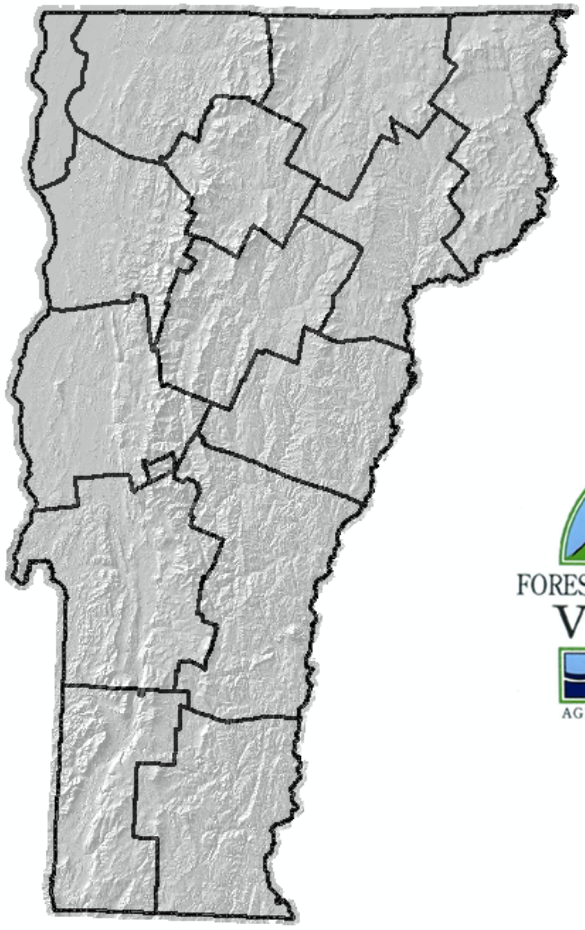
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2021



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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 2021

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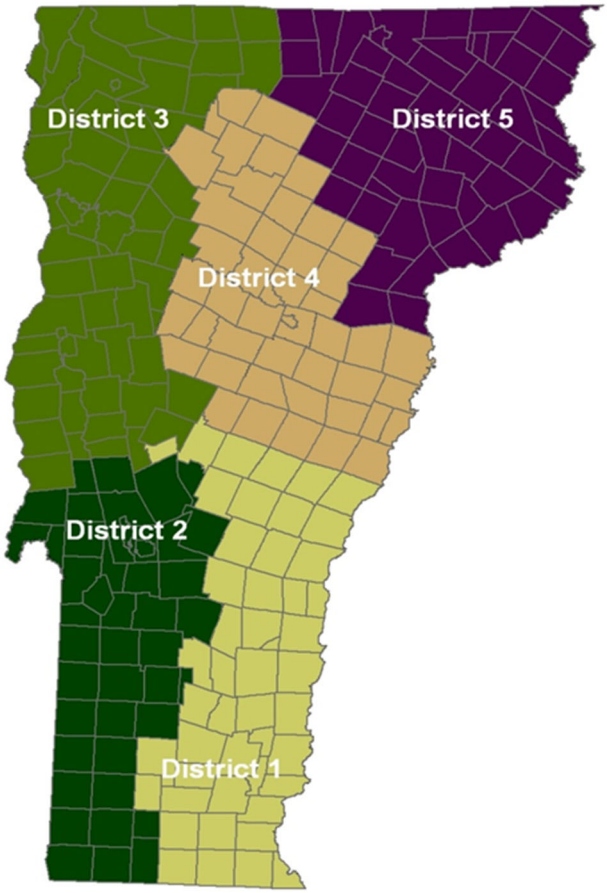

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INTRODUCTION

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

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

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

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

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

ACKNOWLEDGEMENTS

Volunteers assisted with deploying and monitoring purple panel traps as part of our **emerald ash borer detection** efforts. Thank you to Rob Anderregg, Marie Ambusk, Bill Baron, Russ Barrett, Scott Bassage, Robert Brandt, Jon Bouton, Kestrel Craig, Claudia Conrady, Bethany Creaser, Jeff Cueto, Caitlin Cusack, Mark Dillenbeck, Tim Duclos, Peggy Ann Duckless, Kris Dulmer, Steven Farnham, Amanda Garland, Margo Ghia, Michael Gray, Jock Harvey, Stephanie Kaplan, Irwin Kuperberg, Caitlin Littlefield, Bob Little Tree, Guy Maguire, Neil Maker, Neil Monteith, Ken Parrot,Roland Payne Jr., Wilda Pelton, Dave Potter, Michael Quinn, Anne Reed, Kathleen Robbins, Al Sands, Darren Schibler, Dan Steinbauer, Kathleen Stutzman, Sally Thodal, Thomas Toscano, Jack Travelstead, J.E. Townley, Rich Turner, Pieter Van loon, Jim White, Brendan Whittaker, and Robert Zimmerman who participated in this project.

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

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

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

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

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

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WEATHER

2021 WEATHER SUMMARY

Winter 2020-2021

Vermonters faced another short and mild winter in 2020-2021, compared to years past. From December 1 to February 28, state-wide temperatures averaged 22.1°F, which was 0.9 degrees colder than the winter of 2019–2020. Average precipitation across the state was 7.87 inches, which averaged 1.7 inches less than last year's average.

The entire state experienced drier than usual conditions for the duration of the winter, with areas classified as either Abnormally Dry or Moderate Drought according to the U.S. Drought Monitor (https://droughtmonitor.unl.edu/). This was a continuation of drought conditions that began in the state in June 2020.

Spring 2021

The dry weather continued into spring (Figs. 1-6), and by the end of April, 92% of the state was in Moderate Drought and the remaining 8% was classified as Abnormally Dry. Precipitation in May helped reduce the area of the state affected by drought, but 83% of the state was still experiencing some level of drought by the end of the month. Temperatures throughout the spring were slightly warmer than in 2020, and these temperatures coupled with limited rainfall brought the drought-affected portion of the state back to 91% by the end of June.

Although some moderate flowering was observed for sugar maples, this was not a year of heavy flowering for Vermont forests.

Summer 2021

July brought increased precipitation to much of the state (as much as 300% greater than normal in some locations), which alleviated some drought areas in southern Vermont. However, far northern and northeast portions of the state remained in Moderate Drought for the month. On the whole, the state was roughly 3 degrees cooler in July 2021 than normal. August conditions were near normal for temperature and precipitation, which kept southern Vermont drought-free, but drought still persisted in the far north. Drought conditions continued to lessen in the state through September. The month started with 51% of the state drought-free, and increased to over 60% by the month's end.

Fall 2021

Average temperatures in October were 5 degrees warmer than the long-term (20-yr) average. As a result, the progression of fall color and leaf drop was slow in many locations (Fig. 9, Tables 1 and 2).

Some mountain summits received their first snowfall in late October, but snow evaded most of the state until late November. However, precipitation was sufficient enough to bring the proportion of the state unaffected by drought up to 75% by mid-December.

Figures 1-9 *and* ***Tables 1-3*** *provide details on 2021 precipitation and phenological observations.*

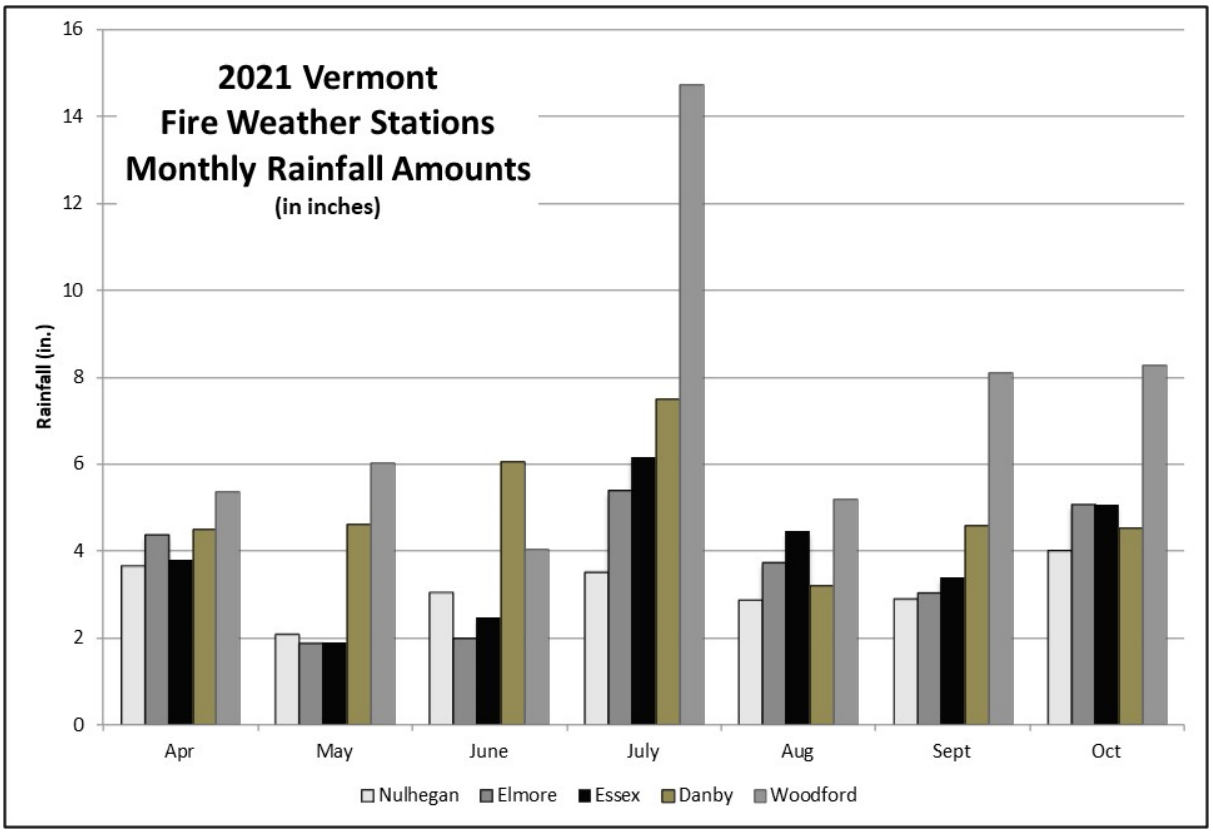


Figure 1. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, April-October, 2021.

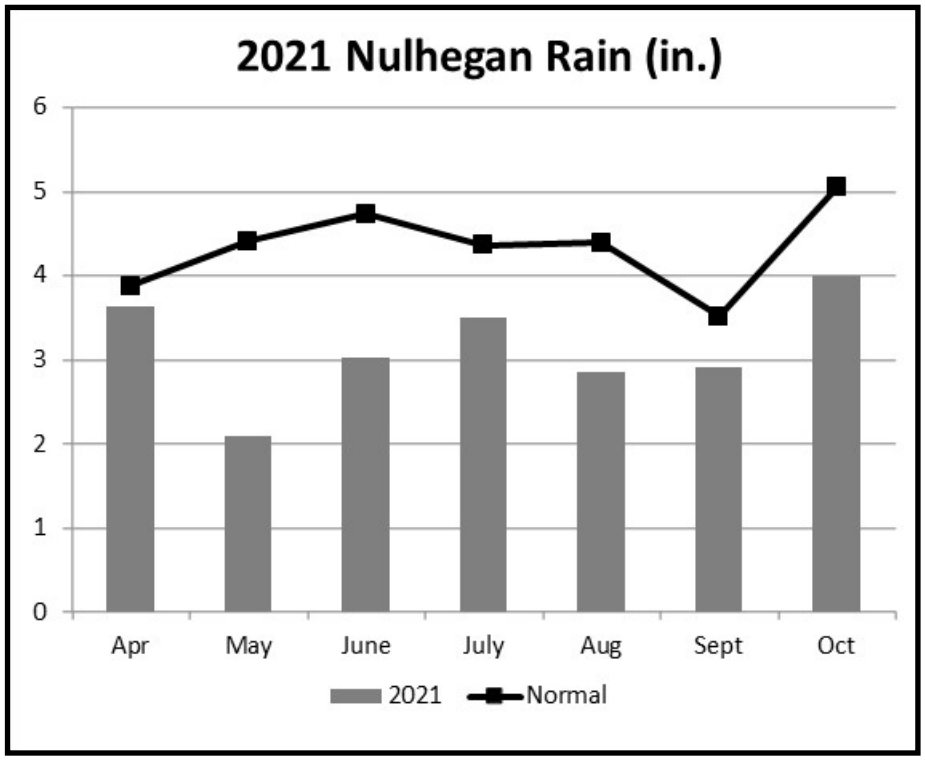


Figure 2. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, VT compared to normal during the fire season, April-October, 2021. Normal is based on 19 years of data.

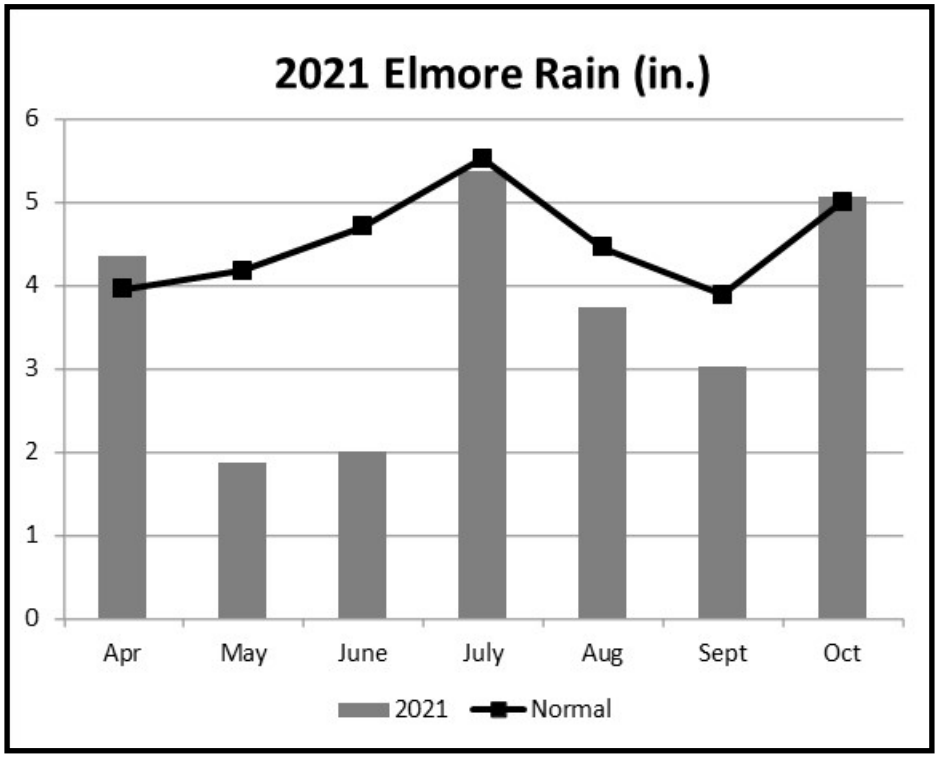


Figure 3. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, VT compared to normal during the fire season, April-October, 2021. Normal is based on 27 years of data.

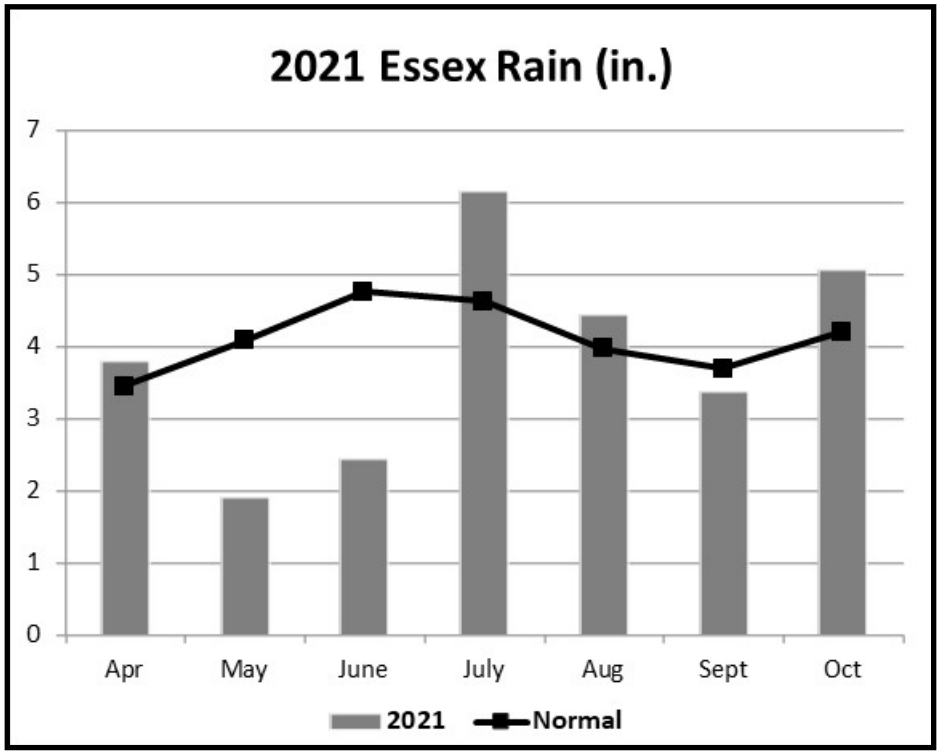


Figure 4. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, VT compared to normal during the fire season, April-October, 2021. Normal is based on 28 years of data.

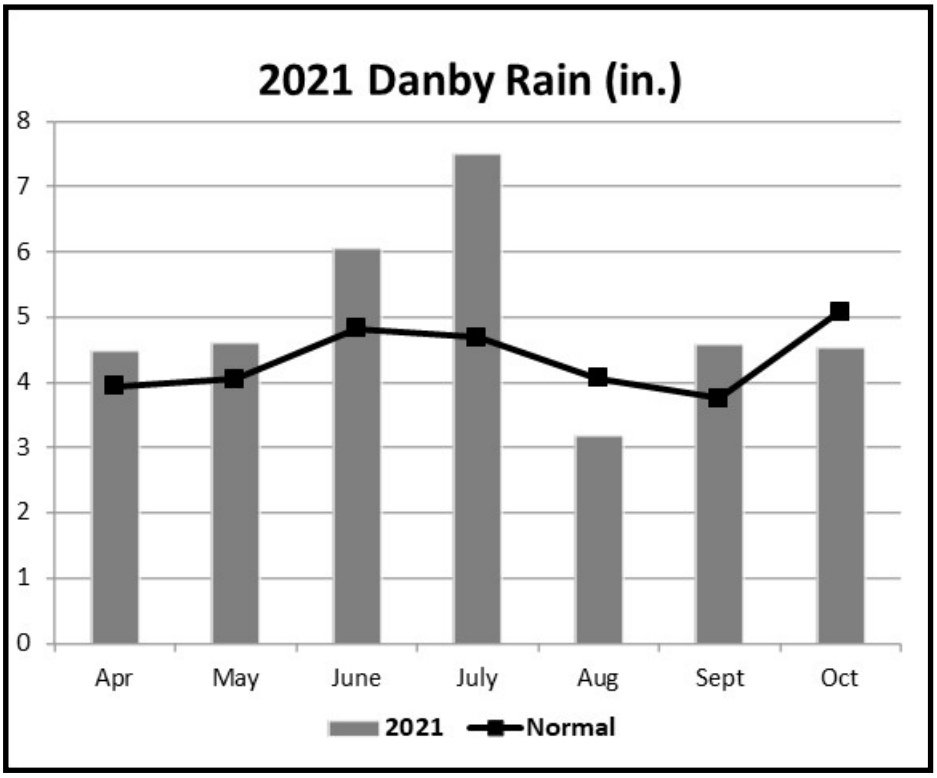


Figure 5. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal during the fire season, April-October, 2021. Normal is based on 21 years of data.

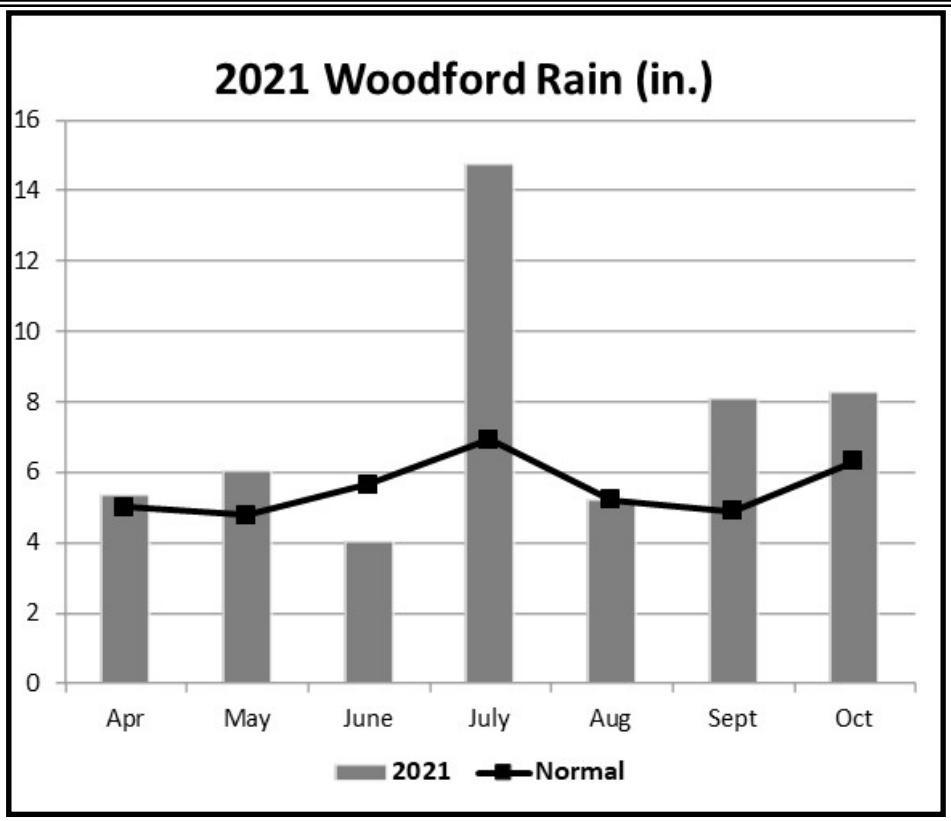


Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont during the fire season, April-October, 2021. Normal is based on 9 years of data.

PHENOLOGY

2021 PHENOLOGY SUMMARY

Spring Budbreak and Leaf Out at Mount Mansfield

Sugar maple trees were monitored for the timing of budbreak and leaf out in the spring at the Proctor Maple Research Center in Underhill as part of the Forest Ecosystem Monitoring Cooperative. Warm April temperatures helped accelerate bud development, with budbreak occurring on April 12. This was nearly a month earlier than 2020 and the earliest budbreak recorded in 31 years of monitoring. Full leaf out was slow in comparison but occurred 4 days earlier than the long-term average (Figure 7). Moderate flowering occurred for some sugar maples, but this did not produce heavy seed in 2021.

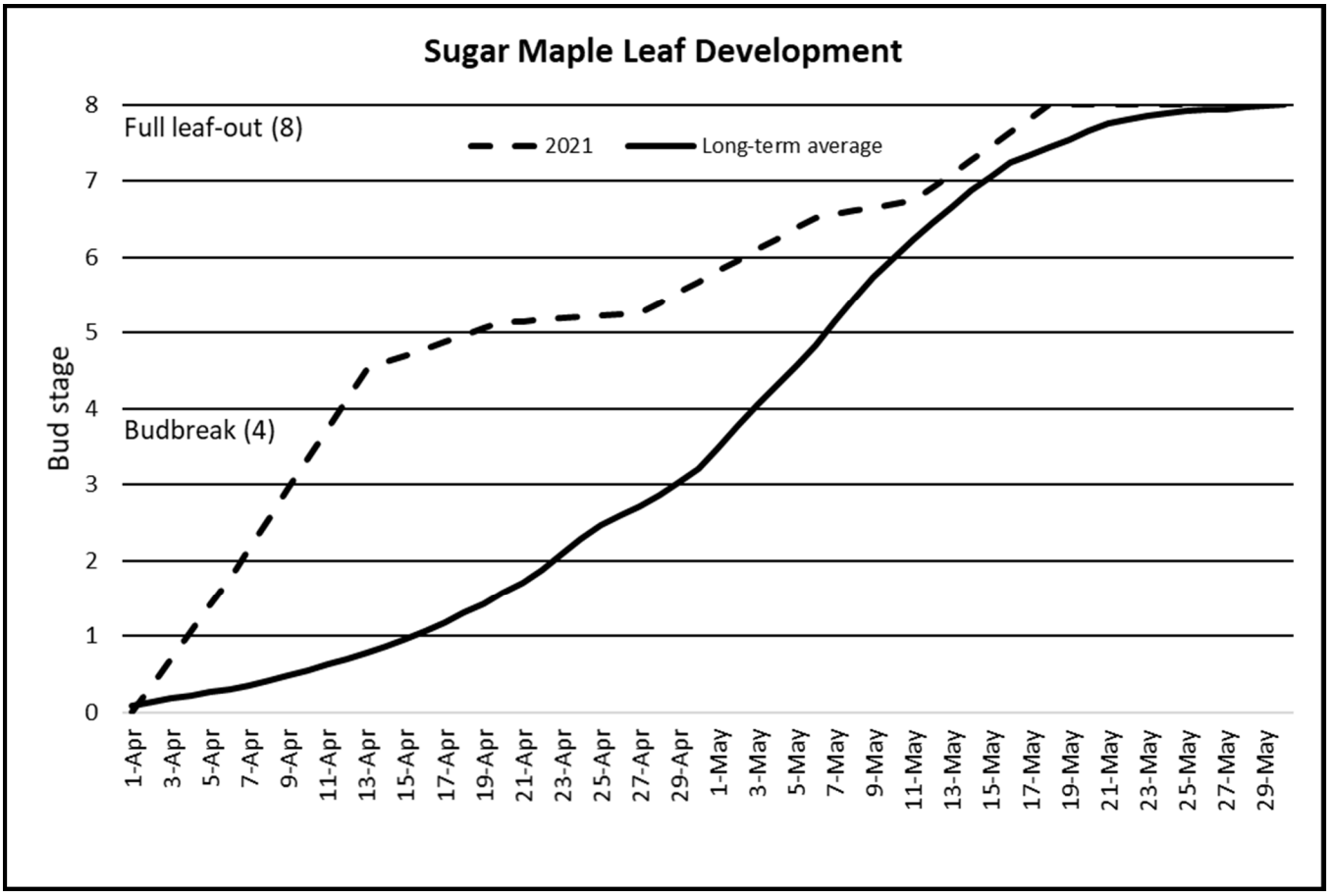


Figure 7. Sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

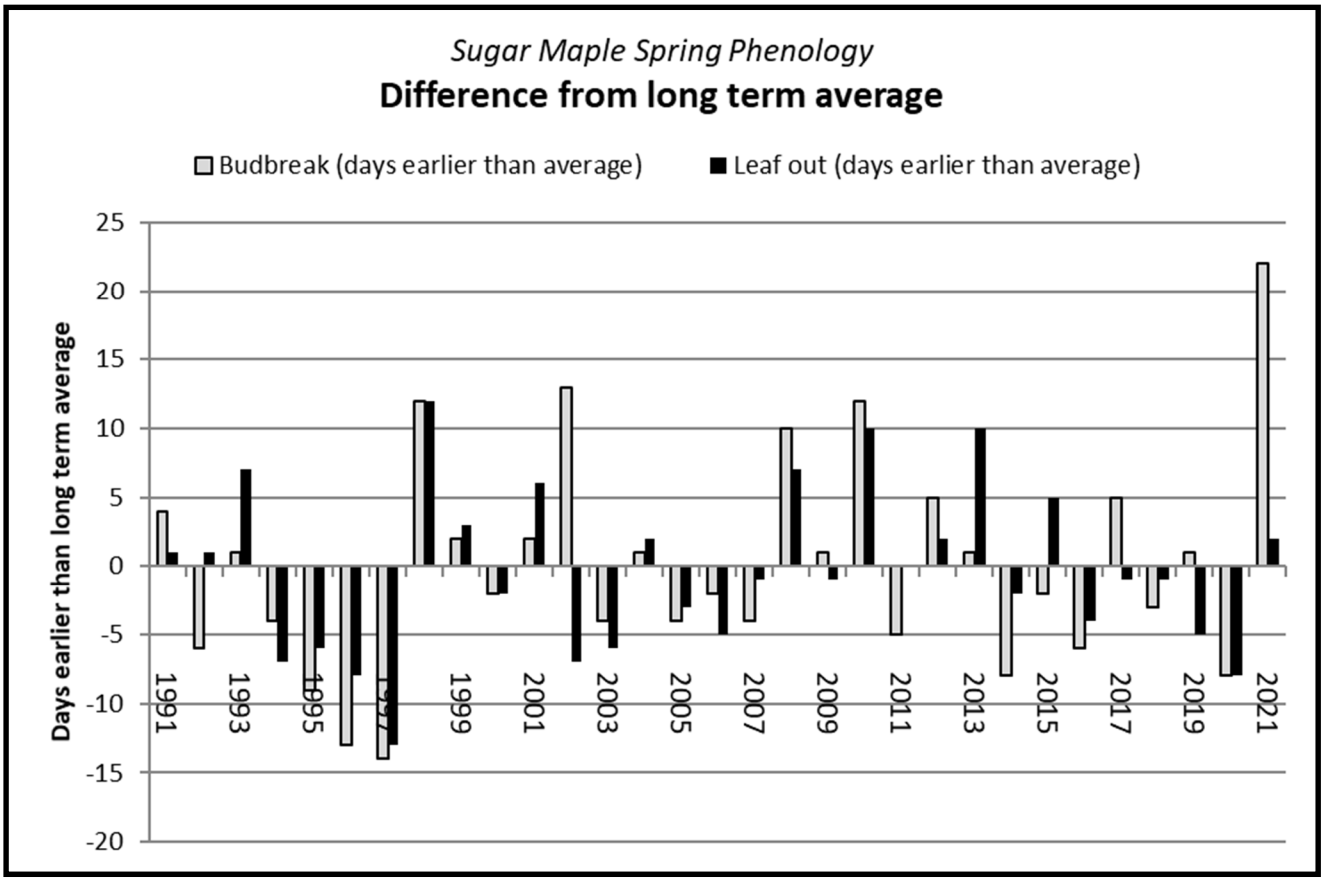


Figure 8. Difference from long-term average of sugar maple budbreak and leaf out at Proctor Maple Research Center, Underhill, VT.

