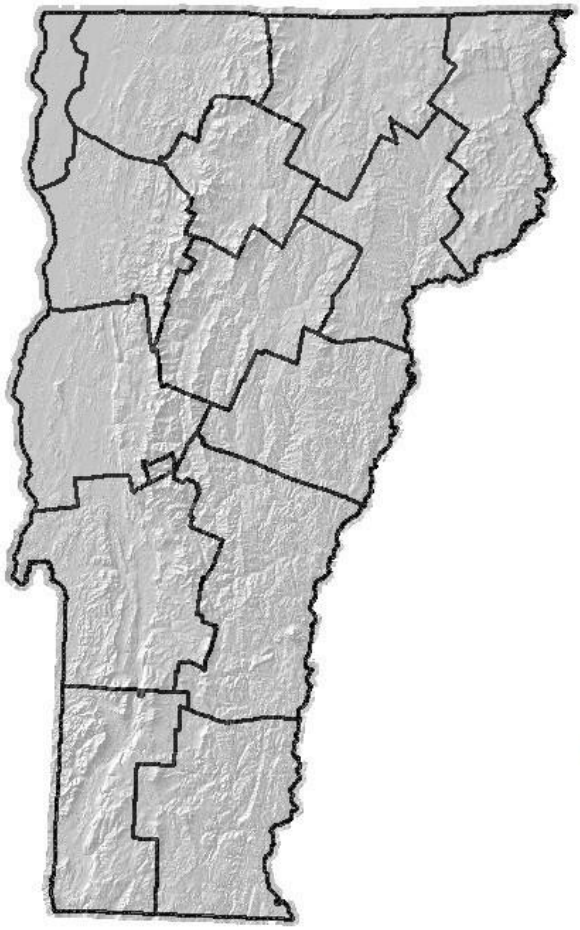
FOREST INSECT AND DISEASE CONDITIONS IN VERMONT 2023



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AGENCY OF NATURAL RESOURCES

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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 2023

PREPARED BY:

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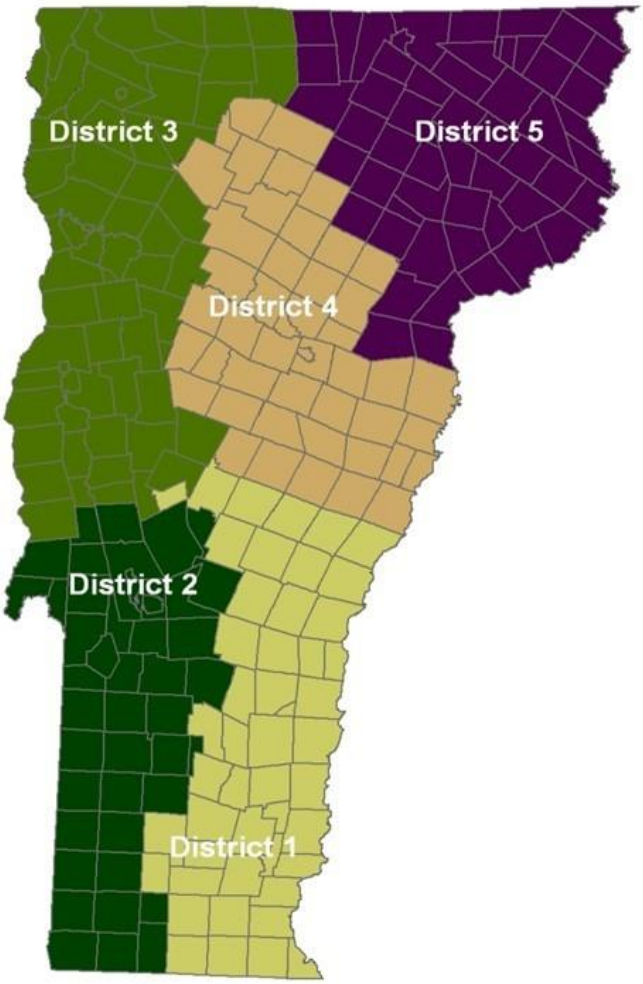

INTRODUCTION

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.

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 . 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

Many thanks to everyone who took part in **invasive plant management and outreach** across the state, individually or through groups, towns, Conservation Commissions, CISMAs, other municipal and private organizations across Vermont. These shared efforts are vital for spreading the word and not the plants. Special recognition goes out to our close colleagues at the Agency of Agriculture, Food & Markets, the Agency of Transportation, Forest Hero! Volunteers, Vermont Woodlands Association, VT Coverts: Woodlands for Wildlife.

The **Forest Biology Lab** received taxonomic and other assistance from Dave Adams, Kate Forrer, Spencer Hardy, Alexandra Kosiba, Rich Holschuh, Caroline Marschner, Kent McFarland, Declan McCabe, Cameron Mcintire, Leif Richardson, and Judy Rosovsky.

Vermonters utilized the **Report It!** feature on the VTinvasives website to report potential cases of invasive fungal pathogens, insects, and 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 USDA Forest Service Forest Health Protection, the Vermont Agency of Agriculture, Food and Markets, University of Vermont, USDA APHIS, the USDA 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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FIGURES AND TABLES

Tables

2023 PUBLICATIONS

Vermont Department of Forests, Parks & Recreation. Insect and Disease Observations -March 2023. Vermont Forest Health Leaflet 2023. Available at https://fpr.vermont.gov/forest/forest-health/current-forest-health-issues-and-updates.

Vermont Department of Forests, Parks & Recreation. Insect and Disease Observations -April 2023. Vermont Forest Health Leaflet. Available at https://fpr.vermont.gov/forest/forest-health/current-forest-health-issues-and-updates.

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Vermont Department of Forests, Parks & Recreation, University of Vermont Extension, Vermont Department of Fish and Wildlife, Atowi Project. Management Guide for Eastern Hemlock Conservation in Vermont. Available at https://fpr.vermont.gov/forest/forest-health. June 2023.

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Vermont Department of Forests, Parks & Recreation. Press Release: Invasive Mile-a-Minute Weed Confirmed in Vermont. Available at http://www.fpr.vermont.gov/news/. October 2023.

WEATHER

2023 WEATHER SUMMARY

Winter 2022-2023

Vermonters faced a warmer and wetter winter of 2022-2023 compared to years past. From December 1 to February 28, state-wide temperatures averaged 25.7°F, which was 5.4°F warmer than the winter of 2021–2022. Average precipitation across the state was 10.17 inches, which was 1.6 inches more than last year's average.

Spring 2023

Spring began with ample rainfall, but by the end of May precipitation totals were lower than in 2022 and resulted in abnormally dry conditions in much of the state (**Figures 2-7**). The most dramatic weather in spring 2023 was the region-wide freeze event that occurred from May 17-18, and resulted in considerable damage to newly emerged leaves of multiple hardwood species. One aerial survey flight was taken on May 31 to map damage in parts of the state that could serve as reference points for flights later in the summer (**Figure 1**).

Summer 2023

June brought with it cooler temperatures than in 2022, but slightly more precipitation. However, much of the state was classified as either abnormally dry or experiencing moderate drought conditions by the end of the month. July was a different story with heavy rain occurring in many locations, resulting in damaging floods in affected areas. The statewide precipitation average for July was 9.46 inches, approximately 5.7 inches more than in 2022 and just shy of the wettest July on record (10.09 inches in 1897). The wet summer continued into August with an average of 6.1 inches of rainfall, which was 2.9 inches greater than in 2022. September saw the start of some drying, with precipitation averaging 3.1 inches across the state, a reduction of 2.47 inches from 2022. Nevertheless, with the ample rain throughout the summer, no drought conditions were being experienced in September.

Fall 2023

Average temperatures in October were 5 degrees warmer than the long-term (100-yr) average, whereas November temperatures were very close to the long-term average. However, December was warm by historical records, with an average temperature of 31°F being 11 degrees warmer than the long-term average.

Some mountain summits received their first snowfall in late October, but snow evaded most of the state until November. However, precipitation was sufficient enough through the growing season and early winter to keep the state out of drought status through the end of 2023.

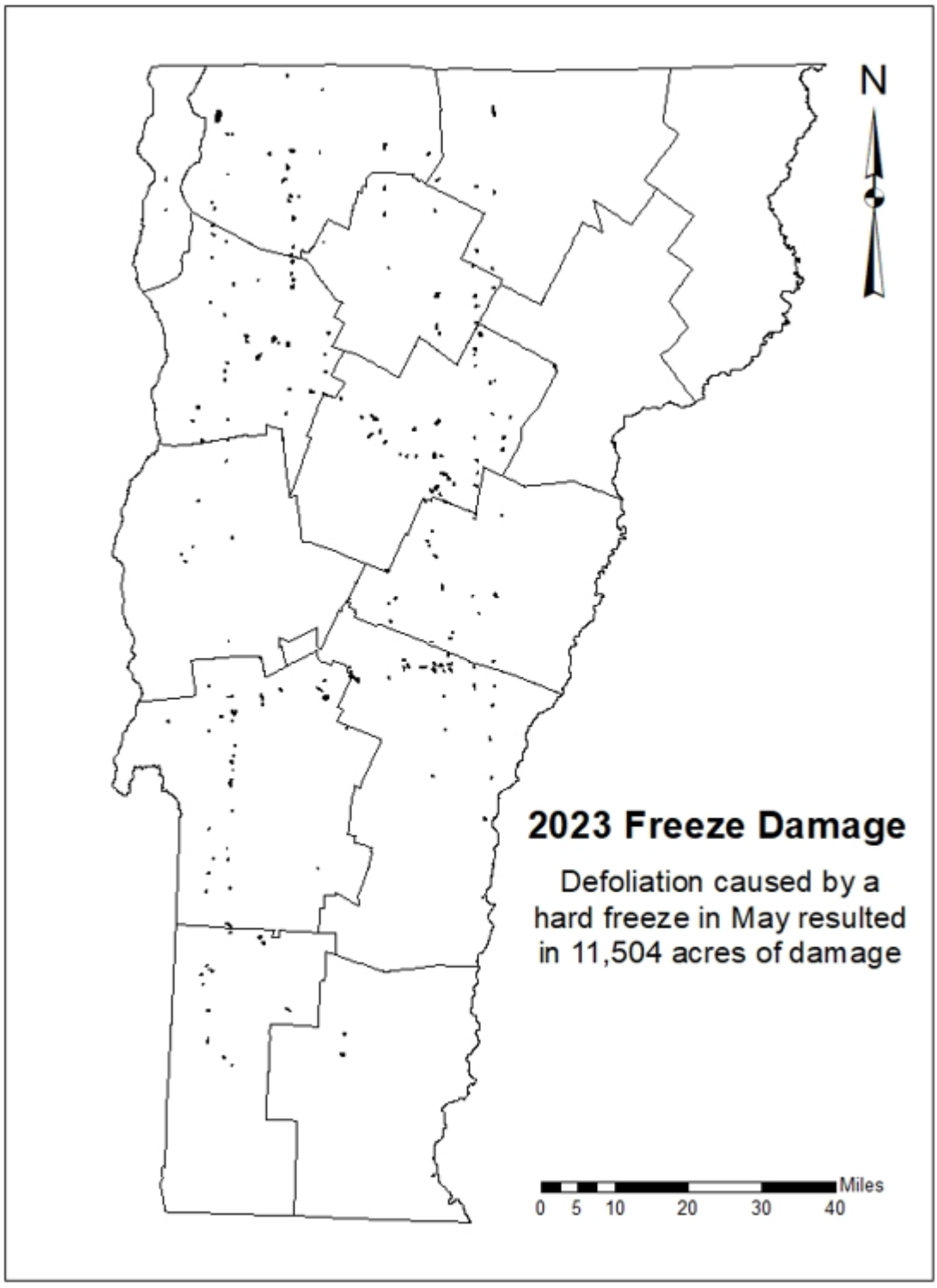

Figure 1. Map of areas impacted by the freezing temperatures in May 2023. Acreage is likely underestimated due to the timing of aerial surveys which took place in mid-late summer after trees were able to recover from the freeze event.

Figures 2-11 *and* ***Tables 1-3*** *provide details on 2023 precipitation and phenological observations.*

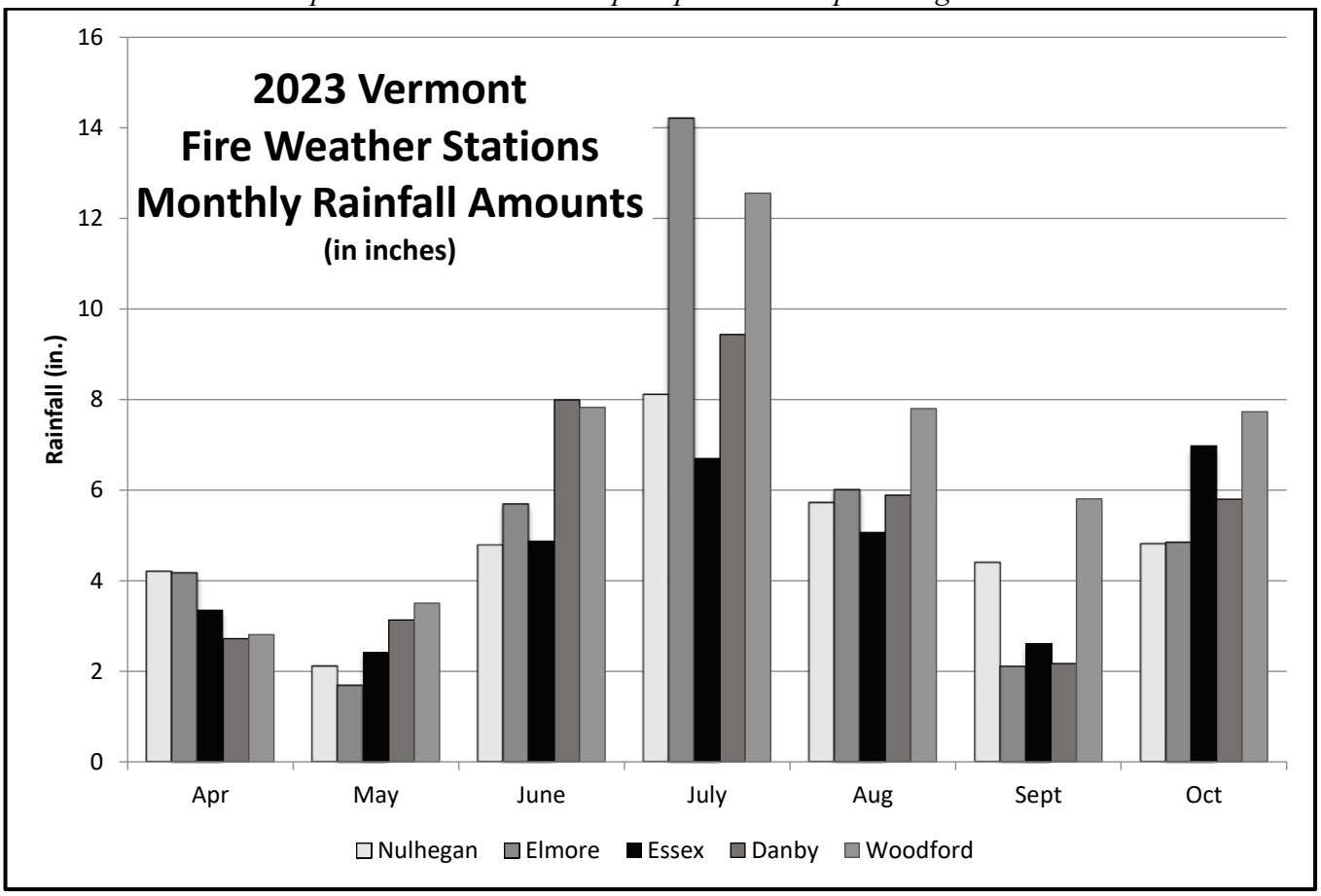

Figure 2. Monthly rainfall amounts (in inches) at Vermont fire weather observation stations through fire season, April-October 2023.

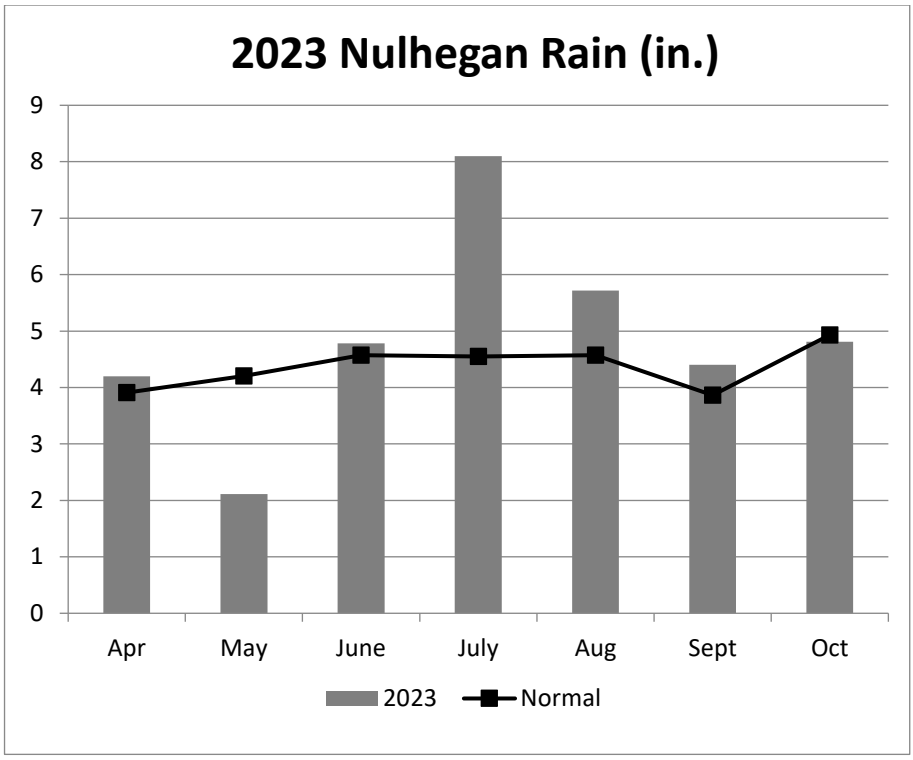

Figure 3. Monthly rainfall amounts (in inches) at the Nulhegan fire weather observation station in Brunswick, VT compared to normal during the fire season, April-October, 2023. Normal is based on 21 years of data.

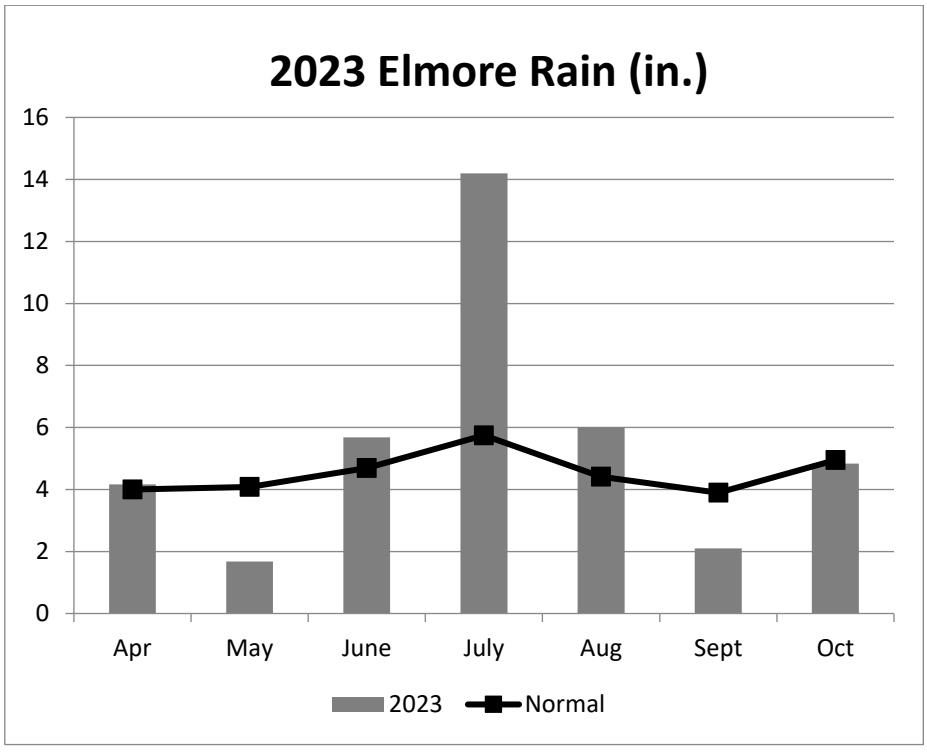

Figure 4. Monthly rainfall amounts (in inches) at the fire weather observation station in Elmore, VT compared to normal during the fire season, April-October, 2023. Normal is based on 29 years of data.

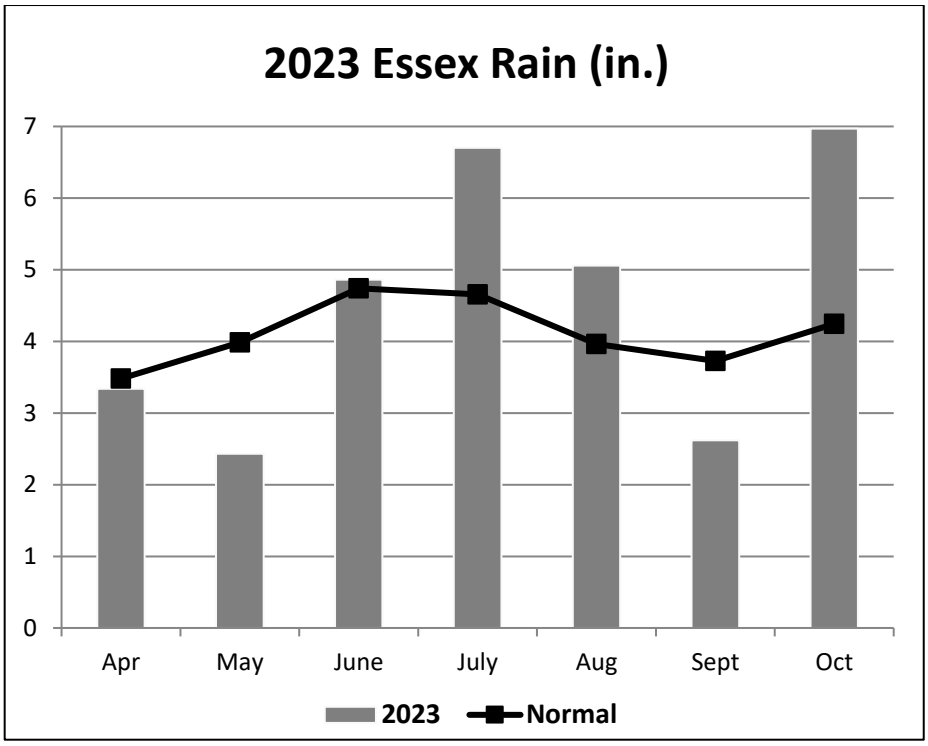

Figure 5. Monthly rainfall amounts (in inches) at the fire weather observation station in Essex, VT compared to normal during the fire season, April-October 2023. Normal is based on 30 years of data.

