW CISMA partnered with the Vermont Youth Conservation Corps on mechanical management of NNIP such as barberry, common buckthorn, honeysuckles, Asiatic bittersweet, and burning bush, in Arlington, Manchester, and Shaftsbury, with 6.5 acres treated and 106.5 person-hours. Chemical treatment was contracted across 21.1 acres with 32 person-hours, in those same towns. Japanese knotweed was managed in Manchester and Sandgate through an integrated pest management plan that involved cutting in early July, and chemical treatment in September (4.4 acres, 143.5 person-hours). Through all this work, there were 28 people who directly contributed to these efforts.

Thetford, VT - The Thetford Conservation Commission hosted a variety of ways for local communities to learn about NNIP, get hands on training, and participate in a town-wide pull throughout May and early June. These events included a presentation in March on garlic mustard, a hands-on training on removal techniques in May, assessing the town for populations of garlic mustard, the participation of 7th grade science students in classroom learning and managing patches nearby, and pulling garlic mustard at identified sites. All these efforts produced 149 bags; over a ton of garlic mustard was pulled (2,400 lbs) and the Selectboard supported the project by helping to get the disposal fee waived at the Lebanon Landfill. The commission plans to continue efforts into 2017.

Burlington, VT - The Winooski Valley Park District is working with multiple local schools to manage NNIP across their parks. NNIP are an ongoing issue at many of the parks, and the WVPD relies heavily on volunteer groups to complete NNIPM. One ongoing project is to map the NNIP on their Ethan Allen Homestead property in Burlington, VT to identify high priority areas where they can focus future removal and mitigation efforts.

County foresters continue to work with land owners and consulting foresters on addressing NNIP in forest management plans and forest management activities on private lands. Other department staff continue to identify and NNIPM on state lands.

Numerous NNIPM activities took place on State Lands.

- District 1 (southeast) completed numerous large-scale NNIPM projects at Roaring Brook WMA, Prison Farm WMA, and Little Ascutney WMA. Other invasive plant treatment occurred at Skitchewaug WMA, Knap Brook WMA, Fort Dummer State Park, Densmore Hill WMA, Wilgus State Park, and Dorand State Forest.
- District 2 (southwest): See Invasive Plant Mitigation on State Land in Vermont: Education, Volunteer Outreach, & Capacity Building (page 107).
- District 3 (northwest). Work at Camel's Hump Management Unit included assessment, treatment, and monitoring on the Dowsville property. Treatment focused on roadsides, was conducted by the Seasonal Forestry Technician, and will be revisited in 2017. Underhill and Kruse Blocks of Mt. Mansfield State Forest are largely free of NNIP. Closer to Lake Champlain, many ANR properties have heavy infestations. Japanese knotweed was treated at Mill River Falls State Park, to eradicate it before it takes hold in the floodplain. In late September, 20 acres heavily infested with invasive honeysuckle, common and glossy buckthorn were treated on the Lower Otter Creek WMA, in Ferrisburgh, VT. A post treatment reconnaissance of the area showed +/- 80% efficacy.
- District 4 (central) worked on NNIPM at the Middlesex Block of Putnam State Forest. Workdays focused on removal of honeysuckles, Japanese barberry, and buckthorns. Other species treated include burning bush, Asiatic bittersweet, and Autumn olive. Work at this site has continued for about a decade, removing roughly 90% of the original infestations, while increasing and maintaining the open areas of land.
- District 5 (northeast) continued NNIPM efforts, including honeysuckle removal from two landings on a timber sale in Lyndon State Forest prior to arrival of logging equipment, Norway maple and Asiatic bittersweet removal at Groton State Forest around Seyon Lodge, and treatment of Common reed at Victory Basin WMA.

The Vermont invasive species website (www.vtinvasives.org) is undergoing an assessment and reboot, but continues to provide a wide range of information to a variety of user groups from citizen scientists to professional foresters, including educational resources and Best Management Practices.

Sugar Maple Health in 2016

Sugar maple tree health, based on the amount of twig dieback on the 30 monitoring plots formerly part of the North American Maple Project (NAMP), remained stable in 2016 (Figure 41). An additional 6 plots were added on state lands. Nearly 95% of trees were rated as having dieback ≤ 15% (Figure 42).

Thin foliage due to forest tent caterpillar defoliation was measured on 22 plots (Figure 43). Of the 36 monitoring plots, 8 had moderate-heavy defoliation (22%) and 14 had light defoliation (39%). The frequency of thin foliage was similar to last year when frost injury affected foliage density. Foliage transparency is sensitive to current stress factors. In other years, spikes in transparency were due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007), and pear thrips (1988-1989). Dry summer conditions and minimal refoliation by affected trees may result in tree declines. New mortality of overstory sugar maple trees was 1.1% in 2016.

Vigor ratings incorporate several tree health measures into a more comprehensive view of a tree's photosynthetic capacity. There was a decrease in vigor 1 trees and an increase in vigor 2 trees, suggesting tree vigor was less favorable to tree growth in 2016 (Figure 44).

Other significant damage agents were recorded at each site and reported as percent of sites affected (Table 36). In addition to forest tent caterpillar, sugar maple borer at 57% of sites and weather breakage at 53% of sites were most frequently recorded.