Fall Color Monitoring at Mount Mansfield

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

Despite reports of late fall color in New England, the timing of peak color for most species was similar to long-term averages. Maples (both red and sugar) at 1400' retained their leaves for an extended period this year due to warm temperatures with few storms late in the season. At upper elevations (2200' and 2600') leaves fell slightly earlier than usual. The growing season length for sugar maples at 1400' was the longest (206 days) in our 31 years of monitoring (Table 1).

Figure 9. Timing of fall color (Figure 9a-9f) and leaf drop was monitored at three elevations on Mount Mansfield in 2021: 1400 feet at the Proctor Maple Research Center and 2200 and 2600 feet near Underhill State Park. Five species are monitored: sugar maple, red maple (male and female trees), white ash, paper birch, and yellow birch.

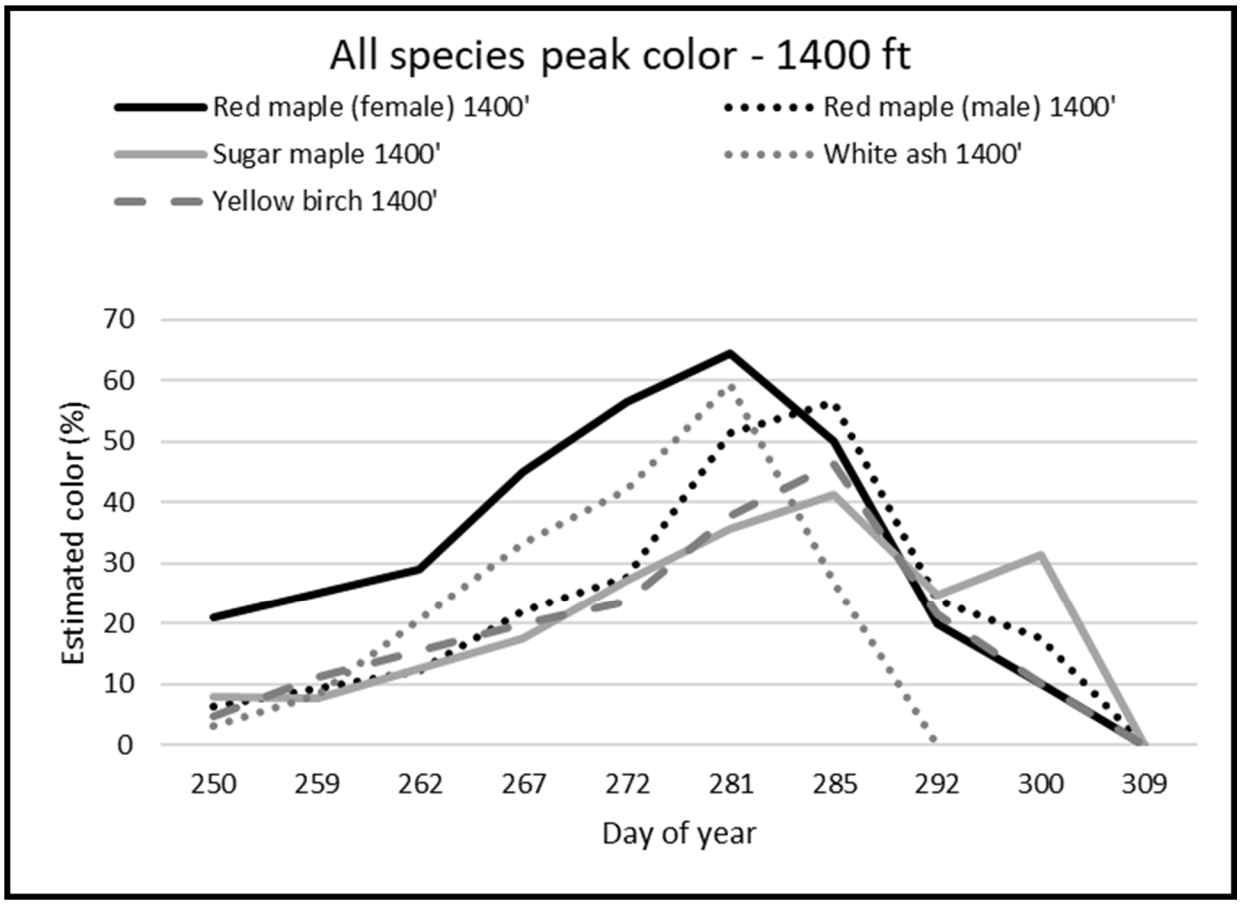


Figure 9a.

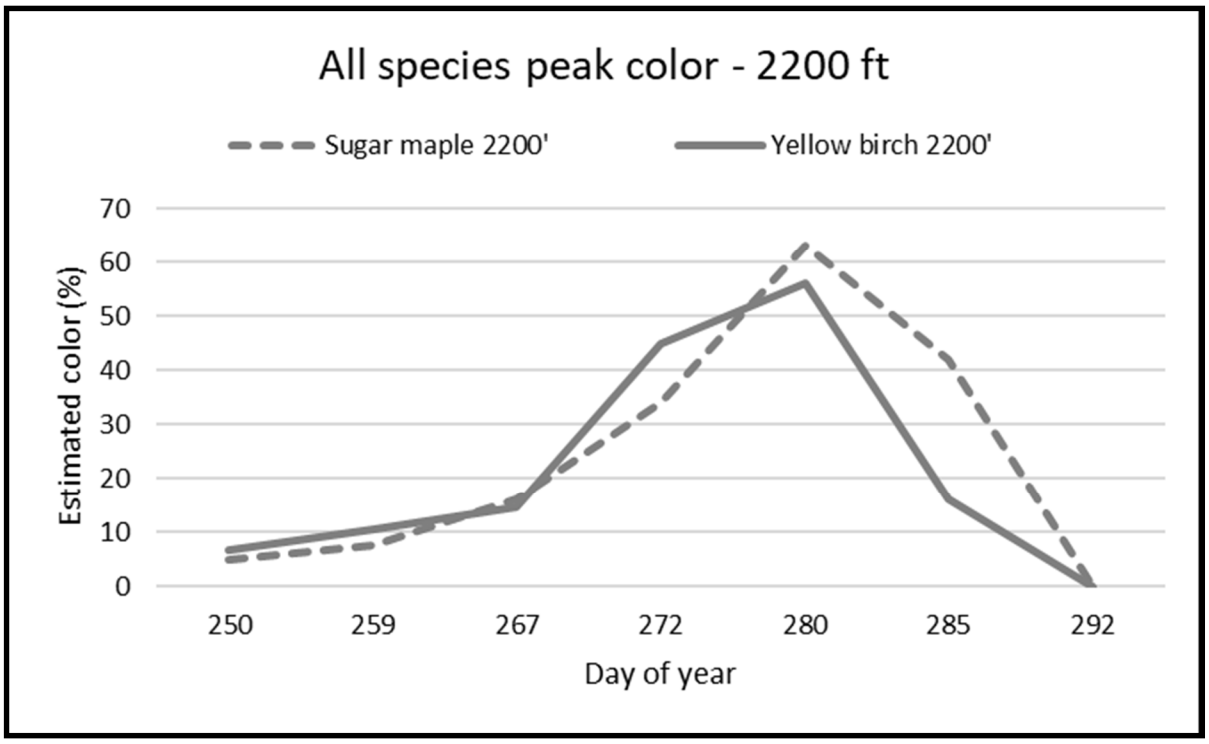


Figure 9b.

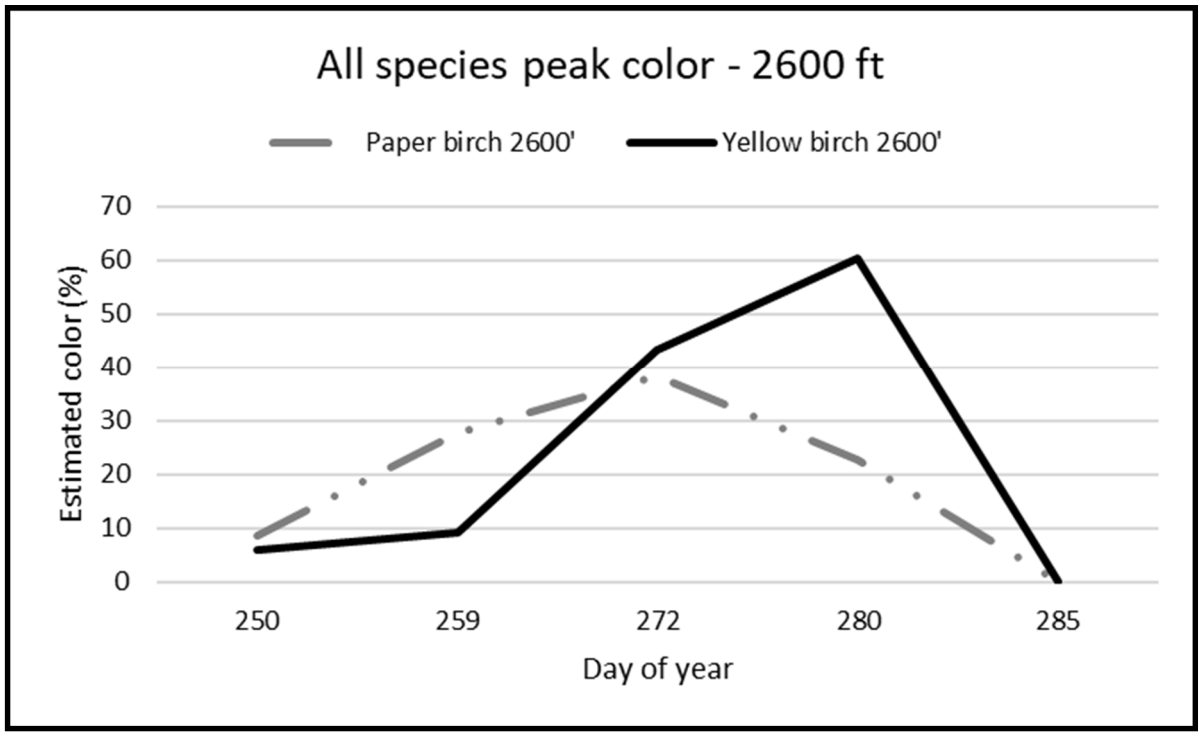


Figure 9c.

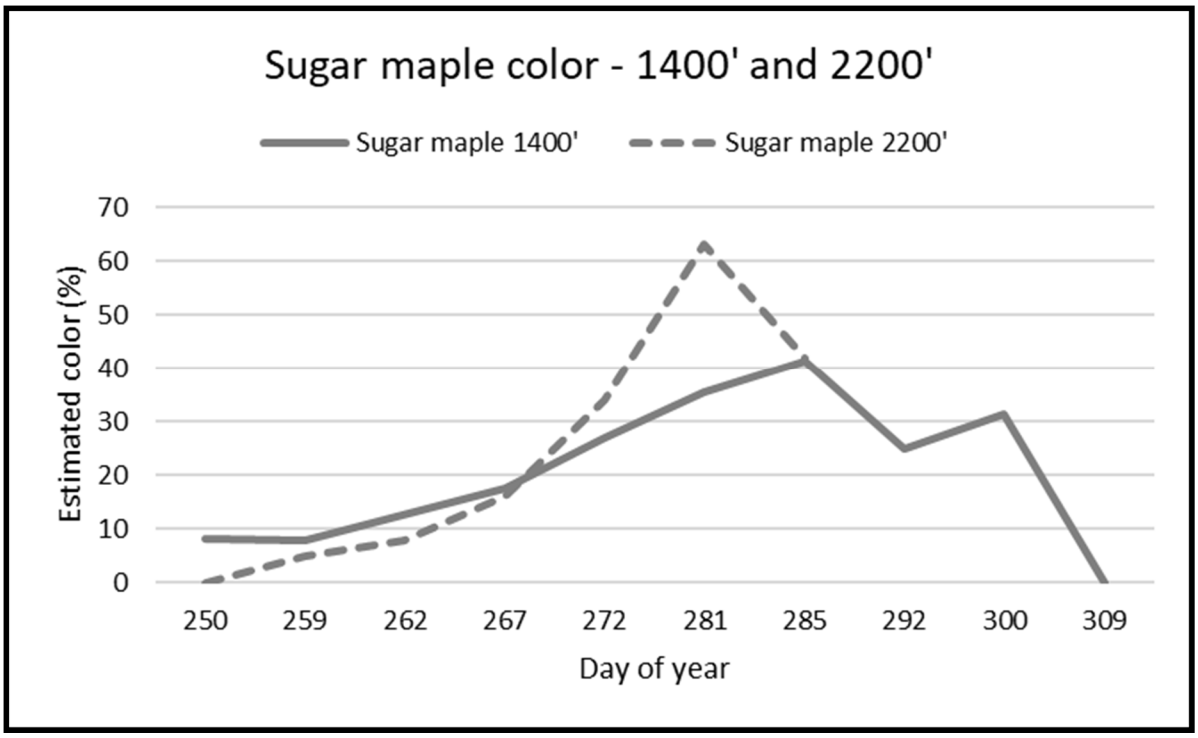


Figure 9d.

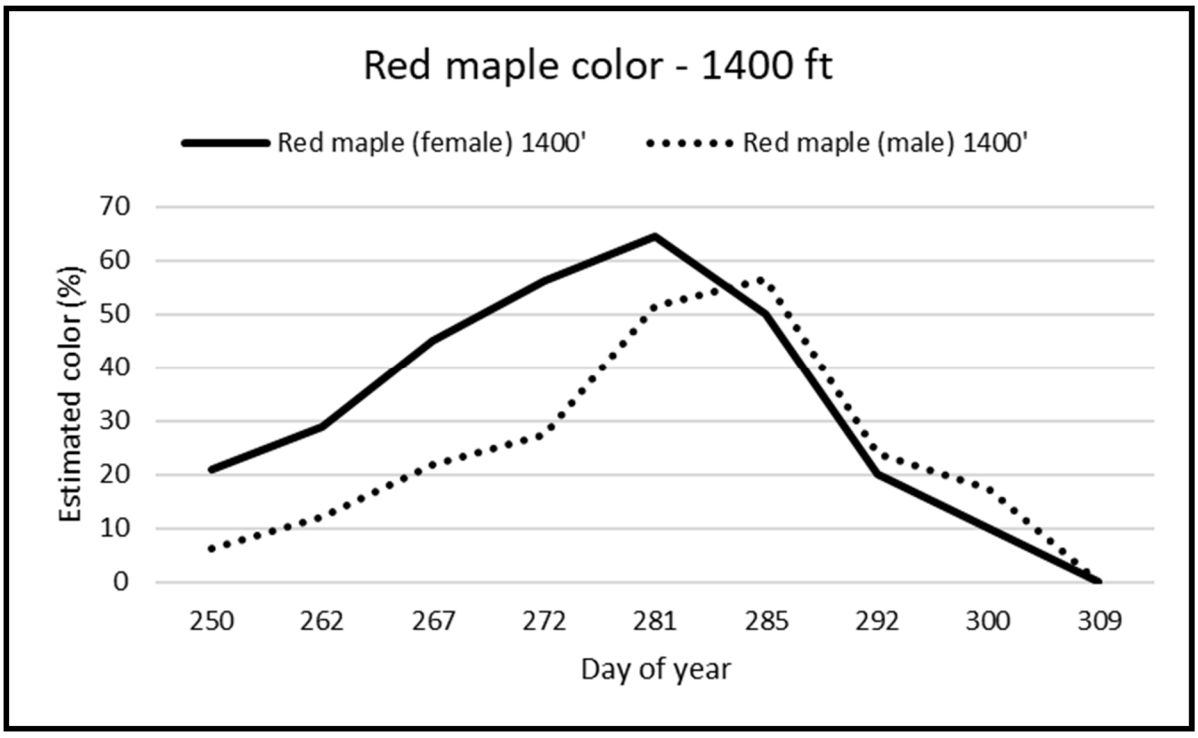


Figure 9e.

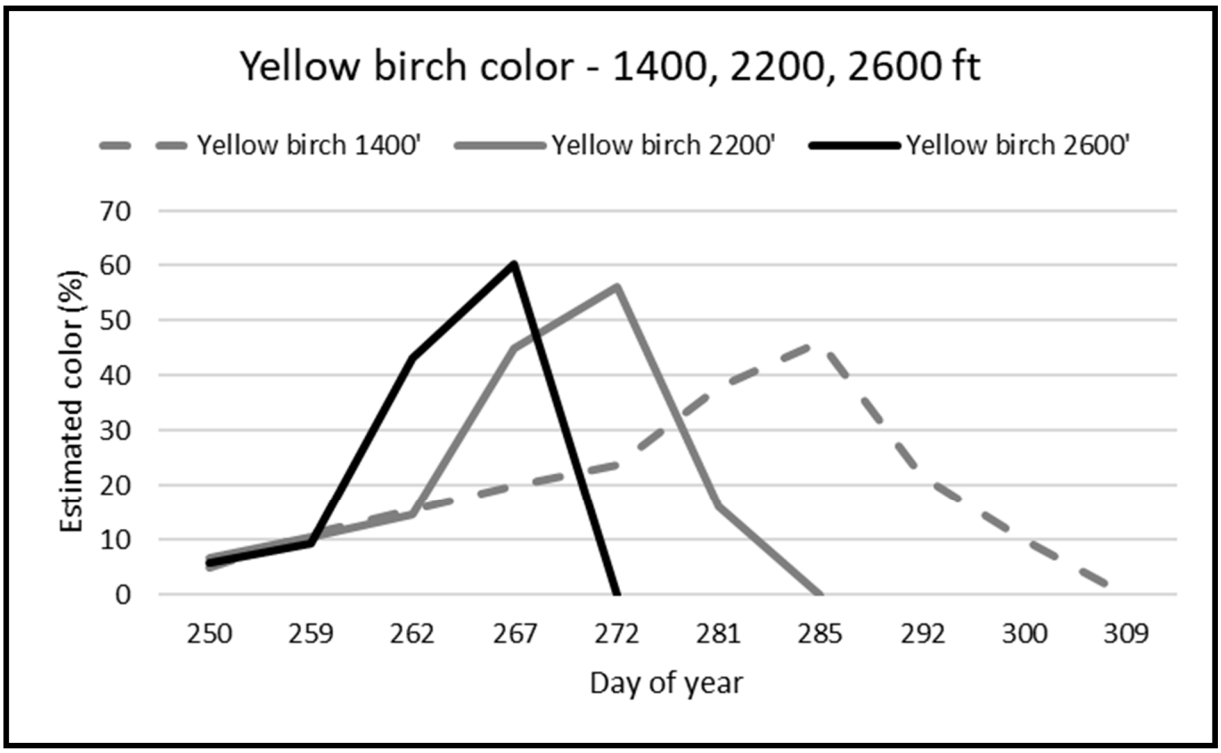


Figure 9f.

Table 1. Estimates of peak color based on percent color and percent of foliage present. Length of long-term averages differ by species, with trees at 2600 ft having a 23-year record, red maple and white ash a 27-year record, sugar maple at 1400 ft a 31-year record, and all other trees a 30-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)	2021 data (Day of year)
Elevation 1400'		
Red maple (Female)	280	281
Red maple (Male)	284	285
Sugar maple	287	285
Yellow birch	285	285
White ash	279	281
Elevation 2200'		
Sugar maple	277	280
Yellow birch	276	280
Elevation 2600'		
Yellow birch	276	269
Paper birch	269	269

Table 2. Date of leaf drop for trees at 3 elevations on Mt. Mansfield. Day of year when more than 95% of foliage had fallen are included for both 2021, and the long-term average (see Table 1 for details on length of long-term averages).

Leaf drop		
	> 95% leaf drop	
	Long-term average (Day of year)	2021 data (Day of year)
Elevation 1400'		
Red maple (Female)	299	305
Red maple (Male)	300	307
Sugar maple	303	308
Yellow birch	298	300
White ash	296	291
Elevation 2200'		
Sugar maple	295	292
Yellow birch	292	290
Elevation 2600'		
Yellow birch	289	285
Paper birch	286	284

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

Year	Date of Bud break	Date of End of Growing Season	Length of growing season (days)
1991	4/28	10/15	171
1992	5/7	10/13	159
1993	5/4	10/18	167
1994	5/6	10/14	161
1995	5/13	10/19	159
1996	5/14	10/22	161
1997	5/16	10/14	151
1998	4/17	10/15	181
1999	5/5	10/19	167
2000	5/9	10/17	161
2001	5/4	10/15	164
2002	4/18	11/5	201
2003	5/9	10/28	172
2004	5/4	10/27	175
2005	5/2	10/27	178
2006	5/2	10/16	167
2007	5/7	10/22	168
2008	4/22	10/15	175
2009	4/30	10/29	182
2010	4/22	10/26	187
2011	5/7	10/19	163
2012	4/16	10/16	186
2013	5/3	10/15	165
2014	5/12	10/20	161
2015	5/6	10/30	177
2016	5/9	10/31	175
2017	4/29	10/29	183
2018	5/7	10/30	176
2019	5/3	10/26	176
2020	5/11	10/24	167
2021	4/12	11/4	206
Long term Average (1991-2021)	**5/3**	**10/22**	**172**

HARDWOOD DEFOLIATORS

Forest Tent Caterpillar (FTC), *Malacosoma disstria*, defoliation was not detected in 2021. No reports of defoliation were received, nor were incidental observations or aerial defoliation recorded. Twenty three traps were once again deployed in 2021 to assess current FTC populations and gauge the risk of defoliation in 2022. The average number of moths per trap declined again this year (0.25 moths/trap) from the already low number of 2020 (0.80 moths/trap; Figure 10, Table 4).

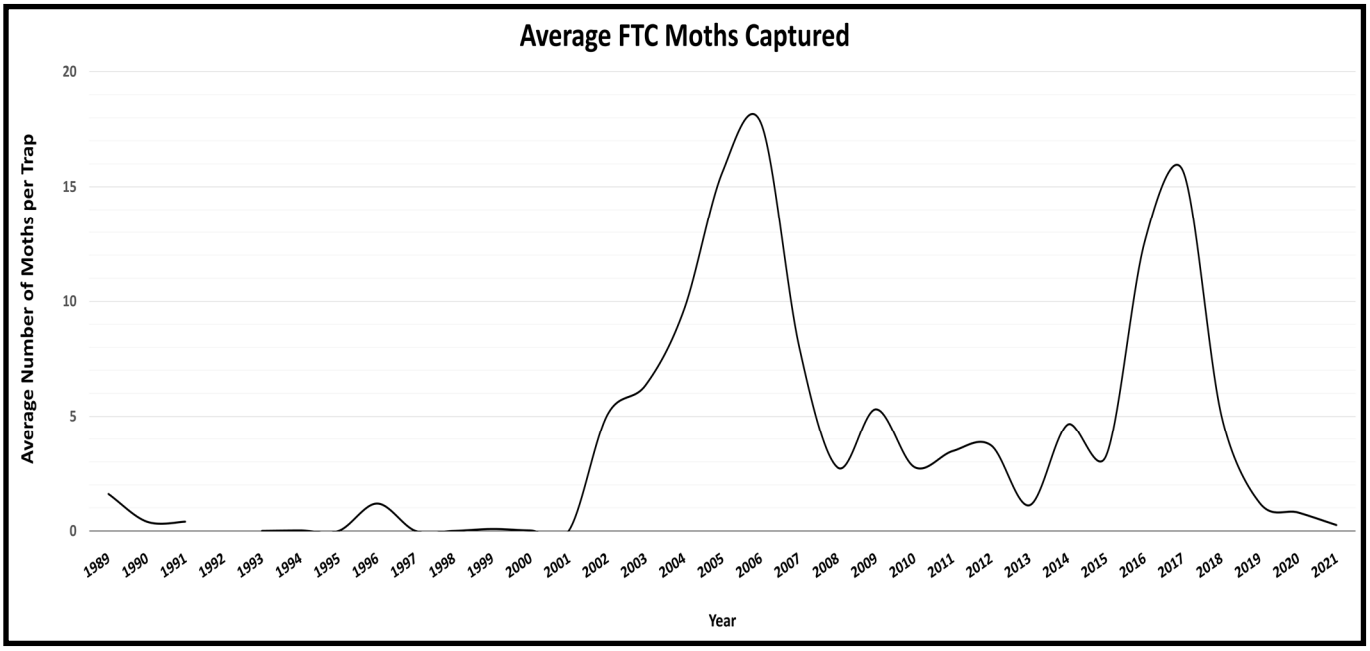


Figure 10. Average number of forest tent caterpillar moths caught in pheromone traps 1999-2021. Populations were not monitored in 1992. Three multi-pher pheromone traps per site, with PheroTech lures, were used in 2021.

Table 4. Average number of forest tent caterpillar moths caught in pheromone traps, 2005-2021. Three multi-pher traps baited with PheroTech lures were deployed at each of the 23 survey locations.

Site	Year																
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Castleton	17	17.3	8.0	1.5	4.7	1.0	1.7	0.3	2.3	1.7	1.7	14.0	13.3	8.7	0.7	1.3	0.3
Fairfield (NAMP 29)	-	4.3	4.7	4.0	10.3	2.0	6.0	4.0	1.7	3.3	1.3	1.3	8.0	2.0	0.0	0.3	0.0
Huntington (NAMP 027)	15.7	16.0	6.3	4.3	4.3	2.7	6.3	6.0	1.7	2.7	0.0	10.3	11.0	6.0	0.7	0.0	0.0
Killington/ Sherburne (Gifford Woods)	15.3	21.0	17.3	7.3	8.0	2.7	0.0	1.0	0.7	6.0	5.3	8.3	18.7	6.7	0.3	0.0	0.0
Manchester	-	-	-	0.0	5.7	3.0	1.0	0.7	0.3	1.3	10.3	12.0	19.3	3.7	0.7	0.3	0.0
Rochester (Rochester Mountain)	4.7	29.0	10.3	0.7	-	0.3	0.0	0.0	0.0	3.5	2.3	9.0	7.3	2.0	0.0	0.3	0.0
Roxbury (Roxbury SF)	7.3	22.0	22.7	8.0	2.7	7.0	2.0	1.5	1.7	6.3	8.5	29.0	15.0	3.3	0.3	0.0	0.0
SB 2200 (Stevensville Brook)	23.3	35.3	6.3	5.7	7.3	2.7	6.3	8.0	1.3	5.3	2.7	7.3	29.0	6.7	-	0.3	0.0
Underhill (VMC 1400)	7.3	9.3	2.7	1.3	8.3	5.7	8.3	7.7	0.3	5.7	0.7	14.3	11.3	2.7	1.0	0.3	0.0
Underhill (VMC 2200)	11.7	6.3	4.7	1.3	4.3	2.0	2.7	4.7	0.7	2.5	1.3	3.7	9.0	3.0	0.3	0.0	0.0
Waterbury (Cotton Brook)	41.0	22.3	0.3	1.0	5.0	3.3	4.3	7.0	0.3	9.3	5.7	36.3	15.7	3.3	0.3	0.3	0.0
Waterville (Codding Hollow/Locke)	17.7	24.7	2.7	2.3	1.3	3.0	4.3	3.0	1.5	12.5	3.3	13.3	28.3	13.3	2.7	1.3	0.0
Stowe (VMC 3800)	26.0	5.7	5.0	1.3	1.7	0.7	2.0	2.3	1.3	1.7	-	-	-	-	-	-	-
Valley	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dillner Farm (Montgomery)	-	-	-	-	-	-	-	-	-	-	1.0	4.3	18.0	4.3	0.0	0.0	0.0
Vershire (NAMP 37)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	0.3	0.0
Wilmington (NAMP 25)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7	4.7	0.0
Westminster (NAMP 21)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	0.0	0.0
Woodstock (NAMP 24)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	2.0	.7
Lincoln (NAMP 34)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.0	0.0
Lahar NAMP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.7	1.3
Glover (NAMP 1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.0	0.0
Norton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.3	4.0	1.7
Victory (Victory SF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.3	0.3
Rupert (Merck Forest)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	0.7	1.3
Average	**15.6**	**17.8**	**8.0**	**2.8**	**5.3**	**2.8**	**3.5**	**3.7**	**1.1**	**4.6**	**3.3**	**12.6**	**15.7**	**5.1**	**1.2**	**0.8**	**.3**

Lymantria dispar (LDD; formerly gypsy moth) caterpillars were responsible for the largest disturbance to Vermont forests as mapped through aerial detection surveys in 2021 (Fig. 12). Defoliation was significant in the Champlain Valley of western Vermont, with 50,945 acres mapped as moderately or severely defoliated.

