2018

Forest Health Annual Report

DEPARTMENT OF NATURAL RESOURCES

June 2019

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

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

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Cover photo: Declining hardwood forest, Nerstrand State Park. Different tree species in varying stages of decline from flooding at Nerstrand State Park; flood-tolerant elms and ashes are holding on.

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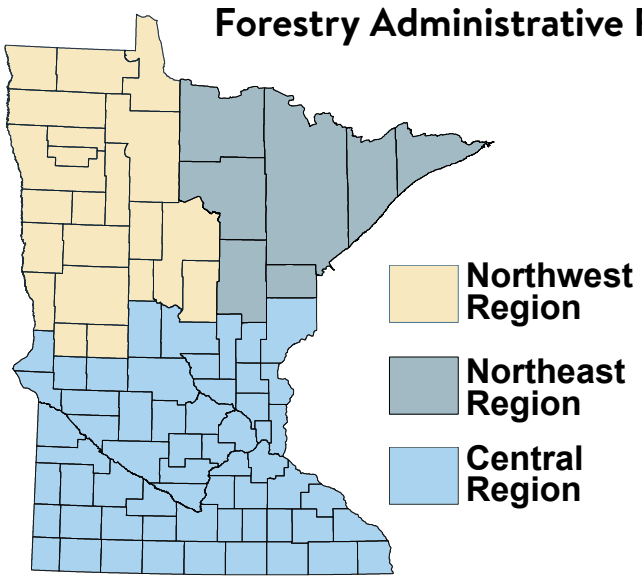
MINNESOTA DEPARTMENT OF NATURAL RESOURCES, DIVISION OF FORESTRY, FOREST HEALTH STAFF



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Forest health program staffing changes

2018 was a year of transition for the forest health program. We started out fully-staffed, then in June lost the northeast region Forest Health Specialist, Jess Hartshorn, to a position at Clemson University, promptly followed in July by northwest region Forest Health Specialist Mike Parisio, who took a position with the Vermont Department of Forests, Parks, and Recreation. That left Brian Schwingle, the central region Forest Health Specialist, to cover the work of three, and Val Cervenka, Forest Health Program Consultant, to encourage and support Brian! Our perseverance and patience paid off with the addition of a new forest health specialist position in Brainerd. All three regional positions were filled at the end of 2018.

ANNUAL AERIAL SURVEY OF FOREST CANOPY

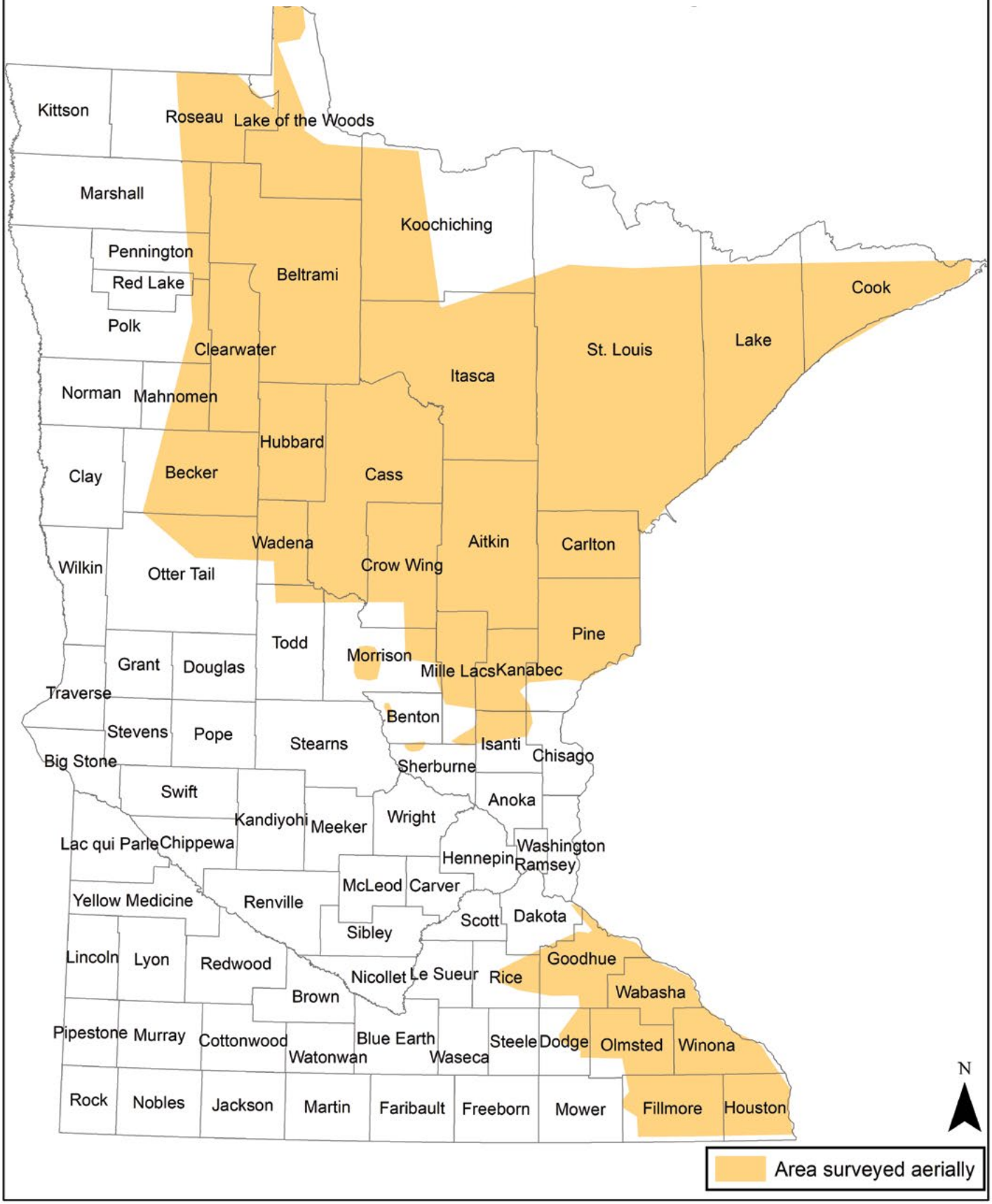
Since the early 1950s, the Minnesota Department of Natural Resources (DNR) aerial survey has been a valuable tool for monitoring forest canopy health across 13 million acres of forest land. The main problems consistently recorded with surveys are large insect outbreaks, wind events, and fire damage. Other recorded problems, such as forest damage from floods or tree-boring insects, do not always coincide with survey timing or they occur in areas that typically are not surveyed (e.g., in southwest Minnesota along the Minnesota River), so their impact is often underestimated. Finally, problems such as root diseases, wilts, and black ash decline 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 Northeastern Area State and Private Forestry (USFS). Survey results can be found in the Minnesota Geospatial Commons (keywords "forest health") located at **https://gisdata.mn.gov/**. The summary table below shows the amount of acres damaged by insects, disease, and other factors as seen in aerial surveys.

Table: Comparison of Aerial Survey Results From 2016 to 2018

Damage agent	Acres affected in 2016	Acres affected in 2017	Acres affected in 2018	Comments
Spruce budworm	128,886	68,213	196,460	2018 had the highest total in eight years for spruce budworm.
Eastern larch beetle	67,983	211,131	180,825	2018 was the 17th straight year of a continuous outbreak, having the second-highest amount of affected acres.
Forest tent caterpillar	14,798	40,433	28,078	The 2016 value is an underestimate due to weather delays postponing surveys.
Aspen and birch decline	15,052	19,054	18,378	
Larch casebearer	15,286	21,938	15,817	The 2018 figure is an underestimate; we were unable to separate damage from arborvitae leafminer and larch casebearer on 13,684 acres.
Flooding	5,692	6,427	5,121	
Arborvitae leafminer	0	11,752	3,977	The 2018 figure is an underestimate; see larch casebearer.
Wind damage	18,953	6,037	3,630	
Emerald ash borer	3,686	Not surveyed	1,881	Only affected forests in southeast Minnesota were surveyed in 2016 and 2018.
Twolined chestnut borer	607	2,845	1,011	
Wildfire	1,557	333	554	
Bark beetles on pine, spruce, and fir	100	1,803	375	
Jack pine budworm	2,392	4,275	193	The 2016 value is likely an underestimate due to storm interference with aerial survey.
Hail	454	3,479	0	
Northern hardwood decline	1,657	15	0	

Map of Forested Areas Surveyed Aerially in 2018



The 2018 aerial survey covered most of northern Minnesota and counties along the southeastern edge of the state.

FOREST PEST CONDITIONS REPORT

The Forest Pest Conditions report contains pest information from a national list of the major forest insects and diseases that occur within the state and any other pests that cause recordable host damage during the year. Data collected in the aerial survey is entered into the federal Pest Event Report database that is used to produce the national *Forest Insect and Disease Conditions* report (**https://www.fs.fed.us/foresthealth/management/fhm-conditions.shtml**).

INSECTS

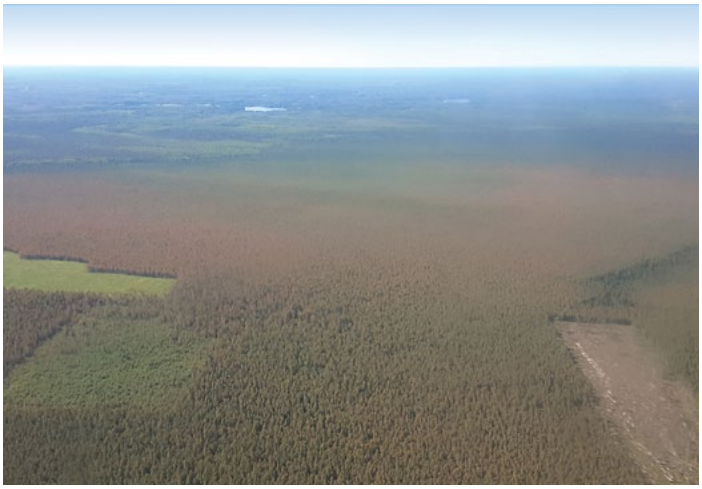
Arborvitae leafminer

Thanks to the University of Minnesota Plant Disease Clinic and several Minnesota DNR foresters in northeastern Minnesota, we were able to confirm that a native arborvitae leafminer *(Argyresthia thuiella)* infested thousands of acres of northern white cedar in 2017 and 2018 (illustrated in the aerial photo). We first became aware of this infestation during our 2017 aerial survey, but because of difficulty in accessing cedar swamps, we were not confident in the cause until later in 2018.

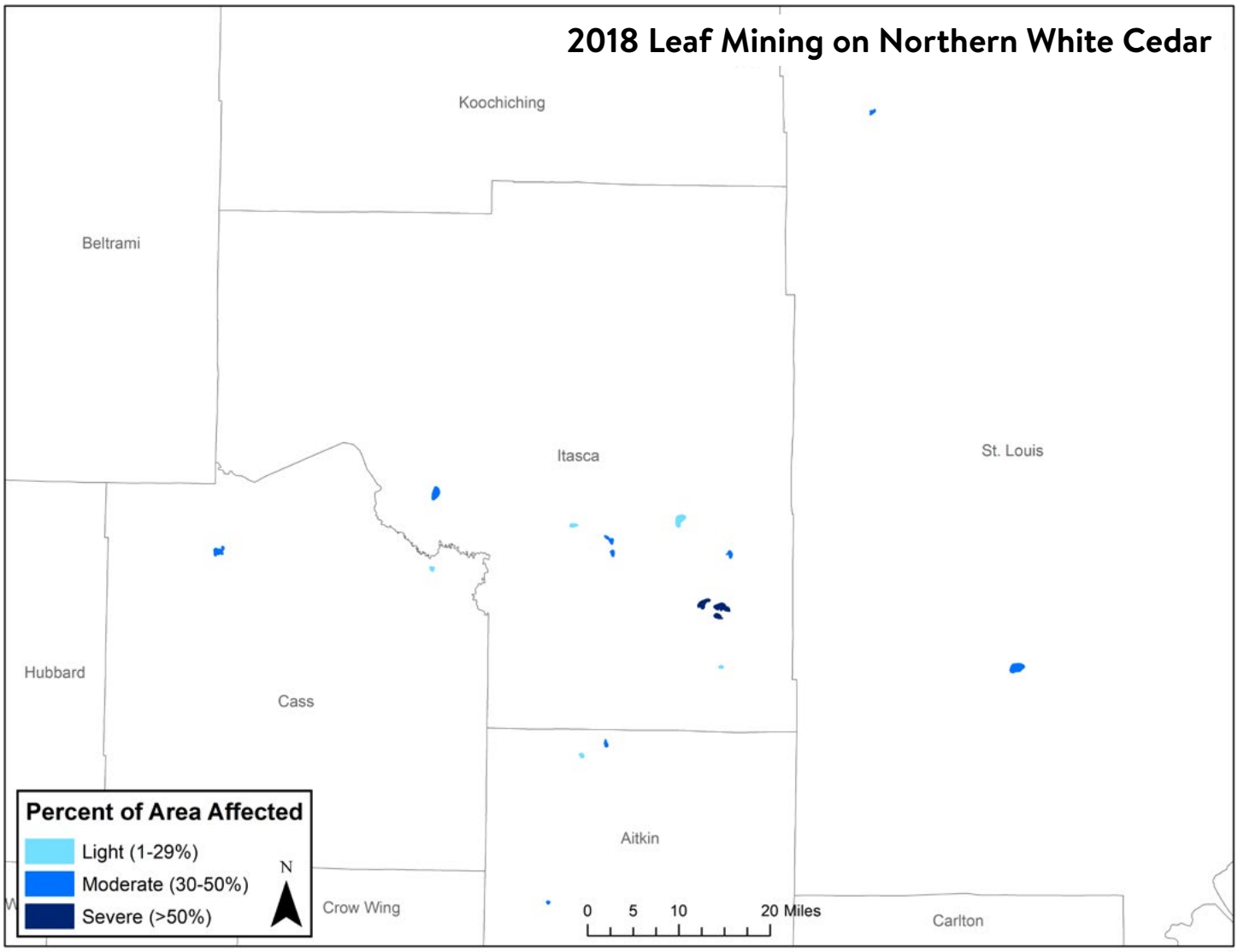
We mapped about 4,000 acres of leafminer damage to northern white cedar in 2018, although this is certainly an underestimate. We mapped an additional 13,700 acres of defoliation or discoloration on unidentified conifers. Swamp conifer species dominated almost all of these areas, so at least some, if not most of this damage was from arborvitae leafminer. All acres considered, arborvitae leafminer impact in 2018 was probably similar to that mapped in 2017 (we mapped about 11,800 acres of damage in 2017).

Most of the defoliated white cedar was in northeastern Minnesota. Fortunately, the leaf feeding was apparently minor in 2018. We will be monitoring this pest's activity in the coming years, and we predict natural enemies will reduce populations. While locations in Maine and Quebec have seen significant arborvitae leafminer damage, Minnesota, Ontario, and Manitoba have not.

Exit hole and damage to white cedar needles from an arborvitae leafminer larva.



Arborvitae leafminer feeding damage seen in aerial survey.



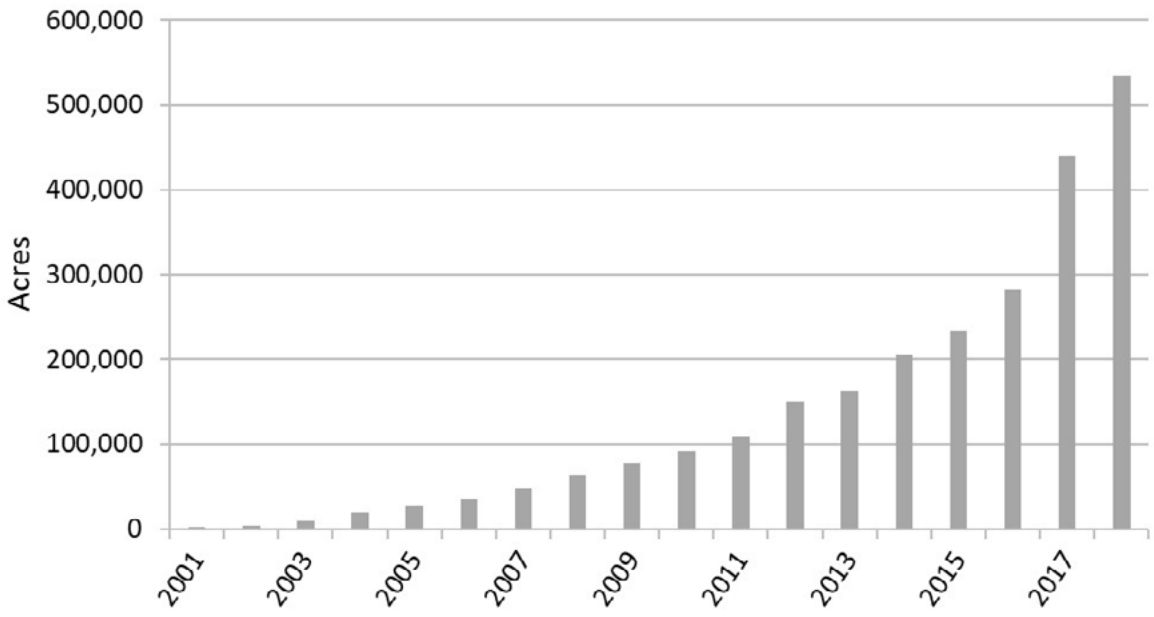
Aerial surveyors detected severe damage in a few isolated areas in southeastern Itasca County and isolated moderate damage in St. Louis, Cass, and Aitkin counties.

