Forest Health Annual Report 2023

Minnesota DNR Forest Health Team

DEPARTMENT OF
NATURAL RESOURCES

The Minnesota Department of Natural Resources Forest Health Annual Report was created by the Forestry Division's Forest Health Program.

Cover photo: Dead and dying balsam fir and white spruce in Tettegouche State Park in Lake County in 2023. This area has been defoliated for approximately 10 straight years according to DNR Forest Health Surveys.

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

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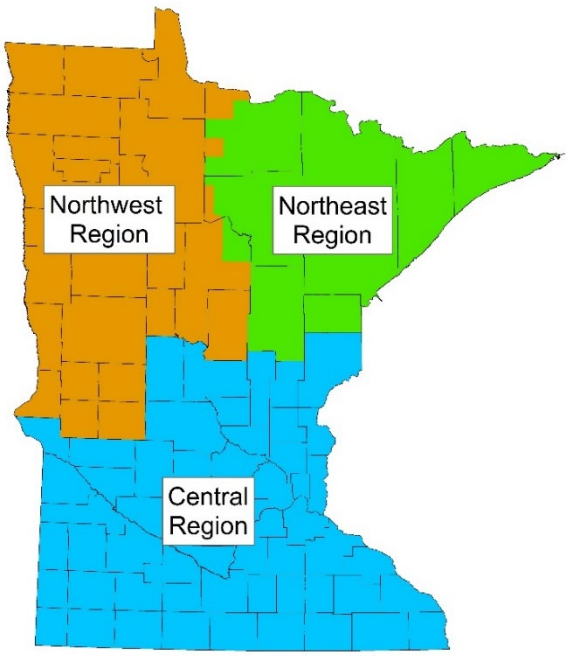
Minnesota DNR Division of Forestry Forest Health Program

Staffing Changes in 2023

Val Cervenka, the Forest Health Program Consultant (Team Coordinator) of many years, retired in January 2023, and Andrew Arends, the section manager who supervised the Coordinator position, became the Forestry Division's Deputy Director. Brian Schwingle was selected as the new Forest Health Team Coordinator, and Jon Drimel became the new section manager. The Central Region Forest Health Specialist position, formerly filled by Schwingle, remains vacant but is actively being filled at the time of writing this report.

Jon Drimel, Forest Operations and Management Section Manager
500 Lafayette Road
St. Paul, MN 55155
651-258-1227
jon.drimel@state.mn.us

Brian Schwingle, Forest Health Program Consultant
500 Lafayette Road
St. Paul, MN 55155
651-259-5296
brian.schwingle@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

Vacant, Central Region Forest Health Specialist
1200 Warner Road
St. Paul, MN 55106
651-259-5821

Program Function

Regional forest health specialists investigate concerning problems to forest trees reported to them by forest managers and larger forest landowners on public and private lands. They also conduct annual tree health surveys over large landscapes to monitor general health trends of the trees in Minnesota's forests. This annual report summarizes findings from these field investigations and surveys, including 17.3 million acres of aerial survey.

Forest health staff provide expertise in DNR policy development regarding forest health, and they play a big role in providing outreach and education on forest health topics. They provided 50 trainings to DNR employees and other agencies and organizations in 2023. Staff create outreach products such as webpages, newsletters, and social media posts to reach a wide audience. We directly contacted at least 2,200 individuals in 2023 through presentations and responses to requests for forest health assistance.

Annual reports from 1969 to the present are available on the Forest Health Annual Reports webpage.

Forest health highlights in 2023

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.

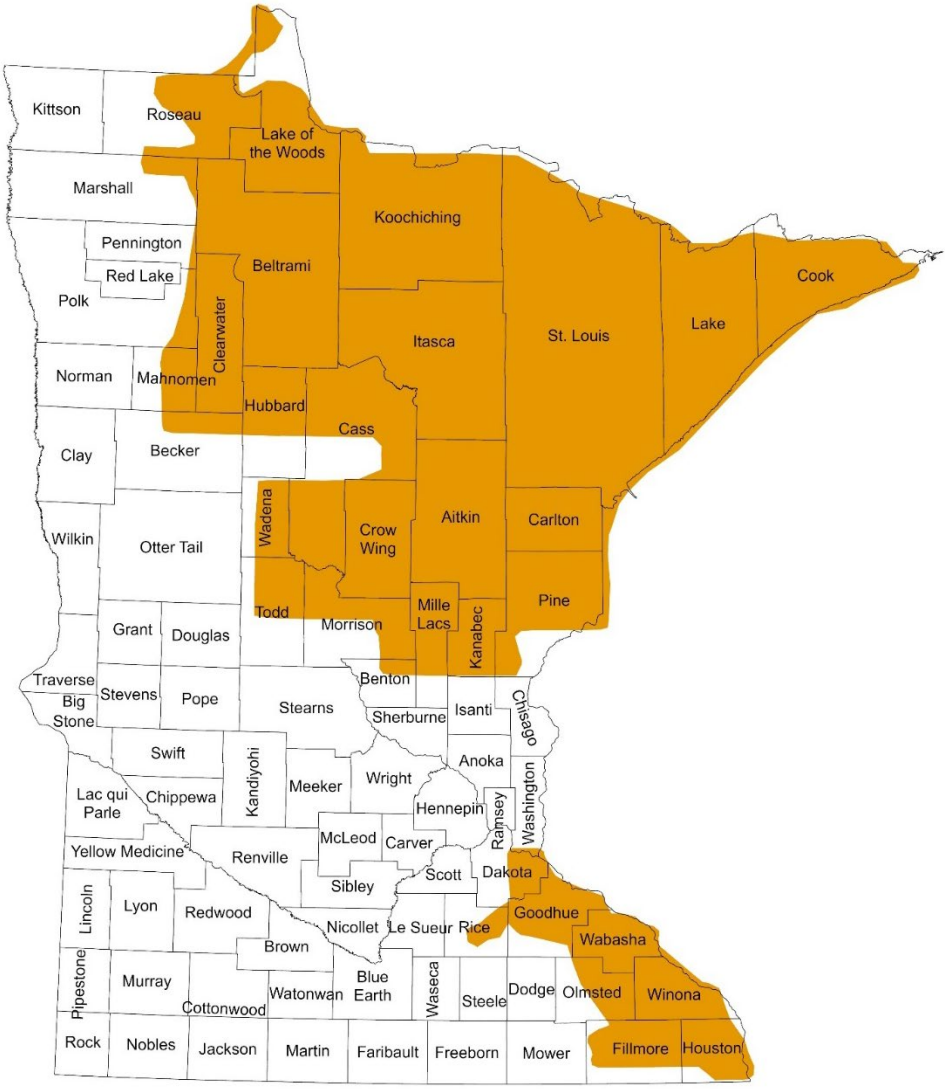
- Forest health staff collaborated with DNR Resource Assessment unit to aerially survey 17.3 million acres of Minnesota for damage to forests. U.S. Forest Service provided funding, survey software, and ground survey support.
- Staff directly responded to 1,099 requests for forest health assistance, including in-depth field investigation requests, simple email inquiries, media interviews, 50 training requests, and requests for assistance from researchers. Over 1,100 others were directly assisted at trainings.
- The 2023 growing season (April through September) was the 9th driest on record for the state and the 4th consecutive year with below normal growing season precipitation.
- Widespread, scattered decline of mature oaks was very common in 2023, incited by exceptionally dry conditions in 2021 and 2023 and the subsequent increase of twolined chestnut borer populations and incidence of Armillaria root disease.
- Minnesota experienced its 23rd straight year of an outbreak of the eastern larch beetle. The area impacted over these years reached over 1 million acres in 2023, an area equivalent to about 75% of Minnesota's tamarack forests.
- Spruce budworm damaged more acres than it has since 1961, mostly in northeast Minnesota.
- Emerald ash borer was confirmed for the first time in 8 counties in 2023. The Red River Valley (in northwest Minnesota) and Northern Minnesota Drift and Lake Plains (in north-central Minnesota) ecological sections had their first confirmations of EAB.

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 the approximately 17.5 million acres of forestland in the state. 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.

Annual surveys are accomplished through the collaboration of DNR Forest Health, DNR Resource Assessment, and the USDA Forest Service, St. Paul Field Office's Forest Health Protection unit. Survey results for 2016–2023* can be found in the Minnesota Geospatial Commons (keywords "forest health").

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



Area covered by aerial survey in 2023 is shaded.

Comparison of aerial survey results, 2022-2023

Damage agent	Acres affected in 2022	Acres affected in 2023	Comments
Aspen and birch decline	29,855	4,582	See article on aspen decline for details on potential reasons for the significant reduction in area mapped.
Pine bark beetles	2,735	1,347	
Basswood leafminer	0	840	
Eastern larch beetle	303,224	262,420	
Flooding	6,733	3,295	
Forest tent caterpillar	9,811	13,281	
Jack pine budworm	0	0	Jack pine budworm was active on some jack pine in Beltrami County from 2020 through 2023 but aerial surveys did not detect it.
Larch casebearer	1,581	42,643	Since damage started to be recorded in 2000, the largest amount mapped in a single year was in 2023.
Large aspen tortrix	3,210	0	Large aspen tortrix was not mapped in 2023, but signs of life stages were found during ground surveys.
Spruce budworm	488,838	664,825	The largest number of acres mapped in a single year since 1961 was in 2023.
Twolined chestnut borer	1,550	2,301	The 2022 and 2023 figures underestimate the area impacted by twolined chestnut borer. See article for details.
Wind	13,689	1,615	

Forest Health Report

The following forest health report contains information on significant and notable causes of forest damage in 2023.

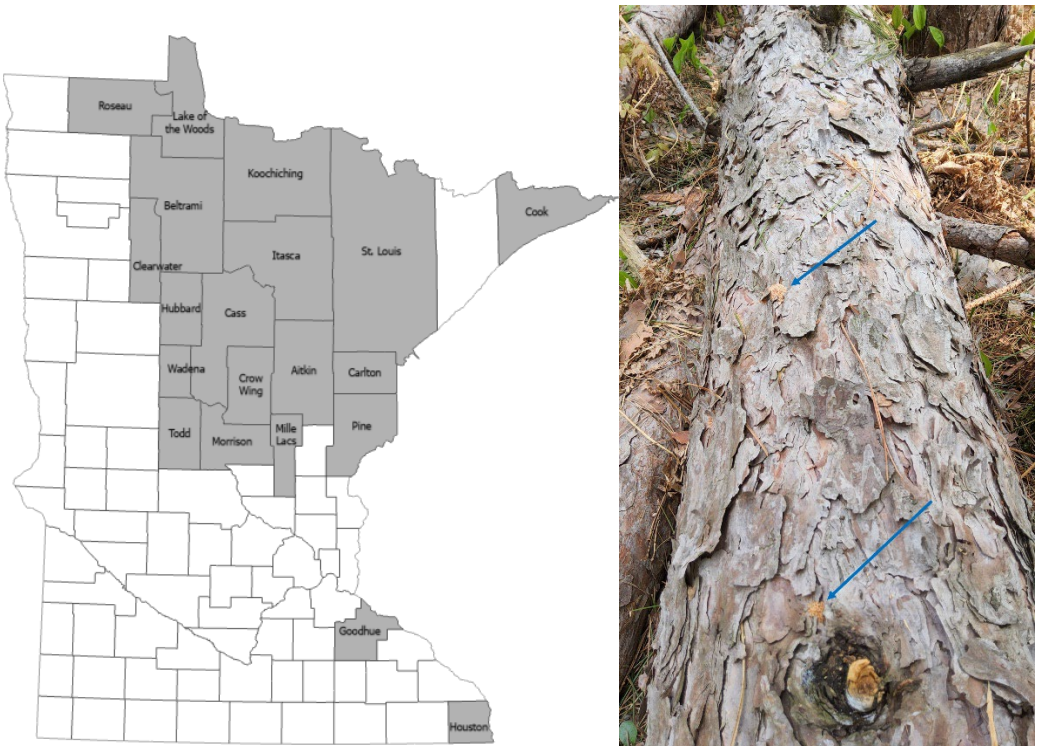
Insects

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. The plantations that were preferentially attacked were those that were thinned during or immediately before the droughts in 1987, 1988, and 2021. Despite significant drought in 2023, no extensive bark beetle outbreaks were recorded or reported. For the past two years, north central and northwest Minnesota have sustained most of the bark beetle attacks.

Acreage mapped with bark beetle-infested pines in 2023 was 50% of that mapped in 2022. A caveat is aerial survey often cannot detect bark beetle infestation due to drought until the following year, since symptoms of infestation often develop later in the fall after surveys are completed. Therefore, bark beetle activity that we aerially map in 2024 may be the result of droughty conditions in 2023.

