DEPARTMENT OF NATURAL RESOURCES

2020 Forest Health Annual Report

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

Cover photo: Leaf disease on aspen.

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Annual aerial survey of forest canopy

Due to COVID-19 and state social distance requirements in 2020, the aerial survey did not take place. We conducted forest health monitoring through a variety of other methods, including ground checks of 2019 survey polygons, monitoring changes in vegetation sensed by satellites through the ForWarn II system, ground checks based on 2019 National Agriculture Imagery Program (NAIP) imagery, reports from DNR foresters, assistance from the USDA Forest Service St. Paul Field Office, windshield surveys, and insect life stage surveys.

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. Other issues such as forest damage from floods or wood-boring insects do not always coincide with survey timing or they occur in areas not typically surveyed (e.g., in southwest Minnesota along the Minnesota River), so their impact is often underestimated. Finally, some problems such as root diseases, wilts, and tree declines cannot be consistently detected from the air and are therefore not recorded in surveys.

Annual surveys are accomplished through the collaboration of the DNR forest health and resource assessment units and the USDA Forest Service Eastern Region, St. Paul Field Office, State and Private Forestry (USFS). Survey results for 2016-2019 can be found in the Minnesota Geospatial Commons (keywords “forest health”).

Some survey results from 2020:

Damage causal agent	Acres	Comments
Flooding	700	This is an underestimate of damaged acres. Mapped from the ground using the ForWarn II system
Forest tent caterpillar	12	Underestimate of damaged acres. Mapped from the ground using the ForWarn II system
Frost	122,525	Overestimate of damaged acres. Mapped using the ForWarn II system, including some ground-checks
Spruce budworm	346,000	Overestimate of damaged acres. Mapped based on ground surveys, 2019 defoliation, airplane surveys (short flights by DNR), and primary host occurrence data
Wind	700	Underestimate of damaged acres. Mapped using satellite imagery change detection (before v. after storms) of two tornado paths; ground-checked several locations

Forest Pest Conditions Report

Insects

Arborvitae leafminer

Arborvitae leafminer is a native insect that feeds inside the needles of white cedar and leaves a tiny exit hole when it emerges. In 2018 we identified arborvitae leafminer as the cause of damage to thousands of acres of northern white cedar. In 2019 we mapped 165 acres of leafminer damage in St. Louis County. In 2020 we did not find evidence of arborvitae leaf miner while doing ground surveys in St. Louis County.

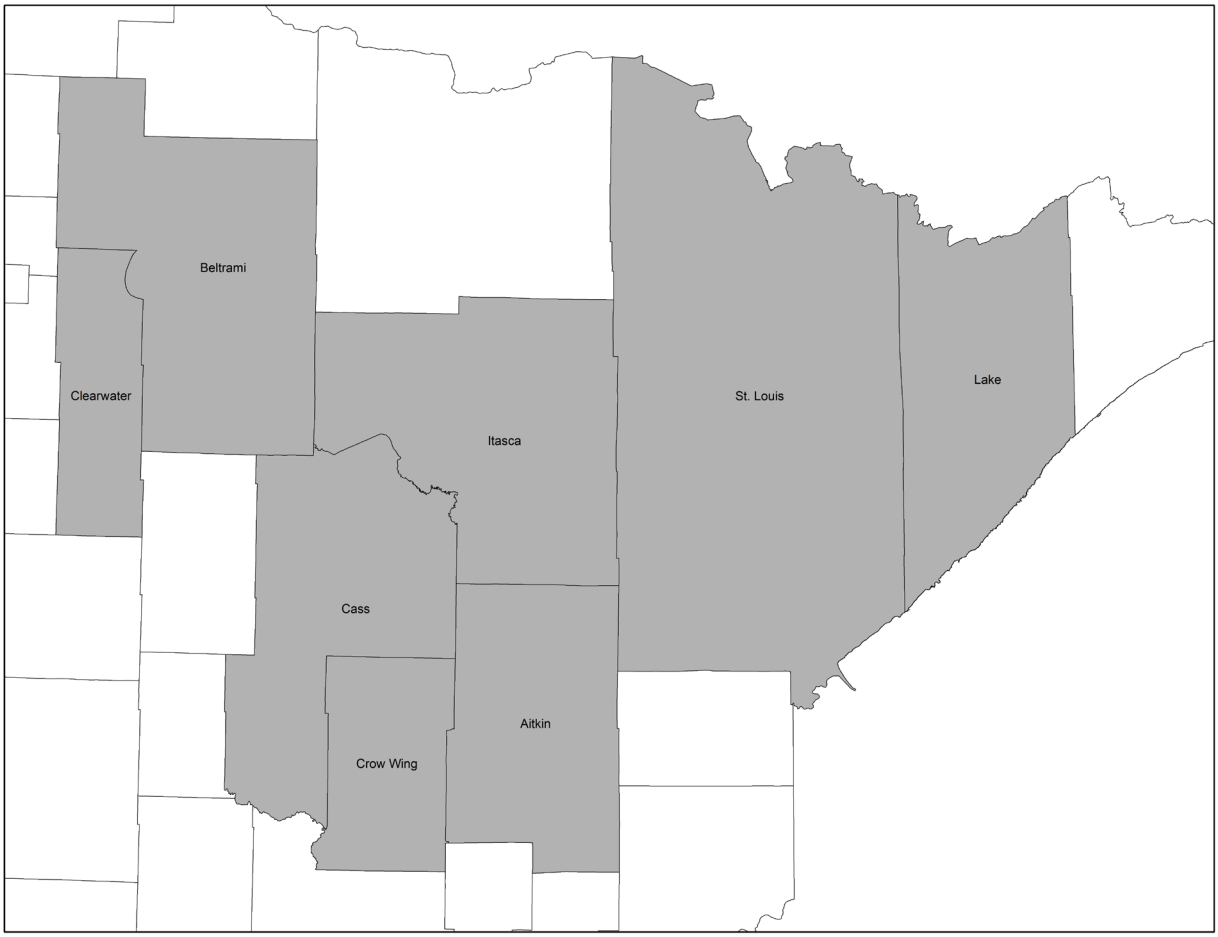
Tiny exit hole made by arborvitae leaf miner on northern white cedar.

Aspen blotch miner

The native leaf miner *Phyllonorycter tremuloidiella* is a caterpillar that feeds on the tissue between the surfaces of aspen leaves. Yellow blotches form on the leaves and eventually become brown. The blotches can be numerous and concerning, but aspen trees can tolerate the damage; impact to tree health and vigor is minimal.

Damage was common on trembling aspen from July to October in northern Minnesota counties. The extent of damage in 2020 appears to have slightly increased compared to 2019.

Aspen blotch miner damage on aspen.



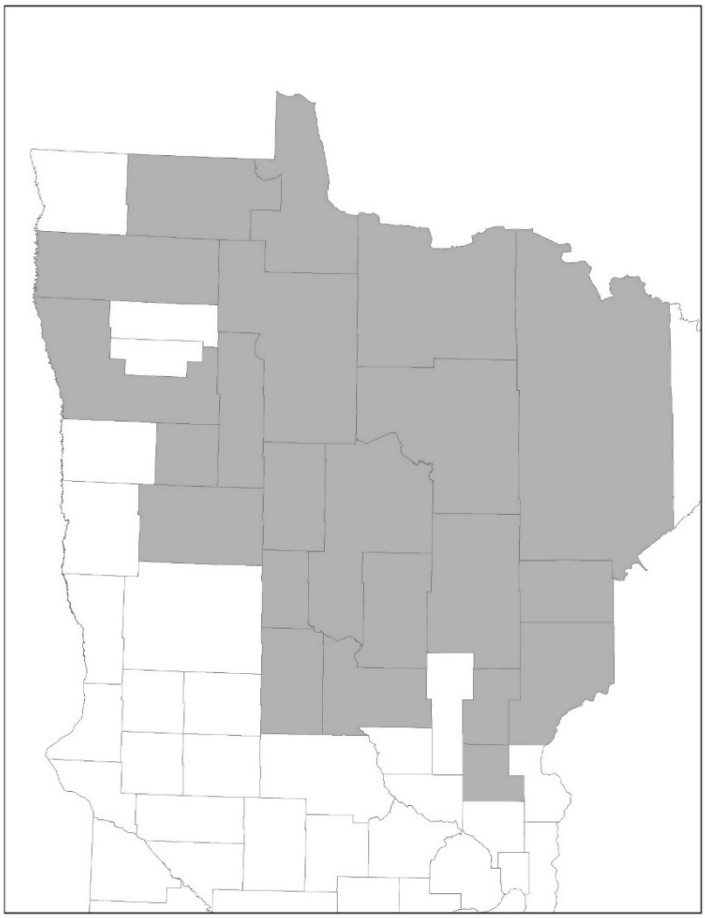
Counties with damage to aspen leaves in 2020 from aspen blotch miner.

Eastern larch beetle

Eastern larch beetle is native to Minnesota and is known to attack weakened tamarack. Since the beginning of the larch beetle outbreak in 2001, about 666,000 acres, or almost 50 percent of tamarack in the state, have been impacted to some degree by eastern larch beetle.

In 2019 we found 244,302 acres affected to some degree by eastern larch beetle. There has been an upward trend in damaged acres since the beginning of the outbreak in 2001, and we suspect the trend continued in 2020.

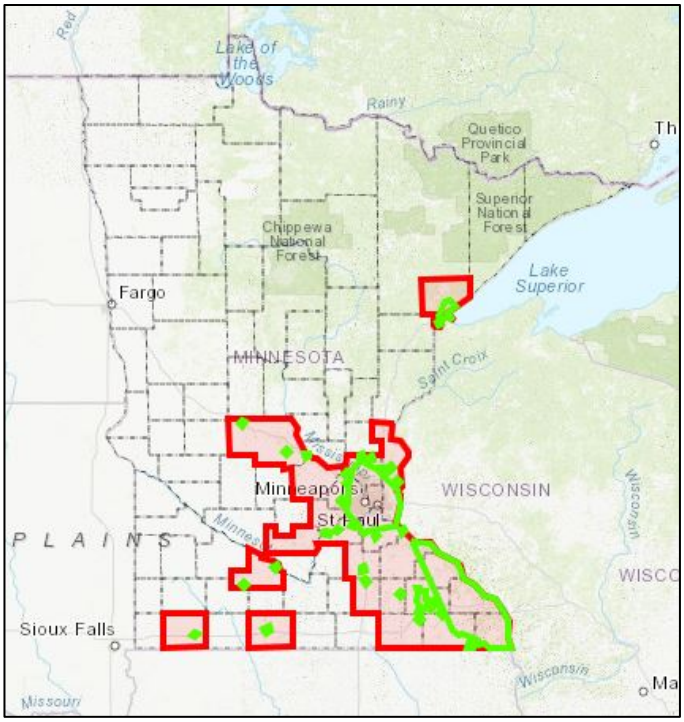
We surveyed seven tamarack stands in Isanti, Kanabec, Morrison, Pine, Stearns, and Todd counties in fall 2020 to understand the level of larch beetle infestation and found live larch beetles at six sites. The level of infestation was lower than in previous years, suggesting that the outbreak in the southern half of Minnesota is decreasing. Young tamarack regeneration was common at most of these sites, showing that infested tamarack stands can naturally recover from larch beetle devastation. Future surveys will determine if the intensity of larch beetle outbreak is also declining in northern Minnesota.