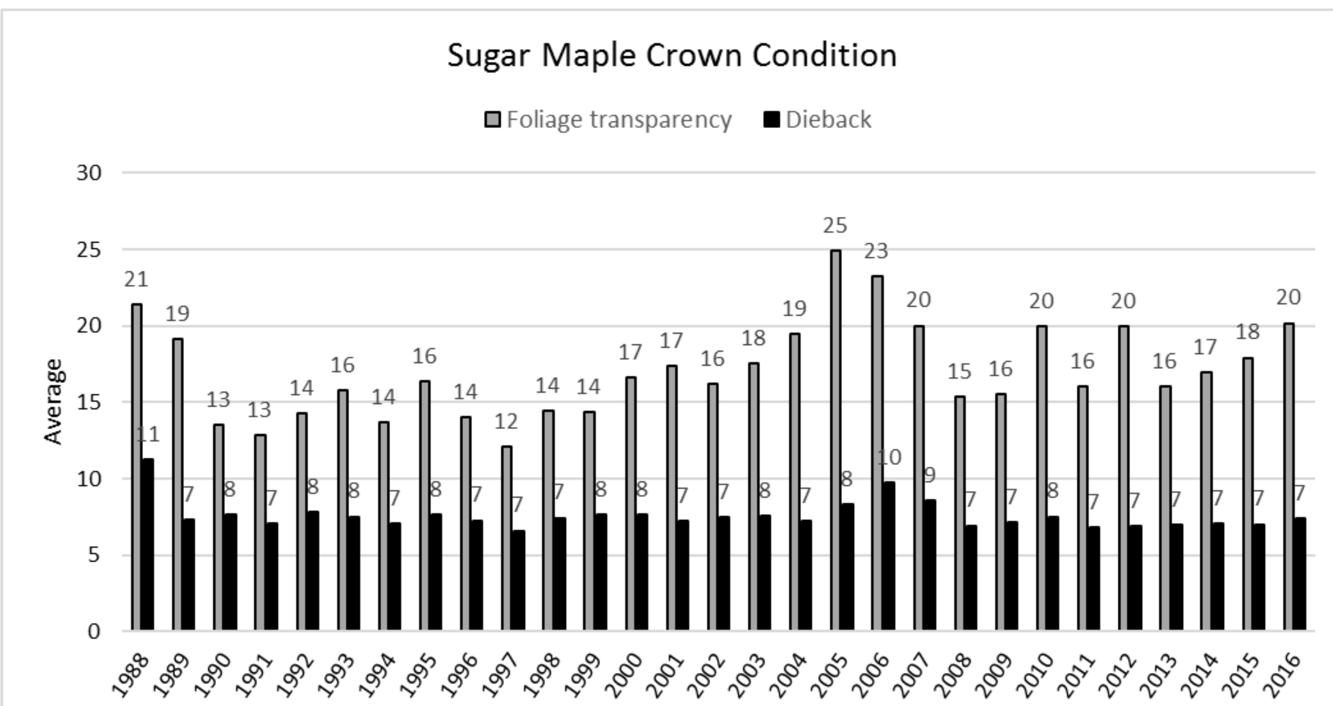


Figure 41. Trend in average dieback and foliage transparency of overstory sugar maple trees on NAMP plots. N=965 trees at 30 sites.

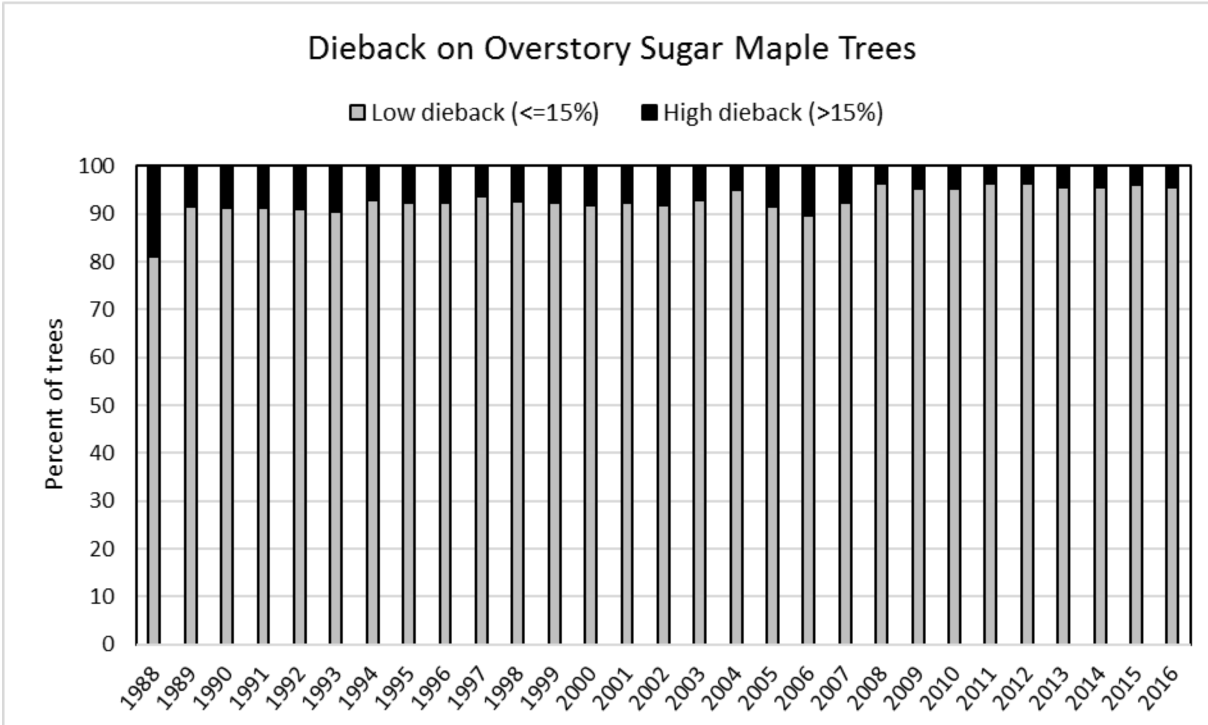


Figure 42. Percent of overstory sugar maple trees on NAMP plots with low (0-15%) or high (>15%) dieback levels. N=965 trees at 30 sites.