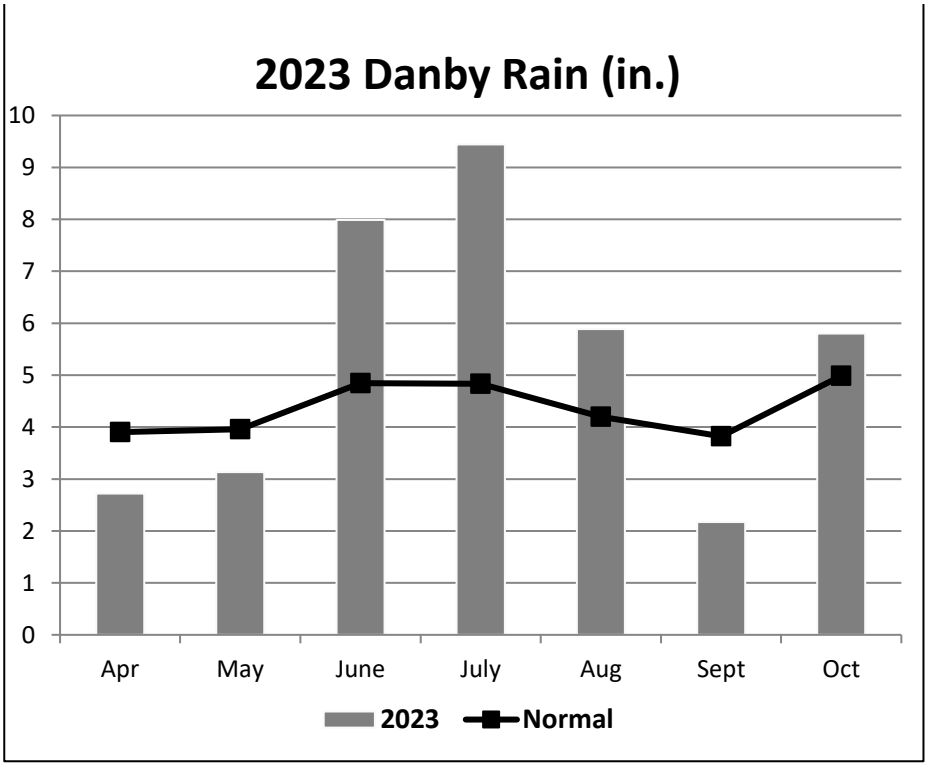

Figure 6. Monthly rainfall amounts (in inches) at the fire weather observation station in Danby, Vermont compared to normal during the fire season, April-October 2023. Normal is based on 23 years of data.

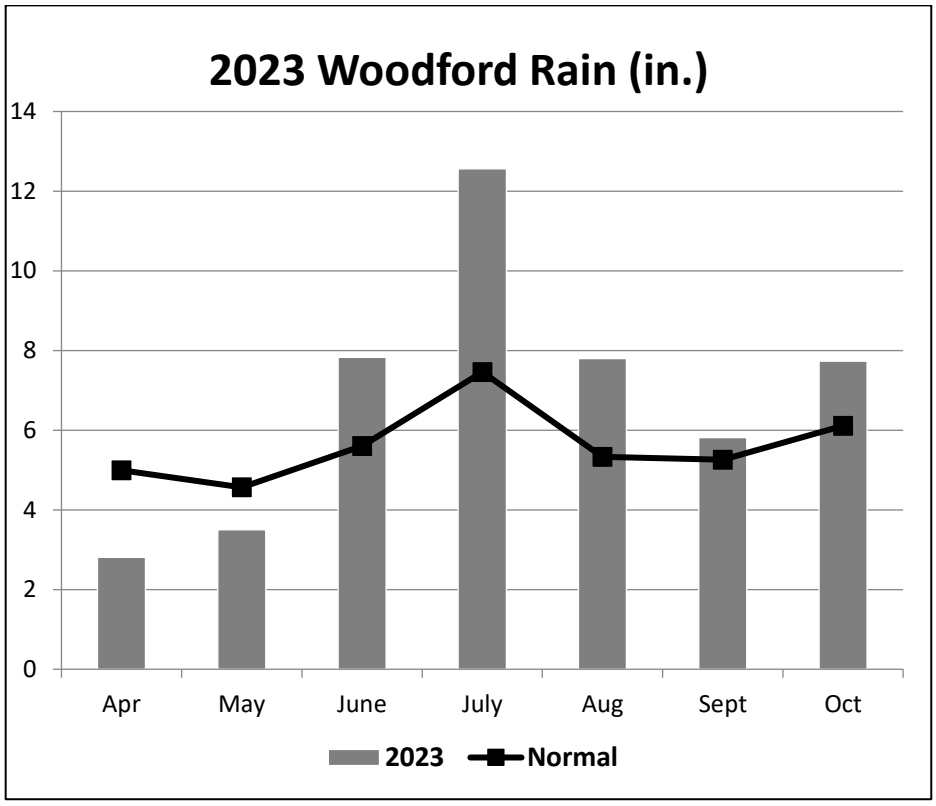

Figure 7. Monthly rainfall amounts (in inches) at the fire weather observation station in Woodford, Vermont during the fire season, April-October 2023. Normal is based on 11 years of data.

PHENOLOGY

2023 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. With higher April temperatures than 2022, budbreak occurred two weeks earlier (April 20) than the previous year and 13 days earlier than the long-term average. Similarly, full leaf-out occurred on May 12, six days earlier than in 2022 (**Figure 8 and Figure 9**). Some heavy flowering was noted in 2023 but following the stress of a late spring frost on May 17-18, little seed was produced.

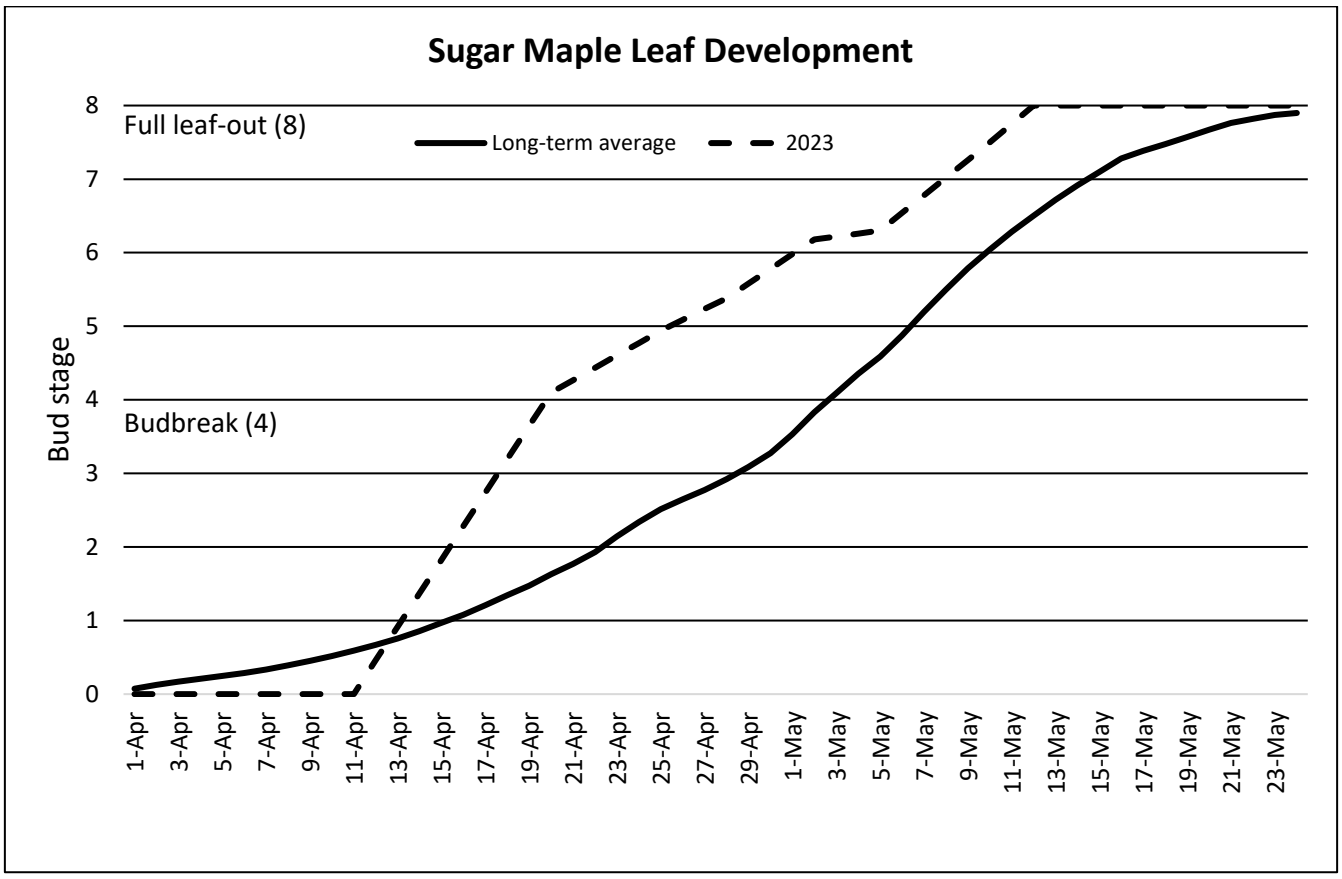

Figure 8. Sugar maple budbreak and leaf-out at Proctor Maple Research Center, Underhill, VT.

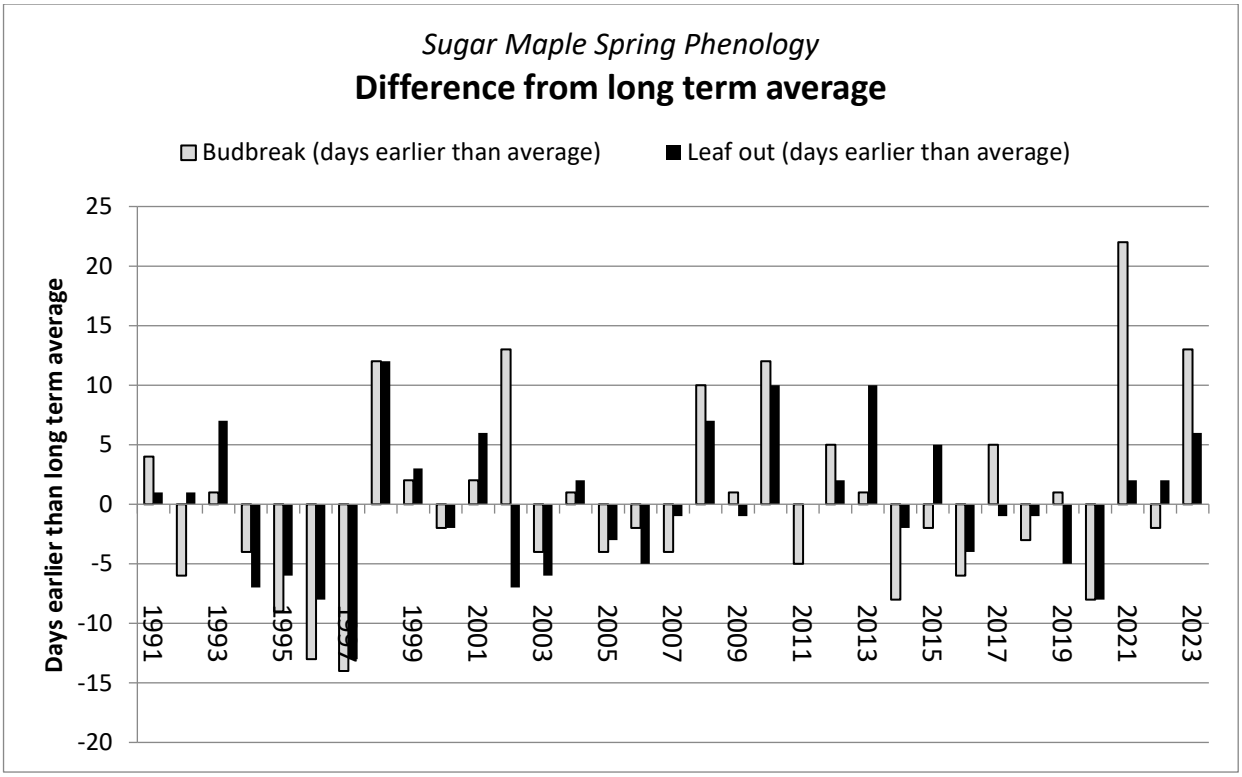

Figure 9. Difference from long-term average of sugar maple budbreak and leaf out at Proctor Maple Research Center, Underhill, VT.

Fall Color Monitoring at Mount Mansfield

Trees at three elevations in Underhill at the base of Mount Mansfield were monitored for the timing of peak fall color and leaf drop (**Figure 10a-10f**). 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.

Peak color for all species at all elevations was similar to the long-term average, with the exception of red maples (male) at 1400', which occurred two weeks later than the average (**Table 1**). At the two lower elevations, leaf-drop occurred slightly later than the long-term average, while at 2600' trees dropped leaves slightly earlier than the average. The growing season length for sugar maples at 1400' was longer than the average (**Table 3Table *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. The most recent ten years of data are displayed, while the long-term average is computed using the full dataset (1991-2023).) and resulted in a continuation of the trend in a lengthening growing season over the 33-year record for the site (**Figure 11**).

Figure 10. Timing of fall color (**Figures 10a-10f**) and leaf drop was monitored at three elevations on Mount Mansfield in 2023: 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.

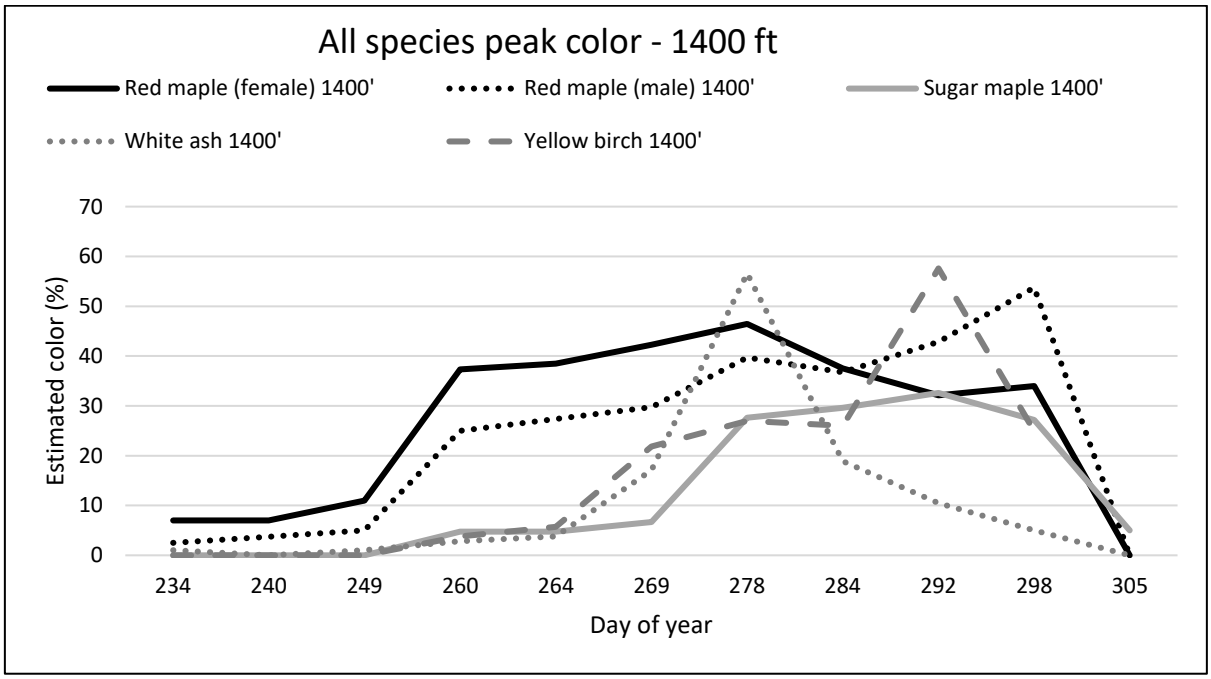

Figure 10a.

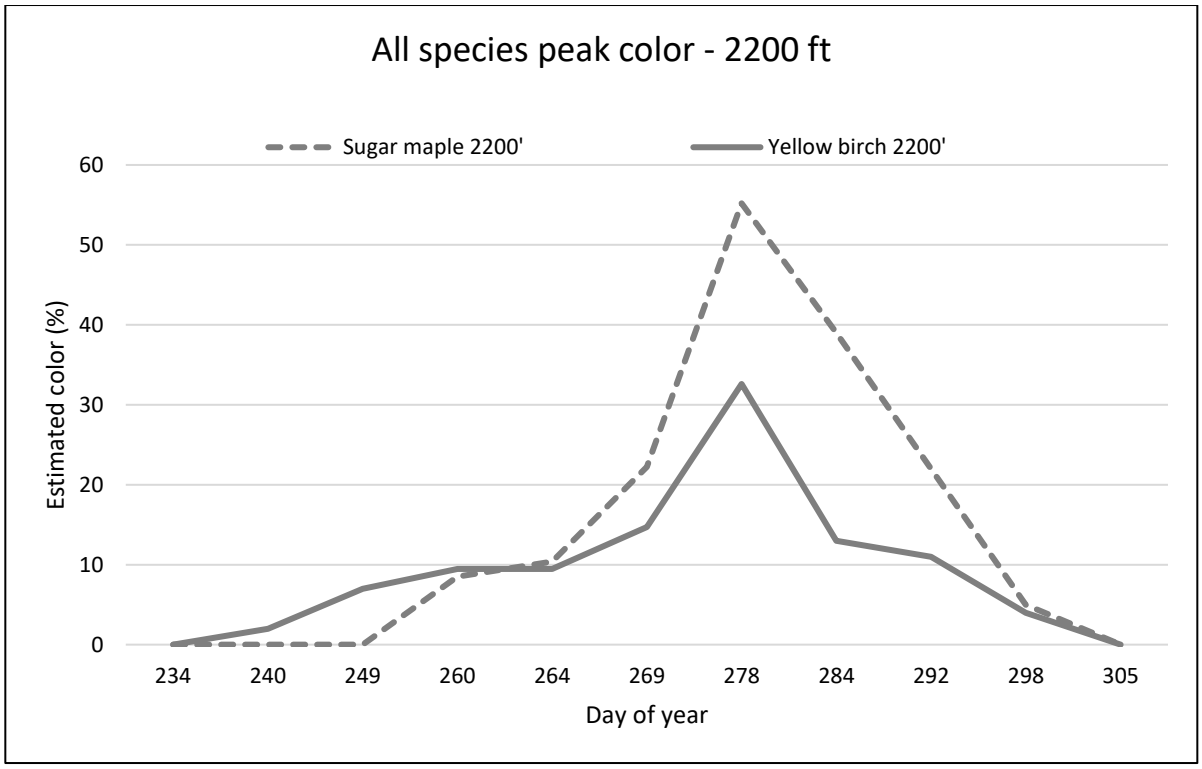

Figure 10b.

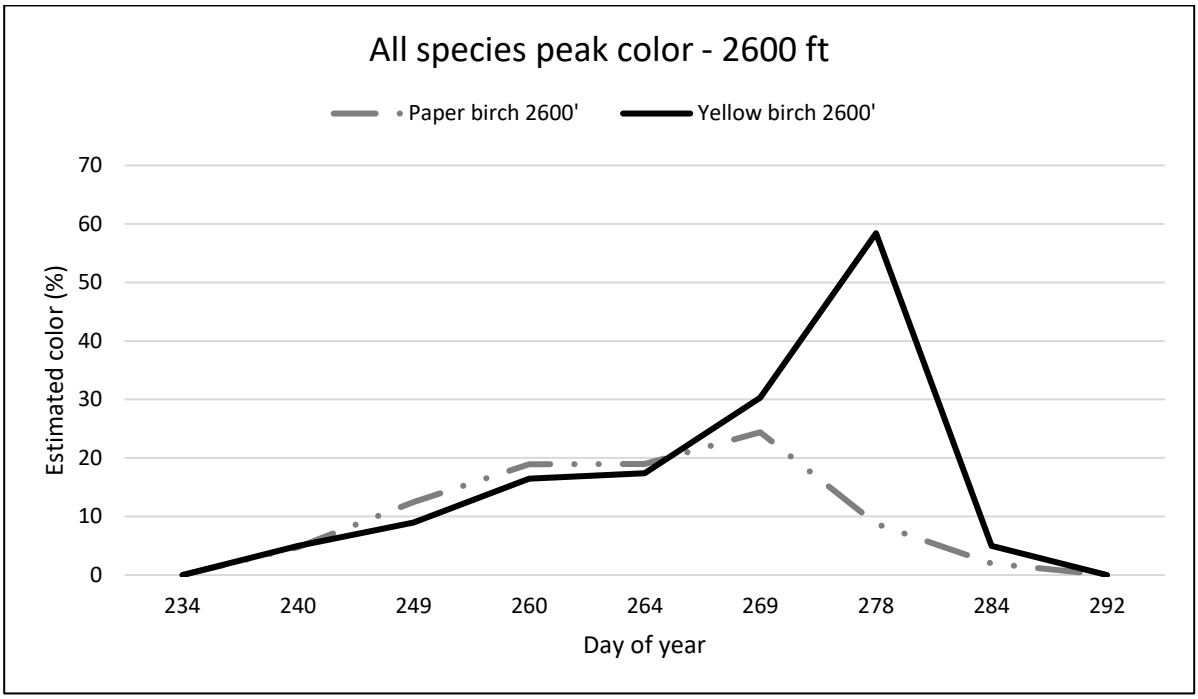

Figure 10c.

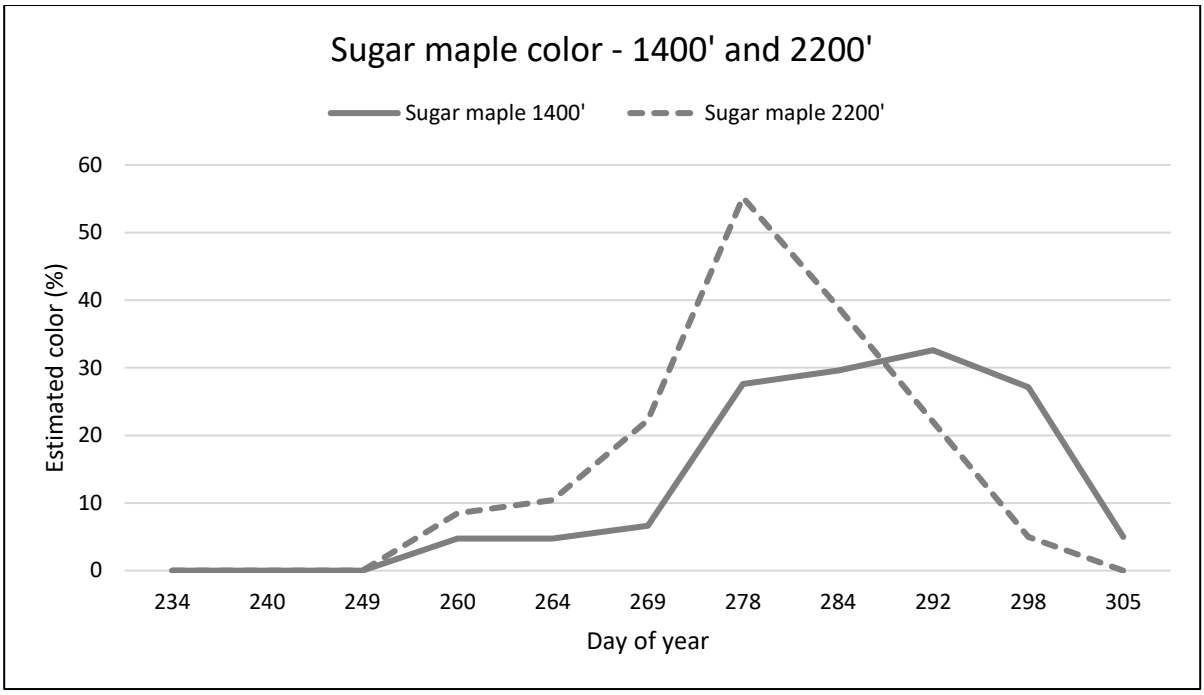

Figure 10d.