Counties with damage from eastern larch beetle.

Emerald ash borer

The Minnesota Department of Agriculture (MDA) is the lead agency for the emerald ash borer program in the state. In 2020, emerald ash borer infested four new counties (Carver, Mower, Rice, and Sibley) bringing the total of quarantined counties to 25 (refer to the map of counties quarantined for emerald ash borer at right).



Quarantined counties in red; green outline shows generally infested areas.

In 2020, MDA staff released 16,847 parasitoids for biological control of emerald ash borer: 8320 *Oobius agrili*, 4062 *Tetrastichus planipennisi*, and 4465 *Spathius galinae*.

Release numbers were down due to COVID precautions at the rearing facility in Michigan as well as a restructuring of the release methods to allow for a greater production of *Spathius galinae*. Beginning in 2020 and onward, new release sites will receive primarily *Tetrastichus planipennisi* in the first year of releases and the other parasitoids in year two. Only one release site in 2020 was in the first year of releases, which accounts for lower numbers of *T. planipennisi* released in 2020. MDA plans to scout in November and December for new release sites in 2021, and hopes to add five new sites if possible.

Fall webworm

Fall webworm is a native web-making caterpillar that feeds on a wide variety of tree species. We have observed it making nests in walnuts in southeast Minnesota and cherries immediately north of the Twin Cities. Even though fall webworm is not a concern for tree health, its unsightly, large webs can be alarming.

The fall webworm population increased in at least one suburb of the Twin Cities between 2018 and 2020, making more nests in urban ash, birch, crabapple, and linden. Our anecdotal observations indicate the population of fall webworm also increased this year in southeast Minnesota.

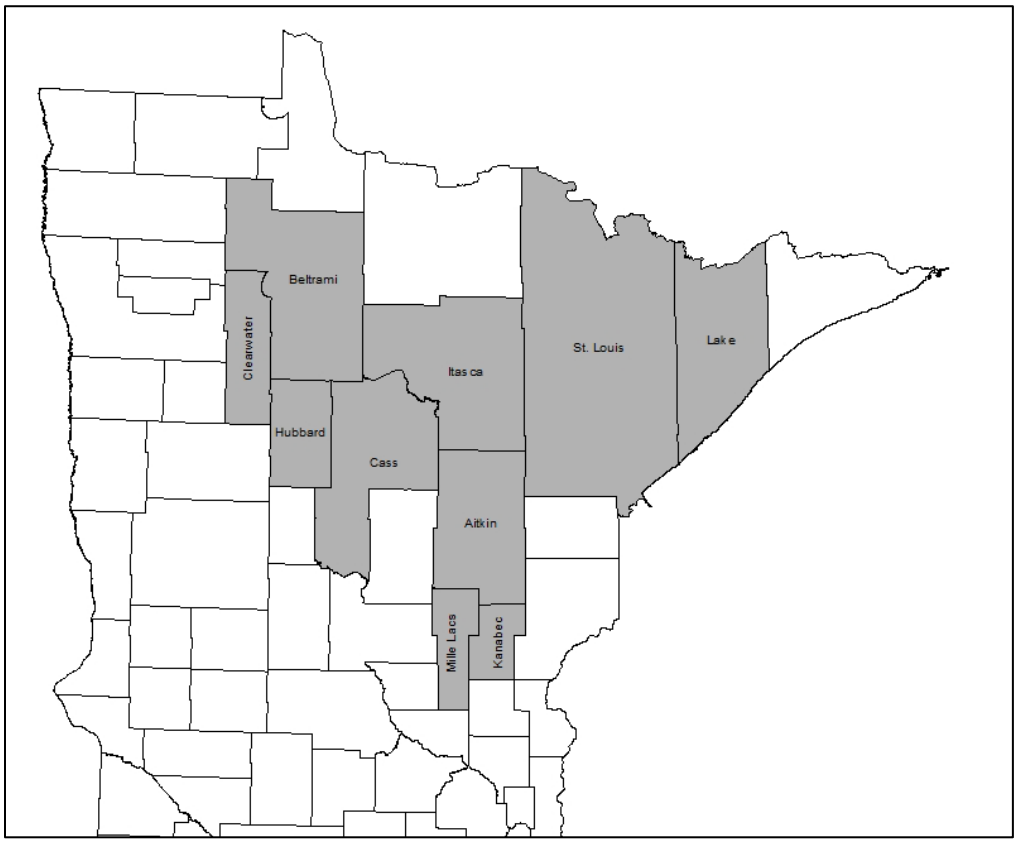
Fall webworm nests in a cherry tree in southeast Minnesota.

Forest tent caterpillar

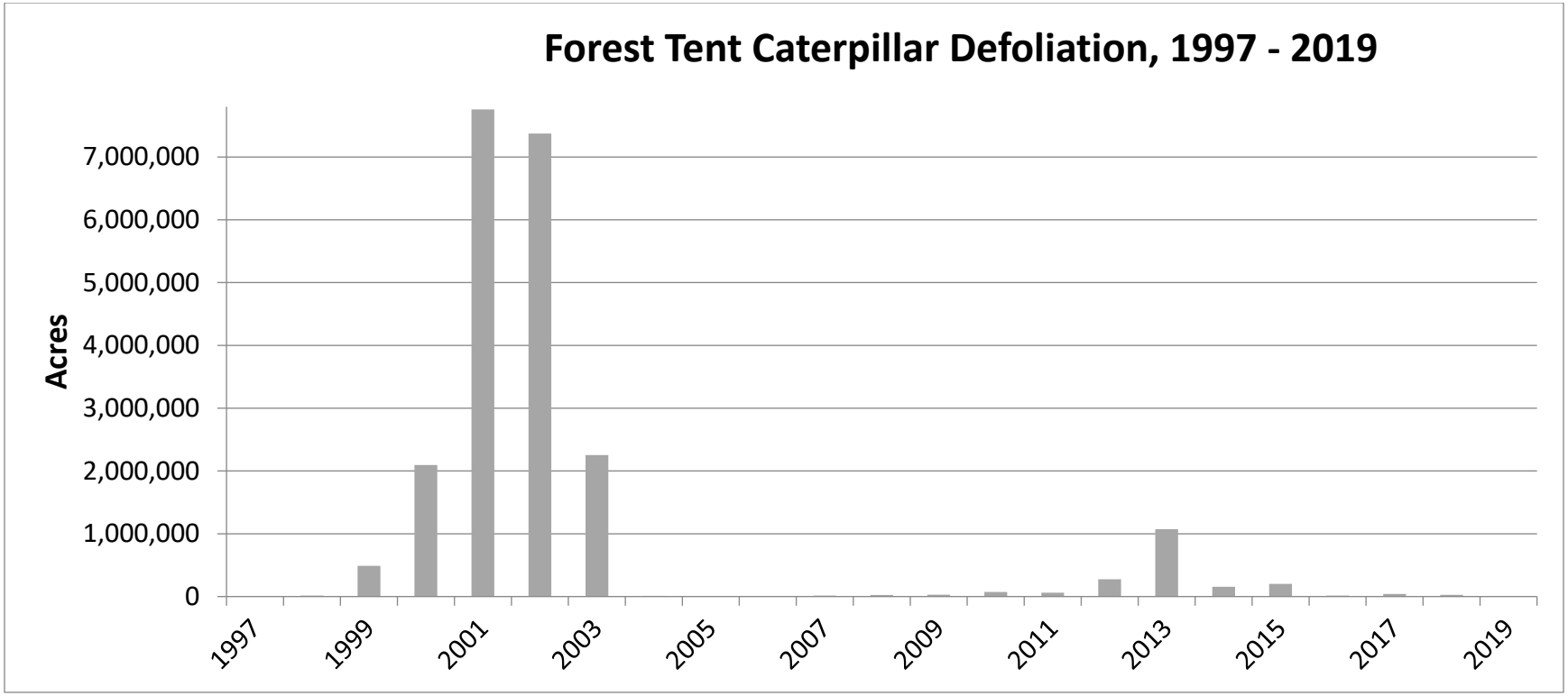
Forest tent caterpillar is a native insect that feeds primarily on aspen, oak, birch, and basswood. Forest tent caterpillar defoliation and damage decreased substantially from 2018 to 2019, and population levels appeared to remain low across Minnesota in 2020. Damage in most affected areas appeared to be light. The only areas significantly defoliated were several small locations in Mille Lacs and Kanabec counties.

Forest tent caterpillar egg mass surveys can be used to predict defoliation the following year. We conducted a small number of egg mass surveys in Aitkin, Itasca, and St. Louis counties, resulting in only one egg mass found in northern St. Louis County. Although not performed on a large scale, these surveys predict little defoliation for 2021.

There has been a general decline in acres impacted by forest tent caterpillar since 2012. Forest tent caterpillar populations peak every 10-16 years in Minnesota, and if populations begin to increase and we see increasing levels of defoliation, the next population peak could be sometime between 2023 and 2029 (assuming that a true population peak occurred in 2013).



Counties with forest tent caterpillar damage or life stages present in 2020.



Annual forest tent caterpillar damage from 1997 to 2019. The surge to over one million acres in 2013 was mostly from light defoliation.

Gypsy moth

The annual male gypsy moth trapping survey is conducted by the Minnesota Department of Agriculture (MDA). Most of the traps are placed in the eastern half of Minnesota, as the invasion front is coming from the east, with fewer traps rotated throughout western counties. Cooperators also help supplement the survey:

- The U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine staff and volunteers set about 200 traps annually in areas the MDA is not surveying that season.
- Three Rivers Parks District staff volunteer to set traps annually on MDA's survey grid that fall within their park boundaries in the metro area.

MDA County Agricultural Inspectors may also set traps on a volunteer basis in areas the MDA is not surveying that season.

