

2022 Forest Health Annual Report



The Minnesota Department of Natural Resources Forest Health Highlights report was created by the Division of Forestry Forest Health Program.

Cover photo: DNR Northeast Region Forest Health Specialist Eric Otto with *Pholiota squarrosa*, or scaly Pholiota.

Photo credits: Photos and other images are from DNR staff unless indicated otherwise.

Some projects were funded in whole or in part through a grant awarded by the USDA Forest Service, St. Paul Field Office State and Private Forestry.

Equal opportunity to participate in and benefit from programs of the Minnesota Department of Natural Resources is available to all individuals regardless of race, color, creed, religion, national origin, sex, marital status, public assistance status, age, sexual orientation, disability, or activity on behalf of a local human-rights commission. Discrimination inquiries should be sent to Minnesota DNR, 500 Lafayette Road, St. Paul, MN 55155-4049 or to the Equal Opportunity Office, Department of the Interior, Washington, D.C. 20240.

Contents

Minnesota Department of Natural Resources Division of Forestry Forest Health Staff	5
Forest health highlights	6
Aerial survey coverage.....	7
Annual aerial survey of forest canopy	8
Comparison of aerial survey results, 2021-2022	9
Forest Health Report.....	10
Insects	10
Pine bark beetles.....	10
Eastern larch beetle	11
Emerald ash borer.....	13
Forest tent caterpillar	15
Introduced basswood thrips damage to basswood in central Minnesota	17
Jack pine budworm	19
Larch casebearer	21
Large aspen tortrix.....	23
Oak twig girdler.....	24
Spongy moth (formerly gypsy moth)	25
Spruce budworm.....	27
Twolined chestnut borer.....	30
Diseases.....	32
Bur oak blight	32
Diplodia assessment on red pine at the Badoura State Forest Nursery.....	33
Heterobasidion root disease.....	34
Oak wilt	35
Declines and Abiotic Problems	37
Aspen decline	37
Impact of the 2021 drought on planted trees	38
Flood damage.....	39
Heavy snow damage from December storm	40
Sparse aspen crowns.....	41
Wind.....	43

Other tree pest and tree health events noted in 2021 and 2022..... 44
2022 North Central Forest Pest Workshop: *Forest Health in a Changing Climate*..... 46
Great Lakes Forest Fires Compact Forest Health Committee training 47

Minnesota Department of Natural Resources Division of Forestry Forest Health Staff

Forest health specialists conduct annual insect and disease surveys and interpret associated data for forest managers. They respond to requests from forest managers and forest landowners on public and private lands for assistance with insect and disease management issues. Staff prioritize investigating significant insect and disease threats to state forest land.

Forest health staff provide expertise in DNR policy development regarding forest health. They provide training to DNR employees and other agencies and organizations. Staff create outreach products such as [webpages](#) and the [Forest Insect & Disease Newsletter](#) to reach a wide audience. Annual reports from 1969 to the present are available on the [Forest Health Annual Reports](#) website.

Andrew Arends, Forest Operations and Management Section Manager
500 Lafayette Road
St. Paul, MN 55155
651-259-5261
andrew.arends@state.mn.us

Val Cervenka, Forest Health Program Consultant
500 Lafayette Road
St. Paul, MN 55155
651-259-5296
val.cervenka@state.mn.us

Rachael Dube, NW Region Forest Health Specialist
1601 Minnesota Drive
Brainerd, MN 56401
218-203-4427
rachael.dube@state.mn.us

Megan O'Neil, NW Region Forest Health Specialist
2115 Birchmont Beach Road NE
Bemidji, MN 56601
218-308-2364
megan.oneil@state.mn.us

Eric Otto, NE Region Forest Health Specialist
1201 East Hwy 2
Grand Rapids, MN 55744-3296
218-328-8897
eric.otto@state.mn.us

Brian Schwingle, Central Region Forest Health Specialist
1200 Warner Road
St. Paul, MN 55106
651-259-5821
brian.schwingle@state.mn.us

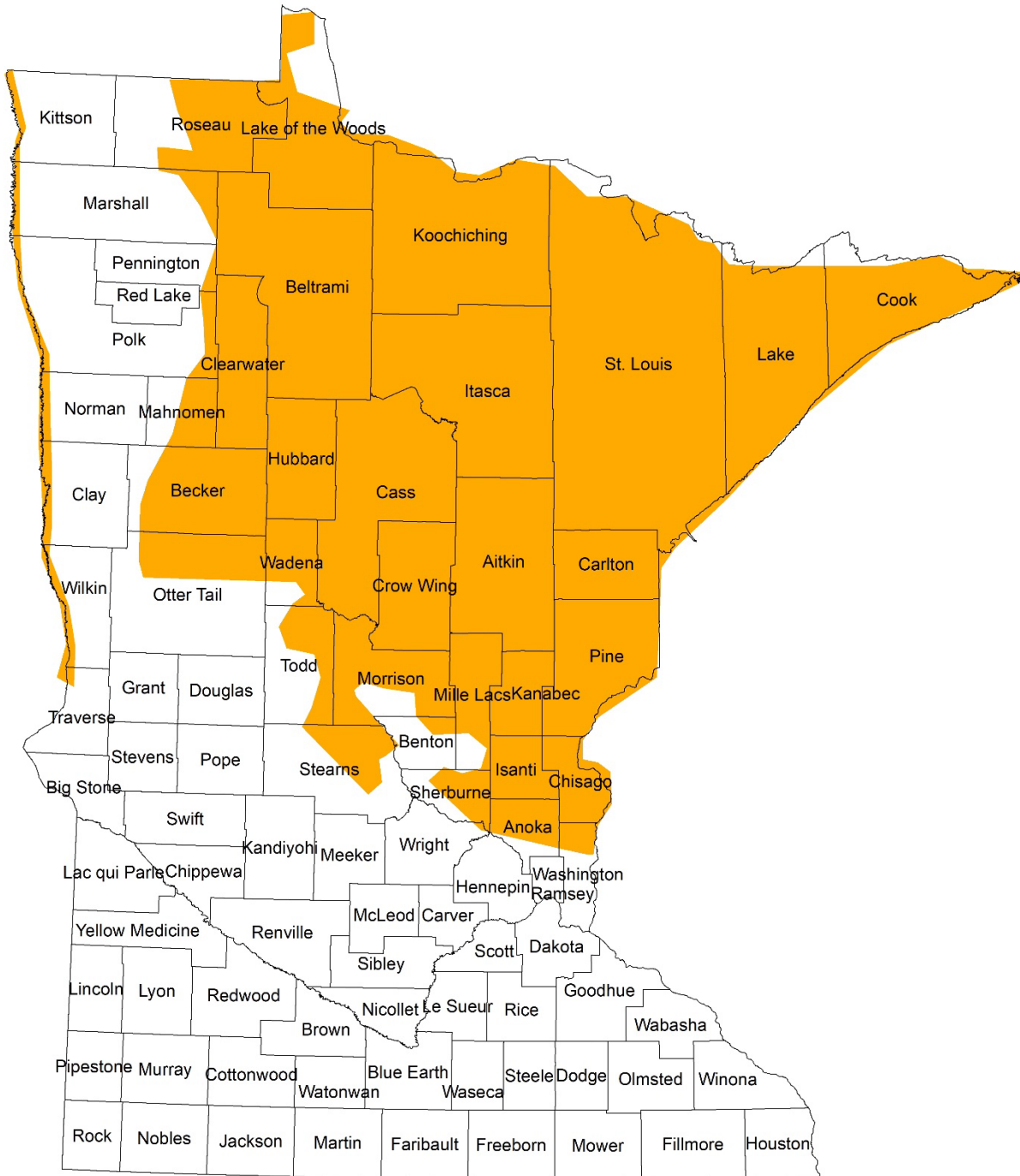


Forest health highlights

The annual forest health report provides information about significant damage to forests recorded in our aerial and ground surveys and highlights other staff accomplishments. The report is of special interest to foresters who can use it to learn what is threatening forests they manage.

- Forest health staff collaborated with the DNR Resource Assessment unit and the U.S. Forest Service to aerially survey about 17.4 million acres of Minnesota for damage to forests.
- The northern third of Minnesota (specifically the northern three [climate divisions](#)) experienced its second wettest spring dating back to 1895.
- Eastern larch beetle infested more acres than ever before, exceeding 300,000 acres.
- Spruce budworm damaged more acres than it has since 1995, mostly in northeast Minnesota.
- Introduced basswood thrips severely damaged patches of basswoods from central to north-central Minnesota for the second year in a row.
- A large winter snowstorm in mid-December produced extremely heavy snow that severely damaged many young aspen stands in Pine County.
- Residual effects from the extreme drought in 2021 include:
 - Twolined chestnut borer outbreaks killed co-dominant and dominant forest canopy oaks in patches across the landscape, particularly in central and east-central Minnesota.
 - Twolined chestnut borer and Armillaria root disease killed thousands of intermediate (trees shorter than the canopy that receive little sunlight from above and none from the sides) and suppressed (trees whose crowns are completely covered by crowns of neighbors) oaks from northwest Minnesota to east-central Minnesota.
 - Aspens produced a tremendous seed crop across northern Minnesota, possibly in reaction to the 2021 drought. This seed crop was paired with stunted leaves all through the growing season.
 - Bronze birch borer killed some intermediate and suppressed birch trees, and bronze poplar borer killed some intermediate and suppressed aspens in north-central Minnesota.

Aerial survey coverage



Annual aerial survey of forest canopy

Since the early 1950s, the Minnesota Department of Natural Resources (DNR) aerial survey has been a valuable tool for monitoring forest canopy health across 17.7 million acres of forest land. Surveys consistently record information such as large insect outbreaks, wind events, and fire damage that happen prior to or during the flight. Other problems such as root diseases, wilts, and tree declines cannot be consistently detected from the air and are not reliably recorded in surveys.

An additional aerial survey was conducted in the spring of 2022 to map damage caused by pine bark beetles on state land in the northern half of Minnesota. The flight focused on red pine plantations. Bark beetles impacted some areas in Beltrami Island and Lake of the Woods state forests more heavily. The goal of the survey was to provide management opportunities to foresters in those areas.

Annual surveys are accomplished through the collaboration of the DNR Forest Health and Resource Assessment units and the USDA Forest Service, St. Paul Field Office, State and Private Forestry. Survey results for 2016-2022* can be found in the [Minnesota Geospatial Commons](#) (keywords “forest health”).

*Due to COVID-19, no aerial survey was conducted in 2020.

Comparison of aerial survey results, 2021-2022

Damage agent	Acres affected in 2021	Acres affected in 2022	Comments
Aspen and birch decline	29,108	29,855	
Pine bark beetles	1,069	2,735	Many or most acres mapped in 2022 were infested after aerial survey in 2021 and died later in 2021.
Basswood leafminer	163	0	
Eastern larch beetle	252,100	303,224	
Flooding	3,710	6,733	
Forest tent caterpillar	9,081	9,811	
Jack pine budworm	0	0	Jack pine budworm was active on some jack pine in Beltrami County in 2020, 2021, and 2022, but aerial surveys did not detect it.
Larch casebearer	11,884	1,581	Larch casebearer was only found in Aitkin County in 2022.
Large aspen tortrix	0	3,210	Large aspen tortrix was mapped for the first time since 2014.
Spruce budworm	383,685	488,838	This is the largest number of acres affected since 1995, when 506,000 acres were impacted.
Twolined chestnut borer	962	1,550	The 2022 figure is largely underestimated because aerial surveys happened before twolined chestnut borer symptoms appeared.
Wind	1,955	13,689	

Forest Health Report

The following forest health report contains information on significant and notable causes of forest damage in 2022.

Insects

Pine bark beetles

Two native bark beetles, *Ips pini* and *Ips grandicollis*, attack and kill stressed pines in Minnesota. We have recorded regional outbreaks, typically in red pine plantations, during years of extreme drought: 1976, 1987, 1988, and 2021. Plantations thinned during or immediately before the droughts in 1987, 1988, and 2021 were preferentially attacked.