Eastern larch beetle

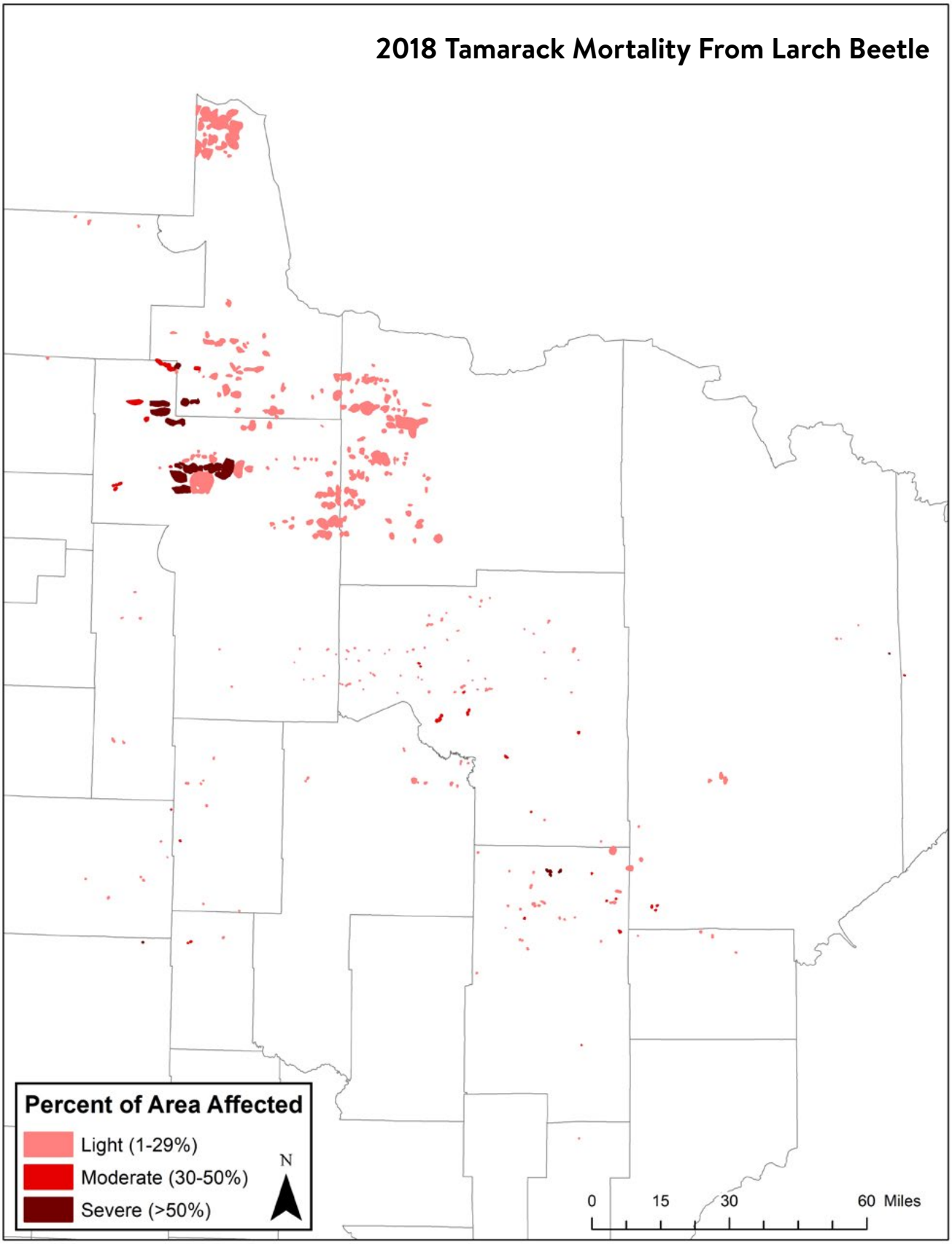
Eastern larch beetle is a native bark beetle that attacks tamarack, and 2018 represented the 17th consecutive year of damaging larch beetle populations. We found 180,820 acres (283 square miles) affected by eastern larch beetle in 2018. Though this is a 15 percent decrease in area impacted by eastern larch beetle from the previous year, it is too early to say that this is a trend, and there have been other, proportionately larger, decreases in area impacted over the course of the outbreak. Since the beginning of the larch beetle outbreak in 2001, about 534,910 acres (836 square miles) have been impacted, which is 45 percent of the tamarack covertype in the state.

Eastern larch beetle tunneling, or galleries, in a dead tamarack.

Accumulated Acreage Affected by Eastern Larch Beetle



Since 2001, tamarack damaged by eastern larch beetle has increased from 1,200 acres to a total of more than 530,000 acres in 2018.



Aerial surveyors mapped more than 180,000 acres of larch beetle damage in 2018. The heaviest damage was in northern Beltrami county, with scattered light to moderate damage in the north-central counties.

Emerald ash borer

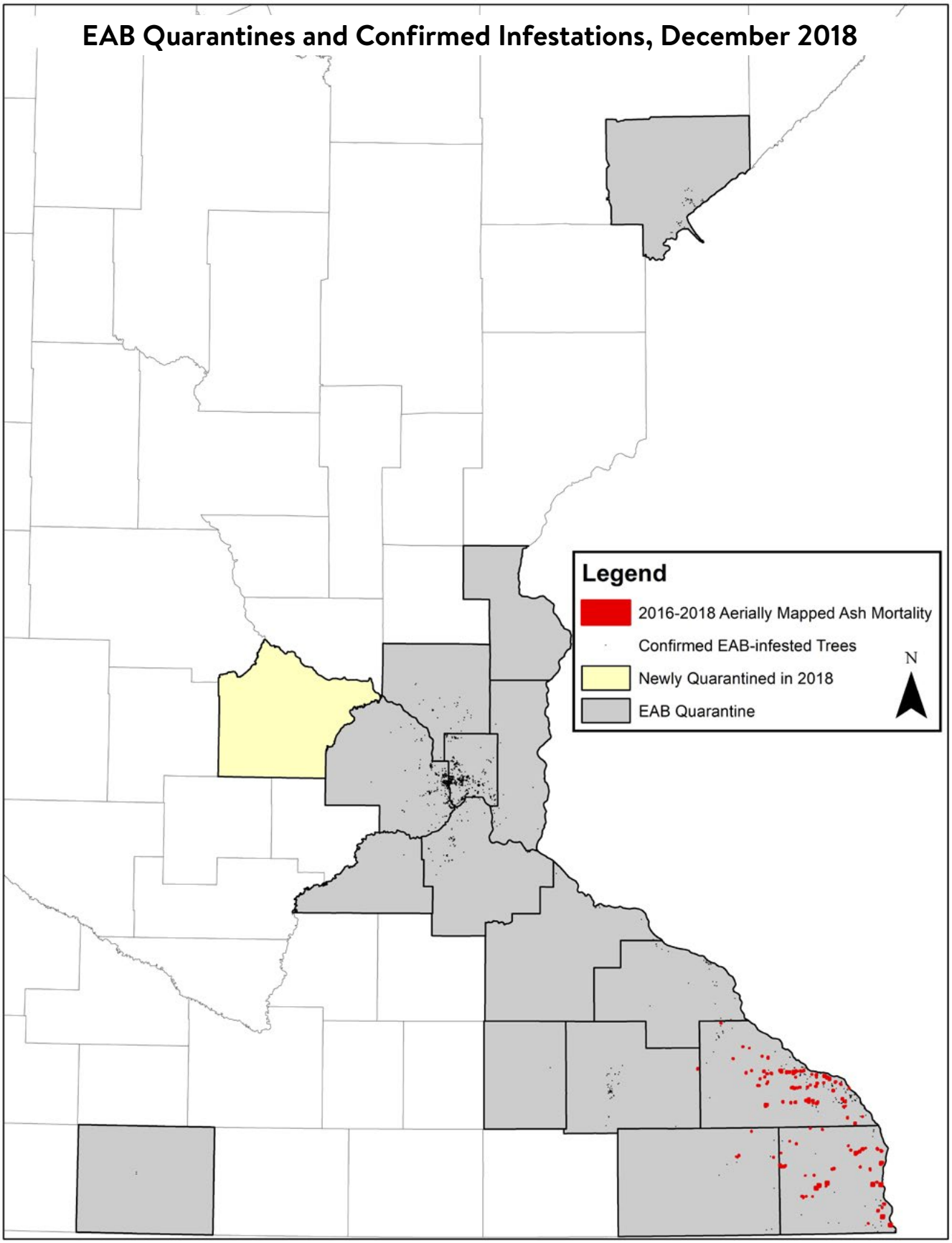
The Minnesota Department of Agriculture (MDA) continues to be the lead agency for the Minnesota emerald ash borer program (**https://www.mda.state.mn.us/eab**) in general. USDA Animal and Plant Health Inspection Service deploys sticky panel traps around the state.

Emerald ash borer was discovered in St. Paul in 2009. By the beginning of 2018, EAB had spread to 16 counties. In September, EAB was found in several infested ash around the junction of Interstate 94 and State Highway 24 in Clearwater, Wright County. This new find in Wright County is about 35 miles from the closest confirmed EAB infestations in Anoka and Hennepin counties.

We conducted an aerial survey of ash in southeast Minnesota, and mapped 1,950 acres of forests with ash dying due to EAB infestation. This is a smaller area than the 3,890 acres mapped in 2016, but mapping efforts in 2016 were focused on establishing a baseline of dead and dying ash on the landscape, and mapping in 2018 delineated new death and dieback. The area that was severely impacted by EAB in southeast Minnesota was seven times greater in 2018 than in 2016.

Since we began aerially surveying EAB, we have documented 5,630 impacted acres. This is a large underestimate of the area infested by EAB since we do not fly in the Minneapolis–St. Paul airport airspace and since EAB symptoms do not appear widespread in the landscape until at least six years after infestation. By combining our aerial survey data with the Minnesota Department of Agriculture's infested tree data and by buffering individual infestations by a half-mile, we estimate that at least 208,000 acres (325 square miles) are infested with EAB. Almost all of this acreage is urban forest or a mix of rural farmland and oak-dominated forest.

Tops of dead ash trees are visible above healthy trees of other species.



Most of the counties quarantined for EAB are along the southeastern border of Minnesota, with the exceptions of Martin Co. and part of St. Louis Co. Aerial surveyors mapped 5,630 acres of dead ash in Winona and Houston counties.

Forest tent caterpillar

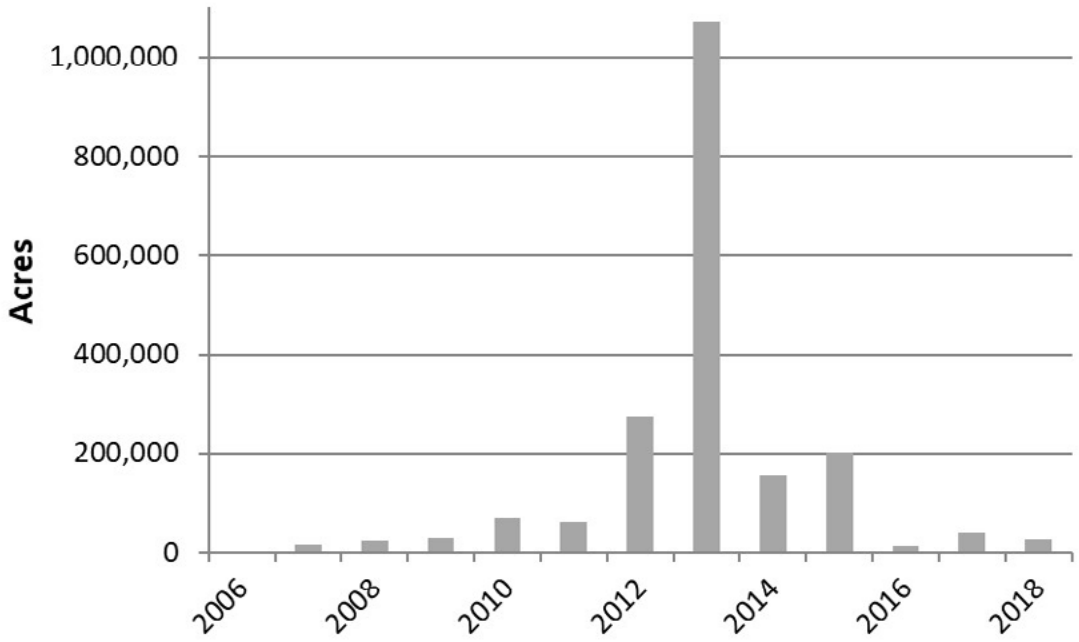
Forest tent caterpillar is a native insect that feeds mostly on aspen, oak, birch, and basswood. We mapped only 28,080 acres of defoliation this year, which were widely distributed across northern Minnesota from Mahnomen and Becker counties to Carlton and Lake counties. Only four areas had more than 100 acres of defoliation that affected most trees, and those areas were in eastern Lake County and in one spot in the middle of Itasca County.

Forest tent caterpillar populations fluctuate over time, with peaks occurring every 10–16 years. If we assume that the peak in defoliation in 2013 was a true population peak, then we would expect to see populations start to increase again in 2019 or 2020, peaking sometime between 2023 and 2029.

We assess damage to forests mainly from aircraft, and our accuracy is greatly affected by weather conditions and the distance we are covering visually from the air. Changes in aerial survey protocol and technology also makes long-term analysis challenging. From 2004 to 2016, our surveyors recorded trace, or very light levels of defoliation that likely had minimal impact to tree health. In compiling data for the chart below, we included trace levels of defoliation (we did not include them in the 2016 and 2017 annual reports). Ninety-seven percent of the defoliation in 2013 was at these very light levels of defoliation, indicating that the impact to forests was negligible.

Forest tent caterpillars congregating on tree trunk.

Forest Tent Caterpillar Defoliation



Annual forest tent caterpillar damage from 2006 to 2018 mostly kept to below 200,000 acres. The spike to more than one million acres in 2013 was mostly light defoliation.

Photo, Doug Page, USFS/BLM, Bugwood.org

From 2004 to 2016, our surveyors recorded trace, or very light levels of defoliation that likely had minimal impact to tree health.

Gypsy moth

The Minnesota gypsy moth program (**https://www.mda.state.mn.us/plants/pestmanagement/gmunit**) is led by the Minnesota Department of Agriculture Division of Plant Protection. The following is an excerpt from a report on the 2018 survey year.

Trapping:
The Minnesota Department of Agriculture (MDA) began conducting gypsy moth surveys in Minnesota in 1973. In 2018, MDA placed 20,067 detection traps within their survey grid. USDA Animal and Plant Health Inspection Service placed an additional 141 traps. Statewide moth captures totaled 438, the lowest count since 2006.

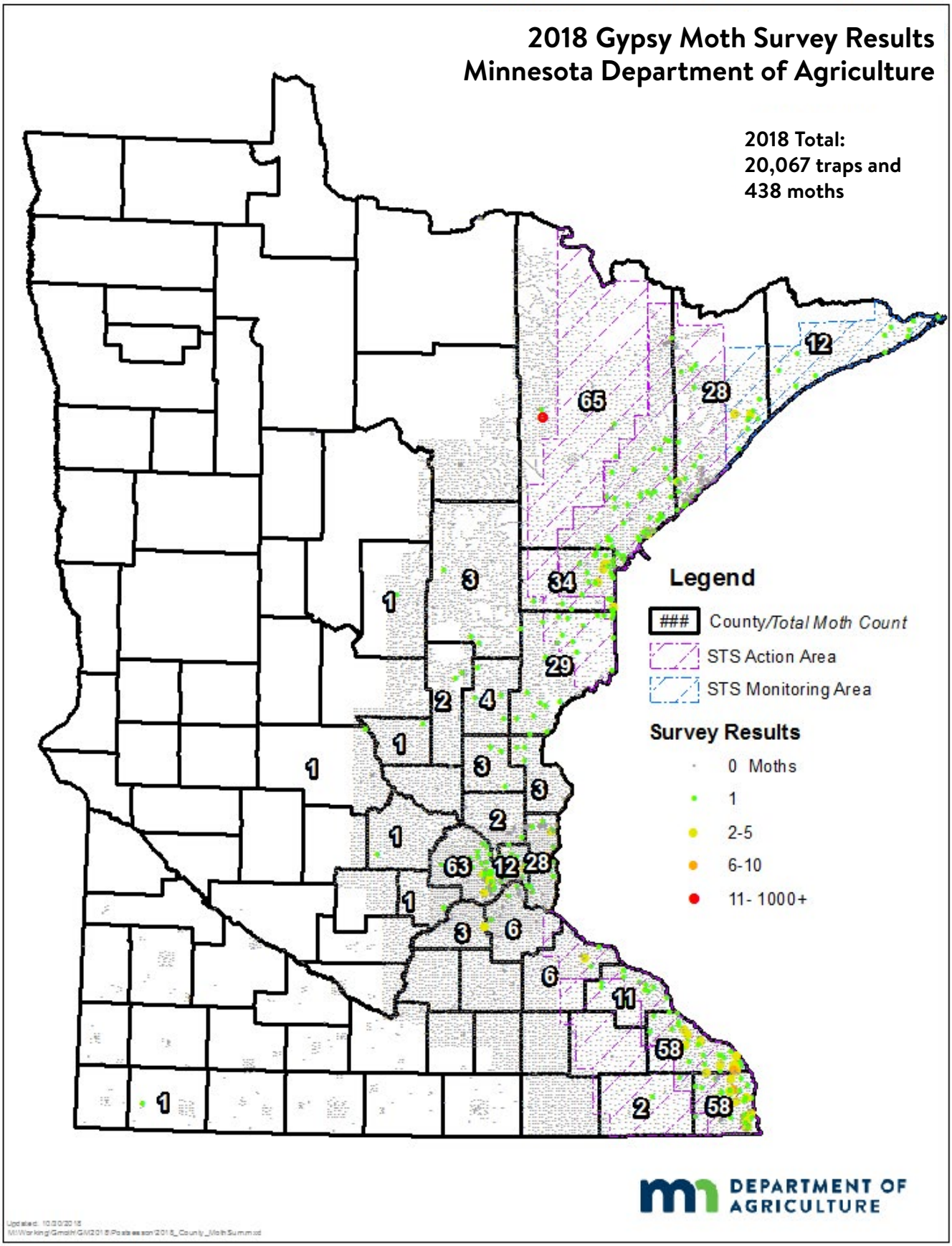
Treatments:
The MDA 2018 gypsy moth aerial treatments were conducted in Hennepin, Carlton, St. Louis and Lake counties. Planning for the treatments began in the summer of 2017 when gypsy moth caterpillars were discovered in Minneapolis and reported to the MDA. The MDA confirmed the gypsy moth infestation, implemented an emergency quarantine, and began planning eradication treatments. Three treatments of the biological pesticide *Bacillus thuringiensis* var. *kurstaki* (Btk) were applied to 376 acres in Hennepin County. Carlton County received a Btk treatment of 460 acres. St. Louis County received a Btk treatment of 352 acres. Lake County received Btk treatments totaling 603 acres and one treatment using mating disruption on about 73,000 acres.