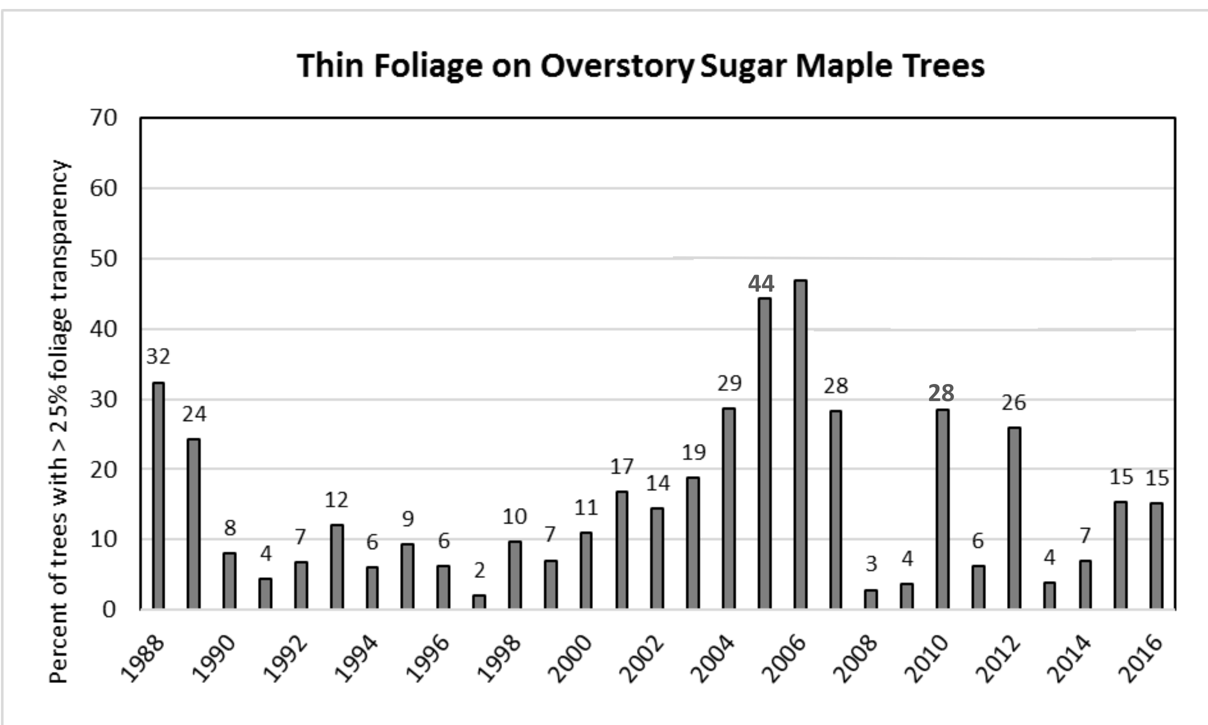


Figure 43. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage, >25% foliage transparency. N=965 trees at 30 sites.

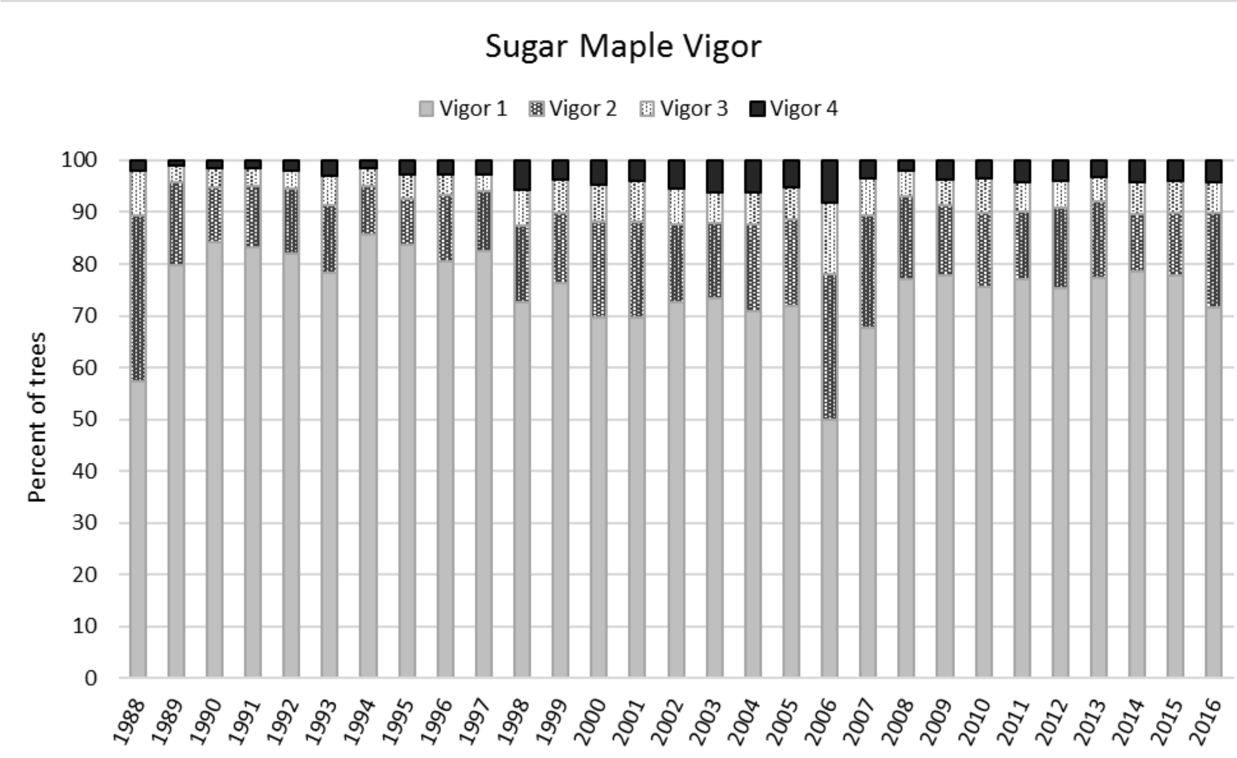


Figure 44. Trend in the percent of overstory sugar maple trees on NAMP plots in each vigor category: 1= $\leq$10% dead or missing branches; 2= 11-25%; 3= 26-50%; 4= >50%ratings (vigor>2). N= 965 trees at 30 sites.