Bark beetle attacks eased in 2022, even though the aerial survey recorded more acres affected in 2022 than in 2021. The reason for this is that bark beetles attacked many pines in the summer of 2021 after our 2021 survey, and many of their crowns didn't die from the attack until the fall or early winter of 2021-2022. Combining the 2021 and 2022 surveys to understand the impact of the 2021 drought, there were five-and-a-half times more instances of bark beetle attack than from the combined 2018 and 2019 survey data.

Thinning risk after drought

Red pine plantations are frequently thinned in early spring in Sherburne County due to the relatively low risk of soil compaction at that time of year. Some managers had concerns spring thinning the year after a drought would promote bark beetle infestation. To address these concerns, we surveyed two adjacent Sherburne County plantations of the same age, one thinned in March-April 2022 and one not thinned. The plantations suffered 19 consecutive weeks of at least moderate drought from April through October 2021, with 11 consecutive weeks in severe or extreme drought ([Map Archive](#) | [U.S. Drought Monitor \(unl.edu\)](#)).

Ips bark beetles uniformly infested slash in the thinned stand by late May 2022. At the end of the growing season, we detected no significant difference in mortality rate from bark beetles between the two plantations; both lost about 1% of pines to bark beetle attack. We plan to survey the plantations again in 2023, but tentatively conclude negligible risk of bark beetle attack from spring thinning the year *after* a serious single drought during the growing season.



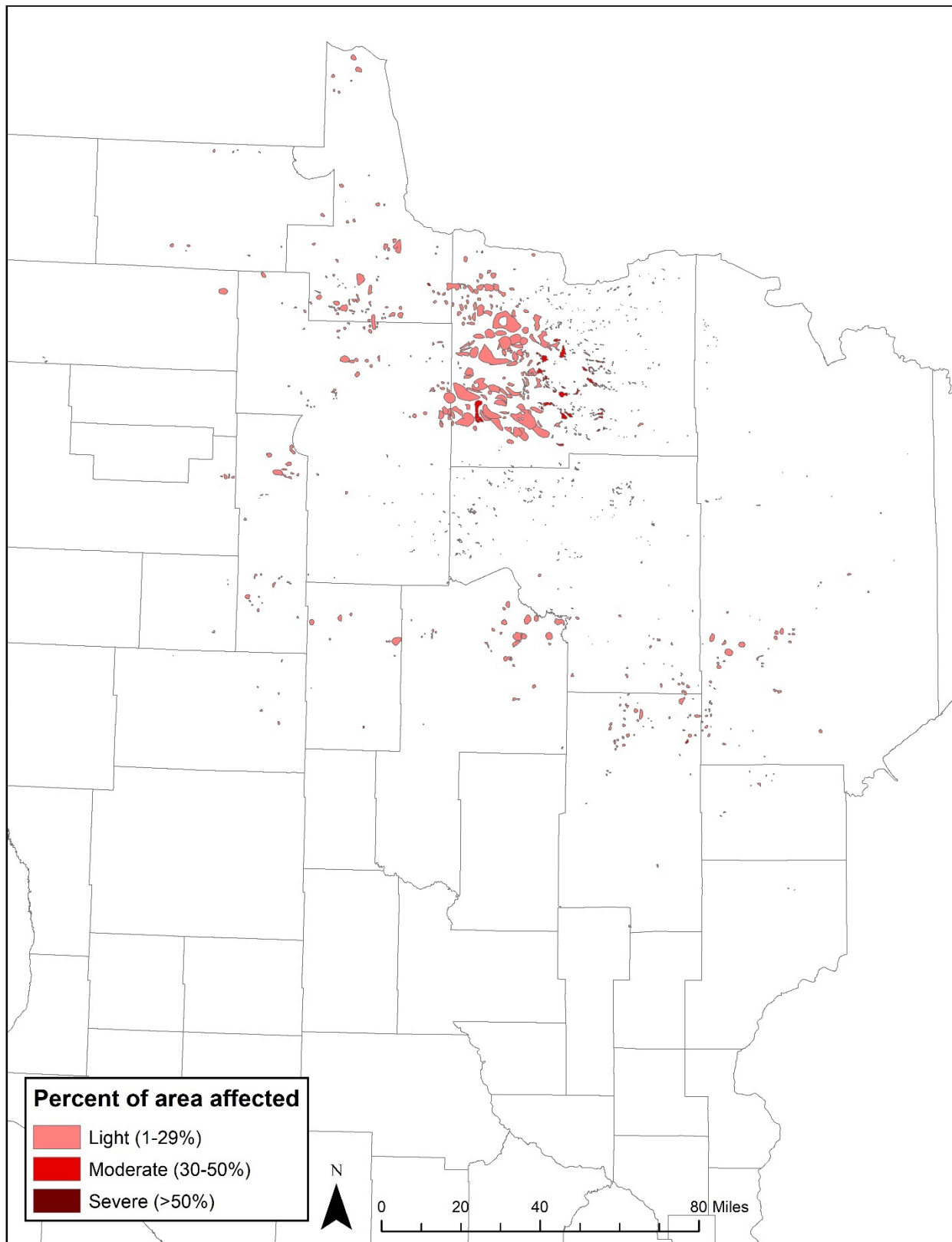
Ips galleries in slash, Sherburne County, late May 2022.

Eastern larch beetle

Eastern larch beetle (*Dendroctonus simplex*) is native to Minnesota and continues to attack hundreds of thousands of acres of tamarack every year. The eastern larch beetle life cycle has changed due to our warming climate. Research by the University of Minnesota Department of Entomology on the [population dynamics of the eastern larch beetle](#) revealed that a portion of the larch beetle population does not require an overwintering period to reproduce. Due to this change, more than one generation of beetle per year is sometimes able to develop. This ability to reproduce more quickly has led to an increase in beetle populations in tamarack stands. Another factor aiding larch beetle populations is defoliation by larch casebearer, which stresses tamarack trees, making them more attractive to bark beetles. Other factors may be aiding the larch beetle outbreak as well. Since the beginning of the eastern larch beetle outbreak in 2001, about 971,794 acres, or 69% of tamarack in Minnesota, have been impacted to some degree.

The aerial survey found that eastern larch beetle affected 303,224 acres this year. Most of the acres were only lightly affected, meaning that 1-29% of trees in the stand showed symptoms of infestation.

The area of infested tamarack continues to grow. Future surveys will determine if the intensity of the larch beetle outbreak will continue at a similar rate. We have observed regeneration of tamarack (and other species) in many of the stands killed early in the outbreak, showing that infested tamarack stands could recover from larch beetle mortality with time.



Areas with eastern larch beetle damage in 2022.

Emerald ash borer

The Minnesota Department of Agriculture (MDA) is the lead agency for the emerald ash borer (EAB) program in the state. Thirty-eight cities detected EAB for the first time in 2022. The MDA added seven new county detections (Carlton, Isanti, Kandiyohi, Lake, Le Sueur, Sherburne, and Waseca), shown in yellow in the map below, bringing the total to 37 out of 87 counties now fully or partially under the state’s [emerald ash borer quarantine](#).

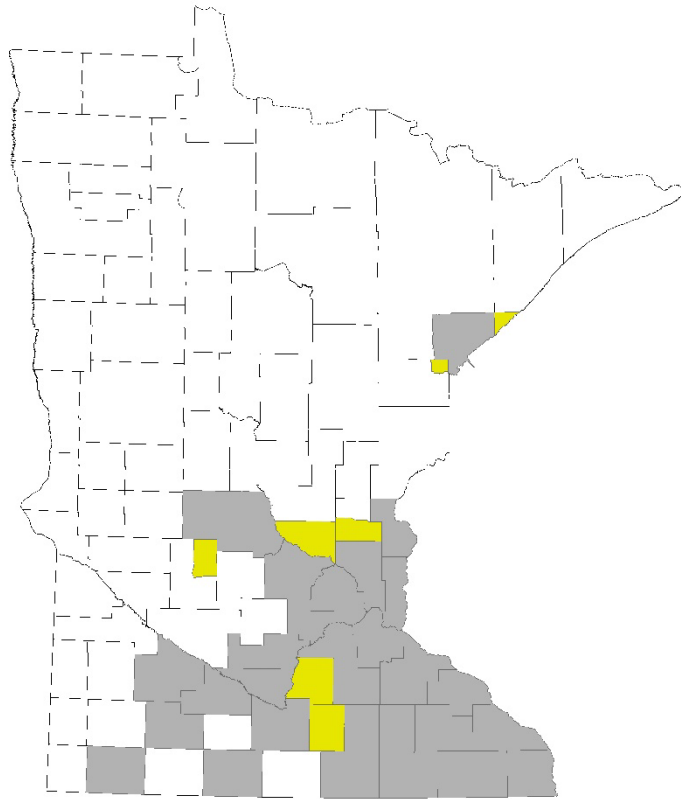
The MDA’s EAB biological control efforts continued during the summer of 2022 with 20,333 parasitoid wasps of three different species released at five sites (see table of release numbers and sites below). They prioritize new release sites in counties with no previous parasitoid releases. The MDA hopes to release additional wasps in Carver, Goodhue, and Mower counties in 2023. Updated parasitoid release and recovery locations may be found on the MDA’s [EAB biocontrol map](#).

Release sites	Number of <i>Tetrastichus planipennis</i> released	Number of <i>Oobius agrili</i> released	Number of <i>Spathius galinae</i> released
Fort Snelling (Hennepin Co.)	0	0	1,025
Rockville (Stearns County)	0	1,400	1,240
North St. Paul (Ramsey Co.)	4,531	1,400	1,106
Faribault (Rice County)	4,508	1,400	1,331
Whitewater Wildlife Management Area (Olmsted, Wabasha, and Winona counties)	0	1,200	1,006

DNR Forest Health did not aerially survey regions of the state heavily infested with EAB in 2022, but the survey picked up 33 acres of EAB damage. Combining aerial survey data from 2016-2022, we have mapped 10,196 acres of forest with EAB damage, but this is an underestimate since our aerial surveys do not cover the Twin Cities metro area and do not pick up lightly infested or widely scattered infested ash.

The DNR Forest Health staff conducted early detection ground surveys on state lands immediately surrounding the core EAB infestation area in the metro area and in Little Falls (Morrison County). We detected EAB in five of these surveys, all surrounding the core metro area infestation. Forest health staff also conducted ground surveys near newly infested areas, including Cloquet (Carlton County), areas north of Duluth (St. Louis County), and Two Harbors (Lake County), and found additional infested trees around the core infestation in Two Harbors. We also delivered EAB updates and management guidance during several trainings.

The DNR Division of Forestry continues to prepare for EAB by accelerating sales of harvest permits in black ash stands and diversifying black ash stands by planting other tree species prior to its arrival. The DNR Silviculture Program partnered with the Leech Lake Band of Ojibwe and the American Bird Conservancy on two projects to diversify black ash-dominated forests and with the DNR Division of Parks and Trails on planning a diversification planting in William O'Brien State Park. Lastly, DNR Silviculture partnered with USDA Forest Service and DNR state forest nursery staff to plant a field at the nursery with balsam poplar that will be used to diversify ash forests.