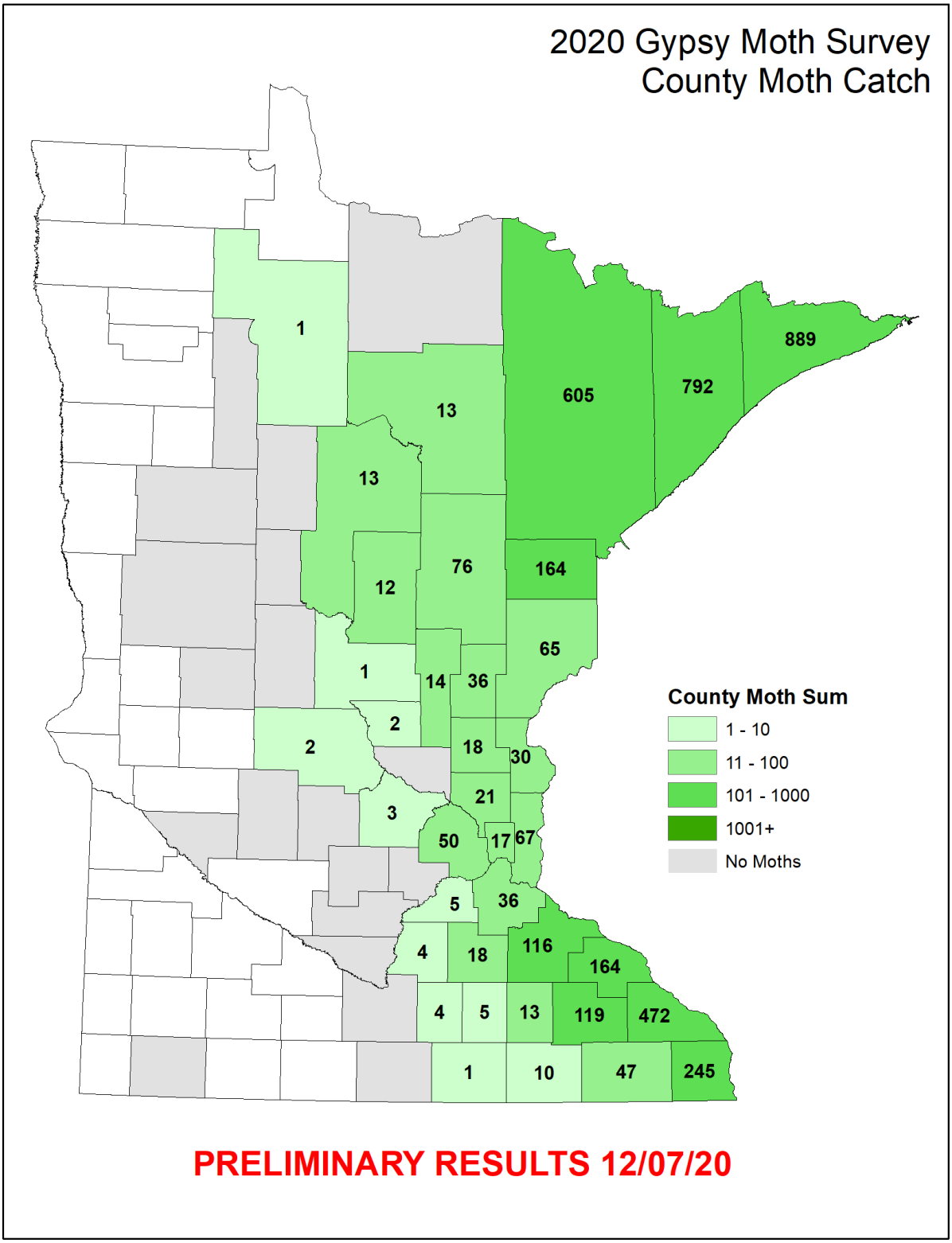
Trapping surveys

The MDA and cooperators have conducted annual trapping surveys for gypsy moth since 1973. In 2020, MDA staff and cooperators placed 21,691 detection traps statewide, primarily along the eastern border of Minnesota and with special attention paid to high-risk sites such as nursery, mills, parks, and urban communities. The number of captures statewide increased almost eight times the number captured in 2019; preliminary counts in December 2020 were 4,144 moths caught in 2,085 traps (see map of moth catch by county below).

Treatments

The MDA conducted aerial applications of *Bacillus thuringiensis kurstaki* at three sites in the spring of 2020: Minneapolis (Hennepin Co.), 298 acres; Oak Center (Wabash Co.), 1,421 acres; and Hokah (Houston Co.), 1,618 acres. Gypsy moth immature life stages were found at each of the treatment sites in 2019.

Staff found multiple life stages of gypsy moth, including fresh egg masses, at a number of sites this year. The MDA is proposing approximately 225,000 acres of gypsy moth treatments in 2021.

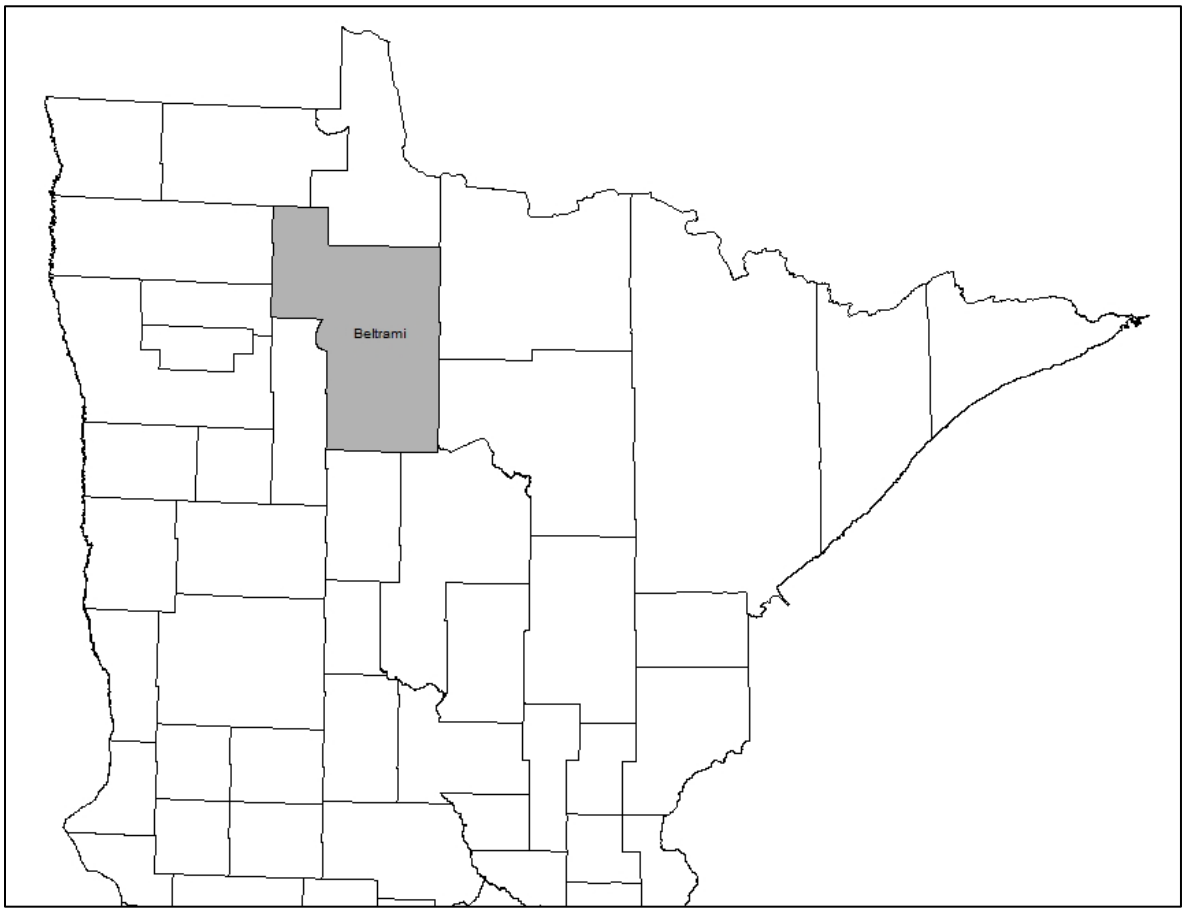


Gypsy moth traps caught 4,144 male moths.

Jack pine budworm

Jack pine budworm is a native moth whose caterpillar feeds on jack pine. In 2020, roughly 300 acres of moderate to severe damage occurred in Beltrami County. Their populations were very low, as indicated by June surveys in 12 locations in Cass, Crow Wing, Morrison, Pine, and Cook counties. No budworm larvae were found in plots in Cass, Pine, and Cook counties.

Jack pine budworm populations peak every eight to 10 years in north central and northwest Minnesota and about every 24 years in northeast Minnesota. It defoliated over 70,000 acres each year in 2005 and 2006, and the population peak in 2015 affected less than 6,000 acres. We expect a population peak to occur sometime between 2023 and 2025 in north central and northwestern Minnesota.



Beltrami County was the only location with jack pine budworm damage in 2020.