The major snow damage event that occurred in December 2022 did not result in extensive outbreaks of bark beetles to undamaged pine in 2023. However, some harvesting took place in Pine County to salvage timber from bark beetles attacking pine damaged or killed by heavy snow.



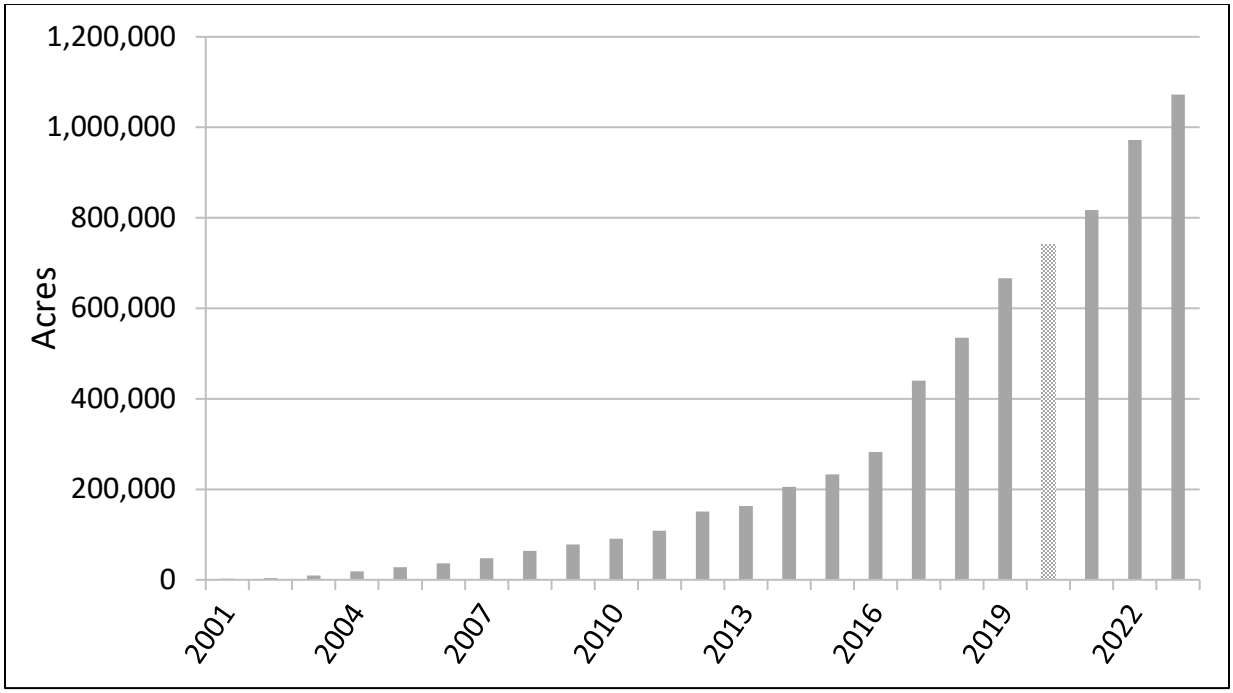
Counties with mapped bark beetle infestation in pines (left). Arrows point to sawdust piles on snow-damaged pines from egg-laying adult Ips, Pine County, May 2023 (right).

Eastern larch beetle

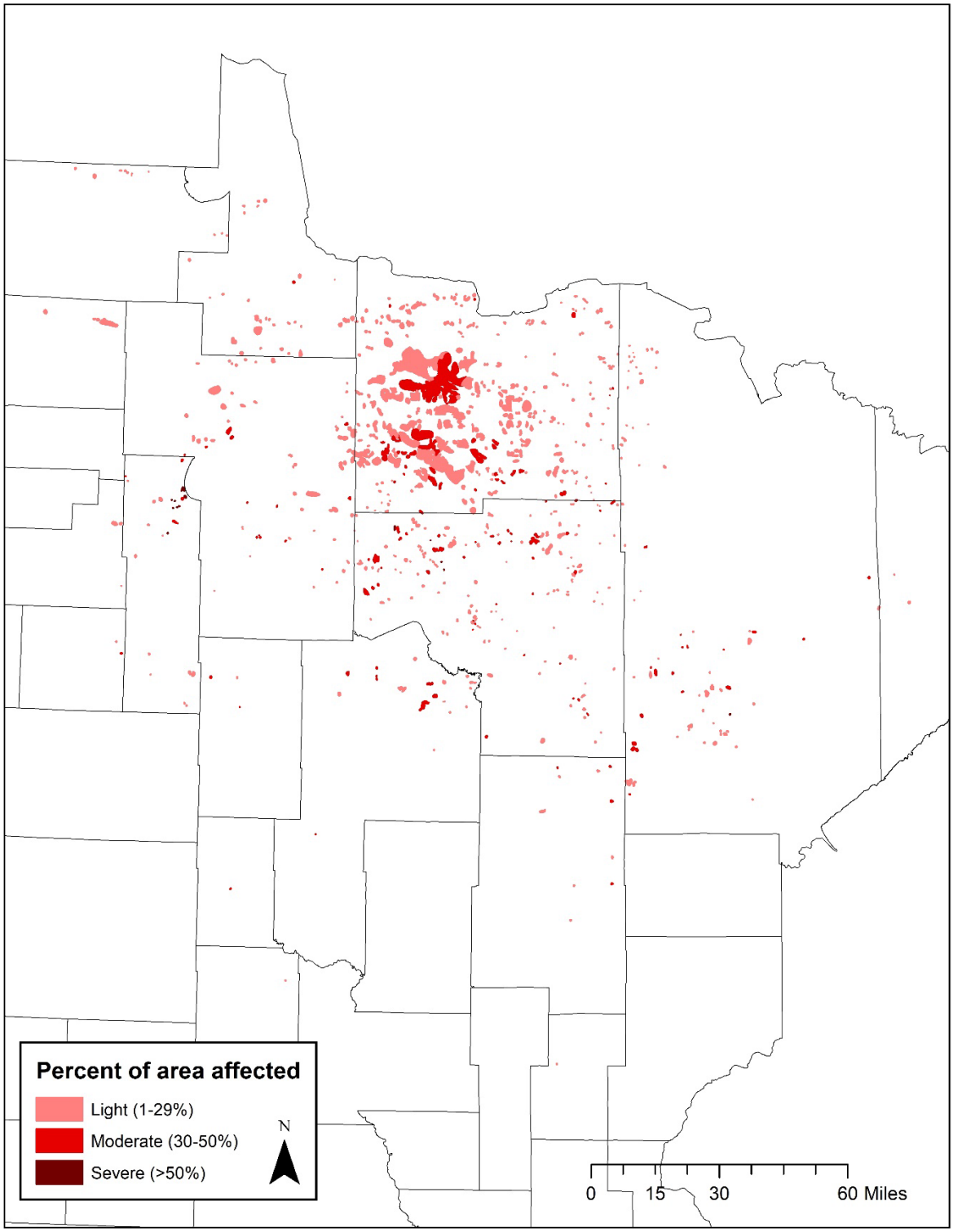
Eastern larch beetle *(Dendroctonus simplex)* is native to Minnesota and continues to attack hundreds of thousands of acres of tamarack every year. The eastern larch beetle life cycle has changed due to our warming climate. Research by the University of Minnesota Department of Entomology on the population dynamics of the eastern larch beetle revealed that a portion of the larch beetle population does not require an overwintering period to reproduce. Longer growing seasons have allowed these beetles to reproduce more quickly and has led to an increase in beetle populations in tamarack stands. Other factors that aid larch beetles are stressors, such as defoliation by larch casebearer, years with flooding, and years with drought. Since the beginning of the eastern larch beetle outbreak in 2001, over a million acres, or 75% of mature tamarack forest in Minnesota, have been impacted to some degree.

In 2023 the aerial survey program found that eastern larch beetle affected approximately 262,420 acres, down slightly from 2022.

DNR offered more harvest permits in tamarack forests in recent years to ensure a future healthy forest. The wet and remote sites on which tamarack forests tend to grow, and low market demand for tamarack, resulted in less management through harvesting in these stands than in earlier years. Fortunately, recent research conducted by the University of Minnesota and DNR Forestry showed that some of these infested and unharvested forests that have lost their mature tamarack are recovering naturally over time, so there is hope for tamarack forests in some areas.



Accumulated forests impacted by eastern larch beetle from 2001 through 2023 (Aerial survey data was not collected in 2020 due to the COVID-19 pandemic. The 2020 value is an estimate based on the midpoint between 2019 and 2021).



Areas with eastern larch beetle damage in 2023.

Emerald ash borer

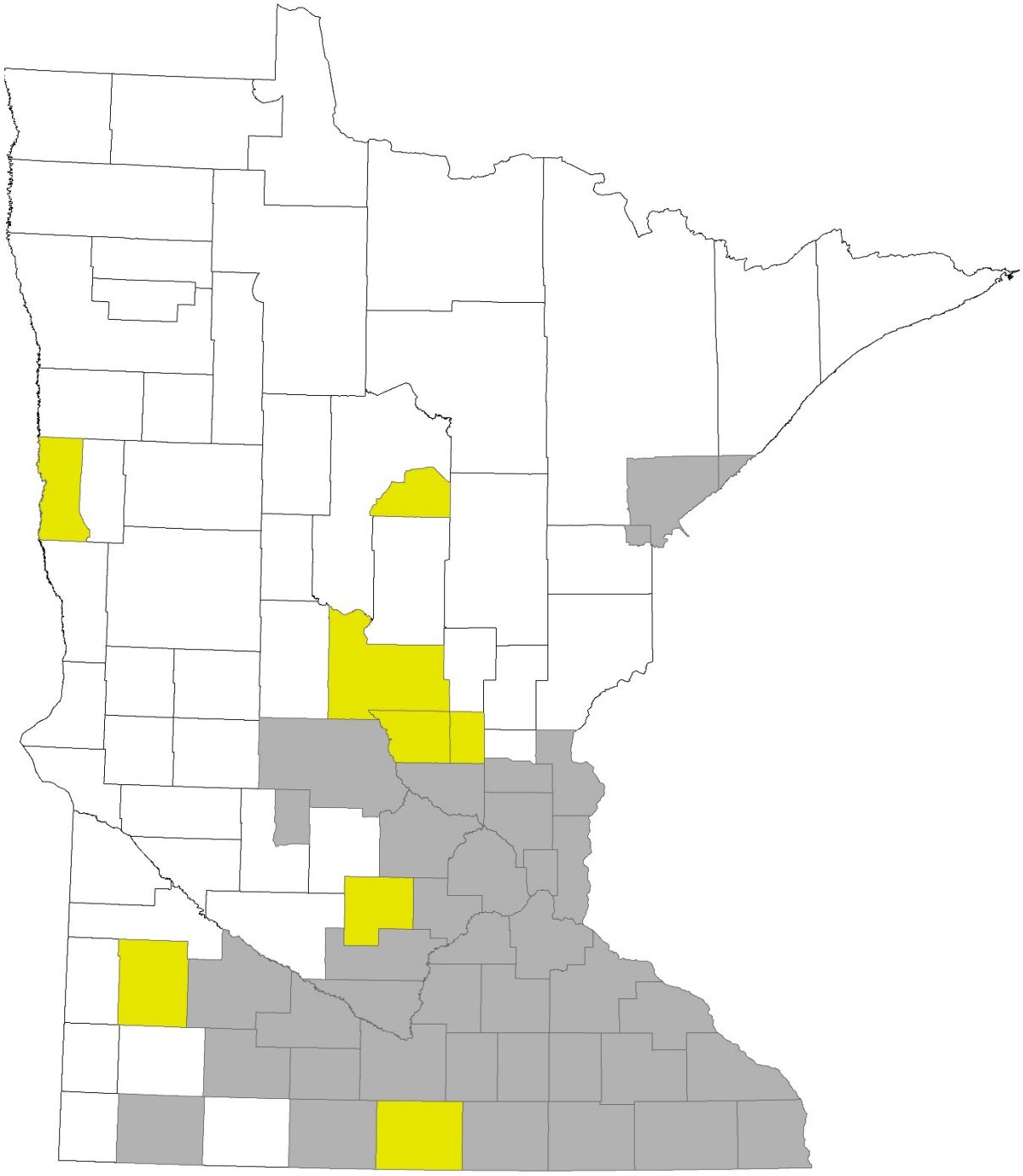
Emerald ash borer (*Agrilus planipennis*) is an invasive beetle that feeds on ash trees' inner bark and cambium. It was first discovered in North American in 2002 and Minnesota in 2009. Since that time, it has been confirmed throughout most of southeastern Minnesota.