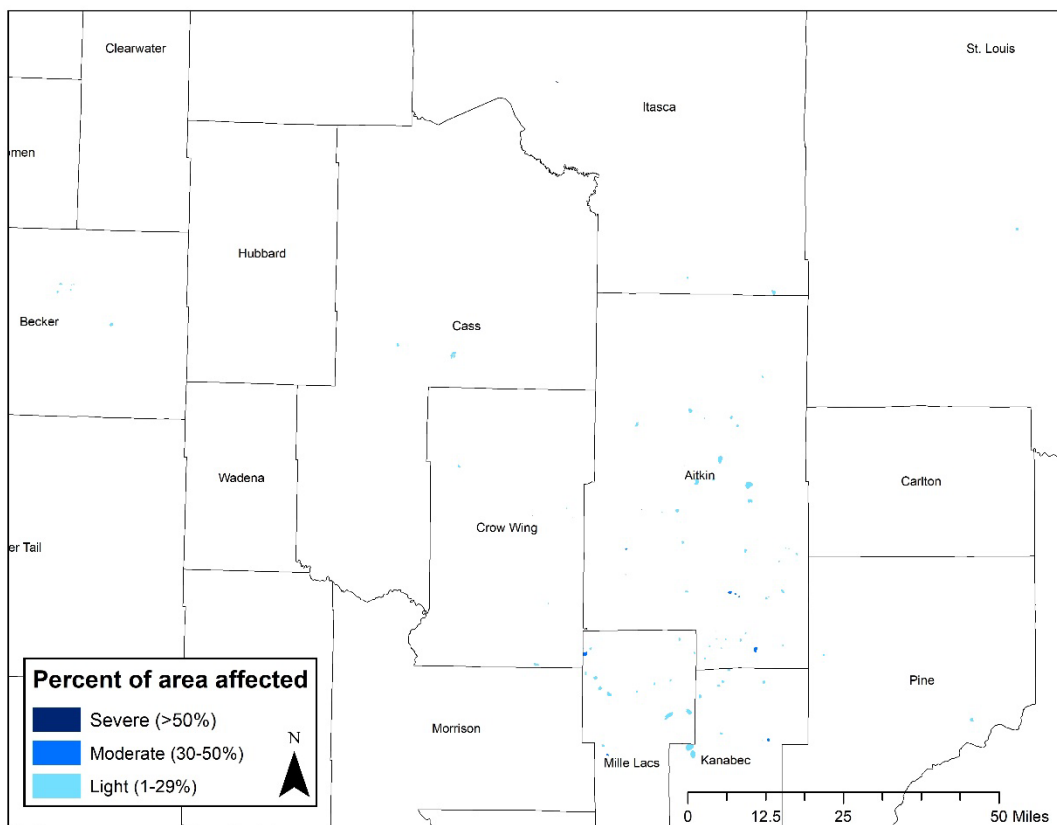
Emerald ash borer quarantine counties. Yellow counties or areas were quarantined for the first time in 2022.

Forest tent caterpillar

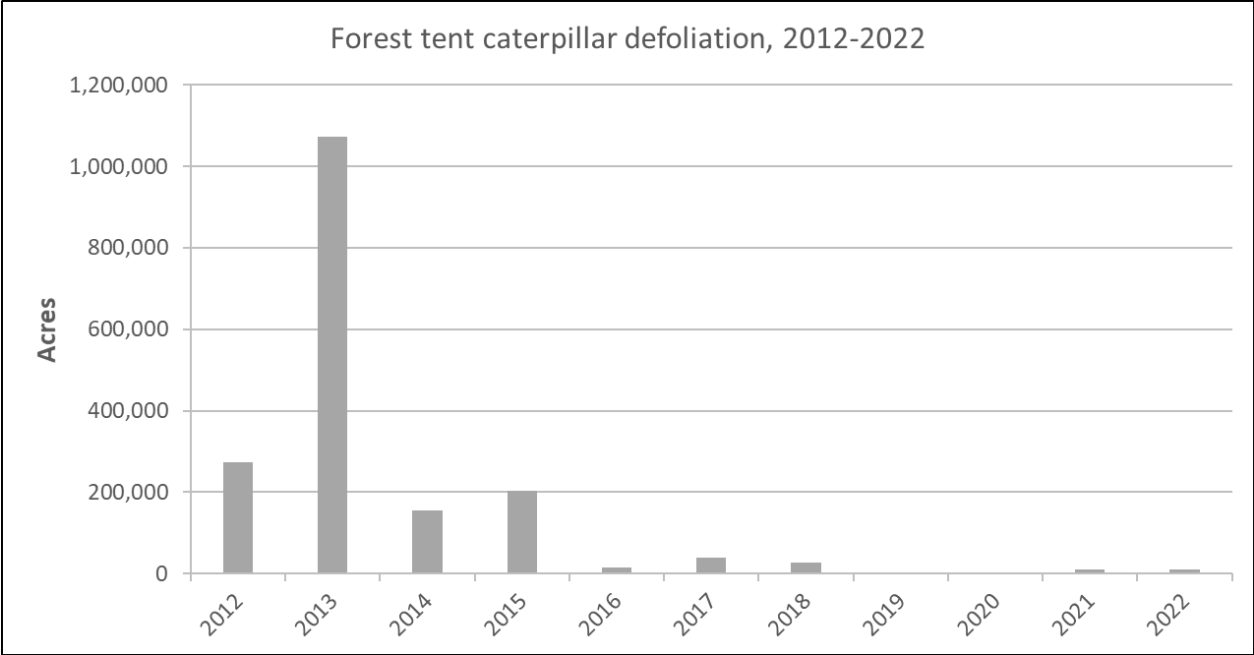
Forest tent caterpillar (*Malacosoma disstria*) is a native insect that feeds on a variety of hardwood and shrub leaves, especially aspen, oak, birch, and basswood. We recorded just over 9,800 acres of defoliation in 2022, a small increase from damage detected in 2021 (9,100 acres). Forest tent caterpillar populations continued a slight upward trend following a decline in 2019.

Most of the defoliation occurred in Aitkin County and northern Mille Lacs and Kanabec counties. Other affected counties include Becker, northern Cass, Crow Wing, Itasca, Pine, and southern St. Louis. Nearly 90% of the defoliation in 2022 was light, affecting less than 30% of the trees in damaged areas.

The only severe defoliation detected in 2022 was in Itasca County – a relatively small area of about 30 acres. A local forest tent caterpillar outbreak in Grand Rapids that started in 2021 also continued this year, although the damage was not detected in the aerial survey. Moderate damage affecting 30-50% of trees was mostly detected in Aitkin and Mille Lacs counties, but this level of defoliation was also recorded in Crow Wing and Kanabec counties.



Areas with defoliation from forest tent caterpillar in 2022.

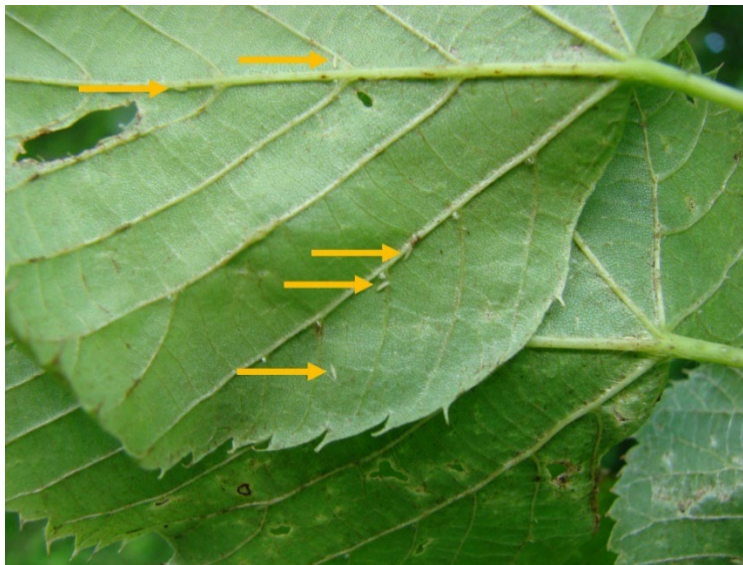


Acres with forest tent caterpillar from 2012 to 2021. No aerial survey was conducted in 2020.

Introduced basswood thrips damage to basswood in central Minnesota

Introduced basswood thrips (*Thrips calcaratus*) damaged basswood trees for a second consecutive year in Minnesota. This tiny, non-native insect does the most damage to buds in early spring, causing a variety of leaf symptoms, including stippling, dead margins, and deformity, which can appear to be caused by late frost.

Surveys revealed scattered areas of affected basswoods, from Kandiyohi County north to Beltrami and Becker counties (see map below of counties documented with thrips damage). Thrips activity expanded north this year. Feeding activity lessened in Kandiyohi County, but it remained very intense in Birch Lakes State Forest in northern Stearns County.

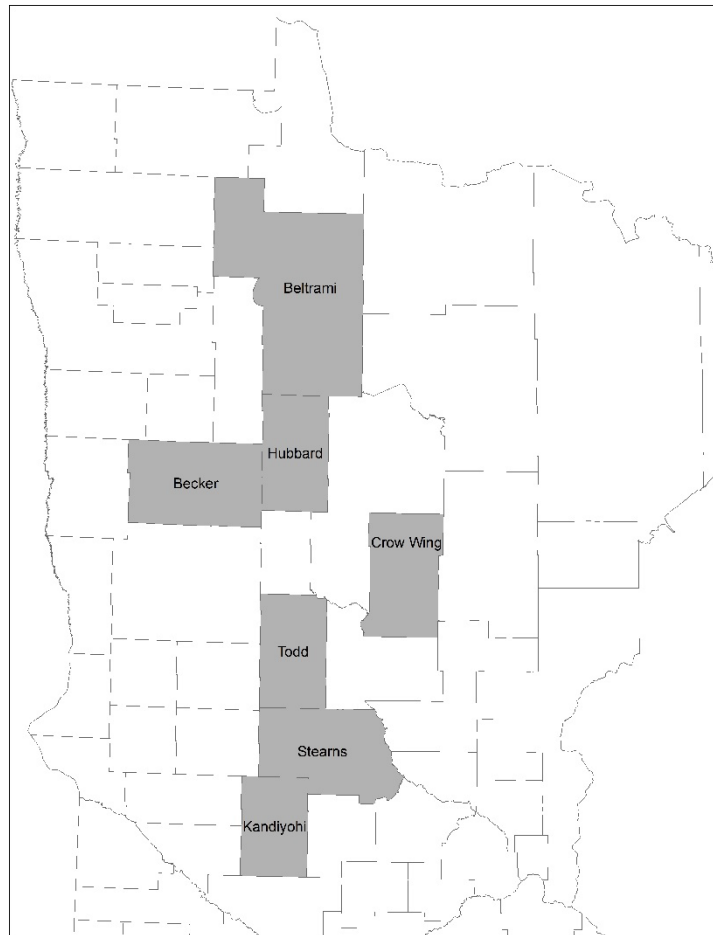


Arrows pointing to introduced basswood thrips (light-green flecks).



Introduced basswood thrips feeding damage, Kandiyohi County, 2021.

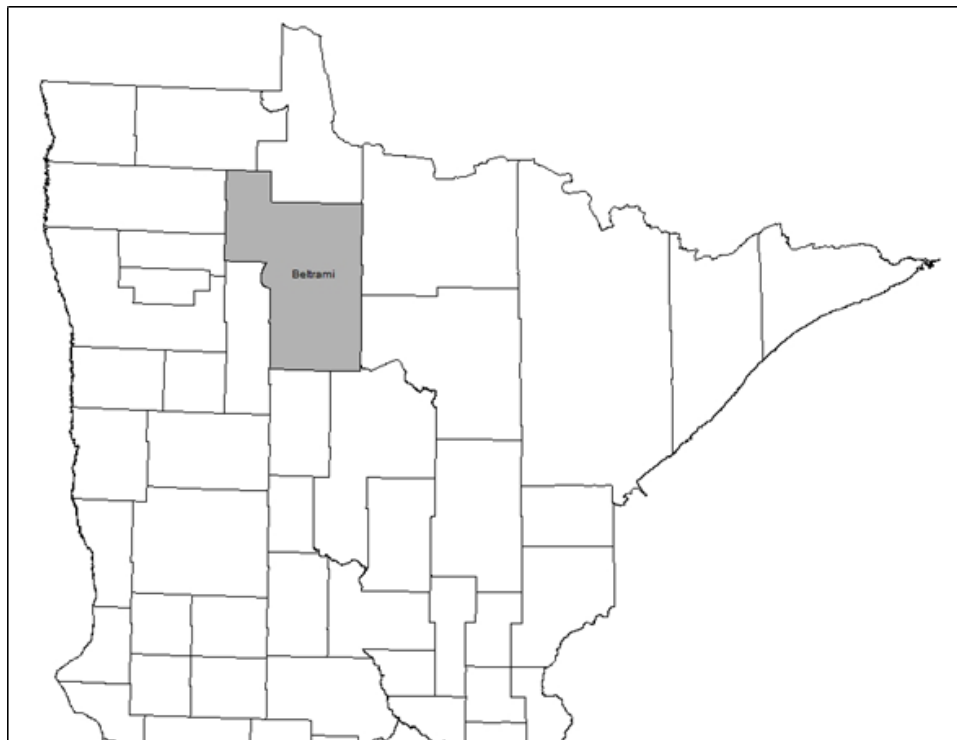
Before 2021, we last documented problems with introduced basswood thrips in Minnesota in 1995, and before then from 1982 to 1988. Introduced basswood thrips can affect basswoods in the same area for many years in a row, eventually stunting their crowns. We expect introduced basswood thrips to be active again in central Minnesota in spring 2023. After a few years, predacious insects or weather conditions will likely reduce populations. We are unaware of long-term negative impacts to basswoods across Minnesota from introduced basswood thrips.