Red pine shoot moth

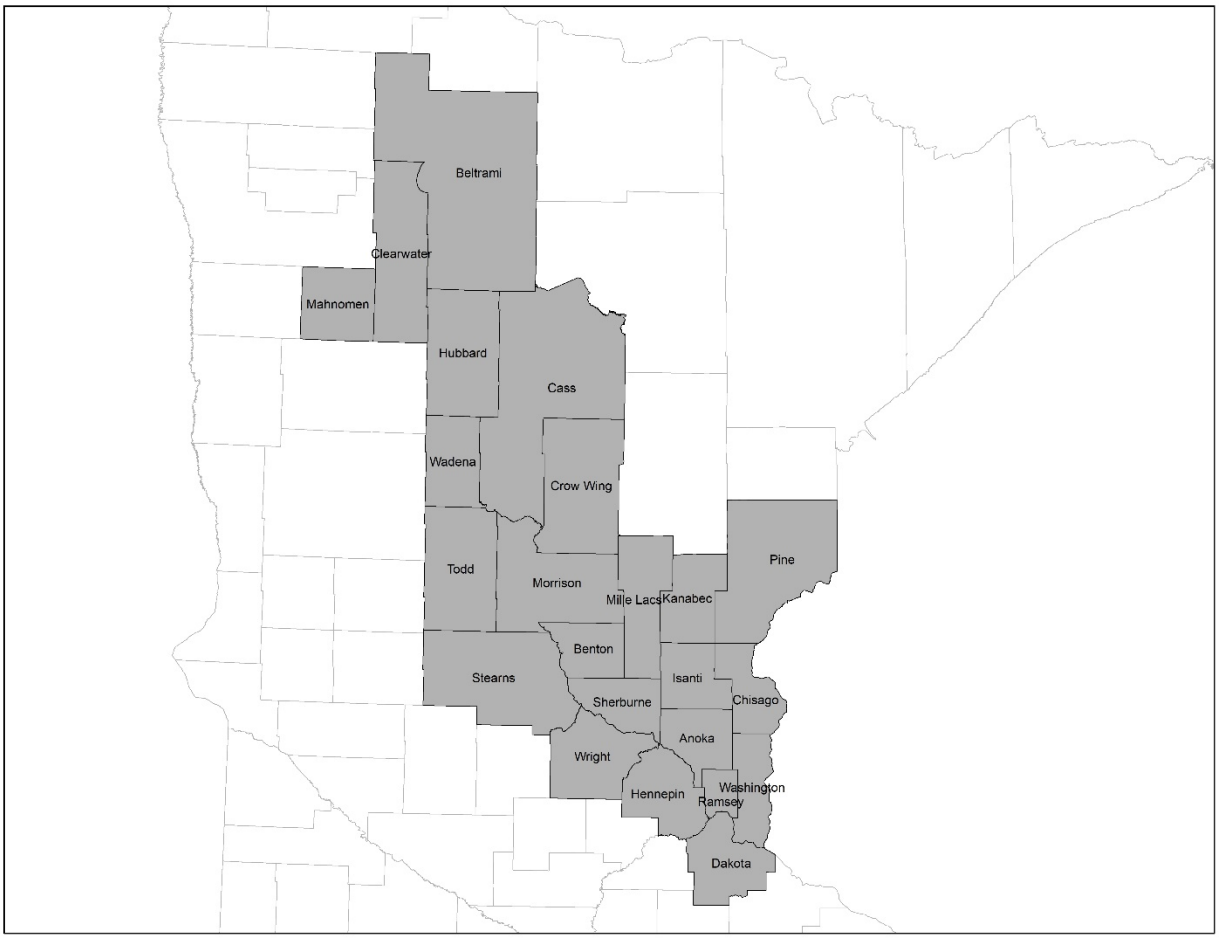
Red pine shoot moth (Pyralidae: *Dioryctria resinosella*) had an extensive outbreak in Minnesota this year. Forest health specialists first noticed dead shoots on red pine in early July, most often along plantation edges or in open-grown stands. We estimate that 25 to 80 percent of the red pine we saw was infested, from Wadena (Wadena Co.) to north of Bemidji (Beltrami Co.), east to Remer (Cass Co.) and Willow River (Pine Co.), to south of the Twin Cities. Caterpillars can only damage this year's shoot growth and can't kill branches, so attacked red pine can easily tolerate this sort of damage for a number of years.

The last time there was a large outbreak of red pine shoot moth in Minnesota was in the late 1990s. We do not anticipate the outbreak will extend more than a few years, as we found evidence of disease and parasitism in many sampled caterpillars.

Dead red pine shoot.

Red pine shoot moth caterpillar.

Parasitized red pine shoot moth caterpillar.



Counties with red pine shoot damage to red pines in 2020.

Spruce budworm

Spruce budworm is a native caterpillar that prefers 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. The Arrowhead Region of Minnesota is unique compared to other parts of North America, as a consistent budworm population has been observed there since 1954. In Minnesota, spruce budworm typically feeds in a given zone for six to eight years, which is about how long balsam fir can withstand defoliation before it dies. The population then moves to a different zone in northeast Minnesota.

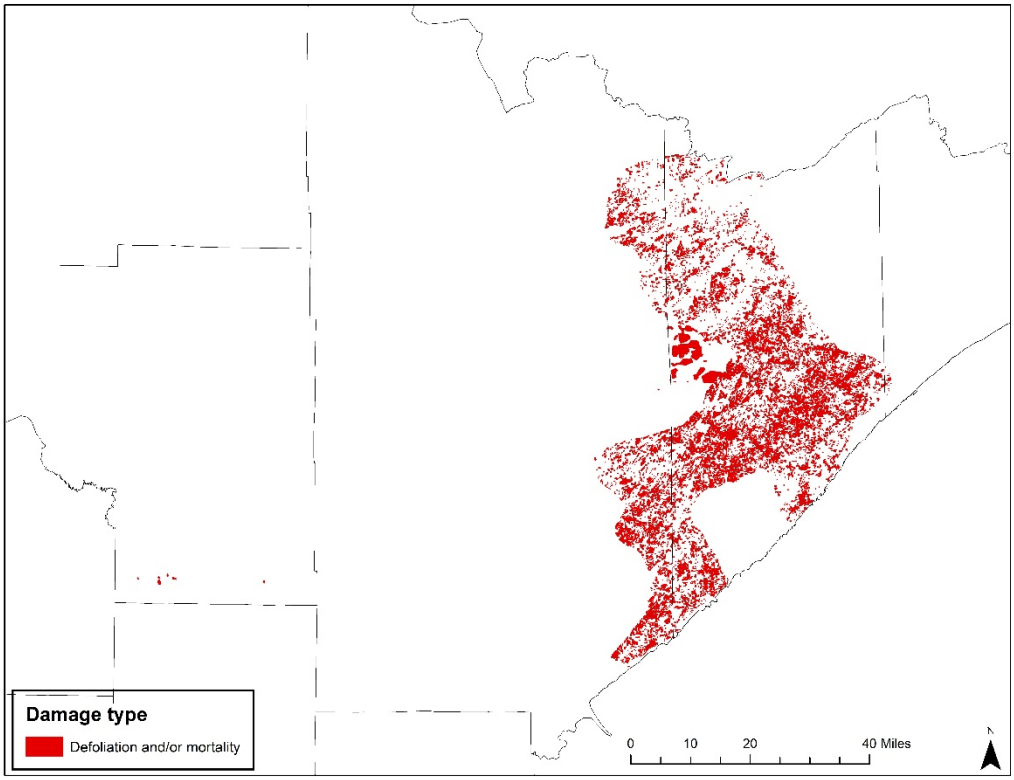
We used ground surveys and a small aerial survey to record 345,997 acres impacted by spruce budworm this year. This is likely an overestimate, as the extent of the area affected was primarily based on 2019 spruce budworm damage, and most of the balsam fir and white spruce (based on modeled white spruce and balsam fir basal area data) was considered infested within this area. The aerial survey mapped part of trailing edge of the infestation in St. Louis and Lake Counties.

Spruce budworm impacted 201,538 acres in 2019, very close to the 196,460 acres mapped in 2018. In 2020, new impacted areas occurred in southern and eastern Lake County into western Cook County. A small outbreak is also occurring in southern Itasca County. The area impacted by spruce budworm since 2010 has averaged about 138,000 acres, including the 2020 estimate.

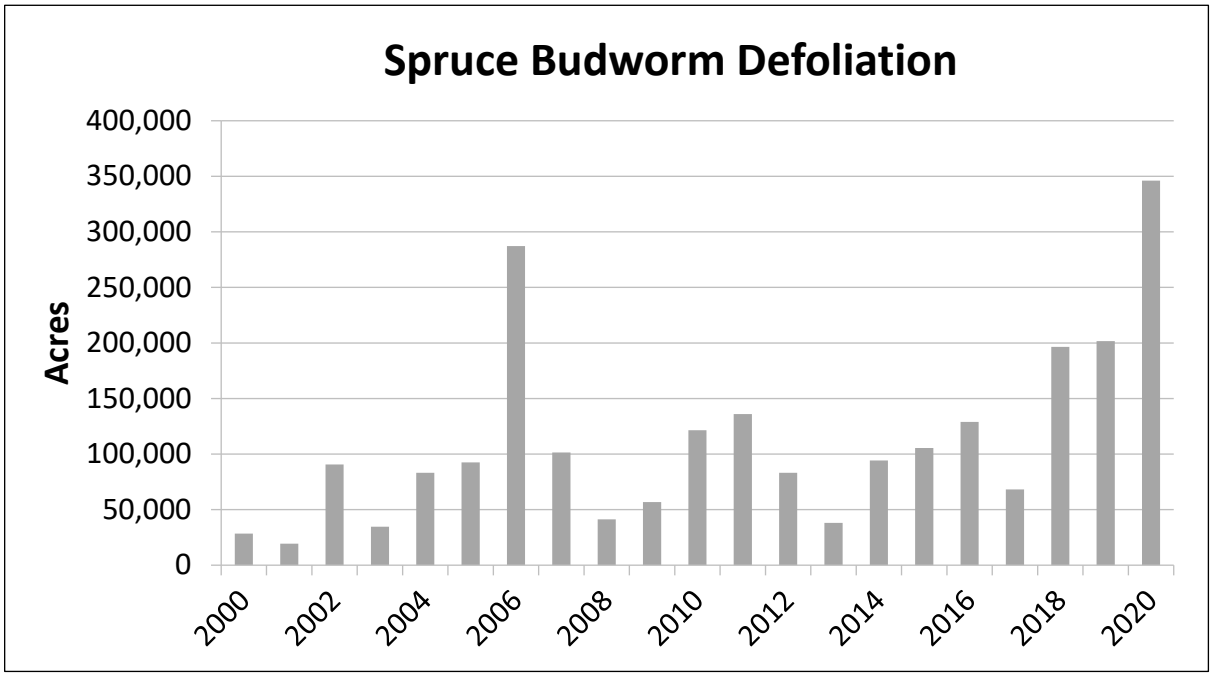
We also conducted egg mass surveys on the leading edge of the main infestation in Lake and Cook counties. Egg masses were found and defoliation observed, confirming that the main outbreak is moving eastward and closer to Lake Superior.

The spruce budworm defoliation and mortality aerial survey data are incorporated into Community Wildfire Protection Plans by St. Louis County, the DNR, and the USDA Forest Service. Since dead standing conifers with needles can increase the risk of quickly spreading wildfires, this is wise community planning.

Spruce budworm caterpillar and webbing on balsam fir.



Spruce budworm defoliation and mortality in 2020.