In 2023, EAB was officially confirmed for the first time in Benton, Faribault, Lyon, McLeod, Mille Lacs, Morrison, Cass, and Clay counties, shown in yellow in the map below, bringing the total to 46 out of 87 counties under quarantine. The Cass County detection marks the first time EAB has been discovered in a national forest in Minnesota and in our N. Minnesota Drift and Lake Plains ecological section. Minnesota Department of Agriculture (MDA) established quarantines over all or part of these counties to reduce human-mediated EAB spread. MDA also released almost 15,300 parasitic wasps this year to slow the overall impact of EAB. These wasps do not sting and have been studied intensively to determine that they will not negatively impact the environment. Updated parasitoid release and recovery locations may be found on MDA's EAB biocontrol map.

The DNR Forest Health program aerially surveyed forests in southeast Minnesota and recorded about 14,700 acres of forest significantly impacted by EAB. This is a 3x increase from the last time this area was surveyed for EAB damage in 2021. Our 2023 aerial survey also revealed a slight expansion of the overall zone considered generally infested. Combining aerial survey data from 2016–2023, we have mapped 24,600 acres of forest with EAB damage. This is an underestimate since our aerial surveys do not cover the Twin Cities metro area and we have not yet surveyed EAB damage north of the Cities.

Besides tracking overall damage to forests, the DNR Forestry Division is engaged in a wide array of activities related to EAB. Our Silviculture Program has seven ongoing case studies on DNR-managed land, documenting methods that attempt to make ash forests more resilient to EAB by increasing tree species diversity. Two case studies were previously published and can be found in the Great Lakes Silviculture Library. DNR foresters assessed 155 ash stands for our Timber Program in 2023, resulting in timber harvesting permits offered on 1,121 acres. Timber harvesting on these acres will help diversify the forests and capture ash timber value, in most instances, prior to EAB's establishment. Finally, DNR's Urban and Community Forestry Program offered $16 million in grants to local units of government for a wide variety of community forest management activities, including actions aimed at reducing the impact of EAB and improving community forest health.

A black ash healing over an old emerald ash borer gallery, Stearns County, 2023.

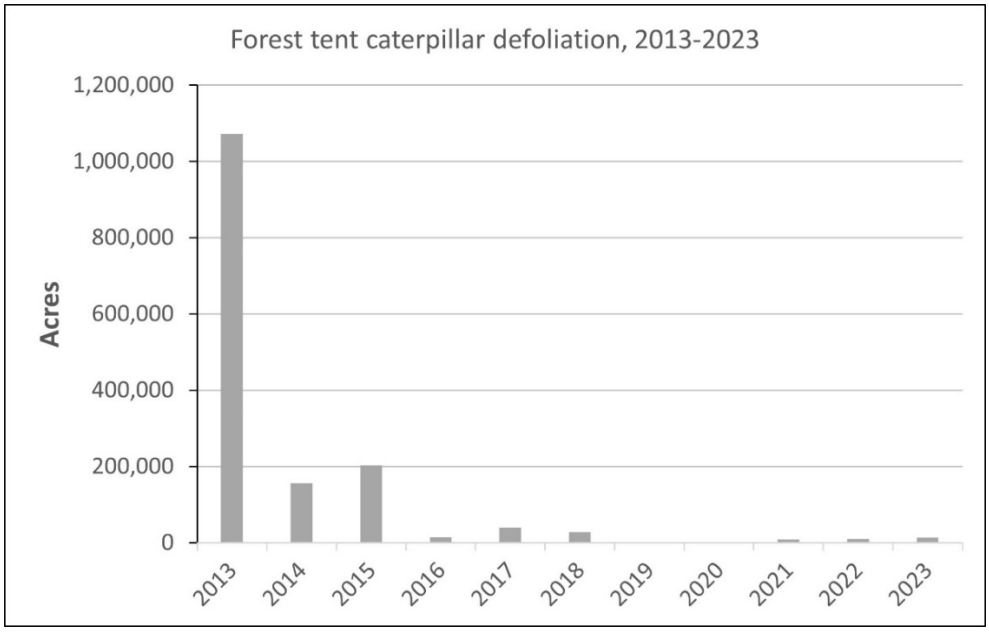


Emerald ash borer quarantine counties. Yellow counties or areas were quarantined for the first time in 2023.

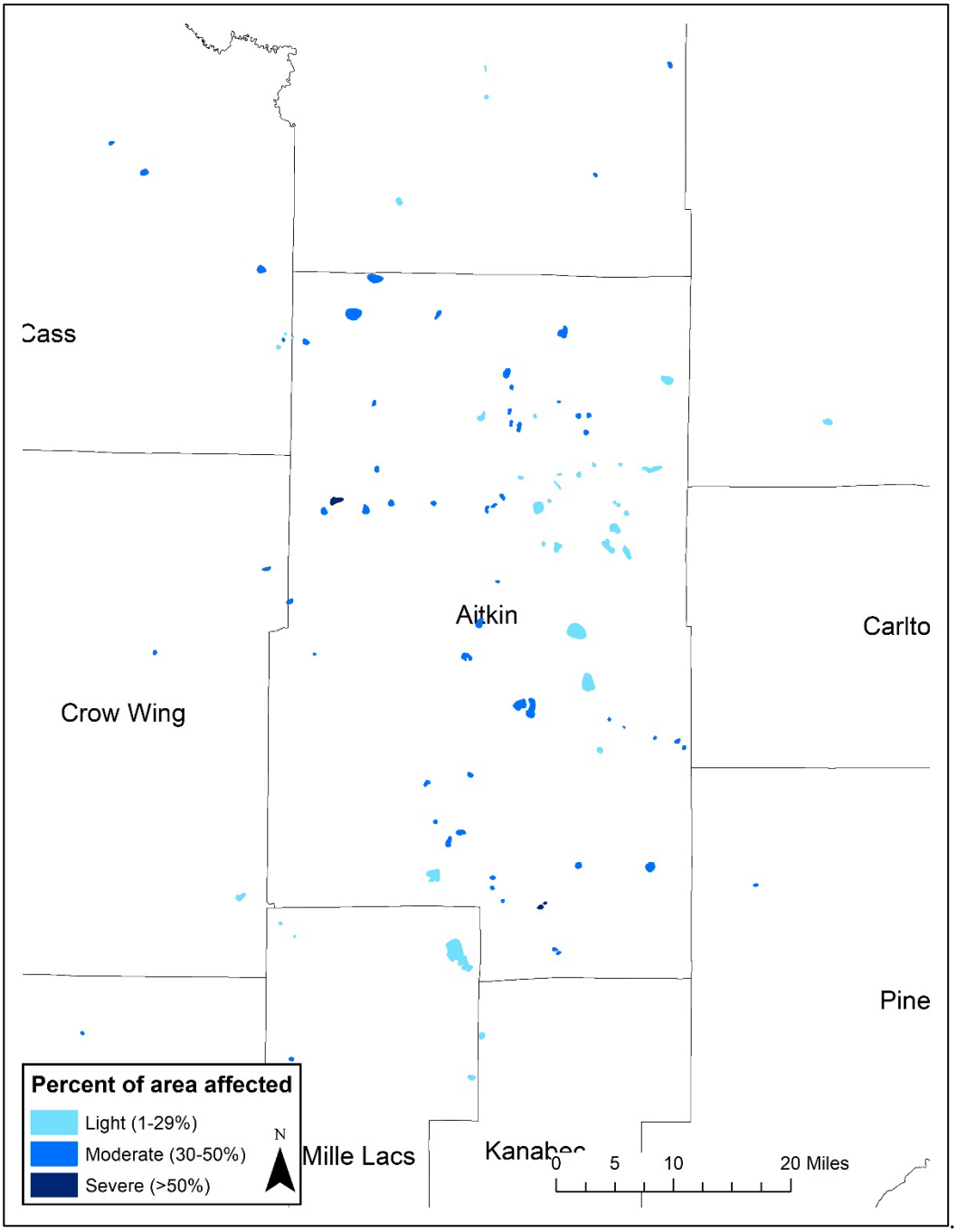
Forest tent caterpillar

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 approximately 13,300 acres of defoliation in 2023, a 35% increase from last year (about 9,800 acres). A slightly upward trend in forest tent caterpillar populations has continued since populations crashed in 2019. A majority of forest tent caterpillar damage and all severe damage mapped this year occurred in Aitkin County (see map below). Defoliation also occurred in Cass, Crow Wing, Itasca, Kanabec, Mille Lacs, Morrison, Pine, and St. Louis counties.

Forest tent caterpillars feeding on basswood in Mille Lacs Kathio State Park in May 2023.



Acres with forest tent caterpillar defoliation from 2013 to 2023. No aerial survey was conducted in 2020.



Areas with defoliation from forest tent caterpillar in 2023.

Hickory bark beetle damage in Houston County

Over the last three years, more landowners have reported dying shagbark hickories from Houston County, Minn. The main and most important biotic agent associated with this death is the native hickory bark beetle (*Scolytus quadrispinosus*). This beetle also attacks bitternut hickories.

Recent years of extreme precipitation could be stressing hickories to the point where they cannot defend themselves against hickory bark beetle. The three wettest growing seasons (April through September) on record in Houston County are 2018, 2016, and 2010, respectively. In contrast, the 2023 growing season was the 12th driest. Both extreme ends of the precipitation spectrum can result in fine root death, twig dieback, and reduced chemical defenses, which could make hickories more susceptible to hickory bark beetle attack.

We have found that hickories as small as 3 inches in diameter can be attacked and killed by hickory bark beetle. However, smaller seedlings and saplings can't be infested, and past research on hickory bark beetle in southeast Minnesota showed that outbreaks don't always kill all the hickories in a stand.

We will continue to monitor the health of hickories in southeast Minnesota but don't foresee a long-term threat to them posed by hickory bark beetle.

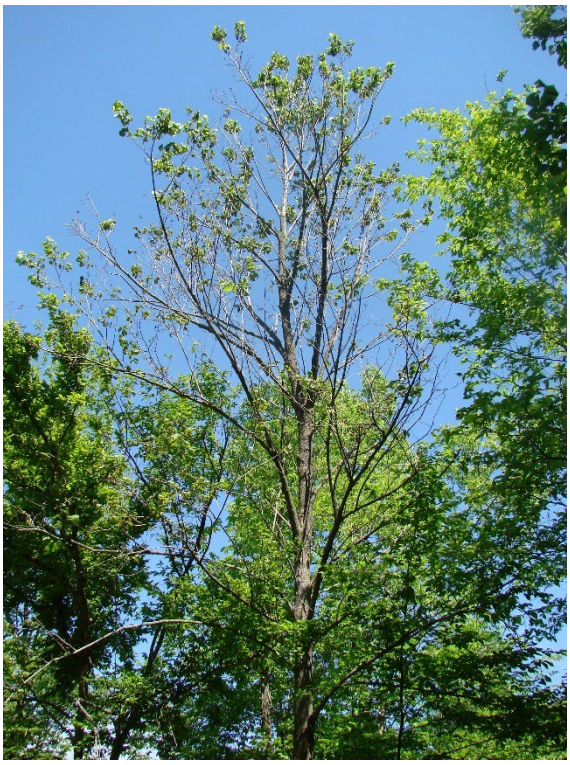
A shagbark hickory dying from hickory bark beetle infestation in Houston County in early September, 2023.

Hickory bark beetle egg-laying and larval feeding galleries.

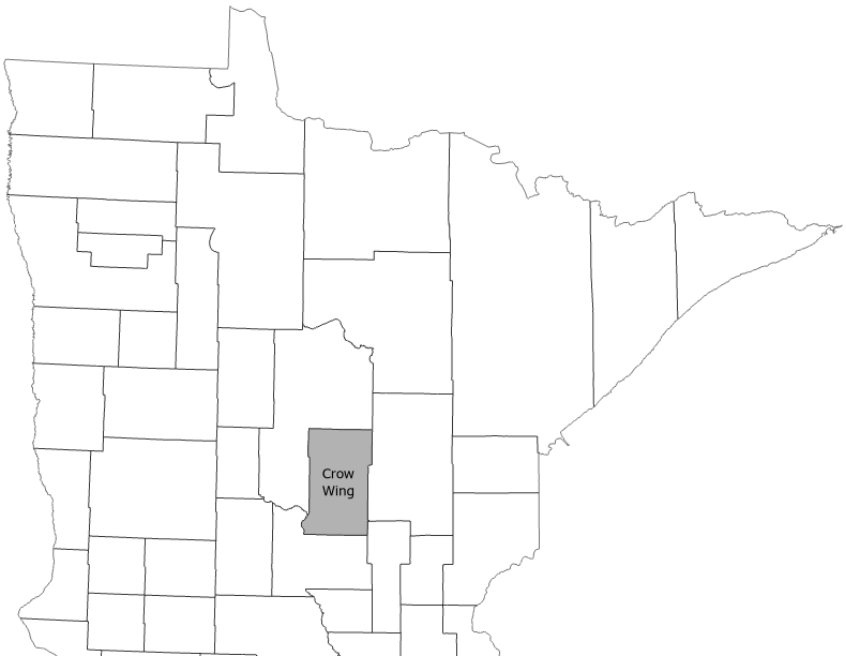
Introduced basswood thrips damage declines in 2023

Introduced basswood thrips (*Thrips calcaratus*) damaged basswood trees for a third 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. In 2023 affected basswood was only found in Crow Wing County. This is a decline from previous years.