Counties with damage to basswood leaves in 2022 from introduced basswood thrips.

Jack pine budworm

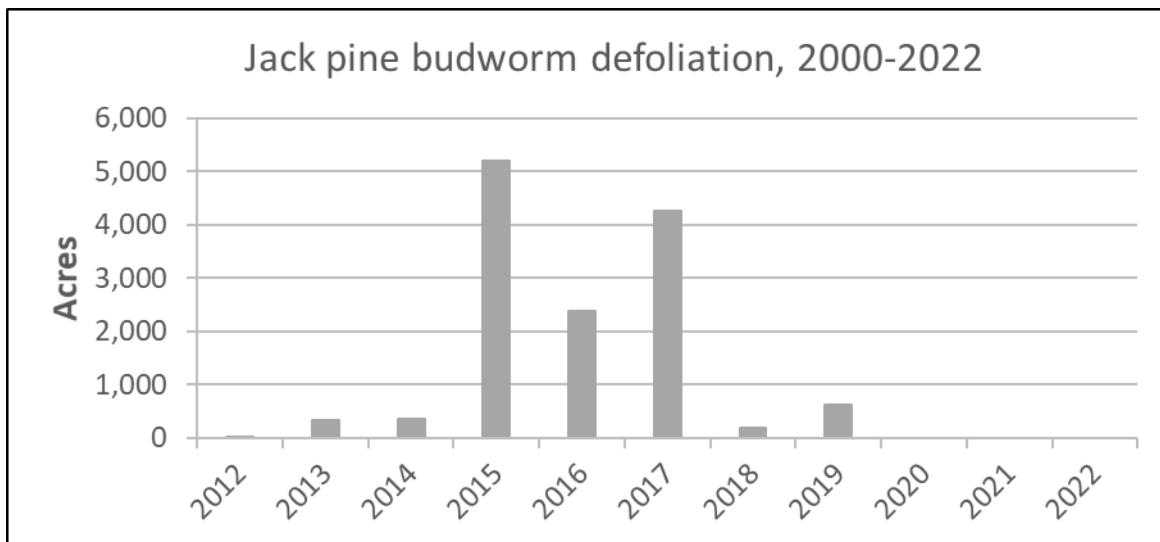
Jack pine budworm (*Choristoneura pinus*) is a native moth whose caterpillar feeds on jack pine. No jack pine budworm damage was detected by the aerial survey in 2021 or 2022, and there were reports of damage only in Beltrami County. Jack pine budworm populations have remained low since they collapsed in 2018. Jack pine budworm populations peak every eight to 10 years in north-central and northwest Minnesota and about every 24 years in northeast Minnesota. Their populations may peak again around 2025 in north-central and northwest Minnesota and around 2031 in northeast Minnesota.



Beltrami County was the only location reporting jack pine budworm damage in 2022.



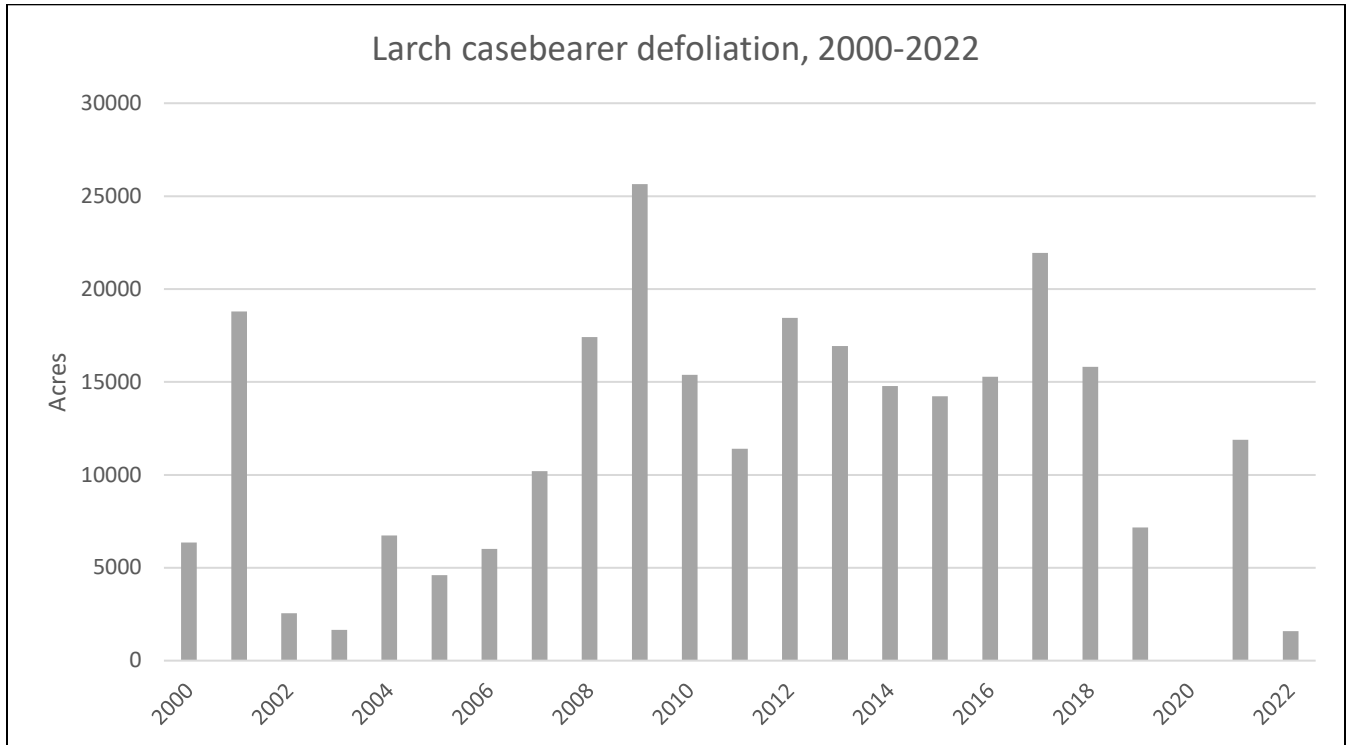
An early-instar larva found in a male cone in Wadena County during 2022 ground surveys, the only larva found during an entire day of surveying.



Acres with jack pine budworm damage from 2012 to 2022. No aerial survey was conducted in 2020.

Larch casebearer

Larch casebearer (*Coleophora laricella*) is a non-native moth whose caterpillar feeds on tamarack needles and can cause defoliation when populations are high. In 2022 we mapped 1,581 acres of defoliation, the fewest mapped since the DNR first started detecting defoliation in 2000. This was a major decrease from 2021 when we mapped 11,884 acres. Damage was only mapped in Aitkin County, but this could be an underestimate due to larch casebearer and eastern larch beetle both affecting tamarack trees.



Acres with larch casebearer defoliation from 2000 to 2022. No aerial survey was conducted in 2020.



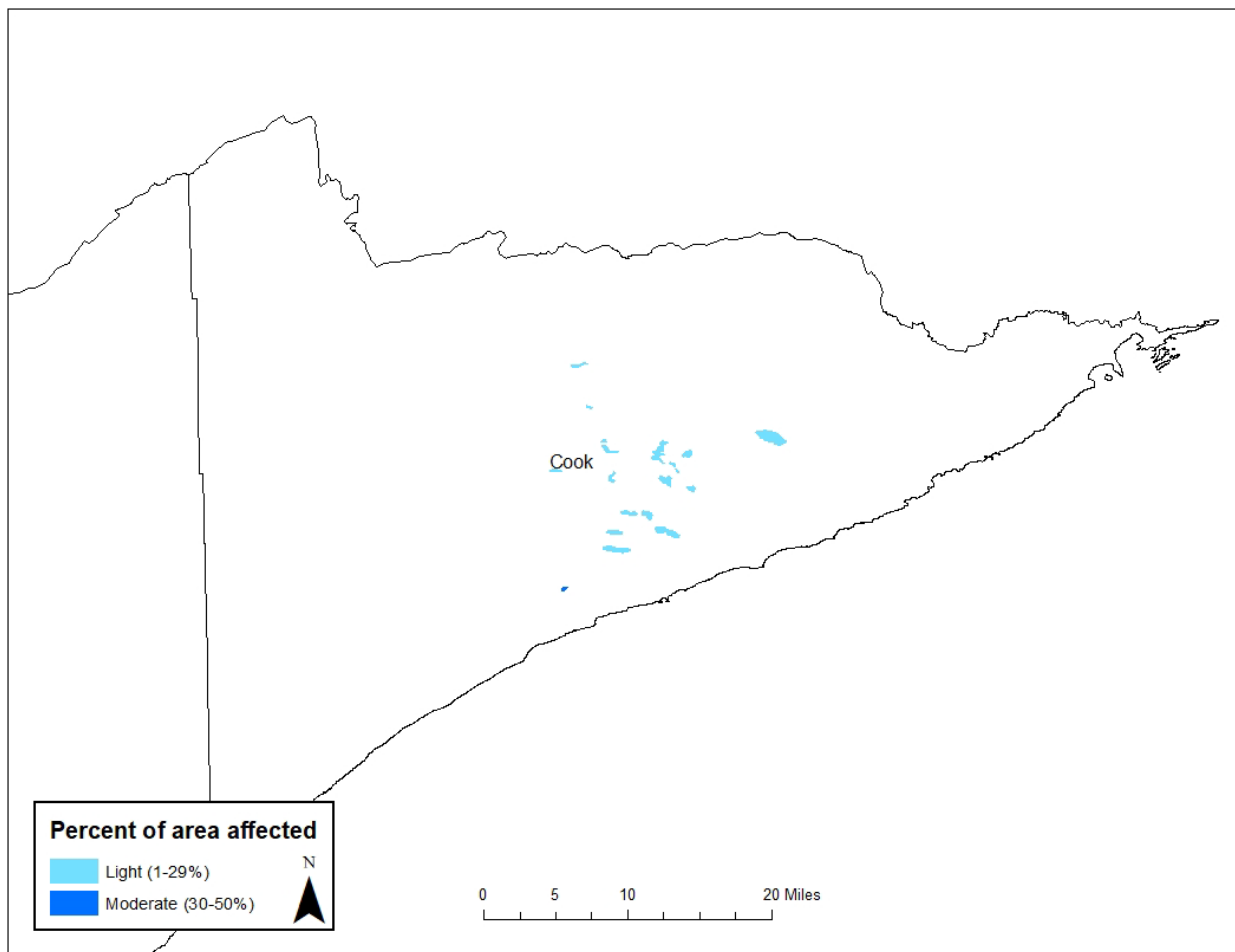
Areas with larch casebearer damage in 2022.