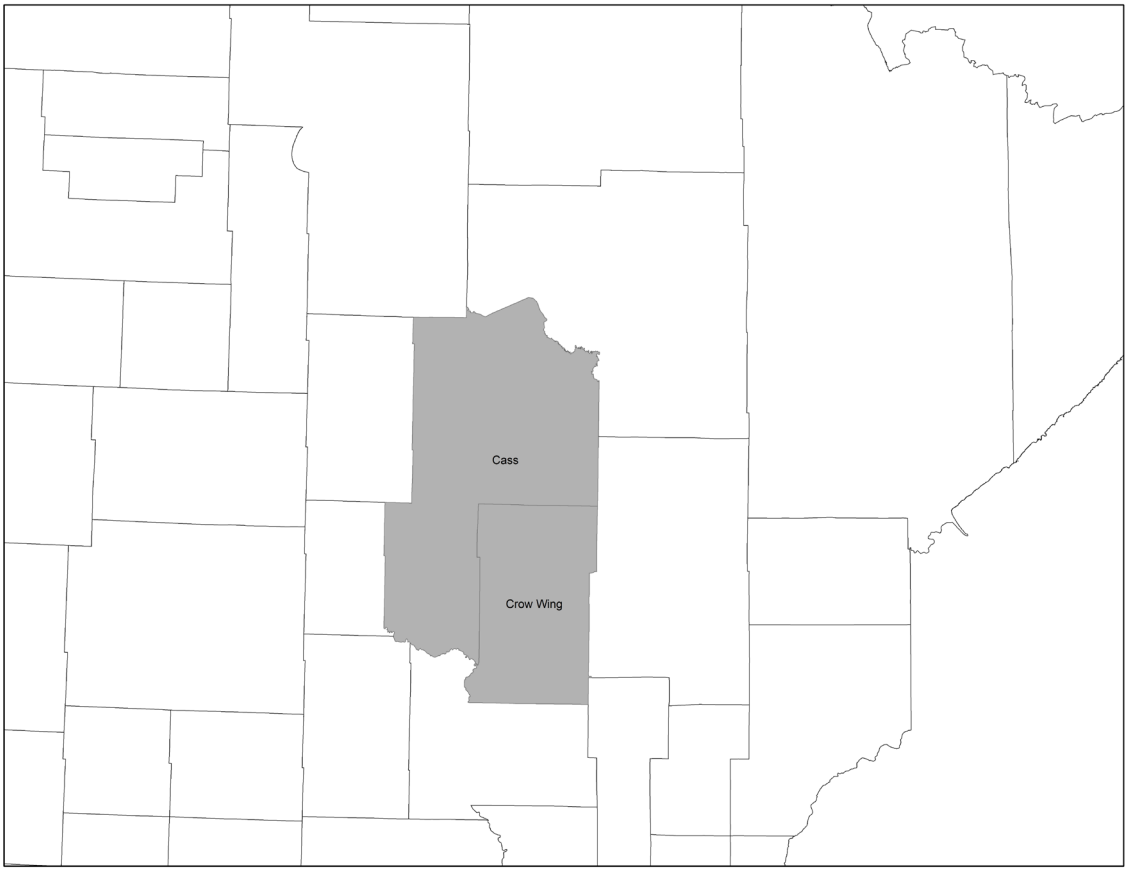
Spruce budworm damage from 2000 to 2020. The 2020 total is an overestimate.

Twolined chestnut borer

Twolined chestnut borer is a native metallic wood-boring beetle that feeds beneath the bark. It commonly attacks oaks stressed and weakened by serious droughts, wind storms, or intense and repeated defoliation events.

There was scattered, minimal damage from twolined chestnut borer this year. In 2019, only 220 acres were impacted, as there was adequate precipitation to keep trees from being stressed. There was also plenty of moisture in most of the state in 2020, but it was a dry growing season in parts of north central Minnesota, including Cass and Crow Wing counties.

Mortality from twolined chestnut borer usually takes two to three years, but death can occur in a single year. Oak wilt can mimic symptoms of twolined chestnut borer, but a distinct difference is that dead leaves stay on the tree on oak trees attacked by twolined chestnut borer, while leaves quickly fall off trees with oak wilt. This is particularly true of red oak.



Counties where dieback and mortality was observed from twolined chestnut borer in 2020. Twolined chestnut borer was not extensively surveyed for, so this is an approximation of counties that had damage.

Walnut defoliation

In early July, DNR foresters reported heavily defoliated walnuts in a small area of Fillmore County. Many caterpillars dangled on silk lines from defoliated branches, and a thick mat of silk covered trees' upper limbs and trunks. Silk was so dense that from a distance the walnuts appeared shrink-wrapped. Butternuts growing adjacent to walnuts were untouched.

A defoliated walnut encased in silk.

By the time forest health staff surveyed the area and collected specimens, feeding had ceased. An entomologist with the Wisconsin Department of Agriculture, Trade, and Consumer Protection identified the caterpillars as *Gretchena amatana* based on a section of its mitochondrial DNA that matched that of a caterpillar collected in Ontario, just outside Detroit, Michigan.

The genus *Gretchena* is in the Tortricidae family of Lepidoptera, which has several caterpillar species known to produce considerable amounts of silk. We are uncertain that caterpillars produced the silk on the defoliated walnuts, but it seems likely, as no mites or bark lice (also known to produce silk webbing) were seen associated with the silk.

Our colleagues in other states in the upper Midwest have not seen defoliation of walnut by *Gretchena* species and associated heavy silk covering trees. Another G*retchena* species, *G. bolliana,* was documented in southern Illinois walnut plantations in a mid-1970s study as being one of the most common defoliators of walnut. This summer, we mapped 30 acres of heavy defoliation, all in Fillmore County. Staff in the Wisconsin DNR documented similar defoliated, silk-covered walnuts in central Wisconsin, and Iowa DNR reported one such walnut in southwest Iowa.

Gretchena species on black walnut.

White pine cone beetle

White pine cone beetle (*Conophthorus coniperda*) infested a notable number of white pine cones this year. There was a heavy white pine cone crop, providing the beetle with ample food. We noted damage in Itasca County, but it is likely present in additional counties.

This native beetle occurs throughout the range of eastern white pine. Attacked small and large cones found on the ground can be brown, dry, hardened, and shriveled. The female beetle bores into a cone at its junction with a twig from early spring to late summer, girdling the connective tissue and killing the cone. The cone eventually falls to the ground with an accumulation of pitch where the initial attack took place at its base. The female beetle creates an egg gallery within the cone and lays eggs along the sides of the gallery. The eggs hatch and larvae feed on cone tissue. Larvae pupate and emerge as adult beetles and remain in the cone to overwinter.

Exit holes are evidence of infestation on a white pine cone.

Willow leaf beetle

For the past two years, foresters have reported leaf beetle damage on lowland and upland willow near Hibbing and elsewhere in northern St. Louis County. Infestations were heavy in July and August this year. The unidentified leaf beetle skeletonized leaves, causing willows to look scorched or dead from a distance. Total browning of leaves in one season is rarely damaging. However, if feeding continues in the next year or two, willow health can deteriorate and in rare circumstances can result in mortality.

Feeding damage on willow leaves associated with a leaf beetle.

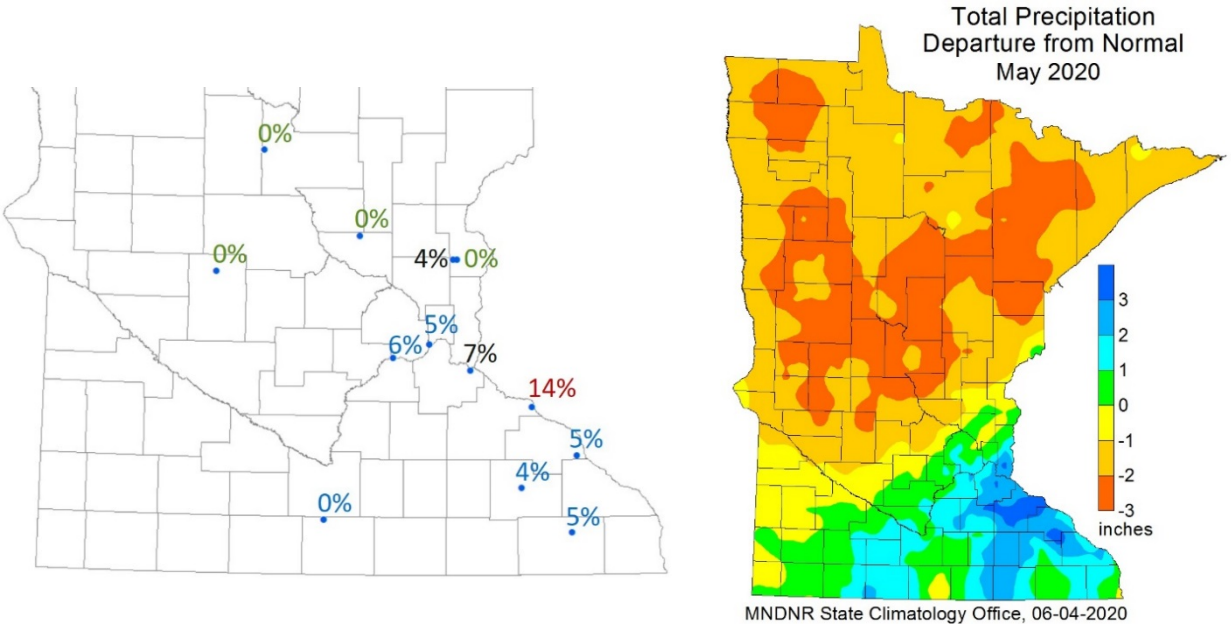
Diseases

Bur oak blight

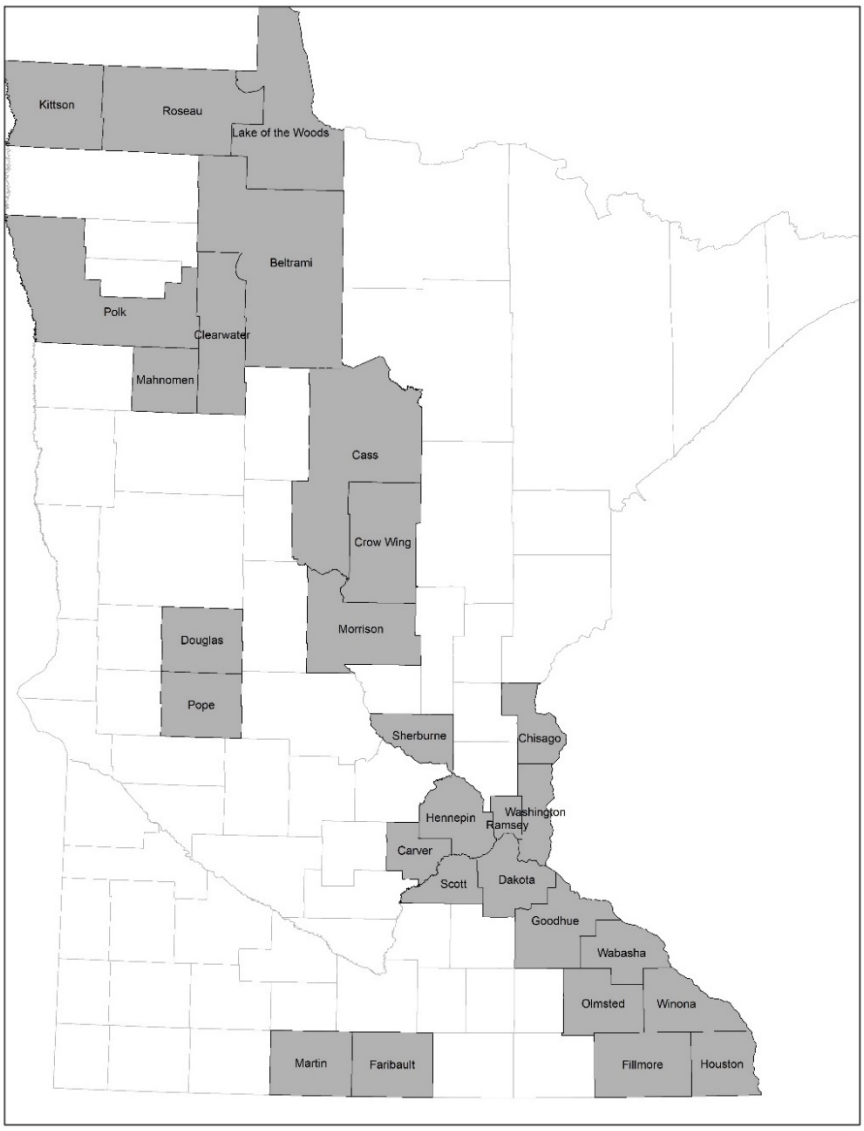
Bur oak blight is a native leaf disease of bur oak that causes leaves to brown (and often prematurely drop) in late summer. Trees almost always recover the following spring. Incidence and severity seem to mirror rainfall patterns during leaf elongation.