Egg mass counts from nine focal area plots (Fig. 11) suggest that defoliation is likely to be observed in Vermont again in 2022. We will be monitoring the severity and extent of defoliation as the growing season begins. One year of defoliation is unlikely to cause substantial damage to most trees, but repeated defoliation can have significant impacts on tree and forest health. The fungus *Entomophaga maimaiga* helps control populations of LDD when spring conditions are wet and/or humid. The drought from 2020 -2021 may have allowed LDD populations to build and expand, and likely contributed to the current outbreak.

Additional information for landowners impacted or concerned about LDD can be found at: https://fpr.vermont.gov/forest/forest-health

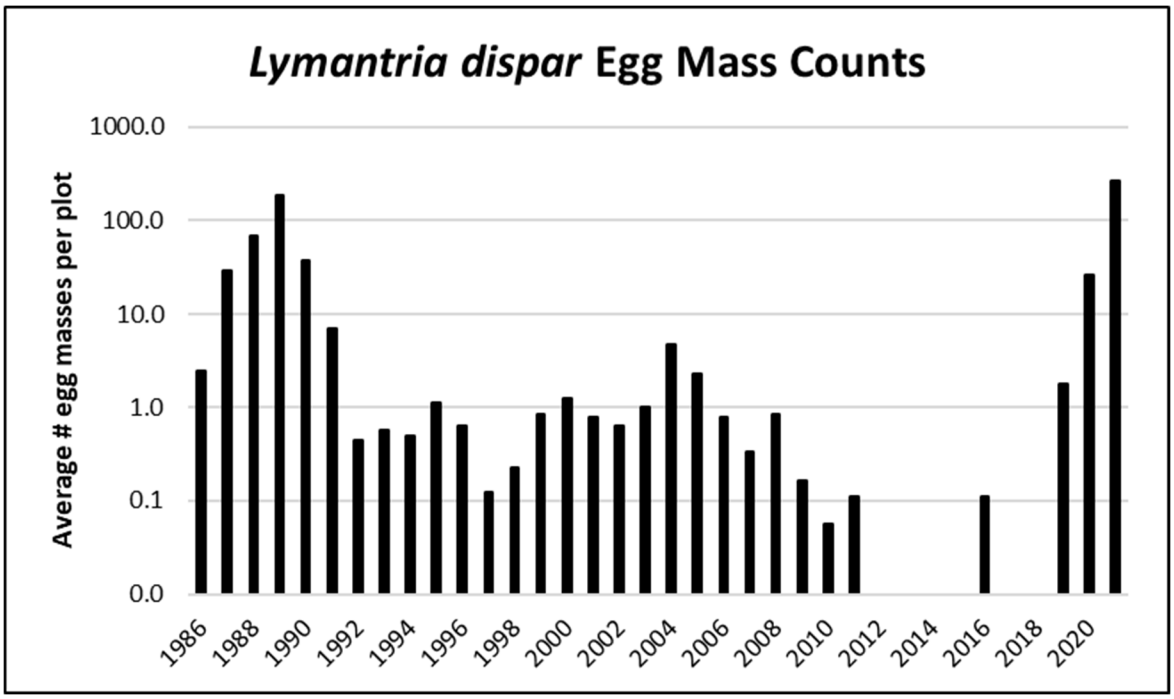


Figure 11. Number of LDD egg masses per 1/25th acre in focal area monitoring plots, 1987-2020. Data reflect the average egg mass counts from ten locations, with two 15-meter diameter plots per location containing burlap-banded trees.

Table 5. Number of LDD egg masses per 1/25th acre in focal area monitoring plots, 2003-2021. Counts are the average of two 15 meter plots per location containing burlap-banded trees.

Site	Town	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Arrowhead	Milton	1.5	2.5	0	0	0	2.5	0	0	0.5	0	0	0	0	0	0	0	0.5	28	72.5
Brigham Hill	Essex	2.5	2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	82	137
Ft. Dummer	Guilford	0	——	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	2	0
Minard's Pond	Rocking-ham	0.5	2	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	2.5	15	186
Mount Antho-ny	Benning-ton	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perch Pond	Benson	0	0	0.5	1	0	0.5	0	0.5	0	0	0	0	0	0	0	0	2	106.5	618
Rocky Pond	Rutland	0	0	0.5	3	3	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5	28
Sandbar	Colchester	3	1.5	0	0	0	2.5	0.5	0	0	0	0	0	0	0	0	0	0.5	2.5	1313.5
Tate Hill	Sandgate	0	30	18	3	0	1.5	0.5	0	0	0	0	0	0	1	0	0	6	0.5	0
Average		1	4.4	2.3	0.8	0.3	0.8	0.2	0.06	0.11	0	0	0	0	0.11	0	0	1.8	26.3	261.7

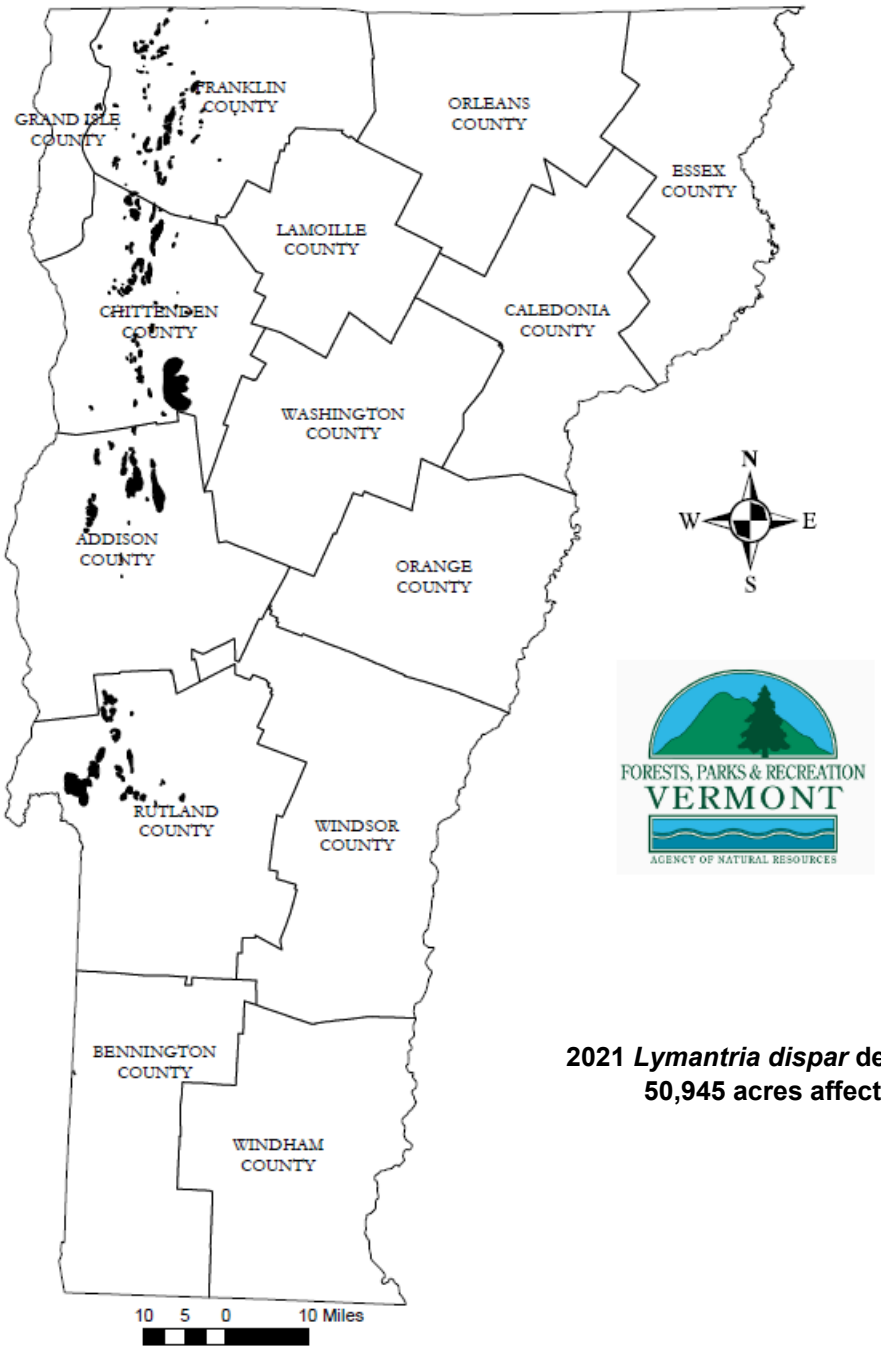


Figure 12. *Lymantria dispar* (LDD) defoliation 2021. Mapped area includes 50,945 acres affected.

Maple leafcutter (MLC), *Paraclemensia acerifoliella,* damage is predominately found on sugar maples, although this insect also feeds on other hardwoods such as red maple, beech, and birch species. This insect caused observable damage to hardwoods during late summer and early autumn in 2021, causing our northern hardwood forests to appear brown and discolored before the onset of typical fall colors. Most reports of MLC came from Orange and Washington counties in 2021, though aerial surveys detected considerable defoliation in Caledonia and Orleans counties as well. In total, 27,791 acres were mapped (Fig. 13).

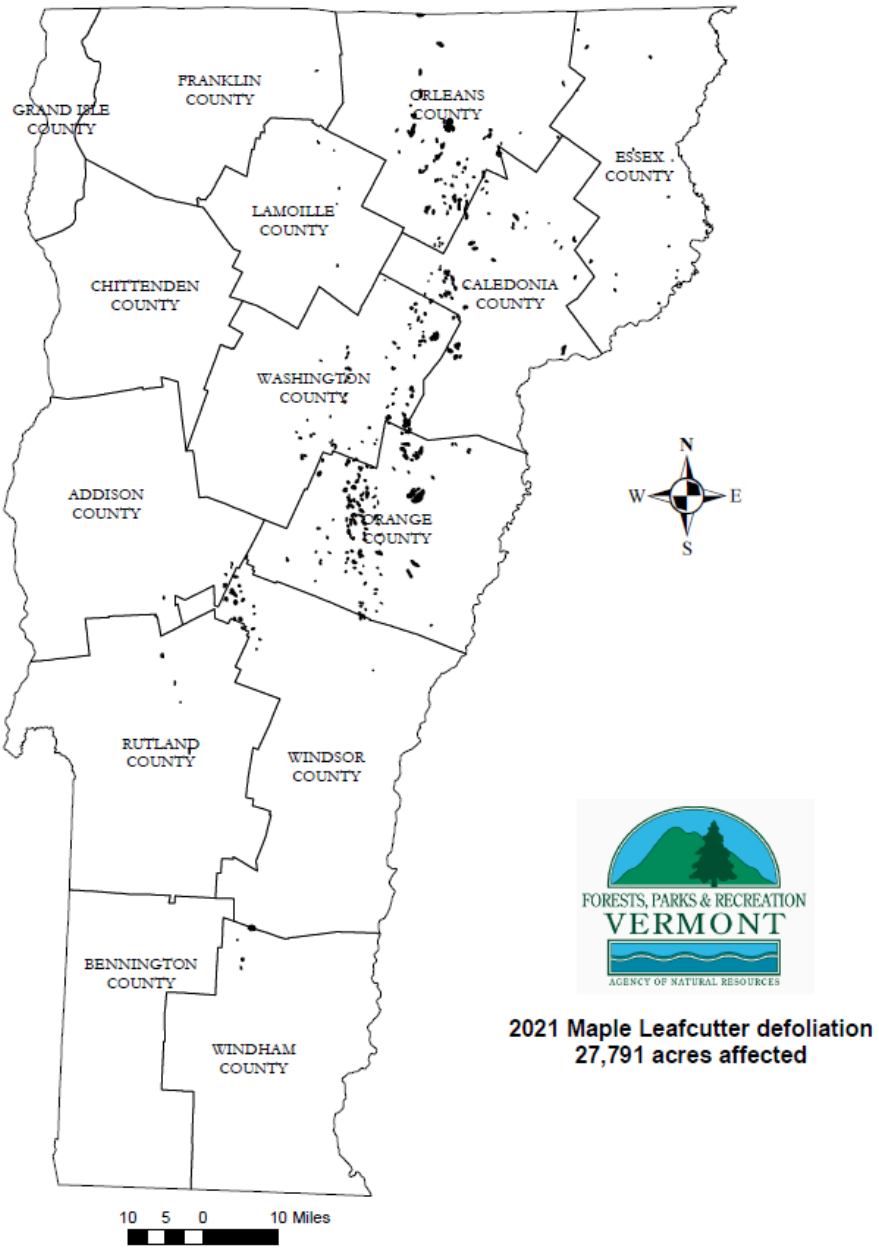


Figure 13. Maple leafcutter defoliation 2021. Mapped area includes 27,791 acres affected.

Saddled prominent (SP), *Heterocampa guttivitta,* are hardwood defoliators native to the northeastern United States. Although a native insect, heavy and repeated defoliation can lead to dieback and mortality of infested hosts. Increased reports of defoliation during the growing season of 2020 led to reestablishing trapping efforts in 2021. In 2021, reports of defoliation were received from Franklin, Orange, Washington, Windsor, and Windham counties, but defoliation was recorded via aerial surveys in eight counties (Fig. 15).

To track population outbreaks, pheromone traps for SP were deployed statewide in late spring. The number of moths per trap averaged 3.3, evidence that populations are increasing in Vermont compared to 2.2 moths per trap in 2018 (Table 6). We do anticipate increased populations of SP in 2022, however current population levels are not predictive of severe defoliation in 2022.

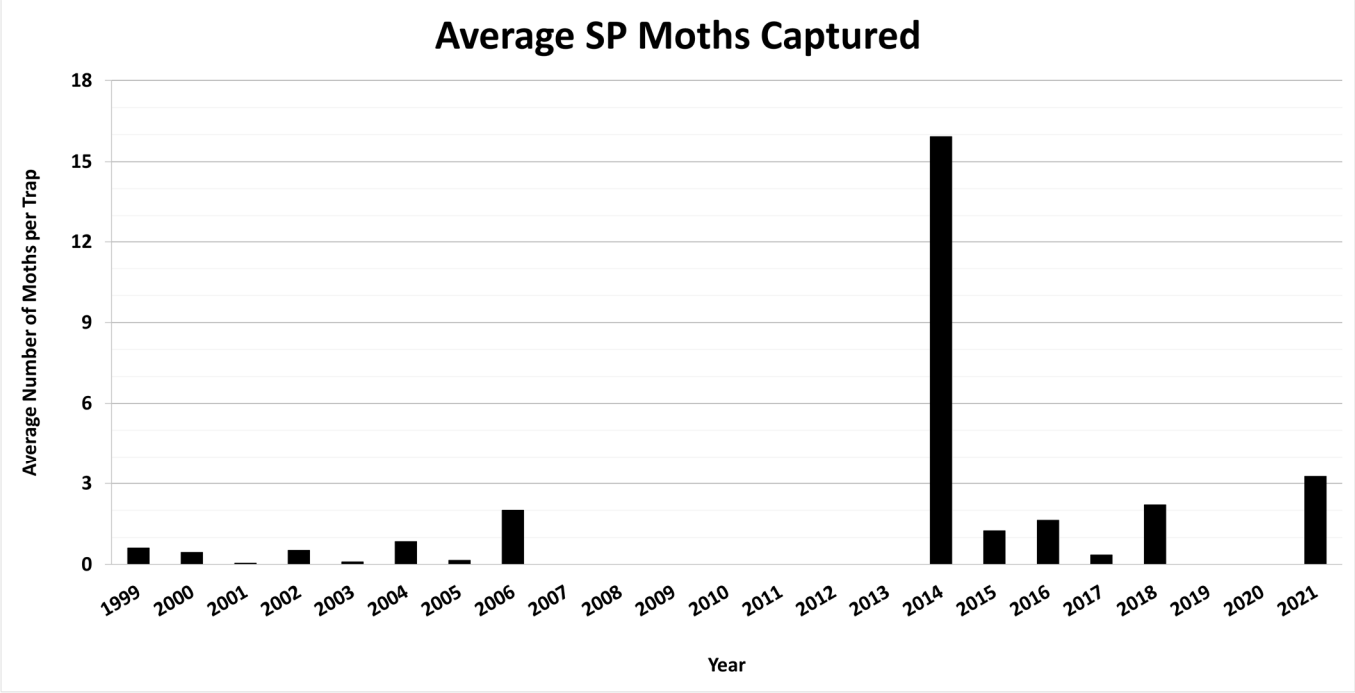


Figure 14. Average number of saddled prominent moths caught in pheromone traps 1999-2021. Populations were not monitored 2007-2013 and 2019-2020. Three multi-pher pheromone traps per site, with aPhinity SP lures, were used in 2021.

Table 6. Average number of saddled prominent moths caught in pheromone traps, 1999-2021. Three multi-pher traps baited with PheroTech lures were deployed at each of the 23 survey locations in 2021.

County and Town	1999	2000	2001	2002	2003	2004	2005	2006	2014	2015	2016	2017	2018	2021
Chittenden Underhill	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	10.0	1.3	0.0	0.0	2.3	2.0
Washington Groton	1.0	0.0	0.0	0.3	0.7	2.3	0.0	3.3	3.3	0.0	-	-	-	-
Orleans Westmore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	10.3	0.3	0.0	0.0	0.0	5.7
Orange Vershire (WP)	0.7	0.5	0.0	0.0	0.0	1.0	0.0	0.3	-	1.7	0.0	0.0	4.0	7.3
Rutland Shrewsbury	0.0	1.0	0.0	0.0	0.0	1.2	0.0	2.0	20.0	2.0	0.7	0.7	1.3	2.0
Chittenden Bolton	2.0	1.0	0.3	0.0	0.0	0.3	0.7	5.3	31.0	1.7	-	-	-	1.7
Rutland Danby	-	-	-	-	-	-	-	-	47.3	1.3	-	-	-	-
Bennington Arlington	-	-	-	-	-	-	-	-	21.3	0.7	-	-	-	-
Orleans Derby	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-
Orange Vershire (JS)	-	-	-	-	-	-	-	-	13	1.0	0.0	0.3	3.0	3.0
Orange Topsham	-	-	-	-	-	-	-	-	11.7	1.7	-	-	-	-
Orleans Glover	-	-	-	-	-	-	-	-	26	0.3	-	-	-	-
Windsor Plymouth	-	-	-	-	-	-	-	-	5.7	0.3	-	-	-	-
Windsor Windsor	-	-	-	-	-	-	-	-	1.3	-	-	-	-	-
Windsor Sharon	-	-	-	-	-	-	-	-	-	0.3	4.3	1.0	0.7	1.3
Windsor Weathersfield	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-
Franklin Sheldon	-	-	-	-	-	-	-	-	-	6.0	5.3	0.7	4.7	-
Franklin Montgomery	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3
Caledonia Walden	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0
Average	**0.6**	**0.4**	**0.1**	**0.5**	**0.1**	**0.9**	**0.2**	**2.0**	**15.9**	**1.2**	**1.6**	**0.4**	**2.2**	**3.3**

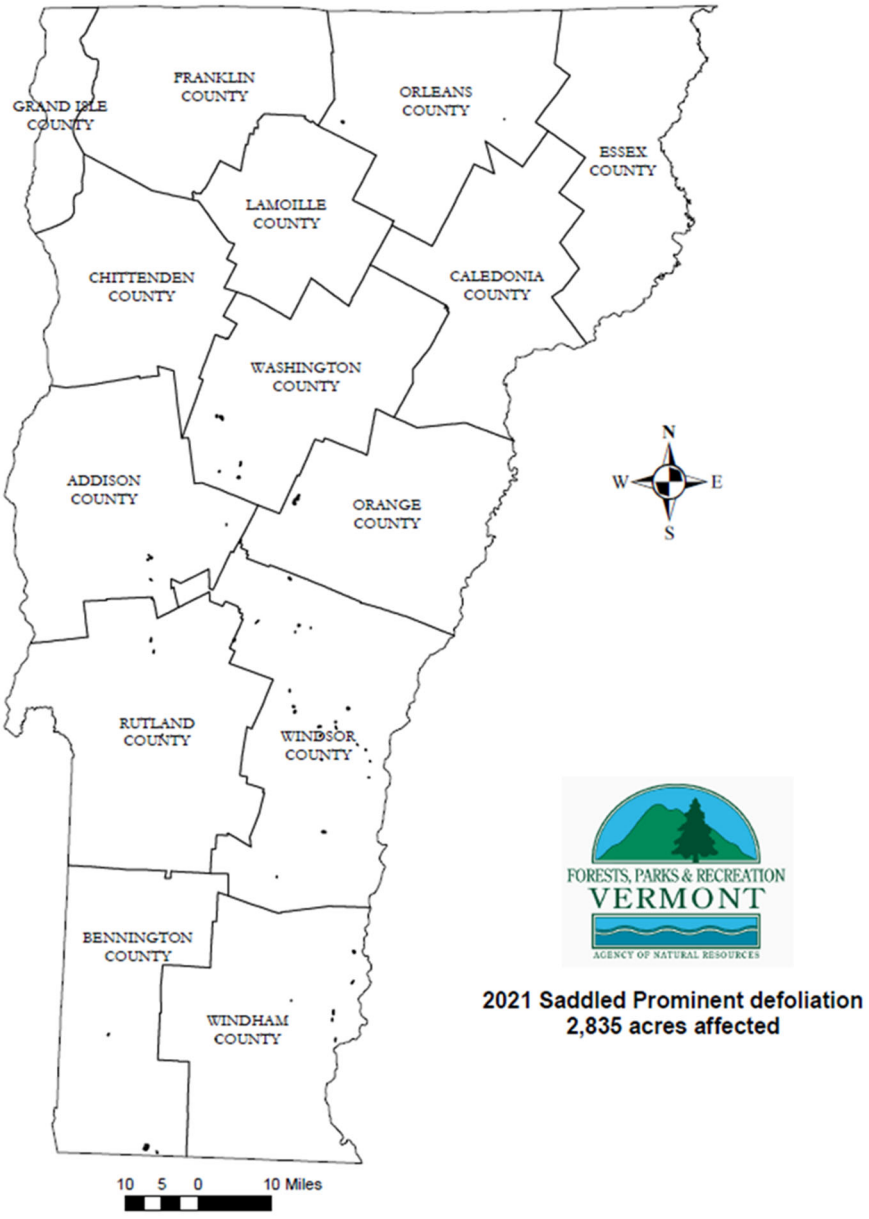


Figure 15. Saddled prominent defoliation 2021. Mapped area includes 2,835 acres affected.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Birch leafmining sawflies	*Messa nana, Fenusa pusilla,* and others.	Birch	Northeastern Vermont	Injury observed by August.
Birch leaffolder	*Ancylis discigerana*	Birch	Northwestern Vermont	
Black headed ash sawfly	*Tethida barda*	Ash	Northeastern Vermont	
Brown angle shades moth	*Phlogophora periculosa*			Observed as bycatch in trap catch.
Brown-tail moth	*Euproctis chrysorrhoea*	Hardwoods		Not observed or known to occur in Vermont.
Bruce spanworm	*Operophtera bruceata*	Hardwoods	Western Vermont	
Butternut woolly worm	*Eriocampa juglandis*	Black walnut	Windham County	
Cecropia moth	*Hyalophora cecropia*		Statewide	
Cherry scallop shell moth	*Hydria prunivorata*	Cherry	Statewide	Occasional nests observed, minimal damage.
Cleft-headed looper	*Biston betularia*	Pin oak	Rutland	
Dark-banded owlet	*Phalaenophana pyramusalis*			Observed as bycatch in trap catch.
Eastern tent caterpillar	*Malacosoma americanum*	Cherry and apple	Widely scattered	Populations remain low.
Elm leaf beetle	*Xanthogaleruca luteola*	Elm	Orleans County	
Eyed baileya moth	*Baileya ophthalmica*			Observed as bycatch in trap catch.
Fall webworm	*Hyphantria cunea*	Hardwoods, especially cherry and ash	Statewide	Remains widely noticeable, including heavy defoliation along roadsides with webbing covering entire trees.
Friendly Proble	*Probole amicaria*			Observed as bycatch in trap catch.
Forest tent caterpillar	*Malacosoma disstria*	Hardwoods	Statewide	*See narrative.*

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Green-striped mapleworm/ rosy maple moth	*Dryocampa rubicunda*	Sugar maple	Statewide	Larvae occasionally observed, often in association with saddled prominent.
LDD moth	*Lymantria dispar*	Hardwoods	Statewide	*See narrative.*
Hackberry leaf miner	*Agromyza spp.*	Hackberry	Windsor	
Hickory tussock moth	*Lophocampa caryae*	Hardwoods	Statewide	
Isabella tiger moth	*Pyrrharctia isabella*	Hardwoods	Statewide	Only light feeding, but overwintering pupae noticeable.
Japanese beetle	*Popillia japonica*	Many	Statewide	Observed in gardens, but tree injury not reported in 2021.
Large maple spanworm moth	*Prochoerodes lineola*			Observed as bycatch in trap catch.
Maple leafcutter moth	*Paraclemensia acerifoliella*	Sugar maple, occasional yellow birch and beech	Statewide	Populations high. *See narrative* .
Maple trumpet skeletonizer moth	*Catastega aceriella*	Sugar maple	Statewide	Occasionally observed, but negligible damage.
Oak shothole leafminer	*Japanagromyza viridula*	Red oak	Statewide	Characteristic feeding damage widely observed in June.
Oblique banded leaf roller	*Choristoneura rosaceana*			Observed as bycatch in trap catch.
Orange-humped mapleworm moth	*Symmerista leucitys*	Maple	Southern Vermont	
Saddled prominent moth	*Heterocampa guttivata*	Sugar maple	Widely scattered; Especially southeastern Vermont	*See narrative.*
Salt and pepper moth	*Syngrapha rectangula*			Observed as bycatch in trap catch.

OTHER HARDWOOD DEFOLIATORS

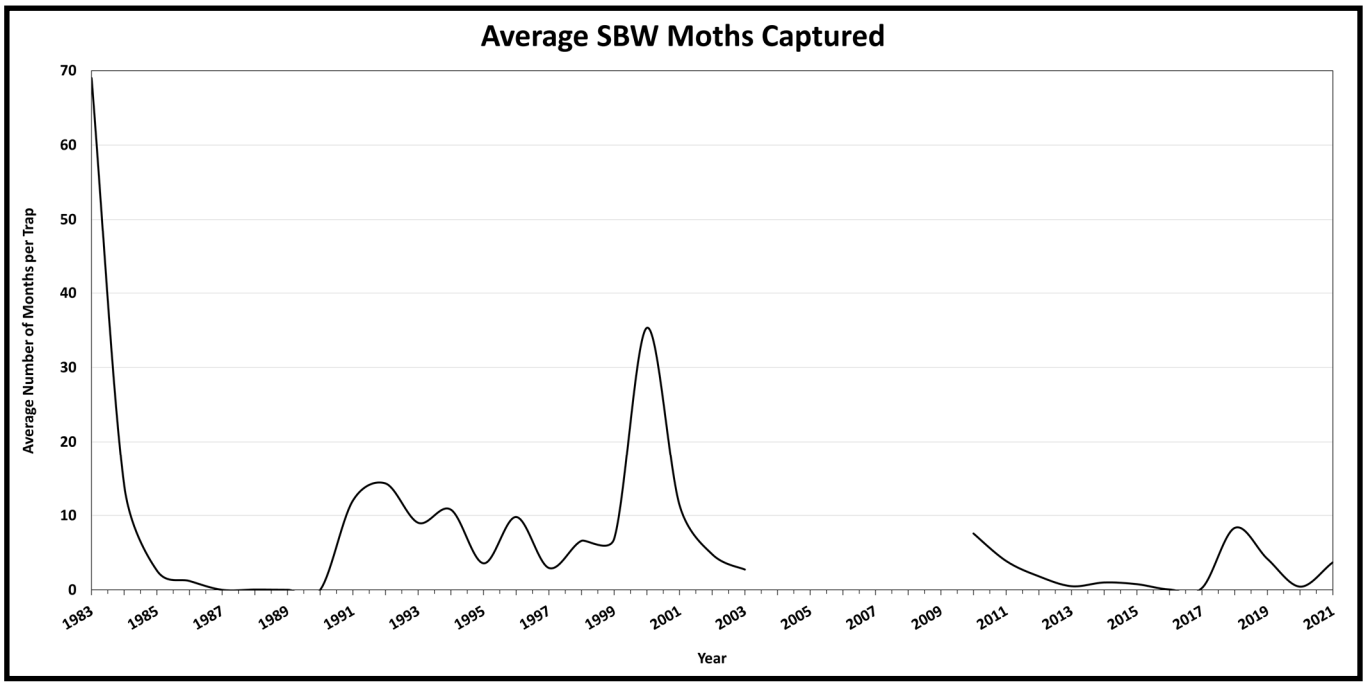
INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Satin moth	*Leucoma salicis*		Castleton	
Spiny oak sawfly	*Periclista albicollis*	Red oak	Northern Vermont	
Spotted sawfly	*Macremphytus lovetti*	Hardwoods	Londenderry	Observed in ornamentals.
Two-lined hooktip	*Drepana bilineata*	Hardwoods		Observed as bycatch in trap catch.
Viburnum leaf beetle	*Pyrrhalta viburni*	cranberrybush viburnum	Essex County	Heavy defoliation on ornamental shrubs.
Winter moth	*Operophtera brumata*	Hardwoods		Not observed or known to occur in Vermont.
White-marked tussock moth	*Orgyia leucostigma*	Hardwoods		
White spring moth	*Lomographa vestaliata*	Cherry, mountain-ash, apple, viburnum		
Variable Zanclognatha	*Zanclognatha laevigata*	Hardwoods		Observed as bycatch in trap catch.