Large aspen tortrix

Large aspen tortrix (*Choristoneura conflictana*) is a defoliator and leaf roller of aspen. In 2022, 3,210 acres with defoliation were mapped. This was the first time it was mapped in Minnesota since 2014. All defoliation was recorded in aspen stands in Cook County, where ground surveys found a small number of tortrix pupae.

Outbreaks of large aspen tortrix have occurred in northeast Minnesota in the past, and this appears to be the start of a new outbreak. Outbreaks typically last two or three years; the previous outbreak lasted from roughly 2012 to 2014 with 3,217 acres of damage recorded by aerial surveys. However, outbreaks can be significant -- 336,000 acres of defoliation were mapped in 1999, primarily along the north shore of Lake Superior.

The aerial survey detected 8,130 acres of additional damage by an unknown aspen defoliator, primarily in St. Louis County and a very small amount in Itasca County. Even without physical evidence of large aspen tortrix, such as pupae, it's possible that defoliation could be the result of tortrix and will be investigated next year.



Areas with large aspen tortrix damage in 2022.

Oak twig girdler

Many insect pests and pathogens can kill oak shoot tips (called shoot blight). This year, we noted bur and red oaks with blighted tips across a broad area, from Dakota County to Pine County. The cause of the shoot blight was novel to us.

We submitted blighted shoot samples to the University of Minnesota Plant Disease Clinic for diagnosis. Clinic staff discovered very tiny larvae of a species of *Agrilus* associated with the samples. Clinic staff closely matched DNA from the samples to that of *Agrilus arcuatus*.

Personal communication with staff in the University of Minnesota Entomology Department confirmed that shoot blight from *Agrilus arcuatus* (oak twig girdler) had been previously documented. We do not anticipate any real problems from this pest.



A bur oak with scattered shoot blight from *Agrilus arcuatus*, Pine County, 2022.



Shoot blight from *Agrilus arcuatus* on a tree in the red oak group, Dakota County, 2022.



Close-up of *Agrilus arcuatus*. Photo from University of Minnesota Plant Disease Clinic.

Spongy moth (formerly gypsy moth)

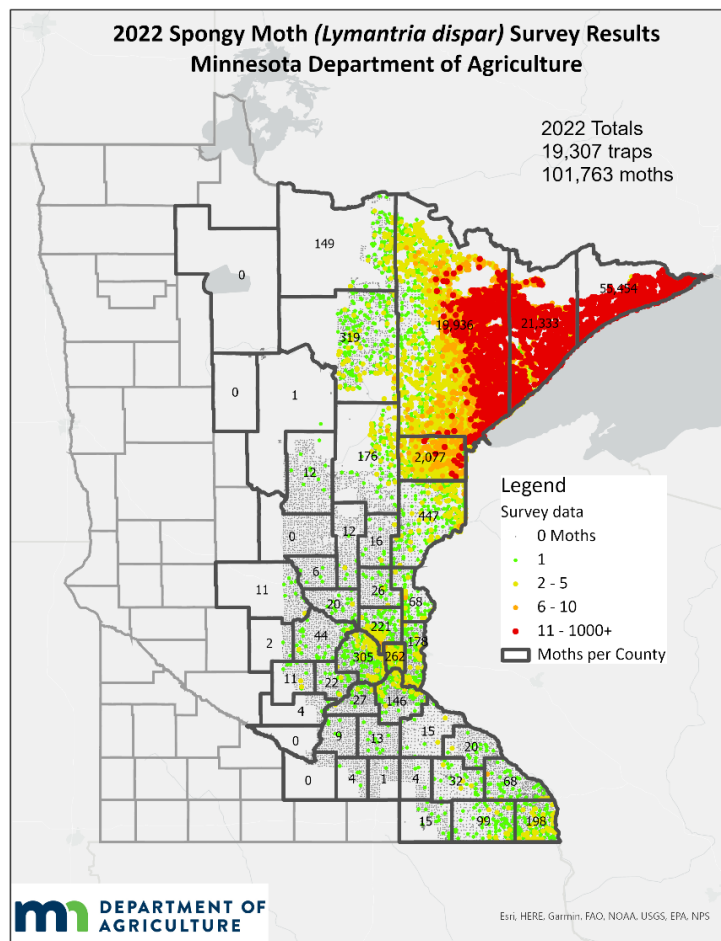
Spongy moth (*Lymantria dispar*) is an invasive forest pest that feeds on more than 300 species of trees and shrubs, including aspen, oak, and birch. Spongy moth is slowly encroaching upon Minnesota from the east and has not yet defoliated forests in Minnesota. Population outbreaks occur every eight to 12 years in areas where it is established, resulting in widespread and repeated defoliation, which stresses trees.

Trapping surveys

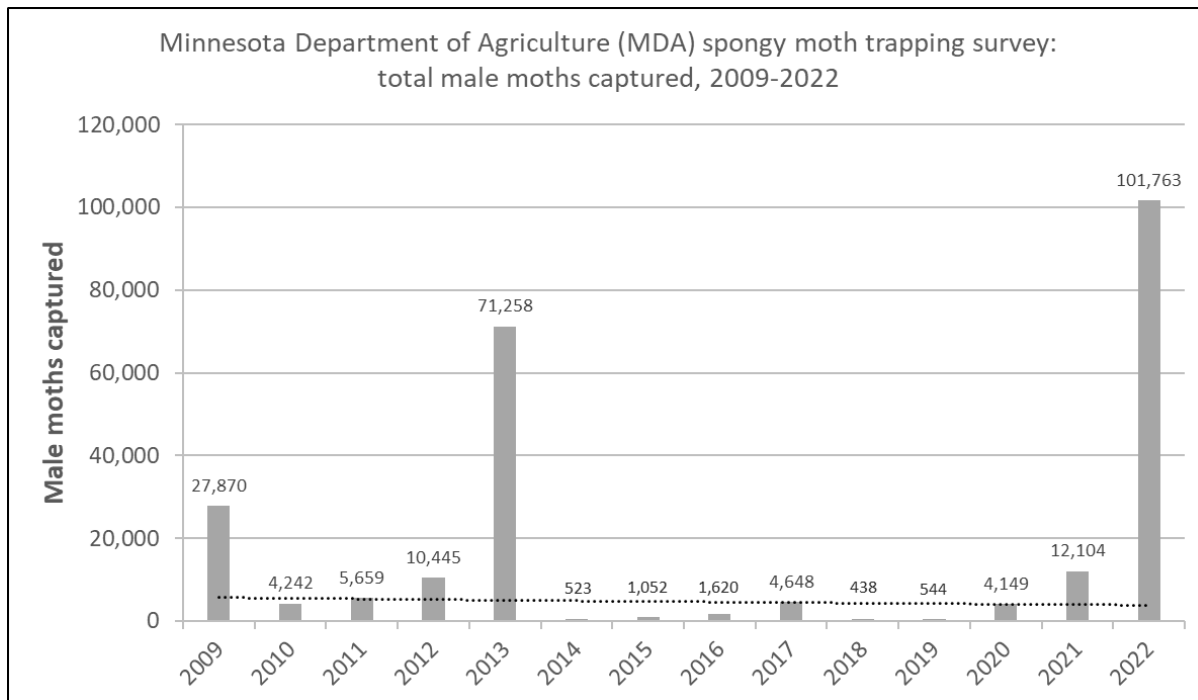
The Minnesota Department of Agriculture (MDA) coordinates and conducts an annual spongy moth trapping survey, catching male moths in pheromone-baited traps to detect spongy moth populations (find program details at the [Minnesota Department of Agriculture spongy moth website](#)). More than 100,000 male spongy moths were caught in traps in 2022, eight times the number caught in 2021. Most moths were caught in Lake and Cook counties.

This year's trap catch broke the previous record set in 2013, when more than 70,000 male moths were trapped, most of which were also trapped in Lake and Cook counties. Only 500 moths were trapped the following year.

The high number of male moths trapped this year does not necessarily indicate defoliation by caterpillars in the near future. Male spongy moths can disperse long distances, but females are flightless. However, for the first time since the quarantine of Lake and Cook counties took effect in 2014, there were a few citizen reports of spongy moth egg masses, caterpillars, and pupal cases this year. Additionally, MDA and DNR staff conducted egg mass surveys along the North Shore at locations with high moth trap catches (more than 300 moths per trap) and found a small number of egg masses at almost every location surveyed. Additional surveys are planned for the spring as the snow recedes and before egg masses hatch.



2022 spongy moth survey results from Minnesota Department of Agriculture.



Male spongy moths trapped in Minnesota annually from 2009 to 2022.

Treatments

In collaboration with federal, state, and local partners, the MDA works to slow the spread of spongy moth by treating isolated populations along the advancing population front. Four treatments took place in northeast Minnesota in June and July. Aerial applications of *Bacillus thuringiensis kurstaki* were applied in Carlton and St. Louis counties. Lake County received two mating disruption treatments of the gypsy moth sex pheromone.

Common name change

The Entomological Society of America approved “spongy moth” as the new common name for *Lymantria dispar* in March 2022. This name replaces the old common name “gypsy moth,” which was removed in 2021 due to its use of a derogatory name for Romani people. The new name – derived from “spongieuse,” the common name used in France and French-speaking Canada – refers to the moth’s sponge-like egg mass, an important target for management efforts to slow the spread of the insect.

Spruce budworm

Spruce budworm (*Choristoneura fumiferana*) is a native caterpillar that prefers to feed on balsam fir but feeds readily on white spruce. When the budworm population is high, feeding damage can also occur on black spruce, tamarack, and pine. The first observed outbreak in Minnesota was in 1912 and lasted until the early 1920s. In other parts of North America, spruce budworm outbreaks occur every 30 years or so, but the budworm population in Minnesota is unique, where a continuing population has been observed in the Arrowhead region since 1954. In Minnesota, spruce budworm typically feeds in an area for six to 10 years, roughly the amount of time balsam fir and white spruce can withstand defoliation before they die. The population then moves to a different area in northeast Minnesota.

In 2022, spruce budworm defoliated or killed 488,838 acres of fir and spruce forests. The majority (approximately 484,680) of those acres were defoliated, and about 4,160 acres had a mix of mortality and defoliation. This exceeds last year's total of 383,685 acres and is now the highest number of acres the caterpillar has impacted in one year since 1995, when it damaged 506,000 acres. Since 2018, spruce budworm has defoliated or damaged an average of 323,340 acres of fir and spruce forests per year in northeastern Minnesota. To put that into context, it's almost the size of Lower and Upper Red Lake and Lake Winnibigoshish combined.

Most of the present outbreak is in northern St. Louis, Lake, and Cook counties. Scattered damage mostly to white spruce stands has also been mapped in Itasca, Beltrami, Roseau, and Lake of the Woods counties.