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. In 2023 we saw a reduction in the areas where introduced basswood thrips was reported. After a few years, predacious insects or weather conditions have likely reduced populations. We are unaware of long-term negative impacts to basswoods across Minnesota from introduced basswood thrips.



Leaf damage from introduced basswood thrips.

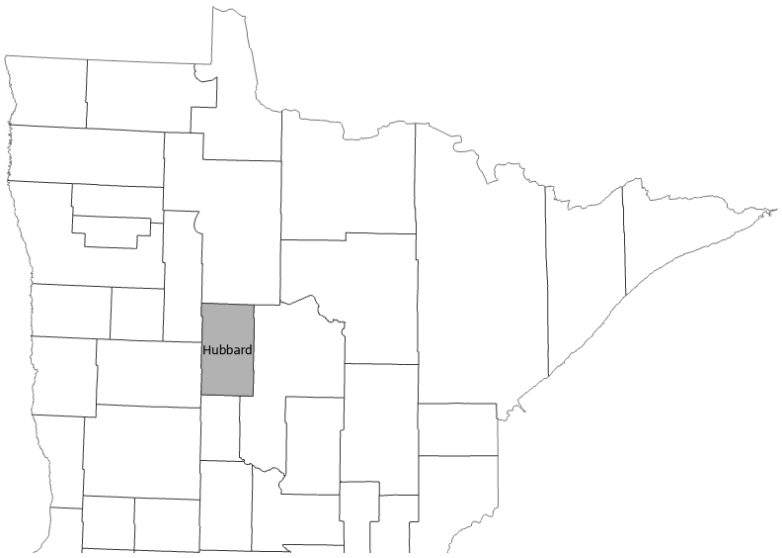


Crow Wing County had activity from introduced basswood thrips in 2023.

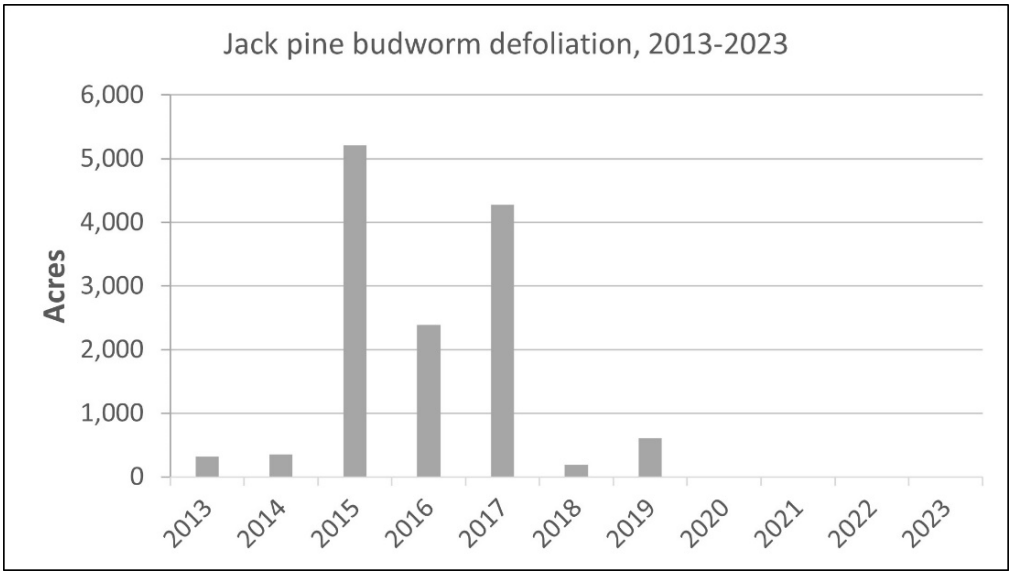
Jack pine budworm activity detected in Hubbard County

Jack pine budworm (*Choristoneura pinus*) is a native moth whose caterpillar feeds on jack pine. Our aerial surveys have detected no jack pine budworm damage for the past three years; however, caterpillars have defoliated isolated areas of jack pine in northwest Minnesota in that timeframe. In 2023, several heavily infested older stands (older than 60 years) were reported in southeast Hubbard County.

Early instar population surveys conducted in summer 2023 indicate populations could be rising in northwest Minnesota, which is expected due to natural population cycling (see graph below). Jack pine budworm populations have remained low since they collapsed in 2018. Jack pine budworm populations peak every 8–10 years in north-central and northwest Minnesota and about every 24 years in northeast Minnesota.



Hubbard County was the only county known to have jack pine budworm damage in 2023.

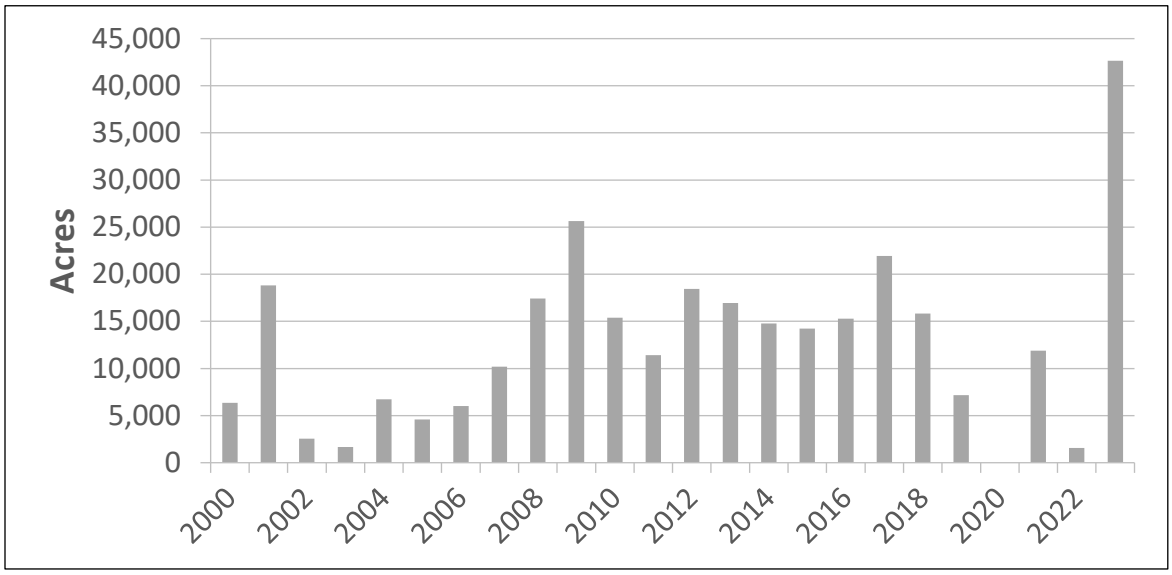


Acres with jack pine budworm damage from 2013 to 2023. No aerial survey was conducted in 2020.

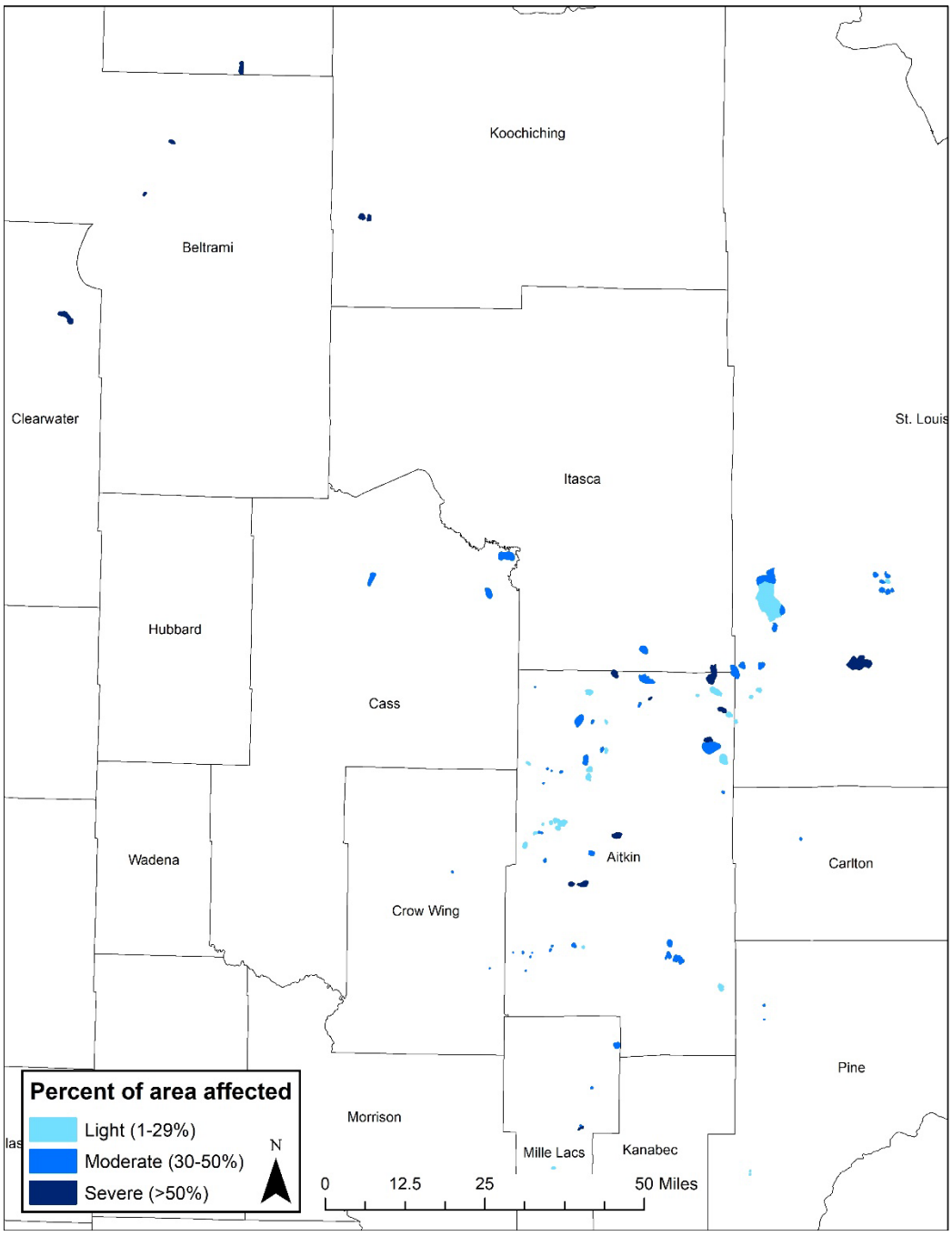
Larch casebearer

Larch casebearer (*Coleophora laricella*) is a non-native moth whose caterpillar feeds on tamarack needles and can cause defoliation when populations are high. In 2023 we mapped about 42,600 acres of defoliation, the highest amount mapped since the DNR first started detecting defoliation in 2000. This was a major increase from 2022 when we mapped very little defoliation (approximately 1,580 acres). Recent research indicates various climate factors are associated with casebearer defoliation — higher temperatures the prior growing season, higher precipitation in spring, and warmer late falls and winters. Some of these factors might have played a role in more casebearer activity, but decreased populations of natural enemies may also have been a factor. Additionally, the majority of the damage was mapped 2–3 weeks earlier than previous years, possibly coinciding with peak casebearer damage and allowing us to see and map the damage better.

The majority of damage in 2023 was mapped in Aitkin County. Large amounts of defoliation were also mapped in St. Louis County.



Acres with larch casebearer defoliation from 2000 to 2023. No aerial survey was conducted in 2020.



Areas with larch casebearer damage in 2023.