The amount of bur oak blight was about the same in 2020 as it was in 2019. Four percent of 595 bur oak trees surveyed across 13 sites were substantially defoliated by bur oak blight by early October 2020 (see survey results in the map at left below).

This year, precipitation in May during leaf elongation was above average in southeast Minnesota and lower in central Minnesota. Bur oak blight intensity matched the rainfall pattern (see map at right below), being more abundant and severe in southeast Minnesota than elsewhere. The upward trend in abundance has generally continued for the past 14 years, promoted by consecutive years of wetter-than-average springs.



Plot locations of bur oak blight surveys and the percent of bur oaks seriously defoliated. In the map at left, green numbers are lower than in 2019, black are the same, red are higher, and blue numbers represent new plots. The map at right shows May 2020 precipitation departure from normal.



Counties known to have either significant bur oak blight by early autumn 2020 or where landowners reported concerns. Not all counties were surveyed, so the map does not represent all counties where bur oak blight occurred.

Caliciopsis canker of white pine found in Sand Dunes State Forest

Brian Schwingle and James Jacobs (USFS) found Caliciopsis canker of white pine this year on the Sand Dunes State Forest. The pathogen that causes the canker is very likely native to Minnesota, but recently there have been more reports of symptoms of this disease throughout the Midwest.

Cankers can form on the branches and main bole of trees of any size, although they are most easily observed on sapling and pole-sized trees and parts of large trees that retain the characteristic smooth bark of young white pine. The often nondescript cankers (Figure 1) can be easily overlooked, and in the Midwest the overall health of the crown is usually unaffected unless trees are stressed by other factors. Occasionally, as in Figure 1, dust and waxy coating on the bark can obscure cankers. Rubbing the bark with a bit of water may make the canker margins more noticeable.

Figure 1. Caliciopsis canker on white pine with characteristic pitching. Image on left before rubbing away waxy coating. Image on right shows more noticeable canker margin after removal of waxes. Images courtesy of James Jacobs, USFS.

There are likely many fungi that can invade damaged bark or cause superficial necrosis on white pine. Confirm that the damage is caused by Caliciopsis species by identifying the fruiting bodies of the fungus (Figure 2).

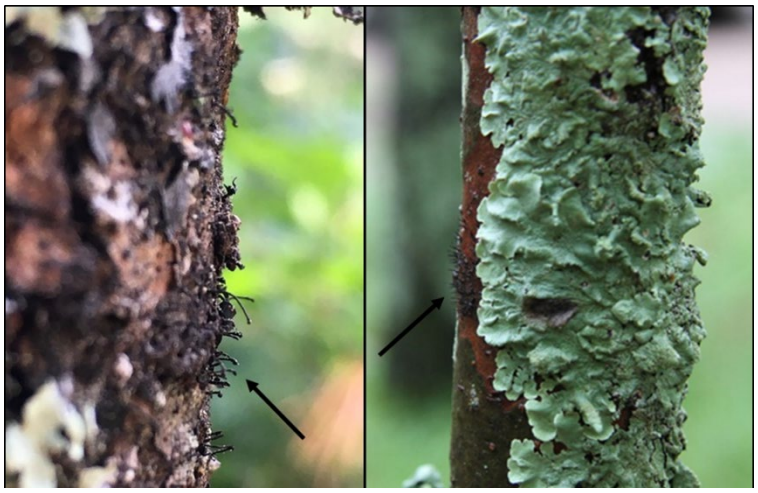


Figure 2. Fruiting bodies of Caliciopsis spp. on cankered white pine. Images courtesy of James Jacobs, USFS.

The fruiting structures have been described as having an “eyelash” appearance, and they persist for long periods of time (unlike a mushroom). Stand off to the side of a canker and look past the tree to observe the fruiting bodies projecting from cankered bark. Fruiting bodies of this fungus are not necessarily present on every canker every year.

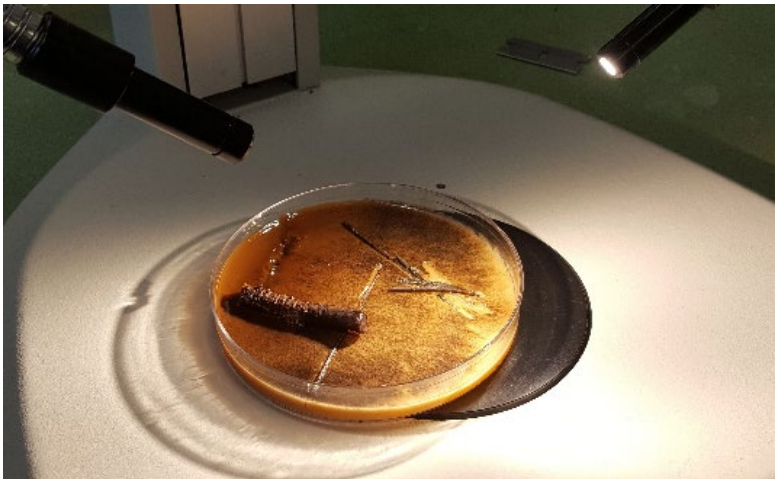
We don’t know the long-term impact of Caliciopsis canker on white pine in Minnesota. Repeated infections can cause defects in sawlogs when old cankers are healed over. Branch death from cankering may decrease live crown ratio and negatively affect the overall health of dominant and codominant white pine. More studies are needed to understand this disease in Minnesota and develop management recommendations. See Figures 3 and 4 for additional symptoms of Caliciopsis canker.

Figure 3. Flagging of small branches caused by Caliciopsis canker on large white pine. Photo courtesy of Linda Williams, WI DNR.

Figure 4. Heavily cankered young white pine in understory likely killed by the multiple infections. Image courtesy of James Jacobs, USFS.

Diplodia assessment on nursery red pine

Diplodia is a fungal pathogen that kills red pine seedlings and causes crown loss and top-kill in stressed mature pines. *Diplodia* can also cause latent, or hidden, infections that do not have visible symptoms until trees become stressed. Forest nurseries test for latent *Diplodia* infections to avoid distributing diseased stock. The Minnesota State Forest Nursery does not sell seedlings when latent *Diplodia* infections exceed 10 percent of the crop. Seedlings at the nursery surpassed this threshold in 2016 and 400,000—500,000 red pine seedlings with possible latent *Diplodia* infections were destroyed.



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

The State Forest Nursery has assessed levels of latent *Diplodia* infections annually since 2016. It was great news when no seedlings tested positive for latent *Diplodia* infections in 2020. This is the fourth consecutive year where latent *Diplodia* infections at the nursery were at acceptable levels.

Heterobasidion root disease

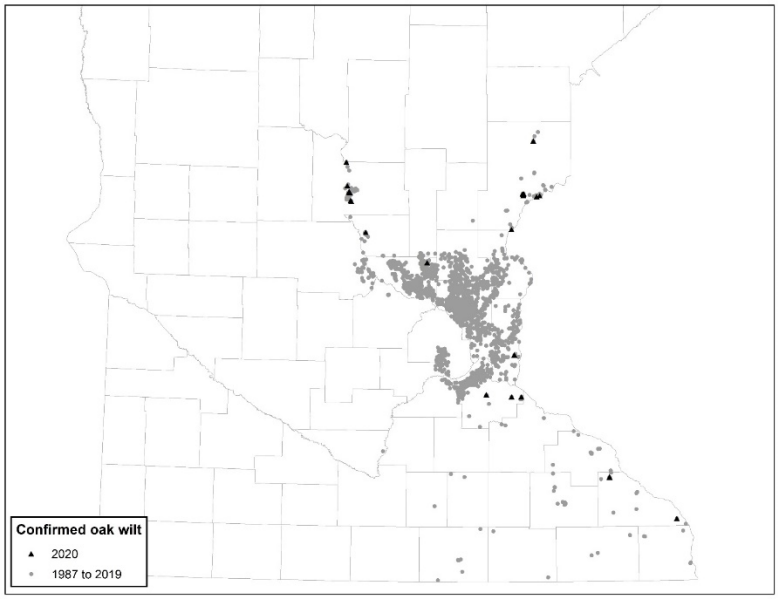
Heterobasidion root disease was previously confirmed at one site in Winona County. We attempted to eradicate Heterobasidion from the site in 2017. The University of Minnesota surveyed the site in 2020 and found no evidence of Heterobasidion. We will continue to survey the site for Heterobasidion fruiting bodies or spore detection in 2021.

In addition to the Winona County site, we surveyed for Heterobasidion in 20 other pine disease centers in Anoka, Beltrami, Itasca, Koochiching, Morrison, Pine, and Sherburne counties. We found no Heterobasidion during any of these investigations.

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 about 50 percent of the state's red oak range and is common in central, east-central and southeast Minnesota.

In order to slow the spread of oak wilt northward into uninfected forests, we prioritize early disease detection, outreach efforts, and management at two strategic locations, the northern three-quarters of Pine County and all of Morrison County.



Confirmed locations of oak wilt between 1987 and 2020.

Early Detection

Since we could not aerially survey in 2020, we used 2019 aerial photographs to look for oak wilt in northern Morrison County. The surveys resulted in an important find: an oak wilt pocket less than one-quarter mile south of the Crow Wing County border. The infection was treated by removing healthy oaks and their stumps surrounding diseased oaks in December.

Management

In Pine County, treatments in St. Croix State Park represent our highest priority control efforts. Since 2017, park staff have found and controlled decreasing numbers of oak wilt pockets: 26 pockets in 2017, 16 in 2018, 16 in 2019, and 11 in 2020.