Table 36. Percent of NAMP sites reporting various damages in 2016.

Damage Agent	Percent of sites
Forest tent caterpillar	61
Sugar maple borer	57
Weather breakage	53
Internal bole decay	36
Cracks/seams	33
Eutypella canker	17
Sapsucker damage	11
Logging wounds (>20% of circumference)	8

Vermont Monitoring Cooperative

Trends in Forest Health at Mount Mansfield and Lye Brook in 2016

Fourteen plots on Mount Mansfield and five plots on the Lye Brook Wilderness Area were remeasured in 2016 using standard forest health metrics. Additional metrics and canopy photos were collected by University of Vermont field crews to better document tree growth and regeneration changes.

Trends in crown condition on Lye Brook plots showed average foliage transparency lower than previous years (i.e. denser foliage) but an increase in average dieback to 13.7% (Figure 45). Similarly, trends in crown condition measurements at Mount Mansfield showed an increase in crown dieback, 13.7%, and an improvement in foliage transparency from recent years (Figure 46). More dramatic changes are visible when looking at trends in percent of trees with high dieback (>15%) (Figure 47) or percent of trees with thin foliage (>25%) (Figure 48). Foliage transparency is usually a response to current or recent stress events. While dieback tends to reflect a cumulative response to recent or past stresses, it is generally more visible when foliage is thin.

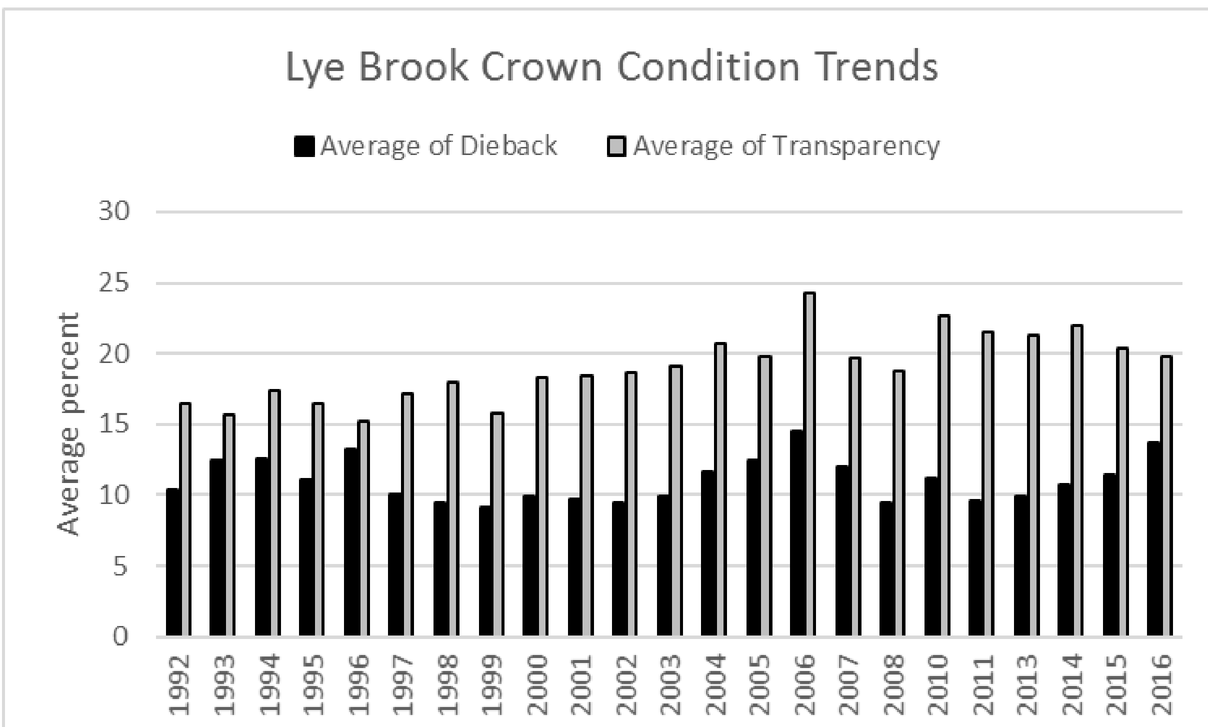


Figure 45. Average dieback and foliage transparency of overstory trees on five forest health monitoring plots in the Lye Brook Wilderness Area.