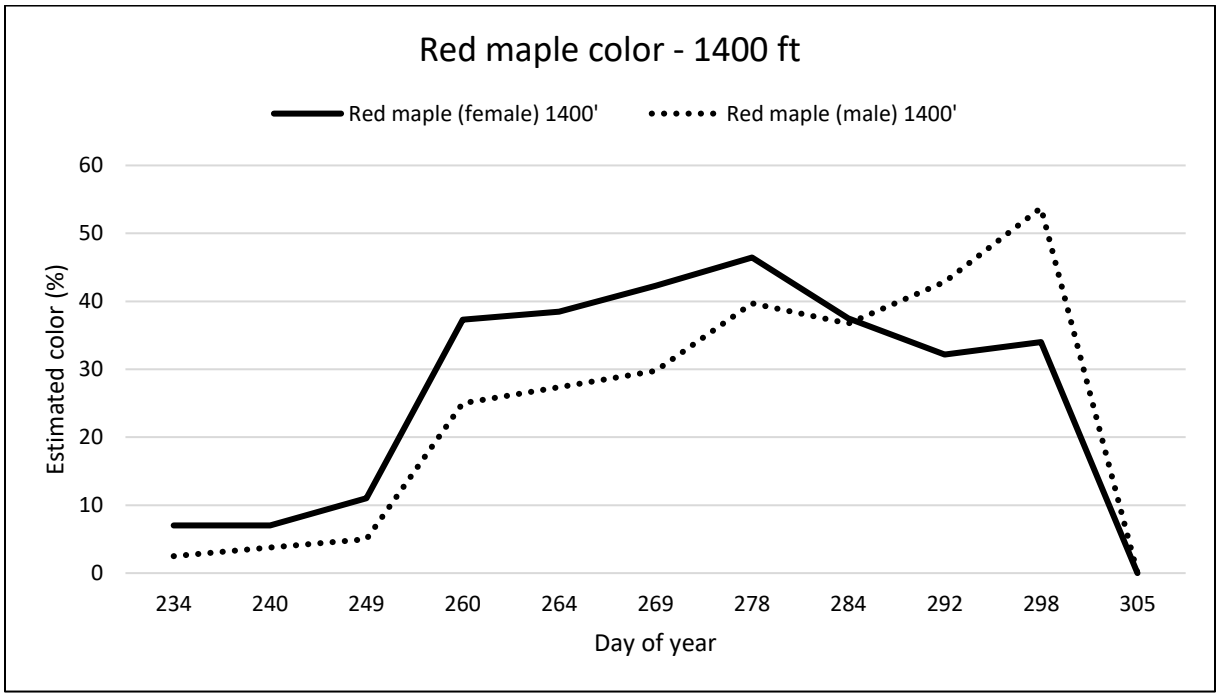

Figure 10e.

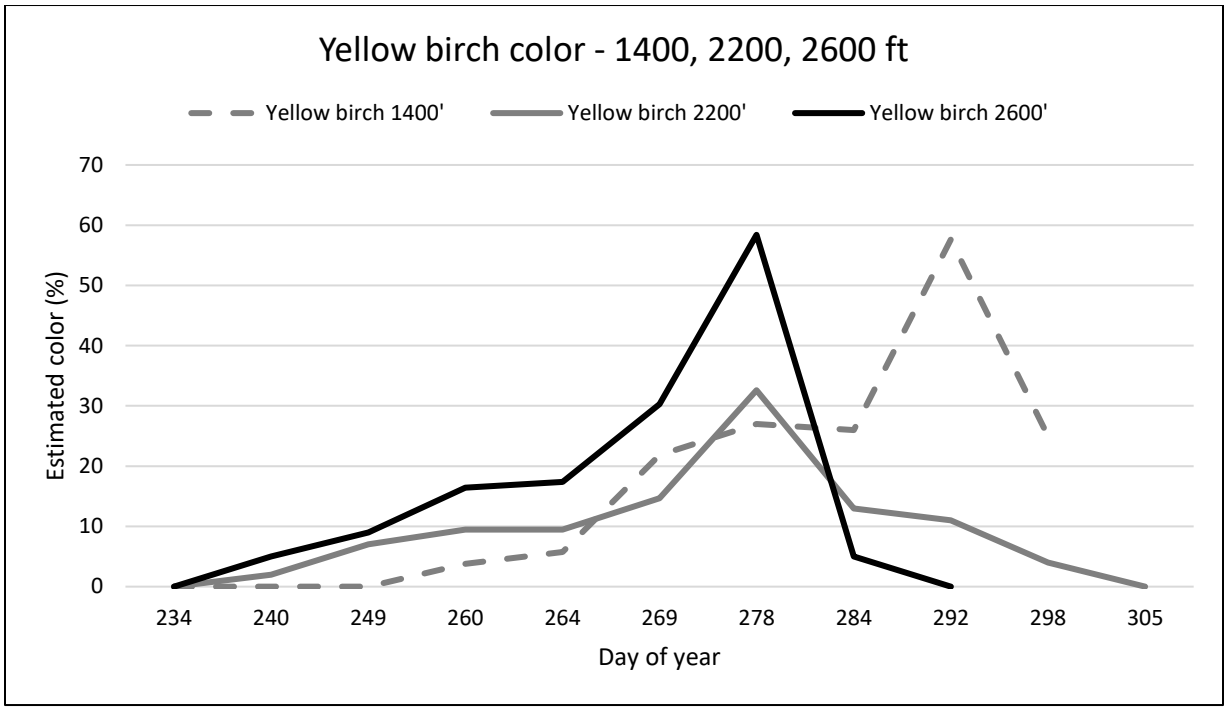
Yellow birch color - 1400, 2200, 2600 ft
Yellow birch 1400'
Yellow birch 2200'
Yellow birch 2600'
Estimated color (%)
70
60
50
40
30
20
10
0
234
240
249
260
264
269
278
284
292
298
305
Day of year

Figure 10f.

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 24-year record, red maple, and white ash a 28-year record, sugar maple at 1400 ft a 32-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)	2023 data (Day of year)
Elevation 1400'		
Red maple (Female)	282	278
Red maple (Male)	284	298
Sugar maple	287	292
Yellow birch	285	292
White ash	279	278
Elevation 2200'		
Sugar maple	278	278
Yellow birch	276	278
Elevation 2600'		
Yellow birch	276	278
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 2023, 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)	2023 data (Day of year)
Elevation 1400'		
Red maple	299	304
Red maple	300	305
Sugar maple	303	305
Yellow birch	298	304
White ash	296	298
Elevation 2200'		
Sugar maple	295	298
Yellow birch	292	298
Elevation 2600'		
Yellow birch	289	284
Paper birch	286	282

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. The most recent ten years of data are displayed, while the long-term average is computed using the full dataset (1991-2023).

Year	Date of Bud break	Date of End of Growing Season	Length of growing season (days)
2013	3-May	15-Oct	165
2014	12-May	20-Oct	161
2015	6-May	30-Oct	177
2016	9-May	31-Oct	175
2017	29-Apr	29-Oct	183
2018	7-May	30-Oct	176
2019	3-May	26-Oct	176
2020	11-May	24-Oct	167
2021	12-Apr	4-Nov	206
2022	5-May	27-Oct	175
2023	20-Apr	1-Nov	195
Long term Average (1991-2023)	**3-May**	**23-Oct**	**173**

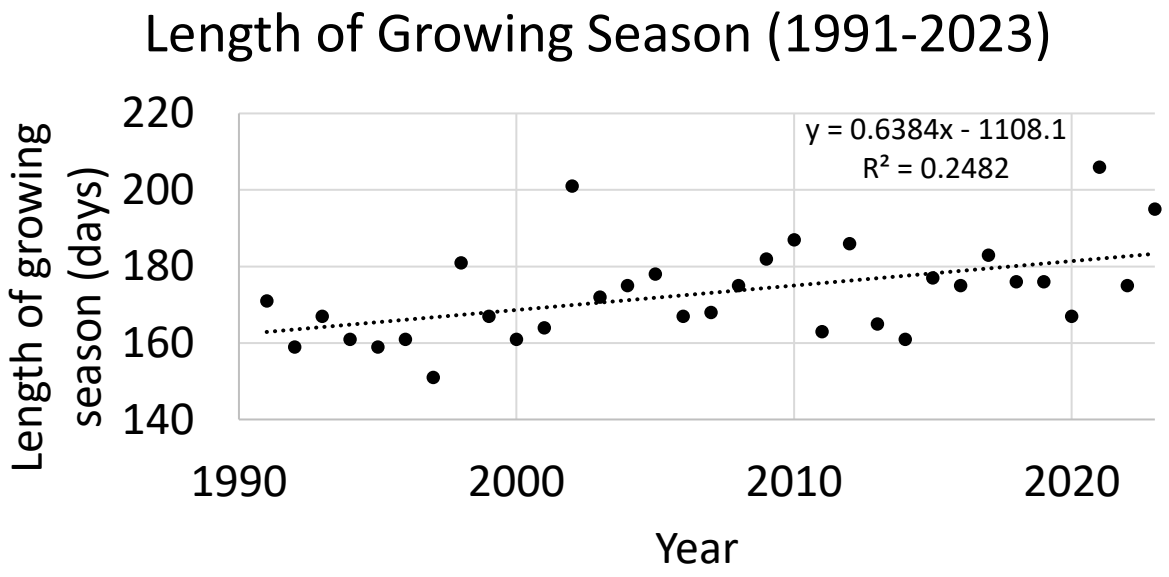

Figure 11. Trend in growing season length at Proctor Maple Research Center, Underhill, VT. Start and end of the growing season are defined as date of sugar maple budbreak and full leaf-drop at 1400'.

FOREST INSECTS

HARDWOOD DEFOLIATORS

Elm zigzag sawfly (EZS), *Aproceros leucopoda*, is an invasive hardwood defoliator of elms that was observed for the first time in Vermont in 2023. This pest causes a zig-zag pattern on leaves and can cause complete defoliation when populations are high. Initial confirmation came from samples located in the Missisquoi National Wildlife Refuge in Swanton, Vermont. Since then, additional evidence of feeding has been noted in Alburg, Burlington, Colchester, Essex, Highgate, Milton, North Hero, Sheldon, and South Hero.

EZS is a relatively new pest to the United States, now present as far south as Virginia. Research into the species' phenology, biology and management is ongoing. Monitoring will continue in Vermont to determine the extent of its distribution.

Forest tent caterpillar (FTC), *Malacosoma disstria*, is a native hardwood defoliator of sugar maple, poplars, oaks, and other hardwoods. In 2023, no reports of defoliation were received, nor were incidental observations or defoliation recorded by aerial detection surveys. Twenty-one sites, totaling 63 traps, were deployed in 2023 to assess current FTC populations and gauge the risk of defoliation in 2024. The average number of moths per trap declined again this year (0.0 moths/trap) from the already low number observed in 2022 (0.15 moths/trap; **Figure 12**, **Table 4**).

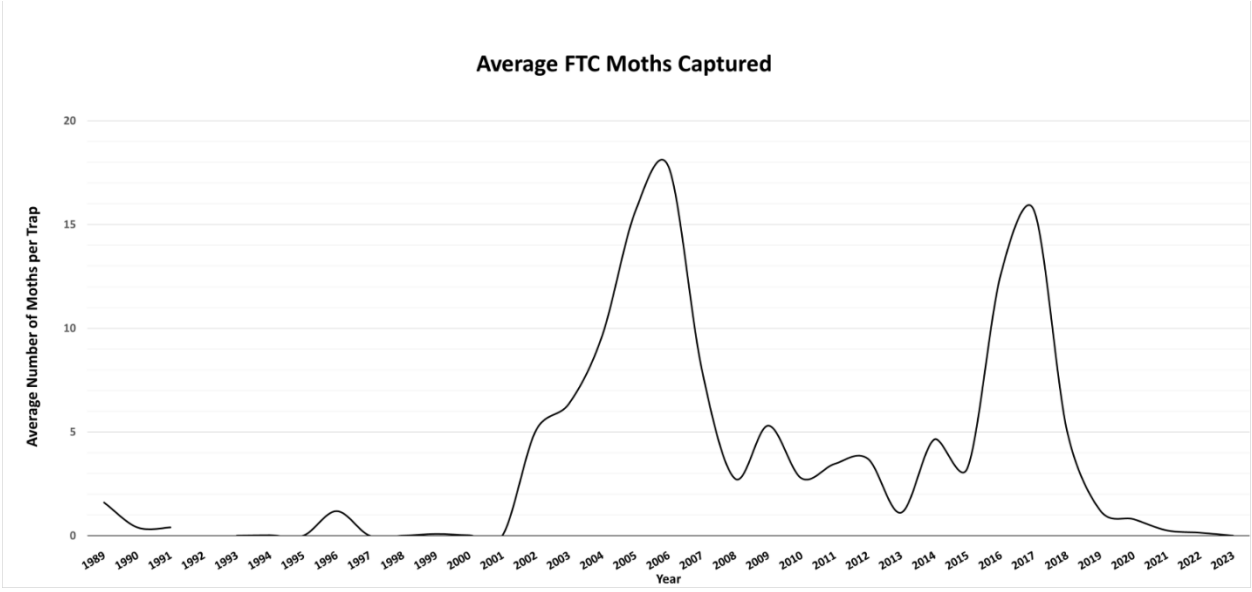

Figure 12. Average number of forest tent caterpillar moths caught in pheromone traps 1999-2023. Populations were not monitored in 1992. Three multi-pher pheromone traps per site, with PheroTech lures, were used in 2023.

Table 4. Average number of forest tent caterpillar (FTC) moths caught in pheromone traps, 2007-2023. Three multi-pher traps baited with PheroTech lures were deployed at each of the 21 survey locations.

County and Town	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Rutland Castleton	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	0.0	0.0
Franklin Fairfield	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	0.0	-
Chittenden Huntington	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	0.0	0.0
Chittenden Sherburne	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	0.0	0.0
Bennington 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	0.0	0.0
Windsor Rochester	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	0.0	0.0
Washington Roxbury	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	0.0	0.0
Chittenden Underhill (SB 2200)	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	0.0	0.0
Chittenden Underhill (VMC 1400)	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	0.0	0.0
Chittenden Underhill (VMC 2200)	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	0.0	0.0
Washington Waterbury	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	0.5	0.0
Lamoille Waterville	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	1.5	0.0
Lamoille Stowe	5.0	1.3	1.7	0.7	2.0	2.3	1.3	1.7	-	-	-	-	-	-	-	-	-
Franklin Montgomery	-	-	-	-	-	-	-	-	1.0	4.3	18.0	4.3	0.0	0.0	0.0	0.0	-
Orange Vershire	-	-	-	-	-	-	-	-	-	-	-	-	1.7	0.3	0.0	0.0	0.0
Windham Wilmington	-	-	-	-	-	-	-	-	-	-	-	-	2.7	4.7	0.0	0.0	0.0
Windham Westminster	-	-	-	-	-	-	-	-	-	-	-	-	0.7	0.0	0.0	-	-
Woodstock Windsor	-	-	-	-	-	-	-	-	-	-	-	-	1.0	2.0	.7	0.0	0.0
Addison Lincoln	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.0	0.0	0.0	0.0
Orleans Irasburg	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.7	1.3	0.5	0.0
Orleans Glover	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.0	0.0	0.0	0.0
Essex Norton	-	-	-	-	-	-	-	-	-	-	-	-	8.3	4.0	1.7	0.0	0.0
Caledonia Kirby	-	-	-	-	-	-	-	-	-	-	-	-	1.0	0.3	0.3	0.0	0.0
Bennington Rupert	-	-	-	-	-	-	-	-	-	-	-	-	1.3	0.7	1.3	0.0	0.0
Franklin Sheldon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0
Average	**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**	**0.2**	**0.0**

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 27,791 acres of mapped damage. In 2022, observable damage decreased dramatically across the state, with only 1,557 acres of damage mapped. Little defoliation from MLC was reported in 2023, and no defoliation was observable during aerial detection surveys.

Saddled prominent (SP), *Heterocampa guttivitta,* are native hardwood defoliators that commonly feed on sugar maple, beech, and other hardwoods. Unlike other pests we monitor, SP populations do not follow a typical outbreak cycle, with populations reaching outbreak levels sporadically, and then crashing within 1-3 years. Increased reports of defoliation during the growing season of 2020 led to reestablishing trapping efforts in 2021. To track population outbreaks, pheromone traps for SP were deployed statewide in late spring at nine sites. The number of moths per trap averaged 0.57, a decrease from the 2.15 moths per trap in 2022 (**Figure 13**, **Table 5**).

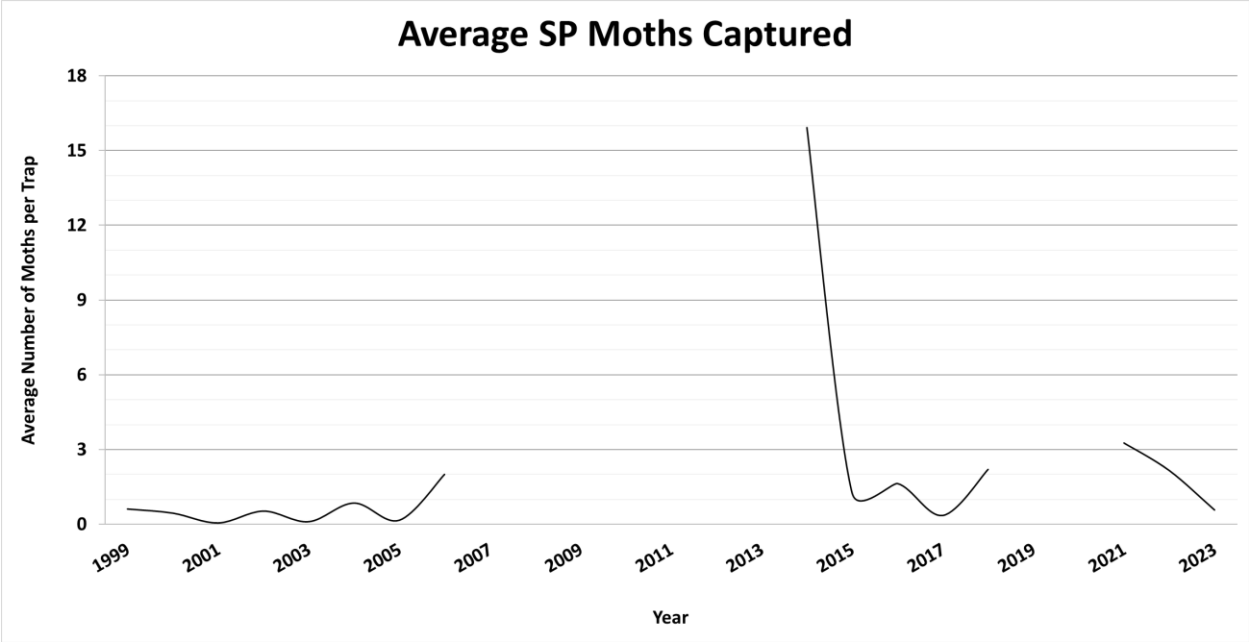

Figure 13. Average number of saddled prominent moths caught in 9 pheromone traps 1999-2023. Populations were not monitored 2007-2013 and 2019-2020. Three multi-pher pheromone traps per site, with aPhinity SP lures, were used in 2023.

Table 5. Average number of saddled prominent moths caught in pheromone traps, 1999-2023. Three multi-pher traps baited with aPhinity SP lures, were deployed at each of the 9 survey locations in 2023.

County and Town	1999	2000	2001	2002	2003	2004	2005	2006	2014	2015	2016	2017	2018	2021	2022	2023
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	0.5	0..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	0.3	0.3
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	11.3	1.3
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	1.3	0.0
Chittenden Bolton	2.0	1.0	0.3	0.0	0.0	0.3	0.7	5.3	31.0	1.7	-	-	-	1.7	0.0	0.0
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	2.0	0.5
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	0.3	0.0
Windsor Weathersfield	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-
Franklin Sheldon	-	-	-	-	-	-	-	-	-	6.0	5.3	0.7	4.7	-	-	2.7
Franklin Montgomery	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	2.0	-
Caledonia Walden	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	1.0	0.3
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**	**2.2**	**0.6**

Spongy moth, *Lymantria dispar*, caterpillars were responsible for the largest disturbance to Vermont forests in 2021 and 2022, with populations crashing dramatically in 2023 (Figure 14). This most recent outbreak began with more than 50,000 acres of defoliation in 2021, followed by defoliation of 42,797 acres in 2022, and only 98 acres in 2023. Spongy moth egg mass surveys from our 9 long-term monitoring plots resulted in lower counts than in 2022 with an average of 0.5 egg masses per 1/25-acre plot, compared to 62.1 egg masses per 1/25-acre plot in 2022 (**Figure 14**).

A wet spring and high population counts allowed the activity of the fungus *Entomophaga maimaiga* and the nuclear polyhedrosis virus to increase and resulted in notable caterpillar mortality, which may help explain the reduction in acres defoliated, and 2023 egg mass counts. During this outbreak, defoliation was primarily mapped in the Champlain Valley of western Vermont, although a small number of locations in the Connecticut River Valley (eastern Vermont) were mapped as well. As expected, oak species suffered most of the defoliation, but other hardwoods were also affected.

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

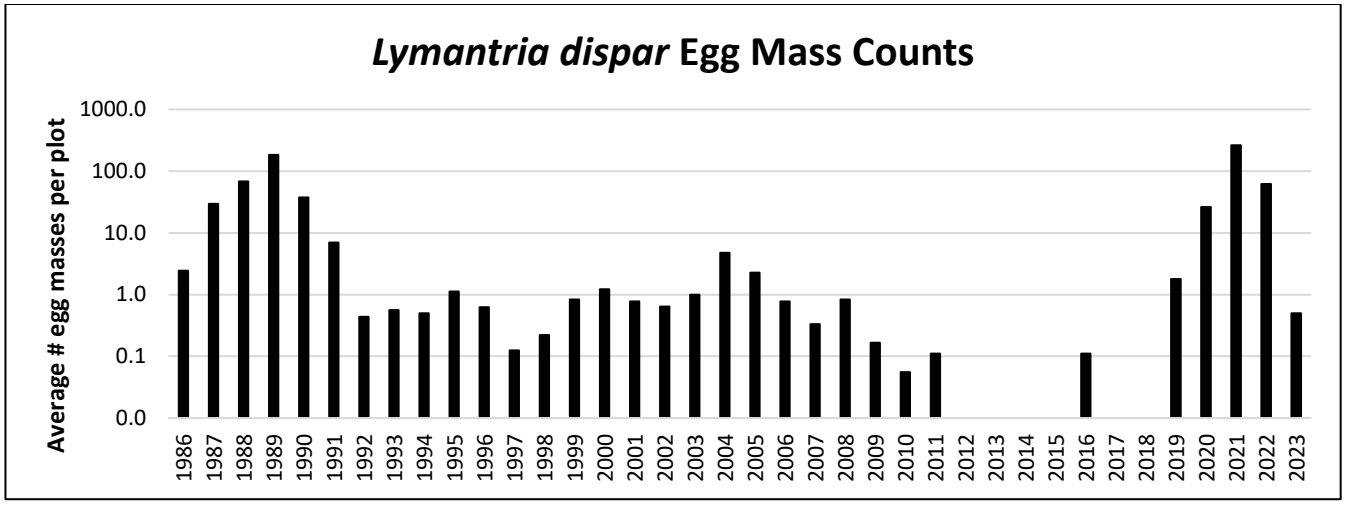

Figure 14. Number of spongy moth egg masses per 1/25th acre in focal area monitoring plots, 1987-2023. Data reflect the average egg mass counts from nine locations, with two 15-meter diameter plots per location containing burlap-banded trees.