Large aspen tortrix

Large aspen tortrix (*Choristoneura conflictana*) is a defoliator and leaf roller of aspen. There was no defoliation from this insect mapped in 2023. However, we found a small amount of tortrix pupae in a forested stand in Cook County during field investigations. In 2022, 3,210 acres with defoliation were mapped, which was the first time it was mapped in Minnesota since 2014.

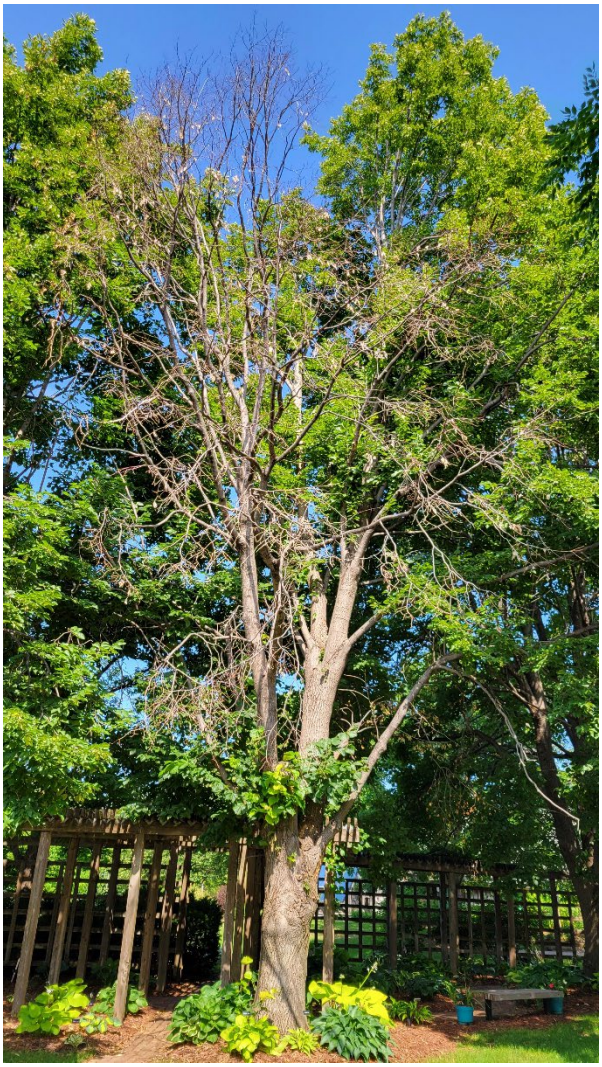
Outbreaks of large aspen tortrix have occurred in northeast Minnesota in the past, and it was thought a new outbreak was starting. Aerial surveys in Cook County were conducted two weeks earlier in 2023 compared to 2022, so it's possible that defoliation was not as noticeable.

Large aspen tortrix outbreaks typically last two or three years; the previous outbreak lasted from roughly 2012 to 2014 with about 3,200 acres of damage recorded. Outbreaks can be much larger though as about 336,000 acres of defoliation were mapped in 1999, primarily along the north shore of Lake Superior.

Large aspen tortrix pupal case found in Cook County in 2023.

Linden borer damaging some community boulevard lindens in southern Minnesota

Linden borer (*Saperda vestita*) is a native roundheaded wood borer that attacks stressed lindens and basswoods (*Tilia* species). In our 2018 annual report, we described ongoing mortality of boulevard lindens that the city of Mankato had been dealing with for a number of years. In 2023, the City of Minneapolis reported an outbreak in a south Minneapolis neighborhood. Mankato continued to remove infested lindens in 2023. DNR forest health staff noted an infested ornamental linden in 2023 in St. Peter, Nicollet County.



A linden dying from linden borer infestation, St. Peter, 2023.

Neighborhoods in these communities are likely seeing linden borer attack because the lindens are stressed and unable to defend themselves against attack. We know that extremely wet and dry growing seasons stress trees, and trees growing in urban environments are more predisposed to those precipitation stresses by growing in suboptimal conditions (frequently growing in highly compacted soils with limited rooting space due to concrete). Both Blue Earth and Hennepin County have experienced extremely wet and dry growing seasons in the last decade. For both counties, the growing seasons in 2016 and 2019 were amongst the wettest 10 on record, and 2021 was amongst the driest 20 on record. 2022 and 2023 also were amongst the driest 20 years for Hennepin County.

Fortunately, these infestations spread slowly. In Mankato, infested trees are clustered, and the city is having to remove roughly 2% of their lindens per year. No outbreaks of linden borer have been reported damaging any basswoods in rural forests of Minnesota. Residents may be able to ward off attack by deeply but infrequently watering their yard lindens during drought. Such irrigation may prevent a linden from reaching a stress level that attracts and allows attack.

Spongy moth

Spongy moth (*Lymantria dispar dispar*) is an invasive forest pest that feeds on more than 300 species of trees and shrubs, including aspen, oak, and birch. Populations of this invasive are slowly encroaching upon Minnesota from the east, but they have not yet established to defoliate large forested areas. However, very small pockets of defoliation have been discovered. One location was at Palisade Head along the North Shore in 2021. Egg masses were treated at this location and no defoliation has been observed since. Once populations are large enough, outbreaks can occur every 8 to 12 years. Defoliation stresses trees, and heavy and repeated defoliation kills trees.

Minnesota Department of Agriculture (MDA) implements a national program in Minnesota to slow the advancing front of the spongy moth population. This program includes early detection surveys, establishing quarantines, and implementing an aerial spray program. Program details can be found on MDA's spongy moth website.

Trapping surveys

MDA catches male moths in traps to estimate spongy moth populations. Trappers caught more male moths in 2023 than in prior years, setting the record at nearly 113,000 moths across 46 counties. The most moths caught per trap, by far, were in Cook and Lake counties.

High numbers of male moths do not necessarily indicate defoliation by caterpillars in the near future. Male spongy moths can disperse long distances, but females are flightless. A better indicator of established populations is the presence of egg masses. MDA, DNR, and others are finding higher frequencies of egg masses in northeast Minnesota over time, which indicates northeast Minnesota could experience outbreaks in certain parts. DNR Forest Health aerial surveys would detect any such outbreaks and we would report them here.

Spongy moth egg mass and young caterpillar (photograph courtesy of Wisconsin DNR).

Treatments

MDA treats isolated populations of spongy moths along the advancing population front. This slows population advance. Four treatments took place in mid-July, three in the Duluth vicinity and one area in Carlton County. An organic, biodegradable formulation of spongy moth mating pheromone was sprayed in all four spray blocks. This treatment disrupts mating. MDA anticipates applying treatments to a larger area in 2024.

Spruce budworm

Damage from spruce budworm (*Choristoneura fumiferana*), a native caterpillar, has been mapped every year in northern Minnesota since annual aerial surveys started in 1954. This budworm prefers to feed on balsam fir followed by white spruce. It will also feed on black spruce, tamarack, and pine when the budworm population is high. In Minnesota, spruce budworm typically feeds in an area for 6–10 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. However, in some parts of the state budworm has been active for over 10 years.

In 2023, spruce budworm defoliated or killed about 664,800 acres of fir and spruce forests. The majority of those acres were defoliated, while about 13,200 acres had a mix of mortality and defoliation. This exceeds last year's total of approximately 488,800 acres and is now the highest number of acres the caterpillar has impacted in one year since 1961. Since 2019, spruce budworm has annually defoliated an average of about 417,000 acres of fir and spruce forests in northeastern Minnesota. For context, that's slightly larger than the size of Lower and Upper Red Lake and Leech Lake combined.

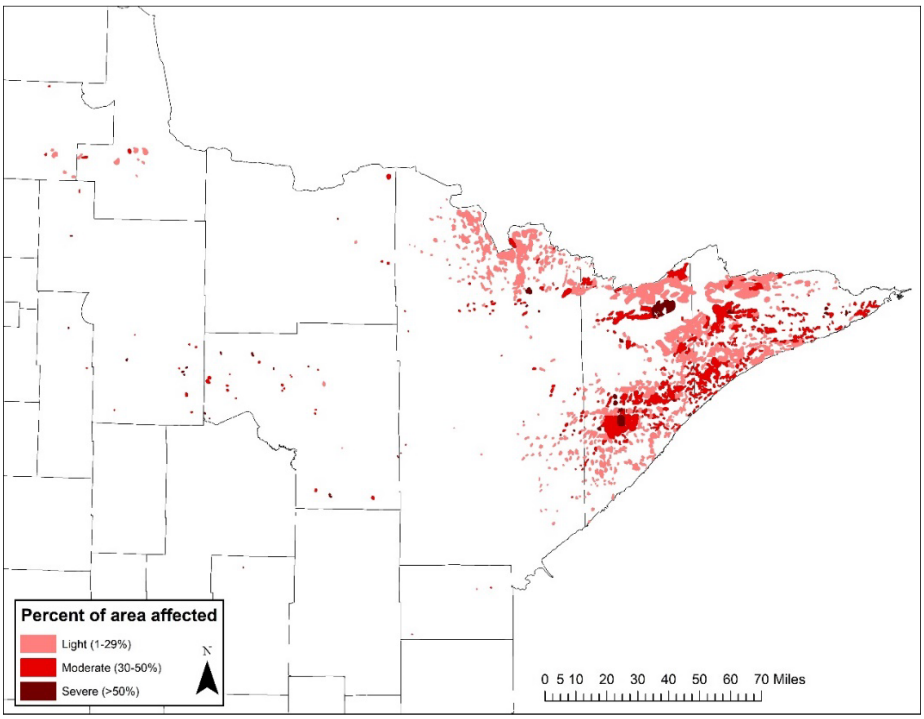
Most of the present outbreak is in northern St. Louis, Lake, and Cook counties. Scattered damage, mostly to white spruce stands, has also been mapped in Itasca, Beltrami, Roseau, and Lake of the Woods counties.

Defoliation and mortality from spruce budworm in Tettegouche State Park in 2023.

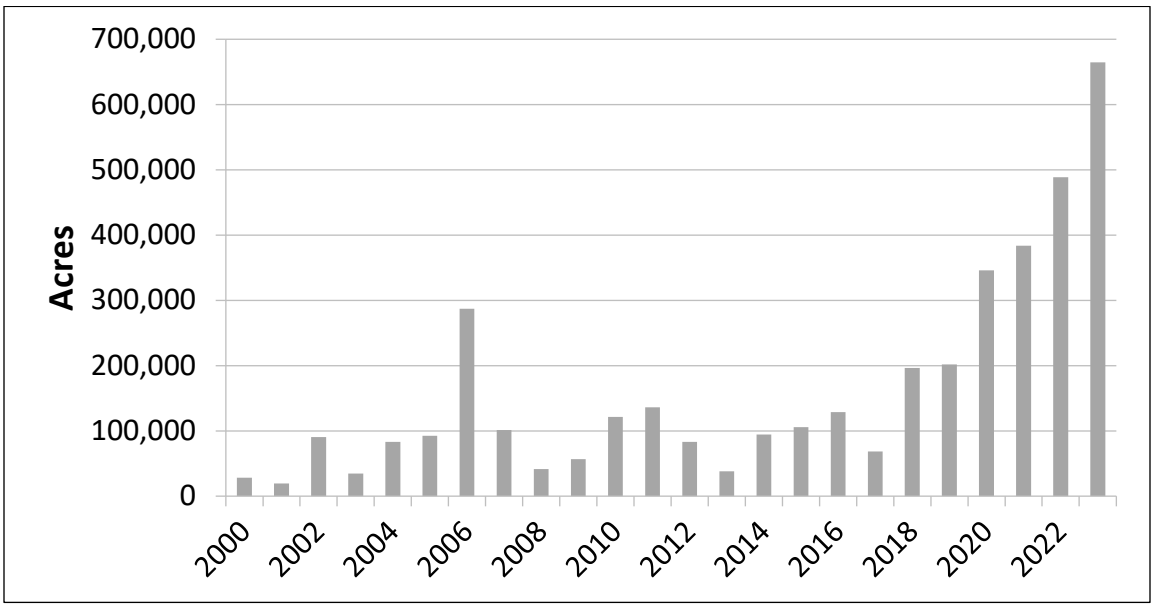
Current damage from spruce budworm is not out of the ordinary, as large outbreaks have occurred in Minnesota since the early twentieth century. An abundance of mature and overmature balsam fir has possibly prolonged and intensified budworm outbreaks when contrasted to pre-settlement times. Part of the reason for higher densities of older balsam fir is a lack of repeated, low-intensity 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 where there were many dying and dead fir and spruce trees. These conditions caused by spruce budworm likely altered the behavior of the Greenwood Fire.