Hardwood defoliators not reported in 2021 include alder flea beetle, *Altica ambiens* ; American dagger moth, *Acronicta americana* ; beech leaftier, *Psilocorsis sp* .; birch skeletonizer moth, *Bucculatrix canadensisella* ; dogwood sawfly, *Macremphytus tarsatus* ; dusky birch sawfly, *Croesus latitarsus* ; elm spanworm moth, *Ennomos subsignaria* ; euonymus caterpillar, *Yponomeuta cagnagella* ; imported willow flea beetle, *Plagiodera versicolora* ; large aspen tortrix, *Choristoneura conflictana* ; large grey dagger moth, *Acronica insita* ; locust leafminer, *Odontata dorsalis* ; maple webworm moth, *Pococera asperatella* ; mountain ash sawfly, *Pristiphora geniculata* ; oak skeletonizer moth, *Bucculatrix ainsliella* ; red-humped oakworm moth, *Symmerista canicosta* ; rose chafer, *Macrodactylus subspinosus* ; splendid dagger moth, *Acronica superans* ; spotted tussock moth, *Lophocampa maculata* ; spring cankerworm, *Paleacrita vernata* ; sycamore tussock moth, *Halysidota harrisii* ; ugly-nest caterpillar, *Archips cerasivoranus* ; willow weevil leafminer, *Isochnus sequensi* ; yellow-necked caterpillar, *Datana ministra* .

SOFTWOOD DEFOLIATORS

Spruce Budworm (SBW), *Choristoneura fumiferana*, are native softwood defoliators commonly found in our Vermont forests. In consecutive years of severe outbreaks, trees may experience complete defoliation which can lead to dieback and mortality of infested hosts. SBW moth trap catches in Vermont increased to an average of 3.70 moths per trap, compared to an average of 0.44 moths per trap in 2020. Traps were deployed in Caledonia, Chittenden, Essex, and Orleans Counties in 2010-2021, with the addition of Victory Basin WMA in Essex county in 2021. Catches increased at all locations. We do anticipate increased populations of SBW in 2022, however current population levels are not predictive of severe defoliation in 2022.

Figure 16. Average number of spruce budworm moths caught in pheromone traps 1983-2021. Trapping was discontinued, 2004-2009. Average of six locations in 2021.



Trap Location	Town	Latitude	Longitude
Steam Mill Brook WMA	Walden	44.474319	-72.191728
Willoughby S.F.	Sutton	44.695500	-72.036084
Tin Shack/Silvio Conte	Lewis	44.859107	-71.742206
Black Turn Brook S. F.	Norton	44.995089	-71.812876
Holland Pond WMA	Holland	44.976260	-71.930960
VMC 1400	Underhill	44.526110	-72.871470
Victory Basin WMA	Victory	44.534370	-71.790850

Table 7. Locations of spruce budworm pheromone traps in 2021. Note: the trap site in Willoughby State Forest is in the town of Sutton rather than Burke, as designated in some earlier reports.

Table 8. Average number of spruce budworm moths caught in pheromone traps, 1998-2021. Trapping had been discontinued from 2004-2009. There were three traps per location, one location per town, in 2021.

County and Town	1999	2000	2001	2002	2003	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Essex Norton	34.7	44.5	26.5	1.3	2.0	5.7	1.0	1.3	0.7	0.0	0.3	0.3	0.3	6.0	1.3	0.0	8.0
Orleans Holland	4.7	29.3	5.0	5.7	3.7	7.3	8.0	1.0	0.7	1.7	1.3	0.0	0.3	9.0	1.0	0.0	5.0
Caledonia Walden	5.0	85.0	16.7	9.7	3.7	6.7	1.0	0.7	0.0	0.3	1.0	0.0	0.0	4.0	3.3	0.3	2.5
Essex Lewis	4.3	14.0	6.7	1.3	1.7	4.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.3	0.0	0.5
Chittenden Underhill	7.3	14.7	7.0	8.5	2.4	19.0	11.3	8.0	1.3	3.7	1.7	0.0	1.0	26.3	18.3	1.7	2.3
Caledonia Sutton	9.3	34.7	32.7	3.3	2.3	4.0	1.7	0.0	0.3	0.3	0.3	0.0	-	2.0	0.7	0.7	2.5
Caledonia Burke	6.0	22.5	15.0	3.0	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Essex Victory	9.3	31.7	8.0	2.7	1.3	-	-	-	-	-	-	-	-	-	-	-	5.0
Orleans Derby	3.3	73.0	13.3	0.0	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Caledonia Hardwick	6.7	93.0	35.7	9.7	3	-	-	-	-	-	-	-	-	-	-	-	-
Orange Orange	0.7	20.0	0.0	3.3	3.0	-	-	-	-	-	-	-	-	-	-	-	-
Orange Newbury	0.3	16.0	0.0	7.0	2.0	-	-	-	-	-	-	-	-	-	-	-	-
Caledonia Wheelock	3.2	53.2	10.8	10.7	2.5	-	-	-	-	-	-	-	-	-	-	-	-
Lamoille Wolcott	5.3	17.2	3.7	0.4	3.2	-	-	-	-	-	-	-	-	-	-	-	-
Lamoille Hyde Park	11.7	25.7	6.3	0.3	4.3	-	-	-	-	-	-	-	-	-	-	-	-
Lamoille Stowe	-	43.0	17.0	12.0	4.7	-	-	-	-	-	-	-	-	-	-	-	-
Washington Cabot	2.0	22.5	14.7	2.3	2.0	-	-	-	-	-	-	-	-	-	-	-	-
Washington Marshfield	-	5.5	5.0	2.0	4.0	-	-	-	-	-	-	-	-	-	-	-	-
Washington Groton	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	**6.9**	**35.3**	**11.4**	**4.9**	**2.7**	**7.6**	**3.9**	**1.8**	**0.5**	**1.0**	**0.8**	**0.1**	**0.3**	**8.3**	**4.2**	**0.4**	**3.7**

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Arborvitae leafminer	*Argyresthia thuiella*	Arborvitae	Northern Vermont	Ornamental.
Eastern spruce budworm	*Choristoneura fumiferana*	Balsam fir and spruce	Statewide	See narrative.
European pine sawfly	*Neodiprion sertifer*	Red pine	Statewide	
Gray spruce looper moth	*Caripeta divisata*			Observed as bycatch in trap catch.
Hemlock looper	*Lambdina fiscellaria*			Observed as bycatch in trap catch.

Softwood defoliators not reported in 2021 included balsam fir sawfly, *Neodiprion abietis* ; introduced pine sawfly, *Diprion similis* ; larch sawfly, *Pristiphora erichsonii* ; pine false webworm, *Acantholyda erythrocephala* ; rusty tussock moth, *Orygia antigua* ; yellow-headed spruce sawfly, *Pikonema alaskensis* ; spruce needleminer, *Taniva albolineana* ; web-spinning sawfly, *Pamphiliidae* ; white pine sawfly, *Neodiprion pinetum* .

SAPSUCKING INSECTS, MIDGES, AND MITES

Balsam Woolly Adelgid (BWA), *Adelges piceae*, populations remain mostly low, with increased public reports in 2021. During 2021 aerial surveys, 589 acres of fir dieback and mortality attributed to BWA were mapped as compared to 942 and 3,434 acres in 2019 and 2018, respectively (Table 9). Due to aerial survey restrictions, we were not able to document tree mortality in 2020 for areas where BWA-initiated mortality was previously reported.

Table 9. Mapped acres of balsam woolly adelgid-related decline 2016-2021. Due to aerial survey restrictions in 2020, no acres were mapped.

County	Acres Mapped					
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Addison	107	0	0	0	X	0
Bennington	69	0	0	17	X	0
Caledonia	1,096	412	807	211	X	79
Chittenden	51	0	0	0	X	0
Essex	736	20	1,082	0	X	336
Franklin	59	0	5	0	X	0
Grand Isle	0	0	0	0	X	0
Lamoille	683	13	188	174	X	15
Orange	1,101	320	322	53	X	0
Orleans	518	399	316	252	X	147
Rutland	240	122	88	0	X	12
Washington	895	279	561	235	X	0
Windham	57	4	9	0	X	0
Windsor	4	72	56	0	X	0
Total	**5,616**	**1,641**	**3,434**	**942**	X	**589**

Hemlock Woolly Adelgid (HWA), *Adelges tsugae*, continues to threaten hemlock trees in southern Vermont, especially in combination with drought and elongate hemlock scale. Traditionally infested sites are still infested, with no observed spread despite low winter mortality and higher population counts.

Only 16 acres of hemlock decline related to HWA was mapped during aerial surveys. In the past, drought was observed to be the primary cause of symptoms on unhealthy hemlock trees in 2019 aerial surveys, a trend that would have likely been observed in 2020 if aerial surveys were conducted.

As of 2021, known infested counties that were surveyed included Windham, Windsor, and Bennington counties. High-risk counties adjoining known infested counties were also surveyed including Rutland and Orange counties. High-risk areas, and plant hardiness zones 5a and 5b, in Windsor County, were also surveyed since Windsor County is only known to be infested at its southernmost edge.

Twenty-three sites in five counties were surveyed (Table 10), with a positive find in Guilford, VT, a site previously known to be infested. The shift to the county-by-county surveying resulted in coarser "resolution" and may account for the fact that no expansion of the infestation was observed.

Table 10. Sites inspected for the presence of hemlock woolly adelgid (HWA) by visual survey, winter 2020-2021.

County	Town	Number of Sites	Positive for HWA
Windsor	Springfield	1	0
Rutland	Danby	1	0
	Fair Haven	1	0
	Hubbardton	1	0
	Mendon	1	0
	Poultney	2	0
	Wallingford	3	0
Orange	Fairlee	1	0
	Thetford	7	0
	Strafford	1	0
	West Fairlee	1	0
Windham	Guilford	1	1
Addison	Bristol	1	0
	East Middlebury	1	0
Total	14 towns	23	1

Fifty-one percent of the hemlock woolly adelgids (HWA) examined during the annual winter mortality survey were dead. Although winter temperatures were only slightly colder than last year, in March we experienced periods of warming temperatures followed by successive days of deep freezes. This temperature fluctuation could have contributed to winter mortality by killing otherwise surviving HWA before they could reproduce. In the past, we have often found infestations in new locations following years with mild winters and low levels of HWA mortality. Currently, HWA is primarily found in Windham County, however, it has also been observed in Springfield and Pownal. 2020 surveys observed the spread of HWA within the state, with a new infestation being identified in Weathersfield. Similar to past years, Vermont, as well as nearby states, continue to find HWA occasionally mixed with elongate hemlock scale.

Table 11. Assessment of hemlock woolly adelgid winter mortality over the 2020-2021 winter. Data from four assessment sites include location, date, number of HWA ovisacs collected, number of HWA that were dead, number of HWA that were alive, and percent mortality.

Site	Date	Total Number	Number Alive	Number Dead	% Mortality
Brattleboro	3/15/2021	1176	594	582	49%
Jamaica	3/15/2021	470	214	256	54%
Townshend	3/15/2021	818	476	342	42%
Vernon	3/15/2021	401	174	227	57%

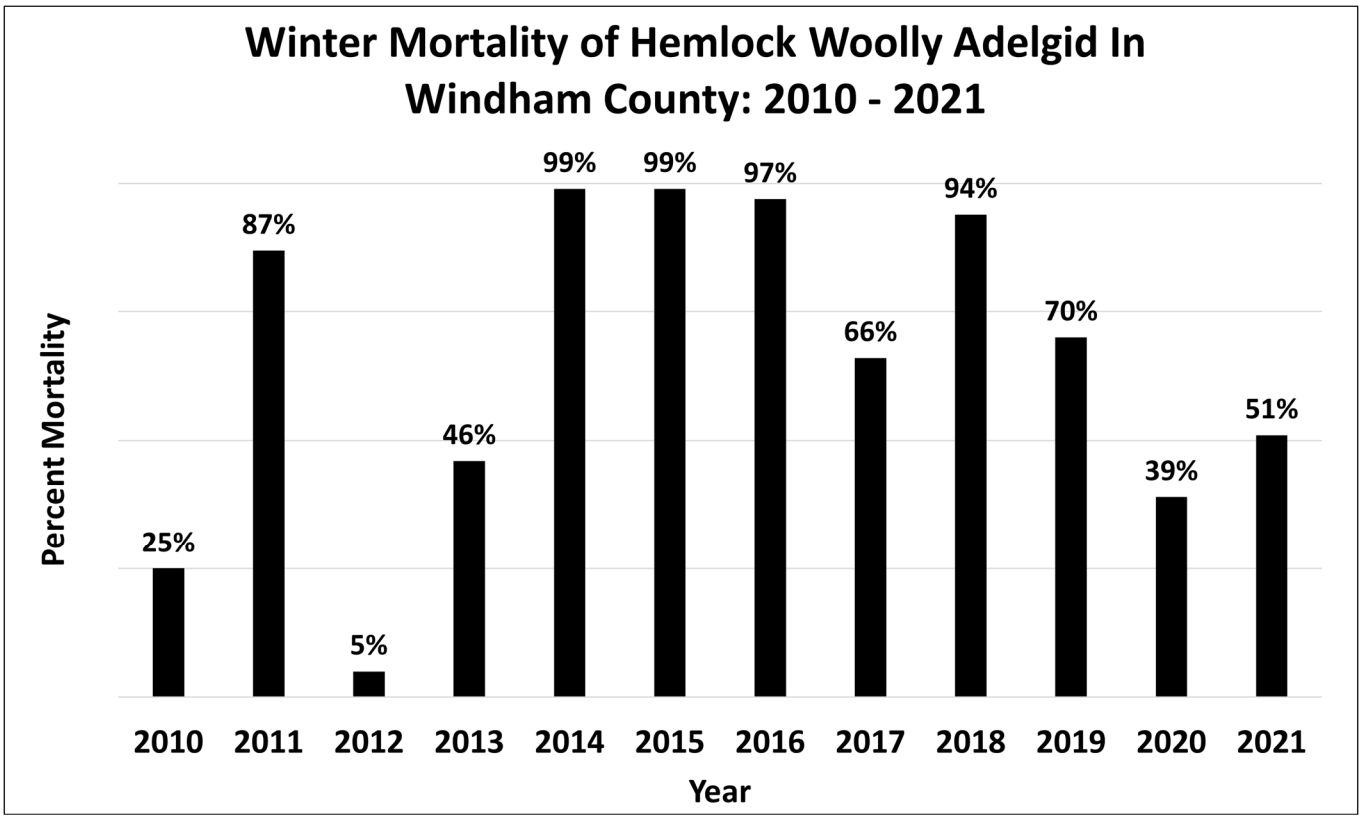


Figure 17. Average overwintering mortality of hemlock woolly adelgid at four sites in Windham County, 2010-2021.

We continue to maintain five HWA impact monitoring plots. In 2021, monitoring assessments were done at the Atherton Meadows Wildlife Management Area and Townshend State Park. Diameters were re-measured, and crowns were assessed for live crown ratio, crown density, crown transparency, and crown position. In general, the crowns seemed to be smaller and thinner than in the previous monitoring.

Biocontrol efforts in 2021 used 1500 wildlings of the predatory beetle *Laricobius nigrinus,* captured from Whidbey Island, WA, and 500 *Laricobius nigrinus* obtained from the rearing laboratory at Virginia Tech, were released at Jamaica State Park this fall. Follow-up monitoring in winter and spring had no recoveries.

Forty-three percent of the hemlock woolly adelgids (HWA) examined during the second annual summer mortality survey were dead. HWA did not break aestivation or the dormancy period that this insect enters during the summer months. The reasons why summer mortality happens are still being researched, but some studies suggest that warming temperatures and excessive sunlight increase mortality. This summer mortality may be supplementing low winter mortality enough to limit the spread of HWA in Vermont, however, more surveys are still needed.

Table 12. Assessment of hemlock woolly adelgid mortality over the 2021 summer. Data from 4 assessment site includes location, date, number of HWA ovisacs collected, number of HWA that were dead, number of HWA that were alive, and percent mortality.

Site	Date	Total Number	Number Alive	Number Dead	% Mortality
Brattleboro	11/16/2021	821	610	211	26%
Jamaica	11/16/2021	1662	935	727	44%
Townshend	11/16/2021	1772	895	877	49%
Vernon	11/16/2021	539	247	292	54%

Pear Thrips, *Taeniothrips inconsequens*, numbers in our long-term monitoring plot at the Proctor Maple Research Center in Underhill were slightly higher in 2021 than in recent years. Sticky trap counts totaled 505, compared to 312 and 455 in 2019 and 2018, respectively. Emergence began the week of April 6. Scattered damage was reported throughout Vermont.

Table 13. Pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, VT in 2021. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.

Sample Dates	Counts
4/6-4/13	149
4/13-4/20	78
4/20-4/27	52
4/27-5/11	127
5/11-5/18	79
5/18-5/25	18
5/25-6/1	2
6/1-6/8	0
Total	505

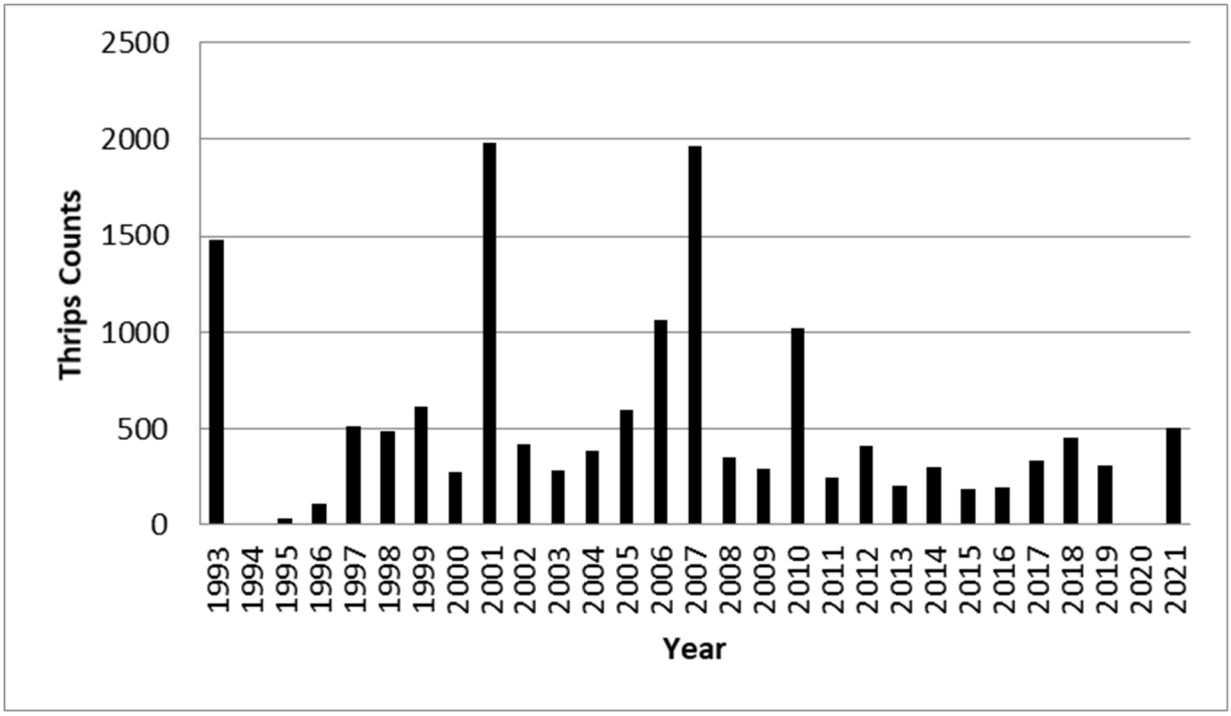


Figure 18. Total number of pear thrips collected at Proctor Maple Research Center in Underhill, VT on sets of four sticky traps, 1993-2021. Data were not collected in 2020 due to COVID-19 restrictions.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Balsam woolly adelgid	*Adelges piceae*	Balsam and Fraser fir	Northern Vermont	See narrative.
Bark lice	*Psocidae spp.*	Poplar	Milton	
Beech blight aphid	*Grylloprociphilus imbricator*	Beech	Bennington county	
Beech erineum mite	*Aceria ferruginea*	Beech	Widely scatttered	
Beech scale	*Cryptococcus fagisuga*	Beech	Widely scatttered	See Beech Bark Disease narrative.
Box elder bug	*Leptocoris trivittatus*	Maple	Widely scatttered	
Eastern spruce gall adelgid	*Adelges abietis*	Spruce	Statewide	Observed on regeneration.
Elongate hemlock scale	*Fiorinia externa*	Hemlock and balsam fir	Southeastern Vermont and Champlain Valley	Co-occurring with HWA in SE VT; isolated area without HWA in Champlain Valley
Erineum mites	*Aceria spp.*	Maples	Northwestern Vermont	
Hemlock woolly adelgid	*Adelges tsugae*	Hemlock		See narrative.
Jumping oak galls	*Neuroterus spp.*	Bur oak	Vergennes	
Pear thrips	*Taeniothrips inconsequens*	Maples and beech	Southern Vermont	See narrative.
Pine bark adelgid	*Pineus strobi*	White pine	Northeastern Vermont	Light population.
Pine needle scale	*Chionaspis pinifoliae*	Hemlock and red pine	Widely scattered	See Red Pine Decline and Mortality Narrative.
Orange tipped leaf footed bug	*Acanthocephala terminalis*		Chittenden	
Red pine scale	*Matsucoccus resinosae*	Red pine	Single report from Orange and Rutland Counties.	Not observed in Vermont since 2015. Also see Red Pine Decline and Mortality.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Spotted lanternfly	*Lycorma delicatula*	Many hosts	Multiple single reports.	No infestations observed in Vermont.
Woolly apple aphid	*Eriosoma lanigerum*	Elm	Rutland	
Woolly elm aphid	*Eriosoma americanum*		Wallingford	
Woolly larch aphid	*Adelges laricis, and A. lariciatus*	Larch	Winooski	

Sapsucking Insects, Midges and Mites that were not reported in 2021 include ash flowergall mite, *Aceria fraxiniflora* ; ash plant bug, *Tropidosteptes amoenus;* balsam gall midge, *Paradiplosis tumifex* ; balsam twig aphid, *Mindarus abietinus;* black treehopper, *Acutalis tartaria* ; cinara aphids, *Cinara* sp.; brown marmorated stink bug, *Halyomorpha halys;* conifer root aphid, *Prociphilus americanus* ; elm cockscomb aphid, *Colopha compressa* ; hickory leaf stem gall aphid, *Phylloxera caryaecaulis;* lacebugs *Tingidae;* leafhoppers, *Cicadellidae* ; oak leaf blister mite, *Aceria triplacis* ; oystershell scale pine, *Lepidosaphes ulmi* ; leaf adelgid, *Pineus pinifoliae* ; pine spittlebug, *Aphrophora parallela* ; spider mite, *Tetranychidae* ; sumac gall aphid, *Melaphis rhois.*

BUD AND SHOOT INSECTS

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

Bud and Shoot Insects not reported in 2021 included balsam shootboring sawfly, *Pleroneura brunneicornis;* common pine shoot beetle, *Tomicus piniperda.*

ROOT INSECTS

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

Root Insects not reported in 2021 included Asiatic garden beetle, *Maladera castanea* ; broadnecked root borer, *Prionus laticollis* ; conifer root aphid, *Prociphilus americanus* ; conifer swift moth, *Korsheltellus gracilis* ; June beetle, *Phyllophaga spp* .; Oriental beetle, *Exomala orientalis* .

BARK AND WOOD INSECTS

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

2021 marked our fifth year of deploying flight intercept/pheromone traps for detection of ALB (Table 14, Figure 19). We deployed eight traps across the state 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 the 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.

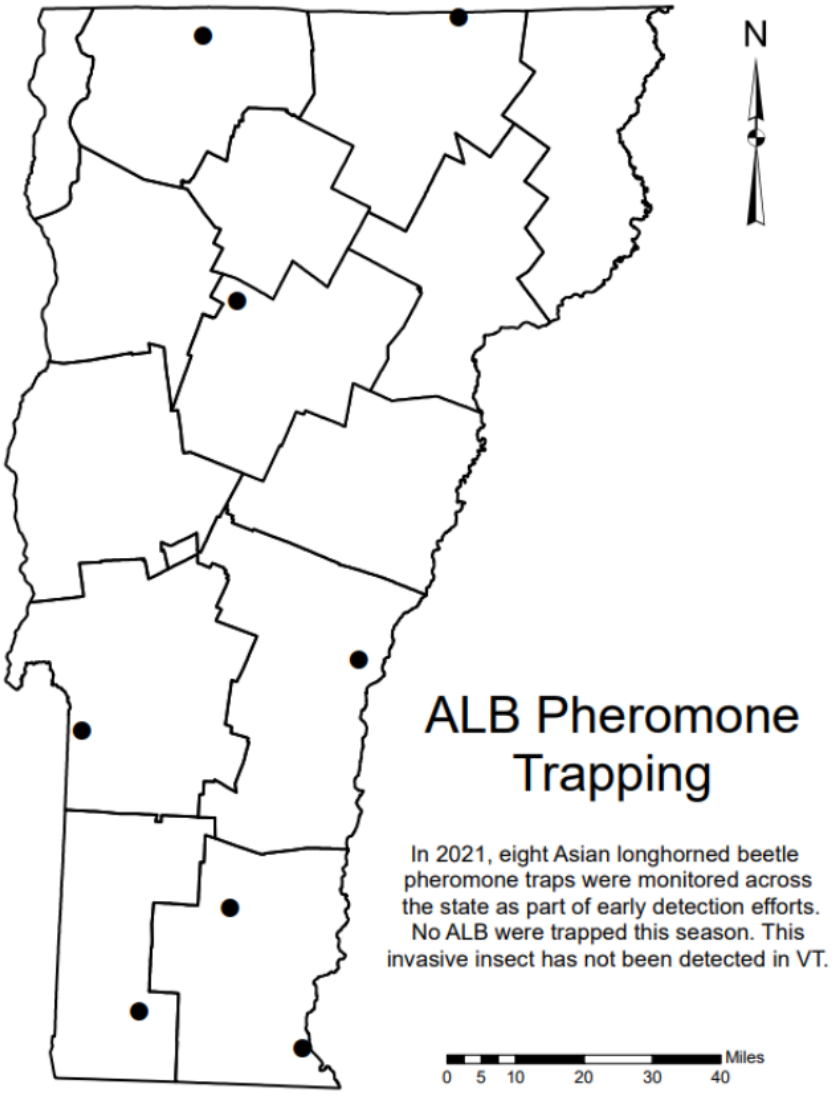


Figure 19. Asian longhorned beetle trap locations in 2021. There was a single trap at each location.

Table 14. Location of Asian longhorned beetle traps deployed in Vermont in 2021. Data include county, town, site, tree species, coordinates, dates of deployment and number of trap checks.

County	Town	Site	Tree Species	Lat	Long	Date Out	Date In	Number of Trap Checks
Windham	Guilford	I-91 Visitor Center	sugar maple	42.81263	-72.566	7/1/2021	9/23/2021	6
Windham	Jamaica	Jamaica State Park	sugar maple	43.10879	-72.7747	7/1/2021	9/23/2021	6
Windsor	Hartford	Quechee State Park	sugar maple	43.63593	-72.4037	7/1/2021	9/23/2021	6
Rutland	Poultney	Lake St. Catherine State Park	sugar maple	43.48074	-73.2069	7/1/2021	9/23/2021	6
Bennington	Bennington	Woodford State Park	sugar maple	42.88771	-73.0363	7/1/2021	9/23/2021	6
Franklin	Franklin	Lake Carmi State Park	red maple	44.95542	-72.8655	7/7/2021	9/20/2021	6
Washington	Waterbury	Little River State Park	sugar maple	44.39394	-72.7613	7/1/2021	9/23/2021	6
Orleans	Derby Line	Derby Line Welcome Center	sugar maple	44.99443	-72.1034	7/1/2021	9/23/2021	6

Emerald Ash Borer (EAB), *Agrilus planipennis*, was first discovered in Vermont in February 2018, and new detections continued in 2021. As a result, EAB has now been confirmed in thirteen counties in the state. We continue to send specimens from new counties to a USDA APHIS identifier, while specimens from new towns within counties known to be infested are confirmed by FPR or VT Agency of Agriculture, Food and Markets' identifiers.

Emerald ash borer was detected in many significant new locations in 2021, including 15 new towns and two new counties. New towns include Belvidere, Berlin, Brookfield, Colchester, East Montpelier, Grand Isle, Hartford, Highgate, Middlebury, North Hero, Rupert, Saint Albans Town, Shaftsbury, Vernon, and Wilmington. New counties with EAB this year include Lamoille and Windsor counties (Table 15). Essex county is currently the only county in the state without a confirmed detection.