OTHER HARDWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
	Anomala marginata	Many		Observed as bycatch in trap catch.
Baltimore bomolocha	*Hypena baltimoralis*	Maples		Observed as bycatch in trap catch.
Banded tussock moth	*Halysidota tessellaris*	Many	Statewide	Observed as bycatch in trap catch.
Basswood leafroller moth	*Pantographa limata*			Observed as bycatch in trap catch.
Birch leaf miner	*Messa nana, Fenusa pusilla*, and others	Birch	Northeastern Vermont	
Birch skeletonizer	*Bucculatrix canadensisella*	Birch	Northeastern Vermont	
Brown angle shade	*Phlogophora periculosa,*	Alder		Observed as bycatch in trap catch.
Brown-tail moth	*Euproctis chrysorrhoea*	Hardwoods		Not observed or known to occur in Vermont.
Easterntent caterpillar	*Malacosoma americanum*	Cherry and apple	Widely scattered	Populations remain low.
Elm zigzag sawfly	*Aproceros leucopoda*	Elm		*See narrative.*
Euonymus Caterpillar	*Yponomeuta cagnagella*	Euonymus	Montpelier, VT	
Fall webworm	*Hyphantria cunea*	Hardwoods, especially cherry and ash	Statewide	
Forest tent caterpillar	*Malacosoma disstria*	Hardwoods	Statewide	*See narrative.*
Green-striped mapleworm/ rosy maple moth	*Dryocampa rubicunda*	Sugar maple	Statewide	Larvae occasionally observed, often in association with saddled prominent.

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Imported willow leaf beetle	*Plagiodera versicolora*	Willow	Franklin County	
Isabella tiger Moth	*Pyrrharctia isabella*	Hardwoods	Statewide	
Japanese beetle	*Popillia japonica*			Observed in gardens, but tree injury not reported in 2023.
Maple looper moth	*Parallelia bistriaris*	Many		Observed as bycatch in trap catch.
Maple leafcutter moth	*Paraclemensia acerifoliella*	Sugar maple, occasional yellow birch and beech	Statewide	*See narrative.*
Maple trumpet skeletonizer moth	*Catastega aceriella*	Sugar maple	Statewide	Occasionally observed, but negligible damage.
Oblique banded leaf roller	*Choristoneura rosaceana*	Many	Statewide	Observed as bycatch in trap catch.
Pale tussok moth	*Halysidota tessellaris*	Many		Observed as bycatch in trap catch.
Saddled prominent moth	*Heterocampa guttivata*	Sugar maple	Widely scattered;	*See narrative.*
Spongy moth	*Lymantria dispar*	Hardwoods	Statewide	*See narrative* . Also observed as bycatch in trap catch.
Straw besma	*Besma endropiaria*	Sugar maple		Observed as bycatch in trap catch.
Winter moth	*Operophtera brumata*	Hardwoods		Not observed or known to occur in Vermont.
Variable Zanclognatha	*Zanclognatha laevigata*	Hardwoods		Observed as bycatch in trap catch.

Hardwood defoliators not reported in 2023 include: *Acleris cornana;* Aspen petiole gall moth, *Ectoedemia populella;* Angulose prominent caterpillar, *Peridea angulosa;* Biltmore checkerspot, *Euphydryas phaeton;* Cherry scallop shell moth, *Rheumaptera prunivorata;* Curve-toothed geometer

moth*, Eutrapela clemataria;* Definite tussock moth, *Orgyia definite,* Dogwood sawfly*, Macremphytus tarsatus;* Dotted leaftier moth*, Psilocorsis reflexela;* Friendly Proble, *Probole amicaria;* Harris' three spot*, Harrisimemna trisignata*; Hickory tussock moth, *Lophocampa caryae;* Luna moth, *Actias luna; Mimosa webworm,* Homadaula anisocentra; Mountain ash sawfly, Pristiphora geniculate; Oak shothole leafminer, *Japanagromyza viridula;* Pink underwing*, Catocala concumbens,* Pink-striped Oakworm*, Anisota virginiensis;* Sharp-angled carpet*, Euphyia intermediate,* Ultronia underwing*, Catocala ultronia;* Viburnum leaf beetle*, Pyrrhalta viburni.*

SOFTWOOD DEFOLIATORS

Spruce budworm (SBW), *Choristoneura fumiferana*, are native softwood defoliators of fir, spruce and occasionally larch, pine, and hemlocks. In consecutive years of severe outbreaks, trees may experience complete defoliation which can lead to dieback and mortality of infested hosts. In 2023, SBW moth trap catches in Vermont decreased to 9.6 moths per trap, following a historic count of 99.3 moths per trap in 2022. (**Figure 15**, **Table 6**).

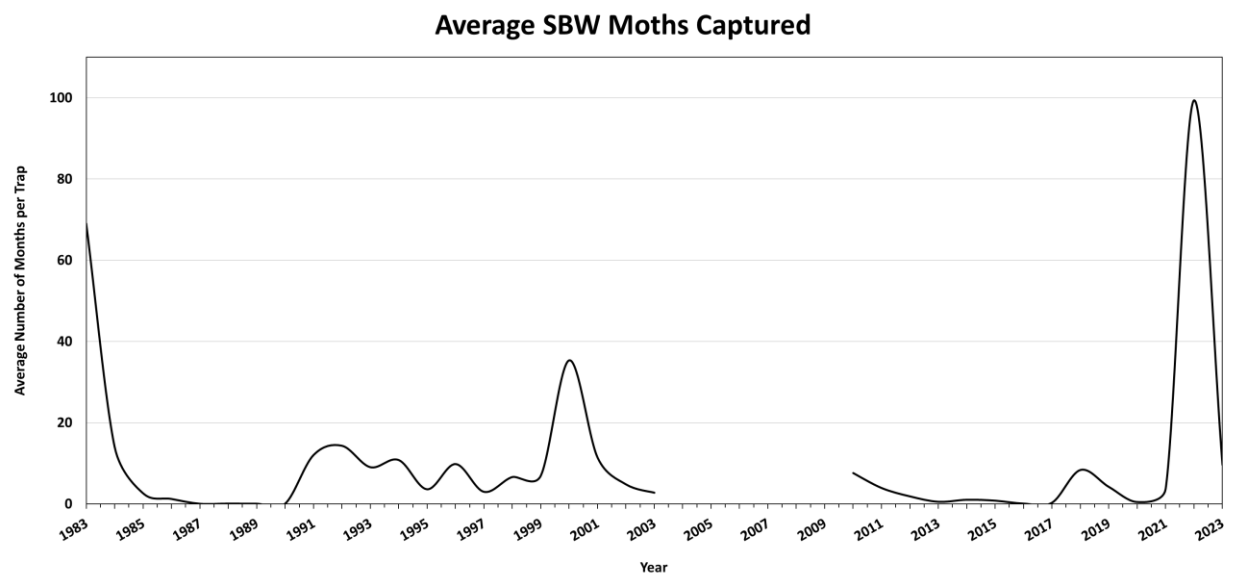

Figure 15. Average number of spruce budworm moths caught in pheromone traps 1983-2023. Trapping was discontinued, 2004-2009. Average of seven locations in 2023. Three multi-pher pheromone traps per site, with aPhinity SBW lures, were used in 2023.

Table 6. Average number of spruce budworm moths caught in pheromone traps, 2010-2023. There were three traps per location, one location per town, in 2023.

County and town	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Essex Norton	5.7	1.0	1.3	0.7	0.0	0.3	0.3	0.3	6.0	1.3	0.0	8.0	58.7	5.3
Orleans Holland	7.3	8.0	1.0	0.7	1.7	1.3	0.0	0.3	9.0	1.0	0.0	5.0	141.7	15.0
Caledonia Walden	6.7	1.0	0.7	0.0	0.3	1.0	0.0	0.0	4.0	3.3	0.3	2.5	64.7	9.7
Essex Lewis	4.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.3	0.0	0.5	22.3	2.0
Chittenden Underhill	19.0	11.3	8.0	1.3	3.7	1.7	0.0	1.0	26.3	18.3	1.7	2.3	233.7	27.3
Caledonia Sutton	4.0	1.7	0.0	0.3	0.3	0.3	0.0	-	2.0	0.7	0.7	2.5	38.3	3.7
Essex Victory	-	-	-	-	-	-	-	-	-	-	-	5.0	136.0	4.0
Average	**7.6**	**3.9**	**1.8**	**0.5**	**1.0**	**0.8**	**0.1**	**0.3**	**8.3**	**4.2**	**0.4**	**3.7**	**99.3**	**9.6**

OTHER SOFTWOOD DEFOLIATORS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Eastern spruce budworm	*Choristoneura fumiferana*	Balsam fir and spruce	Northern Vermont	*See narrative.*
Graymspruce looper moth	*Caripeta divisata*	Spruce, fir, hemlock		Observed as bycatch in trap catch.
Hemlock looper	*Lambdina fiscellaria*	Hemlock	Southern Vermont	Observed as bycatch in trap catch.

Softwood defoliators not reported in 2023 included arborvitae leafminer, *Argyresthia thuiella* ; balsam fir sawfly, *Neodiprion abietis;* European pine sawfly, *Neodiprion sertifer;* introduced pine sawfly, *Diprion similis* ; larch caseberer, *Coleophora laricella;* larch sawfly, *Pristiphora erichsonii* ; pine false webworm, *Acantholyda erythrocephala* ; rusty tussock moth, *Orygia antigua* ; yellow-headed spruce sawfly, *Pikonema alaskensis* ; spruce needleminer, *Taniva albolineana* ; webspinning sawfly, *Pamphiliidae* ; white pine sawfly, *Neodiprion pinetum*.

SAPSUCKING INSECTS, MIDGES, AND MITES

Balsam woolly adelgid (BWA), *Adelges piceae*, has been reported in all VT counties, with continued public reports in 2023. During 2023 aerial survey, 400 acres of fir dieback and mortality attributed to BWA were mapped as compared to 3,945 acres mapped in 2022 (**Table 7**). 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 7. Mapped acres of balsam woolly adelgid-related decline 2016-2023. Due to aerial survey restrictions in 2020, no acres were mapped.

County	Acres Mapped							
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Addison	107	0	0	0	X	0	0	0
Bennington	69	0	0	17	X	0	0	5
Caledonia	1,096	412	807	211	X	79	346	261
Chittenden	51	0	0	0	X	0	631	0
Essex	736	20	1,082	0	X	336	475	41
Franklin	59	0	5	0	X	0	1,798	4
Grand Isle	0	0	0	0	X	0	0	0
Lamoille	683	13	188	174	X	15	231	0
Orange	1,101	320	322	53	X	0	6	41
Orleans	518	399	316	252	X	147	132	27
Rutland	240	122	88	0	X	12	0	19
Washington	895	279	561	235	X	0	332	2
Windham	57	4	9	0	X	0	0	0
Windsor	4	72	56	0	X	0	0	0
Total	**5,616**	**1,641**	**3,434**	**942**	X	**589**	**3,945**	**400**

BWA Monitoring Sites: To monitor BWA population levels and further study the link between balsam fir mortality and BWA, a monitoring site was established in Black Turn Brook State Forest, Norton Vermont, in a several hundred-acre stand of balsam fir in the late fall of 2022.

Plot Layout and Metrics: The site was set up using the FIA forest health monitoring protocols to measure tree health. A monitoring site includes 4 subplots with a fixed radius of 24ft. Each subplot contains a microplot that has a fixed radius of 6.8ft and is set 12ft to the east of the subplot center. At each subplot, all species that measured 5in diameter at breast height (dbh) or greater, were tagged and the following information was measured and recorded: azimuth, distance from subplot center, dbh, and crown position. For each balsam fir tagged within a subplot, the following crown metrics were observed and recorded: live crown ratio, vigor, dieback, crown density, foliar transparency, and the number of BWA woolly masses per 8in square. At each microplot, all fir saplings (1in to 5in dbh) are tallied and presence of gout on twigs is noted. Subplots and microplots will be remeasured annually in the late fall, before snowfall, when presence of BWA woolly masses is likely high. In the following years of remeasurement, site information and results will include basal area percentage of live and dead fir, percentage of fir with BWA flocculence including severity, and severity of gout on saplings. Other sites may be added to the monitoring effort as needed.

In 2023, the monitoring site was revisited for the first time and no changes were observed. No new trees died in 2023, there were no tagged fir trees with BWA flocculence of any severity within the subplots, and there was no gout of any severity on any of the fir saplings within the microplots.

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 observed spread into Windsor, a new town along the north leading infestation edge.

No hemlock decline related to HWA was mapped during aerial surveys in 2023.

As of 2023, known infested counties included Windham, Windsor, and Bennington counties. High-risk counties and/or adjoining known infested counties were included in HWA visual surveys including Addison, Orange, and Washington counties. Seven sites in four counties were surveyed (**Table 8**), with a new positive find in Windsor, VT.

Table 8. Sites inspected for the presence of hemlock woolly adelgid (HWA) and elongate hemlock scale (EHS) by visual survey, 2023.

County	Town	Number of Sites	Positive for HWA	Positive for EHS
Addison	Ferrisburgh	1	0	0
Addison	Orwell	1	0	0
Orange	Thetford	1	0	0
Orange	Williamstown	1	0	0
Washington	Berlin	1	0	0
Windsor	Whitingham	1	1	0
Windsor	Windsor	1	1	0
Total	7	7	2	0

Seventy-nine percent of the hemlock woolly adelgids (HWA) examined during the annual winter mortality survey were dead (**Table 9**, **Figure 16**). Winter temperatures were warmer than 2022, however temperature fluctuations in late winter could have contributed to winter mortality by killing otherwise surviving HWA before they could reproduce. We have often found infestations in new locations following years with mild winters and low levels of HWA mortality, a trend evident with the 2023 Windsor confirmation.

Table 9. Assessment of hemlock woolly adelgid winter mortality over the 2022-2023 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	3/21/2023	423	50	373	88.18
Jamaica	3/21/2023	119	11	108	90.76
Townshend	3/21/2023	388	114	274	70.62
Vernon	3/21/2023	391	124	267	68.29

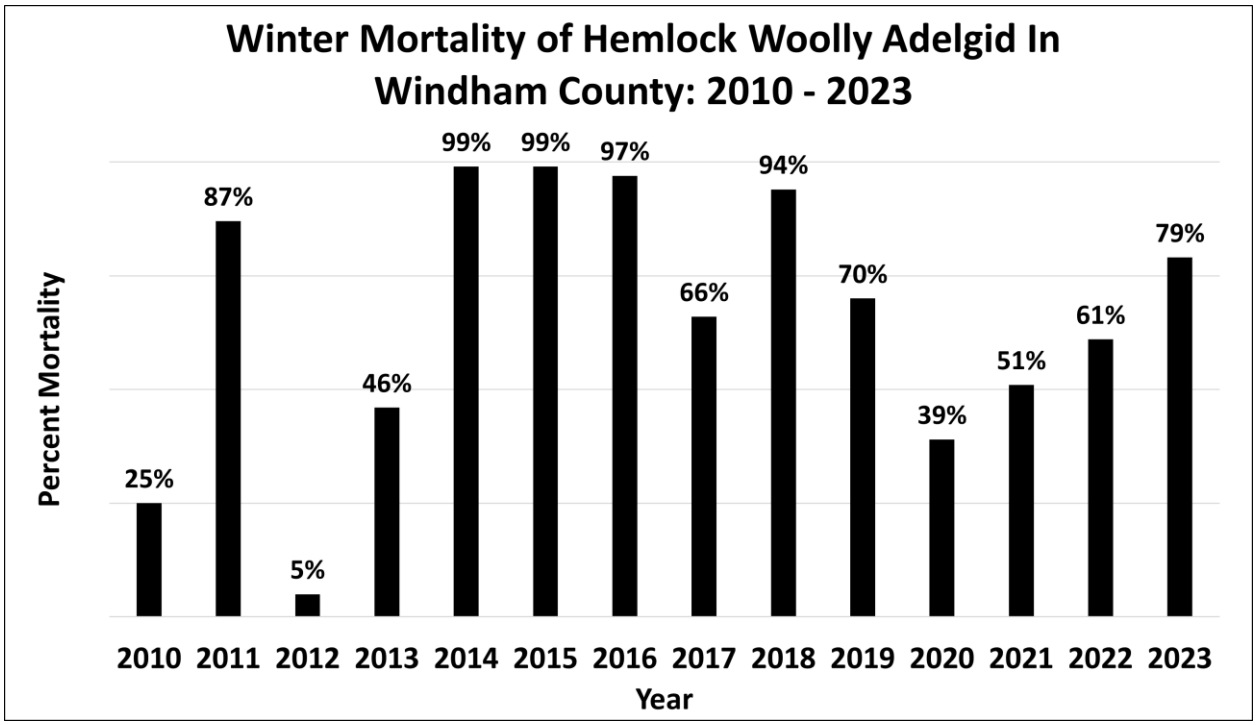

Figure 16. Average overwintering mortality of hemlock woolly adelgid at four sites in Windham County, 2010-2023.

We continue to maintain five HWA impact monitoring plots where HWA is known to be present and impacts of infestation are documented. In 2023, monitoring assessments were done at the Guilford Visitor Center. Diameters were re-measured, and crowns were assessed for live crown ratio, crown density, crown transparency, and crown position.

Biocontrol efforts in 2023 used 377 predatory beetles (*Laricobius nigrinus*) obtained from the rearing laboratory at Virginia Tech, were released at Ft. Dummer State Park in the fall. Follow-up monitoring in winter and spring had no recoveries.

Fifty three percent of the hemlock woolly adelgids (HWA) examined during the third annual summer mortality survey were dead (**Table 10**, **Figure 17**). In these cases, 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. Although low, summer mortality may be supplementing low winter mortality enough to limit the spread of HWA in Vermont, however, more surveys are needed.

Table 10. 2023 assessment of hemlock woolly adelgid summer mortality. Data from 4 assessment sites includes location, date, number of HWA ovisacs collected, number of HWA that were dead (did not break aestivation), number of HWA that were alive, and percent mortality.

Site	Date	Total Number	Number Alive	Number Dead	% Mortality
Brattleboro	11/17/23	440	238	202	45.91
Jamaica	11/17/23	607	212	395	65.07
Townshend	11/17/23	602	382	220	36.54
Vernon	11/17/23	572	192	380	66.43

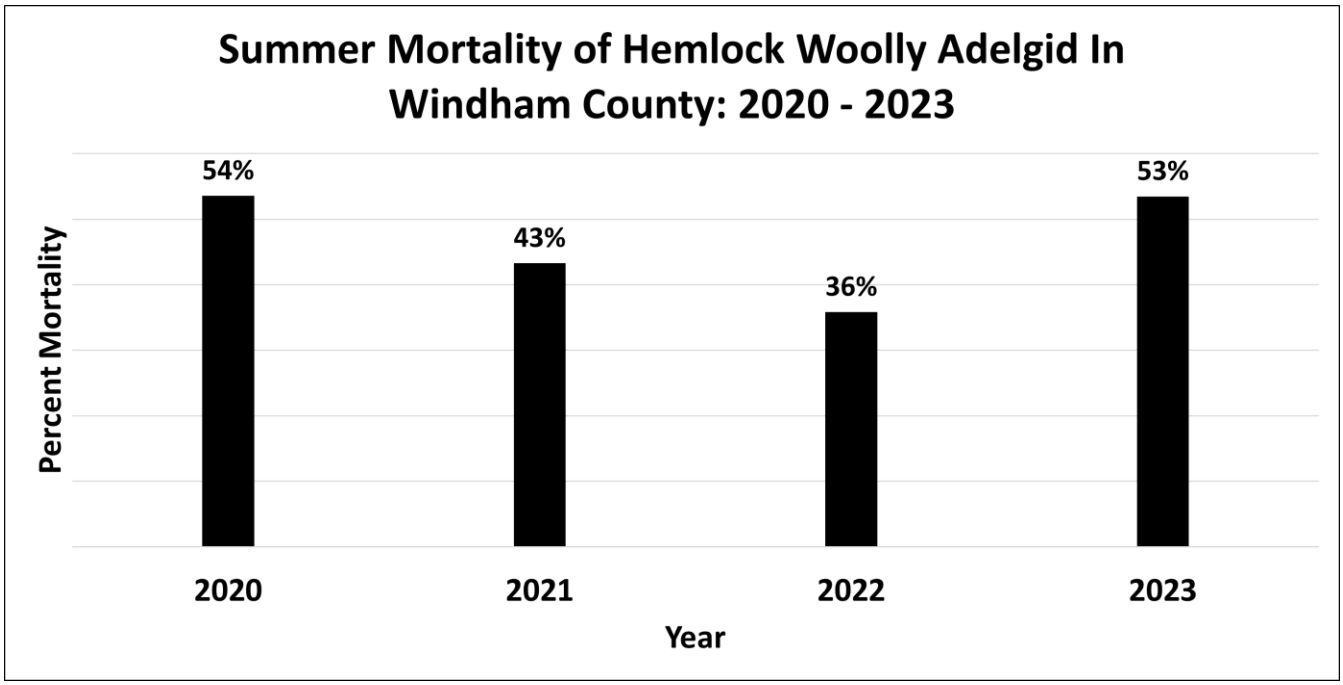

Figure 17. Average summer mortality of hemlock woolly adelgid at four sites in Windham County, 2023. 2020 average is only from one site in Jamacia due to COVID-19 restrictions.

Pear thrips, *Taeniothrips inconsequens*, numbers in our long-term monitoring plot at the Proctor Maple Research Center in Underhill were much lower in 2023 than in recent years. Sticky trap counts totaled 94 (**Table 11.** Pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, VT in 2023. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.), compared to 775 in 2022 (**Figure 18**). Emergence began the week of April 11. No damage was reported throughout Vermont.

Table 11. Pear thrips counts on yellow sticky traps at Proctor Maple Research Center in Underhill, VT in 2023. Sticky traps are deployed in sets of four. Traps are evaluated and replaced each week and monitored throughout pear thrips emergence.