The MDA gypsy moth trapping survey will continue to focus on the eastern half of Minnesota, with special attention paid to high-risk sites such as nurseries, mills, parks, and urban communities. There will be limited surveys conducted in the western portion of the state, mainly due to funding limitations.

No noticeable gypsy moth defoliation occurred in Minnesota in 2018.

Gypsy moth egg mass.

No noticeable gypsy moth defoliation occurred in Minnesota in 2018.



Gypsy moth traps caught 438 male moths, primarily along the eastern Minnesota border from Cook to Houston counties.

Jack pine budworm

Jack pine budworm is a native moth whose caterpillar feeds on jack pine. After about four years of noticeable defoliation in central Minnesota, populations crashed in 2018. We documented only two spots where we saw defoliation during aerial surveys, in Cass and Wadena counties. The recent outbreak did not result in much mortality across the landscape except in one small stand in Camp Ripley. The widely scattered dead and dying jack pines we noted in the 2017 aerial assessment in northern Morrison County and northeastern Todd County did not sustain additional significant mortality in 2018.

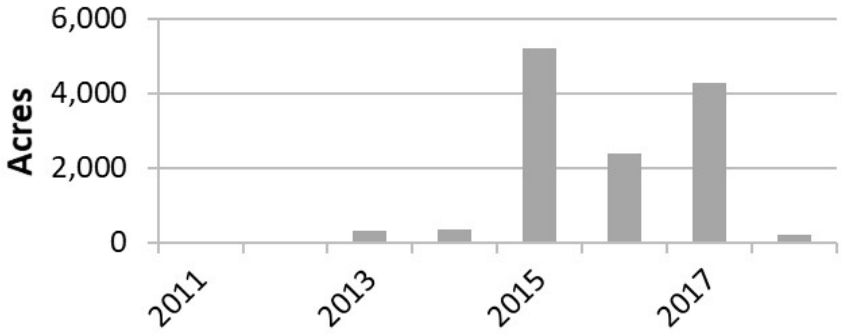
Jack pine budworm populations fluctuate over time, with peaks in central Minnesota occurring every 8–10 years. We expect to see populations peak again in central Minnesota around 2025.

In the 2017 annual report, we wrote about the potential beginnings of a separate jack pine budworm outbreak in northwestern Minnesota. We learned early in 2018 that those areas actually had sustained heavy hail damage.

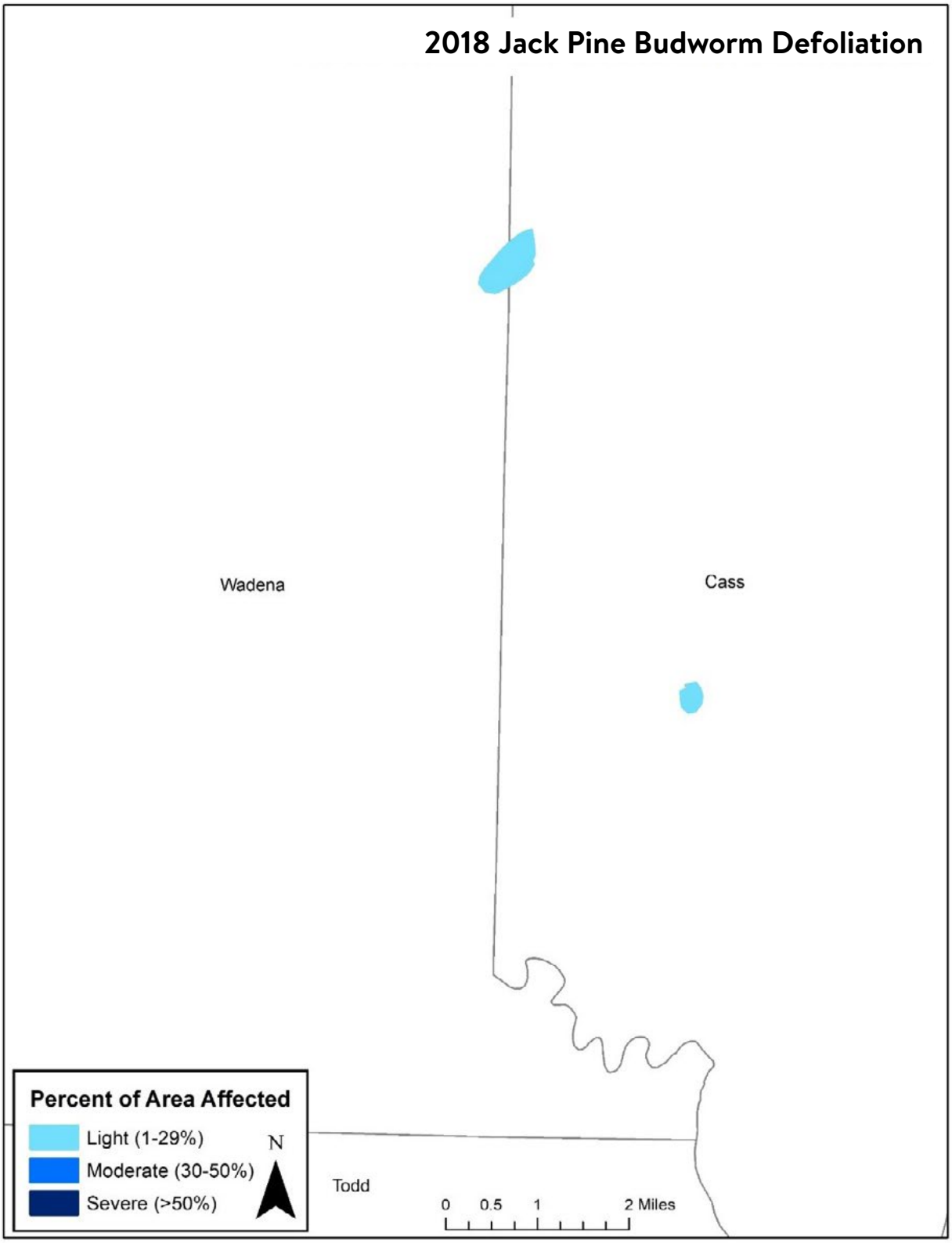
Feeding damage by jack pine budworm.

We expect to see populations peak again in central Minnesota in 2025.

Acres of Jack Pine Budworm Defoliation



Acres of jack pine budworm damage peaked in 2015 with 5,200 acres. The 4,000 acres mapped in 2017 was a result of hail damage.



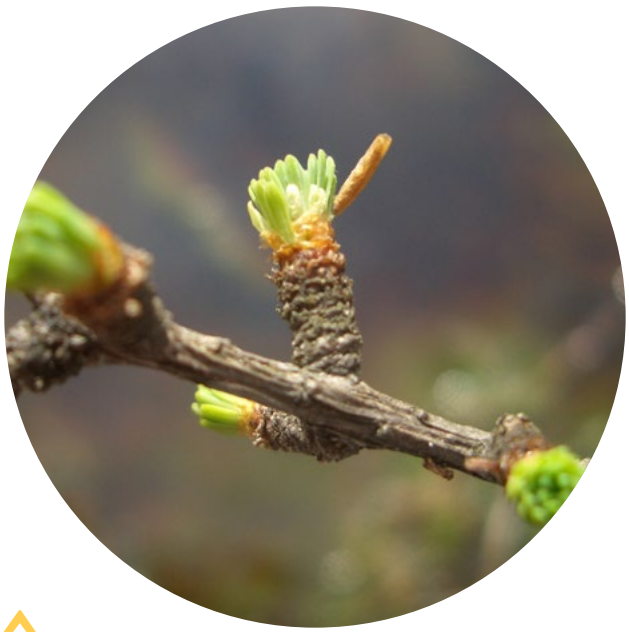
Aerial surveyors mapped two areas of jack pine budworm damage, in southern Cass Co. and crossing the border between Cass and northern Wadena counties.

Larch casebearer

Larch casebearer is a non-native moth whose caterpillar feeds on tamarack. The latest outbreak began in 2000, and since 2010, larch casebearer has defoliated between 11,000 and 22,000 acres each year. This year was no different, and we mapped about 15,800 acres. Newly affected areas this year were in Lake of the Woods, Beltrami, and western Koochiching counties.

Fortunately, we are not aware of any mortality resulting from repeated casebearer defoliation, but it's a possibility. The concurrent eastern larch beetle outbreak could mask our ability to detect serious damage caused by larch casebearer. Still, tamarack can tolerate defoliation for several consecutive years before serious dieback or mortality occurs, and we usually do not detect tamarack stands that sustain defoliation in consecutive years. For example, only about 8 percent of the acreage affected by larch casebearer in 2017 was also affected in 2018.

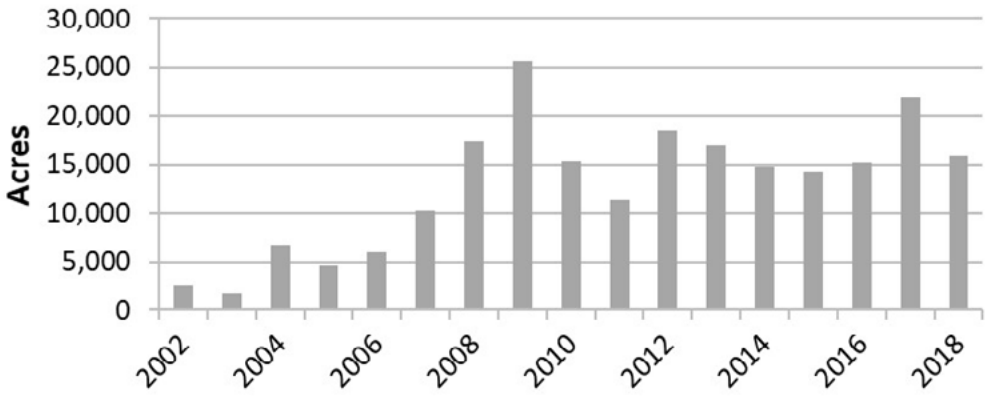
The amount of acreage we mapped in 2018 is likely an underestimate. Due to occasional poor visibility and the long distances we are trying to see during aerial surveys, it is not always possible to clearly identify tree species. For example, for the last two years, northern white cedar, found in swampy habitats along with tamarack, has suffered from defoliation.



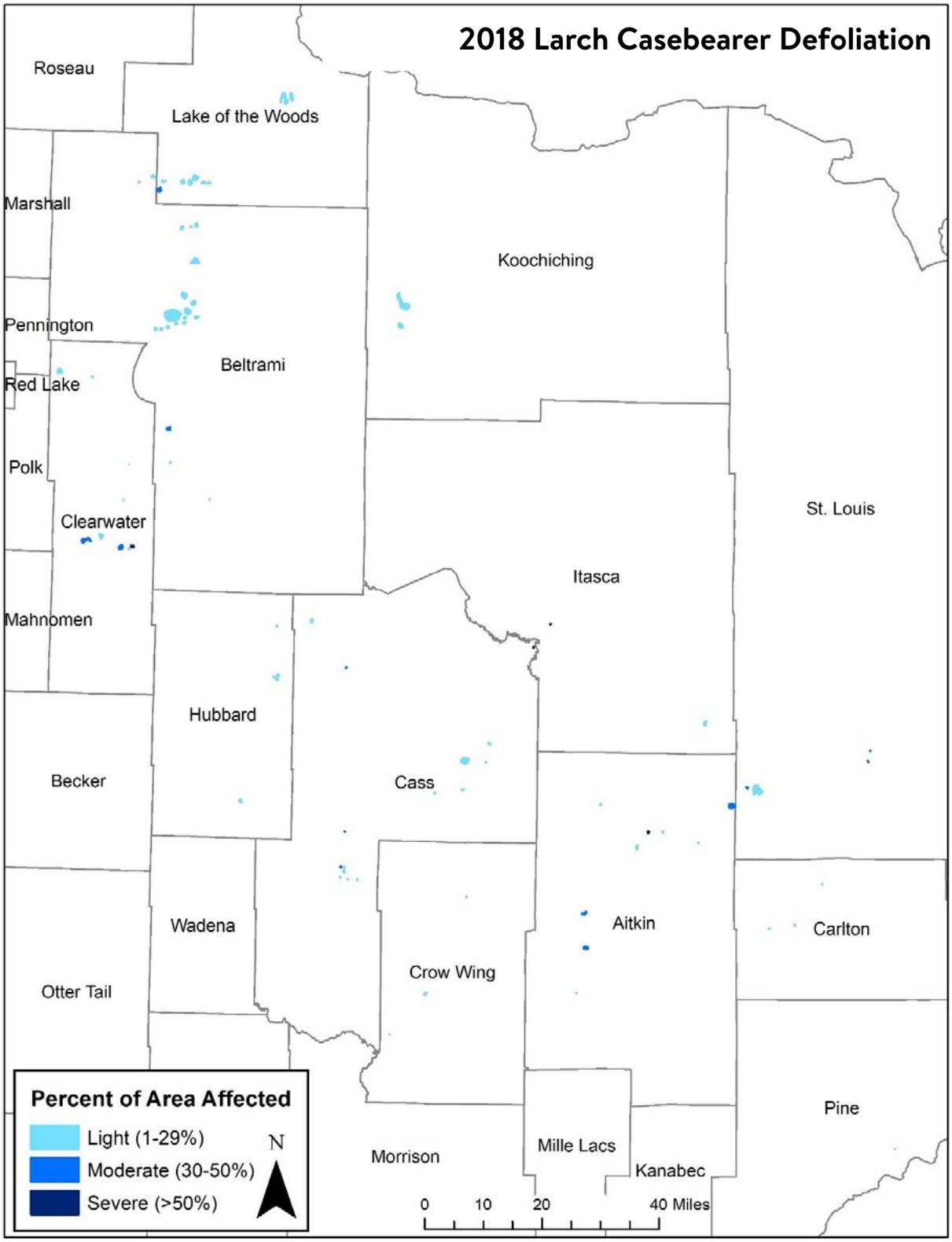
Larch casebearer larvae overwinter in cases attached to buds and resume feeding in spring on new foliage. Photo, Wisconsin DNR.

In 2018, we mapped about 13,700 acres of defoliation or discoloration to either tamarack or northern white cedar. We estimate that most of this acreage was on white cedar, but the amount on tamarack was probably significant as well.

Larch Casebearer Defoliation



Aerial surveys have recorded larch casebearer damage since 2002, with peaks of 25,000 acres recorded in 2009 and a little more than 20,000 in 2017.



Scattered larch casebearer defoliation was mapped from Lake of the Woods Co., south and east to Aitkin and St. Louis counties. Moderate damage was mapped in Clearwater and Aitkin counties; in the other counties the damage was light.

Linden borer killing lindens in Mankato

In late summer 2017, a Mankato urban forester expressed concern to us about how many boulevard lindens had been dying quickly in recent years (primarily cultivars of littleleaf linden, *Tilia cordata).* The lindens were highly decayed, which was a safety concern for people near these infested trees. We suspected linden borer *(Saperda vestita)* was the cause. Linden borer is a native longhorned beetle that occasionally attacks many lindens in communities, and favors weakened trees. We found roundheaded wood borer larvae, large round insect emergence holes, and decay fungi in the trees.

To confirm linden borer, we had to rear adults out of infested trees, so Mankato forestry staff cut up segments of infested lindens in December 2017 for us. We placed these logs in insect rearing chambers starting in late January 2018. In early March, adult longhorned beetles emerged from the log segments, and we identified them as linden borers. Some parasitic wasps also emerged from the logs, indicating some level of natural biological control occurring in Mankato.