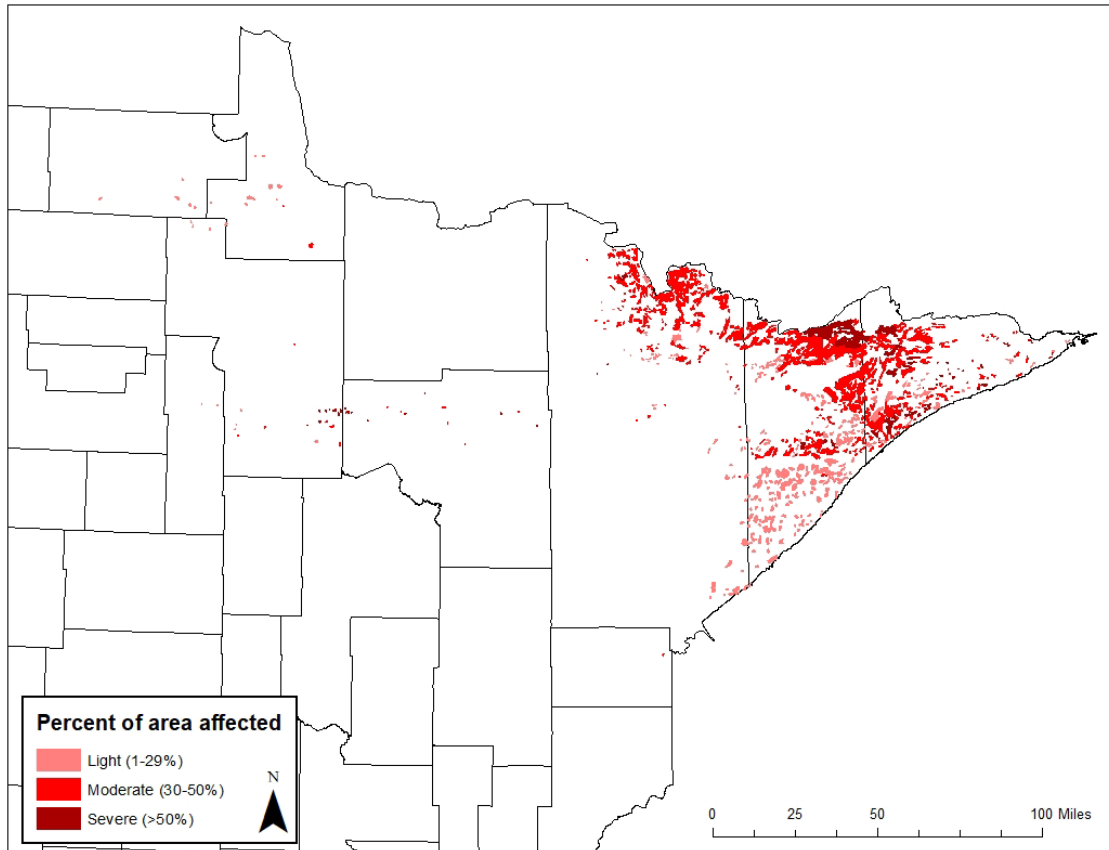
Historically, this year's damage from spruce budworm is not out of the ordinary, as large outbreaks have occurred in Minnesota since the early twentieth century. However, an overabundance of balsam fir has possibly prolonged the presence of spruce budworm. Part of the reason for the excessive amount of balsam fir could be due to the lack of fire on the landscape. Now, with vast acres of defoliated and dead trees from spruce budworm and fewer low-intensity fires at regular intervals, there are more chances for large, damaging fires. This was evident in 2021 with the Greenwood Fire. The fire burned about 27,000 acres near Isabella in Lake County, in the heart of the budworm outbreak with many dying and dead fir and spruce trees. Dying trees and recently killed trees with needles are fuel through which fire can more easily burn than if trees are healthy or on the ground and decaying, but healthy balsam fir is extremely combustible as well. It seems probable that these conditions caused by spruce budworm altered the behavior of the Greenwood Fire. While there is no clear link in published literature between budworm damage and increased fire damage, the high level of fuel from dead and dying trees likely affects fire behavior.

The spruce budworm outbreak will undoubtedly continue to have a large impact next year as it moves farther into Cook County. As predicted by egg mass surveys from 2021, defoliation and damage are occurring in the Grand Marais area. A small number of egg mass surveys conducted in Itasca County this year indicate that spruce budworm will continue in white spruce stands.

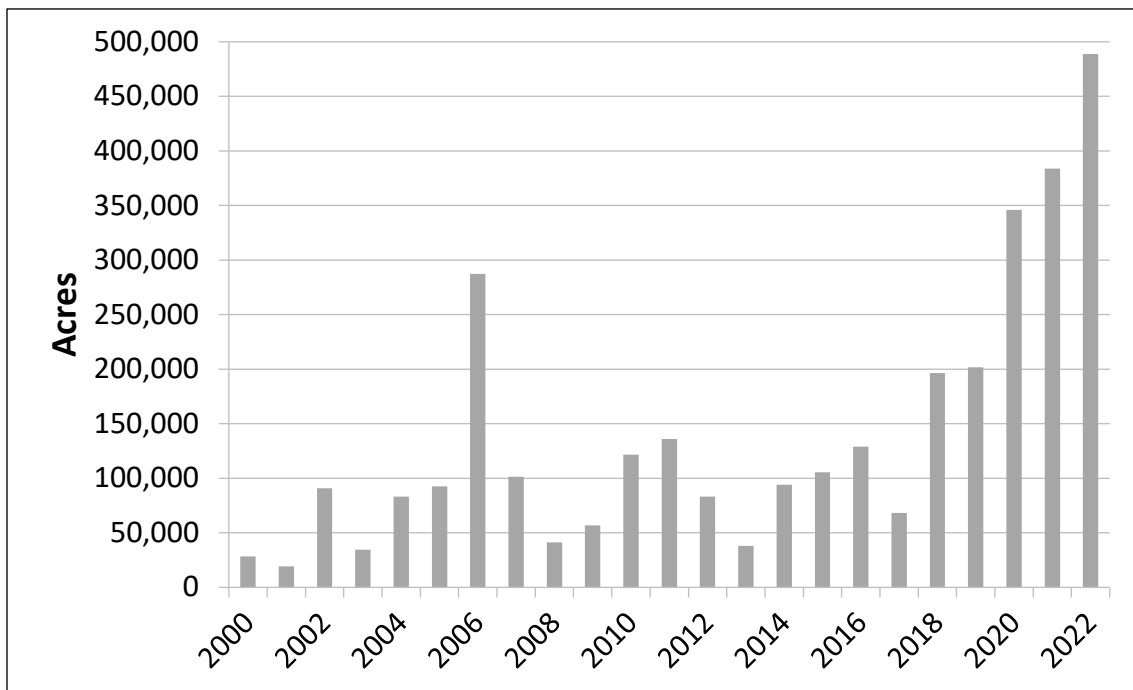
Defoliation and mortality from aerial survey data is incorporated into Community Wildfire Protection Plans by St. Louis County, the DNR, and the USDA Forest Service. This is wise community planning since the conditions that promote spruce budworm defoliation (lots of balsam fir, particularly older balsam fir) are the same conditions that increase the risk of quickly spreading wildfires.



Spruce budworm caterpillar on balsam fir observed in northern St. Louis County.



Spruce budworm defoliation and mortality in 2022.



Acres with spruce budworm defoliation and mortality from 2000 to 2022.

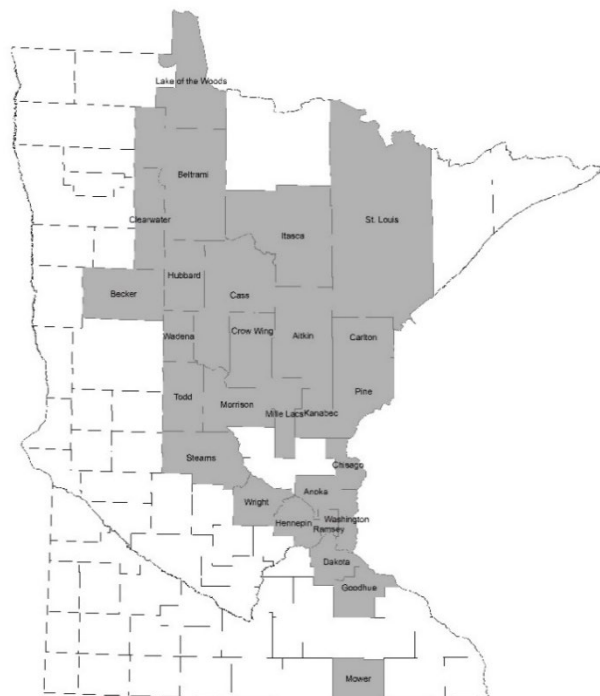
Twolined chestnut borer

Twolined chestnut borer (*Agrilus bilineatus*) is a native metallic wood-boring beetle whose larvae feed beneath the bark of oak trees. Oaks stressed and weakened are commonly attacked and die after two to three years of infestation. Symptoms of twolined chestnut borer can resemble those of oak wilt, but a distinct difference is that dead leaves stay on the tree for many weeks when attacked by twolined chestnut borer, while leaves quickly fall off branches infected with oak wilt.

A serious drought such as Minnesota had in 2021 promotes landscape-level twolined chestnut borer outbreaks, which we saw this year. The aerial survey showed seven times more instances of twolined chestnut borer in 2022 than in 2021. Throughout the growing season, oaks in the shaded understory succumbed to twolined chestnut borer attack. Starting in mid-August, scattered upper-canopy oaks died from attack, where some canopies browned within a few weeks. Forests were severely affected in central Minnesota from Wadena County to the Twin Cities.

We frequently saw *Armillaria* root disease on trees attacked by twolined chestnut borer. *Armillaria* is also a fungal pathogen that commonly attacks stressed oak trees, often in tandem with twolined chestnut borer.

Damage from twolined chestnut borer is expected to continue in 2023, as trees recover from drought in 2021 and dry conditions continued in some places in 2022, particularly in central Minnesota and the Twin Cities metro area.



Counties where dieback and mortality were observed from twolined chestnut borer in 2022.



A partially shaded oak succumbing to twolined chestnut borer and Armillaria root disease in early August.



Dying oaks in the distance from twolined chestnut borer in mid-August in Morrison County.

Diseases

Bur oak blight

Bur oak blight is a leaf disease of bur oak caused by the fungus *Tubakia iowensis*. The disease creates wedge-shaped dead zones on leaves in late summer, particularly in the lower canopy, sometimes resulting in premature leaf drop and heavy defoliation. Trees almost always recover the following spring.

As in 2021, we found few bur oaks that were significantly defoliated by bur oak blight in early fall 2022. Fewer than 1% of surveyed bur oaks were defoliated across three sites in Chisago, Dakota, and Sherburne counties.

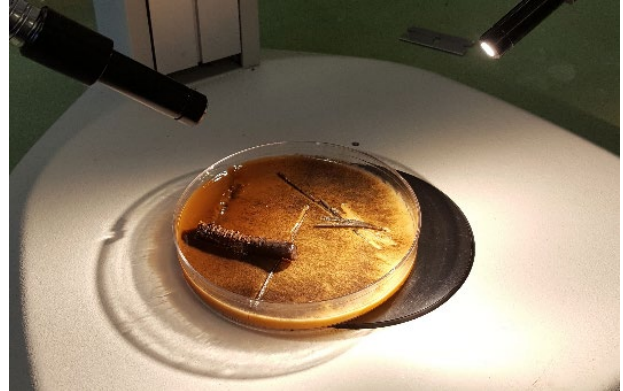
Since we began bur oak blight severity and incidence surveys in 2017, we have not found more than 5% of bur oaks significantly defoliated by early October. Defoliation was recorded only on bur oaks that had greater than 50% leaf area loss. Our data, seen in the table below, generally show that as late spring and early summer precipitation increases, the amount of bur oak blight increases.

Survey year	Number of sites surveyed	May-June average precipitation (inches)	Average % of oaks with significant defoliation (95% confidence interval)
2017	10	7.6	2.0 (0.8-3.2)
2018	6	6.1	0.2 (0-0.5)
2019	10	9.9	4.3 (1.8-6.7)
2020	13	8.8	3.8 (1.6-6)
2021	10	4.8	0.7 (0-1.5)
2022	3	6.0	0.5 (0-1.3)

Diplodia assessment on red pine at the Badoura State Forest Nursery

Diplodia sapinea is a fungal pathogen that can kill red pine seedlings and saplings. On extremely stressed, old red pines it can cause dieback. Diplodia can also cause latent, or hidden, infections that do not have visible symptoms until trees become stressed. The Minnesota State Forest Nursery tests for latent Diplodia infections to avoid distributing diseased stock and does not sell seedlings when latent Diplodia infections exceed 10% of the crop. Infected seedlings at the nursery surpassed this threshold in 2016, and 400,000-500,000 red pine seedlings with possible latent Diplodia infections were destroyed.

The State Forest Nursery has assessed levels of latent Diplodia infections annually since 2016. Lab testing results found that less than 1/10 of 1% of all seedlings tested positive for latent Diplodia infections in 2022. This is the sixth consecutive year where latent Diplodia infections at the nursery were at acceptable levels.