Sample Dates	Counts
4/4-4/11	0
4/11-4/20	47
4/20-4/28	18
4/28-5/5	5
5/5-5/10	10
5/10-5/19	7
5/19-5/26	7
5/26-6/1	0
Total	**94**

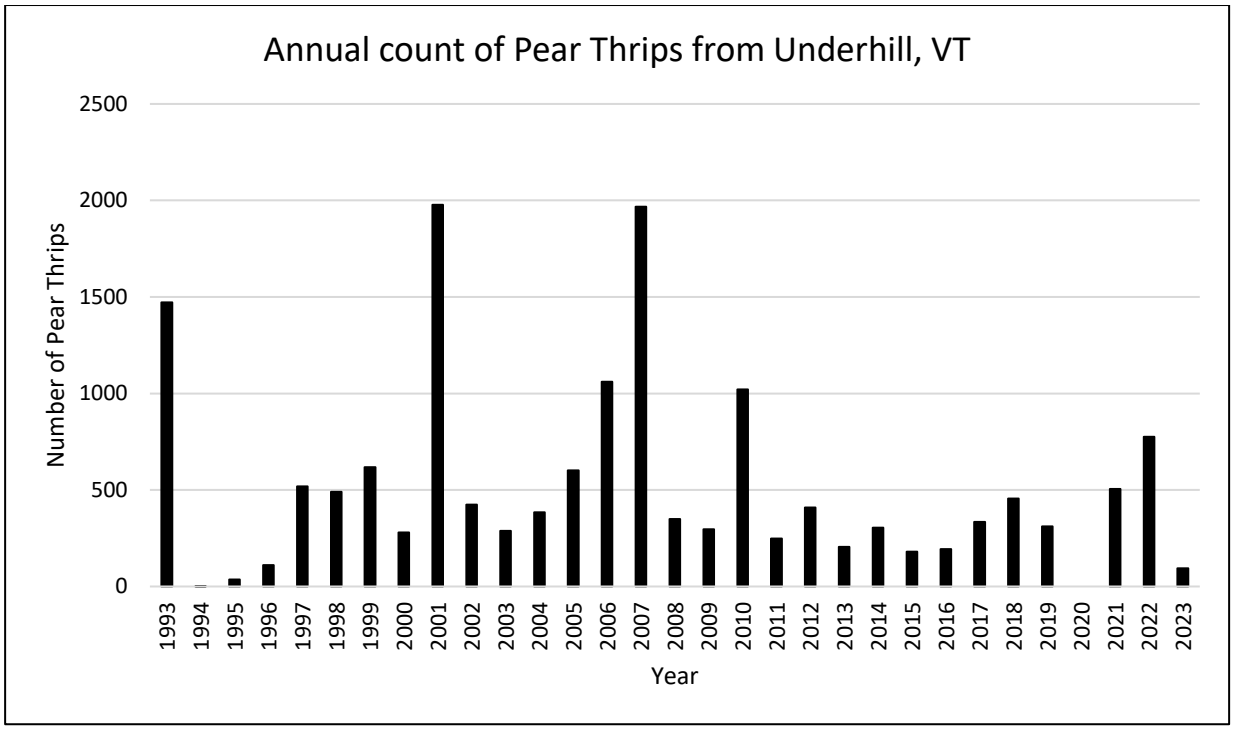

Figure 18. Total number of pear thrips collected at Proctor Maple Research Center in Underhill, VT on sets of four sticky traps, 1993-2023. Data were not collected in 2020 due to COVID-19 restrictions.

OTHER SAPSUCKING INSECTS, MIDGES, AND MITES

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Aphids	Aphididae	Many hosts	Statewide	
Balsam woolly adelgid	*Adelges piceae*	Balsam and Fraser fir	Northern Vermont	*See narrative.*
Beech scale	*Cryptococcus fagisuga*	Beech	Statewide	*See Beech Bark Disease narrative.*
Boxelder bug	*Leptocoris trivittatus*	Boxelder	Widely scattered	
Crimson erineum mite	*Aceria elongata*	Sugar maple	Widely scattered	
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
Eriophyidae mites	*Eriophyidae*	Many	Widely scattered	
Hemlock woolly adelgid	*Adelges tsugae*	Hemlock	Southern Vermont	*See narrative.*
Magnolia Scale	*Neolecanium cornuparvum*	Magnolia	Windsor and Addison Counties	
Oak vein pocket midge			Westminster	
Pear thrips	*Taeniothrips inconsequens*	Maples and beech	Statewide	*See narrative.*
Pine bark adelgid	*Pineus strobi*	White pine	Widely scattered	Light population.
Pine needle scale	*Chionaspis pinifoliae*	Hemlock and red pine	Widely scattered	*See Red Pine Decline and Mortality Narrative.*
Red pine scale	*Matsucoccus resinosae*	Red pine		Not observed in Vermont. Also see *Red Pine Decline and Mortality narrative.*

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Spider mites	*Tetranychidae*	Many	Widely scattered	
Spotted lanternfly	*Lycorma delicatula*	Many hosts	Multiple single reports.	No infestations observed in Vermont.

Sapsucking Insects, Midges and Mites that were not reported in 2023 include: ash flower gall, *Aceria fraxiniflora;* ash leafcurl aphids*, Prociphilus fraxinifolii;* Balsam twig aphid*, Adelges piceae;* Bark lice*, Psocidae;* beech blight aphid, *Grylloprociphilus imbricator;* Hickory leaf stem gall aphids, *Phylloxera caryaecaulis;* white-margined burrower bug*, Sehirus cinctus;* woolly poplar aphid, *Phloeomyzus passerinii.*

BUD AND SHOOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
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 2023 included balsam shootboring sawfly, *Pleroneura brunneicornis;* common pine shoot beetle, *Tomicus piniperda;* Oak twig pruner*, Anelaphus parallelus;* Willow pine gall, *Rhabdophaga strobiloides.*

ROOT INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
	Anomala marginata	Many		Observed as bycatch in trap catch.
Broad-necked root borer	*Prionus laticollis*	Many	Northeastern Vermont	
Japanese beetle	*Popillia japonica*	Many		Observed as bycatch in trap catch.
June beetle	*Phyllophaga spp*	Many		Observed as bycatch in trap catch.
Oriental beetle	*Anomala orientalis*	Many		Observed as bycatch in trap catch.

Root Insects not reported in 2023 included Asiatic garden beetle, *Maladera castanea* ; broadnecked root borer, *Prionus laticollis* ; conifer root aphid, *Prociphilus americanus* and conifer swift moth, *Korsheltellus gracilis.*

BARK AND WOOD INSECTS

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

2023 marked our seventh year of deploying flight intercept/pheromone traps for detection of ALB (**Figure 19**, **Table 12**). We deployed six 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 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.

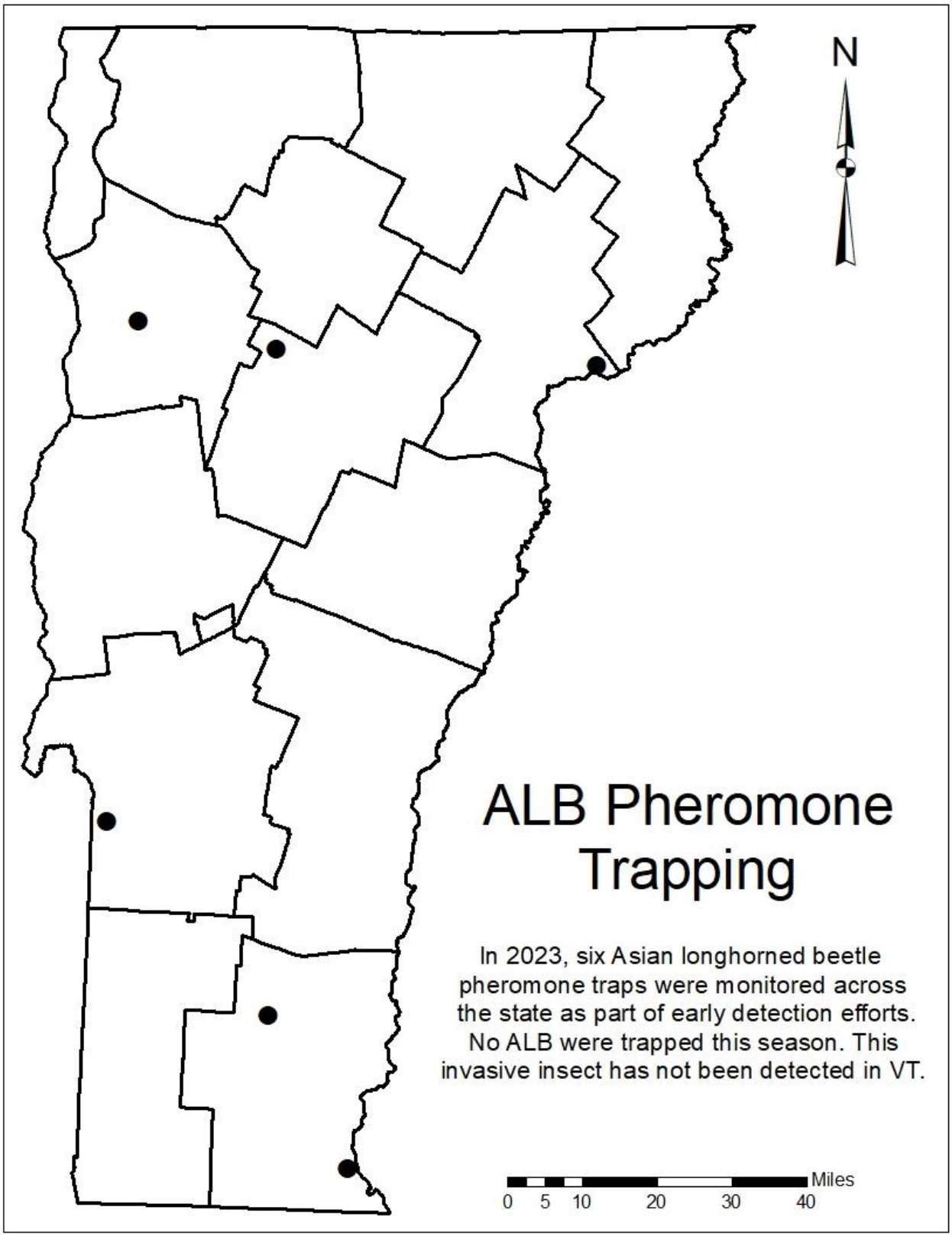

Figure 19. Asian longhorned beetle trap locations in 2023. There was a single trap at each location.

Table 12. Location of Asian longhorned beetle traps deployed in Vermont in 2023. Data include county, town, tree species, date deployed, and date collected.

County	Town	Tree Species	Lat	Long	Date set	Date collected
Caledonia	Waterford	red maple	44.36151	-71.89799	6/30/23	9/22/23
Chittenden	Williston	red maple	44.447572	-73.132771	6/30/23	9/22/23
Rutland	Poultney	sugar maple	43.480952	-73.205765	6/30/23	9/26/23
Washington	Waterbury	sugar maple	44.393861	-72.761408	6/30/23	9/21/23
Windham	Guilford	sugar maple	42.813579	-72.567316	6/30/23	9/25/23
Windham	Jamaica	sugar maple	43.108391	-72.774661	6/30/23	9/25/23

Emerald ash borer (EAB), *Agrilus planipennis*, was first discovered in Vermont in February 2018, and new detections continued in 2023. 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 new locations in 2023, including 20 new towns (**Table 13**). No new counties with EAB were identified in 2023. Essex county is currently the only county in the state without a confirmed detection. Aerial surveys detected 1,381 acres of mortality due to EAB in 2023. Areas most impacted included those near the initial detection site in Orange and Washington counties, as well as Grand Isle and Franklin counties (**Figure 21**.)

Table 13. Locations of new emerald ash borer discoveries in 2023.

Town	County	State
Barre City	Washington	VT
Berkshire	Franklin	VT
Brattleboro	Windham	VT
Calais	Washington	VT
Cavendish	Windsor	VT
Enosburg	Franklin	VT
Essex Junction	Chittenden	VT
Franklin	Franklin	VT
Fayston	Washington	VT
Guilford	Windham	VT
Halifax	Windham	VT
Marlboro	Windham	VT
Montgomery	Franklin	VT
Putney	Windham	VT
Sheldon	Franklin	VT
Washington	Orange	VT
Westminster	Windham	VT
Whitingham	Windham	VT
Winooski	Chittenden	VT
Woodstock	Windsor	VT

Maps indicating known EAB-infested areas in Vermont (**Figure 21**) are posted at VTinvasives.org. The mapped areas indicate the likelihood of EAB based on where it has been observed; EAB is not necessarily present throughout the mapped infested areas. By the time the insect is detected, it has already dispersed, so any ash within ten miles of a known EAB location is 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 2023 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 2023.

Due to the deregulation of the federal quarantine in 2021, USDA APHIS did not conduct any trapping efforts in the state for EAB. However, FPR staff were able to hang 20 pheromone traps for EAB in 2023 (**Figure 22**).

Girdled trap tree surveys are the most sensitive technique currently used for the early detection of EAB. In total, 19 ash trees were girdled across 11 Vermont counties in 2023. Girdled trap trees were established by state forestry staff on state lands (**Figure 23**). EAB was positively identified in trap trees in Cavendish and Franklin. Together with requested site visits, these tools resulted in 20 new towns with EAB in Vermont in 2023 (**Figure 24**).

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.

EAB Biocontrol Releases—biological control agents were released at three locations in the state in 2023 (Bennington, Brookfield, and Swanton). The Brookfield and Swanton sites were new in 2023 and will have additional parasitoids released on site in 2024. The Bennington site received its final release in 2023, and parasitoid recovery efforts will begin there in 2025. The two original EAB Biocontrol release sites in Vermont (South Hero and Plainfield) will be sampled for parasitoid recovery in 2024. Releases in 2023 included a total of 3134 *Spathius galinae*, 3760 *Oobius agrili*, and 6970 *Tetrastichus planipennisi*.

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.

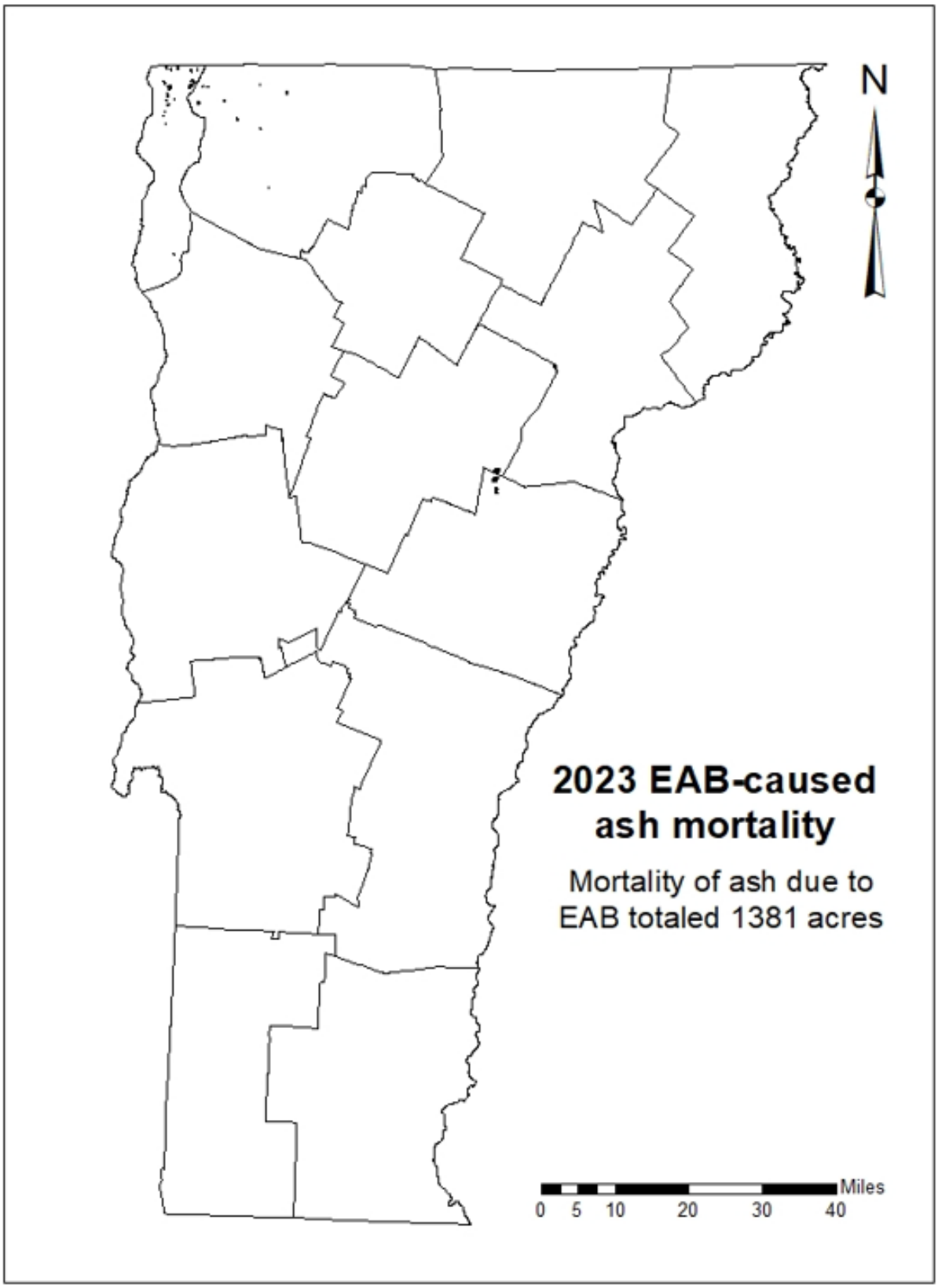

Figure 20. Areas where ash mortality was observed due to Emerald Ash Borer in 2023. In total, 1,381 acres of damage were observed.

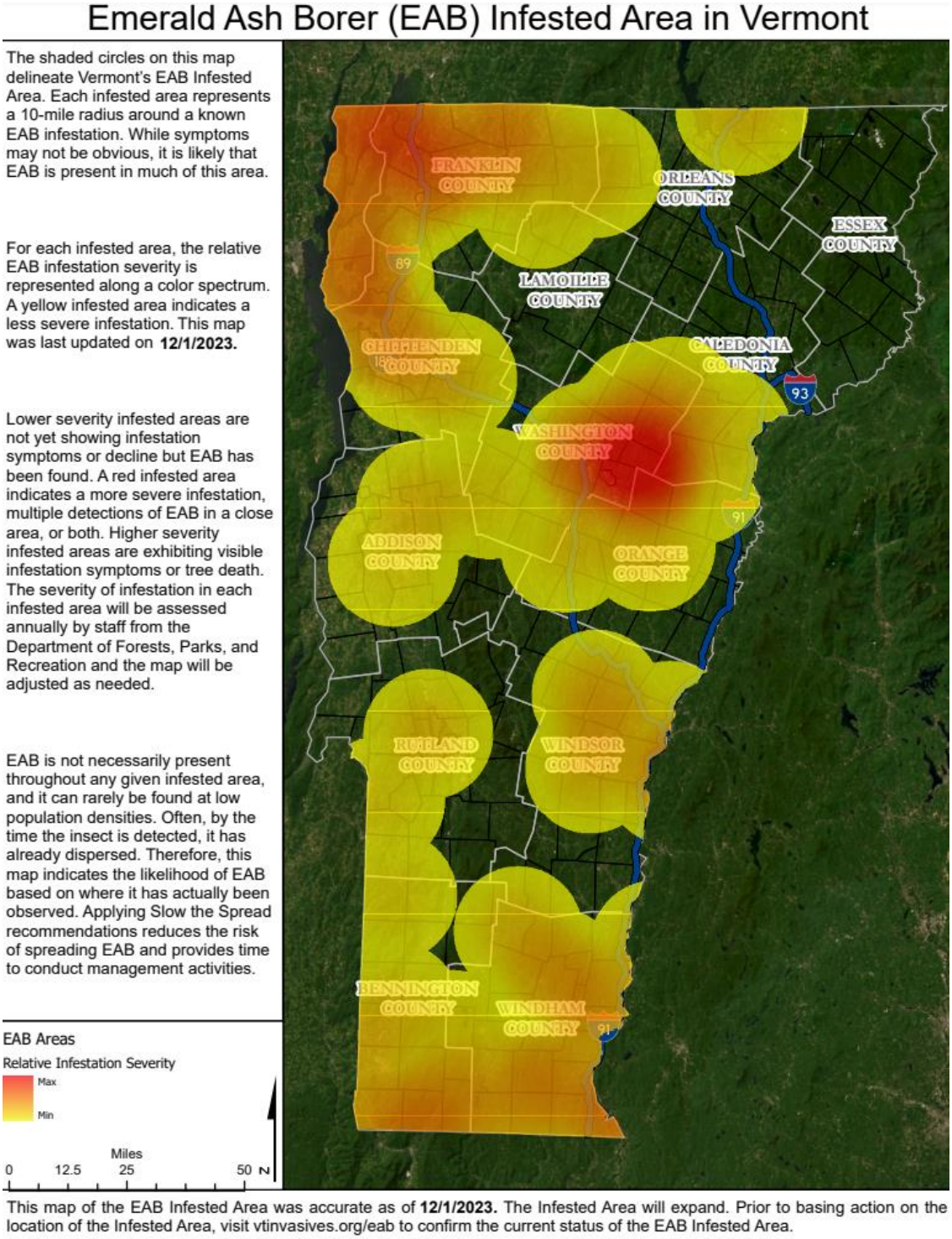

Figure 21. The mapped emerald ash borer infested area (December 2023). For each infested area, the relative EAB infestation severity is represented along a color spectrum. A dark orange infested area indicates a severe infestation and a yellow infested area indicates a less severe infestation. The "confirmed 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.

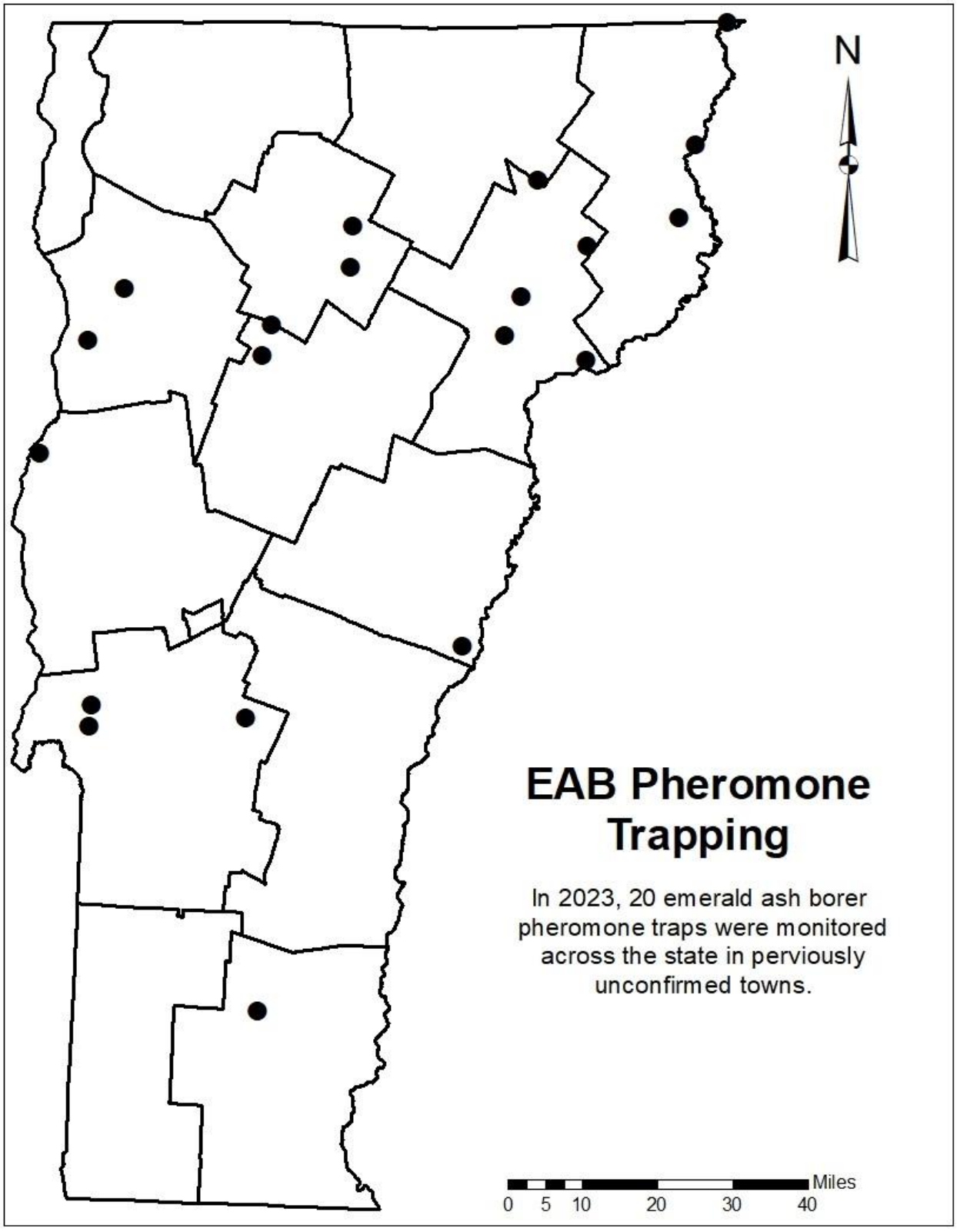

Figure 22. Locations of purple pheromone traps for emerald ash borer deployed by FPR staff in 2023.