Table 15. Locations of new emerald ash borer discoveries in 2021, and towns now considered to be within the EAB infested area because of each detection.

Town	County	State	Towns now included in the Infested Area
Belvidere	Lamoille *	VT	Bakersfield, Belvidere, Berkshire, Cambridge, Eden, Enosburgh, Johnson, Lowell, Montgomery, Richford, Waterville, and Westfield
Berlin	Washington	VT	Roxbury and Brookfield
Brookfield	Orange	VT	Bethel, Braintree, Chelsea, Randolph, Rochester and Tunbridge
Colchester	Chittenden	VT	Colchester, Milton, Shelburne, Burlington, South Burlington, Westford, Winooski, and Essex
East Montpelier	Washington	VT	Moretown, Middlesex, Worcester, Calais, Marshfield, Plainfield, Barre Town, Berlin, Montpelier
Enfield	Grafton	NH	Hartland and Hartford
Grand Isle	Grand Isle	VT	South Hero, Milton, Georgia, St. Albans Town, North Hero
Hartford	Windsor *	VT	Pomfret, Sharon and Thetford
Highgate	Franklin	VT	St. Albans City, Franklin, Fairfax, Fairfield and Fletcher
Hinsdale	Cheshire	NH	Vernon, Guilford, Brattleboro and Dummerston
Middlebury	Addison	VT	Bridport, Goshen, Leicester, Salisbury, Shoreham and Whiting
North Hero	Grand Isle	VT	Grand Isle, Georgia, St. Albans Town, Swanton, Alburg
Plainfield	Sullivan	NH	Windsor, West Windsor, Woodstock, Hartford
Rupert	Bennington	VT	Danby, Pawlet and Wells
Shaftsbury	Bennington	VT	Bennington, Woodford, Glastenbury, Sunderland and Arlington
St. Albans Town	Franklin	VT	St. Albans city, Franklin, Fairfax, Fairfield and Fletcher
Vernon	Windham	VT	Guilford, Brattleboro and Dummerston
Wilmington	Windham	VT	Readsboro, Searsburg, Somerset, Dover, Wardsboro, Newfane, Marlboro, Halifax, Whitingham
Winchester	Cheshire	NH	Vernon, Guilford, Brattleboro and Dummerston

* New County

Maps indicating known EAB-infested areas in Vermont (Figure 20) are posted at vtinvasives.org. The mapped areas indicate the likelihood of EAB based on where it has actually been observed; EAB is not necessarily present throughout the mapped infested areas. By the time the insect is detected, it has already dispersed, so any ash within ten miles of a known EAB location is considered to be at-risk. The infested areas are also available for download on the ANR Atlas http://anrmaps.vermont.gov/websites/anra5/.

EAB inspections continued in Vermont in 2021 and were conducted in response to many landowner or FPR staff requests. Additionally, the Report It! feature at vtinvasives.org allowed users to submit locations, symptoms, and/or photographs of suspect trees. These submissions were reviewed by FPR and Agency of Agriculture, Food and Markets (AAFM) staff and relayed to district Protection staff to investigate. These yielded additional EAB finds in 2021.

Due to the deregulation of the federal quarantine in 2021, USDA APHIS did not conduct any trapping efforts in the state for EAB. However, through the multi-agency Forest Pest Survey and Outreach Program, 50 volunteers were trained to hang and monitor purple prism traps. As a result, 112 traps were deployed in 61 towns throughout the state (Figure 21). Girdled trap tree surveys are the most sensitive technique currently used for the early detection of EAB. In total, 35 ash trees were girdled across 11 Vermont counties. Girdled trap trees were established by state forestry staff and USDA Forest Service staff, on state lands (n = 35) and the Green Mountain National Forest (n =10), respectively (Figure 22). Beginning in early October and completed by December, protection staff felled many girdled trees and peeled back their bark in search of EAB presence or damage (some trees were left to cut in spring 2022). EAB was positively identified in trap trees in Bennington and Swanton.

Over the course of the year, we responded to many observations of possible EAB. These resulted in a follow-up site visit to 22 locations to inspect ash trees (Figure 23).

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

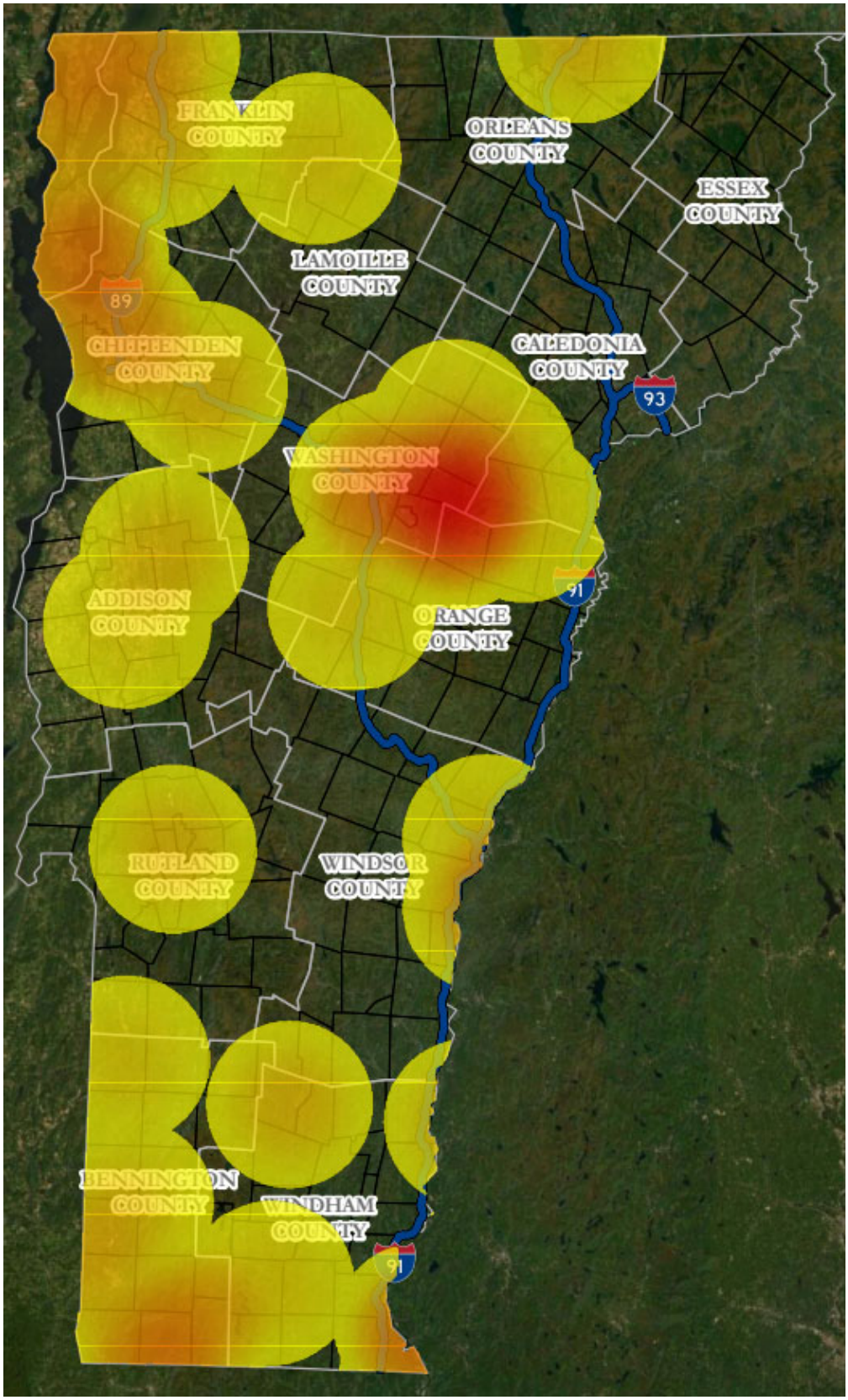


Figure 20. The mapped emerald ash borer infested area in December 2021. For each infested area, the relative EAB infestation severity is represented along a color spectrum. A dark orange infested area indicates a severe infestation and a yellow infested area indicates a less severe infestation. The "confirmed infested areas" are within five miles of these locations. High-risk areas extend five miles from the outside of the confirmed infested areas; EAB is likely expanding into and present in some of these areas. The mapped infested area now includes 145 towns in 13 counties.

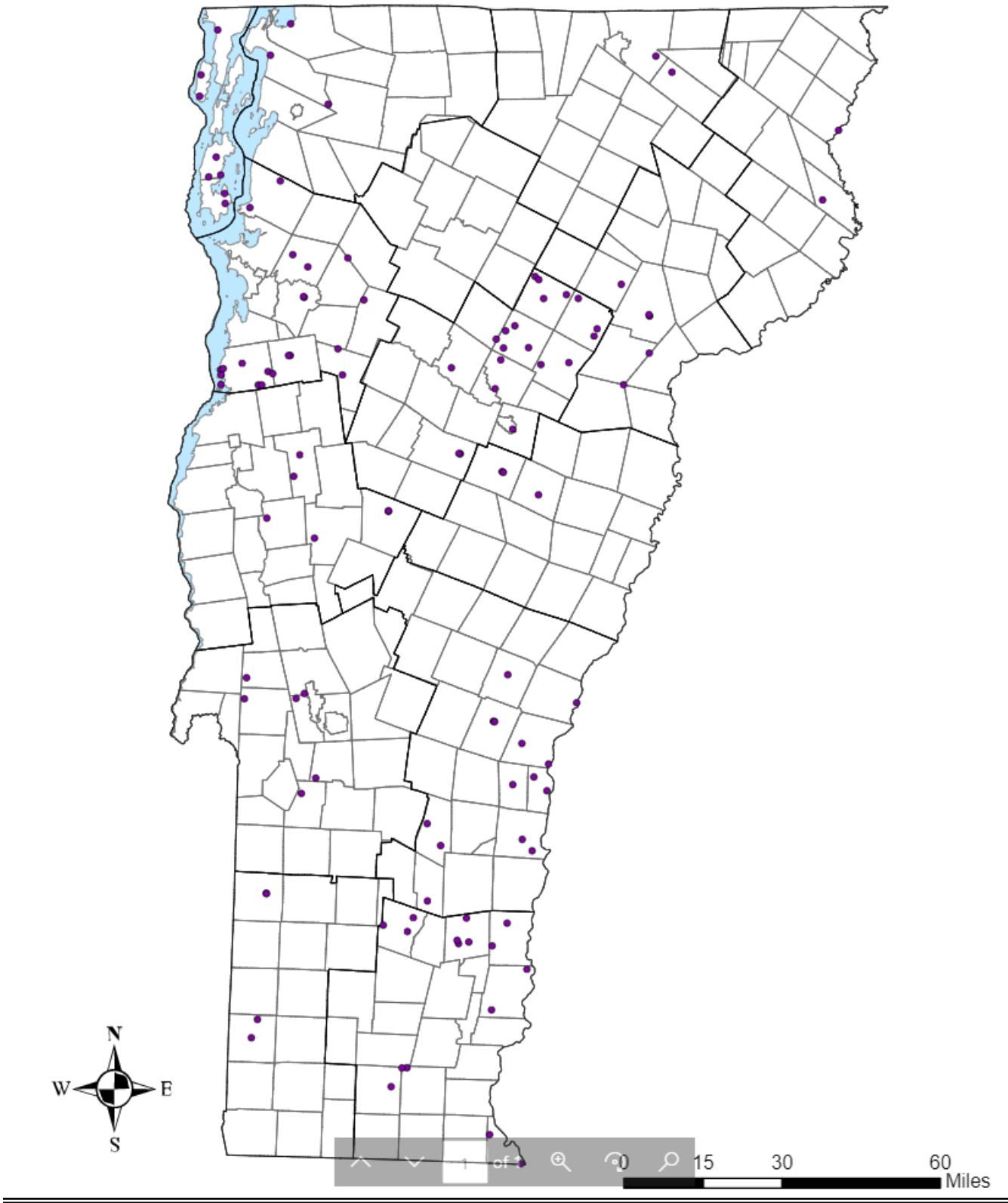


Figure 21. Approximate locations of purple pheromone traps for emerald ash borer, deployed by volunteers, in 2021. At least 112 traps were deployed.

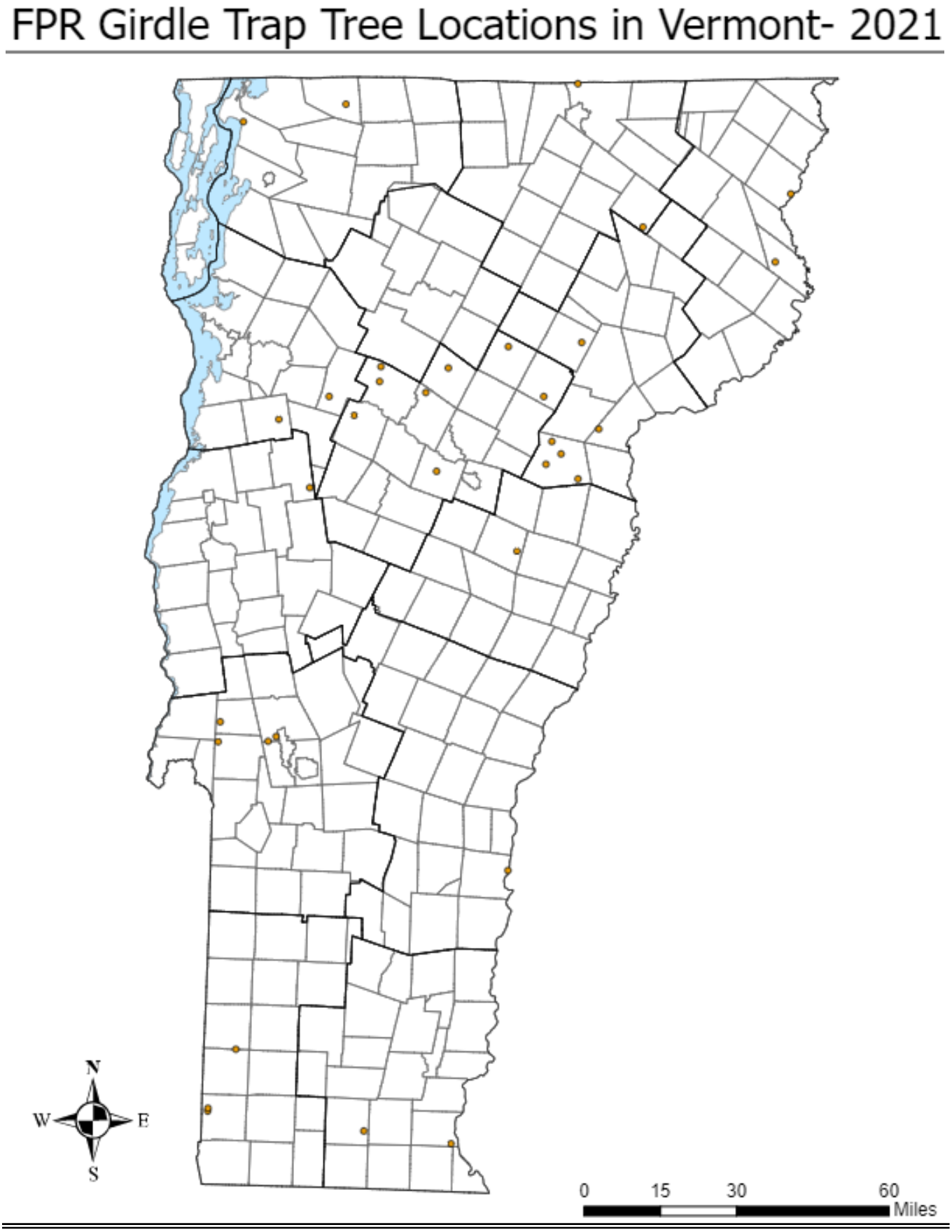


Figure 22. Location of girdled trap trees on state and private lands in Vermont in 2021. A single ash was girdled and later peeled, at each location. Two trees containing EAB were found on state land as a result.

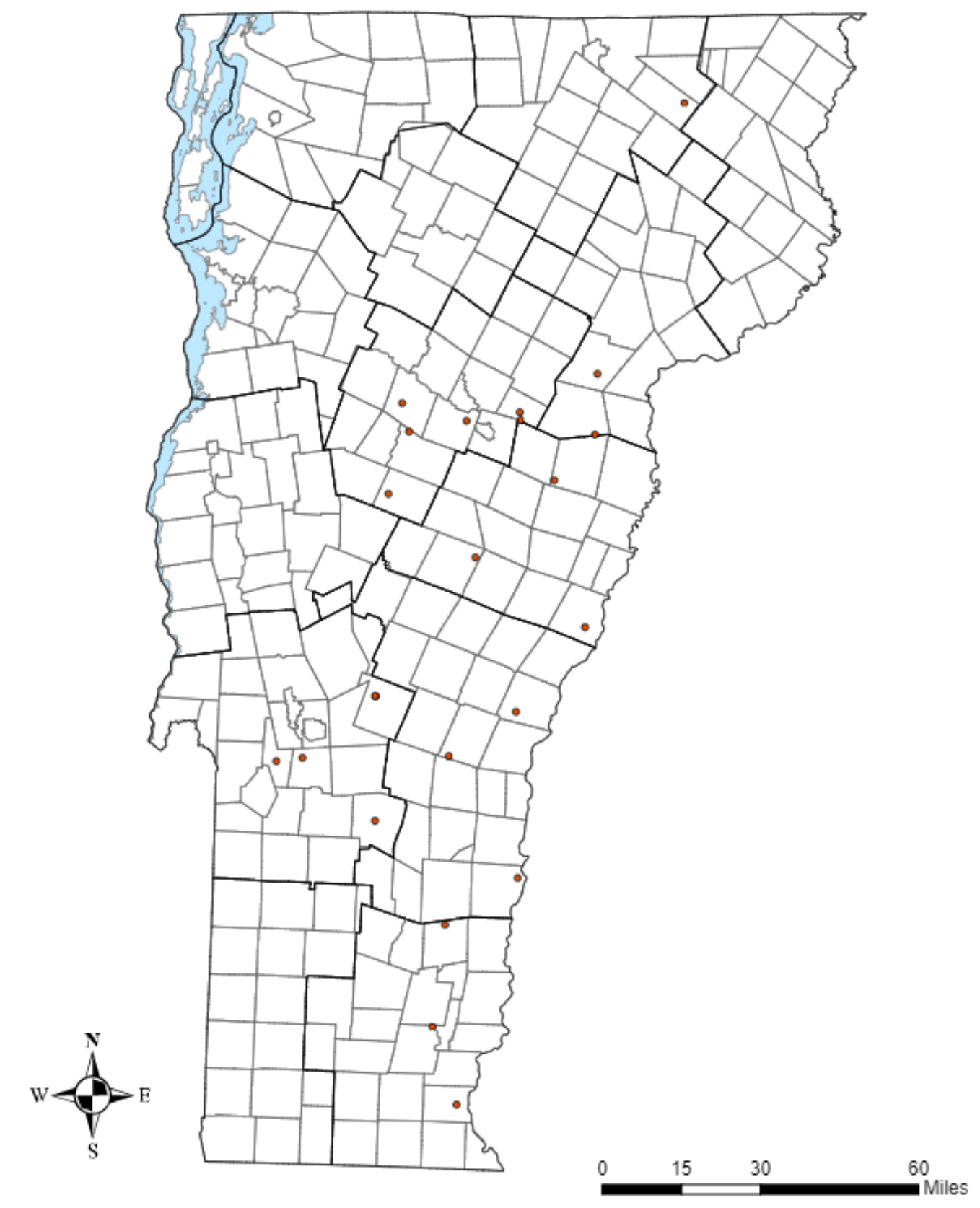


Figure 23. Locations where additional ash tree inspections were made in 2021 as a result of reports from the public or through incidental observations.

The Vermont Forest Pest Outreach Program, implemented by the Urban and Community Forestry Program and UVM Extension with oversight and funding provided through Vermont Agency of Agriculture, Food and Markets (VAAFM), reached 452 people at workshops, presentations, and trainings and an estimated 138,280 people were exposed to forest pest educational material through exhibits, newsletters, radio, and social media messaging.

Hosted webinars on: the status of emerald ash borer in Vermont, a webinar co-hosted with Vermont Land Trust on black ash with speakers from the Abenaki basket making community, University of Maine, and the Saint Regis Mohawk Tribe.

On-line Forest Pest First Detector Training: We created an on-line FPFD course. In addition to providing a safe way to train Forest Pest first Detectors during COVID, the on-line course allows interested people to participate in the program without having to drive long distances and work at a pace that fits their schedules. Twenty-eight people from twenty-six towns participated in the first six-week course. Eleven graduates of the course elected to receive educator kits containing insect specimens, larval gallery bark samples, wallet pest ID cards and other educational materials to use in education efforts in their communities.

Created new forest pest identification cards . Our team designed new wallet-sized pest identification cards with VTinvasives.org branding for emerald ash borer, hemlock woolly adelgid/ elongate hemlock scale and spotted lanternfly.

Purple Trap Program - This program was supported by the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) which supplied the traps, other materials, and staff support. Fifty FPFD volunteers and FPR staff monitored 112 traps in 61 towns and 14 counties. This resulted in confirmed infestations in 7 new locations: Middlebury, Highgate, Swanton, Rupert, Wilmington, Vernon, and Hartford with repeat finds in Alburgh, South Hero, and Shaftsbury.

Targeted social media on forest pests to different recreation groups, including:

- **Adapted and distributed a Don't Move Firewood handout on EAB and holes in trees to people involved in the winter bird count through Facebook**, resulting in **2,912 people reached** and 619 engagements on Facebook
- **Distributed an illustrated article on EAB, HWA and ALB** to 44 recreationist organizations, 4 local television stations, 50 radio stations and over 64 print media outlets. (See attachments for example from one publication)
- **Offered EAB Trailhead Signs to 37 Nordic Ski Centers** (10 accepted)
- **EAB Awareness Week :**

* Provided ash tagging kits and EAB educational materials to 9 new communities that had not received a kit in the past: Braintree, Georgia, Guilford, Huntington, Sharon, Tinmouth, Williamstown, Windsor, and Woodstock), as well as to Grand Isle County communities under the Grand Isle EAB Task Force. Each community had to submit a publicity plan before receiving a kit, and submit photo documentation of their EAB Week activities (see attachments)
* State-wide press release distributed to 4 local television stations, 50 radio stations and over 64 print media outlets
* WCAX Across the Fence segment on why and how municipalities can conduct ash tree inventories (Potential audience of 18,000; 115 YouTube views)

EAB Biocontrol Release—biological control agents were rereleased in the 2020 biocontrol locations in 2021. One release site was located on LR Jones State Forest in Plainfield, the first State Forest in Vermont, as well as the first State Forest, to become infested with EAB, and the second located in the town of South Hero. The first year of releases included *Tetrastichus planipennisi* exclusively, with over 4,300 wasps released at each site. In 2021, all three parasitoids were available for release, and each site received at least 4,000 *T. planipennisi*, 1,100 *Spathius galinae*, and 1,000 *Oobius agrili*.

Recovery efforts will begin in 2022 for T. *planipennisi*, with another year of releases for both *S. galinae* and *O. agrili*. New sites for biocontrol releases in 2022 are being evaluated for suitability and will be submitted to APHIS-PPQ for consideration in the program.

The biocontrol agents, are tiny stingless wasps that parasitize EAB by laying eggs in either EAB eggs or EAB larvae, where they eventually hatch and grow, and ultimately kill the EAB larvae. They are known to target EAB exclusively, and do not parasitize other insects or pose a human health risk. These particular parasitic wasps (or parasitoids) are effective on smaller trees and saplings and have been shown to reduce the number of EAB larvae in young trees by as much as 50%.

The goal of these releases is not to eradicate EAB (which is considered impossible in the U.S. at this point), but to establish a self-sustaining population of the parasitic wasps that will improve ash regeneration and lessen the impact of EAB in infested areas in Vermont.

The **State Parks Firewood Exchange Project** continued for the 13th year. Along with the many COVID-19 induced changes to the 2021 camping season, the protocol was modified to reduce the amount of outside firewood entering Vermont State Parks. In order to slow the spread of invasive pests, campers were encouraged to bring no more than one night's worth of firewood into Vermont State Parks, regardless of the firewood's location of origin. Unless it was certified to have been heat-treated, outside firewood was confiscated, bagged, labeled, and exchanged for heat treated wood as campers began their stays at Vermont State Parks. In the 2021 camping season, **149 bags of firewood were confiscated**, compared to 210 bags of out-of-state wood in 2020 (Table 16).

Table 16. Numbers of bundles of firewood brought into Vermont State Parks from 2009-2021. From 2009-2012, firewood from over 50 miles away was exchanged. From 2013-2019, wood was exchanged if it was brought in from out of state. In 2021, all untreated firewood brought into parks that could not be burned in the first night was exchanged.

Year	Number of Bundles of Firewood
2009	212
2010	379
2011	158
2012	136
2013	148
2014	51
2015	46
2016	64
2017	27
2018	31
2019	10
2020	210
2021	149

Sirex Woodwasp, *Sirex noctilio*, was recovered in one trap deployed as part of the AAFM and USDA APHIS trapping effort for non-native wood-boring insects in 2021. This insect has been trapped in twelve Vermont counties since 2007 (Table 17). No new observations of *Sirex*-infested trees were reported, with the only known location in Jericho.

Table 17. Locations in Vermont where *Sirex noctilio* has been collected by APHIS, AAFM and FPR.

Year	Town	County
2007	Stowe	Lamoille
2010	Burlington	Chittenden
2012	Brattleboro	Windham
2012	Montpelier	Washington
2013	East Burke	Caledonia
2013	Jericho	Chittenden
2013	Randolph	Orange
2013	Swanton	Franklin
2013	Randolph	Orange
2013	Island Pond	Essex
2014	Island Pond	Essex
2014	Swanton	Franklin
2014	Ryegate	Caledonia
2015	Burlington	Chittenden
2016	Rockingham	Windham
2016	Middlebury	Addison
2016	Rutland	Rutland
2017	Burlington	Chittenden
2017	Burlington	Chittenden
2017	Burlington	Chittenden
2017	Rutland	Rutland
2018	Lyndon/Lyndonville	Caledonia
2018	Hardwick	Caledonia
2018	Newport	Orleans
2018	Royalton/South Royalton	Windsor
2018	Lyndon	Caledonia
2020	Randolph	Orange
2021	Chelsea	Orange

Early Detection Rapid Response Survey: In 2021, FPR staff deployed traps for non-native bark and ambrosia beetles. Trap catches were submitted to the Michigan State University for identification. Twelve sites across the state were chosen in locations that were potentially high risk for importing, storing or recycling potentially infested solid wood packing material, dunnage, crating, pallets or other items. Three traps were deployed at each site, using ultra high release (UHR) alpha-pinene, UHR ethanol lure and a three-component exotic *Ips* lure. One trap had only UHR ethanol lure, one trap had UHR alpha-pinene and UHR ethanol lure, and one trap had only three-component exotic *Ips* lure. Lure combination was for the target insects *Hylurgops palliates, Hylurgus ligniperda,* Orthotomicus erosus, *Ips sexdentatus*, *Ips typographus, Tomicus minor, Tomicus piniperda, Trypodendron domesticum, Xyleborus* and *Xylosandrus* spp. Traps were checked every two weeks for a total of four times from May-June, 2021. This survey is currently incomplete and will be completed in April of 2022.

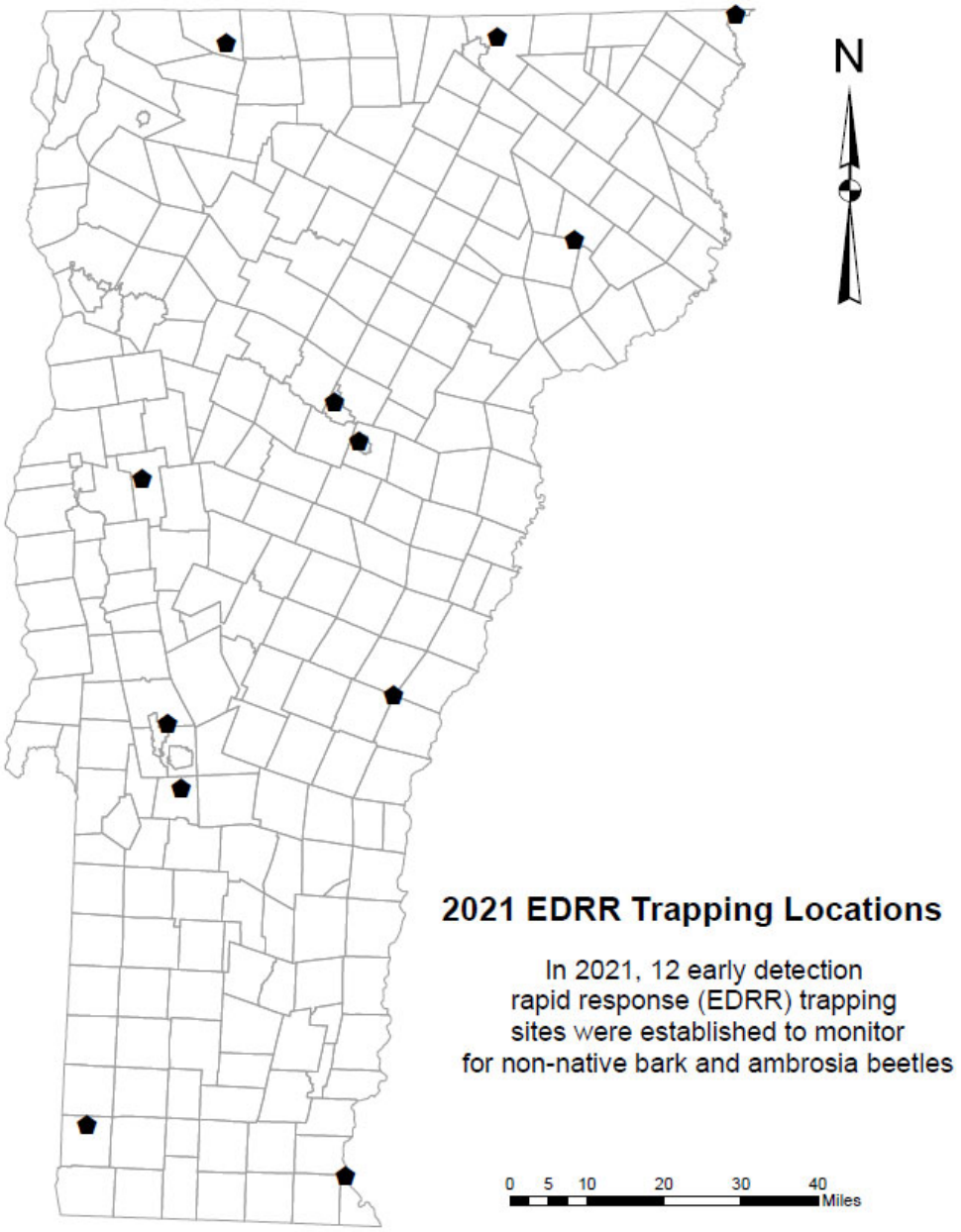


Figure 24. Early detection rapid response (EDRR) trapping locations in 2021. Three traps were monitored at each location.