Spruce budworm will continue to have a large ecological impact in Lake and Cook counties in the coming years, as its populations will likely continue to be high there. Predicting populations outside the Arrowhead is more difficult. However, a small number of egg mass surveys conducted in Itasca County in 2023 indicate that spruce budworm will continue defoliating white spruce stands in that area in 2024.

Community Wildfire Protection Plans by St. Louis County, the DNR, and the USDA Forest Service utilize defoliation and mortality data from aerial surveys annually. Two grant proposals were submitted by the DNR in 2023 to reduce wildlfire fuels and restore forests damaged by spruce budworm. One was for a Community Wildfire Defense Grant and the second was for funds from the Lessard-Sams Outdoor Heritage Council. Our aerial survey data was used to target initial areas that would receive fuels treatment.



Spruce budworm defoliation and mortality in 2023.

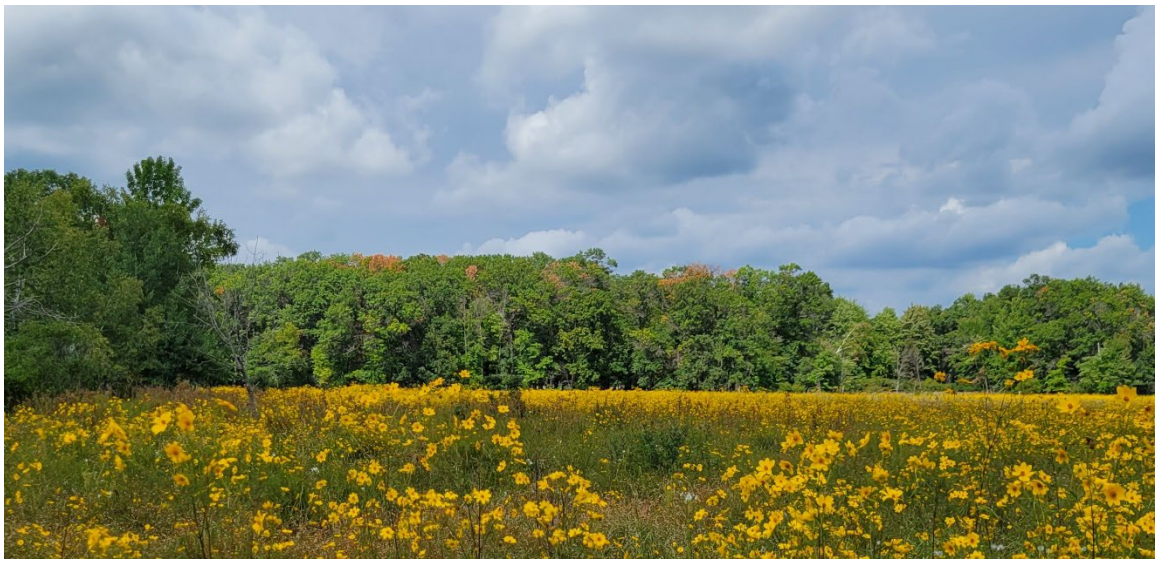


Acres with spruce budworm defoliation and mortality from 2000 to 2023.

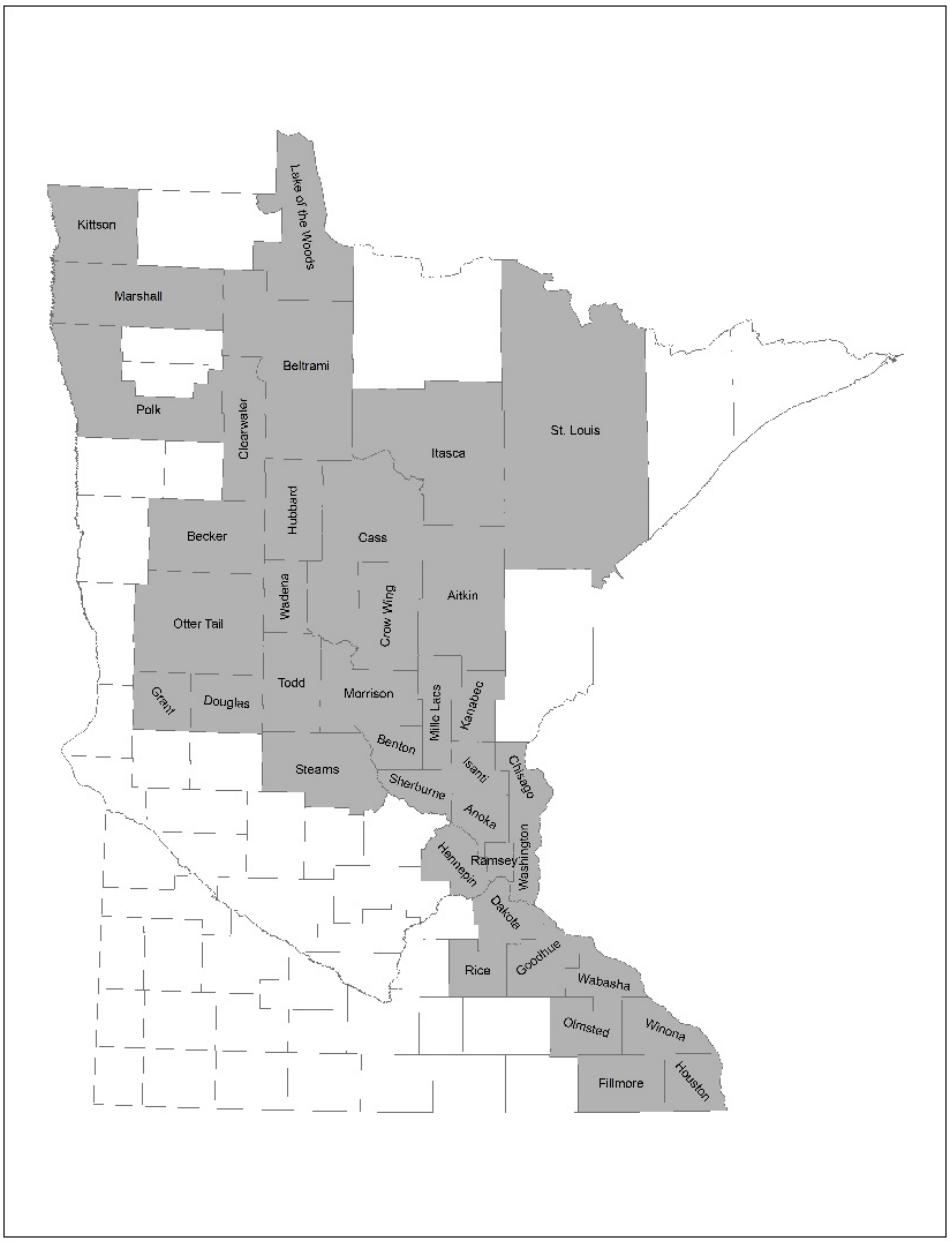
Twolined chestnut borer

Twolined chestnut borer (*Agrilus bilineatus*) is a native metallic wood-boring beetle whose larvae feed in the inner bark and cambium of oak trees, particularly stressed oak trees. The amount of twolined chestnut borer that we've mapped in the last three years has risen each year. We observed a considerable increase in damage from twolined chestnut borer in many areas of the state in 2023. However, aerial surveys significantly underestimated twolined chestnut borer damage at just over 2,300 acres. This is because survey timing did not coincide with twolined chestnut borer symptom development, and landscape infestation pattern typical of this pest is very difficult to capture in aerial surveys. Please see our oak decline article in the Declines and Abiotic Problems section for more details about twolined chestnut borer.

Many twolined chestnut borer adults were flying around Carlos Avery Wildlife Management Area in May 2023.



Scattered dying northern pin oaks from twolined chestnut borer infestation in Anoka County in late August 2023.



Counties where dieback and mortality were observed from twolined chestnut borer in 2023.

Diseases

Minimal bur oak blight in 2023

Bur oak blight is a leaf disease of bur oak caused by the native 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 (see picture below). Some of these dead leaves persist in the canopy throughout the winter. Trees almost always recover the following spring. Very little bur oak blight was observed in 2023.

Forest Health staff did observe or receive reports of a few bur oaks with symptoms of bur oak blight in Beltrami, Clearwater, and Hubbard counties in northwest Minnesota, and Fillmore, Houston, and Rice counties in southeast Minnesota this year. These affected bur oaks represented less than 1% of all bur oaks in the landscape. With the exception of Murray County in southwest Minnesota, no county in the state experienced above-normal precipitation in both May and June. We've shown that more rain in May and June equates to more bur oak blight symptoms across the landscape (2022 Annual Report).

From past observations and surveys, we currently do not think bur oak blight is a significant threat to healthy bur oaks. In-depth tree ring analyses could provide further evidence of bur oak blight's impact to tree health.

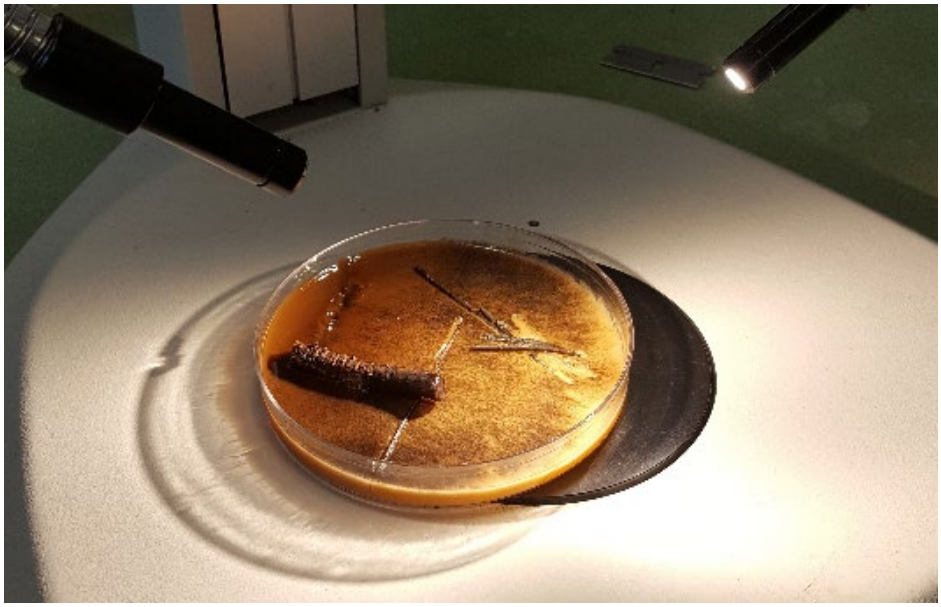
A bur oak with bur oak blight symptoms in 2015. Very little bur oak blight was observed in 2023.

No latent Diplodia found in red pine in 2023 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 results in disease until trees become stressed.

The Minnesota State Forest Nursery tests for latent Diplodia infections to avoid distributing stock with too much disease, and it does not sell seedlings when latent Diplodia infections exceed 10% of the crop. Infected seedlings at the nursery surpassed this threshold in 2016, due to highly favorable regional weather conditions for disease infection and development, and 400,000–500,000 red pine seedlings were destroyed to avoid potential widespread mortality from Diplodia after planting.

The DNR State Forest Nursery, DNR Forest Health, and University of Minnesota Plant Disease Clinic have assessed levels of latent Diplodia infections in state nursery stock since 2016. No samples tested positive for latent Diplodia infections in 2023. Since 2017, we have found an average of 0.27% of tested seedlings with latent Diplodia. As this disease is abundant in Minnesota's landscape and cannot be avoided, this is well below an acceptable level for planting seedlings from the state nursery.



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

No Heterobasidion root disease centers found in 2023

Heterobasidion irregulare is a fungal pathogen that causes root disease in conifers. It is particularly threatening to pine and spruce plantations. We are not aware of any Heterobasidion root disease (HRD) centers in Minnesota. This disease was confirmed at one site in Winona County in 2014, but DNR staff eradicated it from that site in 2017.

Like other tree root diseases, once established at a site, HRD is very difficult, if not impossible, to get rid of. Unlike other root diseases, there are a couple ways to prevent HRD infection. These preventative techniques are expensive and sometimes unavailable. For these reasons, we prioritize early detection surveys for HRD.

As in recent years, University of Minnesota researchers in the Department of Plant Pathology surveyed for Heterobasidion spores with traps on DNR-managed and private lands in Clearwater (Itasca State Park), Goodhue, Wabasha, Washington, and Winona counties in 2023. Their results suggested Heterobasidion fruiting bodies may be present in Minnesota near the originally infested plantation in Winona County. University personnel plan to survey more for Heterobasidion near this site in 2024.

Eradication of Heterobasidion took place in late 2017 at the only known infected site in Minnesota. No Heterobasidion mortality centers have been found in the state since then.