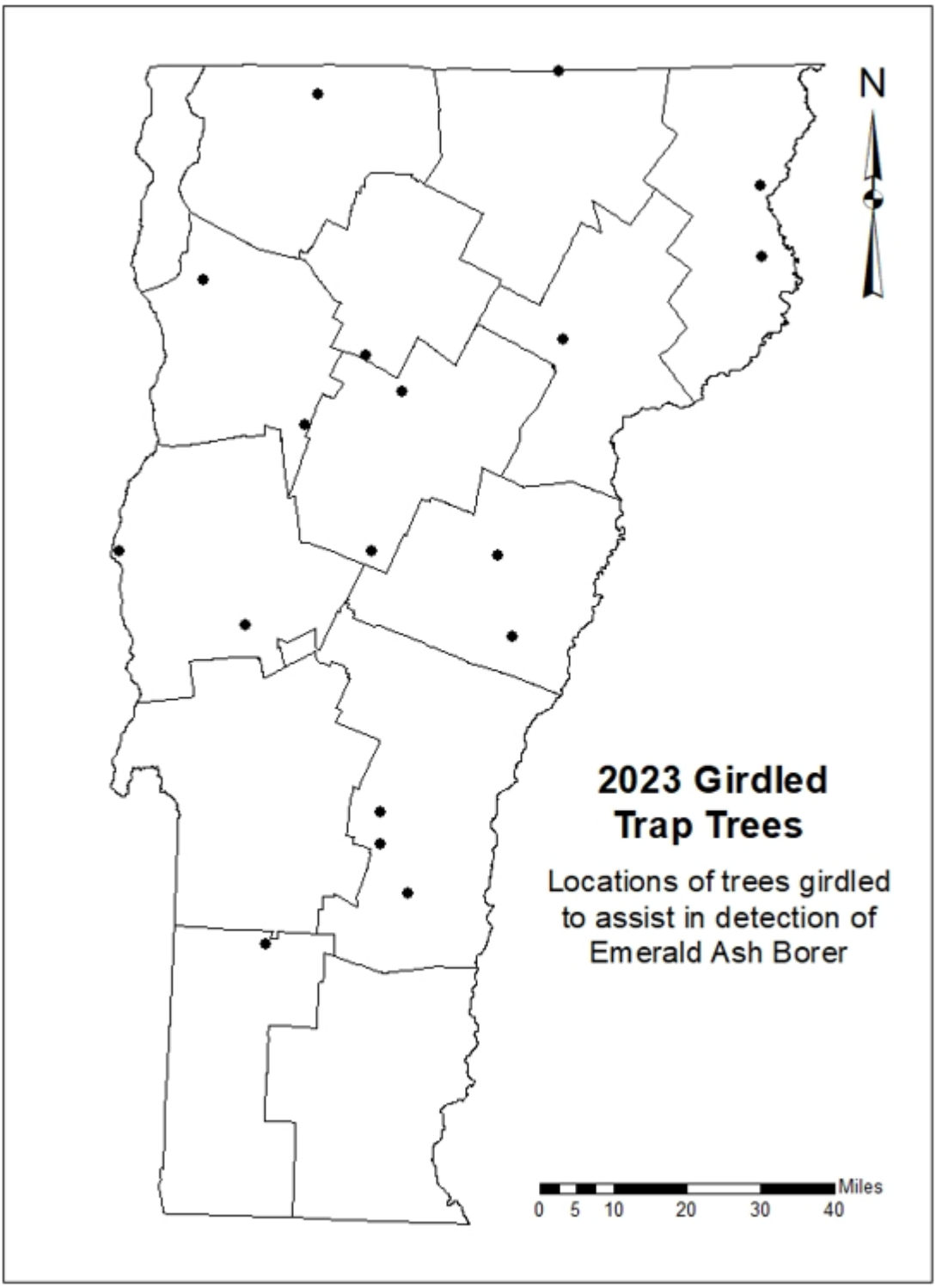

Figure 23. Location of girdled trap trees on state and private lands in Vermont in 2023. A single ash was girdled and later peeled, at each location. Two trees containing EAB were found on state land as a result.

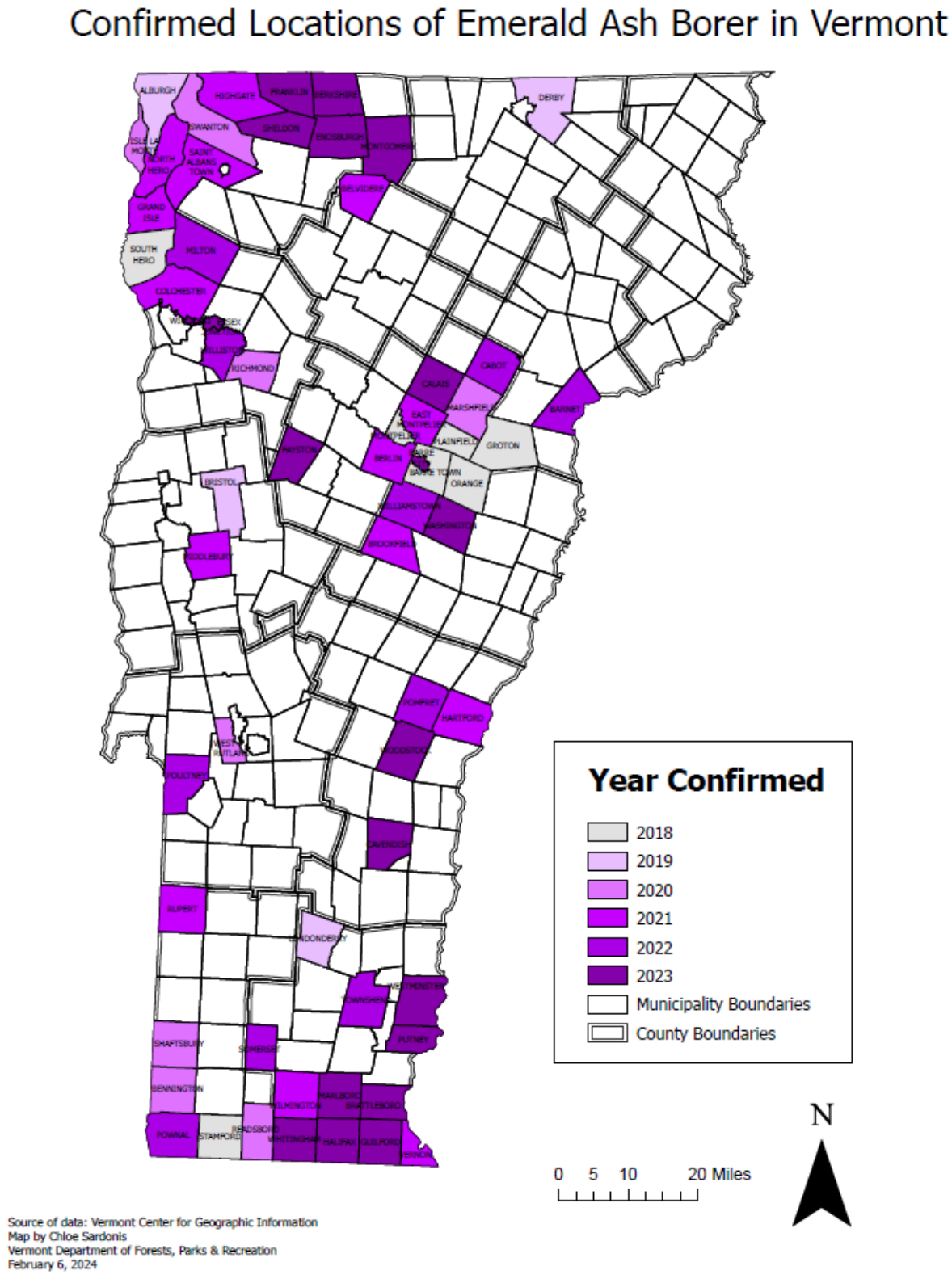

Figure 24 Towns with confirmed detections of EAB color-coded by year of detection.

Sirex woodwasp, *Sirex noctilio*, was recovered in one trap (Waterville, VT) deployed as part of the AAFM and USDA APHIS trapping effort for non-native wood-boring insects in 2023. This insect has been trapped in twelve Vermont counties since 2007 (**Figure 25**). No new observations of *Sirex*-infested trees were reported, with the only known location in Jericho.

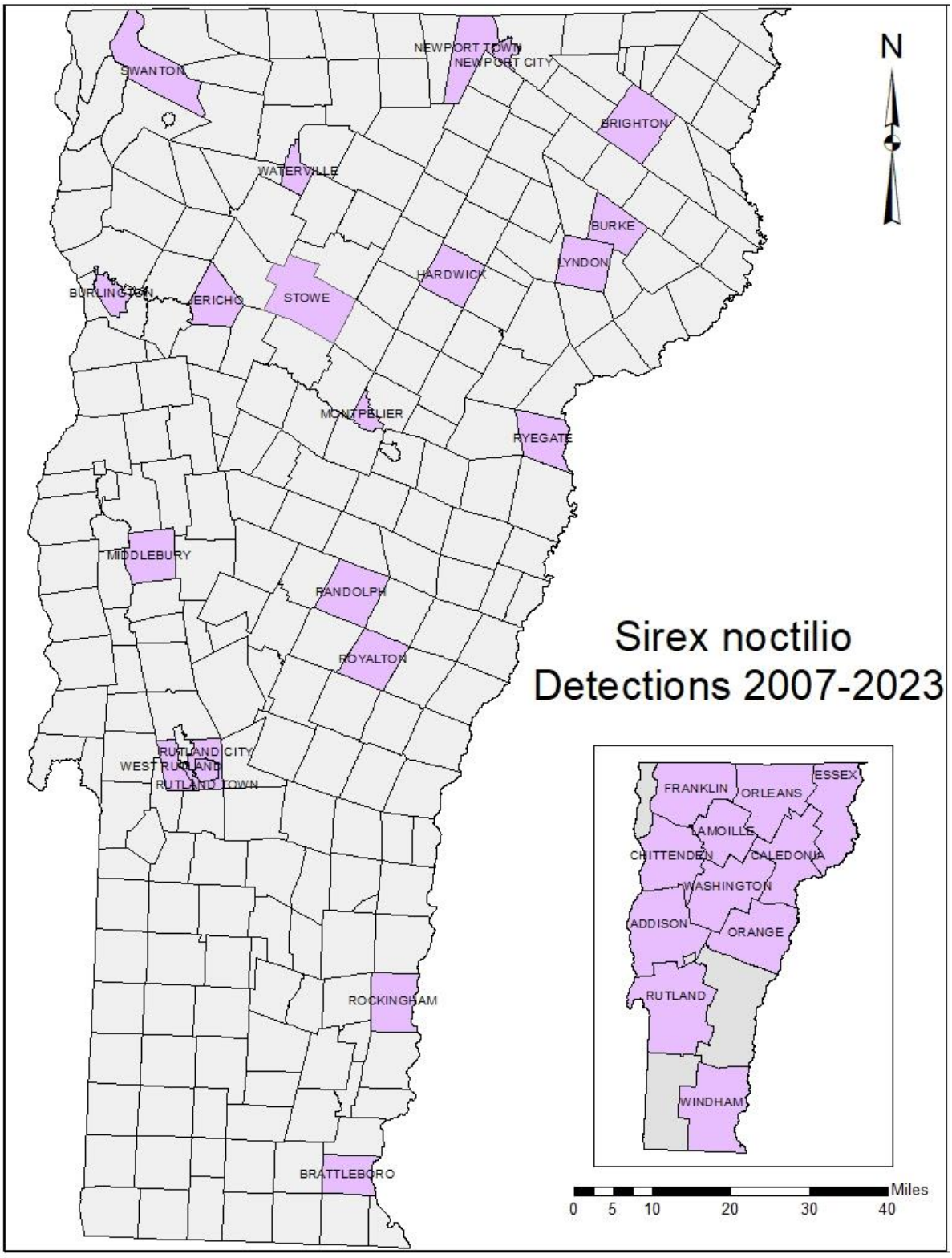

Figure 25. Locations in Vermont where *Sirex noctilio* has been collected by APHIS, AAFM and FPR.

OTHER BARK AND WOOD INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Asian longhorned beetle	*Anoplophora glabripennis*	Various hardwoods		Not observed or known to occur in Vermont.
Buprestid	*Buprestis* spp.	Many	Widely scattered	Inquiries from people concerned about emerald ash borer.
Eastern ash bark beetle	*Hylesinus aculeatus*	Ash	Scattered statewide	Multiple inquiries initiated by galleries from people concerned about emerald ash borer.
Elm bark beetle	*Hylurgopinus rufipes*	Elm, baswood, ash	Scattered statewide	
Emerald ash borer	*Agrilus planipennis*	Ash	Widely scattered	See narrative.
European elm bark beetle	*Scolytus multistriatus*	Elm and Zelkova	Scattered statewide	
Jewel beetle	*Dicerca sp.*	Various hardwoods and conifers		Mulitple inquiries from people concerned about emerald ash borer.
Golden jewel beetle	*Buprestis striata*			Mulitple inquiries from people concerned about emerald ash borer.
Japanese cedar longhorned beetle	*Callidiellum rufipenne*	Arborvitae and other conifers		Not observed or known to occur in Vermont.
Native ash borers	*Cerambycidae*	Ash	Statewide	Ash cerambycid larvae widely observed while following up on EAB suspect trees.

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Southern pine beetle	*Dendroctonus frontalis*	Pine		Not observed or known to occur in Vermont.
Sugar maple borer	*Glycobius speciosus*	red oak	Scattered throughout	Stand-level damage occasionally significant.
Turpentine beetles	*Dendroctonus* spp.	White pine	Scattered throughout	Observed in stands stressed by white pine needle diseases.
Whitespotted Sawyer	*Monochamus scutellatus*	White pine and other conifers	Scattered throughout	We continue to receive adults submitted as Asian longhorned beetle suspects.
Pole borer	*Neandra brunnea*	Many		Observed as bycatch in trap catch.
Round-necked long-horned beetle	*Clytus ruricola*	Maple		Observed as bycatch in trap catch.
Pigeon tremex	*Tremex columba*	Maple and various hardwoods		Also observed as bycatch in trap catch.
Poplar and willow borer	*Cryptorhynchus lapathi*	Willow, poplar, alder, birch	Franklin County	

Other Bark and Wood Insects not reported in 2023 included Black turpentine beetle, *Dendroctonus tenebrans;* Apple wood stainer*, Monarthrum mali;* Bronze birch borer*, Agrilus anxius;* Chestnut brown bark beetle, *Pityogenes hopkinsi;* Common pine shoot beetle, *Tomicus piniperda;* Eastern larch beetle, *Dendroctonus simplex;* Eastern larch beetle*, Dendroctonus simplex; Hylastes criddlei; Hylastes opacus; Hylastes porculus; Hylesinus pruinosus; Hylurgops rugipennis pinifex; Hylastes porculus; Hylesinus pruinosus; Orthotomicus caelatus;* Pine engraver*, Ips pini;* Poplar ambrosia beetle, *Trypodendron retusum*; Red headed ash borer, *Neoclytus acuminatus;* Red turpentine beetle*, Dendroctonus valens*; Shothole borer*, Scolytus rugulosus;* Striped ambrosia beetle*, Trypodendron lineatum; Xyleborinus attenuates; Xyloterinus politus.*

FRUIT, NUT AND FLOWER INSECTS

INSECT	LATIN NAME	HOST	LOCALITY	REMARKS
Brown marmorated stink bug	*Halyomorpha halys*		Washington County	
Butternut curculio	*Conotrachelus juglandis*	Butternut	Southern Vermont	
Western conifer seed bug	*Leptoglossus occidentalis*		Chittenden County	Reported as accidental home invaders

Fruit, Nut and Flower Insects not reported in 2023 included acorn plum gall wasp, *Amphibolips quercusjuglans*

STEM DISEASES

Beech bark disease related dieback, caused by *Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*, was mapped on 2,154 acres in 2023 (**Table 14, Figure 26)** a decrease from the 31,086 acres mapped in 2022. Bark symptoms remain common and crown symptoms are increasingly noticeable in mid-summer. Indeed, symptomatic trees were highly visible in 2022, likely due to multiple years of drought. Symptoms were especially severe along ridges where drought effects may be most commonly experienced.

Table 14. Mapped acres of beech bark disease in 2023.

County	Acres
Addison	0
Bennington	31
Caledonia	16
Chittenden	51
Essex	644
Franklin	102
Grand Isle	0
Lamoille	108
Orange	131
Orleans	0
Rutland	395
Washington	11
Windham	148
Windsor	517
Total	2,154

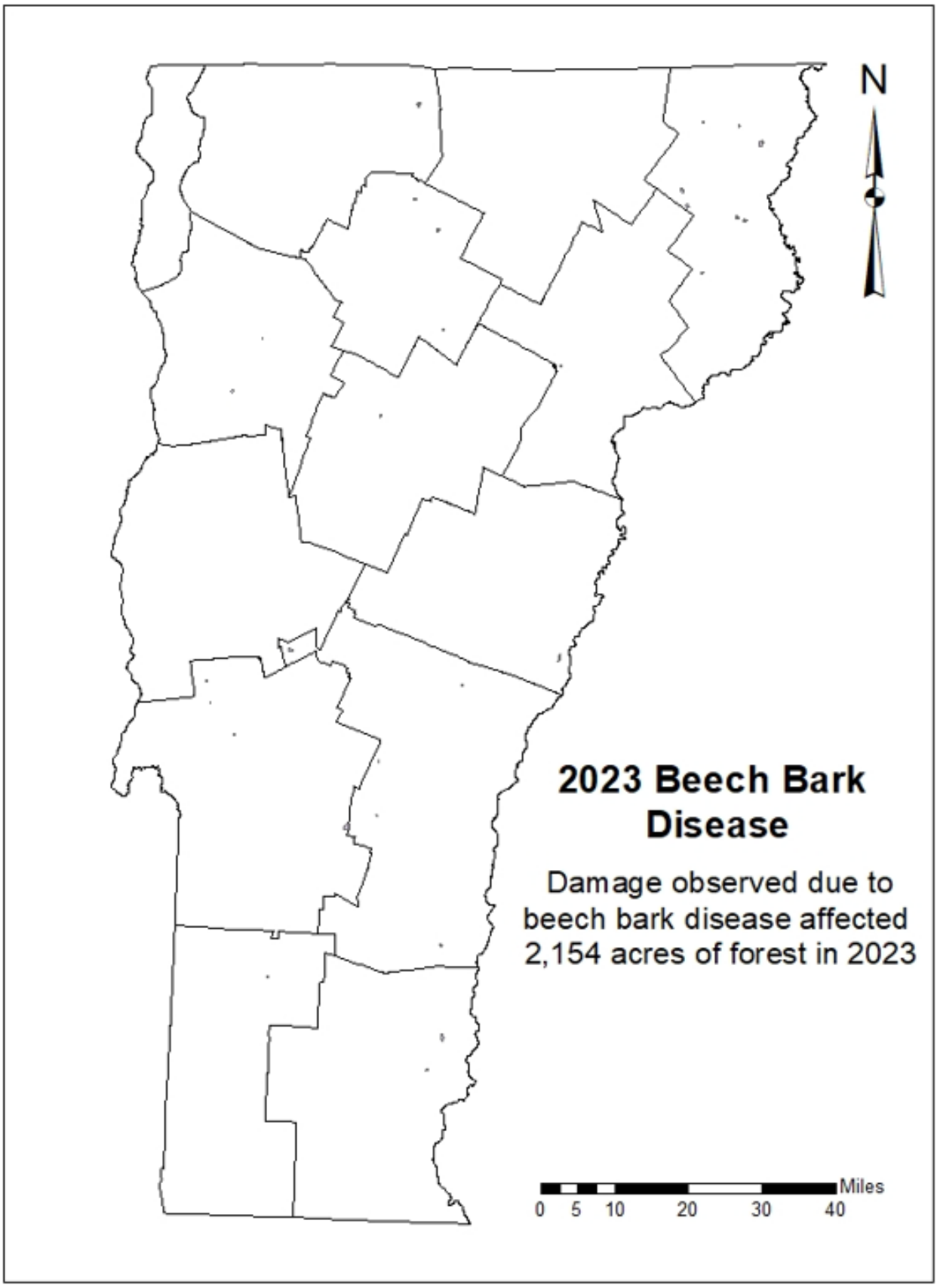

Figure 26. Dieback due to beech bark disease as mapped through aerial detection surveys in 2023. Damage was observed in 11 of 14 counties this year and totaled 2,154 acres.

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. This pathogen was first documented in Wisconsin in 1944 and has currently not been observed in Vermont. 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 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 12 states, and the province of Ontario CA, with the closest to Vermont being Glennville, New York. Due to these recent detections Vermont and nearby states are participating in a regional effort to monitor for this pathogen. In Vermont, the primary detection method is outreach. As a result of this effort, four oak wilt suspects were reported in 2023, with one having symptoms consistent with oak wilt and therefore was mailed to Cornell for lab testing. The mailed sample was negative for both culture and PCR 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 low levels.
Butternut canker	*Ophiognomonia clavigignentijuglandacearum*	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	
Diplodia tip blight	*Diplodia pinea*	Red pine	Statewide	See Red Pine Decline and Mortality and Foliage Diseases Other.
Dutch elm disease	*Ophiostoma ulmi; Ophiostoma himalulmi; Ophiostoma novo-ulmi*	Elm	Scattered throughout	Similar to other years. Dead trees commonly observed along roadsides.
Eutypella canker	*Eutypella parasitica*	Maples	Scattered throughout	
Fir-brrom rust	*Melampsorella caryophyllacearum*	Balsam fir	Washington County	
Hypoxylon canker	*Hypoxylon pruinatum*		Scattered throughout	Occurs on many hardwoods at low levels.

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Nectria canker	*Nectria spp.*	Hardwoods	Scattered throughout	
Oak wilt	*Bretziella fagacearum*			Not observed or known to occur in Vermont. See narrative.
Red ring rot	*Phellinus pini*	Conifers	Northeastern VT	`
Smooth patch	*Aleurodiscus spp., Dendrothele spp. and Hyphoderma spp.*	Ash	Statewide	
Sydowia blight	*Sydowia polyspora*	Red pine	Statewide	See Red Pine Decline and Mortality.
Thousand cankers disease	*Geosmithia morbida*	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 2023 included cedar apple rust, *Gymnosporangium, juniperi-virginianae*; golden canker pagoda dogwood, *Cryptodiaporthe corni*; Phomopsis galls, *Phomopsis* spp.; poplar truck rot, *Phellinus tremulae*; yellow witches' broom rust, *Melampsorella caryophyllacearum*.