Based on when linden borers emerged from the rearing chambers, we calculated that they would emerge from Mankato's lindens in late June 2018. We found active linden borer adults under bark in late June on lindens with healthy-looking crowns and round emergence holes already in their trunks.

Linden borer emergence holes on a linden with a healthy canopy.

In addition to the infestation in Mankato, we learned of linden death in St. Paul and Bloomington in 2018. One of those cases was due to linden borer, but the dying Bloomington lindens had been planted too deeply, which caused stress to the trees. In 2018, Mankato was the only community we were aware of that continued to see lindens die. Fortunately, this outbreak appears to be restricted to planted lindens and has not been reported from forests in southern Minnesota.

Rapidly dying, infested linden in Mankato.

Healthy-looking, yet heavily infested linden.

Pine leaf adelgids attacking white pine in Lake County

A USDA Forest Service entomologist reported that white pine saplings from Isabella in Lake County east into Cook County had branch-flagging and twisted, distorted growth in spring 2018. This was noted on the Tofte Range District of the Superior National Forest. White pine trees of all sizes were affected. The damage was caused by pine leaf adelgid *(Pineus pinifoliae)*, a native insect that has not been widely reported causing damage in Minnesota. At least one 12- to 15-foot tall white pine planting was heavily damaged.

A white pine with flagging branches from pine leaf adelgid infestation. Photo, USDA Forest Service.

Pine leaf adelgids attached to white pine shoots in late May. Photo, Wisconsin DNR.

White pine trees of all sizes were affected.

Severe dieback on bur oak from a twig-boring wasp

Widely scattered bur oaks in central and east-central Minnesota did not leaf out at the same time as their neighboring bur oaks and had branch tips that died. This outbreak extended into many Wisconsin counties. Most of them recovered their canopy with epicormic shoot growth by the end of June. The hardest-hit oaks displayed dieback at the edges of their crowns and appeared dead in late May, while others had widely-scattered tufts of leaves in their canopies. These oaks were in open-grown situations in yards or along woodlot edges. With close inspection, we found many tiny insect emergence holes slightly more than .02 inch in diameter on dead twigs, and pupating .08-inch-long wasps buried in twig wood. Only twigs with a diameter of 0.5 inch or less were infested.

We reared adult wasps from infested twigs, and sought experts at the USDA Systematic Entomology Lab in Washington, D.C. to help us put a name on them. The experts identified the most abundant wasp as a species of *Ceroptres*, a wasp in the family Cynipidae known to inhabit galls produced by other organisms, especially those made by other cynipids. Systematic Entomology Lab staff also identified two wasp species that parasitize other cynipid wasps.

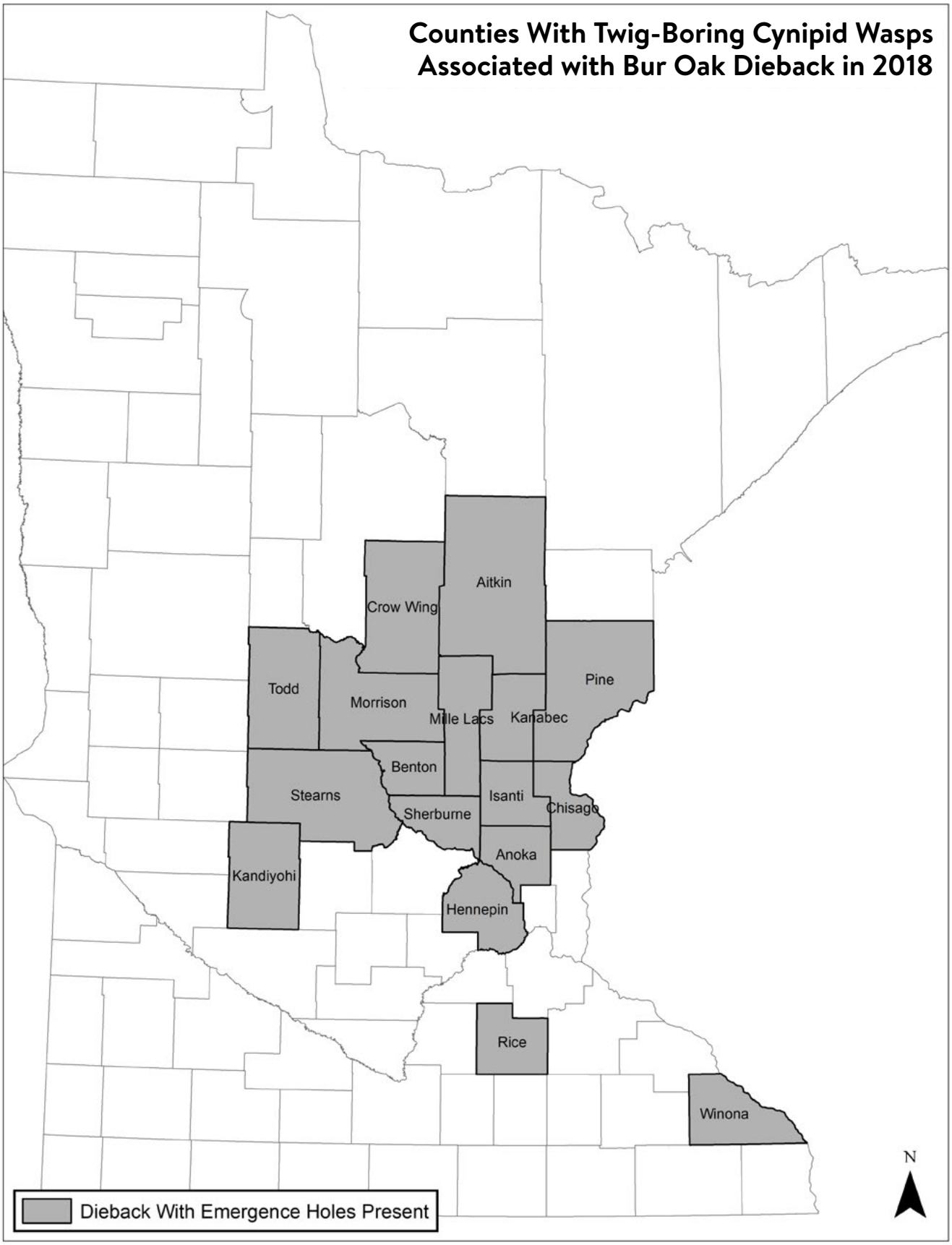
Though it is possible that the *Ceroptres* species was the actual cause of dieback, it seems more likely that the insect causing the damage emerged prior to discovery of the problem in May 2018, and that the *Ceroptres* wasps parasitized the insect that initially bored into the twigs. To find the cause of the dieback, we plan to collect twigs before the growing season in 2019 to attempt to find the insect that likely bores into twigs in late summer or early fall and emerges in March or April.

A cynipid wasp (.08-inch-long) that emerged from dead bur oak twigs.

The parasitic wasps that the taxonomists identified suggest the cause of the twig dieback was a native cynipid. We anticipate that these parasitic wasps will keep the causal pest under control.

Wasp emergence holes from killed bur oak twigs.

Same bur oak affected by the twig-damaging cynipid wasp, May 23 (left) and September 5 (right), 2018.



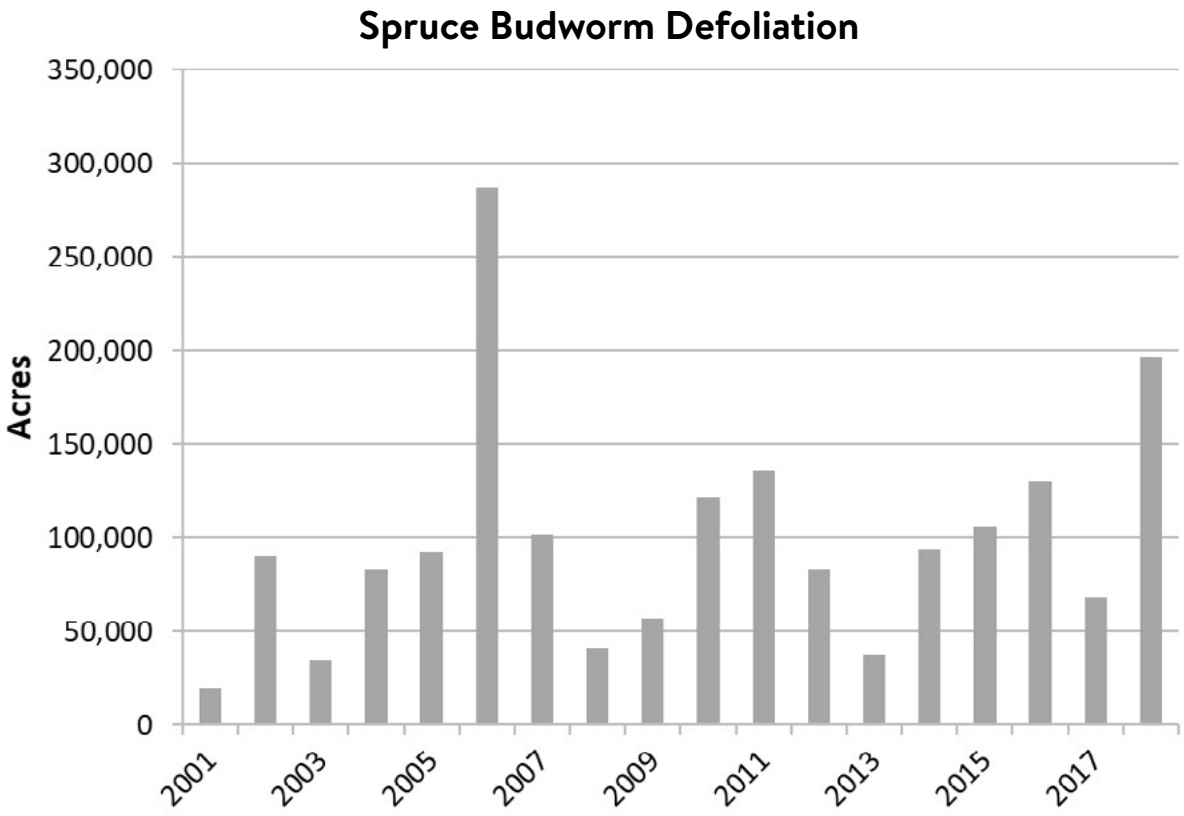
Cynipid wasps caused damage to oaks mainly in 15 counties in east-central Minnesota; Rice and Winona counties also had oaks damaged by cynipid wasps.

Spruce budworm

Spruce budworm is a native, needle-feeding caterpillar that prefers balsam fir but also readily feeds on white spruce. This caterpillar has been recorded defoliating large tracts of forests in various areas in the Arrowhead Region every year since at least 1954. The chart below shows the annual affected acreage since the most recent minimum in 2001. Typically, spruce budworm will feed in a given zone for about eight years, which is about the maximum period in which balsam fir can sustain defoliation before it dies.

We documented about 196,500 acres affected by spruce budworm in 2018. This is almost a three-fold increase in affected acreage from 2017, although the dip in affected acres in 2017 seems to be an anomaly. Newly affected areas in 2018 lie to the west of Two Harbors in southeastern St. Louis County.

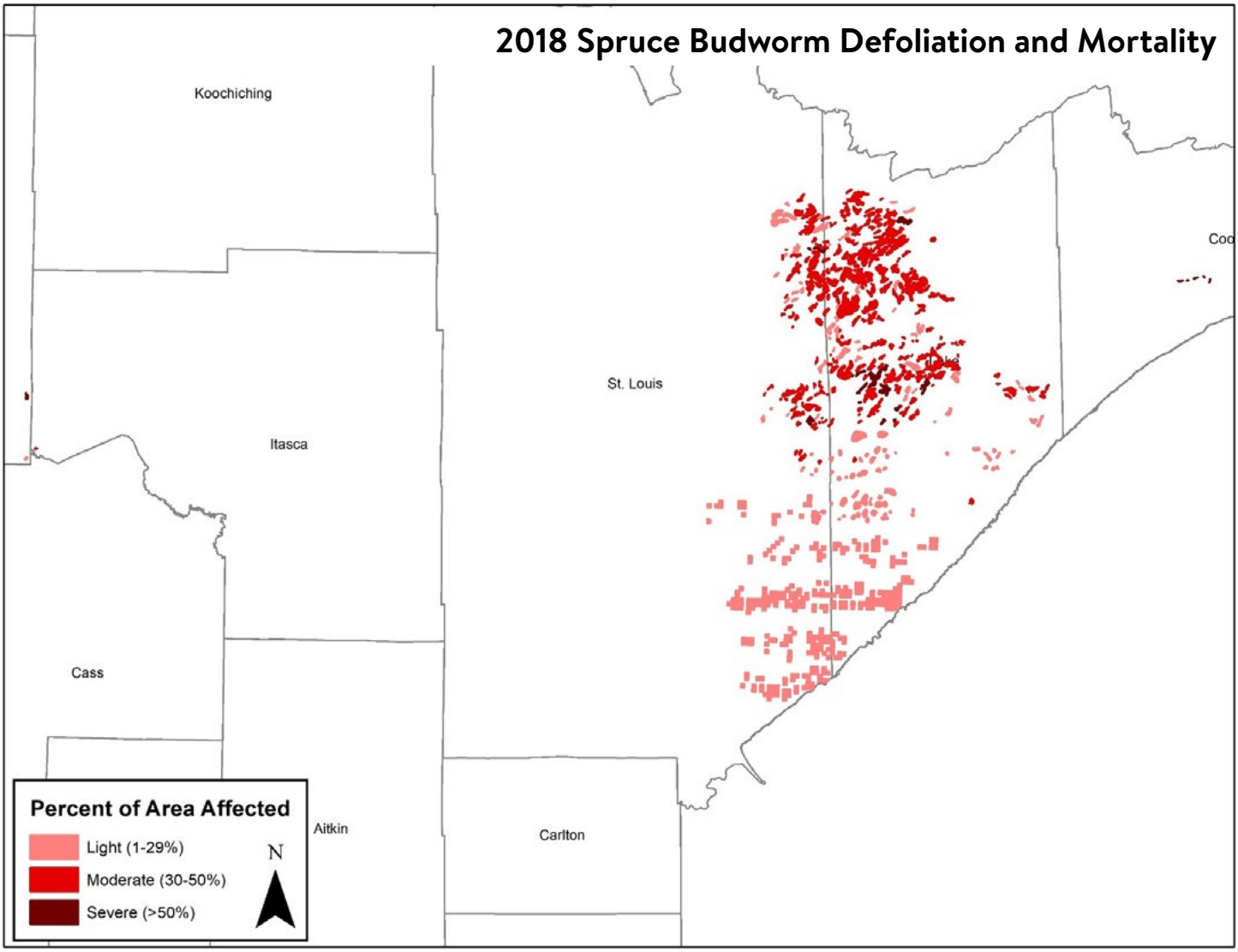
Spruce budworm caterpillar on balsam fir.



Spruce budworm damage from 2001 to 2018 shows two peaks, in 2006 and 2018, reflecting the fact that in Minnesota, spruce budworm tends to stay in an area for 8 to 10 years, or until much of its host is dead.

The heaviest landscape-level impact is an area southeast of Ely, which has been impacted since 2013. Spruce budworm will likely stay active in that area, mostly National Forest land, until about 2021. Only about 8 percent of the heavily impacted acreage is managed by the state.

St. Louis County, the DNR, and the USDA Forest Service are incorporating our aerial survey data of spruce budworm defoliation and mortality into Community Wildfire Protection Plans. This is insightful community planning, since dead standing conifers with needles generally increase risks of quickly spreading wildfires.



In 2018, aerial surveyors mapped 196,500 acres of spruce budworm damage in a rectangular area from northern to southern St. Louis Co. on its eastern border and from northern to southern Lake Co. on its western border. The heaviest spruce budworm damage occurred in central Lake Co., southeast of Ely.

Twolined chestnut borer

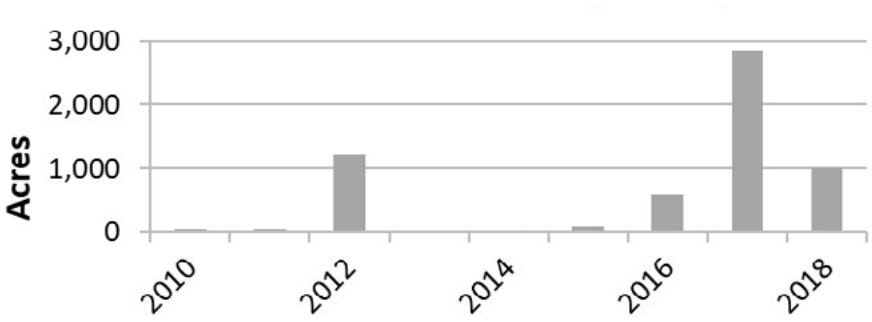
Twolined chestnut borer (TLCB) is a native wood-boring beetle that feeds on the inner bark of stressed oak, causing widespread dieback and mortality after serious droughts, wind storms, or intense and repeated defoliation events.

We mapped 1,010 acres impacted by TLCB in 2018, a 65 percent decrease from 2017. After three or four years of impacting oaks in central Minnesota, we expect that TLCB will not be a problem in this area in 2019 or 2020, as long as no stressful events occur in the short-term.