Table 18: Beetles that were trapped in EDRR pheromone traps. Data include pest scientific name, pest common name (if known), and total count.

Pest Scientific Name	Pest Common Name	Count
Trypodendron lineatum	striped ambrosia beetle	2312
Polygraphus rufipennis	four-eyed spruce bark beetle	1073
Orthotomicus caelatus		1018
Dryocoetes autographus		613
Xylosandrus germanus	black timber bark beetle	384
Gnathotrichus materiarius		350
Anisandrus sayi		249
Dendroctonus valens	red turpentine Beetle	135
Pityogenes hopkinsi	chestnut brown bark beetle	126
Hylastes opacus		113
Ips pini	pine engraver	110
Ips grandicollis	eastern five-spined engraver	101
Hylastes porculus		97
Anisandrus dispar	European shot-hole borer	65
Xyleborinus saxesenii	fruit-tree pinhole borer	62
Dryocoetes affaber		60
Pityokteines sparsus	balsam fir bark beetle	60
Hylesinus criddlei		53
Monarthrum mali		50
Dendroctonus rufipennis		41
Pityophthorus		41
Xyloterinus politus		40
Xyleborus seriatus		31
Hylesinus pruinosus		27
Hylurgopinus rufipes	native elm bark beetle	21
Anisandrus obesus		19
Xyleborinus attenuatus		14
Crypturgus		12
Phloeotribus liminaris	peach bark beetle	11
Dendroctonus simplex	eastern larch beetle	9
Hylurgops pinifex		8
Hypothenemus		7
Monarthrum fasciatum		7
Lymantor decipiens		6
Euwallacea validus		5
Hylurgops rugipennis pinifex		4
Xyleborus xylographus		4
Hylocurus rudis		3
Ips calligraphus		3
Phloeosinus canadensis	cedar bark beetle	3
Hylastes salebrosus		2
Cyclorhipidion pelliculosum		1
Phloeotribus piceae		1
Scolytus multistriatus		1
Xyleborus ferrugineus		1
Xyleborus pubescens		1

Southern pine beetle (SPB), *Dendroctonus frontalis*, was not observed and is not known to occur in Vermont.

2021 marked our first year of deploying flight intercept/pheromone traps for detection of SPB (Table 19, Figure 25). We deployed six traps across the state in locations with suitable host species (e.g., hard pine species). Traps were removed at 60 days and were checked 4 times. No SPB suspects were found. Education and outreach that can prevent movement of infested wood and promote early detection remain priorities.

Table 19. Location of southern pine beetle traps deployed in Vermont in 2021. Data include county, town, site, coordinates, dates of deployment and number of trap checks.

County	Town	Site	Lat	long	Date Out	Date In	Number of Trap Checks
Caledonia	Peacham	New Discovery	44.3244	-72.2802	5/21/2021	7/15/2021	4
Washington	Plainfield	LR Jones	44.22604	-72.3772	5/12/2021	7/7/2021	4
Chittenden	Bolton	Camel's Hump SF – Honey Hollow	44.3657	-72.9102	5/7/2021	7/2/2021	4
Addison	S. Starksboro	Camel's Hump SF – Jerusalem Trail	44.17806	-72.9684	5/7/2021	7/2/2021	4
Chittenden	Essex	Essex area	44.49588	-73.1272	5/7/2021	6/4/2021	2- trap damaged
Windham	Dummerston	Black Mountain Natural Area	42.92222	-72.6047	5/14/2021	7/13/2021	4

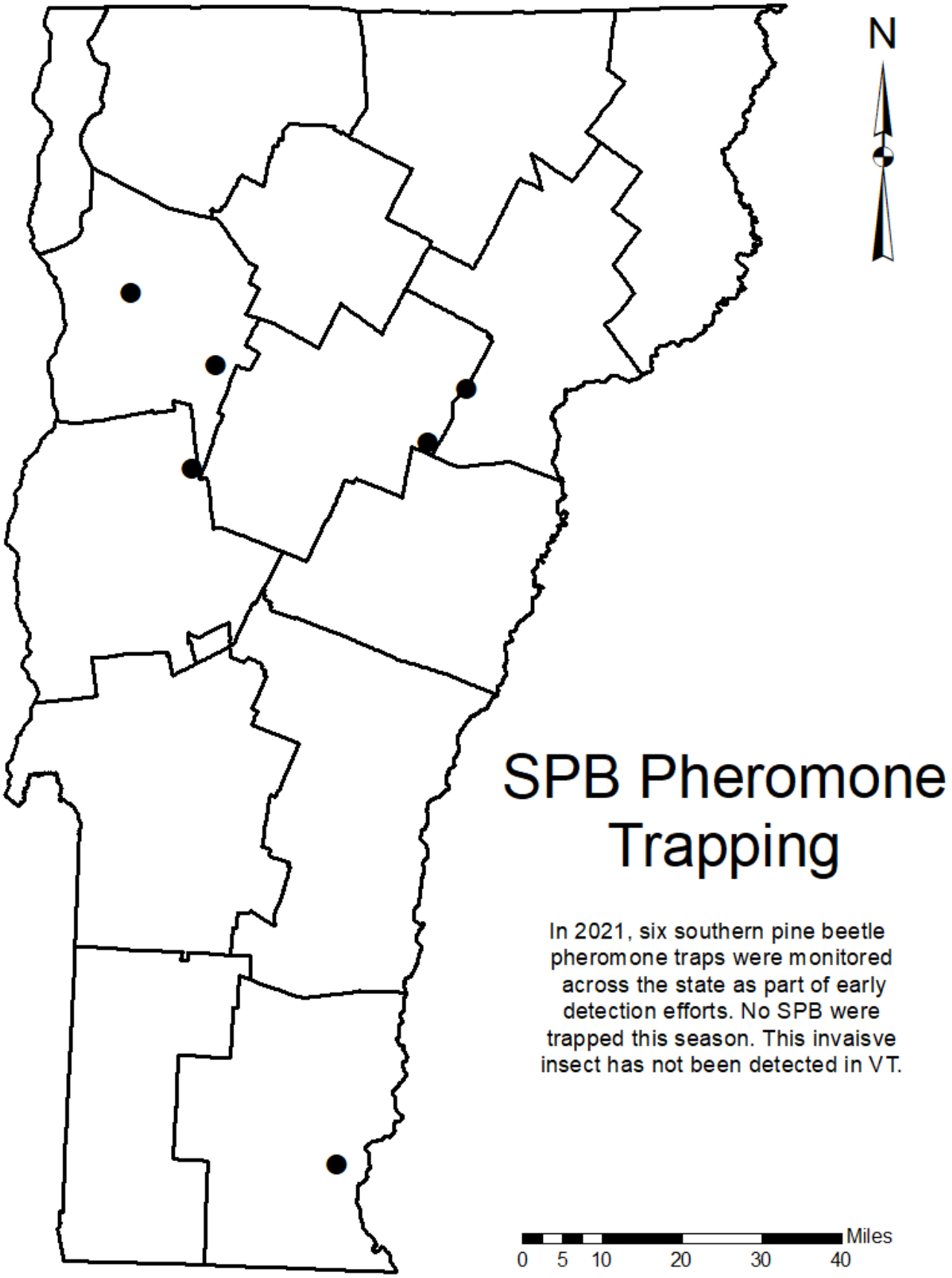


Figure 25. Southern pine beetle trap locations in 2021. There was a single trap at each location.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
	Anisandrus obesus	Beech, poplar, oak		Observed as bycatch in trap catch.
Asian longhorned beetle	*Anoplophora glabripennis*	Various hardwoods		Not observed or known to occur in Vermont.
Native ash borers	*Neoclytus acuminatus, Cerambycidae, Neoclytus caprea*	Ash	Statewide	Ash cerambycid larvae widely observed while following up on EAB suspect trees. Trees involved are usually dead or dying.
Balsam fir bark beetle	*Pityokteines sparsus*	Balsam fir		Observed as bycatch in trap catch.
Big eyed click beetle	*Alaus oculatus*			Mulitple inquiries from people concerned about emerald ash borer.
Black twig borer	*Xyleborus ferrugineus*			Observed as bycatch in trap catch.
Black timber bark beetle	*Xylosandrus germanus*	Various hardwoods and conifers	Known invasive species; unknown distribution in VT	Observed as bycatch in trap catch.
Brown prionid	*Orthosoma brunneum*			Found in household
Cedar bark beetle	*Phloeosinus canadensis*	Arborvitae		Observed as bycatch in trap catch.
Chestnut brown bark beetle	*Pityogenes hopkinsi*	Pines		Observed as bycatch in trap catch.
	Crypturgus	Conifers		Observed as bycatch in trap catch.
	Cyclorhipidion pelliculosum	Maple, oak, alder		Observed as bycatch in trap catch.
	Dryocoetes affaber	Various hardwoods		Observed as bycatch in trap catch.
	Dryocoetes autographus	Spruce, pine, fir, Douglas fir, larch		Observed as bycatch in trap catch.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Eastern ash bark beetle	*Hylesinus aculeatus*	Ash	Scattered statewide	Mulitple inquiries initiated by galleries from people concerned about emerald ash borer.
Eastern five-spined engraver	*Ips grandicollis*	Pines		Observed as bycatch in trap catch.
Eastern larch beetle	*Dendroctonus simplex*	Larch	Northeastern Vermont	Also observed as bycatch in trap catch.
Elm bark beetle	*Hylurgopinus rufipes*	Elm, baswood, ash	Scattered statewide	Also observed as bycatch in trap catch.
Emerald ash borer	*Agrilus planipennis*	Ash	Widely scattered	See narrative.
European elm bark beetle	*Scolytus multistriatus*	Elm and Zelkova	Scattered statewide	Also observed as bycatch in trap catch.
European shot-hole borer	*Anisandrus dispar*	Various hardwoods		Observed as bycatch in trap catch.
	Euwallacea validus	Various hardwoods and conifers		Observed as bycatch in trap catch.
Four-eyed spruce bark beetle	*Polygraphus rufipennis*	Spruce		Observed as bycatch in trap catch.
Fruit-tree pinhole borer	*Xyleborinus saxesenii*	Various hardwoods		Observed as bycatch in trap catch.
	Gnathotrichus materiarius			Observed as bycatch in trap catch.
Hemlock borer	*Phaenops fulvoguttata*	Hemlock	Scattered statewide	Mulitple inquiries from concerned public.
	Hylastes porculus	Pine		Observed as bycatch in trap catch.
	Hylesinus pruinosus	Ash		Observed as bycatch in trap catch.
	Hylastes salebrosus	Pine		Observed as bycatch in trap catch.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Jewel beetle	*Dicerca sp.*	Various hardwoods and conifers		Mulitple inquiries from people concerned about emerald ash borer.
	Lymantor decipiens	Maple, which· hazel, sumac, willows		Observed as bycatch in trap catch.
Golden jewel beetle	*Buprestis striata*	Pines, hemlocks		Mulitple inquiries from people concerned about emerald ash borer.
	Hylastes opacus	Conifers		Observed as bycatch in trap catch.
	Hylocurus rudis	Hardwoods		Observed as bycatch in trap catch.
	Hylurgops pinifex	Spruce, pine, larch		Observed as bycatch in trap catch.
	Hylurgops rugipennis pinifex	conifers		Observed as bycatch in trap catch.
	Hypothenemus			Observed as bycatch in trap catch.
Japanese cedar longhorned	*Callidiellum rufipenne*	Arborvitae and other		Not observed or known to occur in Vermont.
	Monarthrum fasciatum	Various hardwoods, Pines		Observed as bycatch in trap catch.
	Monarthrum mali	Conifers		Observed as bycatch in trap catch.
Northeastern sawyer	*Monochamus notatus*	Conifers	Widely scattered	Mulitple inquiries from people concerned about Asian longhorned beetle.
	Orthotomicus caelatus	Pine, spruce, larch		Observed as bycatch in trap catch.
Peach bark beetle	*Phloeotribus liminaris*	Peach, cherry		Observed as bycatch in trap catch.
	Phloeotribus piceae	Spruce		Observed as bycatch in trap catch.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Pigeon tremex	*Tremex columba*	Maple and various hardwoods		
Pine engraver	*Ips pini*	Pines		Observed as bycatch in trap catch.
Red headed ash borer	*Neoclytus acuminatus*	Ash and various harwoods		Mulitple inquiries initiated by galleries from people concerned about emerald
Red shouldered pine borer	*Stictoleptura canadensis*	Various hardwoods and conifers		Household
Red turpentine beetle	*Dendroctonus valens*	Fir, spruce and pine		Observed as bycatch in trap catch.
Six-banded longhorned beetle	*Dryobius sexnotatus*			
Six-spined ips	*Ips calligraphus*	Conifers		Observed as bycatch in trap catch.
Striped ambrosia beetle	*Trypodendron lineatum*	Conifers		Observed as bycatch in trap catch.
Southern pine beetle	*Dendroctonus frontalis*	Pine		Not observed or known to occur in Vermont.
Spruce beetle	*Dendroctonus rufipennis*	Spruce		Observed as bycatch in trap catch.
Sugar maple borer	*Glycobius speciosus*	Sugar maple	Scattered throughout	Stand-level damage occasionally significant.
Turpentine beetles	*Dendroctonus* spp.	White pine	Scattered throughout	Observed in stands stressed by white pine needle diseases.
	Pityophthorus			Observed as bycatch in trap catch.
Whitespotted Sawyer	*Monochamus scutellatus*	White pine and other conifers	Throughout	We continue to receive adults submitted as Asian longhorned beetle suspects.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
	Xyleborinus attenuatus	Alder, birch, oak, willow, basswood		Observed as bycatch in trap catch.
	Xyloterinus politus			Observed as bycatch in trap catch.
	Xyleborus pubescens	Pine		Observed as bycatch in trap catch.
	Xyleborus seriatus			Observed as bycatch in trap catch.
	Xyleborus xylographus			Observed as bycatch in trap catch.

Other Bark and Wood Insects not reported in 2021 included ant-like longhorn, *Cyrtophorus verrucosus* ; bronze birch borer, *Agrilus anxius* ; brown spruce longhorned beetle, *Tetropium fuscum* ; carpenterworm, *Prionoxystus robiniae* ; locust borer, *Megacyllene robiniae* ; round-headed apple tree borer, *Saperda candida* .

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Western conifer seed bug	*Leptoglossus occidentalis*		Williston	

Fruit, Nut and Flower Insects not reported in 2021 included acorn plum gall wasp, *Amphibolips prunus* ; Asiatic garden beetle, *Autoserica castanea* ; butternut curculio, *Conotrachelus juglandis;* fir coneworm*, Dioryctria abietivorella;* pine coneworm, *Dioryctria reniculelloides;* pip gall wasp, *Callirhytis operator* ; plum curculio, *Conotrachelus nenuphar.*

STEM DISEASES

Dieback from **beech bark disease,** caused by *Cryptococcus fagisuga* and *Nectria coccinea* var. *fagina-ta*, was mapped on 21,093 acres in 2021 (Table 20, Figure 26), an increase from the 15,073 acres mapped in 2019. Due to COVID restrictions, aerial surveys were not conducted in 2020.

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

Table 20: Mapped acres of beech bark disease in 2021.

County	Acres
Addison	3456
Bennington	873
Caledonia	157
Chittenden	1402
Essex	2311
Franklin	765
Grand Isle	0
Lamoille	1852
Orange	506
Orleans	1036
Rutland	1472
Washington	2829
Windham	2891
Windsor	3097
Total	21,093

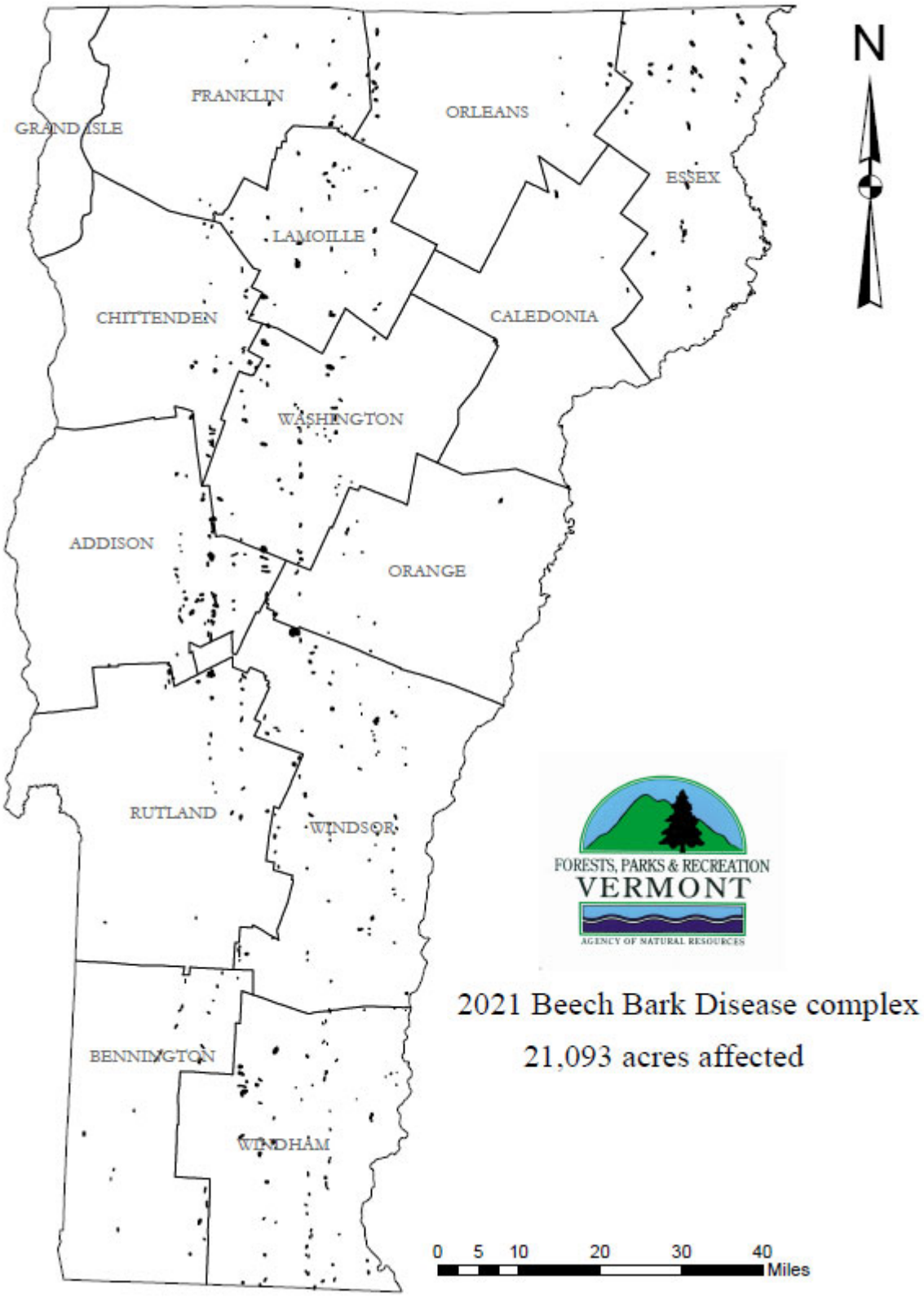


Figure 26. Beech bark disease related decline and mortality mapped in 2021. Mapped area includes 21,093 acres.

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

This pathogen has currently been reported in 22 states, with the most recent being in New York in 2008. Due to recent detections in New York State, Vermont and nearby states are participating in a regional effort to monitor for this pathogen. In Vermont, the primary detection method is outreach, with an estimated 3,300 contacts through newsletters and social media and 420 contacts through workshops in 2020. As a result of this effort, four oak wilt suspects were reported in 2021, however, symptoms were not consistent with oak wilt symptoms, so no samples were sent to Cornell for lab testing.

OTHER STEM DISEASES

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

OTHER STEM DISEASES

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

Other Stem Diseases not reported in 2021 included American mistletoe, *Phoradendron leucarpum* ; Coryneum twig bight, *Coryneum spp.;* chestnut blight, *Cryphonectria parasitica* ; crown gall rust, *Puccinia coronata* ; cytospora canker, *Leucostoma kunzei* ; eastern dwarf mistletoe, *Arceuthobium pusillum* ; fireblight, *Erwinia amylovora* ; sapstreak, *Ceratocystis coerulescens* ; scleroderris canker, *Ascocalyx abietina;* verticillium wilt, *Verticillium albo-atrum;* woodgate gall rust, *Endocronartium harknessii;* yellow witches broom rust, *Melampsorella caryophyllacearum.*

FOLIAGE DISEASES

Eight long-term **Beech Leaf Disease** (BLD) monitoring sites were established across the state in 2021 as part of a regional monitoring effort coordinated by the USDA – Forest Service. No BLD was detected in any of these sites. BLD affects both American and European beech trees and causes leaf deformation, dieback, and mortality of infested hosts. The causal agent of BLD is an introduced nematode from Japan, *Litylenchus crenatae mccannii.* This pest can affect all ages and sizes of beech, being most deadly to saplings and understory beech. This pest has currently been reported in 7 states and Ontario, Canada. The most recent reports are in Maine (2021), Massachusetts (2020), and Rhode Island (2020). This pest has currently not been observed in Vermont. Data collected from asymptomatic sites in Vermont are critical to serve as a baseline to track disease severity and progression if, and when, BLD becomes established in the state.

Maple Anthracnose (causal agents *Auerobasidium apocryptum, Discula campestris,* and *Colleto-trichum* gleosporoides) reports increased throughout the growing season due to persistent late-season rainfall. Reports came from Addison, Caledonia, Franklin, Rutland, Washington, and Windsor counties. Although present throughout most of the state, aerial detection surveys did not detect damage in all counties (Figure 27). This is most likely due to the timing and prevalence of MLC on the landscape, which may have masked symptoms otherwise visible from the air.

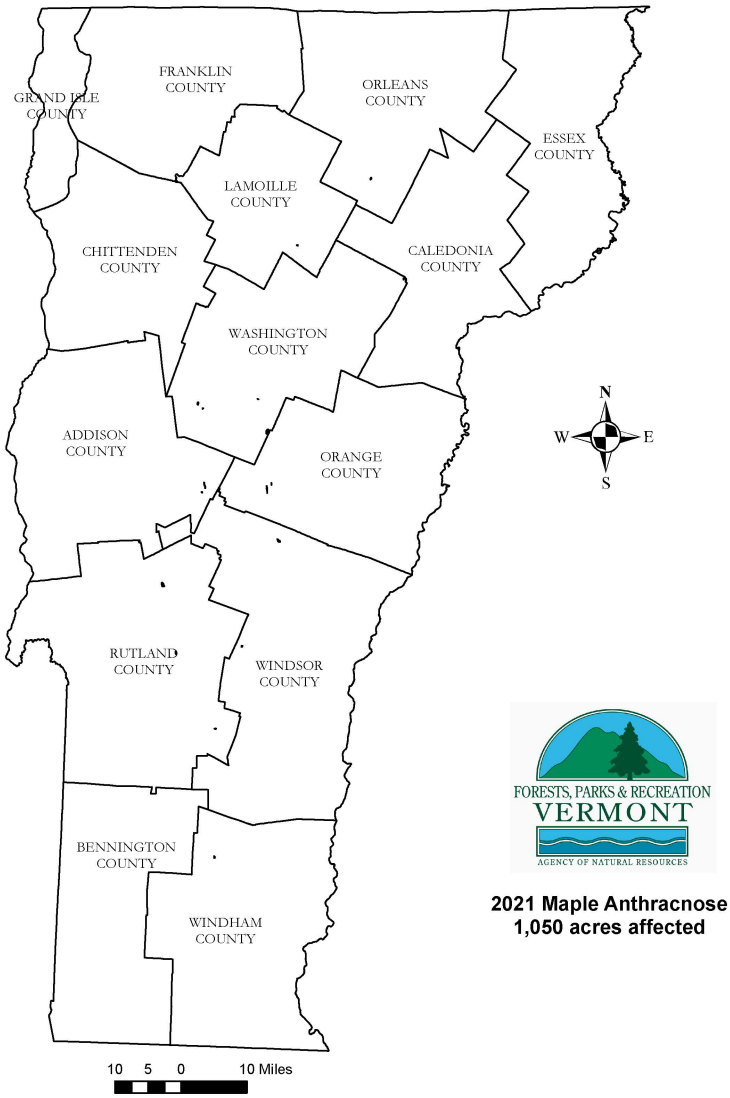


Figure 27. Areas damaged by maple anthracnose affected 1,050 acres in the state in 2021.

White pine needle damage (WPND) is a fungal complex of four different foliar pathogens, *Bifusella linearis*, *Lecanosticta acicola*, *Lophophacidium dooksii*, and *Septorioides strobi*, that have been associated with both needle cast and needle blight on eastern white pine trees throughout Vermont. Although this is an increasingly damaging complex, individually these pathogens are not documented as causal agents of large-scale defoliation. Infected trees have been observed having chlorosis (yellowing) and necrosis (browning) of 1-year-old needles, with heavy infections having defoliation and dieback (Figure 28). Decline and mortality of white pine have been observed in stands that have had multiple years of needle damage where other stress factors are also present such as wet site conditions, wind impact, or wounding. Weak pests and pathogens, such as turpentine beetles, Caliciopsis canker, and Armillaria root rot have been observed in some stressed stands.

The expression of WPND is linked to the amount of humidity and moisture from the previous spring (e.g., 2021 damage is influenced by 2020 weather). Spore production typically peaks in June during shoot elongation. WPND accounted for 2,683 acres of observable damage on white pine trees throughout the state in 2021 (Figure 29). Severity of symptoms in 2021 was similar to 2020, with those trees initially identified as unhealthy continuing to express greater chlorosis and defoliation (Figures 30 and 31). We expect WPND to be present again in 2022, but to be less severe than in recent years due to the dry spring in 2021.

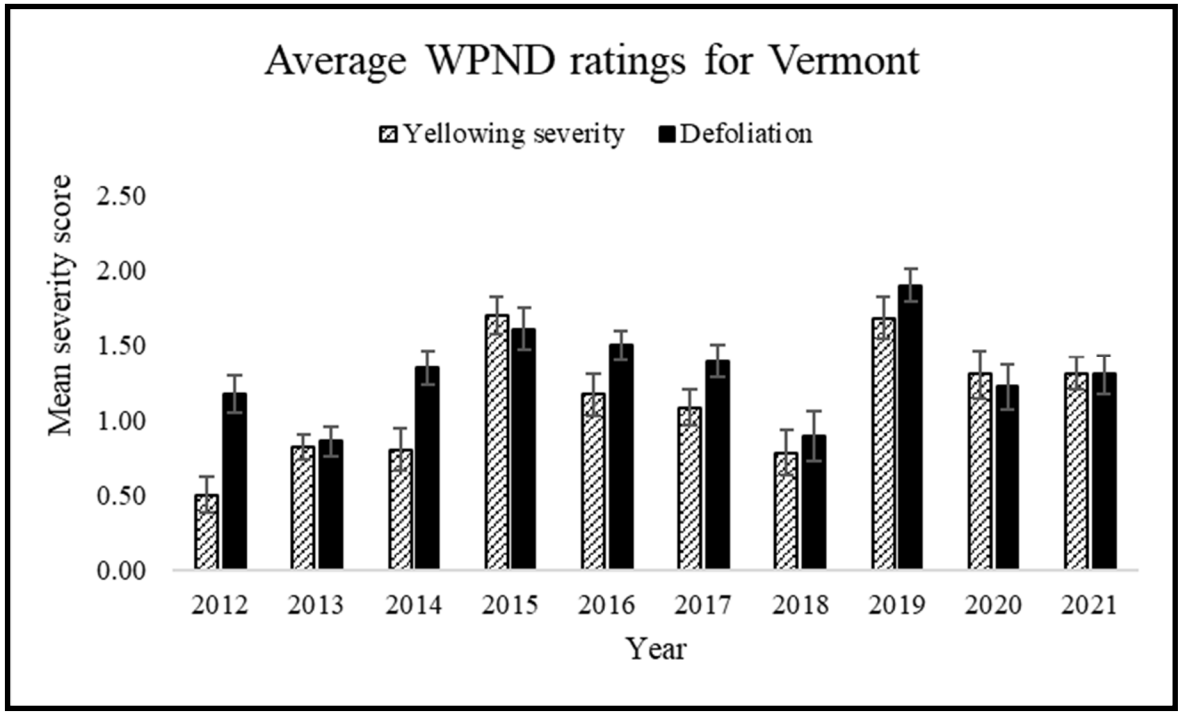


Figure 28. Mean chlorosis (yellowing) and defoliation of white pine trees from four plots (n = 50) in Vermont. Mean severity score indicates what portion of the crown is impacted (1 = 1/3, 2 = 2/3, 3 = entire crown).