Morrison County is our second high-priority oak wilt control zone. With help from the DNR forest stewardship cost-share program, the northernmost oak wilt pocket was controlled there in 2020. Also in 2020, Morrison County Soil and Water Conservation District (SWCD) received a $423,000 grant from the Environment and Natural Resources Trust Fund for control on private lands in Morrison County and northward, available starting July 1, 2021.

For several years, staff in the DNR Division of Parks and Trails and the forest health unit have delineated oak wilt in Lake Maria State Park. The park is at the western edge of oak wilt, and represents another strategic spot in which to control the disease. In 2020, park staff controlled 14 of 16 known oak wilt pockets.

Finally, the DNR forest health team received a federal grant in 2020 to control oak wilt on public lands at the leading edge of the disease. This grant, along with the grant to Morrison County SWCD, will greatly aid us in keeping oak wilt from spreading north.

A red oak wilting rapidly from oak wilt.

Outreach

Oak wilt poses a serious threat to natural and urban forests in Crow Wing and Cass Counties. We predict that if oak wilt becomes established in communities there, it would significantly degrade the natural landscape and property values. We are concerned that oak wilt is underreported and easy for citizens to miss until it's too late to manage effectively, so the DNR forest health team and the University of Minnesota Extension (Extension) partnered to increase oak wilt awareness in the cities of Brainerd and Baxter.

An action plan resulted from this partnership. The first goal of the action plan was to develop oak wilt identification and reporting materials for Extension's Invasive Species Citizen Science project, achieved through creation of a webpage instructing citizens on how to identify and report oak wilt (see graphic below).

The second goal of the action plan was to enable homeowners and landowners to report suspected oak wilt to the Early Detection and Distribution Mapping System (EDDMapS) and start thinking about prevention and control. Extension posted this project to Twitter and Facebook and the DNR sent out a press release in July. The Brainerd Dispatch, Bemidji Now and Lakeland PBS TV all covered the project. While the public reported no new oak wilt finds via EDDMapS during the July-August time frame, the local DNR office received more than 20 calls and emails reporting possible oak wilt. DNR Forestry staff confirmed that none of these reports were oak wilt.

Stop Oak Wilt

Do you have property in Cass and Crow Wing counties? Oak wilt, *Bretziella fagacearum*, is an invasive tree disease that's close to entering these counties for the first time. It's easy to prevent, and deadly if left unchecked. Oak wilt can quickly kill oak trees, especially those in the red oak group (oaks with pointed leaf lobes).

Homeowners and Landowners

Simple measures can prevent oak wilt (see video below) and there are control options if it's caught early. But control can be expensive. Look for and report oak wilt in red oak trees on your property or in your neighborhood.

Oak wilt is harder to identify on trees in the white oak group (rounded lobes) and often requires laboratory testing.

Resort and Tourism Operators

Look for and report suspected oak wilt in red oaks on your property to allow quick management to reduce negative impacts.

Oak wilt ID

Check out this Minnesota DNR website to learn how to identify oak wilt. Pay close attention to rapid leaf drop in mid-summer and leaf wilting starting at the top and edges of the tree canopy.

When to report

If you live in Cass or Crow Wing counties, report suspected oak wilt in red oak trees between July 4 and mid-August. Clear photos of the tree, branch and leaves are most helpful.

How to report

1. Great Lakes Early Detection Network (GLEDN) smartphone app
2. EDDMapS online

University of Minnesota Extension website.

Shoot dieback on oaks, including a first report of *Diplodia corticola* in Minnesota

During frost damage surveys this spring, we noted moderate dieback on bur oaks in a savanna at Wild River State Park in eastern Chisago County. In early autumn, we reassessed the bur oaks to better understand the fundamental cause of the dieback.

Shoot blight from *Diplodia corticola* on bur oak in early September in eastern Chisago County.

From a distance, these bur oaks displayed symptoms similar to bur oak blight. However, unlike bur oak blight, diseased leaves and shoots were evenly scattered throughout the canopy, and the outer canopy already showed dieback from prior years.

Disease symptoms were similar to the dieback caused by *Tubakia dryina* we documented on white oaks (*Quercus alba*) in Dakota and Houston counties in 2019, and to dieback caused by *Botryosphaeria* that is common on oaks. To confirm the cause, we submitted samples to the University of Minnesota Plant Disease Clinic.

The most common fungal cultures that grew from the diseased shoots were identified through DNA sequencing of an area in fungal genomes (known as the internal transcribed spacer (ITS) region) that are unique to fungal species. Previously sequenced ITS regions of *Diplodia corticola* matched over 99 percent with the cultures from Chisago County.

As far as we and staff at the Plant Disease Clinic are aware, this is the first documentation of *D. corticola* in Minnesota. Not much is known about this species. It is considered invasive in Europe and possibly an aggressive pathogen in California. It was previously isolated from several oaks in central and southern Wisconsin. Smith and Stanosz (2018) demonstrated it causes rapid dieback on infected bur, northern red, white, and swamp white oak seedlings.

Diplodia corticola is just one of several pathogens that cause dieback on oak. Besides documenting moderate dieback on white oaks caused by *Tubakia dryina* in 2019 and 2020, we also found a *Botryosphaeria* pathogen causing dieback on northern pin oaks in Chisago County in 2020. The bur oak blight pathogen, *Tubakia iowensis*, is known to cause minor dieback, too. This year we determined that white oaks recovered somewhat from moderate dieback caused

by *Tubakia dryina* in 2019 (see image below). We suspect healthy oaks can recover from other shoot blight diseases as well.

Works cited

Smith DR, Stanosz GR. 2018. Occurrence of *Diplodia corticola*, including new oak host records, in Wisconsin, USA. Forest Pathology 2018; e12427. Forest Pathology .

White oak with shoot blight from *Tubakia dryina* in autumn 2019 (left) and 2020 (right).

Declines and Abiotic Problems

Bark splitting on northern white cedars in southern Minnesota

Some white cedars (*Thuja* species) planted in wind rows died suddenly in scattered areas of Stearns, Steele, and Rice counties in the southern half of Minnesota this year. We investigated some affected properties and noted that bark splits were surrounded by healthy callus tissue and wound-wood free of disease or insect damage (see images below). The healthy wound-wood was about two years of growth, suggesting the cause of damage occurred in 2018 and was environmental.

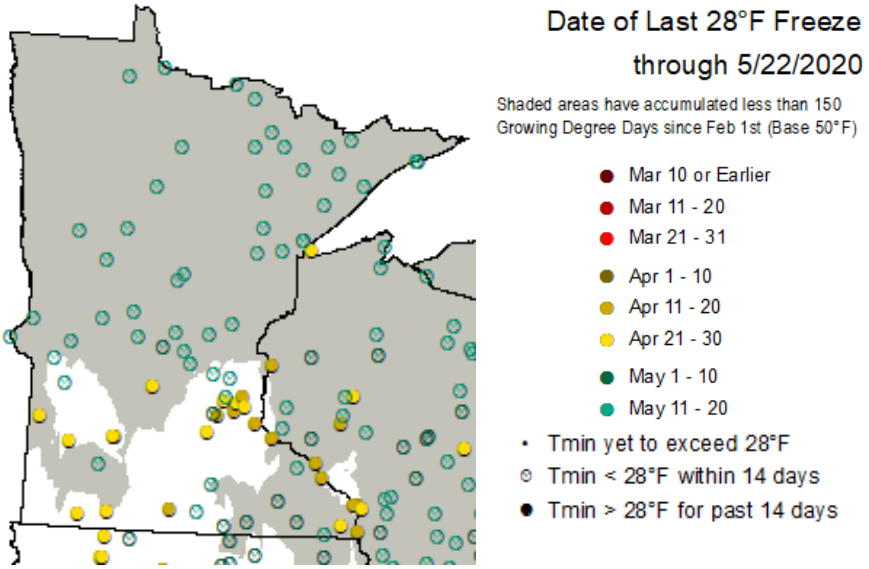
We looked back at previous weather records and found that in 2018, April was substantially colder than normal, while May was warmer than average. Drastic temperature fluctuation is known to split bark in some thin-barked species. According to the Minnesota DNR Climate Trends Tool, April 2018 was the coldest April on record for Rice, Stearns, and Steele counties, while May 2018 was the 3rd or 4th warmest on record. Bark splitting can also be caused by unusually high temperatures in late fall coupled with high nitrogen levels and drastic swings in precipitation, none of which occurred in 2018 in the affected areas. The spring temperature swing likely caused the bark splits. Seed source is another possible reason for the splitting.

Bark split on white cedar. Photo from Steele County Soil and Water Conservation District.

Bark peeled around split showing no disease or infestation. Photo from Steele County Soil and Water Conservation District.

Frost damage to oaks

Late spring freezes frequently kill oak leaves--especially red oak leaves-- emerging in early May. The damage doesn't seem to hurt trees over the long-term since it happens frequently, and individual trees reliably re-leaf one to two weeks after the freezing temperatures. This year, damaging temperatures of 28°F and lower were reported on May 12 and May 13 in many locations, killing new oak leaves. One weather station in the city of Mabel in Fillmore County (near the Iowa border) recorded 21°F on May 12. The last time May frost damage seemed this widespread in central and southern Minnesota was in 2016. Frost damage was particularly severe in southeast Minnesota on the lower parts of hills.



Damaged oaks had already started growing new leaves around May 20 in Goodhue County. Since cold air sinks, oaks in low-lying areas and leaves in the lower canopies are more severely damaged from frost.

Frost damage to oaks can be seen along the lower half of hills.

Oaks declining from variable growing season precipitation

DNR foresters and the forest health team fielded many calls this summer from concerned landowners in northwestern, central, and southern Minnesota reporting dieback and mortality of their oaks.

This is not new, as we have been investigating areas experiencing abundant mortality or dieback of bur and red oak for several years. This year, some of the reported dieback happened rapidly. On most sites, though, decline in the health of these trees started before 2020. We refer to all of this death as "decline."

We use decline to describe progressive dieback and eventual death of oak trees from multiple factors over several years. Decline commonly starts with stunted leaves and proceeds with epicormic shoots, dieback, and sudden death. Decline occurs when multiple factors such as severe drought, excess rainfall, soil compaction, tree age, and pest and disease issues interact to stress or kill trees. A common instance of decline we have seen in central and southern Minnesota is older oaks dying along wetland edges. Abundant precipitation over many years flooded their roots, eventually killing the trees. In almost all cases of decline, twolined chestnut borer and Armillaria root disease infest and kill the stressed oaks.