A piece of red pine seedling being examined for latent Diplodia infection at the University of Minnesota Plant Disease Clinic.

Heterobasidion root disease

Heterobasidion irregulare is a fungal pathogen that causes root disease in conifers. Heterobasidion spores usually infect freshly cut stumps during thinning operations of pine or spruce plantations. From infected stumps, the fungus slowly grows through roots to the grafted roots of surrounding living pines, where it slowly kills trees. Over time, this disease slowly spreads from an infection center, creating pockets of declining trees in plantations.

Heterobasidion root disease was confirmed at one site in Winona County in 2014. DNR staff eradicated it from that site in 2017 through sanitation and cover-type conversion. The University of Minnesota surveyed the site for Heterobasidion spores from 2020-2022 and found a low number of spores, but no indications that Heterobasidion was present on the site.

In addition to the spore surveys by the University, we surveyed for Heterobasidion in 30 pockets of dying mature red pine in 2022. The pockets were in Beltrami, Carlton, Cass, Crow Wing, Hubbard, Isanti, Itasca, Koochiching, Lake of the Woods, Morrison, St. Louis, Sherburne, and Winona counties. We found no Heterobasidion fruiting bodies during any of the investigations.



White-edged fruiting bodies of *Heterobasidion* growing on a stump. The orange, spherical fruiting bodies above the *Heterobasidion* are wolf's milk slime mold.

Oak wilt

Oak wilt is a non-native, fatal oak disease that has been spreading slowly northward in Minnesota since the 1940s. It can be devastating in nearly pure oak forests. The disease currently covers close to 40% of the state's red oak group range and is common in east-central and southeast Minnesota.

To slow the spread of oak wilt northward into uninfected forests, we prioritize early disease detection, outreach efforts, and management in the northern three-quarters of Pine County and in Morrison, Crow Wing, and Cass counties in central Minnesota.

Early Detection

Oak wilt did not make any large leaps in spread in 2022. We found the westernmost oak wilt in the state (Stearns County) during aerial surveys, as well as two discoveries in northern Pine and northern Morrison counties, each 4 miles from the nearest known oak wilt infection. DNR staff made 31 additional oak wilt confirmations in Morrison, Pine, Stearns, and Cass counties.

Management

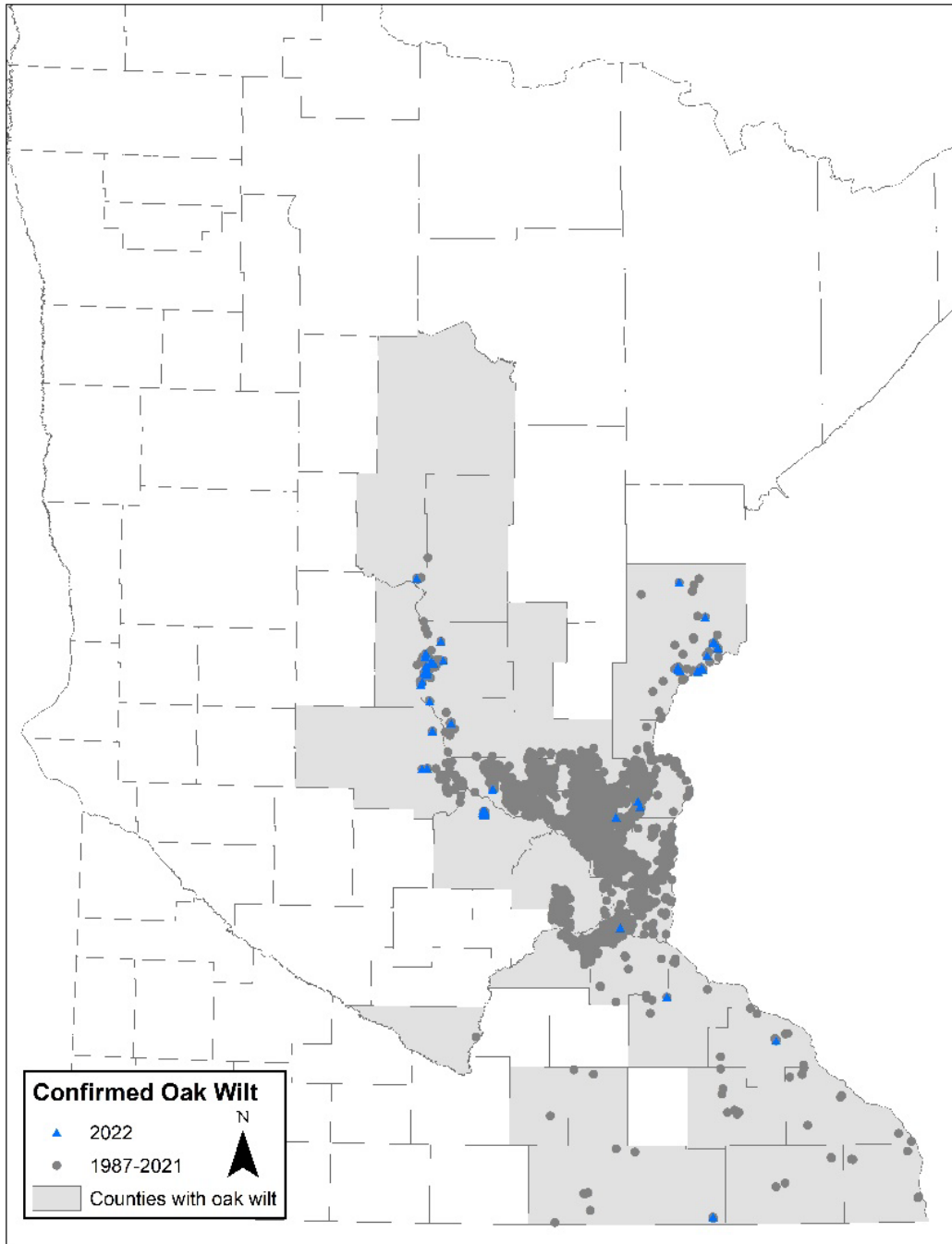
Morrison County Soil and Water Conservation District (SWCD) continued to fund oak wilt control in Morrison County and northward using a grant from the Environment and Natural Resources Trust Fund. The DNR Division of Forestry assisted the SWCD with several aspects of this program. The SWCD financially assisted 16 property owners in 2022 to control about 20 oak wilt pockets.

Most of the known oak wilt in Pine County is in St. Croix State Park. This year St. Croix State Park staff controlled approximately 20 new pockets. The Mille Lacs Band of Ojibwe controlled oak wilt in locations farther north of the state park.

Along the western edge of oak wilt, staff at Lake Maria State Park controlled 11 pockets of oak wilt in 2022 and a private property owner controlled the westernmost spot in the state in Stearns County with the help of DNR Forest Stewardship cost-share funds.

Rapid response project

Lastly, Minnesota, Michigan, and Wisconsin Departments of Natural Resources received a grant from the USDA Forest Service to study the effectiveness of a rapid control procedure for single oaks infected overland by the oak wilt pathogen (spread by sap beetles contaminated with fungal spores). This year we were able to carry out the experiment on two oaks in the Carlos Avery Wildlife Management Area. If the procedure is effective, results will be summarized in 2027.



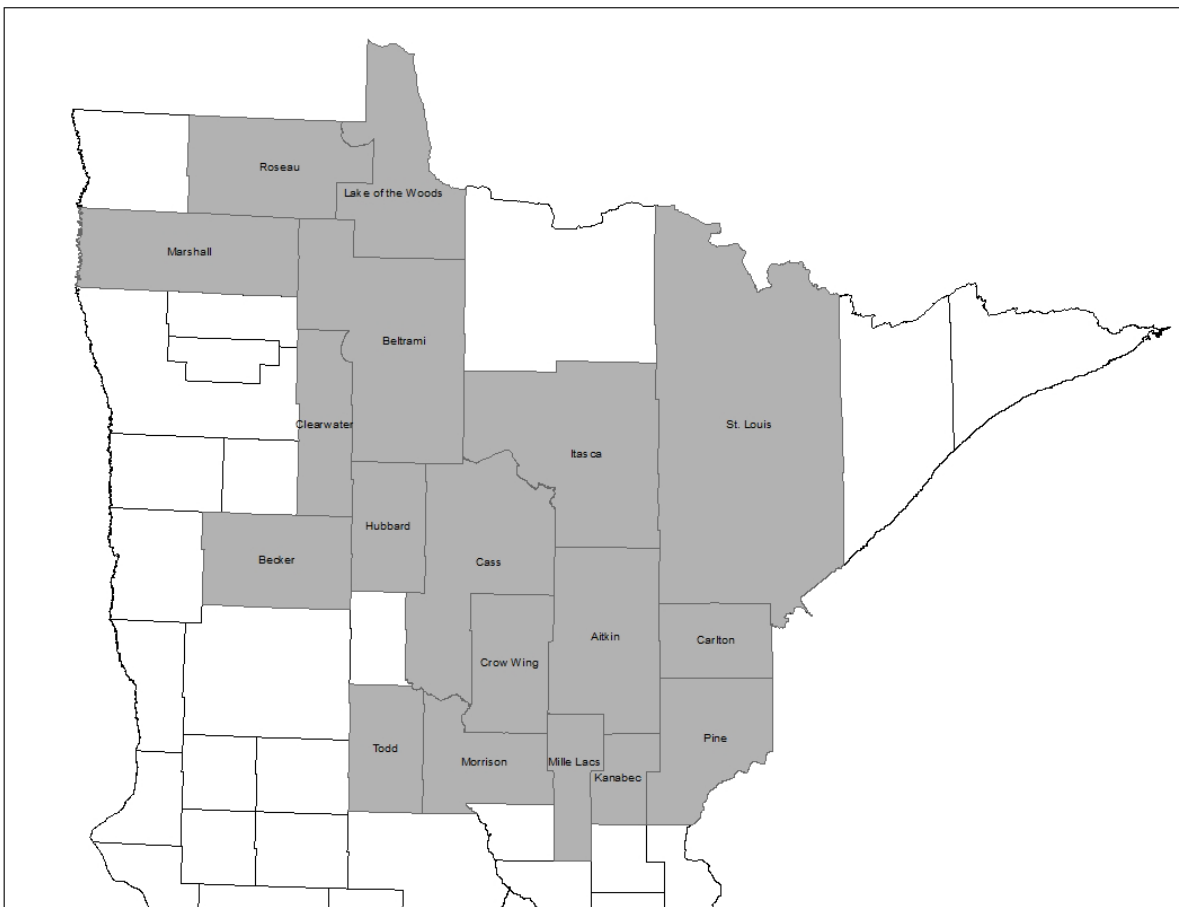
Oak wilt confirmations and counties with oak wilt.

Declines and Abiotic Problems

Aspen decline

We mapped 29,855 acres of aspen decline in 2022, comparable to 2021 when 29,108 acres were recorded. Multiple factors typically contribute to aspen decline. Symptoms can include leaf discoloration and dieback, and in some cases, decline can result in mortality.

Aerial surveys in Minnesota typically pick up aspen decline. Aspen decline was isolated in the past, especially in the Arrowhead region of the state. Decline in the mid- to late 2000s followed two consecutive years of intense late summer drought, which followed two consecutive years of severe defoliation by forest tent caterpillar. Causes of recent decline are likely from a variety of stressors occurring over multiple years, such as old age, flooding, drought, wind damage, late spring frost, and defoliation. Recent years of drought have likely contributed to decline in northwest Minnesota, where most of the aspen decline was mapped again in 2022. We will likely continue to see more aspen decline in the coming years due to the drought in 2021.



Counties recorded with aspen decline in 2022.