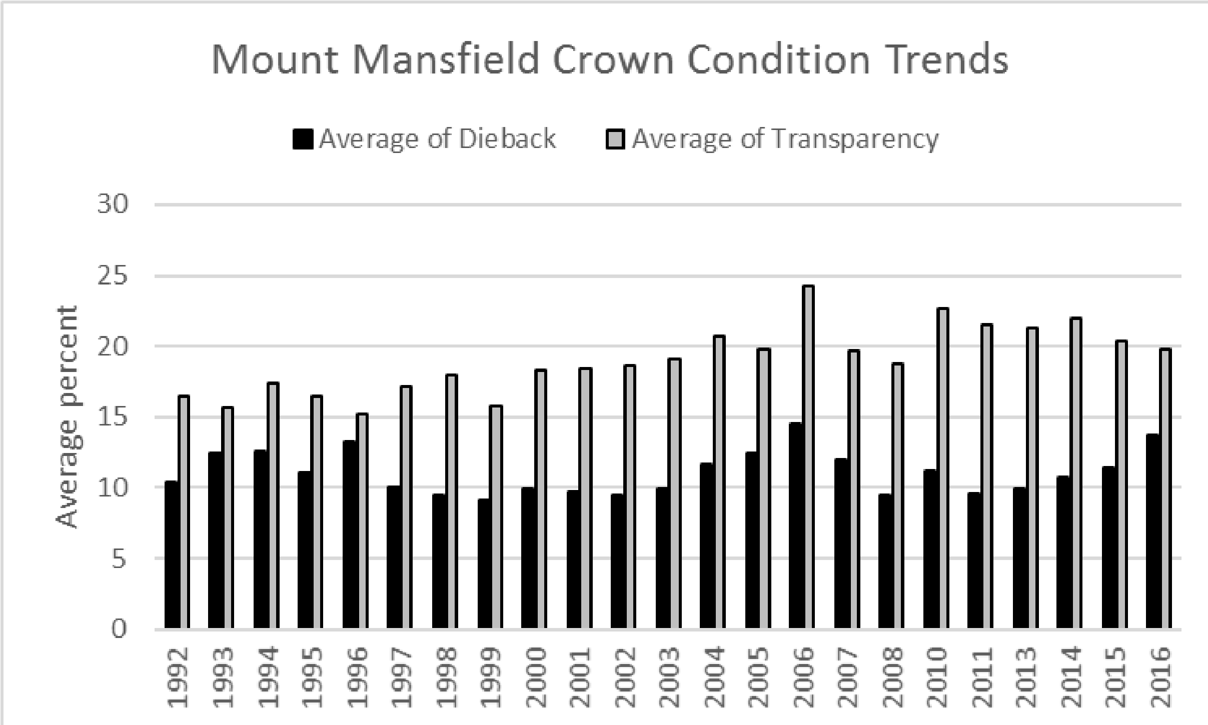


Figure 46. Average dieback and foliage transparency of overstory trees on 14 forest health monitoring plots on Mount Mansfield.

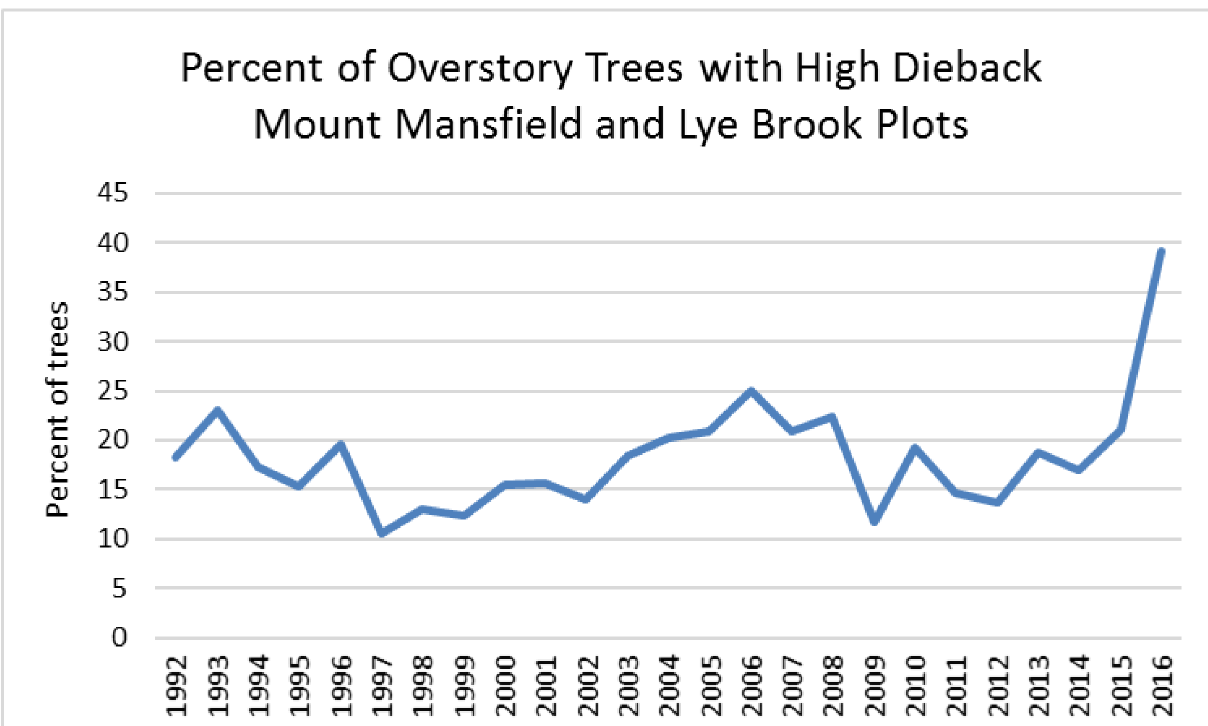


Figure 47. Percent of overstory trees with high dieback (>15%) on Mount Mansfield and Lye Brook plots.