Oak wilt

Oak wilt is a non-native, fatal oak disease that has spread slowly northward in Minnesota since the 1940s. The disease currently covers close to 40% of the state's red oak group range and is common in east-central and southeast Minnesota (black area in map below). As an invasive species, it is unique in that it spreads slowly across the state, and there are several different ways to control it on individual sites.

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

No oak wilt finds in 2023 significantly expanded the known range of oak wilt in Minnesota. However, DNR Forest Health staff did document a 1.25 mile eastward expansion in far southeast Cass County (see blue dots in map below).

Management

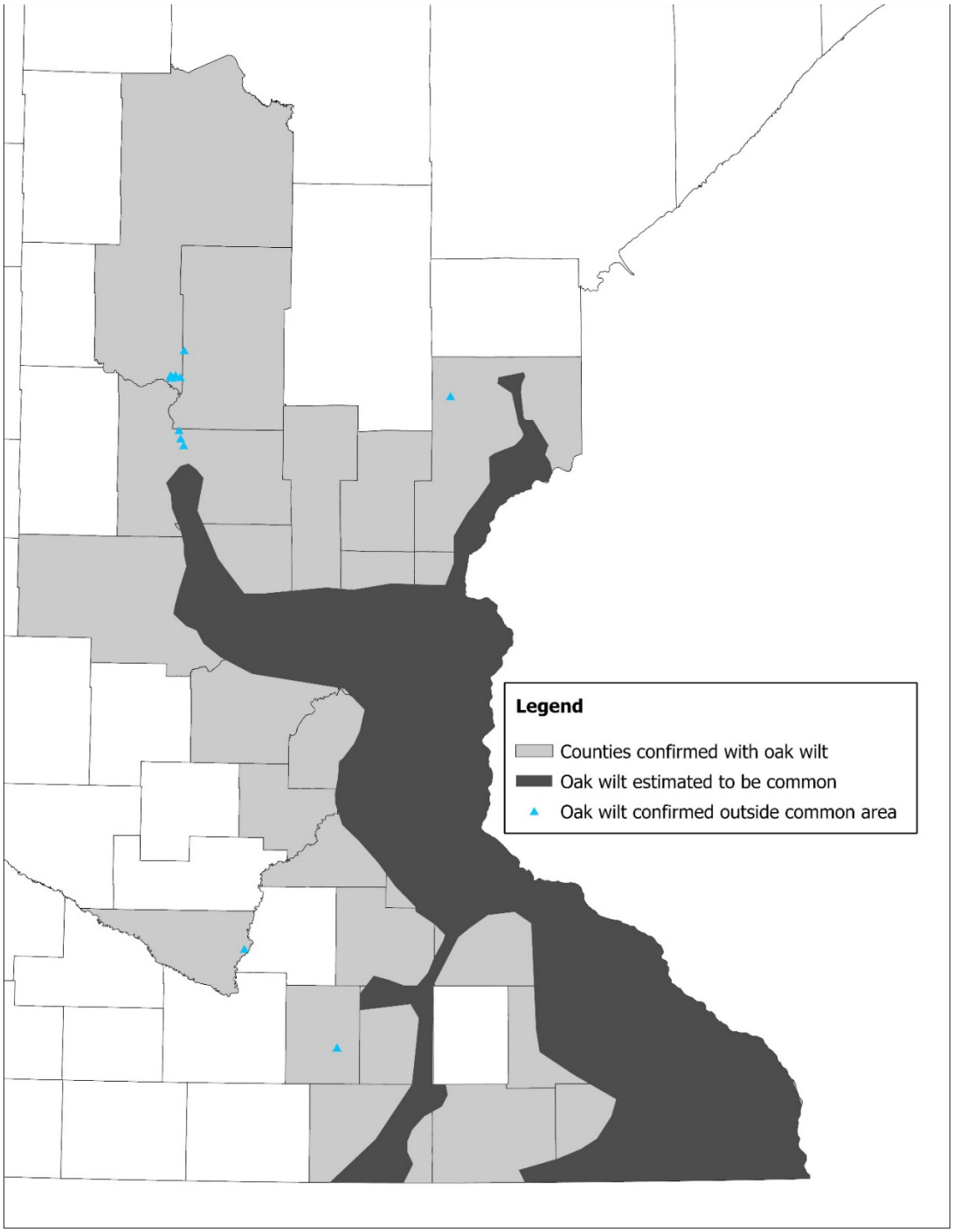
Morrison County Soil and Water Conservation District (SWCD) continued to fund oak wilt control in Morrison County and northward using a grant from the Environment and Natural Resources Trust Fund. DNR Forestry Division assisted the SWCD with several aspects of this program. The SWCD funded control for 16 oak wilt centers in Morrison and Cass County in 2023. Unfortunately, the SWCD won't receive oak wilt control funding in 2024. DNR Forest Health submitted a grant proposal late in 2023 to cost-share oak wilt control if discovered beyond the known range of the disease in 2024.

Most of the known oak wilt in Pine County is in St. Croix State Park. From autumn 2023 through early 2024, St. Croix State Park staff cut and burned over 100 oaks capable of producing oak wilt spores in spring 2024. Unfortunately, park staff were unable to rent a vibratory plow for belowground oak wilt control due to high demand for vibratory plows in the private utility sector. For that reason, DNR Forest Health submitted a grant proposal late in 2023 to purchase a vibratory plow.

A vibratory plow operating to stop the belowground spread of oak wilt, Cass County, 2023.

Rapid response project

Minnesota DNR Forest Health continued to partner with the U.S. Forest Service, Michigan DNR, and Wisconsin DNR on research to evaluate the effectiveness of a rapid control procedure for single, isolated oaks infected aboveground by oak wilt. Twelve oaks were successfully treated at Carlos Avery Wildlife Management Area in 2023, bringing Minnesota's total treatments to 14. This is a longer-term study, and results will be ready for publication around 2030.



Areas where oak wilt is common, counties with known confirmations, and oak wilt mortality centers outside the area where oak wilt is common.

Septorioides needle blight

A needle pathogen on eastern white pine was commonly observed in 2023 in northeast Minnesota. Counties with white pines that had symptoms of this pathogen include Aitkin, Itasca, Koochiching, and St. Louis. A small set of needles were sent to the University of Minnesota's Plant Disease Clinic and all samples yielded the fungal pathogen *Septorioides strobi*. This species is one of several needle pathogens that are part of the disease complex known as white pine needle damage. This damage has been problematic in the northeastern parts of the United States.

The reason this pathogen caused disease in northeast Minnesota in 2023 was likely due to recent drought and an above average amount of precipitation early in the growing season in 2022. The excess precipitation resulted in infection, and the drought allowed disease to develop.

The year after infection, older needles develop symptoms of chlorosis (yellowing). These symptoms appear in late May and early June and can persist through the growing season. Diseased needles can drop after symptom development.

We don't expect that this needle pathogen will impact the health of white pines, unless it continues for consecutive years, in which case it could lead to slowed growth.

White pine needles showing symptoms of infection by Septorioides strobi, Aitkin County, 2023.

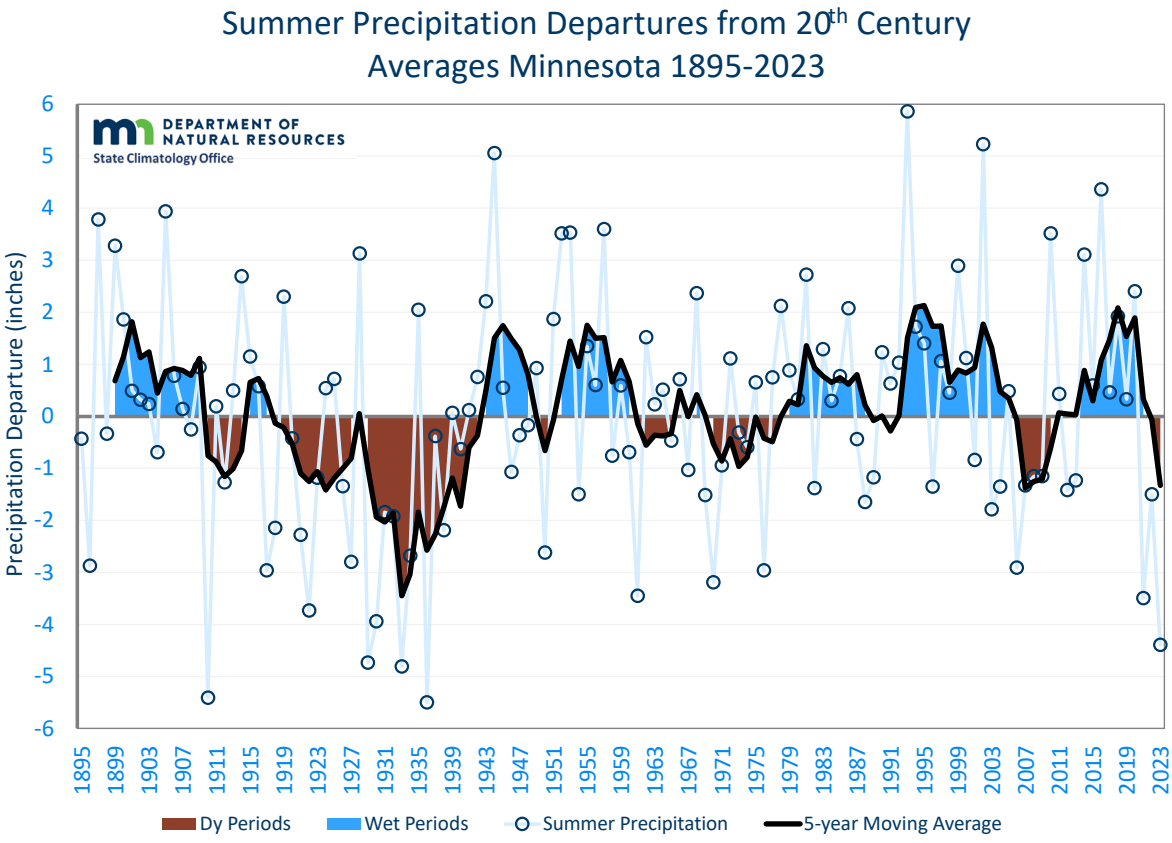
Declines and Abiotic Problems

Recent Drought

In the last decade, Minnesota has experienced wild precipitation swings during the growing season, defined here as April through September. Precipitation during the growing season, when the ground is thawed and trees are actively drawing moisture, is critical to tree health.

On a statewide-scale, 2023 was the 9th driest growing season on record, going back to 1895. Just two years before, 2021 was the 11th driest on record. These dry years greatly contrast with the excessively wet years of 2014, 2016, and 2019, all amongst the wettest 12 growing seasons on record. Both extreme high and low seasonal precipitation stress trees, but extreme drought causes more widespread and acute tree damage than extreme wetness.

Precipitation deficits during the summer months of June, July, and August have been particularly extreme. Due to the droughts in 2021, 2022, and 2023, the current statewide summer precipitation 5-year average deficit matches that last seen in 2007, and before that, 1938 (see graph).



Serious drought drastically reduces photosynthesis and kills plant cells, resulting in stunted foliage and canopy dieback. It also limits trees' abilities to defend themselves against pests and pathogens that normally are incapable of seriously damaging a tree. We have seen increases in recent years of bark beetle problems and cambium-feeding native borers like twolined chestnut borer, bronze poplar borer, and bronze birch borer. We anticipate we'll see more of these problems in 2024, even if we don't experience a drought in 2024.