Impact of the 2021 drought on planted trees

Drought during the growing season is very hard on recently planted trees. In 1976, the DNR forest health team reported high levels of mortality in trees planted that year, Minnesota's driest growing season on record. As in 1976, DNR foresters found high levels of mortality in trees planted in 2021 (see table below). We report bareroot red pine mortality in 2021, but the 1976 report did not specify which trees were surveyed. We know they surveyed plantations, and we know that bareroot red pines were commonly planted then.



Red pine saplings that died in 2021 from drought.

Year planted	April through September precipitation departure from normal (1991-2020 mean) in areas surveyed (departure range)	Species and stock type	Average mortality (range)
1976	-8.4 inches (-11.4 to -7.0)	Unspecified	53% (8-95%)
2021	-5.8 inches (-7.5 to -5.3)	Bareroot red pine	55% (22-88%)

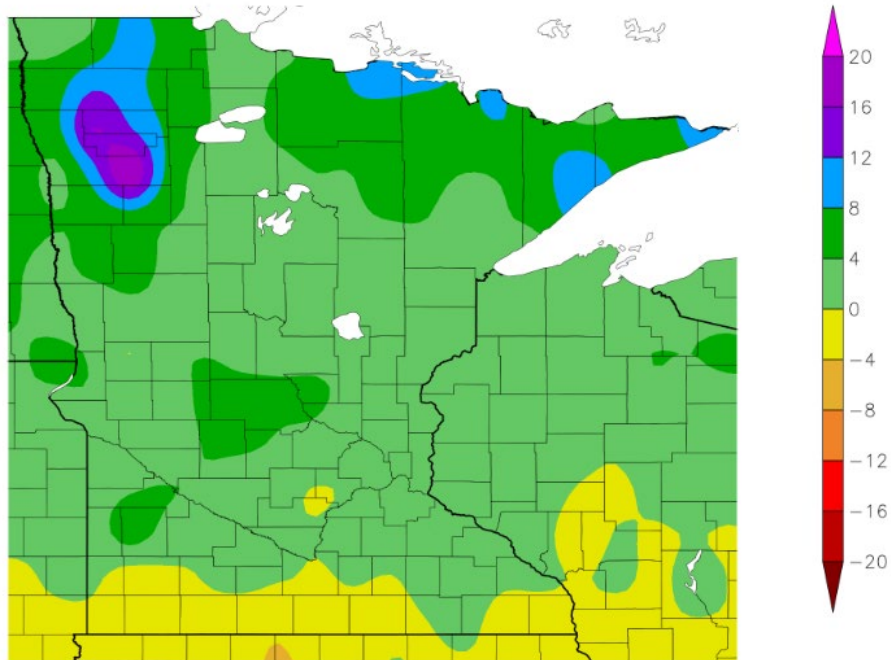
Preliminary reports across the state indicate that mortality levels of planted trees were not nearly as high in 2022 as in 2021.

Flood damage

Flooding in April and May was common in central and northern Minnesota. A swath from Polk to Kittson counties in northwestern Minnesota received at least 6 inches above normal precipitation in April, and several areas from southwest to northeast Minnesota received at least 4 inches above normal precipitation in May. In 2022, Minnesota's northeast climate zone received the highest amount of spring (March through May) precipitation on record. Late snowstorms followed by intense rains in May contributed to historic flooding along the Rainy and Pigeon rivers along the Canadian border. Serious flooding also occurred along the Red River. Our aerial survey captured at least some flood damage to forests throughout the entire area surveyed. We found that 81% more flood damage to forests occurred this year than in 2021.

Despite flooded forests, DNR Forest Health staff received few reports from land managers about flooding. The intense rains in northern Minnesota in April occurred when many trees were still dormant, so damage from flooding may be limited. For May flooding, symptoms on deciduous trees may not develop until 2023 or after.

Departure from Normal Precipitation (in) 3/1/2022 – 5/31/2022



Generated 6/20/2022 at HPRCC using provisional data.

NOAA Regional Climate Centers

Various areas in northern Minnesota had precipitation of 8 inches or more above normal from March through May.

Heavy snow damage from December storm

An unusually [large-scale and wet winter storm](#) produced an abundant amount of freezing rain and extremely heavy snow over several days in mid-December 2022. The heavy snow stayed in tree canopies and weighed down branches, resulting in widespread tree damage from central to northeast Minnesota.

Foresters surveying southeastern Carlton County to central Pine County found that younger aspen forests (around 15 years old) sustained heavy losses. In many stands, most aspen saplings bent down to the ground. Besides young aspen, significant crown damage occurred to pine with small crowns and thin trunks in recently thinned plantations. Losses in pine plantations were not nearly as great as in young aspen stands.

Based on our experience from a significant blowdown in 2011 where many damaged aspen stands had to be restarted, we do not expect the heavily damaged young aspen stands to recover and grow into healthy trees. We don't expect the pine plantations to become infested with bark beetles unless there is significant drought in spring 2023.

Surveys in 2023 will reveal a more accurate assessment of the scale and severity of this damage.



Aspen saplings damaged by heavy ice and snow in Pine County, December 2022.



Red pine plantation with some snow damage in Pine County, December 2022.

Sparse aspen crowns

At the beginning of the growing season this year, we observed abundant seed crops and sparse crowns with small leaf development on aspen throughout the state. At first it seemed that forest tent caterpillar caused the symptoms, but we found no defoliators associated with these trees. The sparse crowns were most likely a result of the significant drought in 2021 that stressed the trees, causing thin crowns and prolific seed crops.

Stress events, particularly drought, can cause trees to shift their resources toward survival. Stressed trees can direct their energy into seed production to ensure they produce progeny. As a result, there is not much energy left for trees to produce a full crown of leaves, and we think this is why aspen trees had minimal leaf development in 2022. Aspen crowns were also observed to be thin in 1989 and 2005 following years of drought. Crowns on aspen trees often bounced back this year, some producing a second set of leaves in early to mid-July, while others remained thin throughout the summer. Affected aspens will be monitored in 2023.



Abundant aspen seed covered the ground in Crow Wing County.

The phenomenon of thin aspen crowns was not observed in the upper peninsula of Michigan, central Wisconsin, or in Manitoba, Canada, but in northeast Wisconsin, staff in the Wisconsin DNR observed thin aspen crowns in early summer. The thin crowns were attributed to foliar pathogens such as *Venturia* leaf and shoot blight and *Phyllosticta* leaf spot; the trees produced a second set of leaves in mid-summer.

The prolific production of fluffy, white aspen seed was remarkable in early June. The cottony aspen seed is quite flammable and its abundance on a forest floor in Niswaga (Crow Wing County) caused a wildfire to quickly spread.



Stunted leaf development on aspens in Mille Lacs County.

Other tree pest and tree health events noted in 2021 and 2022

Pest or event	Pest stage or cause	2021 (county in which observed)	2022 (county in which observed)
Sudden ash leaflet drop	Anthracnose	Not observed	June 13 (Itasca)
Eastern tent caterpillar	Caterpillars, 0-0.5"	Not recorded	May 26 (Sherburne)
European pine or red pine sawfly on red pine	Caterpillars, 0.5-1"	Not recorded	June 9 (Anoka)
Fall webworm nests	Caterpillars	July 15 (Pine)	Not recorded
Forest tent caterpillar	Emergence of first-instar larvae	Not recorded	May 14 (Itasca)
Forest tent caterpillar	Caterpillars, > 1"	May 25 (Itasca) June 2 (Mille Lacs) June 7 (Aitkin)	June 7 (Itasca)
Bitternut and shagbark hickory dieback or mortality	Hickory bark beetle (<i>Scolytus quadrispinosus</i>)	July 28 (Houston)	May 31 (Houston)
Spongy moth	Female moths laying egg masses	August 19 (Lake)	Not recorded
Diseased maple leaves	Anthracnose	Not observed	June 14 (Fillmore) June 22 (Kanabec) June 23 (Itasca) June 25 (Crow Wing)
Diseased oak leaves	Anthracnose	Not observed	Not observed
Oak shoot blight	<i>Diplodia corticola</i> on bur oak	Early September (Chisago) (less than in 2020)	Not observed
Oak wilt	Spore mats	July 23 (Cass) September 2 (Pine)	May 26 (Sherburne)
Oak wilt	Wilting noted for the first time	June 9 (Mille Lacs, Sherburne)	June 23 (Morrison) August 30 (Cass)
Pine bark beetles (<i>Ips</i> species)	Females constructing egg galleries in spring	Not recorded	May 26 (Sherburne)

Pest or event	Pest stage or cause	2021 (county in which observed)	2022 (county in which observed)
Defoliation on red maple	Greenstriped mapleworm (<i>Dryocampa rubicunda</i>)	Not observed	July 22 (Pine)
Defoliation on red oak	Pinkstriped oakworm (<i>Anisota virginiensis</i>)	Not observed	July 22 (Pine)
Dead red pine shoots	Red pine shoot moth	June 29 (Isanti) June 30 (Ramsey) July 1 (Carver) July 23 (Cass)	Summer (Beltrami, Cass, Crow Wing, Hubbard, Pine, Wadena)
Spruce budworm	Caterpillars, ¾ to 1" (full-grown)	June 23 (St. Louis)	June 16 (St. Louis)

2022 North Central Forest Pest Workshop: *Forest Health in a Changing Climate*

This year it was Minnesota's turn to host the annual North Central Forest Pest Workshop (NCFPW), the first in-person workshop since 2019. The workshop was held in Grand Rapids, Minnesota, with 77 practitioners, professionals, academicians, and students attending from locations including Indiana, Michigan, Missouri, North Dakota, Wisconsin, Manitoba, and Ontario. Twelve people attended virtually, making this the first hybrid NCFPW. Workshop planners included Eric Otto, Rachael Dube, Megan O'Neil, Brian Schwingle, and Val Cervenka from the Minnesota DNR forest health team, Susan Crocker with USDA Forest Service, and Simeon Wright with Michigan DNR.

Presentations and posters focused mainly on forest health issues in the context of climate change, but like a typical NCFPW, many other topics were covered, such as eastern dwarf mistletoe, eastern larch beetle, oak wilt, herbicide injury to trees, and emerald ash borer and other invasive pests and pathogens. Anna Yang of the University of Minnesota won the student presentation competition this year.

A highlight of the workshop every year is the all-day field trip to look at sites with forest pests or diseases and other forest health-related issues. Attendees this year had the opportunity to visit a forest stand owned by the UPM Blandin Paper Company to learn about the impact spruce budworm is having on their forests and how they are building resilience to mitigate future forest health issues. Attendees also visited the Marcell and Cutfoot experimental forests. The [Marcell Experimental Forest](#) is home to the Spruce-Peatland Response Under Climatic and Environmental Change (SPRUCE) project, a unique climate change manipulation study sponsored by the US Department of Energy. At the Cutfoot Experimental Forest, attendees visited a research site evaluating adaptation approaches in wetland black ash forests facing emerald ash borer invasion and climate change.

The NCFPW location rotates to Wausau, Wisconsin in 2023.



Minn. DNR forest health team members, l to r: Eric Otto, Brian Schwingle, Val Cervenka, Rachael Dube, Megan O'Neil



SPRUCE site at Marcell Experimental Forest

Great Lakes Forest Fires Compact Forest Health Committee training

In September this year, Minnesota DNR forest health staff attended a three-day training workshop in Ohio for members of the Great Lakes Forest Fire Compact Forest Health Committee (members include Michigan, Minnesota, Wisconsin, Manitoba, and Ontario). The Forest Health Committee provides Compact members with mutual aid for forest health incidents, training, research, or other needs across state and provincial boundaries. The committee provides a quick response to requests for help on forest health incidents with qualified personnel, resources, training, or other needs.

The training focused on spotted lanternfly, Asian longhorned beetle, Dutch elm disease, emerald ash borer, beech leaf disease, and beech bark disease, pests that are or threaten to become issues in the represented states. The training provided skills in identification, information on current research, and how to manage these invasives.

Staff from the Ohio Department of Natural Resources, Cleveland Metroparks, and USDA Forest Service Northern Research Station gave presentations.



A spotted lanternfly adult observed during the training.