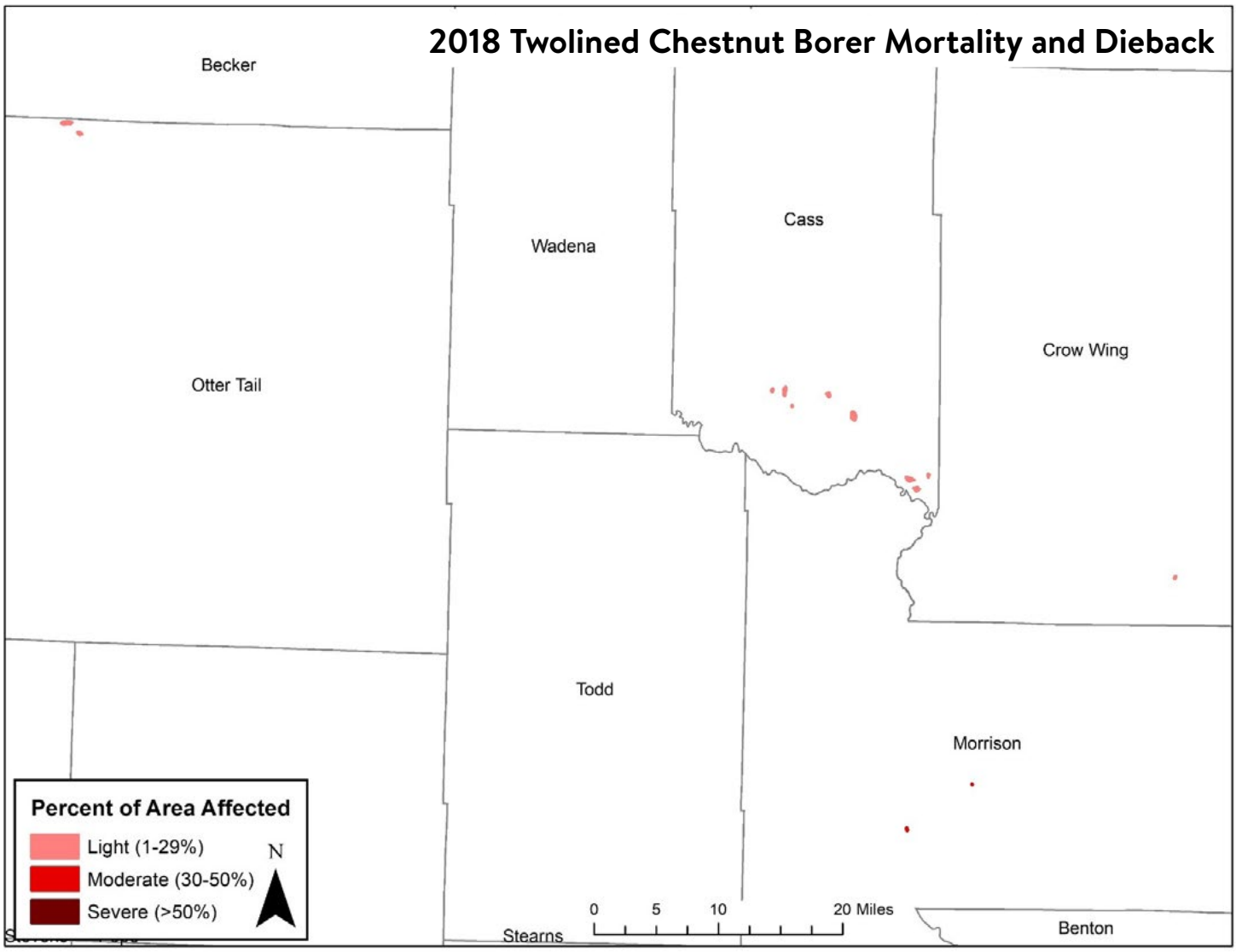
Twolined chestnut borer can kill very stressed oaks in one year, but it usually takes two to three years. The pattern of death closely resembles mortality from oak wilt. This is a concern in central Minnesota, since oak wilt was discovered in 2015 east of Little Falls in Morrison County, and we have put much effort into early oak wilt detection in that area. We have intensively surveyed areas in northern Morrison County and southern Cass and Crow Wing counties for oak wilt, but have not found it in those areas.

Typical symptoms of twolined chestnut borer in an oak tree are dead branches at the top, followed by dead red leaves, followed by green healthy foliage.

Twolined Chestnut Borer Mortality and Top Kill



Mapped damaged due to twolined chestnut borer from 2010 to 2018 was relatively sporadic. One thousand acres were recorded in 2012 and 2018, and a peak of nearly 3,000 acres in 2017 from twolined chestnut borer attacking oaks stressed by a 2015 wind storm.



Scattered damage from twolined chestnut borer was recorded in northern Ottertail, southern Cass, southeastern Crow Wing, and central Morrison counties.

We mapped 1,010 acres impacted by twolined chestnut borer in 2018.

DISEASES

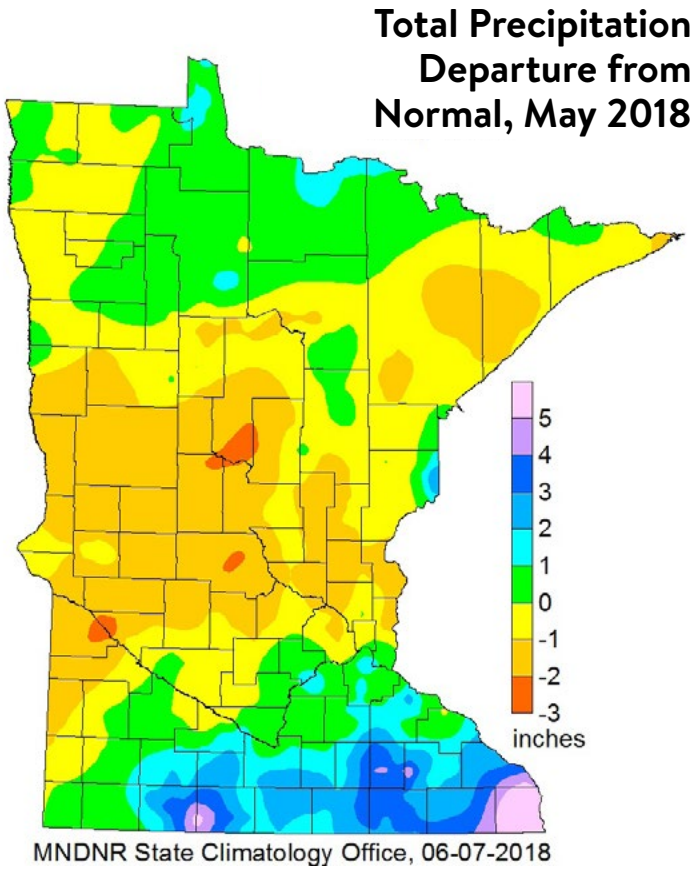
Bur oak blight

Bur oak blight is a native leaf disease of bur oak that causes leaves to brown (and sometimes drop) in late summer. However, vigorous trees affected by bur oak blight can recover and look normal again the following spring. In our 2006 annual report, forest health staff noted an increase of bur oak blight in southern Minnesota. That upward trend in abundance has generally continued for the past 12 years, likely promoted by consecutive years of wetter-than-average springs. In contrast, most of Minnesota experienced dry conditions in 2018 when bur oak leaves were emerging and elongating. Only Houston County, with the state's wettest conditions during leaf elongation in May, had significant bur oak blight this year.

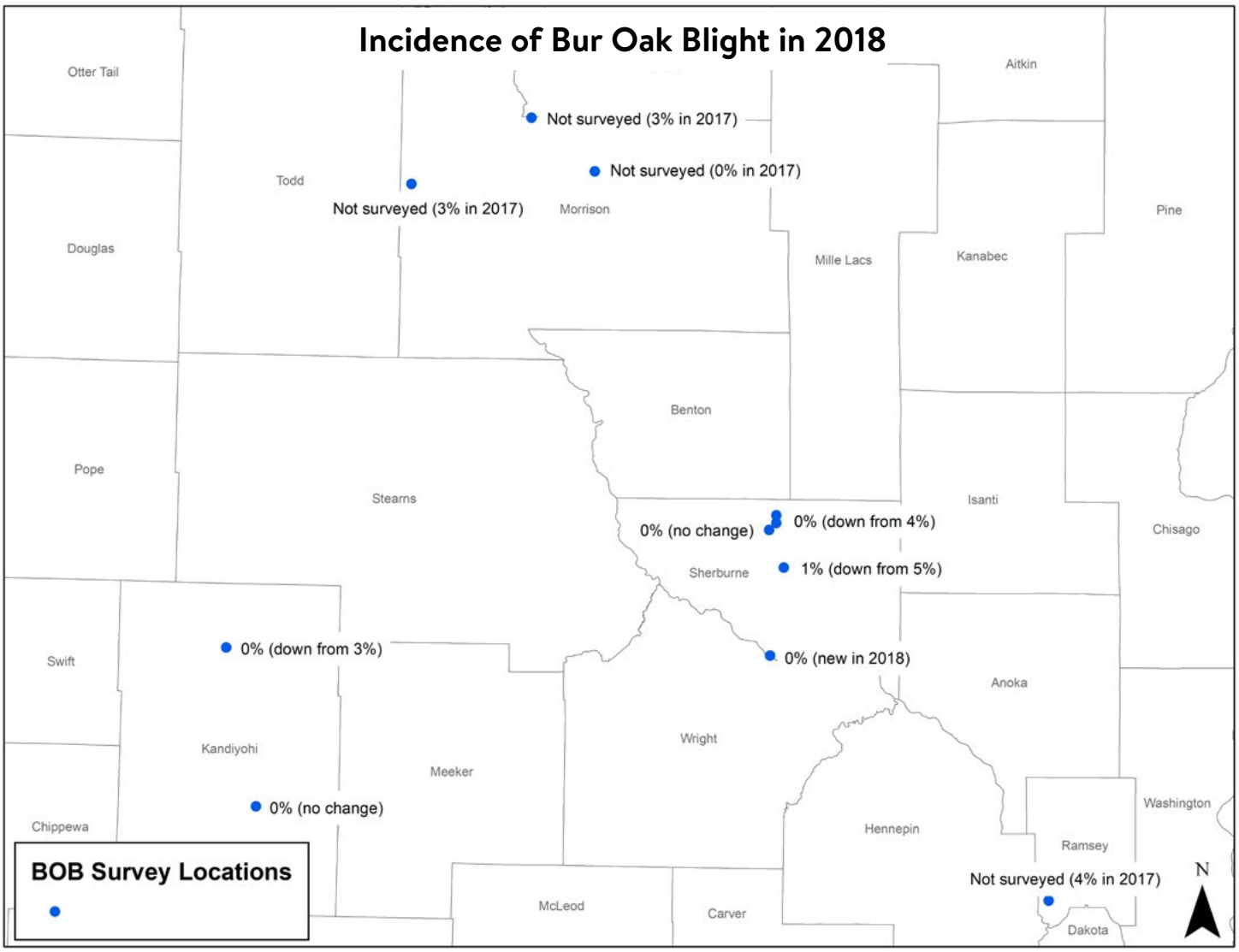
In 2017 we started a survey to evaluate bur oak blight frequency and aggressiveness in central Minnesota, and surveyed 398 bur oaks across 10 plots. Two percent of those oaks were significantly defoliated by early October. In 2018, we surveyed 286 bur oaks across six plots, and 0.2 percent of those oaks were significantly defoliated by early October. Only five of the 2017 plots were resurveyed, and a new plot was added. We plan to expand the survey into southeast Minnesota in 2019.

The low level of bur oak blight in 2018 demonstrates that the disease can essentially disappear from susceptible bur oaks if the weather is dry during leaf expansion.

Wedge-shaped symptom of bur oak blight.



The very wet conditions in southeastern Minnesota in May, 2018 promoted bur oak blight in Houston Co. The rest of the state had normal or slightly less than normal rainfall in May.



Bur oak blight surveys begun at 10 sites in Morrison, Kandiyohi, Sherburne, and Ramsey counties in 2017. In 2018, one site was new and had no bur oak blight, four sites were not surveyed, two had no change, and three had a decrease in bur oak blight from 2017.

Continued study on *Diplodia*

Diplodia is a fungal pathogen that frequently kills red pine seedlings, causing crown loss and top-kill on mature pines after stressful conditions. Unfortunately, *Diplodia* can also cause latent infections, those that show no signs of disease until trees become stressed. In 2017, we reported having to destroy 400,000–500,000 red pine seedlings with possible latent infections in order to avoid distributing unhealthy seedlings. Traditionally, when latent *Diplodia* infections are above 10 percent, we advise destroying the nursery crop.

To understand what the fate of the seedlings would have been had they been planted, the forest health unit planted 616 bare-root seedlings from the affected Badoura field in a vacant field at the General Andrews Tree Improvement Center in April 2017. To compare mortality of infected and uninfected stock, 628 uninfected containerized seedlings from an outside source were planted next to the bare-root seedlings from Badoura.

Forest health staff assessed mortality in June and October 2017. By October 2017, we found 24 percent of containerized seedlings had died and 61 percent of bare-root seedlings had died. We again assessed mortality in June and August 2018. By August 2018, 25 percent of containerized seedlings had died and 62 percent of the bare-root seedlings had died. Most of the bare-root stock mortality was attributed to *Diplodia*.

Badoura State Nursery has assessed levels of latent *Diplodia* infections since 2016, and there was good news from their 2018 analysis: no latent infection was found in 2-0 or 3-0 stock (the first number is the number of years the seedling has been in the bed where the seed was sown; the second number is the number of years the seedling was in a transplant bed), and only 1.3 percent of 2-2 stock had latent *Diplodia* infections, which is an acceptable level. This represents the second consecutive year where latent *Diplodia* infections at the State Nursery were at acceptable levels.

Diplodia causing brown shoots in nursery seedlings.

Heterobasidion root disease

Heterobasidion root disease (HRD) is a potentially serious and persistent fungal disease in pine plantations. It was first confirmed in Minnesota in 2014 by University of Minnesota staff in a state-managed red pine plantation in Winona County. It had infected at least eight pines.

Intensive surveys for additional HRD in eastern Minnesota happened after the confirmation of HRD, but no additional positive HRD locations were found. We attempted to eradicate Heterobasidion from the Winona County site in 2017 by clearcutting the small plantation and extracting stumps from within 50 feet of known infected pines. Hardwood tree species were direct-seeded into the site later. Stump piles and pine stumps left in the ground near the original infection center were surveyed for Heterobasidion fruiting bodies in 2018, and none were found. We intended to burn the piles of extracted stumps, but clods of soil on the root wads prevented burning. Extracting the stumps eliminated the underground pathway for the disease, and conversion of the site to hardwood species makes the stand no longer susceptible to HRD. A visual survey will continue annually.

DNR forest health staff and University of Minnesota researchers have been looking intensively for HRD since 2014, surveying more than 210 locations through 2018. In addition, this year University of Minnesota personnel started surveying with spore traps, a new monitoring technique for Heterobasidion. Spore levels can be an indicator of the existence of Heterobasidion. For example, after sampling for one week at a Wisconsin plantation infected with Heterobasidion, spore traps caught about 32,450 spores. That same week at the previously confirmed plantation in Winona County, researchers caught only 256 spores, suggesting spores may have drifted from sources in Wisconsin or unknown sources in Minnesota. Related research suggests that the minimum number of spores needed to start an infection in this southeastern Minnesota stand needs to be considerably higher than 256. Researchers trapped spores at several other eastern Minnesota spots, as well as in Itasca State Park. None of these surveys suggest HRD was present.

Red pine stump with fruiting body at base of stump.

Extracted red pine stumps.

Oak wilt

Oak wilt is a non-native, fatal tree disease that has been slowly spreading northward in Minnesota since about 1950. The disease is common in east-central and southeast Minnesota but has been confirmed only recently farther north and west. It currently covers 30 percent of the state's red oak range. We estimate that at least 655,400 acres of rural and urban forests are threatened by oak wilt (number of acres was derived from the area of land within a half mile of confirmed oak wilt).

A key element in landscape-scale disease control projects is knowing the location of the disease, so in recent years we tested three ways to detect oak wilt: (1) with our standard aerial survey, (2) using high-resolution imagery analysis, and (3) targeting small areas with high-density aerial survey. Results from 2018 show that surveying for oak wilt over relatively small areas with one mile between flight transects can be successful. For example, the number of oak wilt confirmations we made from our 2018 aerial survey in Morrison County increased the total number of confirmations in that county more than 600 percent.

We estimate that at least 655,400 acres of rural and urban forests are threatened by oak wilt.