To illustrate further, we documented large areas of bur and red oak death in central and south-central Minnesota starting in 2015. Much of this was due to the following:

- drought late in the 2011 growing season, one of the top 10 driest in central and south-central Minnesota
- flooding early in the 2012 growing season, one of the top 10 wettest in east-central and central Minnesota
- drought late in the 2012 growing season, one of the top 10 driest in east-central, central, north-central, and south-central Minnesota
- Armillaria and twolined chestnut borer attacks on extremely stressed oaks

Drastic swings in precipitation damage roots, which can kill an oak outright or make it susceptible to diseases and pests over the following decade while it attempts to regrow its roots. Oak mortality in 2020 in north-central Minnesota was due in part to the extremely dry growing season in early 2017, the seventh driest on record. In contrast, mortality in 2020 in south-central Minnesota was partly due to extremely wet growing seasons since 2016, three of the wettest from May through October.

As Minnesota continues to experience record-setting weather, we expect to see periods of tree decline. Fortunately, the current and future climate of Minnesota is a good one for oaks, so even though we predict more decline, we also suggest that oaks are one of the best species to plant on upland sites in most of Minnesota.

Wind

DNR Forestry staff observed a small amount of scattered wind damage in 2020 in Chisago, Lake of the Woods, Morrison, and Otter Tail counties. (Several other tree damage reports from tornados were documented in the National Weather Service Damage Assessment Toolkit found on ArcGIS online.) We partnered with a student at the University of Wisconsin-Madison to assess damage from two tornados in Chisago and Morrison Counties. From ground-truthing and satellite change detection data before and after the tornados, we found that they damaged at least 697 acres of forest.

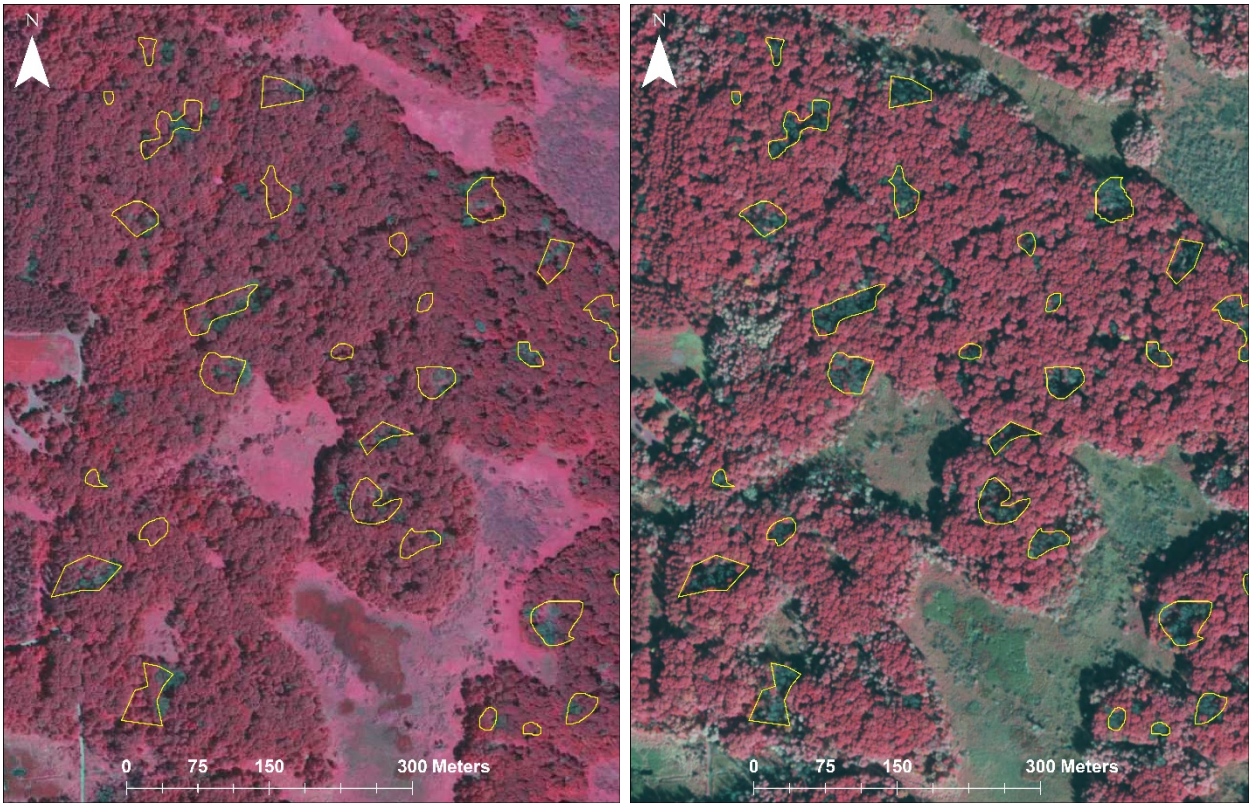
Other tree pest and tree health events noted in 2019 and 2020

Pest or event	Pest stage or cause	2019 (county in which observed)	2020 (county in which observed)
Sudden ash leaflet drop	Anthracnose	May 29 (Dakota) June 2 (Dodge) June 5 (Isanti)	May 23 (Goodhue, Rice, Sherburne)
Deformed leaves on oak	Anthracnose	May 31 (Dakota) June 7 (Pine) June 10 (Kanabec)	June 5 (Rice) June 6 (Chisago)
Dieback on walnut	Winter cold temperatures	June 11 (Houston) July 3 (Olmsted)	Not observed
Eastern tent caterpillar	Caterpillars, 0-0.5 inches long	Not recorded	May 6 (Goodhue)
European pine or red pine sawfly on jack pine	Caterpillars, 0.5-1 inch long	Not observed	June 10 (Cass, Crow Wing, Morrison) June 17 (Pine)
Fall webworm nests	Caterpillars	Observed in various areas in southern Minnesota (more than in 2018)	Observed in various areas in southern Minnesota (more than in 2019)
Forest tent caterpillar	Caterpillars, 1-1.5 inches long	Not recorded	June 5 (Morrison) June 11 (Mille Lacs)
Ips bark beetle	Emerging adult egg-laying	May 17 (Sherburne)	Not recorded
Japanese beetle	Adults active	July 1 (Ramsey)	Not recorded
Larch casebearer	Larvae starting to feed	May 28 (Chisago)	Not recorded
Oak wilt	Spore mats	May 28 (Chisago)	Not recorded
Oak wilt	Wilting noted for the first time	June 21 (Chisago)	June 16 (Chisago)
Oak leaf skeletonizing	Oak slug sawfly	July 3 (Freeborn) July 9 (Isanti)	Not observed
Premature acorn drop	Bur oaks: unknown Red oaks: pip gall wasp	July 12 (Hennepin) Summer (Blue Earth, Crow Wing, Nicollet, Pine)	Not observed
Rust on glossy buckthorn leaves and fruit	*Puccinia* species	June 21 (Chisago) July 9 (Isanti)	Not observed

Image Analysis Homes in on Oak Wilt Pockets

Due to the COVID-19 pandemic and social distancing restrictions in 2020, aerial detection surveys for oak wilt were not conducted. We were interested in knowing the current locations of oak wilt in Minnesota, so the DNR Resource Assessment and Forest Health Units conducted a desktop survey using color infrared images from the 2019 National Agriculture Imagery Program (NAIP). Through past efforts we have found that experienced aerial forest image interpreters using color infrared imagery can successfully identify older oak wilt pockets on flat terrain where oaks make up the majority of the forest (2016 Forest Health Annual Report).

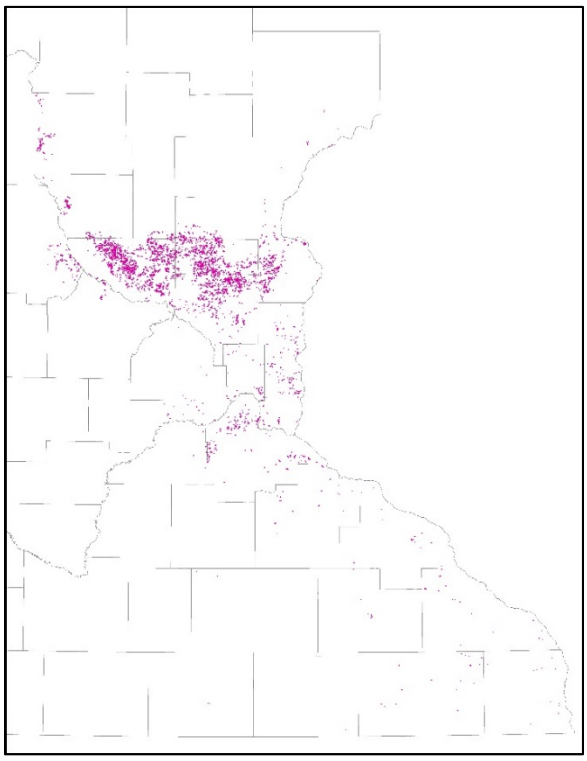
Oak wilt produces pockets of dead oaks that expand from year to year, creating a distinct signature in photographs of progressively expanding oak mortality (see photos below). NAIP imagery from 2019 was useful in identifying dying oaks surrounding previously killed oaks. Imagery from 2008, 2015, and 2017 confirmed outward disease progression from a central dead oak or oaks. Known locations of oak wilt also aided us in mapping oak wilt.



Color infrared photographs of a Benton County forest in 2017 (left) and 2019 (right) showing progressive expansion of oak wilt mortality centers, outlined in yellow.

Staff searched more than 4.3 million acres of imagery to identify visible damage from oak wilt, and nearly 11,600 oak wilt pockets were outlined using ArcMap software.

Oak wilt pocket size ranged from nearly nine acres to less than 1/100 acre, averaging almost 1/5 acre. Most of the damage was in Sherburne, Anoka, and Isanti counties in the Anoka Sand Plain, illustrated on the map above.



Pink areas are mapped oaks killed from oak wilt based on 2019 photographs.

To put the number of oak wilt pockets into context, between 1987 and 2020 we recorded about 9,700 pockets, mainly through reports to communities and the DNR – yet another method of tracking oak wilt. When we compare the results from mapping oak wilt on NAIP imagery to traditional aerial survey, mapping on imagery results in detecting 11 times more oak wilt pockets – clearly a more thorough mapping technique.

Yet the 11,600 pockets of oak wilt statewide is still likely an underestimate, since:

- imagery can only be reliably used to map older oak wilt pockets.
- oak wilt in diverse forests is more difficult to detect.
- oak wilt on hillsides and valleys is more difficult to see because of shadows created by the topography.
- some areas of the state were photographed in late autumn, when leaf color change makes oak wilt identification impossible.

- oaks killed by oak wilt around homes and communities are frequently removed, thus undetectable.
- vegetation continues to grow in the middle of oak wilt pockets, making imagery detection challenging for older, larger pockets.

This mapping effort updates the locations of mostly unmanaged oak wilt in Minnesota. We now have a good idea of how much oak wilt is unmanaged and slowly eating away at mature oak forests. In many cases, maple and buckthorn are taking over canopy openings created by oak wilt, diminishing the positive long-term benefits that mature oak forests provide.

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