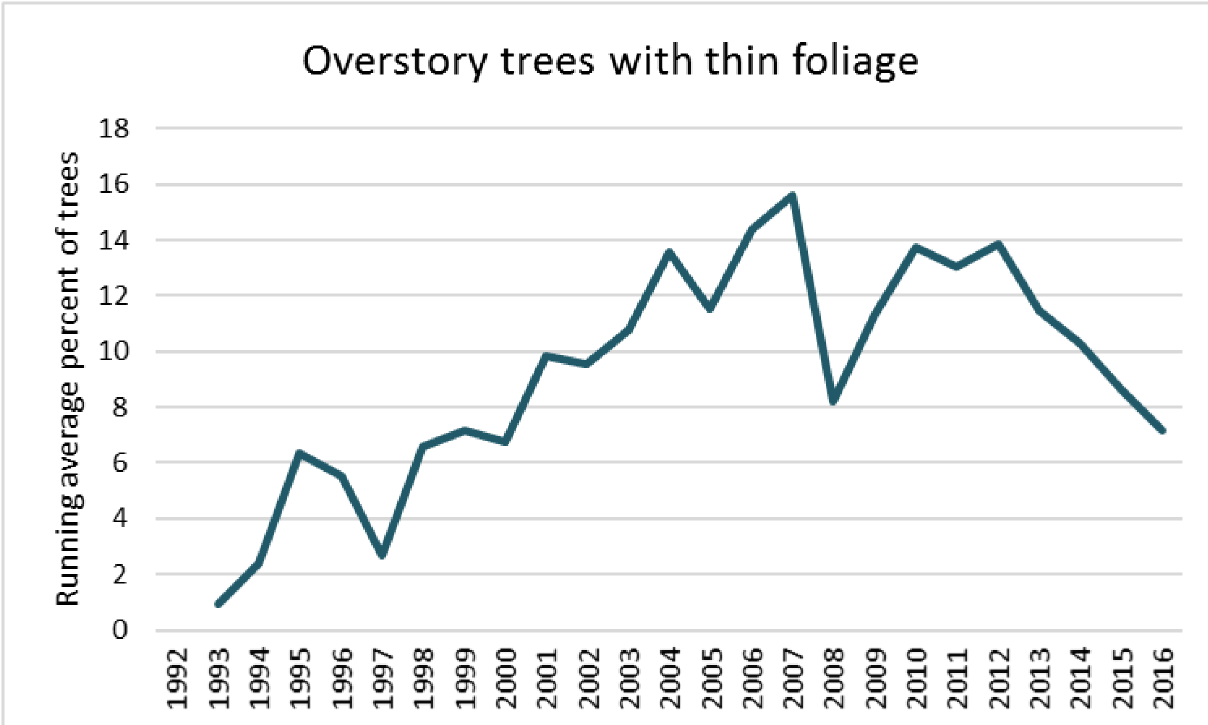


Figure 48. Percent of overstory trees with thin foliage (>25%) on Mount Mansfield and Lye Brook plots, 2 year running average.

Additional forest condition data collected in 2016 are as follows: Seed production was low on these monitoring plots in 2016. Five of the 19 plots at Mansfield and Lye Brook had new dead trees. Overall the average mortality for overstory trees was 2.1%, ranging from 1.1 to 3.8% on individual plots. Tree damages were recorded on 77 trees (11.3 % of live trees). Several trees had multiple damages. Beech bark disease was the most prevalent damage with 35 trees affected (70.6% of beech trees) (Table 37). Other damages included weather-related cracks and seams (26 % of trees), several canker species (1.0% of trees), sugar maple borer (4.7% of sugar maple trees) and animal damages (3.8% of trees).

Table 37. Number of occurrences of special damages in 2016 on plots at Mount Mansfield and Lye Brook. Percent of susceptible live trees affected is in parentheses.

Beech bark disease	Cracks and seams	Canker	Eutypella canker	Sugar Maple Borer	Animal damage
35 (70.6%)	26 (3.8%)	7 (1.0%)	3 (3.5%)	4 (4.7%)	3 (3.8%)

Additional analyses were conducted on data through 2015 as part of the VMC Annual Report (VMC Annual Monitoring Report for 2015), and are accessible on the VMC website. Results from all 42 forest health plots will be included in the VMC Annual Monitoring Report for 2016 along with other ecosystem monitoring results.

VERMONT FOREST CARBON ASSESSMENT

Vermont recently received updated information on forest carbon storage and annual uptake from the U.S. Forest Service, Forest Inventory and Assessment, based on completion of the national forest carbon inventory. There were significant changes in methods and results that are clarified in a separate Forest Service document and summarized below[1].

> *"As a signatory to the United Nations Framework Convention on Climate Change, the United States annually prepares an inventory of carbon that has been emitted and sequestered among sectors (e.g., energy, agriculture, and forests). For many years, the United States developed an inventory of forest carbon by comparing contemporary forest inventories to inventories that were collected using different techniques and definitions from more than 20 years ago. Recognizing the need to improve the U.S. forest carbon inventory budget, the United States is adopting the Forest Carbon Accounting Framework, a new approach that removes this older inventory information from the accounting procedures and enables the delineation of forest carbon accumulation by forest growth, land use change, and natural disturbances such as fire.*
>
> *By using the new accounting approach with consistent inventory information, it was found that net land use change is a substantial contributor to the United States forest carbon sink, with the entire forest sink offsetting approximately 15 percent of annual U.S. carbon dioxide emissions from the burning of fossil fuels. The new framework adheres to accounting guidelines set forth by the Intergovernmental Panel on Climate Change while charting a path forward for the incorporation of emerging research, data, and the needs of stakeholders (e.g., reporting at small scales and boreal forest carbon)."*[1]

The 2015 Vermont data show that forests store approximately 480 million metric tons of carbon; that they sequestered an additional 4.39 million metric tons of carbon dioxide in 2015; and that on average, each acre of forest land stores 653 metric tons of carbon (Table 38). Forest storage steadily increased from 1990 to 2015 (Figure 49), although the annual uptake rate has declined from -4.70 MMTCO2e per year to -4.39 MMTCO2e (Figure 50). (Note: negative values are used to mean negative emissions, or rather, uptake.) The average carbon storage per hectare of forestland increased to current level of 264 metric tons carbon/hectare (107 metric tons carbon/acre) (Figure 51).