FOLIAGE DISEASES

Beech leaf disease (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.

Eight monitoring sites were established across the state in 2021 (**Figure 27**) as part of a regional monitoring effort coordinated by the USDA – Forest Service. This pest has currently been reported in 15 states including Vermont. BLD was not observed in our monitoring plots but was observed in Vermont for the first time in 2023 and is now present in two towns in Windham County.

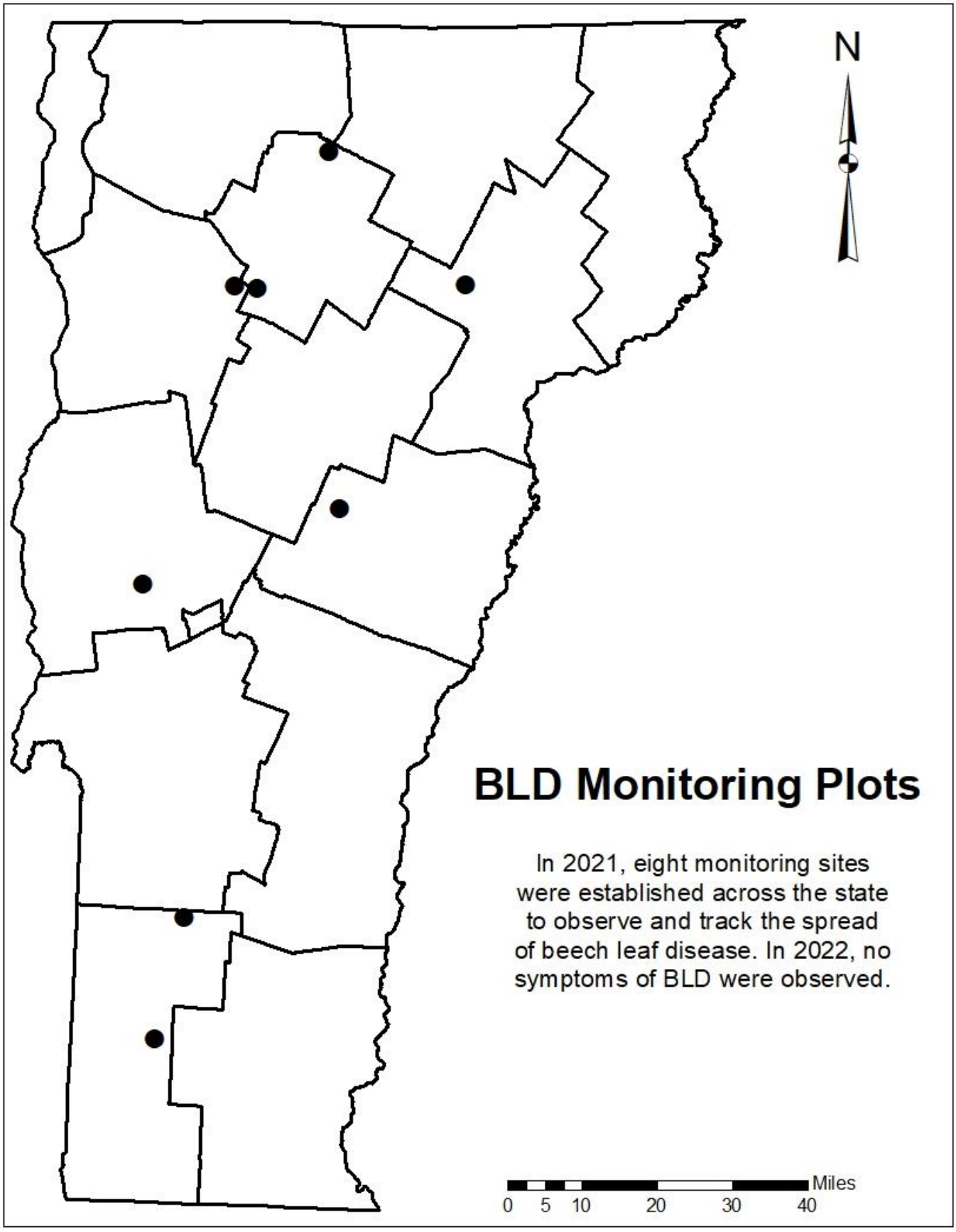

Figure 27. BLD Monitoring locations established in 2021.

Beech leaf disease was detected in two new towns (**Table *15***, **Figure 28**) in 2023. Windham county is currently the only county in the state with a confirmed detection.

Table 15. Locations of new beech leaf disease discoveries in 2023.

Town	County	State
Vernon	Windham	VT
Dummerston	Windham	VT

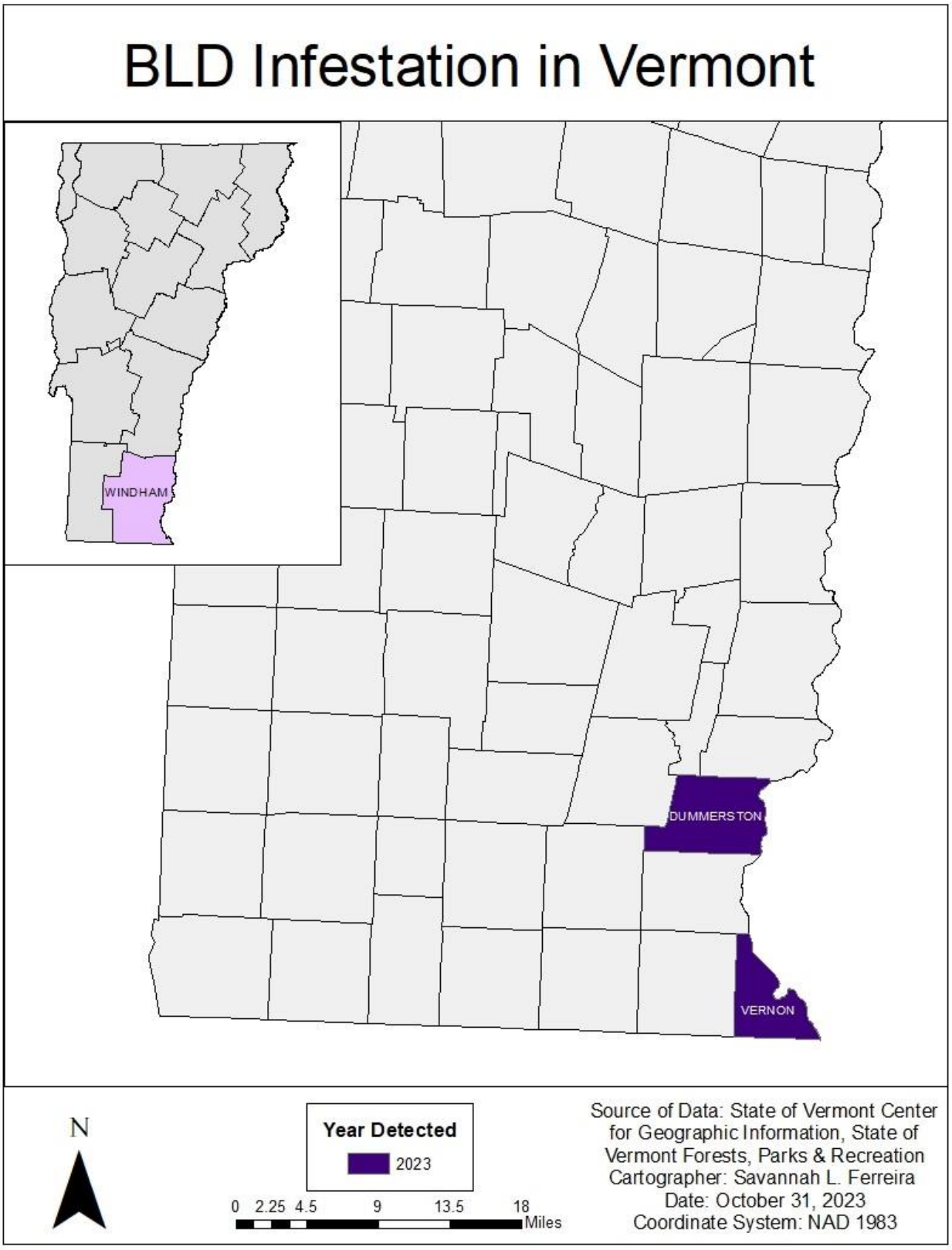

Figure 28. Towns in Vermont where beech leaf disease (BLD) has been confirmed. Two towns were confirmed to have BLD in 2023.

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 29**,**Figure 30**, **Figure 31**). 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, wounding, or weak pests and pathogens, such as turpentine beetles, *Caliciopsis* canker, and Armillaria root rot.

The expression of WPND is linked to the amount of humidity and moisture from the previous spring (e.g., 2023 damage is influenced by 2022 weather). Spore production typically peaks in June during shoot elongation. WPND accounted for 3,349 acres of observable damage on white pine trees throughout the state in 2023 (**Figure 32**), compared to 4,624 acres mapped in 2022. We expect WPND to be present again in 2024, with an increase in damage due to the wet spring in 2023.

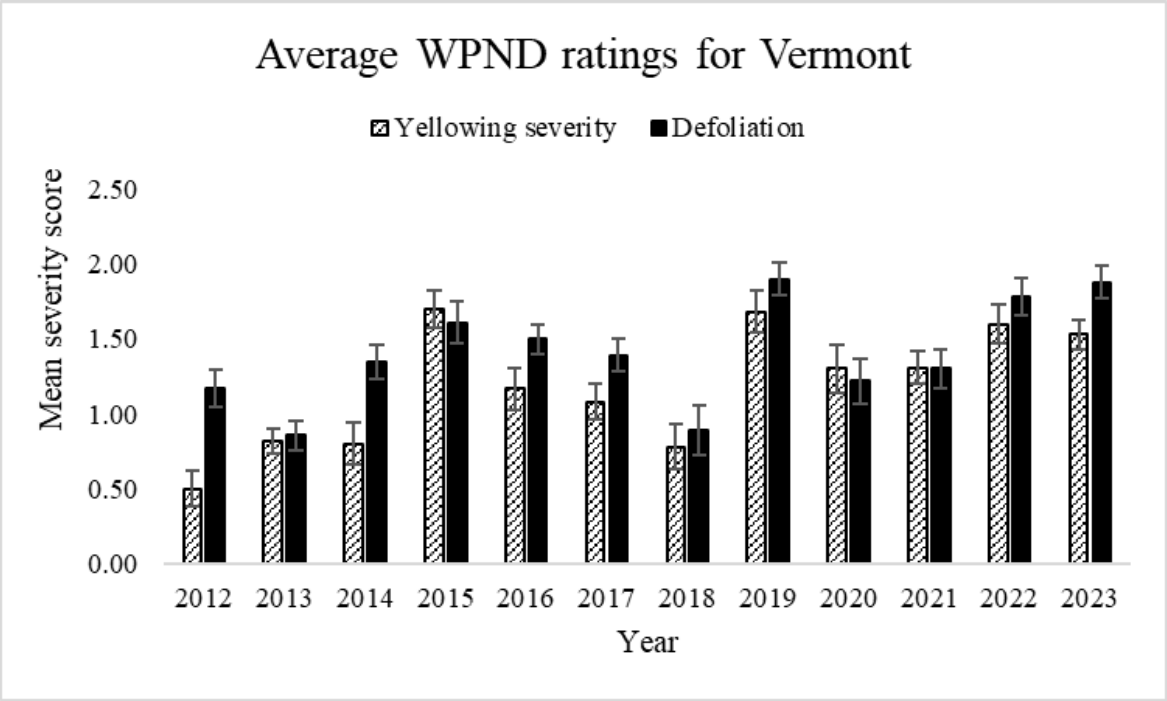

Figure 29. Mean chlorosis (yellowing) and defoliation of white pine trees from four plots (n = 50) in Vermont in 2023. Mean severity score indicates what portion of the crown is impacted (1 = 1/3, 2 = 2/3, 3 = entire crown).

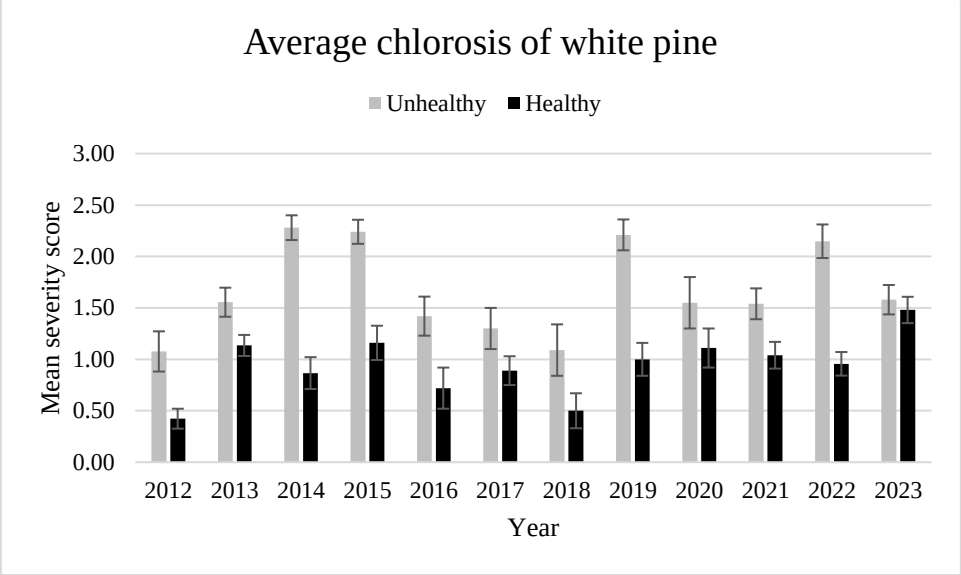

Figure 30. Chlorosis (yellowing of foliage) severity of unhealthy and healthy white pines surveyed between 2012-2023 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no chlorosis, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

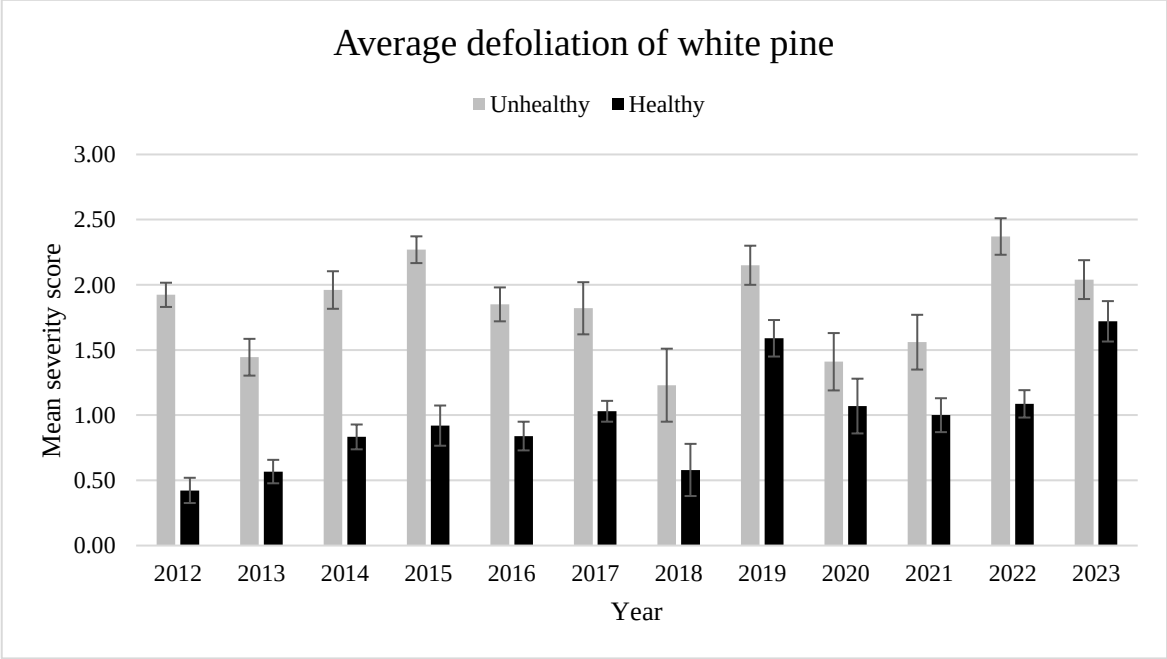

Figure 31. Defoliation severity of unhealthy and healthy white pines surveyed between 2012-2023 at four sites in Vermont. Trees were rated as unhealthy or healthy in 2012, based on white pine needle damage symptoms. Data presented are mean severity scores (0 = no defoliation, 1 = less than 1/3 crown affected, 2 = between 1/3 and 2/3 affected, 3 = more than 2/3 affected) ± standard error.

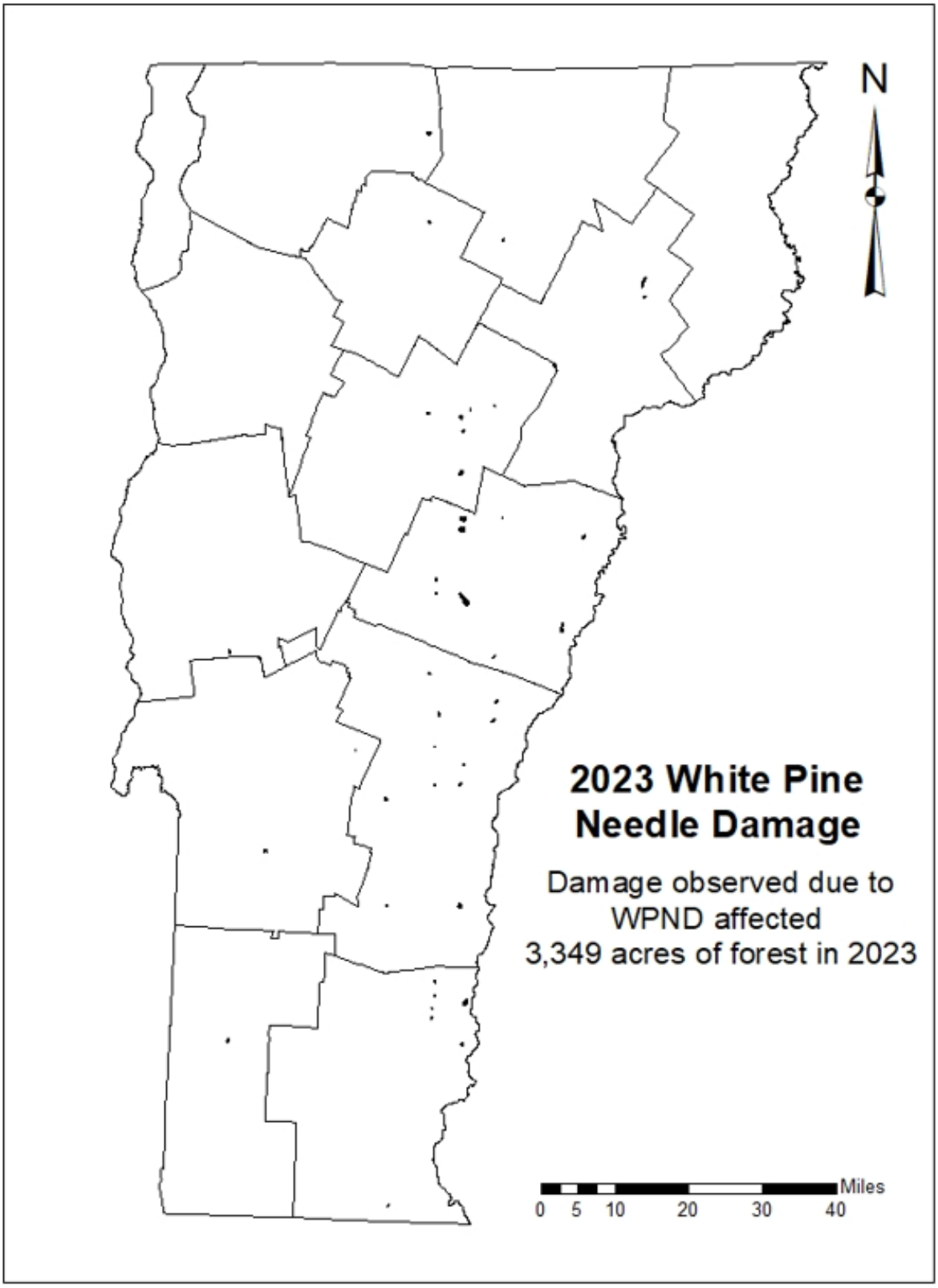

Figure 32. Defoliation caused by white pine needle diseases (WPND) affected 3,349 acres in the state in 2023.

OTHER FOLIAGE DISEASES

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
Anthracnose	*Aureobasidium apocryptum; Discula campestris; Colletotrichum gleosporoides; Discula umbrinella; Gnomoniella fraxini*	Maple, beech, ash	Statewide	Increase from 2022.
Apple scab	*Venturia inaequalis*	Apple	Orange County	Statewide
Balsam fir needlecast	*Lirula sp.*	Balsam fir	Statewide	Commonly observed on ornamental and Christmas tree plantings.
Balsam fir needle rust	*Uredinopsis* spp. and *Milesina* spp.	Balsam fir		Commonly observed on ornamental and Christmas tree plantings.
Bud blast	*Seifertia azalea*	Rhododendron	Orange County	
Diplodia shoot blight	*Diplodia pinea*	Red pine	Statewide	See Red Pine Decline and Mortality and Stem Diseases Other.
Guignardia leaf blotch	*Guignardia aesculi*	Buckeye	Hartford	
Pine needle rust	*Coleosporium asterum*	2-3 needle pines; asters	Washington County	Reports on regeneration
Rhizosphaera needlecast	*Rhizosphaera kalkhoffii, R. pini*	Spruce/Fir	Statewide	Increase in reports and severity in urban trees and Christmas tree plantations.
Tar spots	*Rhytisma: R. acerinum, R. punctatum and R. americanum*	Maple	Statewide	
Sydowia blight	*Sydowia polyspora*	Red pine	Statewide	See Red Pine Decline and Mortality.

DISEASE	LATIN NAME	HOST	LOCALITY	REMARKS
White pine needle decline	*Bifusella linearis, Lecanosticta acicola, Lophophacidium dooksii, Septorioides strobi*	Eastern white pine	Statewide	*See narrative.*
Zonate leaf spot	*Cristulariella moricola*	Many	Southern VT	

Foliage diseases not reported in 2023 included American hawthorn rust, *Gymnosporangium globosum;* Birch leaf fungus*, Septoria betulae;* Cercospora leaf spot*, Cercospora spp.*; Cedar apple rust, Gymnosporangium *juniperi-virginianae*; Fir-blueberry rust, *Pucciniastrum geoppertianum*; Late leaf rust*, Pucciniastrum americanum*; Linden leaf spot, *Cercospora microspore* and pine gall rust, Peridermium *harknessii.*

ROOT DISEASES

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

Root Diseases not reported in 2023 included Berkeley's polypore, *Bondarzewia berkeleyi*; Heterobasidion root disease, *Heterobasidion annosum.*

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. 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.

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 33**). 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 since 2020. 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 2023, average crown density of the Southern region was 51.8%, 1.8% more than our standard, dead shoots of 20%, 10% more than our standard, crown transparency of 33.6%, 3.6% more than our standard, and discoloration of 10%, equal to our standard. One new tree died in 2023 from this region, with 5 dying since 2020 (**Table 16a**).