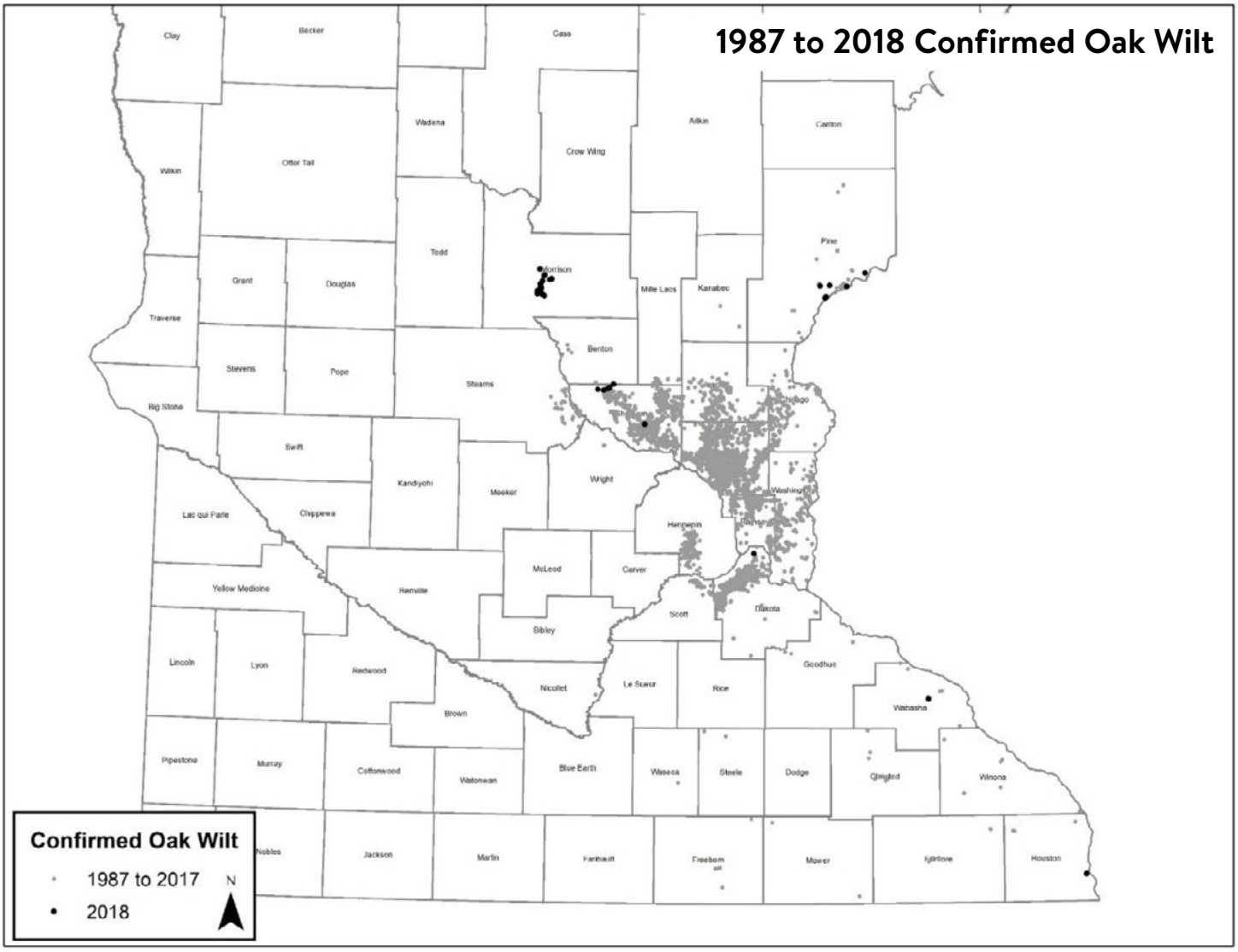
Fallen red oak leaves from tree infected with oak wilt. Photo, Wisconsin DNR.

Controlling oak wilt in the early stages of infestation is possible, but coordinating landscape-level disease management across multiple ownerships at low disease levels is daunting. The forest health unit currently has two landscape-level management projects aimed at the northeastern and northwestern extremes of the known oak wilt range in Minnesota, in Pine and Morrison counties, respectively.

Management in Morrison County

Oak wilt was first discovered in Morrison County in 2015. We now are aware of 44 infection centers there, and we anticipate the number to rise to about 50 confirmed infection centers by spring 2019. All but one of those infection centers is on private property, affecting at least 32 different property owners.

Our experience shows that many landowners will not control an invasive species if the control is expensive or if they see that a neighbor is not controlling the problem on their land. Knowing this, in 2018 we helped Morrison County Soil and Water Conservation District apply for a $100,000 oak wilt control grant to the Legislative-Citizen Commission on Minnesota Resources (LCCMR). The concept is to fully fund oak wilt control work on private land in Morrison County and any areas to the north. The LCCMR approved the grant, but funding is contingent on approval from the 2019 legislature.



Oak wilt is common in east-central and southeast Minnesota but has been recently confirmed in Pine and Morrison counties.

Management in Pine County

Oak wilt has been in southern Pine County at low densities since 2000, but it exploded in abundance in St. Croix State Park after the devastating 2011 blowdown. It was not known to be north of that state park until 2015. From 2015 to the present, oak wilt has been confirmed on seven different private properties north of the state park. As far as we know, all seven of the property owners have controlled oak wilt on their land, and DNR Division of Forestry has aided in advising or cost-sharing control on all of those properties. The forest health unit annually monitors for oak wilt in northern Pine County.

We received a $29,000 grant from the USDA Forest Service to use on oak wilt suppression from 2017 through 2020 in St. Croix State Park. Last year, St. Croix State Park staff used grant funding to control 26 oak wilt pockets. In 2018, the park controlled 16 additional oak wilt infection centers. Barring severe wind storms in the park from May through mid-July, and as long as the Parks and Trails Division continues to enthusiastically carry out the control work, we anticipate oak wilt will decline in and around the state park.

DECLINES AND ABIOTIC PROBLEMS

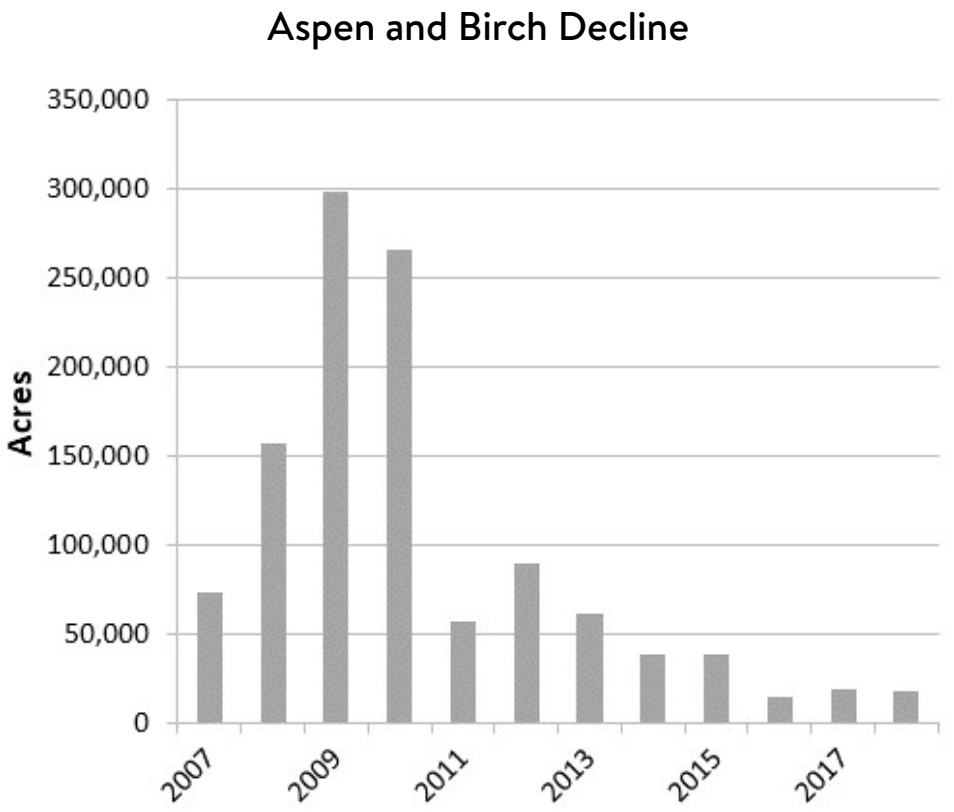
Aspen and birch decline

Aspen and birch decline have been documented in aerial surveys in Minnesota since 2004. Symptoms include combinations of leaf discoloration, dieback, and mortality. There was a spike in declining aspen and birch roughly from 2007-2013. This increase was due to stress from three to four years of intense forest tent caterpillar defoliation (from 2000-2003), and drought in 2002, 2003, and 2006. In addition, many of these birch and aspen were predisposed to stress due to old age and growing on shallow soils.

The aspen and birch decline we have mapped in recent years is distinct from the spike in decline from 2007-2013. Rather than being regionally isolated, it is represented in relatively small declining areas scattered across northern Minnesota. The causes of these areas of decline are likely unique to the region or site, such as a combination of old age, flooding, regional droughts, wind, and stress from harvests. In particular, much of northwest Minnesota has experienced unusually dry weather from May through September in 2011, 2012, 2013, 2015, 2017, and 2018.

Black ash decline

According to the DNR 2007 Annual Forest Health Report, aerial surveyors started noticing declining black ash stands in 2004. Surveyors noted they had little confidence in the actual amount of declining black ash they mapped. Forest health staff has also realized the difficulty in mapping declining ash consistently and accurately, and we did not attempt to quantify the amount of declining black ash in 2018. While there is a significant amount of declining black ash on the landscape, the best method to quantify it may be to analyze Forest Inventory and Analysis data from the USDA Forest Service, or employ change detection analyses of aerial images.



Between 2007 and 2013 there was a spike in aspen and birch decline due to stress from earlier forest tent caterpillar defoliation and drought. From 2014 to 2018, decline is found in scattered pockets due to localized events.

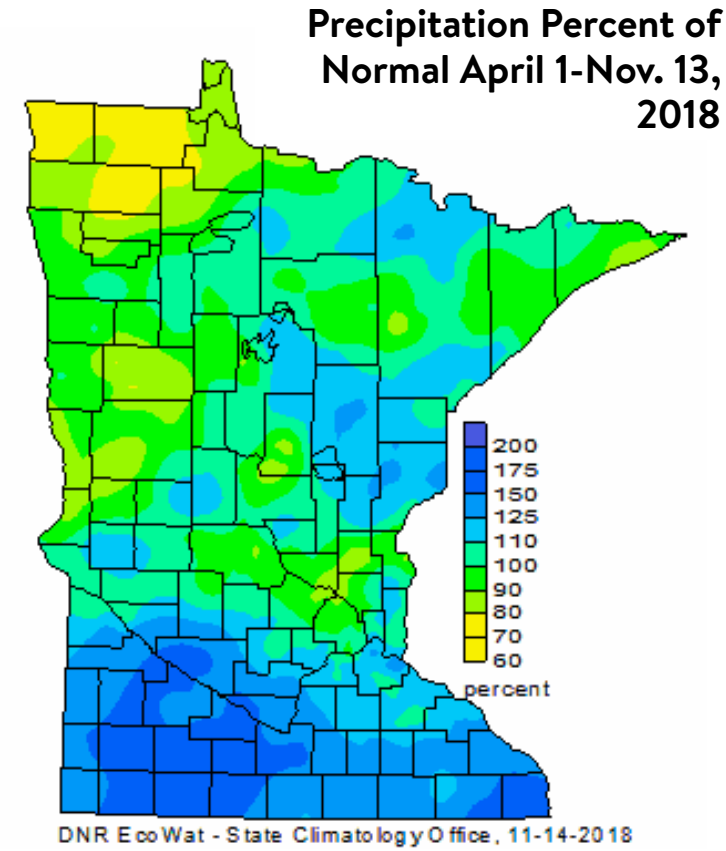
Flooding or high water damage

The DNR Division of Parks and Trails alerted forest health staff of widespread dieback and mortality at Nerstrand State Park in Rice County this year. About 200 acres of Nerstrand State Park's upland forest has been killed, and we confirmed the dieback and mortality was from flood damage, perhaps from long-term and repeated flooding. From aerial imagery, changes to the state park's forests occurred between 2013 and 2015. There was a near-record wet spring in south-central Minnesota in 2013, and this may have spurred the decline of Nerstrand's forest. Affected forests in the park consist of upland tree species, but the ground is flat and poorly drained. Even flood-tolerant species like mature American elm and green ash are dying. The understory is becoming dominated by ash saplings, which is a concern for the future of the forest due to emerald ash borer. Management has started to promote a more flood-tolerant forest in the state park.

According to the Southern Climate Impacts Planning Program Climate Trends tool (www.southernclimate.org), annual precipitation across Minnesota has generally been above average since about 1990, and there were only six years where annual precipitation was below average from 1990 until now. In the century between 1895 and 1989, the record precipitation for southeast Minnesota was 18.18 inches, set in 1981. That amount of summer precipitation was exceeded in southeast Minnesota five times between 1990 and 2018.

According to Minnesota's climate journal website (**https://www.dnr.state.mn.us/climate/journal/index.html**), there were floods in the more northerly Kanabec and Pine counties as well as in southwest Minnesota from heavy thunderstorms in early July, 2018. Aerial and ground forest health surveys in Kanabec County found that aspen adjacent to wetlands suffered from those intense rains. There was flooding in southeast Minnesota from a late August storm, and more flooding from another storm in early September.

Different tree species in varying stages of decline from flooding at Nerstrand State Park. Flood-tolerant elms and ashes are holding on.



From April 1 to November 13, 2018, the southwest and southeast corners of the state received twice as much rainfall as normally received between April and November. Rice Co. received a little more than normal during that time period.

Winter drying on conifers in southern Minnesota

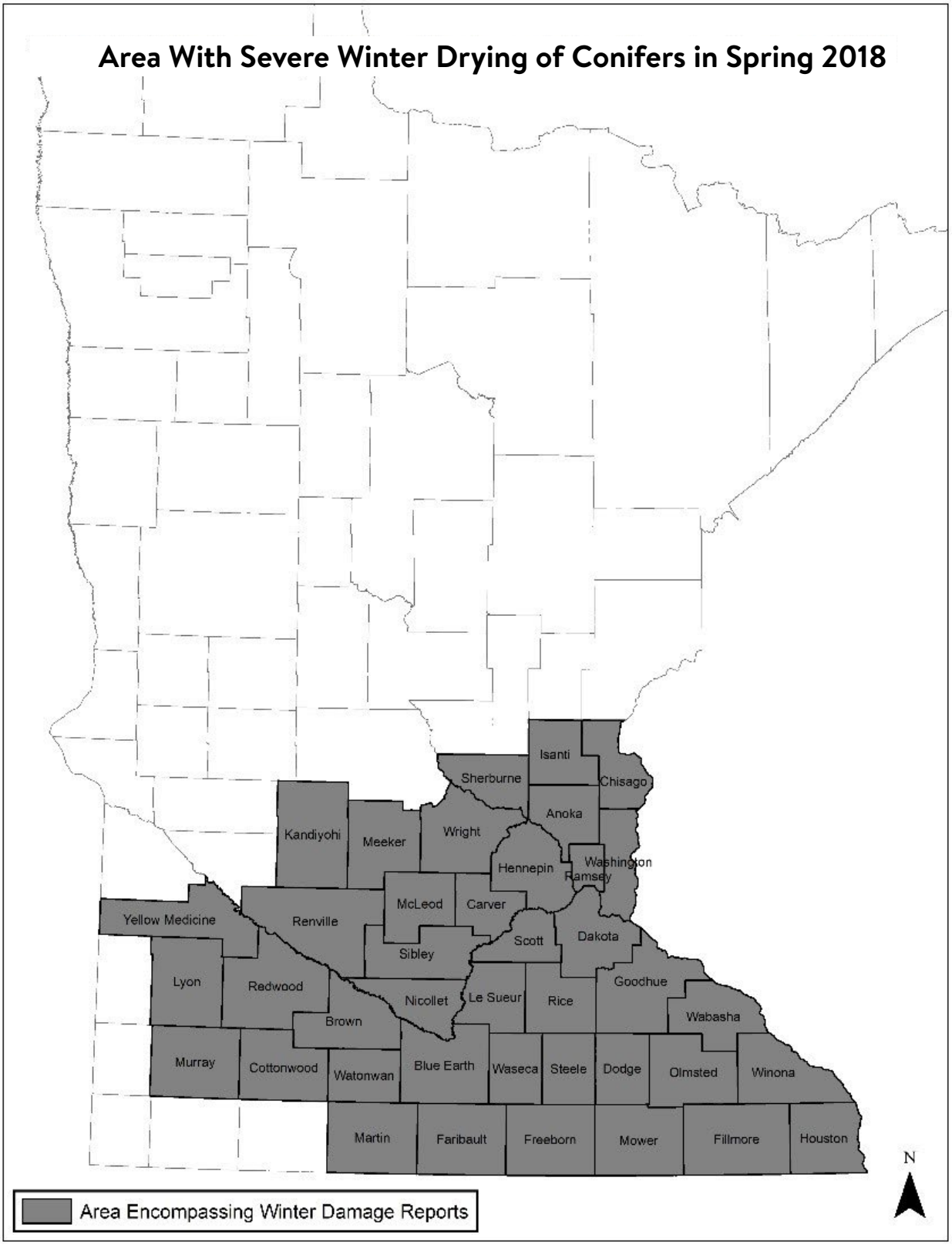
In early May, the DNR forest health team received several reports that Black Hills spruce, northern white cedar (arborvitae), and white pine had died suddenly in several southern counties. Most of the affected trees were relatively young.

The widespread, scattered evergreen death was an example of severe winter drying due to warm, windy, and dry conditions that caused needles to lose moisture when roots were still frozen in soil and unable to replenish needles with lost moisture. The warm weather occurred at the end of one of Minnesota's coldest Aprils on record. To illustrate, on April 30, Preston (Fillmore County) had a high of 80° F, humidity that bottomed-out around 25 percent, and winds that reached almost 40 mph. The previous day was even drier. Similar conditions were present throughout southern and central Minnesota. And yet, soils were still frozen under a Princeton red pine plantation on May 1.

A white spruce cultivar killed by winter drying.

Warm, windy, dry conditions caused needles to lose moisture when roots were still frozen in soil.