These estimates are significantly different than past estimates. For example, the Vermont Governor's Climate Change Commission report of 2007 estimated net sequestration of forest land at -8.23 MMTCO2e using data through 1997, nearly double the current estimate.[2]

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[1] Woodall, Christopher W.; Coulston, John W.; Domke, Grant M.; Walters, Brian F.; Wear, David N.; Smith, James E.; Andersen, Hans-Erik; Clough, Brian J.; Cohen, Warren B.; Griffith, Douglas M.; Hagen, Stephen C.; Hanou, Ian S.; Nichols, Michael C.; Perry, Charles H.; Russell, Matthew B.; Westfall, James A.; Wilson, Barry T. 2015. **The U.S. forest carbon accounting framework: stocks and stock change, 1990-2016.** Gen. Tech. Rep. NRS-154. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 49 p.

[2] *Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030, Center for Climate Strategies, Sept. 2007.*

Table 38. Comparison of Vermont's forest carbon storage and annual uptake (net sequestration) pools in 1990 vs 2015. Units are: MMTC=million metric tons of carbon; MMTCO2e=million metric tons of carbon dioxide equivalents; MtC/ha=metric tons of carbon per hectare; and MtC/acre=metric tons of carbon per acre. Negative values are used with MMTCO2e to mean negative emissions, or rather, uptake of CO_2.

Forest carbon pool	Forest carbon storage (MMTC)		Net sequestration (MMTCO2e)		Forest carbon per hectare (MtC/ha)		Forest carbon per acre (MtC/acre)	
	1990	2015	1990	2015	1990	2015	1990	2015
Above ground Biomass	110.1	131.8	-3.29	-3.05	62.22	72.53	25.19	29.36
Below ground Biomass	22.1	26.4	-0.64	-0.60	12.50	14.51	5.06	5.88
Dead Wood	11.7	14.8	-0.44	-0.37	6.63	8.17	2.69	3.31
Litter	29.2	29.5	-0.05	-0.05	16.51	16.25	6.69	6.58
Soil Organic Carbon	275.7	277.9	-0.28	-0.31	155.85	152.95	63.09	61.92
Total	**448.9**	**480.5**	**-4.70**	**-4.39**	**253.72**	**264.41**	**102.72**	**107.05**

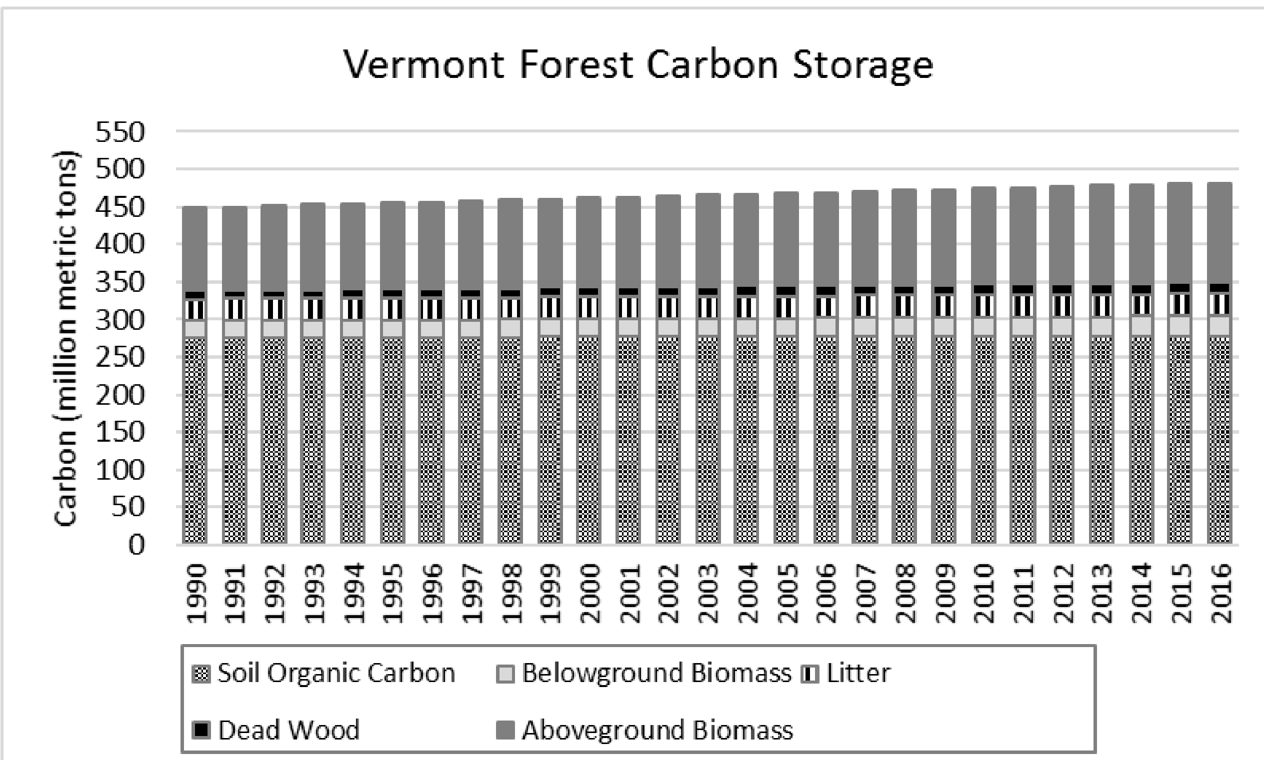

Figure 49. Trend in carbon stored in Vermont forests. The largest pool of stored carbon is in soils, followed by above ground (tree) biomass.