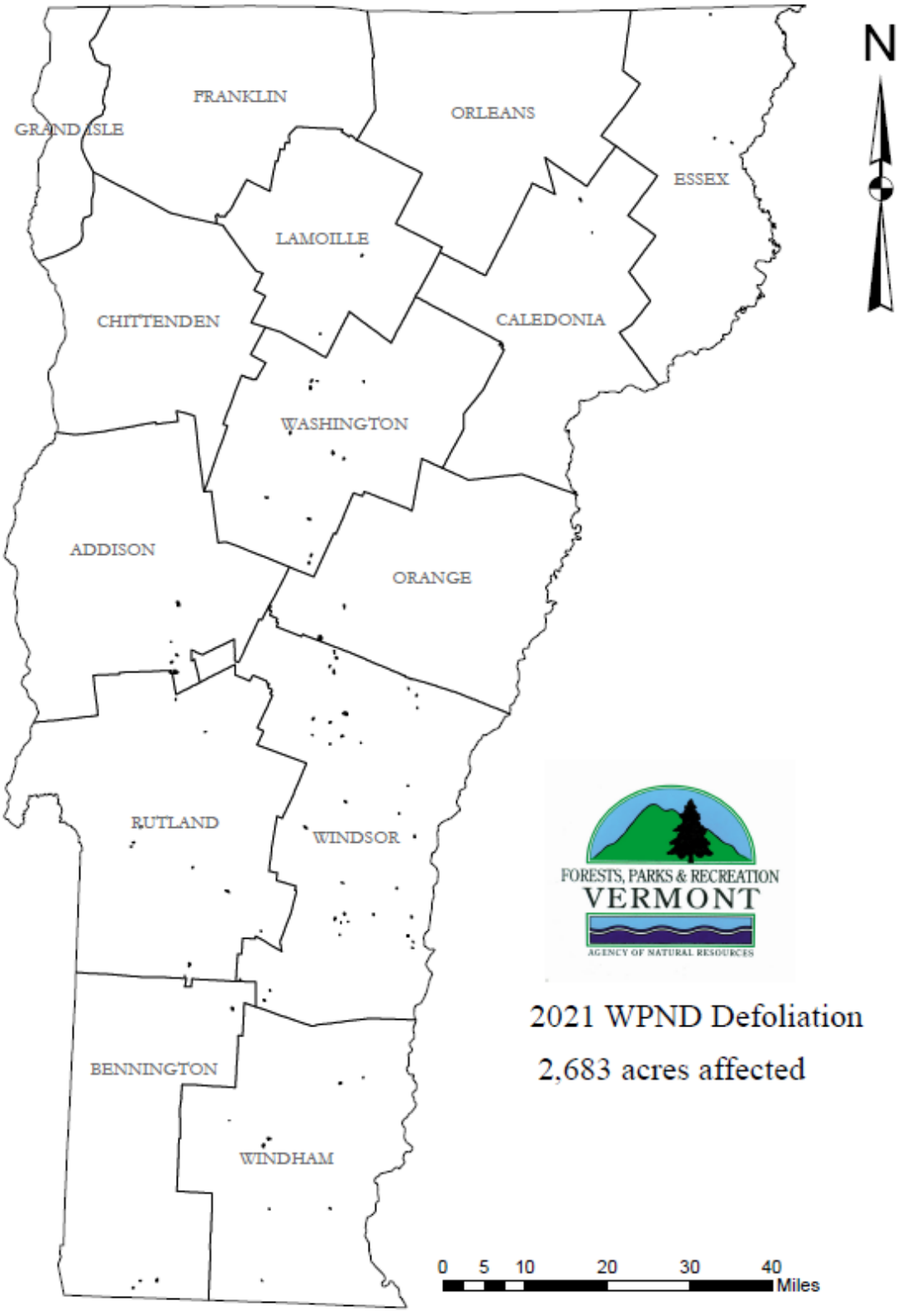


Figure 29. Defoliation caused by white pine needle diseases (WPND) affected 2,683 acres in the state in 2021.

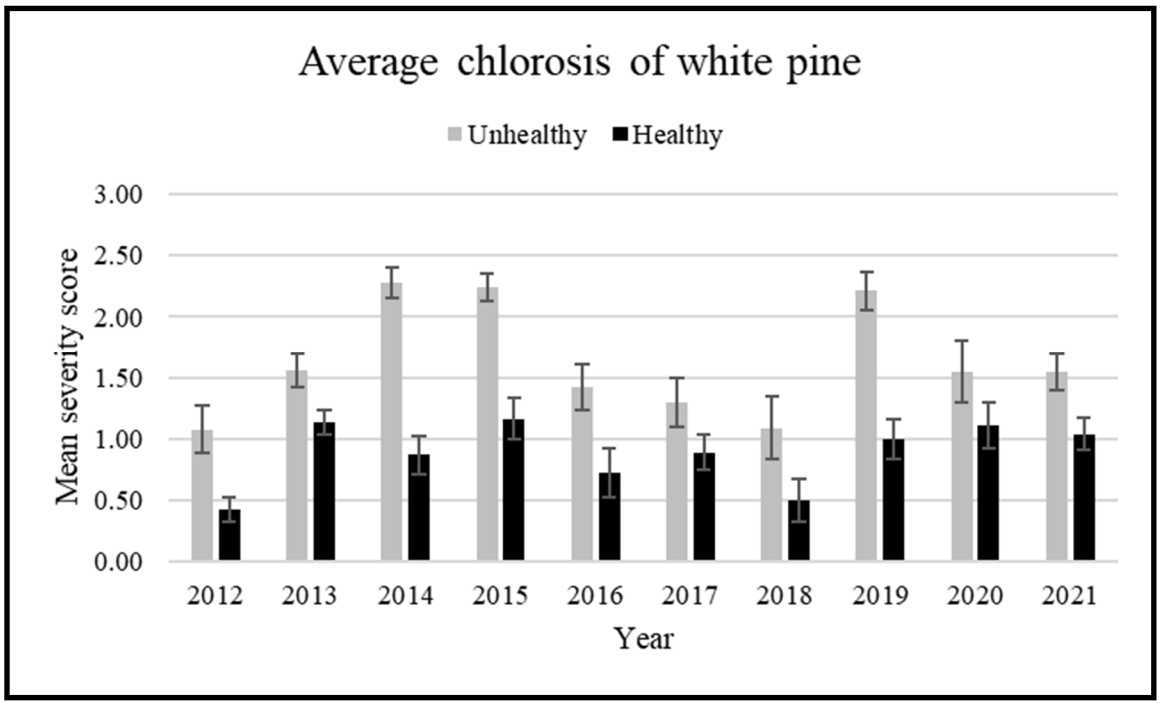


Figure 30. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed between 2012-2021 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

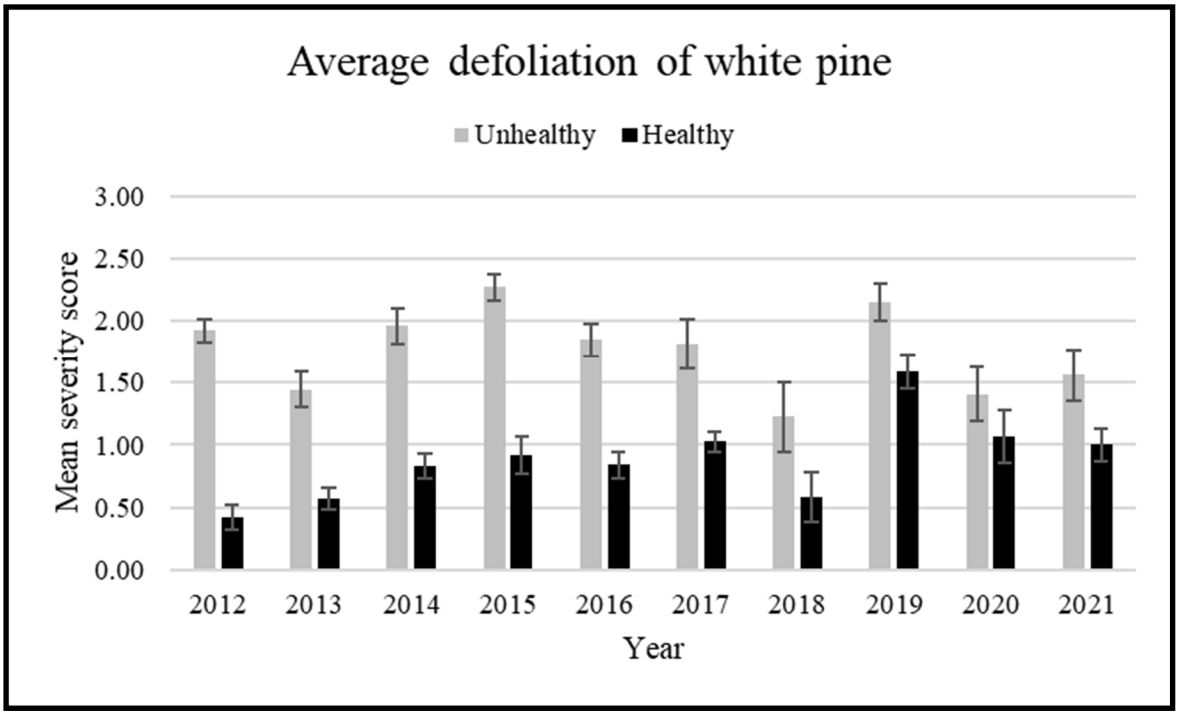


Figure 31. Defoliation severity of unhealthy and healthy white pines surveyed between 2012-2021 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Anthracnose	*Aureobasidium apocryptum; Discula campestris; Colletotrichum gleosporoides; Apiognomonia errabunda Gnomonia ulmea*	Maple, oak, elm	Statewide	Increase from recent years.
Apple scab	*Venturia inaequalis*	Apple	Statewide	
Balsam fir needlecast	*Lirula sp.*	Balsam fir	Statewide	Commonly observed on ornamental and christmas tree plantings.
Birch leaf fungus	*Septoria betulae*	Birch	Statewide	
Brown spot needle blight	*Lecanosticta acicola*	Pines	Statewide	Thin crowns, some decline, and heavy early needle drop. Smilar to 2020 levels. See needle diseases of white pine.
Cedar apple rust	*Gymnosporangium juniperi-virginianae*	Apple	Statewide	
Diplodia shoot blight	*Diplodia pinea*	Red pine	Statewide	See Red Pine Decline and Mortality and Stem Diseases Other.
Giant tar spot	*Rhytisma acerinum*	Norway maple	Statewide	Similar to 2019 levels, but still mostly light damage.
Oat crown rust	*Puccinia coronata*	buckthorn	Burlington, VT	
Peach leaf curl	*Taphrina deformans*	peach	Springfield, VT	
Rhizosphaera needlecast	*Rhizosphaera kalkhoffi*	Many	Statewide	Mortality of ornamental blue and white spruce continues due to heavy defoliation in the past.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Sirococcus tip blight	*Sirococcus tsugae*	Red pine	Peachem, VT	See Red Pine Decline and Mortality and Stem Diseases Other.
Speckled tar spot	*Rhytisma punctatum*	Maple	Northern VT	
Sydowia blight	*Sydowia polyspora*	Red pine	Statewide	See Red Pine Decline and Mortality.
White pine needle decline	*Bifusella linearis, Lecanosticta acicola, Lophophacidium dooksii, Septorioides strobi*	Eastern white pine	Statewide	Similar to 2020 levels. See needle diseases of white pine.

Foliage diseases not reported in 2021 included crown rust, *Puccinia coronata;* dogwood anthracnose, *Discula destructiva* ; fir-fern rust, *Uredinopsis mirabilis* ; phyllosticta leafspot, *Phyllosticta sp* .; poplar leaf blight, *Marssonina* spp.; powdery mildew, *Erysiphaceae;* septoria leafspot, *Septoria aceris* ; tubakia leafspot, *Tubakia dryina* .

ROOT DISEASES

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

Root Diseases not reported in 2021 included heterobasidion root disease, *Heterobasidion annosum;* schweinitzii root and butt rot*, Phaeolus schweinitzii.*

DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

Red pine (*Pinus resinosa*) has been in a state of undetermined decline across Vermont over the last decade. Starting in 2010, pests and pathogens observed in declining red pine stands included pine engravers (*Ips pini*), pine gall weevils (*Podapion gallicola*), parasitic woodwasps (family *Orussidae*), armillaria root rot (*Armillaria* spp.), diplodia shoot blight (*Diplodia sapinea*) and Sirococcus shoot blight (*Sirrococcus conigenus*). These observations remained consistent until 2018 with the addition of annosus root rot (*Heterobasidion annosum)* in 2012, European pine sawflies (*Neodiprion sertifer*) in 2013, brown spot needle blight (*Mycosphaerella dearnessii*) in 2014, and with red pine scale (*Matsucoccus resinosae)* in 2015 (Table 21). Although all biotic stressors are capable of reducing tree health and vigor, no individual pest or pathogen observed was determined to be the causal agent of this decline.

Over the course of eight years (2010-2018), affected red pine damage increased from localized and scattered locations to statewide reports totaling approximately 765 acres (Table 21). To try and better understand and quantify this decline, a single monitoring site was established on a 50-acre,100-year-old red pine plantation in Groton State Forest in the town of Peacham in 2019. A harvest was completed in late winter of 2019 to reduce hazards near trails and roads and to salvage lumber, and four acres were left as a reserve for monitoring. Samples were submitted to the USDA Forest Service for further analysis and were found to have spider mites and pine gall weevil. USDA Forest Service plant pathologist Isabel Munck reported *Diplodia pinea, Sirococcus conigenus*, and *Pestaliopsis* spp. shoot blight(s) on stunted shoots and cone scales.

Table 21: Stressors affecting red pine in Vermont from 2010-2020. Information summarized from VT FPR's Annual Reports of Forest Insect and Disease Conditions 2010-2020.

Stressor	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Insect Pests											
Pine engraver (*Ips pini)*	X										
Pine gall weevil (*Podapion gallicola)*	X	X	X		X	X		X	X	X	X
Pine needle scale (*Chionaspis pinifoliae)*										X	X
European pine sawfly (*Neodiprion sertifer)*				X							X
Parasitic woodwasp (*Orussidae)*	X				X						
Red pine scale (*Matsucoccus resinosae)*						X					
Pathogens											
Annosus root rot (*Heterobasidion annosum)*		X	X					X			
Armillaria root rot (*Armillaria spp.)*	X										
Brown spot needle blight (*Mycosphaerella dearnessii*)					X	X					
Diplodia shoot blight (*Diplodia sapinea)*	X		X	X	X	X	X	X		X	X
Pestalotiopsis shoot blight (*Pestalotiopsis spp.)*										X	
Red band needle blight (*Dothistroma septosporum)*											X
Sirococcus shoot blight (*Sirrococcus conigenus)*	X	X	X		X					X	X
Sydowia blight (*Sydowia polyspora)*											X
Abiotic											
Drought conditions (U.S. Drought Monitor droughtmonitor.unl.edu)	no drought	No drought/ abnormally dry	abnormally dry/ moderate drought	abnormally dry/ moderate drought	No drought/ abnormally dry	abnormally dry/ moderate drought	abnormally dry	abnormally dry/ moderate drought/ severe drought	abnormally dry/ moderate drought	abnormally dry/ moderate drought/ severe drought	abnormally dry/ moderate drought
Mapping											
Red Pine Decline	scattered locations	Moderate to Severe Decline in Central VT			severe in scattered regions	reports of red pine mortality increased substantially	743 acres mapped	516 acres mapped	765 acres mapped	556 acres mapped	

Monitoring Sites: To determine if the 2019 declining pattern and fungal complex are consistent across the state, 12 red pine health monitoring sites were established during the summer of 2020. Including the initial Groton site established in 2019, the 12 monitoring sites were divided evenly among 4 geographical regions: Northeast (NE), Northwest (NW), Central (C), and Southern (S) (Figure 32). At each of the 12 monitoring sites, 4 permanent plots were established. In addition to collecting standard forest inventory data, the following crown metrics were observed and recorded: live crown ratio (LCR), crown density, dead shoots and location, crown transparency, and needle discoloration. FPR is planning on remeasuring plots annually for five years, and sampling as symptoms progress.

Crown Metric Results: Crown metrics and tree measurements as described above were recorded for each tree within the monitoring plot in 2020 and 2021 (Table 22). Standard red pine health metrics for an asymptomatic, open-grown red pine were established as having a crown density of 50%, dead shoots of 10%, crown transparency of 30%, and discoloration of 10%. In 2021, 34 trees in our monitoring plots died, mostly from two sites, Groton State Forest (NE) and Perry Hill (C). In 2021, average crown density across all regions was 44.5%, 5.5% less than our standard, dead shoots of 27.4%,17.4% more than our standard, crown transparency of 35.2%, 5.2% more than our standard, and discoloration of 14.1%, 4.1% more than our standard.

Table 22. Crown measurements for sampled trees in 2021 compared to 2020.Dead Trees have a LCR value of 0%, and Dead shoots value 100%. Density and transparency were not measured on dead trees and were excluded from the dataset.

Region	DBH (in)	Sum of Dead Trees 2020	Sum of Dead Trees 2021	LCR (%) 2020	LCR (%) 2021	Density (%) 2020	Density (%) 2021	Dead Shoots (%) 2020	Dead Shoots (%) 2021	Transparency 2020	Transparency 2021	Discoloration of live trees (%) 2020	Discoloration of live trees (%) 2021
C	14.8	0	10	34.2	25.0	47.9	37.9	25.4	35.2	35.1	27.3	25.4	23.5
NE	15.7	7	19	33.8	34.3	44.0	49.4	31.1	37.8	47.2	35.7	12.5	10.6
NW	14.5	0	1	42.4	40.7	46.8	44.8	13.8	16.8	33.3	39.4	13.3	10.1
S	13.2	1	4	31.7	30.6	47.3	48.1	12.9	20.6	30.3	38.9	13.1	10.5

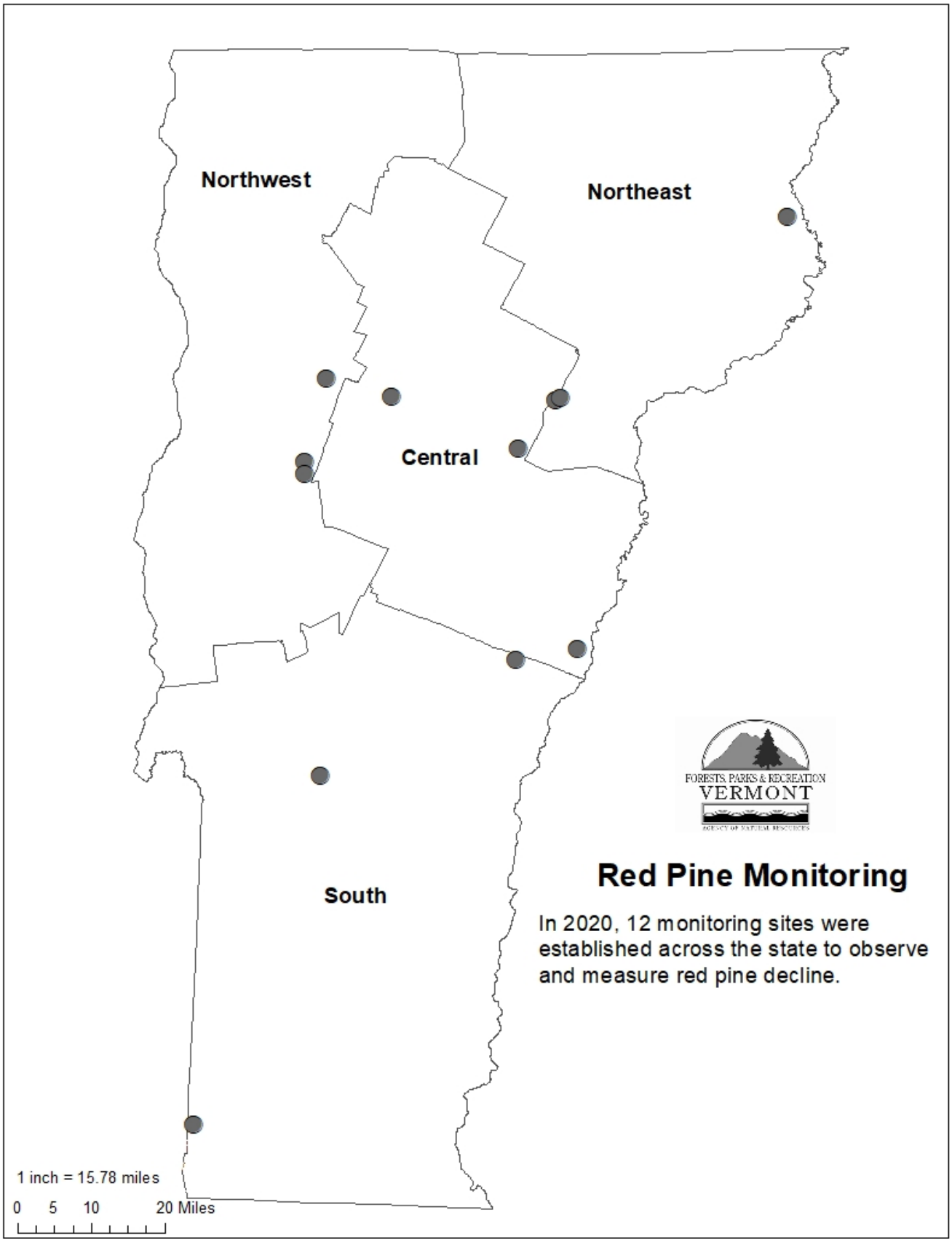


Figure 32. Red pine decline plots established in 2020.

Sampling: In 2020, 10 of the 12 total sites were destructively sampled to assess foliar pathogens and insect stressors in symptomatic trees. Felled red pine trees were micro-sampled from the main bole at DBH and from symptomatic branches in the canopy. In addition, symptomatic needles and cones were harvested. Fungal isolates were identified and sub-cultured as they appeared at the FPR Forest Biology Lab. Fungal isolates were identified based on morphology, and a representative subset was PCR sequenced to amplify their ITS gene region to confirm morphology identification, by Nicholas Brazee at UMASS Amherst.

Foliar pathogens observed across the state included diplodia tip blight and sydowia blight (*Sydowia polyspora*). These pathogens are both native and opportunistic and increase in population and severity when conditions favor tree stress and fungal growth. Abiotic stressors that may promote tree stress and predispose trees to fungal pathogens include drought conditions (Table 21) and insect feeding. Insect pests observed included signs of pine gall weevil (9/10 sites), pine needle scale (9/10 sites), and sawflies (9/10 sites). Observed sawfly damage was likely caused by European sawflies, however, due to late summer sampling, no physical insects were observed. Although these insect stressors have the potential to vector tree pathogens within trees and stands, this relationship was not studied during this project.

To determine how these insect stressors and pathogens may have impacted growth over the past few years, cross-sections were taken from nine sampled trees. Tree-ring analysis of sampled trees was conducted by USDA Forest Service, Northern Research Station's biological sciences technician Paula Murakami. Preliminary analysis shows a steady decline in basal area increment over the last 10 years at nine sites (Figure 32).

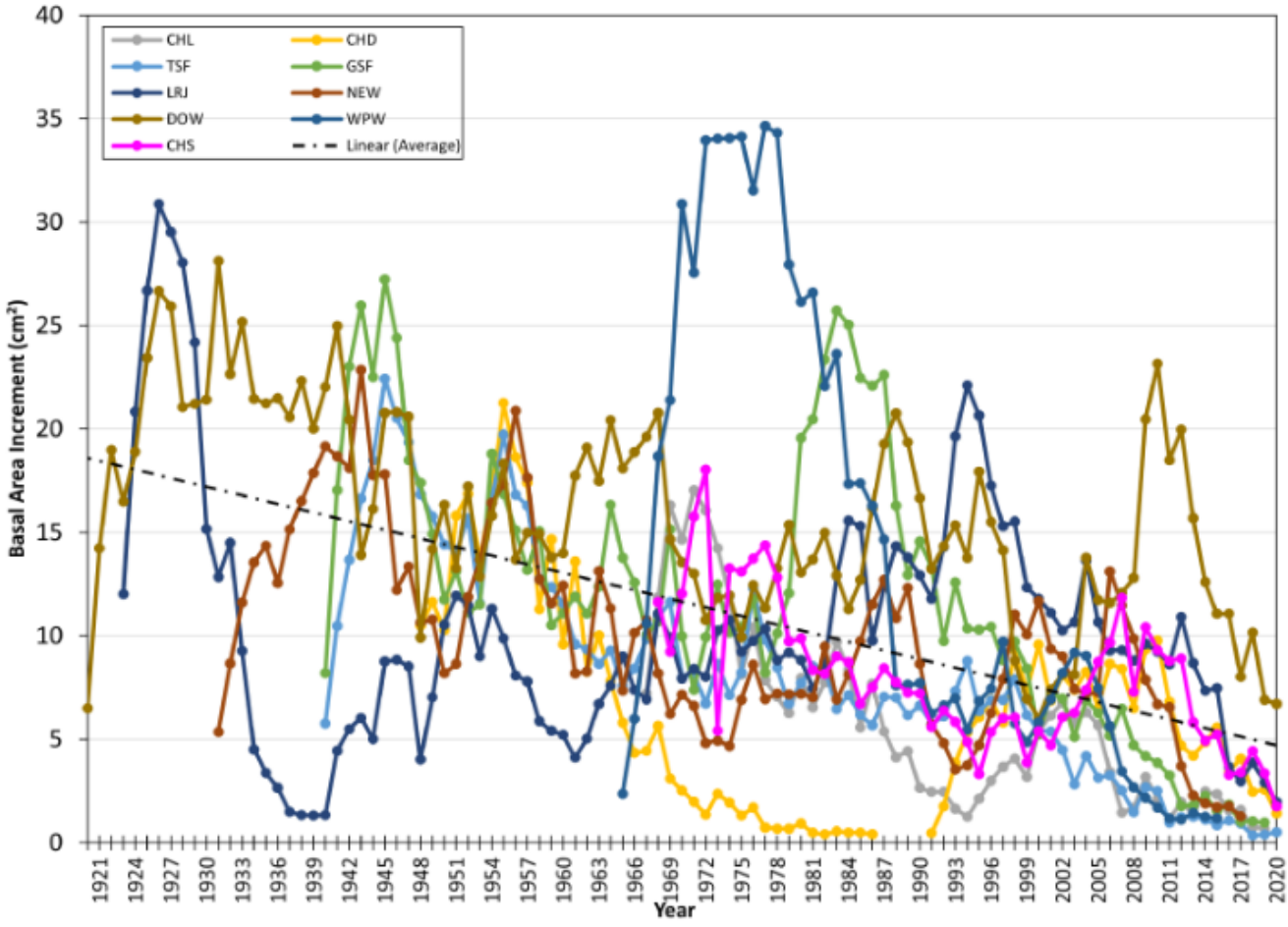


Figure 33: Basal area increment measurements of nine sampled trees with average trendline. Data and Figure credit: Paula Murakami, USDA Forest Service, Northern Research Station.

Conclusion: Although no single observed stressor was identified to be the causal agent of this decline, current hypotheses are that this declining pattern in red pine health is a combination of abiotic and biotic factors which include severe recent droughts, as well as the before mentioned insect stressors and fungal pathogens.

By establishing monitoring sites across the state, FPR will be able to observe and document red pine decline spread and severity. These sites will allow us to better understand red pine health and future management across the state.

OTHER DIEBACKS, DECLINES, AND ENVIRONMENTAL DISEASES

CONDITION	HOST	LOCALITY	REMARKS
Ash dieback	White ash	Scattered statewide	Remains heavy in scattered locations. Increase attributed to ash susceptibility to drought.
Black cherry symptoms	Black cherry	Orange county	In multiple locations, black cherry had thin crowns, premature leaf drop, and scattered mortality. Causal agent(s) unknown.
Drought damage		Northeastern Vermont	Persistent rainfall throughout the growing season alleviated drought in most areas of VT.
Fire damage	Many	Widely scattered	96 fires in 2021 totaling 157.37 acres. See weather for drought conditions.
Frost damage	Beech, maple	Statewide	
Hardwood decline and mortality			See Forest Tent Caterpillar.
Larch decline	Eastern larch	Widely scattered; concentration in Northeast Kingdom	
Ozone injury			Ozone monitoring plots were discontinued in 2018.
Salt damage	Eastern white pine	Widespread	While not unusually severe, foliar browning was common in late winter.
Red pine mortality	Red pine	Statewide	See narrative.
White pine needle damage	Eastern white pine	Statewide	See Foliage Diseases.