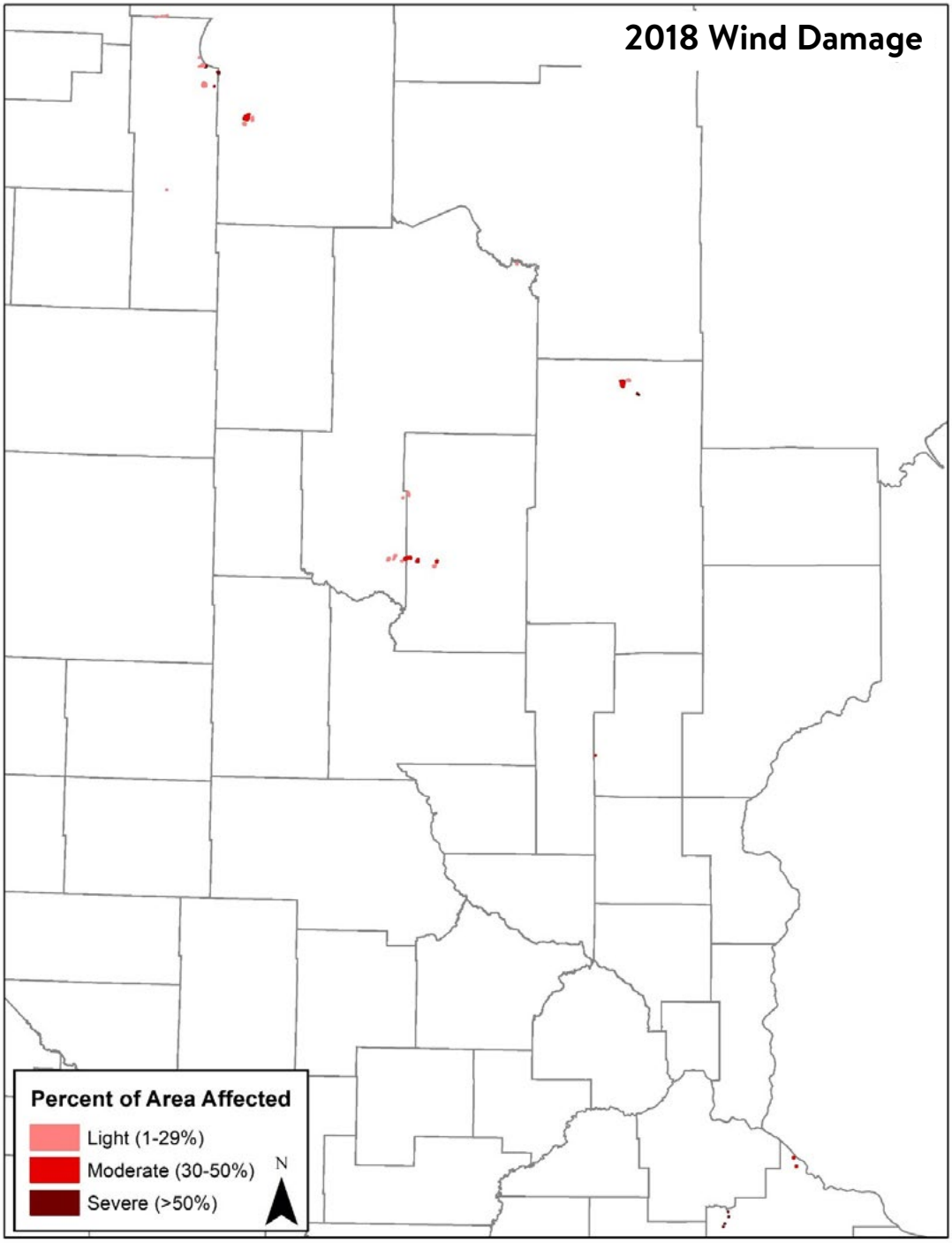
An arborvitae that died from winter drying.



Damage to evergreens due to warm, windy weather while roots were still frozen and unable to transport water was widely reported across the southern half of Minnesota.

Wind damage

Wind is a common forest disturber in Minnesota, and mapping wind damage is a part of our aerial surveys. This year we mapped about 3,600 acres of wind damage. The average annual amount of wind damage from 2003 to 2010 was 1,000 acres per year, but the average annual amount of wind damage from 2011 to 2018 was 10,400 acres per year. This analysis excludes the massive derecho events in the late 1990s.



Aerial surveyors recorded moderate damage from wind events in northern Clearwater, southwestern Beltrami, southeastern Cass, southwestern Crow Wing, northern Aitkin, and northern and western Goodhue counties in 2018.

OTHER TREE PEST AND TREE HEALTH EVENTS NOTED IN 2018

Table: Observed Tree Health Events and Their Locations

Pest or event	Pest stage or cause	2017 (county in which observed)	2018 (county in which observed)
Sudden ash leaflet drop	Anthracnose	May 14-23 (Dakota, Hennepin, Scott, Waseca)	May 27 (Itasca)
Forest tent caterpillar	Caterpillars, 1-1.5 inches long	June 1 (Crow Wing)	June 8 (Stearns)
Oak wilt	Wilting noted for the first time in the year	June 12 (Sherburne)	June 19 (Anoka)
Japanese beetle	Adult	June 25 (Dakota)	June 30 (Dakota)

FOREST PEST FIRST DETECTOR WORKSHOPS

Forest Pest First Detector training continued this year with workshops held in Andover and Mankato. First Detectors are trained volunteers who respond to reports of exotic forest insects, diseases, and plants. Reports are initially made to "Arrest the Pest" at the Minnesota Department of Agriculture (MDA) by phone (888-545-6684) or email (**Arrest.the.Pest@state.mn.us**). The MDA contacts a First Detector near the location of the report and connects them to the reporting homeowner. The First Detector responds to help diagnose the problem and reports the finding to MDA.

Before attending the workshops, participants complete online training modules on various invasive pests. At the workshops, instructors are stationed at information tables, and participants rotate through the stations to learn identifying characteristics of the featured pests.

After the workshops this year, the 25 attendees were able to describe and identify signs and symptoms of emerald ash borer, velvet longhorned beetle, Asian longhorned beetle, gypsy moth, brown marmorated stink bug, Oriental bittersweet, burning bush, Japanese barberry, and oak wilt, and learned how to properly respond to reports of these pests.

The Forest Pest First Detector instruction team consists of agency partners who plan and create the agenda, decide on locations, organize registration, and present information on invasive insects, diseases, and plants at the workshops. The team includes staff from the University of Minnesota Extension, the Minnesota Department of Agriculture, and the Minnesota Department of Natural Resources. The workshops have been held annually since 2008.

Forest Pest First Detector patch.

EARLY DETECTION AND RAPID RESPONSE BARK BEETLE SURVEY RESULTS

In 2017 and 2018, the forest health unit participated in the national Early Detection and Rapid Response (EDRR) project. The goals of the project are to:

- Detect, delimit and monitor newly introduced exotic bark and ambrosia beetles at selected high-risk forest areas
- Quickly assess and respond to newly detected infestations

We selected high-risk sites for trapping in wooded areas in the wildland-urban interface and major transportation corridors. On May 19, 2017, forest health staff hung three Lindgren funnel traps at 12 sites. We coordinated the location of trapping sites with the Minnesota Department of Agriculture regulatory staff, the Cooperative Agricultural Pest Survey coordinator, and USDA Animal and Plant Health Inspection Service.

We baited one trap at each location with ethanol, a second with alpha-pinene and ethanol, and the third with 3-component *Ips* lure. We collected samples every two weeks for 12 weeks and shipped them to staff at the Oregon Department of Agriculture for bark beetle identification. We entered trap and collection data into the EDRR database throughout the trapping season.

In 2018, forest health staff again hung three Lindgren funnel traps at 12 sites in Minnesota, but began on April 24 in an attempt to capture early-season beetles. We collected samples on May 11 and May 22, and removed traps on May 22. We used the same baits and procedure for identification. Collection results are found in the tables on pages 43–51.

Results of the 2017-2018 Early Detection and Rapid Response Survey

Year	Beetle species	County	Location	Count
2017	Anisandrus sayi	Anoka	Boot Lake SNA	323
2017	Corthylus columbianus	Anoka	Boot Lake SNA	1
2017	Corthylus punctatissimus	Anoka	Boot Lake SNA	1
2017	Dryocoetes affaber	Anoka	Boot Lake SNA	1
2017	Gnathotrichus materiarius	Anoka	Boot Lake SNA	6
2017	Ips grandicollis	Anoka	Boot Lake SNA	25
2017	Lymantor decipiens	Anoka	Boot Lake SNA	10
2017	Monarthrum mali	Anoka	Boot Lake SNA	1
2017	Orthotomicus caelatus	Anoka	Boot Lake SNA	4
2017	Phloeotribus liminaris	Anoka	Boot Lake SNA	3
2017	Pityogenes hopkinsi	Anoka	Boot Lake SNA	1
2017	Anisandrus sayi	Anoka	Rum River Central Reg Park	54
2017	Dendroctonus valens	Anoka	Rum River Central Reg Park	1
2017	Dryocoetes autographus	Anoka	Rum River Central Reg Park	9
2017	Gnathotrichus materiarius	Anoka	Rum River Central Reg Park	7
2017	Hylastes porculus	Anoka	Rum River Central Reg Park	45
2017	Hylesinus pruinosus	Anoka	Rum River Central Reg Park	1
2017	Hypothenemus	Anoka	Rum River Central Reg Park	1
2017	Ips grandicollis	Anoka	Rum River Central Reg Park	79
2017	Ips pini	Anoka	Rum River Central Reg Park	7
2017	Lymantor decipiens	Anoka	Rum River Central Reg Park	75
2017	Monarthrum fasciatum	Anoka	Rum River Central Reg Park	1
2017	Monarthrum mali	Anoka	Rum River Central Reg Park	1
2017	Orthotomicus caelatus	Anoka	Rum River Central Reg Park	7
2017	Pseudopityophthorus minutissimus	Anoka	Rum River Central Reg Park	7
2017	Xyleborinus saxesenii	Anoka	Rum River Central Reg Park	1
2017	Xyleborus xylographus	Anoka	Rum River Central Reg Park	1
2017	Xyloterinus politus	Anoka	Rum River Central Reg Park	1
2017	Anisandrus sayi	Beltrami	Bemidji	1
2017	Dendroctonus valens	Beltrami	Bemidji	17
2017	Gnathotrichus materiarius	Beltrami	Bemidji	4
2017	Hylastes porculus	Beltrami	Bemidji	3
2017	Hylurgops pinifex	Beltrami	Bemidji	1
2017	Ips grandicollis	Beltrami	Bemidji	11
2017	Ips perroti	Beltrami	Bemidji	3
2017	Ips perturbatus	Beltrami	Bemidji	2
2017	Ips pini	Beltrami	Bemidji	7
2017	Lymantor decipiens	Beltrami	Bemidji	9
2017	Orthotomicus caelatus	Beltrami	Bemidji	14
2017	Pityophthorus	Beltrami	Bemidji	11
2017	Anisandrus sayi	Crow Wing	Crow Wing Power	1

Year	Beetle species	County	Location	Count
2017	Corthylus punctatissimus	Crow Wing	Crow Wing Power	1
2017	Dendroctonus valens	Crow Wing	Crow Wing Power	2
2017	Dryocoetes affaber	Crow Wing	Crow Wing Power	4
2017	Dryocoetes granicollis	Crow Wing	Crow Wing Power	2
2017	Gnathotrichus materiarius	Crow Wing	Crow Wing Power	27
2017	Hylastes opacus	Crow Wing	Crow Wing Power	9
2017	Hylastes porculus	Crow Wing	Crow Wing Power	2
2017	Hylurgops pinifex	Crow Wing	Crow Wing Power	3
2017	Ips grandicollis	Crow Wing	Crow Wing Power	24
2017	Ips pini	Crow Wing	Crow Wing Power	1
2017	Orthotomicus caelatus	Crow Wing	Crow Wing Power	27
2017	Pityogenes hopkinsi	Crow Wing	Crow Wing Power	2
2017	Pityokteines sparsus	Crow Wing	Crow Wing Power	1
2017	Pityophthorus	Crow Wing	Crow Wing Power	10
2017	Pseudopityophthorus minutissimus	Crow Wing	Crow Wing Power	2
2017	Trypodendron lineatum	Crow Wing	Crow Wing Power	1
2017	Anisandrus obesus	Crow Wing	DNR	1
2017	Anisandrus sayi	Crow Wing	DNR	11
2017	Dendroctonus valens	Crow Wing	DNR	1
2017	Dryocoetes affaber	Crow Wing	DNR	2
2017	Gnathotrichus materiarius	Crow Wing	DNR	5
2017	Hylastes porculus	Crow Wing	DNR	2
2017	Hylurgopinus rufipes	Crow Wing	DNR	1
2017	Hylurgops pinifex	Crow Wing	DNR	1
2017	Ips grandicollis	Crow Wing	DNR	27
2017	Ips perroti	Crow Wing	DNR	1
2017	Lymantor decipiens	Crow Wing	DNR	3
2017	Orthotomicus caelatus	Crow Wing	DNR	9
2017	Pityogenes plagiatus	Crow Wing	DNR	1
2017	Pityophthorus	Crow Wing	DNR	4
2017	Polygraphus rufipennis	Crow Wing	DNR	1
2017	Pseudopityophthorus minutissimus	Crow Wing	DNR	1
2017	Conophthorus resinosae	Hubbard	Cass Lake	5
2017	Dendroctonus rufipennis	Hubbard	Cass Lake	2
2017	Dendroctonus valens	Hubbard	Cass Lake	85
2017	Dryocoetes affaber	Hubbard	Cass Lake	3
2017	Dryocoetes autographus	Hubbard	Cass Lake	1
2017	Gnathotrichus materiarius	Hubbard	Cass Lake	10
2017	Hylastes opacus	Hubbard	Cass Lake	3
2017	Hylastes porculus	Hubbard	Cass Lake	22
2017	Hylurgops pinifex	Hubbard	Cass Lake	25
2017	Hylurgops rugipennis pinifex	Hubbard	Cass Lake	14
2017	Ips grandicollis	Hubbard	Cass Lake	215

Year	Beetle species	County	Location	Count
2017	Ips perturbatus	Hubbard	Cass Lake	5
2017	Ips pini	Hubbard	Cass Lake	60
2017	Lymantor decipiens	Hubbard	Cass Lake	1
2017	Orthotomicus caelatus	Hubbard	Cass Lake	30
2017	Pityophthorus	Hubbard	Cass Lake	9
2017	Anisandrus obesus	Itasca	DNR Resource Assessment	2
2017	Anisandrus sayi	Itasca	DNR Resource Assessment	7
2017	Ips grandicollis	Itasca	DNR Resource Assessment	1
2017	Lymantor decipiens	Itasca	DNR Resource Assessment	1
2017	Anisandrus obesus	Itasca	DNR Resource Assessment	3
2017	Anisandrus sayi	Itasca	DNR Resource Assessment	18
2017	Dryocoetes autographus	Itasca	DNR Resource Assessment	1
2017	Anisandrus sayi	Itasca	MN Power	27
2017	Gnathotrichus materiarius	Itasca	MN Power	8
2017	Hylastes opacus	Itasca	MN Power	1
2017	Hylastes porculus	Itasca	MN Power	5
2017	Hylesinus aculeatus	Itasca	MN Power	1
2017	Hylurgops pinifex	Itasca	MN Power	1
2017	Ips grandicollis	Itasca	MN Power	6
2017	Ips pini	Itasca	MN Power	1
2017	Lymantor decipiens	Itasca	MN Power	1
2017	Orthotomicus caelatus	Itasca	MN Power	2
2017	Pityophthorus	Itasca	MN Power	1
2017	Anisandrus obesus	St. Louis	Hibbing	1
2017	Gnathotrichus materiarius	St. Louis	Hibbing	1
2017	Hylastes opacus	St. Louis	Hibbing	1
2017	Hylastes porculus	St. Louis	Hibbing	1
2017	Ips grandicollis	St. Louis	Hibbing	2
2017	Ips pini	St. Louis	Hibbing	1
2017	Orthotomicus caelatus	St. Louis	Hibbing	7
2017	Anisandrus sayi	Washington	Afton State Park	7
2017	Corthylus columbianus	Washington	Afton State Park	1
2017	Corthylus punctatissimus	Washington	Afton State Park	1
2017	Dryocoetes affaber	Washington	Afton State Park	1
2017	Dryocoetes autographus	Washington	Afton State Park	14
2017	Gnathotrichus materiarius	Washington	Afton State Park	7
2017	Hylastes porculus	Washington	Afton State Park	7
2017	Hylesinus aculeatus	Washington	Afton State Park	2
2017	Ips grandicollis	Washington	Afton State Park	60
2017	Lymantor decipiens	Washington	Afton State Park	16
2017	Orthotomicus caelatus	Washington	Afton State Park	9
2017	Phloeotribus liminaris	Washington	Afton State Park	5
2017	Pityophthorus	Washington	Afton State Park	5