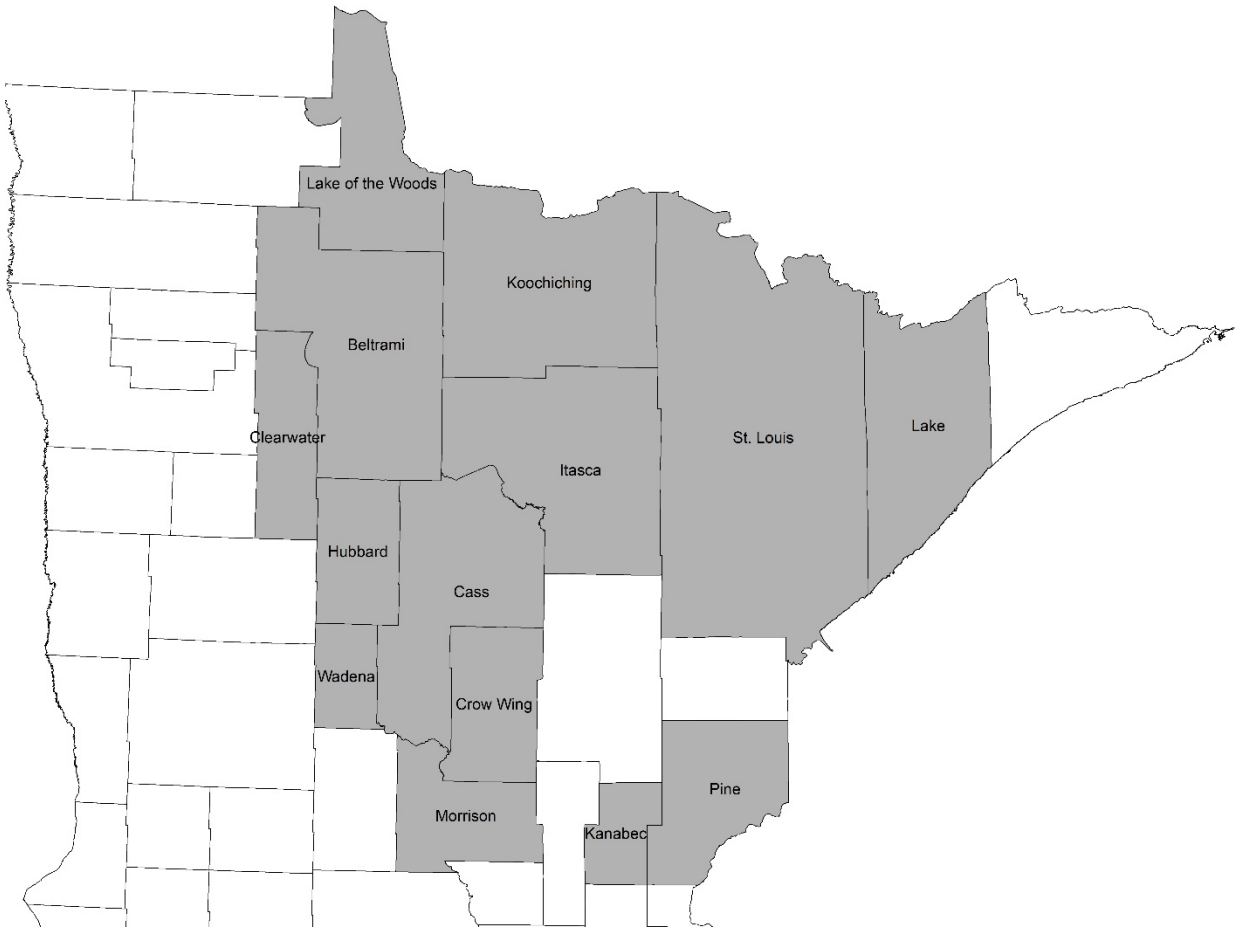
Aspen decline

We mapped almost 4,600 acres of aspen decline in 2023. This is a significant decrease from 2022 when nearly 29,900 acres were recorded. The drastic decline could represent the end of a decline phenomenon that peaked in 2009.

Multiple factors typically contribute to aspen decline. Symptoms can include leaf discoloration and dieback, and in some cases, mortality.

The incidence of aspen decline might rise in the coming years due to recent droughts. Drought is a main inciting factor of decline in aspen and other trees. Other stressors can also contribute to decline, such as old age, flooding, wind damage, late spring frost, and defoliation. After multiple years of these stressors, aspen stands tend to show symptoms of decline.

Historically, aspen decline was somewhat isolated, with one particular location being 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. The average amount of mapped decline was about 87,900 acres over this time period, peaking in 2009 with just under 300,000 acres.



Counties recorded with aspen decline in 2023.

Oak mortality and drought

The most widespread tree problem across Minnesota in 2023 was declining oaks, primarily caused by a combination of older age, consecutive years of significant drought, and two opportunistic pests that are only serious problems on stressed oaks. Decline manifests as dieback and mortality developing over a number of years, scattered across larger areas. Increased levels of oak mortality became noticeable in 2022 but were even more abundant in 2023.

Our forests can tolerate some drought, but the more stress they experience from drought and other stressors (e.g., flooding, defoliation, and compaction), the more likely it is they'll suffer serious problems, like infestation, disease, and mortality. This year, scattered mortality and heavy dieback of oak species exploded across much of Minnesota, from the southern border with Iowa up to Kittson County in the northwest part of Minnesota. In particular, older bur oaks in varying states of decline were commonly reported to our staff (see image below). Almost 45% of old bur oaks in one community in central Minnesota had moderate to severe dieback.

Bur oak decline, Stearns County, 2023.

Two oak pests, Armillaria root disease and twolined chestnut borer, are notorious for attacking stressed oaks, and they were extremely common in woodlots this year. The scattered nature of declining forests is nearly impossible to map from aerial surveys, but we did map 50% more twolined chestnut borer-infested forests in 2023 than we did in 2022. Larger patches of northern pin oak killed off by twolined chestnut borer were noted north of the Twin Cities this year. They had displayed light dieback in 2022, but fully died in 2023 (see image on next page).

Red oaks killed by twolined chestnut borer in 2023 in Carlos Avery Wildlife Management Area.

We expect this decline to continue for a couple years following the conclusion of significant drought. We've advised forest managers to delay thinning forests during this stressful time, when possible, and we've advised homeowners to strategically irrigate their yard oaks.

Heavy snow damage from December 2022 storm

As reported in our 2022 annual report, there was an unusually large-scale wet winter storm in mid-December 2022 that heavily damaged a large amount of forest across Carlton and Pine counties and eastward into Wisconsin.

DNR Forest Health and DNR Resource Assessment staff aerially mapped damage to forests from this storm in early May 2023 over Pine and Carlton counties. We mapped 35,800 acres of damage, 75% of which sustained near-total flattening of the forest or tree mortality. Nearly all the damage we mapped was to young aspen forests (top image, below). Most other forest types were not devastated, although some pine forests or plantations were damaged (bottom image, below).

Local DNR Forestry staff sold salvage harvest permits on 700 acres of damaged mature red pine plantation in Pine County in 2023. Pine salvage sales occurred on private land too. Local and regional DNR Forestry staff contracted out restorative work to 21 sites in 2023 where young pine or aspen were destroyed.

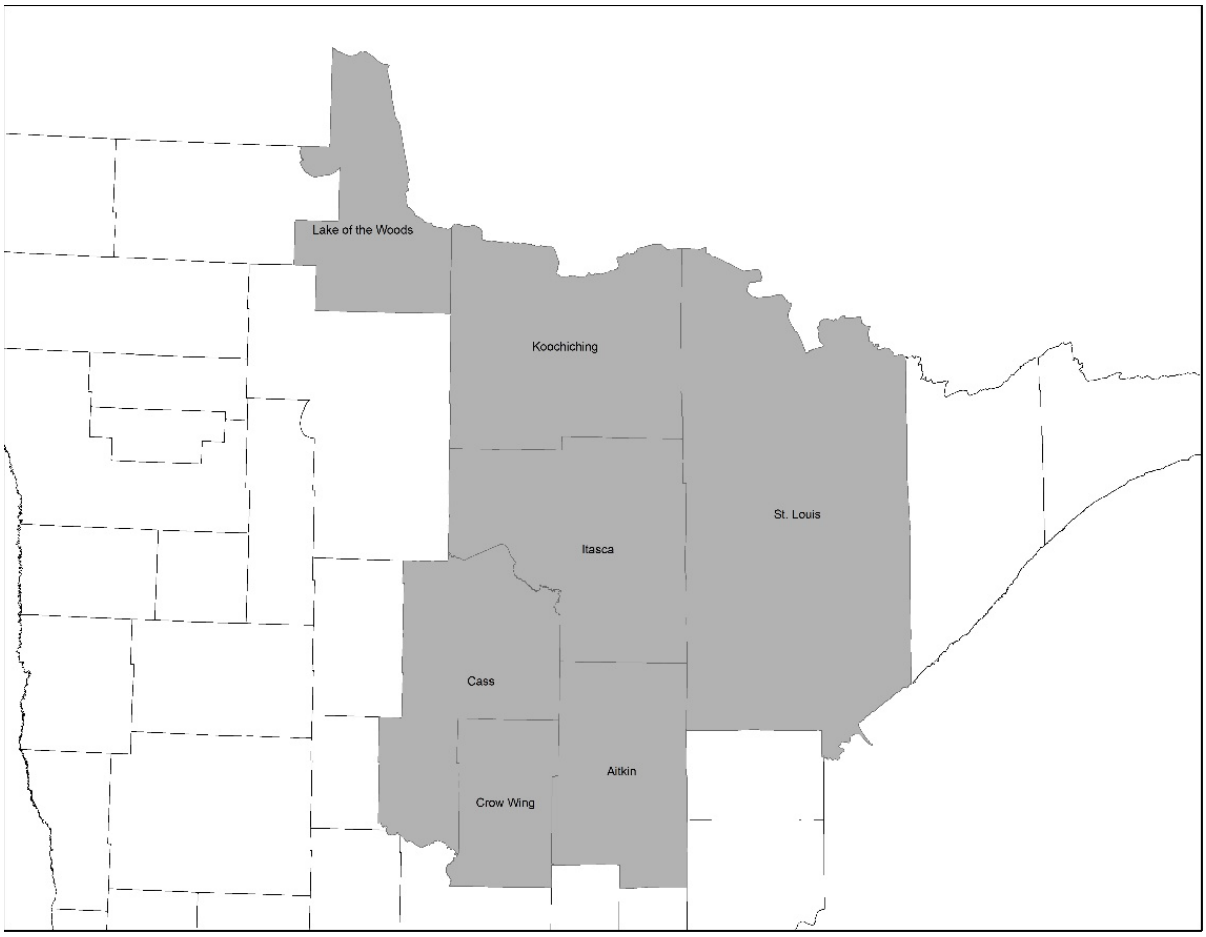
Quaking aspen smashed by heavy snow the previous December, Pine County, May 2023

Heavy snow from the previous December destroyed this young jack pine stand, Pine County, 2023

Wind

There were approximately 1,600 acres of wind damage mapped in 2023, a significant decrease from the nearly 13,700 acres mapped in 2022. Acres mapped with wind damage in 2023 was similar to that of 2021. Overall, there has been no clear trend in wind damage over the years.

Koochiching County had the most wind damage mapped this year, with about 600 acres, followed by St. Louis County with about 550 acres. The damage in Koochiching County was in only one large area and St. Louis had two big areas of wind damage. Wind damage can be missed in our aerial surveys due to timing, location, and limited visibility.



Counties where wind damage was observed in 2023 via aerial survey.

Other tree pest and tree health events noted in 2022 and 2023

Pest or event	Pest stage or cause	2022 (county in which observed)	2023 (county in which observed)
Sudden ash leaflet drop	Anthracnose	June 13 (Itasca)	None observed
Eastern tent caterpillar	Caterpillars, 0.5-1”	May 26 (Sherburne) (0.5” long)	May 30 (Pine) (0.75” long)
European pine or red pine sawfly on red pine	Caterpillars, 0.5-1”	June 9 (Anoka)	June 21 (Anoka)
Forest tent caterpillar	Emergence of first-instar larvae	May 14 (Itasca)	Not recorded
Forest tent caterpillar	Caterpillars, > 1”	June 7 (Itasca)	June 8 (Aitkin)
Diseased maple leaves	Anthracnose	June 14 (Fillmore) June 22 (Kanabec) June 23 (Itasca) June 25 (Crow Wing)	None observed
Oak wilt	Spore mats	May 26 (Sherburne)	Not recorded
Oak wilt	Wilting noted for the first time	June 23 (Morrison) August 30 (Cass)	June 6 (Anoka) July 13 (Cass)
Pine bark beetles (*Ips* species)	Females constructing egg galleries in spring	May 26 (Sherburne)	May 17 (Pine)
Defoliation on red maple	Greenstriped mapleworm (*Dryocampa rubicunda*)	July 22 (Pine)	August 4 (Pine)
Defoliation on red oak	Pinkstriped oakworm (*Anisota virginiensis*)	July 22 (Pine)	None observed
Dead red pine shoots	Red pine shoot moth	Summer (Beltrami, Cass, Crow Wing, Hubbard, Pine, Wadena)	Summer (Crow Wing, Itasca, Sherburne)

Pest or event	Pest stage or cause	2022 (county in which observed)	2023 (county in which observed)
Spruce budworm	Caterpillars, ¾ to 1” (full-grown)	June 16 (St. Louis)	June 16 (Lake)

A family reunion of sorts: a mat of forest tent caterpillars (Malacosoma disstria) *resting on a nest of eastern tent caterpillars* (Malacosoma americanum)*, Pine County, May 2023.*