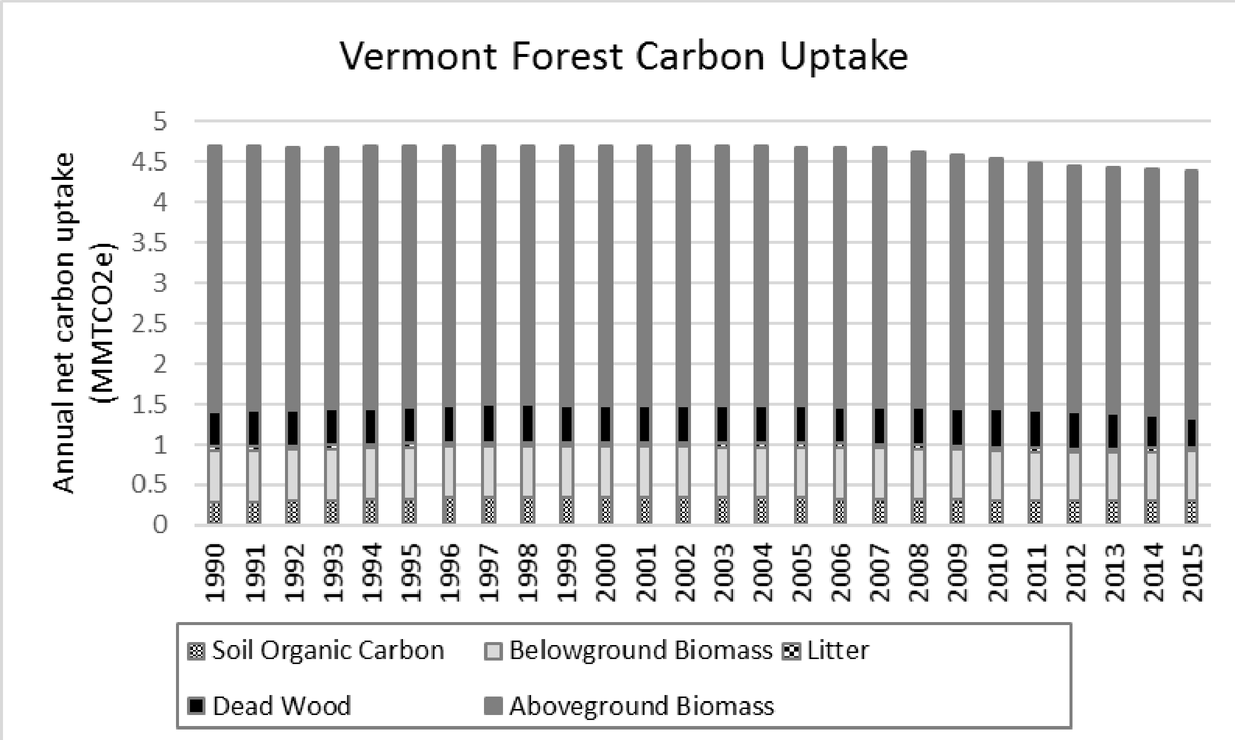

Figure 50. Trends in annual uptake of carbon. The total annual uptake was less in 2015 than in previous decades, in part due to decreasing acres of forest land.

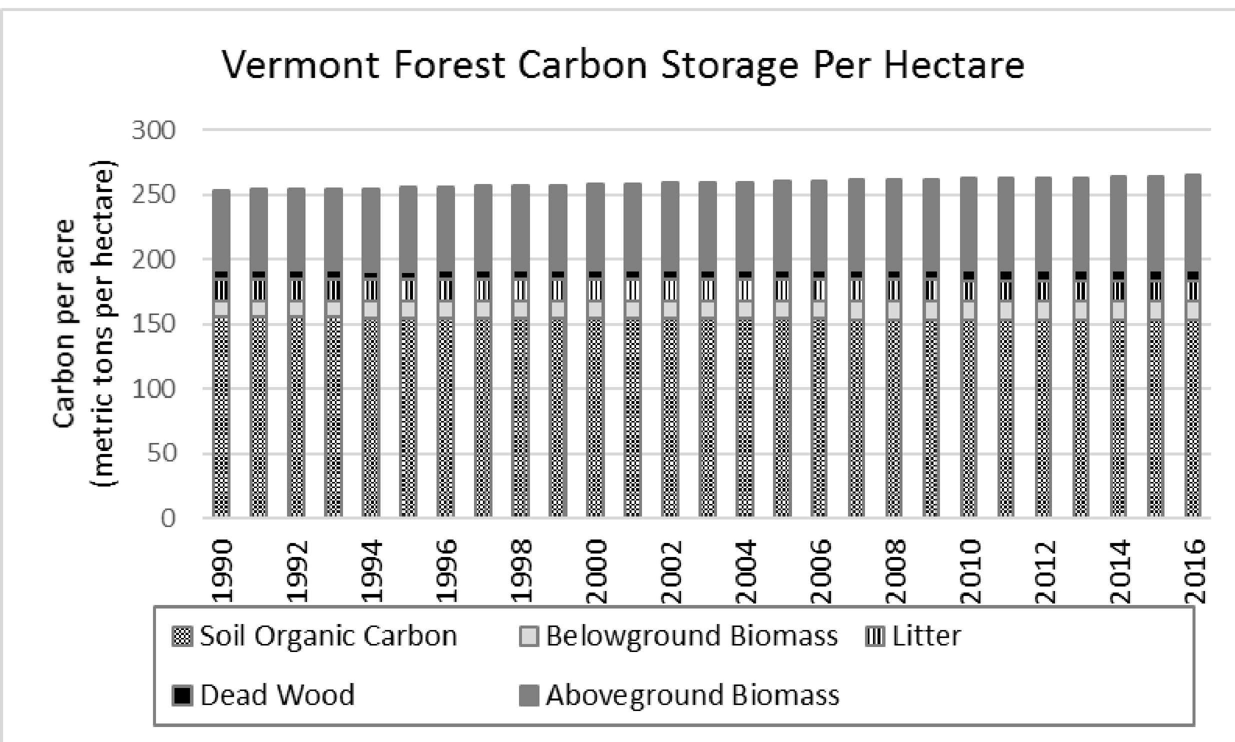

Figure 51. Trends in the per hectare estimates of forest carbon in each of the carbon pools (e.g. soils, litter, aboveground).