Year	Beetle species	County	Location	Count
2017	Polygraphus rufipennis	Washington	Afton State Park	1
2017	Pseudothysanoes rigidus	Washington	Afton State Park	1
2017	Xyleborinus saxesenii	Washington	Afton State Park	2
2017	Xyleborus intrusus	Washington	Afton State Park	1
2017	Anisandrus sayi	Washington	Falls Creek SNA	497
2017	Dendroctonus valens	Washington	Falls Creek SNA	1
2017	Gnathotrichus materiarius	Washington	Falls Creek SNA	3
2017	Hylastes porculus	Washington	Falls Creek SNA	1
2017	Hylurgops pinifex	Washington	Falls Creek SNA	2
2017	Ips grandicollis	Washington	Falls Creek SNA	73
2017	Ips pini	Washington	Falls Creek SNA	3
2017	Lymantor decipiens	Washington	Falls Creek SNA	41
2017	Orthotomicus caelatus	Washington	Falls Creek SNA	8
2017	Pityophthorus	Washington	Falls Creek SNA	2
2017	Pseudopityophthorus minutissimus	Washington	Falls Creek SNA	2
2017	Xyloterinus politus	Washington	Falls Creek SNA	2
2017	Anisandrus sayi	Washington	William O'Brien SP	116
2017	Dryocoetes autographus	Washington	William O'Brien SP	3
2017	Dryocoetes granicollis	Washington	William O'Brien SP	1
2017	Gnathotrichus materiarius	Washington	William O'Brien SP	11
2017	Hylastes porculus	Washington	William O'Brien SP	2
2017	Hylesinus fasciatus	Washington	William O'Brien SP	1
2017	Hylurgopinus rufipes	Washington	William O'Brien SP	1
2017	Ips grandicollis	Washington	William O'Brien SP	98
2017	Ips pini	Washington	William O'Brien SP	3
2017	Lymantor decipiens	Washington	William O'Brien SP	21
2017	Micracis suturalis	Washington	William O'Brien SP	1
2017	Monarthrum mali	Washington	William O'Brien SP	1
2017	Orthotomicus caelatus	Washington	William O'Brien SP	13
2017	Phloeotribus liminaris	Washington	William O'Brien SP	2
2017	Pityophthorus	Washington	William O'Brien SP	2
2017	Pseudothysanoes rigidus	Washington	William O'Brien SP	2
2017	Xyleborinus saxesenii	Washington	William O'Brien SP	1
2017	Xyloterinus politus	Washington	William O'Brien SP	2

Year	Beetle species	County	Location	Count
2018	Dendroctonus valens	Washington	Afton State Park	1
2018	Gnathotrichus materiarius	Washington	Afton State Park	15
2018	Hylastes opacus	Washington	Afton State Park	14
2018	Hylastes porculus	Washington	Afton State Park	10
2018	Hylesinus aculeatus	Washington	Afton State Park	46
2018	Hylesinus criddlei	Washington	Afton State Park	13
2018	Ips grandicollis	Washington	Afton State Park	65
2018	Ips perturbatus	Washington	Afton State Park	1
2018	Orthotomicus caelatus	Washington	Afton State Park	11
2018	Tomicus piniperda	Washington	Afton State Park	6
2018	Trypodendron lineatum	Washington	Afton State Park	6
2018	Trypodendron retusum	Washington	Afton State Park	1
2018	Xylosandrus germanus	Washington	Afton State Park	1
2018	Xyloterinus politus	Washington	Afton State Park	1
2018	Anisandrus sayi	Anoka	Boot Lake Scientific and Natural	68
2018	Anisandrus sayi	Anoka	Boot Lake Scientific and Natural	3
2018	Conophthorus resinosae	Anoka	Boot Lake Scientific and Natural	1
2018	Dendroctonus valens	Anoka	Boot Lake Scientific and Natural	3
2018	Dryocoetes affaber	Anoka	Boot Lake Scientific and Natural	1
2018	Hylastes opacus	Anoka	Boot Lake Scientific and Natural	5
2018	Hylastes porculus	Anoka	Boot Lake Scientific and Natural	1
2018	Hylesinus aculeatus	Anoka	Boot Lake Scientific and Natural	1
2018	Ips grandicollis	Anoka	Boot Lake Scientific and Natural	2
2018	Ips perturbatus	Anoka	Boot Lake Scientific and Natural	1
2018	Ips pini	Anoka	Boot Lake Scientific and Natural	3
2018	Monarthrum mali	Anoka	Boot Lake Scientific and Natural	3
2018	Phloeotribus liminaris	Anoka	Boot Lake Scientific and Natural	10
2018	Pityogenes hopkinsi	Anoka	Boot Lake Scientific and Natural	9
2018	Pseudopityophthorus fagi	Anoka	Boot Lake Scientific and Natural	4
2018	Pseudopityophthorus minutissimus	Anoka	Boot Lake Scientific and Natural	4
2018	Xyleborinus saxesenii	Anoka	Boot Lake Scientific and Natural	1
2018	Xyloterinus politus	Anoka	Boot Lake Scientific and Natural	24
2018	Gnathotrichus materiarius	Anoka	Boot Lake Scientific and Natural	5
2018	Ips grandicollis	Anoka	Boot Lake Scientific and Natural	23
2018	Orthotomicus caelatus	Anoka	Boot Lake Scientific and Natural	1
2018	Pityogenes hopkinsi	Anoka	Boot Lake Scientific and Natural	1
2018	Pityophthorus	Anoka	Boot Lake Scientific and Natural	1
2018	Pseudopityophthorus fagi	Anoka	Boot Lake Scientific and Natural	1
2018	Xyloterinus politus	Anoka	Boot Lake Scientific and Natural	1
2018	Crypturgus borealis	Cass	Cass Forest Products	1
2018	Dendroctonus valens	Cass	Cass Forest Products	85
2018	Dryocoetes affaber	Cass	Cass Forest Products	3
2018	Dryocoetes autographus	Cass	Cass Forest Products	2

Year	Beetle species	County	Location	Count
2018	Gnathotrichus materiarius	Cass	Cass Forest Products	45
2018	Hylastes opacus	Cass	Cass Forest Products	2
2018	Hylastes porculus	Cass	Cass Forest Products	21
2018	Hylesinus aculeatus	Cass	Cass Forest Products	2
2018	Hylurgops rugipennis	Cass	Cass Forest Products	12
2018	Hylurgops rugipennis pinifex	Cass	Cass Forest Products	6
2018	Ips grandicollis	Cass	Cass Forest Products	108
2018	Ips perroti	Cass	Cass Forest Products	66
2018	Ips perturbatus	Cass	Cass Forest Products	45
2018	Ips pini	Cass	Cass Forest Products	16
2018	Orthotomicus caelatus	Cass	Cass Forest Products	58
2018	Pityogenes plagiatus	Cass	Cass Forest Products	11
2018	Pityophthorus	Cass	Cass Forest Products	2
2018	Trypodendron lineatum	Cass	Cass Forest Products	18
2018	Anisandrus obesus	Crow Wing	Crow Wing Power	24
2018	Dendroctonus valens	Crow Wing	Crow Wing Power	27
2018	Dryocoetes affaber	Crow Wing	Crow Wing Power	21
2018	Gnathotrichus materiarius	Crow Wing	Crow Wing Power	83
2018	Hylastes opacus	Crow Wing	Crow Wing Power	69
2018	Hylastes porculus	Crow Wing	Crow Wing Power	15
2018	Hylurgops rugipennis	Crow Wing	Crow Wing Power	13
2018	Ips grandicollis	Crow Wing	Crow Wing Power	40
2018	Ips pini	Crow Wing	Crow Wing Power	3
2018	Monarthrum mali	Crow Wing	Crow Wing Power	1
2018	Orthotomicus caelatus	Crow Wing	Crow Wing Power	734
2018	Pityogenes hopkinsi	Crow Wing	Crow Wing Power	8
2018	Pityogenes plagiatus	Crow Wing	Crow Wing Power	1
2018	Pityophthorus	Crow Wing	Crow Wing Power	3
2018	Trypodendron lineatum	Crow Wing	Crow Wing Power	16
2018	Trypodendron retusum	Crow Wing	Crow Wing Power	7
2018	Xyloterinus politus	Crow Wing	Crow Wing Power	13
2018	Anisandrus obesus	Itasca	DNR Resource Assessment	3
2018	Anisandrus sayi	Itasca	DNR Resource Assessment	2
2018	Gnathotrichus materiarius	Itasca	DNR Resource Assessment	6
2018	Hylastes opacus	Itasca	DNR Resource Assessment	7
2018	Hylastes porculus	Itasca	DNR Resource Assessment	1
2018	Hylesinus aculeatus	Itasca	DNR Resource Assessment	2
2018	Hylurgopinus rufipes	Itasca	DNR Resource Assessment	1
2018	Hylurgops rugipennis pinifex	Itasca	DNR Resource Assessment	1
2018	Ips grandicollis	Itasca	DNR Resource Assessment	3
2018	Ips perturbatus	Itasca	DNR Resource Assessment	1
2018	Ips pini	Itasca	DNR Resource Assessment	1
2018	Orthotomicus caelatus	Itasca	DNR Resource Assessment	29

Year	Beetle species	County	Location	Count
2018	Trypodendron lineatum	Itasca	DNR Resource Assessment	4
2018	Trypodendron retusum	Itasca	DNR Resource Assessment	1
2018	Anisandrus sayi	Washington	Falls Creek SNA	10
2018	Gnathotrichus materiarius	Washington	Falls Creek SNA	1
2018	Hylastes opacus	Washington	Falls Creek SNA	2
2018	Hylastes porculus	Washington	Falls Creek SNA	3
2018	Hylesinus aculeatus	Washington	Falls Creek SNA	1
2018	Hylurgops rugipennis	Washington	Falls Creek SNA	3
2018	Ips grandicollis	Washington	Falls Creek SNA	30
2018	Ips perturbatus	Washington	Falls Creek SNA	1
2018	Micracis	Washington	Falls Creek SNA	2
2018	Orthotomicus caelatus	Washington	Falls Creek SNA	1
2018	Orthotomicus latidens	Washington	Falls Creek SNA	1
2018	Phloeotribus dentifrons	Washington	Falls Creek SNA	1
2018	Pityogenes hopkinsi	Washington	Falls Creek SNA	1
2018	Pityophthorus	Washington	Falls Creek SNA	1
2018	Pseudopityophthorus fagi	Washington	Falls Creek SNA	1
2018	Pseudopityophthorus minutissimus	Washington	Falls Creek SNA	1
2018	Trypodendron betulae	Washington	Falls Creek SNA	2
2018	Trypodendron scabricollis	Washington	Falls Creek SNA	1
2018	Xyloterinus politus	Washington	Falls Creek SNA	16
2018	Anisandrus obesus	St. Louis	Hibbing Industrial Park	2
2018	Gnathotrichus materiarius	St. Louis	Hibbing Industrial Park	1
2018	Hylastes opacus	St. Louis	Hibbing Industrial Park	3
2018	Hylastes porculus	St. Louis	Hibbing Industrial Park	6
2018	Hylurgops rugipennis	St. Louis	Hibbing Industrial Park	1
2018	Ips grandicollis	St. Louis	Hibbing Industrial Park	3
2018	Ips perturbatus	St. Louis	Hibbing Industrial Park	2
2018	Orthotomicus caelatus	St. Louis	Hibbing Industrial Park	28
2018	Trypodendron lineatum	St. Louis	Hibbing Industrial Park	1
2018	Anisandrus obesus	Itasca	Minnesota Power	12
2018	Anisandrus sayi	Itasca	Minnesota Power	4
2018	Dendroctonus simplex	Itasca	Minnesota Power	4
2018	Dendroctonus valens	Itasca	Minnesota Power	1
2018	Dryocoetes affaber	Itasca	Minnesota Power	1
2018	Gnathotrichus materiarius	Itasca	Minnesota Power	59
2018	Hylastes opacus	Itasca	Minnesota Power	19
2018	Hylastes porculus	Itasca	Minnesota Power	14
2018	Hylesinus aculeatus	Itasca	Minnesota Power	7
2018	Hylurgops rugipennis	Itasca	Minnesota Power	8
2018	Hylurgops rugipennis pinifex	Itasca	Minnesota Power	11
2018	Ips grandicollis	Itasca	Minnesota Power	18
2018	Ips perroti	Itasca	Minnesota Power	3

Year	Beetle species	County	Location	Count
2018	Ips pini	Itasca	Minnesota Power	1
2018	Lymantor decipiens	Itasca	Minnesota Power	2
2018	Orthotomicus caelatus	Itasca	Minnesota Power	181
2018	Phloeotribus liminaris	Itasca	Minnesota Power	1
2018	Pityophthorus	Itasca	Minnesota Power	3
2018	Polygraphus convexifrons	Itasca	Minnesota Power	1
2018	Trypodendron lineatum	Itasca	Minnesota Power	50
2018	Anisandrus obesus	Crow Wing	MN DNR	7
2018	Anisandrus sayi	Crow Wing	MN DNR	2
2018	Dendroctonus valens	Crow Wing	MN DNR	1
2018	Dryocoetes affaber	Crow Wing	MN DNR	3
2018	Gnathotrichus materiarius	Crow Wing	MN DNR	23
2018	Hylastes opacus	Crow Wing	MN DNR	7
2018	Hylastes porculus	Crow Wing	MN DNR	5
2018	Hylesinus aculeatus	Crow Wing	MN DNR	1
2018	Hylurgopinus rufipes	Crow Wing	MN DNR	1
2018	Hylurgops rugipennis	Crow Wing	MN DNR	1
2018	Hylurgops rugipennis pinifex	Crow Wing	MN DNR	13
2018	Ips grandicollis	Crow Wing	MN DNR	31
2018	Ips pini	Crow Wing	MN DNR	4
2018	Orthotomicus caelatus	Crow Wing	MN DNR	54
2018	Pityophthorus	Crow Wing	MN DNR	2
2018	Pseudopityophthorus minutissimus	Crow Wing	MN DNR	1
2018	Trypodendron lineatum	Crow Wing	MN DNR	17
2018	Xyloterinus politus	Crow Wing	MN DNR	1
2018	Anisandrus sayi	Hubbard	Potlatch	1
2018	Dendroctonus rufipennis	Hubbard	Potlatch	1
2018	Dendroctonus valens	Hubbard	Potlatch	23
2018	Dryocoetes autographus	Hubbard	Potlatch	3
2018	Gnathotrichus materiarius	Hubbard	Potlatch	1
2018	Hylastes porculus	Hubbard	Potlatch	3
2018	Hylurgops rugipennis	Hubbard	Potlatch	8
2018	Ips grandicollis	Hubbard	Potlatch	12
2018	Ips perroti	Hubbard	Potlatch	9
2018	Ips perturbatus	Hubbard	Potlatch	236
2018	Ips pini	Hubbard	Potlatch	1
2018	Orthotomicus caelatus	Hubbard	Potlatch	6
2018	Pityogenes hopkinsi	Hubbard	Potlatch	1
2018	Pityogenes plagiatus	Hubbard	Potlatch	1
2018	Polygraphus rufipennis	Hubbard	Potlatch	1
2018	Trypodendron lineatum	Hubbard	Potlatch	4
2018	Anisandrus sayi	Anoka	Rum River Central Regional Park	2
2018	Dendroctonus valens	Anoka	Rum River Central Regional Park	5

Year	Beetle species	County	Location	Count
2018	Gnathotrichus materiarius	Anoka	Rum River Central Regional Park	16
2018	Hylastes opacus	Anoka	Rum River Central Regional Park	18
2018	Hylastes porculus	Anoka	Rum River Central Regional Park	52
2018	Ips grandicollis	Anoka	Rum River Central Regional Park	52
2018	Ips perturbatus	Anoka	Rum River Central Regional Park	5
2018	Ips pini	Anoka	Rum River Central Regional Park	1
2018	Lymantor decipiens	Anoka	Rum River Central Regional Park	2
2018	Monarthrum mali	Anoka	Rum River Central Regional Park	1
2018	Orthotomicus caelatus	Anoka	Rum River Central Regional Park	36
2018	Pseudopityophthorus fagi	Anoka	Rum River Central Regional Park	3
2018	Trypodendron lineatum	Anoka	Rum River Central Regional Park	6
2018	Xyloterinus politus	Anoka	Rum River Central Regional Park	1
2018	Anisandrus sayi	Anoka	Rum River Central Regional Park	1
2018	Hylastes opacus	Anoka	Rum River Central Regional Park	1
2018	Pseudopityophthorus minutissimus	Anoka	Rum River Central Regional Park	3
2018	Xyloterinus politus	Anoka	Rum River Central Regional Park	9
2018	Anisandrus sayi	Washington	William O'Brien State Park	2
2018	Dendroctonus valens	Washington	William O'Brien State Park	4
2018	Gnathotrichus materiarius	Washington	William O'Brien State Park	6
2018	Hylastes opacus	Washington	William O'Brien State Park	7
2018	Hylastes porculus	Washington	William O'Brien State Park	1
2018	Hylesinus aculeatus	Washington	William O'Brien State Park	15
2018	Hylesinus fasciatus	Washington	William O'Brien State Park	6
2018	Hylurgops rugipennis	Washington	William O'Brien State Park	1
2018	Ips grandicollis	Washington	William O'Brien State Park	51
2018	Ips perroti	Washington	William O'Brien State Park	1
2018	Ips pini	Washington	William O'Brien State Park	2
2018	Micracis	Washington	William O'Brien State Park	1
2018	Orthotomicus caelatus	Washington	William O'Brien State Park	7
2018	Pityogenes hopkinsi	Washington	William O'Brien State Park	1
2018	Trypodendron lineatum	Washington	William O'Brien State Park	2
2018	Xylosandrus germanus	Washington	William O'Brien State Park	3
2018	Xyloterinus politus	Washington	William O'Brien State Park	20

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