In 2023, average crown density of the Northeastern region was 54.3%, 4.3% more than our standard, dead shoots of 41.2%, 31.2% more than our standard, crown transparency of 34.7%, 4.7% more than our standard, and discoloration of 11.2%, 1.2% more than our standard. One new tree died in 2023 from this region, with 20 dying since 2020 (**Table 16**b).

In 2023, average crown density of the Central region was 47.2%, 2.8% less than our standard, dead shoots of 39.1%, 29.1% more than our standard, crown transparency of 33.3%, 3.3% more than our standard, and discoloration of 10.1%, 0.1% more than our standard. Three new trees died in 2023 from this region, with 26 dying since 2020 (**Table 16**c).

In 2023, average crown density of the Northwest region was 43.8%, 6.2% less than our standard, dead shoots of 13.1%, 3.1% more than our standard, crown transparency of 31.2%, 1.2% more than our standard, and discoloration of 10.4%, 0.4% more than our standard. No new trees died in 2023 from this region, with two dying since 2020 (**Table 16**d).

Table 16a-d Crown measurements for plot trees in 2023 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.

16a

Southern Region Summary												
Site	**DBH (in)**	**Sum of Newly Dead Trees 2023**	**LCR (%) 2020**	**LCR (%) 2023**	**Density (%) 2020**	**Density (%) 2023**	**Dead Shoots (%) 2020**	**Dead Shoots (%) 2023**	**Transparency 2020**	**Transparency 2023**	**Discoloration of live trees (%) 2020**	**Discoloration of live trees (%) 2023**
Aitken SF	12.0	0	31.5	28.5	48.0	45.6	16.5	26.2	30.4	34.4	12.4	10.0
Downer SF	18.7	0	35.9	33.6	49.5	62.7	10.5	12.7	28.6	29.1	12.3	10.0
WP WMA	10.2	1	28.7	23.0	45.0	48.5	11.7	20.0	31.3	36.5	14.3	10.0
Average			***37.1***	***28.0***	***47.3***	***51.8***	***12.9***	***20.0***	***30.3***	***33.6***	***13.1***	***10.0***

16b

Northeastern Region Summary												
Site	**DBH (in)**	**Sum of Newly Dead Trees 2023**	**LCR (%) 2020**	**LCR (%) 2023**	**Density (%) 2020**	**Density (%) 2023**	**Dead Shoots (%) 2020**	**Dead Shoots (%) 2023**	**Transparency 2020**	**Transparency 2023**	**Discoloration of live trees (%) 2020**	**Discoloration of live trees (%) 2023**
Groton SF East	15.8	1	19.2	4.1	35.6	40.0	61.6	92.3	69.4	40.0	13.3	30.0
Groton SF West	17.4	0	32.2	42.2	45.2	49.1	15.7	23.9	32.2	33.2	10.9	10.0
West Mtn WMA	13.8	0	50.4	56.3	49.2	60.8	14.2	10.8	45.0	35.4	13.3	10.0
Average			***33.8***	***35.0***	***44.0***	***54.3***	***31.1***	***41.2***	***47.2***	***34.7***	***12.5***	***11.2***

16c

Central Region Summary												
Site	**DBH (in)**	**Sum of Newly Dead Trees 2023**	**LCR (%) 2020**	**LCR (%) 2023**	**Density (%) 2020**	**Density (%) 2023**	**Dead Shoots (%) 2020**	**Dead Shoots (%) 2023**	**Transparency 2020**	**Transparency 2023**	**Discoloration of live trees (%) 2020**	**Discoloration of live trees (%) 2023**
LR Jones SF	15.7	0	33.4	31.0	49.3	39.8	12.7	19.8	30.5	32.4	10.5	10.2
Perry Hill SF	13.2	3	27.1	1.5	41.8	25.0	58.9	95.4	46.8	40.0	57.5	10
Thetford Hill SF	15.2	0	42.6	37.3	52.2	60.8	10.0	13.5	30.0	34.2	14.8	10
Average			*34.4*	*24.5*	*47.8*	*47.2*	*27.2*	*39.1*	*35.8*	*33.3*	*27.6*	*10.1*

16d

Northwestern Region Summary												
Site	**DBH (in)**	**Sum of Newly Dead Trees 2023**	**LCR (%) 2020**	**LCR (%) 2023**	**Density (%) 2020**	**Density (%) 2023**	**Dead Shoots (%) 2020**	**Dead Shoots (%) 2023**	**Transparency 2020**	**Transparency 2023**	**Discoloration of live trees (%) 2020**	**Discoloration of live trees (%) 2023**
Camels Hump SF Bolton	14.4	0	40.3	30.8	47.0	39.5	17.0	10.5	34.1	31.9	14.3	10.0
Camels Hump SF Starksboro N	16.7	0	40.4	40.7	47.9	48.9	10.0	13.2	30.4	30.0	10.4	11.1
Camels Hump SF Starksboro S	12.1	0	47.6	40.0	45.2	45.5	13.6	22.0	35.6	32.2	15.2	10.0
Average			***42.3***	***35.7***	***46.8***	***43.8***	***13.9***	***13.1***	***33.3***	***31.2***	***13.3***	***10.4***

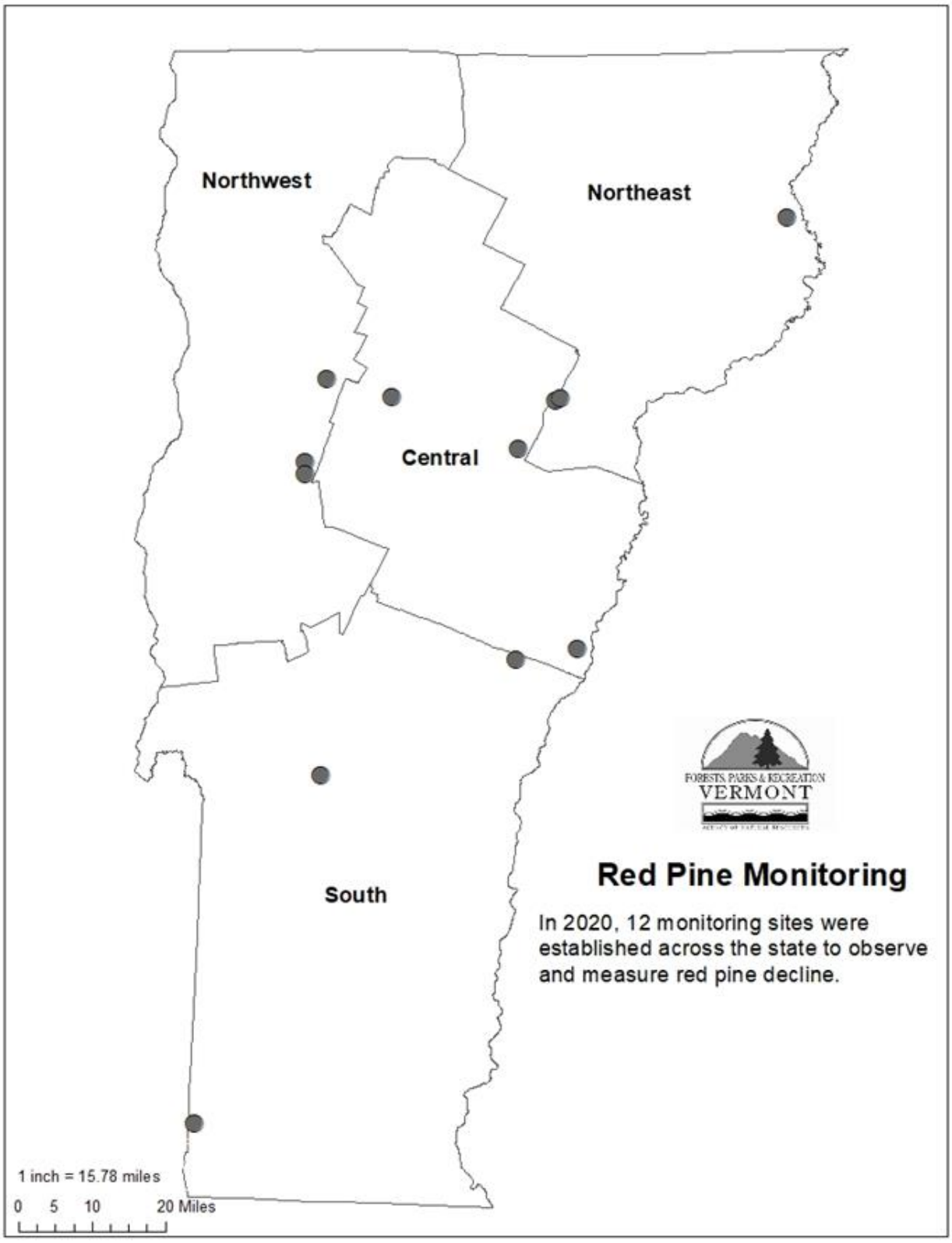

Figure 33. Red pine decline plots established in 2020.

Initial 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 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.

Repeated sampling: In 2022, Groton SF East was resampled using original 2020 methods due to the number of dead trees reported in 2021. Fungal isolates were identified based on morphology, and included foliar pathogens diplodia tip blight and sydowia blight (*Sydowia polyspora*). Insect pests observed included signs of pine gall weevil, pine needle scale, and sawflies. Observed sawfly damage was likely caused by European sawflies, however, due to early fall 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.

Inoculation trials: In 2023, inoculation trials were conducted to observe the pathogenicity of the before mentioned fungal isolates. Pure cultures of *Sydowia polyspora* and *Diplodia sapinea* (both previously DNA confirmed) were transferred from stored slants to potato dextrose agar (PDA). To confirm vascular pathogenicity, seeding inoculations were performed on red pines (*Pinus resinosa*) from the New Hampshire State Forest Nursery. 0.4 cm diameter PDA plugs colonized by either *S. polyspora* or *D. sapinea* were used to inoculate five seedlings/ treatment. Five scalpel-wounded seedlings received sterile 0.4 cm diameter PDA plugs. Inoculation sites were sealed with Parafilm. Saplings (mean diameter 0.74cm) were potted and maintained in a growth room at 21°C for 4 weeks. At 4 weeks, all *D. sapinea* treatment seedlings had cankers while the controls remained canker free and showed limited vascular discoloration from wounding. *D. Sapinea* cankers were the largest, with average length of 0.84cm and average width of 0.54cm, compared to *S. polyspora* cankers (average length 0.68cm and average width 0.58cm) and controls (average length 0.84cm and 0.54cm width). Although *S. polyspora* (a needlecast pathogen) was isolated from needles and cambial tissue, cankers were similar in size to vascular staining observed in controls.

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 and widespread EAB infestations.
Black cherry symptoms	Black cherry	Essex and Orange counties	In multiple locations, black cherry had thin crowns, premature leaf drop, and scattered mortality. Causal agent(s) unknown.
Fir decline	Balsam fir	Statewide	See balsam woolly adelgid
Fire damage	Many	Killington, VT	63 fires in 2023 totaling 58.66 acres.
Flood Damage .		Central and southern Vermont	See narrative
Frost damage	Oaks, beech, apple and others	Widespread	See narrative.
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.
Wind damage	Many	Central and, Northeastern Vermont	In multiple locations, blowdowns and breakage due to high wind.
White pine needle damage	Eastern white pine	Statewide	See Foliage Diseases.

Other Diebacks, Declines, and Environmental Diseases not reported in 2023 included air pollution injury, birch decline, chlorosis due to rainfall, drought damage, hail damage, ice and snow breakage, larch decline spruce decline, and winter injury.

ANIMAL DAMAGE

ANIMAL	SPECIES DAMAGED	LOCALITY	REMARKS
Porcupine	Eastern white pine	Statewide	Scattered throughout the state.
Squirrel	Maples, Oaks	Statewide	Scattered throughout the state.
Woodpecker	Wood products; Ash spp., Balsam fir, Mountain ash, Hemlock	Statewide	Scattered throughout the state.
Deer	Many	Statewide	Browse and girdling damage

INVASIVE PLANTS

2023 INVASIVE PLANT SUMMARY

Non-native invasive plant management (NNIPM) efforts continued in 2023, with progress on **Monitoring and Outreach** made possible through several grant-funded opportunities. In the first half of the year, the Vermont Department of Forests, Parks and Recreation's (FPR) Forest Protection Program's Invasive Plant Coordinator and Invasive Plant Assistant Coordinator finalized deliverables for a multiyear USDA Forest Service Landscape Scale Restoration grant, which included the posting and publication of 69 new outreach resources to VTinvasives.org, all available for free to view and download. This included the new publication 'Youth Volunteer Program Guide', designed as a culminating document of experiences and lessons learned from the work completed by program staff since 2013. In the second half of the year, the coordinators transitioned full attention to a new USDA Forest Service Landscape Scale grant, focused on phenology, early detection, and mapping of invasive plants; all these new projects are in the early stages of long-term implementation. Additionally, the coordinators created and curated invasive plant content for two external-facing webpages, and one internal-facing webpage. 18 articles were written for a variety of newsletters and publications, on the topics of early detection and phenology, and 2 podcast episodes focused on invasive plant phenology were published on VTinvasives.org. The coordinators also worked with multiple state departments and agencies to unify Vermont's approach to NNIPM.

FPR staff continued to provide outreach and information 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 includes the work conducted by County Foresters (see Non-native Invasive Plant Management Supported by the Private Lands Program section below), who help landowners and communities manage their forests, including providing recommendations on the treatment of invasive plants. Agency of Natural Resources (ANR) staff, including FPR, the Vermont Department of Fish and Wildlife, and the Vermont Department of Environmental Conservation, continue to identify and manage invasive plants on State Lands.

Early Detection Species

In 2021, focus shifted to three primary projects: 1) developing an early detection rapid response (EDRR) protocol for invasive plant species; 2) conducting phonologic research projects to a) determine a baseline dataset for invasive plant behavior in Vermont and b) participate in national research projects to measure and model the impacts of climate change on invasive plant species; and 3) to map the places in the state where invasive plant populations cross boundaries between state- and privately-owned lands. 2022 was focused on developing the long-term phenology monitoring projects, which continued to run smoothly in 2023.

Four new species of invasive plant were confirmed in Vermont in 2023: pale swallowwort (*Vincetoxicum rossicum*), porcelain berry (*Ampelopsis brevipedunculata*), mile a minute vine (*Persicaria perfoliate*), and common butterbur (*Petasites hybridus hybridus*). The discovery of these plants kindled a new working relationship with sister agency AAFM and prompted the development of an EDRR protocol that includes a site visit, an infestation assessment and delimitation, an initial treatment, a public outreach campaign, and ongoing support to the landowner. Meanwhile, staff turnover has prompted an organizational overhaul. Now, Forest Health staff will cease to be responsible for fire safety programs and will conduct invasive plant work instead. This will benefit the state by increasing the number of people working on invasive plant species, by allotting more field work to the research and

management of invasive species, and by better integrating invasive plant management into the other forest pest protection work conducted by FPR.

Monitoring and Outreach

Invasive Plant Phenology Monitoring Projects: FPR staff and statewide partners are working to establish a **Vermont Invasive plant Phenology Network** (VIPN). This is a network of projects establishing a baseline dataset for invasive plant phenology in Vermont. 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 to adjust our treatment plans accordingly. Continuing the 7th season for the **Statewide Invasive Plant Phenology Monitoring Project** (SIPPMoP), FPR staff and volunteers observed any invasive plants phenology across the state in the second full week of each month of the growing season. Results were reported in the monthly FPR Insect & Disease Reports. This was year two for the **Vermont Invasive Plant Phenology Project** (VIPPP). This is a multiorganizational collaboration, with sites across the state, utilizing the **National Phenology Network**'s (NPN) database and their online mapping tool, **Nature's Notebook**. The Invasive Plant Coordinator is an NPN trained Local Phenology Leader, and is coordinating and running the project. This project is focused on observing the phenology of three invasive plants, *Lonicera morrowii, Celastrus orbiculatus,* and *Rhamnus cathartica*, and ongoing data collection can be viewed for free through the online NPN visualization tool.

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 dozens of newly published free resources and updating website structure to make said resources easily accessible.

Mapping for Healthy Forests, Vermont: This iNaturalist project remains active, connecting users with location, photos, information on seed production, and level of infestation of each specific observation of invasive plants. This information is stored on the iNaturalist website and is accessible to anyone. As of January 2024, the project had 4,950 observations provided by 190 observers.

TRENDS

Sugar Maple Health in 2023

Vermont has continued to monitor sugar maple health in sugarbushes and in maple stands since 1988. In these North American Maple Project (NAMP) plots, 95% of overstory sugar maples were rated as having low dieback (less than 15%), which is a slight increase compared to 94% in 2022 (Figure 32).

Statewide, there continued to be a decrease in percent of trees with thin foliage (3%) compared with 2022 (4%) (Figure 33). 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 (20042007, 2016-2018), and pear thrips (1988-1989).

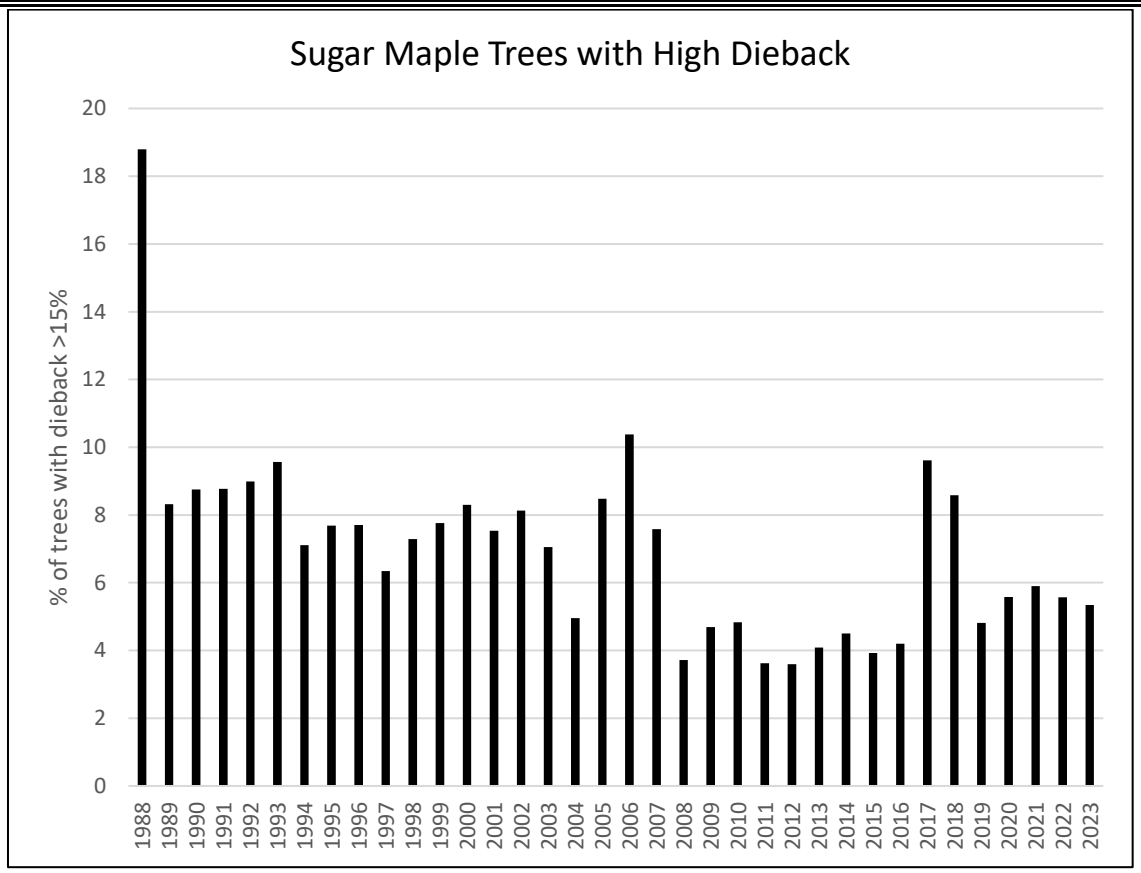

Figure 34. Percent of overstory sugar maple trees on NAMP plots with high dieback (>15%), 1988-2023. *n* = 1,105 trees at 35 sites.

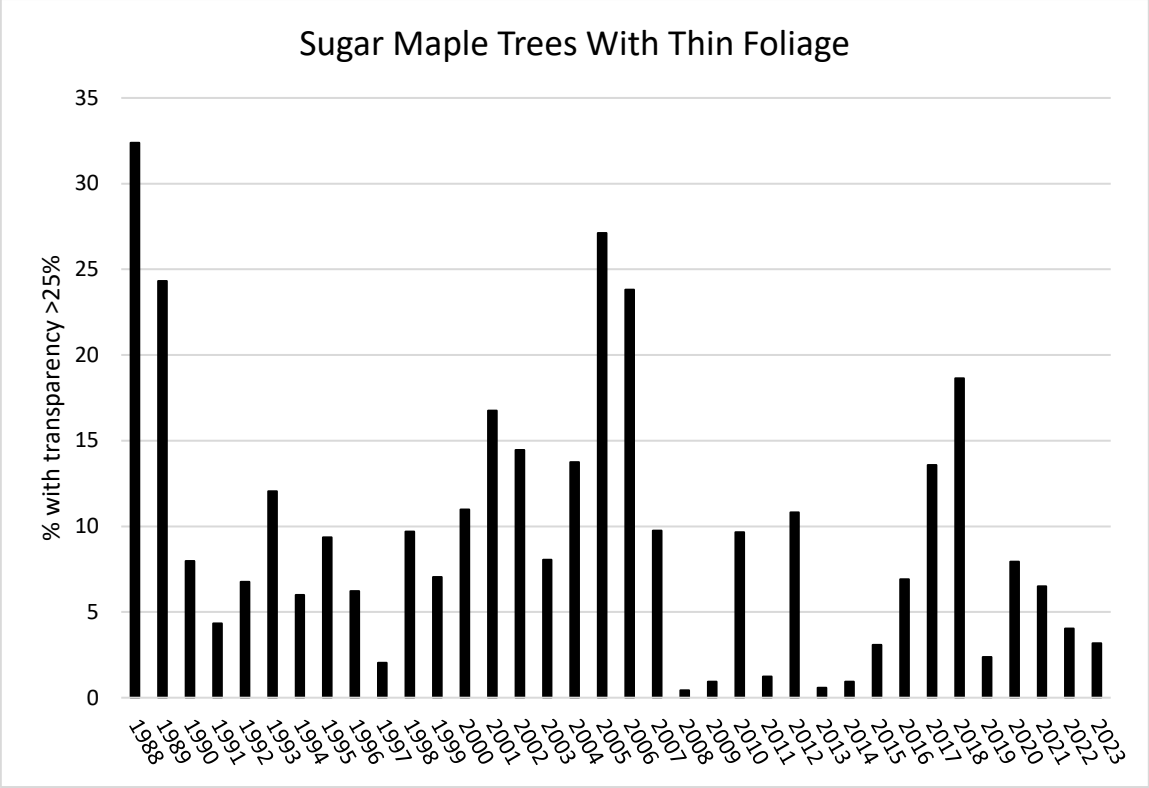

Figure 35. Trend in the percent of overstory sugar maple trees on NAMP plots with thin foliage (>25% foliage transparency), 1988-2023. *n* = 1,105 trees at 35 sites.

Forest Ecosystem Monitoring Cooperative
Trends in Forest Health throughout Vermont in 2023

Vermont forest health monitoring plots were sampled at 48 sites across the state in 2023 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 analyses from this plot network can be obtained in the annual reports produced by FEMC, found at https://www.uvm.edu/femc/ products/reports.