Other Diebacks, Declines, and Environmental Diseases not reported in 2021 included air pollution injury, birch decline, chlorosis due to rainfall, hail damage, ice and snow breakage, spruce decline, wind damage, and winter injury.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Squirrel	Maples, Oaks	Statewide	
Woodpecker	Wood products; Ash spp., Balsam fir, Mountain ash, Hemlock	Statewide	Scattered throughout the state.

2021 INVASIVE PLANT SUMMARY

Non-native invasive plant management (NNIPM) efforts continued in 2021, with progress on **Education, Outreach, and Capacity Building** made possible through several grant-funded opportunities. Together, the statewide Invasive Plant Coordinator and Invasive Plant Assistant Coordinator (Invasive Plant Program) within FPR hosted/participated in 8 virtual workshops, created 5 podcast episodes on invasive plant phenology, made a virtual outreach kit focused on mapping invasive plants, and created posters for state parks to communicate about invasive plants with the public. Additional efforts to make resources more widely available included posting a downloadable version of the '12 Common Invasive Plants in Vermont' guide and more on VTinvasives.org. A special recorded tutorial on how to effectively use the VTinvasives.org website was created and shared via Agency of Natural Resources (ANR) YouTube page and the Vermont Municipal Day hosted by ANR as well as the Southeast Vermont CISMA. The coordinators also worked with multiple state departments and agencies to unify Vermont's approach to NNIPM. They fielded over 470 inquiries about invasive plants. Other FPR staff continued to provide outreach and information (in-person, online) about invasive plants to the public and resource professionals and worked with landowners and consulting foresters on addressing non-native invasive plants (NNIP) on private lands. This was modeled after the work conducted by County Foresters, who help landowners and communities manage their forests, including providing recommendations on the treatment of invasive plants. ANR staff continue to identify and manage NNIP on **State Lands**. Varied NNIPM strategies were conducted within local communities and by many other organizations, some of which are summarized under **Other Activities**.

Early Detection Species

Patches of **stiltgrass** (*Microstegium vimineum)* were originally reported in Vermont in late 2018, photographically confirmed in 2019 by the Vermont Natural Heritage Program. Vouchers were collected for the Windham County population in 2020. Locally driven assessment and management in Windham County started in 2020 and continued in 2021, summarized under **Other Activities**. Current confirmed sites of *M. vimineum* infestation include an isolated patch on private land in Sandgate (Bennington County), along a roadside in Brattleboro (Windham County), and in Poultney (Rutland County).

The Invasive Plant Program received the second ever report of an **aralia tree** (likely *Aralia spinosa* or *Aralia elata*). There has not yet been botanical confirmation of the presence of either plant in Vermont. Regionally, *A. elata* was first reported in Western New York in 2018 and is not yet widely documented in the northeast.

A new location of **giant hogweed** (*Heracleum mantegazzianum*) was confirmed in Huntington.

Education, Outreach and Capacity Building

Mapping for Healthy Forests, Vermont: This iNaturalist project remains active, connecting users with information about the location of common invasive plants in Vermont. Observations made by volunteers are linked to location, photos, information on seed production, and level of infestation of the specific observation. This information is stored on the iNaturalist website and is accessible to anyone. As of December 31st, 2021 the project had 4,777 observations provided by 182 observers.

Forest Hero! Volunteer Network: Ongoing development and delivery continue for this "train the trainer" model funded by a USDA - Forest Service grant. The network of community volunteers is supported by the Invasive Plant Program in collaboration with partners like Vermont State Parks and Vermont Coverts: Woodlands for Wildlife. Since October 2018, 5 trainings have taken place and forty-one people have participated in learning how to effectively communicate information to their communities on invasive plants. As part of the training, participants agree to take what they learn back to their communities

and are expected to complete at least one outreach event within a 12-month period. Continuing education is offered through quarterly newsletters and online workshops.

Tool Loan Program: In an effort to increase access to NNIPM tools, the District 3 (Northwest) office started a pilot program in 2017, loaning out mechanical tools and outreach kits to local organizations, municipalities, and private landowners. The Invasive Plant Program communicates with participants and organizes pick-up and return dates. The loan program was expanded to include tools available through a library at the District 2 (Southwest) office in 2019. The expanded loan program was used 8 times as of December 31st, 2021 (see example in Figure 33). The Invasive Plant Program shared information about the tool loan library during online presentations throughout the year, and the tools are stored and available for pick up at FPR's Essex Junction and Rutland office.

Figure 34. Tools also include outreach kits, such as this one borrowed by and displayed at the Grand Isle State Park Nature Center, Summer 2021.

Invasive Plant Phenology Monitoring Project: In the second full week of each month of the growing season, the Invasive Plant Program, other FPR staff, and volunteers observe invasive plant phenology across the state, submit that data, and it is reported in the monthly FPR Insect & Disease reports. Knowing how invasive plants are behaving at different latitudes and elevations helps us all understand how plants respond to changes in climate and growing conditions, and allows us all to adjust our treatment plans accordingly. 2021 was the fifth season for the project, and this year supported 20 volunteers.

VTinvasives.org Website: The VTinvasives.org website continues to offer information on terrestrial and aquatic invasive plants and continues to provide that information to a variety of user groups from landowners to professional foresters to municipalities, including educational resources and Best Management Practices. The Invasive Plant Program continued work on the website to update and curate relevant information and resources pertaining to terrestrial invasive plants. This included adding homepage links that take users directly to information on NNIPM, engagement, and volunteer opportunities.

Capacity Building: Since 2013, much of the NNIPM throughout state forests and parks in District 2 has been conducted by an internally developed "strike team," called the Habitat Restoration Crew. This year, the Invasive Plant Program coalesced lessons learned from that work into a draft strike team guide. That guide, along with other learning tools – including a school curriculum, a how-to guide for running invasive plant removal workdays with youth, and other resources – will eventually be made available for other regions and entities to utilize. Additionally, Invasive Plant Program staff have worked with five organizations across the state to establish invasive plant management plans.

Non-native Invasive Plant Management on State Lands

District 1 (southeast): FPR Staff in District 1 oversaw multiple NNIPM projects in 2021. Approximately 126 acres of state lands were treated for a variety of invasive plants between May and November. That work included a mix of contracted and internally conducted NNIPM including: 110 acres managed with 6 contracted projects that used chemical treatments for barberries, buckthorn, honeysuckles, and knotweed; 16 acres managed with 13 ongoing internal projects that used a mix of mechanical and chemical treatments for barberries, bittersweet, buckthorn, garlic mustard, honeysuckles, knotweed, multiflora rose, petasites, and wild chervil. Two new projects in Coolidge State Forest were assessed but treatment there has not yet begun.

District 2 (southwest): FPR staff in District 2 oversaw multiple NNIPM projects in 2021. Approximately 37 acres of state lands were treated for dense infestations of invasive plants from July to October. That work involved contracted NNIPM focused at Lake Bomoseen State Park, Mt. Philo State Park, and Emerald Lake State Park. Species managed include barberries, bittersweet, buckthorn, and honeysuckles. Internal efforts included NNIPM at Mt. Philo State Park treating garlic mustard, purple loosestrife, spotted knapweed, and wild parsnip, as well as at Button Bay State Park treating purple loosestrife and spotted knapweed.

District 3 (northwest): At Alburgh Dunes State Park, contractor Long View Forests LLC completed year three of chemical treatment to control the phragmites infestations within and adjacent to the wetland complex (previously treated in 2018 and 2019). Six acres were treated, supporting efforts to protect the integrity of the wetland and several rare, threatened, or endangered (RTE) plant species that exist on site.

District 4 (central): FPR staff in District 4 oversaw multiple NNIPM projects in 2021. Approximately 30 acres of state lands were mechanically and chemically treated for invasive plants, including barberries, bittersweet, buckthorn, false spiraea, knotweed, and honeysuckles. That work included a mix of contracted and internally conducted NNIPM focused on state lands in the towns of Berlin, Groton, Johnson, Newbury, Roxbury, Stratford, Stowe, Thetford, and Waterbury. Of note, at Mt. Mansfield State Forest, in the Woodward Hill Block, Redstart Forestry conducted chemical treatment to control honeysuckles and knotweed across 9 acres. These sites will be monitored in 2022 and considered for additional treatments.

District 5 (northeast): FPR staff in District 5 oversaw an ongoing project to treat barberries at Willoughby State Forest. Initiated in 2019 with mechanical efforts to remove larger stems and patches, this was the second year that barberry plants were chemically treated across approximately 40 acres. The work this year was conducted by contractors from Redstart Forestry, and the need for them to mostly spot treat indicates the success of the previous two years' treatments. Knotweed assessment and treatment began at Victory Basin WMA along the Moose River. Long term honeysuckle and knotweed assessments continued at Calendar Brook WMA.

Other Activities

The 2021 growing season saw many NNIPM projects across the state. These efforts were led by individuals and organizations ranging from community champions, local/state/federal government, nonprofits, and businesses. Below are highlights reported by some of these project leaders.

Cooperative Invasive Species Management Areas
Cooperative Invasive Species Management Areas (a.k.a. CISMAs, CWMAs, or PRISMs) are partnerships among local organizations working to manage invasive species through outreach, prevention, and treatment. Participants in a CISMA share resources to be collectively more effective in their work at protecting the ecological health of a particular area. In Vermont, active CISMAs include the Batten Kill

Watershed CISMA, the Orleans County CISMA, the Southeast VT CISMA, the Upper Connecticut CISMA, and the Upper White River CWMA. While not technically a CISMA, the Black River Action Team deserve mention for their great work at early detection of and rapid response to invasive plants.

Batten Kill CISMA: The Batten Kill CISMA steering committee provided one virtual education and outreach event, and one seed collection/ invasive species control event at a restoration site in Manchester.

Black River Action Team: The Black River Action Team (BRAT) are working to contain several populations of phragmites along the shores of Amherst Lake in Plymouth. In May of 2021, efforts began to complete a shoreline survey of where the populations were currently encroaching. The goal was to establish a baseline knowledge of the infestation prior to the removal of a dam which would dewater the lake. It is expected that post-dam removal, the lake will lower by 2', exposing 10' of shoreline at the shallow northern end. Most of this initial effort for assessment and treatment has been conducted by BRAT volunteers and shoreline landowners who potentially will be affected by the dam removal.

So far efforts include mechanical treatment in the spring to remove aboveground growth of one population that was easier to access, roughly 1/10th of an acre (20'x 200'), with emergent stems cut below the waterline and shoreline stems cut a few inches above surface level. Cut material was removed to a nearby upland property to solarize, be burned, or used as thatch for the roof of a small shed. In the fall, a second cut occurred on the same patch, and included a technique of "spading" (severing underwater roots), as well as digging out stolons, and disposed of in a similar fashion. There are plans to seek funding to support the continued efforts needed (assessment, treatment, monitoring) to contain the northern population of phragmites, as well as begin efforts on populations elsewhere on the lake.

Southeast Vermont CISMA: The Southeast Vermont CISMA (SE VT CISMA) continued their invasive species webinar series into 2021, reaching 116 registrants and more by posting said webinars free-to-view on their website. They also held three in-person events, including two education and removal workdays (one in Brattleboro and one in Bellow's Falls) that reached 25 people, and a presentation on NNIP to 12 garden and floral arts club members.

Southeast Vermont CISMA & Brattleboro Conservation Commission: The SE VT CISMA and Brattleboro Conservation Commission (BCC) joined forces in 2021 to address an early detection population of stiltgrass in Brattleboro. Joint efforts started with a public awareness campaign in June, mailing information to over 100 property owners in the areas in and adjacent to the known locations of stiltgrass. This information included an alert to its presence, how to recognize it, and how to report it. In the summer, outdoor trainings were held to train volunteers on how to identify stiltgrass. Surveys, as well as manual removal, were conducted by individual volunteers. SE VT CISMA will lead the effort this winter in the development of a formal strategy to respond to stiltgrass in Brattleboro, in partnership with BCC, who will also aide in on-the-ground efforts.

Upper White River CWMA: The Upper White River CWMA continued their efforts, as a collaboration of a coordinator position, volunteers, Green Mountain National Forest staff, and Vermont Youth Conservation Corps. Starting in April, they provided a webinar on ecological landscaping, a training in June for members of the public on how to manage for wild chervil, ongoing mechanical treatment of 58.6 acres of wild chervil on National Forest and other roads in the towns of Hancock and Granville, 31.4 acres of wild chervil, garlic mustard, and knotweed in the town of Rochester, and an event in November to remove barberries from along a popular mountain bike trail in Rochester.

Municipalities

Brattleboro, VT: The Brattleboro Conservation Commission continued efforts for their knotweed control project along the river shore at West River Park, a popular water and outdoor recreation site. Since 2018, efforts to contain the knotweed have been purely volunteer based, with a mix of commission

members and town residents. Mechanical treatment occurs throughout the growing season starting in late April/early May and wraps up in September in an area roughly 400-500' x 50' along the shore. Prior to the start of the project, knotweed was crowding out locally evolved riparian species and impeding the recreational use of the site. Since efforts began, the knotweed population is reduced, and locally evolved species are rebounding. In 2021, the group was able to establish and maintain a twice-monthly cutting regime, reducing overall expended efforts as the workload became more predictable. The group plans to continue this ongoing stewardship effort.

Burlington, VT: Burlington Parks, Recreation & Waterfront (BPRW) hosted a workday event in April. Ten volunteers assisted in the removal of about 1 acre covered in buckthorn, honeysuckles, black locust, bittersweet, and spindletree. The event was held at the North Bend Orchard, off Manhattan Drive, to make way for a new public fruit and nut tree orchard there. Another workday in May took place at the Tommy Thompson Community Garden to support the work of creating a new pocket park and establish more pollinator and native plant habitat. Ten volunteers helped to remove weedy pest plants (mainly crabgrass and burdock) by cutting, tarping, and pulling from the perimeter of the garden. BPRW staff removed invasive plants at Schmanska Park and replaced them with ecotypic alternatives, and removed invasive plants such as knotweed, wild parsnip and honeysuckles from along the bike paths and city greenways.

Cabot, VT: The Cabot Conservation Commission hosted a workshop presented by Washington County Forester, Robert Nelson. The event took place in town, was attended by 15 people, and focused on identification and management options for barberry, buckthorn, bittersweet, giant hogweed, and knotweed.

Hinesburg, VT: The Town of Hinesburg owns a 301-acre parcel called the LaPlatte Headwaters Town Forest (LHTF). It is about 170 acres of forest and 130 acres of floodplain/wetland. Efforts are underway for managing invasive plant populations in the forested part of the property, in partnership with FPR. Contractors overseen by the Chittenden County Forester, Ethan Tapper, completed their third year of work at LHTF to chemically treat buckthorn and honeysuckles. This effort is funded by revenue generated from a forest management project at the Hinesburg Town Forest, Hinesburg's other town forest. The floodplain forest at LHTF, now largely reed canary grass, is also undergoing restoration. Those efforts continued into a third year, and included plantings, deer exclosures, and an experimental approach to controlling reed canary grass, with positive preliminary results.

Randolph, VT: The Randolph Conservation Commission, along with the Vermont Woodlands Association, sponsored a presentation by the Orange and Windsor County Forester, AJ Follensbee. The event took place at the Ellis Town Forest, was attended by 6 people, and focused on identification and management options for the different invasive plants present in town, including those seen in the town forest.

Richmond, VT: The town of Richmond has a few notable conservation organizations, including the Great Richmond Root-Out! (Root-Out!). Since 2009, the Root-Out! has worked to control invasive plants on 120 acres of state-significant silver maple-ostrich fern floodplain forest—the largest remaining example of this now rare natural community on the upper Winooski River. In addition to its ecological importance, this floodplain forest is also prized by the people of Richmond who use it extensively for hiking, biking, birdwatching, fishing, boating, and nature exploration. Participating lands are owned by the Town of Richmond, the Richmond Land Trust, The Nature Conservancy, and private landowners. Many volunteers have helped the Root-Out! over the years, including community members, middle and high school science classes, University of Vermont students, land trust members, and more.

2021 was marked by two big new initiatives for the Root-Out!: a tree planting in the floodplain forest, and a partnership to support the health of the new town forest. In the spring, with technical assistance and financial support from the Friends of the Winooski and the U.S. Fish & Wildlife Service's Partners for Fish & Wildlife Program, 300 native trees were planted along the Winooski River to expand the floodplain forest. And in the fall, more than 100 Camel's Hump Middle School students and a UVM Community Forestry class worked with the Root-Out! and FPR staff to remove more than

2,000 barberry, bittersweet, buckthorn, honeysuckle, and multiflora rose plants from Andrews Community Forest (Richmond's town forest).

Shrewsbury, VT: The Shrewsbury Conservation Commission has an active program to deal with a variety of invasive plants, with volunteers amassing 427 hours in 2021 alone. Efforts occurred across 25 sites around town and were conducted by 44 volunteers, with a primary core team of 12 dedicated volunteers. Species managed include garlic mustard, purple loosestrife, wild chervil, and wild parsnip. The main strategy is containment and stopping spread – working from the outer edges of patches along the town roadways and fields, moving towards the center of town. Another important component of their efforts is outreach, providing learning opportunities to landowners on effective removal efforts, and providing support to those taking on initial efforts of management in return for the landowners supporting the town efforts by "adopting" and helping monitor treatment sites.

Future work includes developing plans for honeysuckles, barberry, multiflora rose, and knotweed. Initial steps were taken this year to address knotweed, with a mechanical treatment regime set to a two-week schedule during the growing season, with plans to continue monitoring and treatment.

South Burlington, VT: The city of South Burlington operated its fourth season of NNIPM efforts, with work conducted by volunteers and a contractor. The goal is to build capacity for the stewardship of the city's natural areas. In 2021, 6 volunteer trainings were held, where participants actively learned how to identify and remove invasive plants, and took place at Red Rocks Park, Wheeler Nature Park, Hubbard Recreation & Natural Area, and City Center Park. Mechanical treatment outside of these training days was conducted by individual volunteers. These trainings are held by a consultant, who also spent 14+ days conducting mechanical treatment and monitoring on identified patches of bittersweet, buckthorn, garlic mustard, honeysuckles, multiflora rose, phragmites, and more. This winter, the city plans to partner with Audubon VT and US Fish & Wildlife Services to conduct NNIPM at Wheeler Nature Park. The work of volunteers, the consultant, this upcoming partnership, and the ongoing city efforts to brush hog meadow areas are having a positive cumulative effect on the transition from invasive plants to locally evolved plants in these natural areas.

Springfield, VT: The Springfield Trails and Rural Economy Committee conducted wild parsnip removal and invasive species inventory on the town's multi-use recreation/transportation path, Tonerville Trail. Committee representatives also worked with the FPR Invasive Plant Program to create an Invasive Plant Management Plan for the trail; the plan prioritizes what work to accomplish and what effort and resources are needed.

Williston, VT: The Town of Williston is managing the Catamount Community Forest for early successional habitat. Part of that work is managing extensive invasive plant populations. In partnership with ANR staff, the town has been grinding understory shrubs and trees to replicate a natural disturbance. This initial mechanical cut of the understory (primarily invasive plants) will be followed up by hired contractors to chemically treat resprouting invasive plants. By grinding prior to the chemical treatment, it significantly reduces the volume of chemical used and area needed to be treated. Additionally, town volunteers became licensed pesticide applicators to assist with targeted cut-stump chemical treatment of buckthorn and honeysuckle throughout the community forest.

Land Management Entities

Burlington Wildways: Burlington Wildways (Wildways) is a partnership between Burlington Parks, Recreation and Waterfront, Winooski Valley Park District, Rock Point, Burlington Conservation Board, City Council, and Intervale Center to collaboratively manage land and natural areas accessible to the public. In partnership this year, they hosted 3 University of Vermont interns through the Rubenstein School Perennial Summer Internship Program. These students conducted research over the course of the summer and into the fall on various management techniques for invasive plants. Their work included running pilot projects and monitoring test plots focused on managing for bittersweet and goutweed.

They also supported volunteers during workdays with Wildways partner organizations. Reports of their work will be shared once produced. Partner organizations also individually complete good work, like the Intervale Center that holds weekly volunteer workdays to remove invasive plant species – especially knotweed, spindletree, garlic mustard and buckthorn from the grounds.

Green Mountain National Forest: Green Mountain National Forest (GMNF) botany staff continued NNIPM efforts by inventorying 3,360 acres on GMNF land in the towns of Chittenden, Dover, Goshen, Leicester, Manchester, Mendon, Peru, Readsboro, Ripton, Rochester, Stamford, Stratton, Somerset, and Woodford. Elsewhere in the National Forest, staff, contractors, volunteers, and partner organizations, including Green Mountain Club and Appalachian Trail Conservancy conducted mechanical and chemical treatments for other small infestations. A total of over 373.3 acres in the towns of Goshen, Leicester, Manchester, Mt. Tabor, Pomfret, Ripton, Salisbury, Shrewsbury, Somerset, Wallingford, and Woodford were managed for species including garlic mustard, goutweed, knotweed, wild chervil, wild parsnip, and several shrubby invasive plants.

Winooski Valley Parks District: The Winooski Valley Park District (WVPD) has been working for years to manage invasive species at their parks by engaging the public through service-learning projects. In 2021, WVPD continued an ongoing partnership with Williston Central School by providing a service-learning day at Ethan Allen Homestead. The event saw 88 students and 12 adults spending the day learning outside the classroom, through conservation work that included removing bittersweet, buckthorn, and honeysuckles. The park district also supervised a volunteer who pulled invasive plants throughout the district's properties.

TRENDS

Sugar Maple Health in 2021

Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 94% of overstory sugar maples were rated as having low dieback (less than 15%), which is nearly the same as in 2020 (Figure 35).

Statewide, there was a decrease in percent of trees with thin foliage (6.5%) compared with 2020 (8%) (Figure 35). Foliage transparency is sensitive to current stress factors. Other spikes in transparency have been due to frost injury (2010, 2012, 2015), forest tent caterpillar defoliation (2004-2007, 2016-2018), and pear thrips (1988-1989).

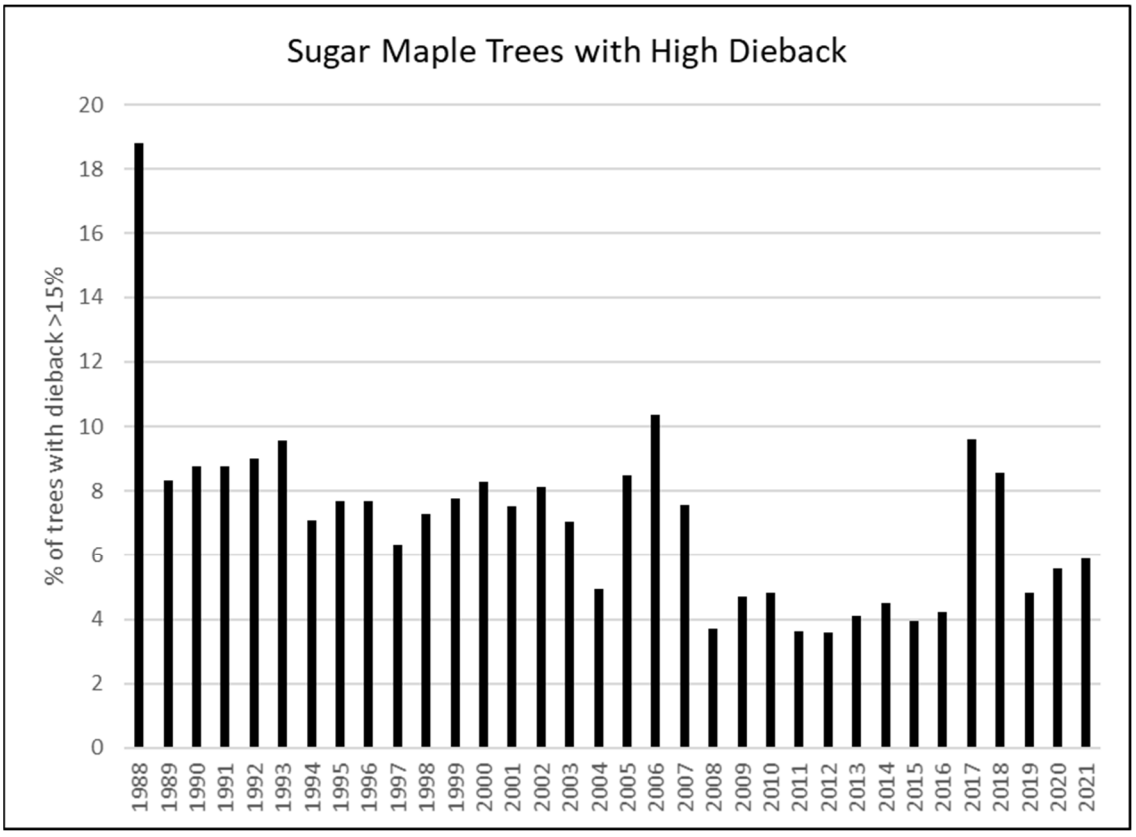


Figure 35. Percent of overstory sugar maple trees on NAMP plots with high dieback (> 15%), 1988-2021. *n* = 1,142 trees at 36 sites.

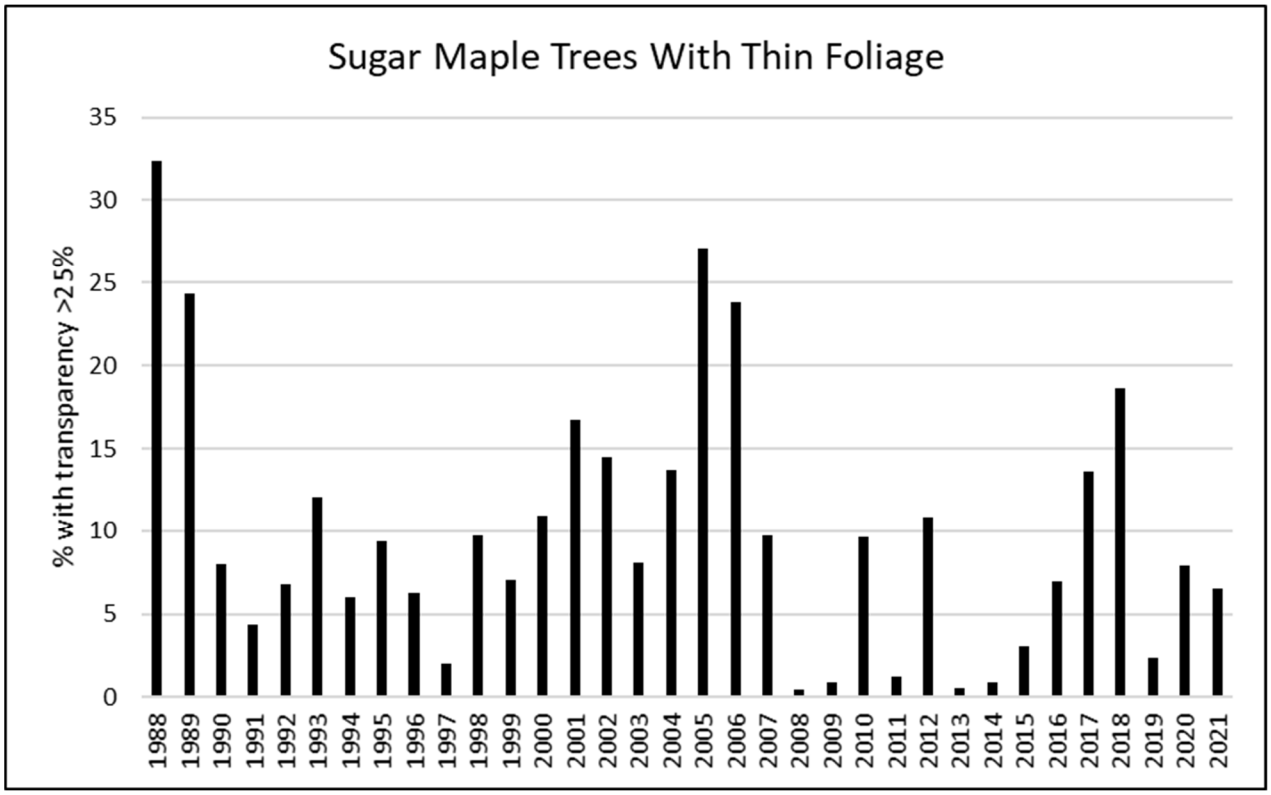


Figure 36. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage (>25% foliage transparency), 1988-2021. *n* = 1,142 trees at 36 sites.

Forest Ecosystem Monitoring Cooperative
Trends in Forest Health throughout Vermont in 2021

Vermont forest health monitoring plots were sampled at 48 sites across the state in 2021 as part of the Forest Ecosystem Monitoring Cooperative (formerly the Vermont Monitoring Cooperative). Measures recorded were comparable to those collected for NAMP plots. Results and analysis from this plot network can be obtained in the annual reports produced by FEMC, found at https://www.uvm.edu/femc/products/reports.